THREE MACROEVOLUTIONARY EPISODES

Deep Time and the Creation/Evolution Controversy

By James Downard

Introduction

The genesis of this book began early in 1998 following an effort by activists in a nearby community to tilt the public school curriculum in the creationist direction. Although my BA was in history from Eastern Washington University, I had long cultivated an interest in dinosaur paleontology, which brought me in on evolutionary theory at the ground floor via the fossil evidence. I had also followed both the Young Earth creationist (YEC) debate and developing Intelligent Design movement from afar, relating their claims to my own understanding of what it meant for all life to be related by common descent.

But on this occasion, amid all the editorial exchanges printed in our local newspaper (including a few letters of my own defending the evolutionary position), I noticed how these antievolutionists were no longer quoting the older generation of creationists like Henry Morris or Duane Gish. Instead, ammunition was drawn from a new field of critics: Berkeley law professor Phillip Johnson for a philosophical perspective, Lehigh University biochemist Michael Behe for the biological details, and British journalist Richard Milton on the fossil evidence.

While I was quite familiar with the views of Johnson and Behe, I had never heard of Richard Milton. On investigation I discovered that he was editor of the online edition of British Mensa magazine. His education and background weren't specified, but his books were critical of evolution and how the current naturalistic scientific paradigm disparaged controversial paranormal research.[1] He was also among those appearing on the notorious NBC television special "The Mysterious Origins of Man." Aired in February 1996 and narrated by Charlton Heston, the show mixed extreme Creation Science believers like Carl Baugh with New Age historical revisionists Graham Hancock and John Anthony West.[2]

Indeed, in the years since *Shattering the Myths of Darwinism* appeared on this side of the Atlantic, Milton has been chiefly favored by peripheral End Times creationists.[3]

This was understandable, as Milton relied on a narrow band of dated neo-catastrophists that included Mormon creationist Melvin Cook disparaging continental drift and radiometric dating from the 1960s, and the 1950s planetary collision theories of Immanuel Velikovsky—territory I happened to know well.[4] Although Velikovsky's theories had gained no more credibility over the years than Flood Geology, Milton showed no critical appreciation of this. For someone writing in the 1990s, he seemed surprisingly out of touch.[5]

Such scholarly lethargy can easily slide out of control, as when Milton claimed apropos my own interest of dinosaurs:

> The very size of some specimens, such as the larger land-living dinosaurs makes it absurd to suppose that they could have been preserved in a few millimeters of sediment. To preserve by burial an adult brontosaurus, or diplodocus, would require tens of meters of sediment, and these quantities can only be explained by catastrophic rather than uniform deposition.[6]

Milton thought he knew what an average annual sedimentation rate was not by citing any geologists, but by flying solo: "Curiously, too, no geologist seems to have checked out the geological column dates with an electronic calculator on a commonsense basis." By charting the thickness of rock in various geological eras he deduced "an average annual rate of deposition of 0.2 millimeters." There weren't any sources given there either (though his caption did *mention* the Natural History Museum in London—formerly the British Museum).[7]

At most, Milton's calculation (which was lower than real world values by about an order of magnitude) would represent a rough ballpark floor for the *minimum* rate of accumulation.[8] But Milton had far grander ambitions for his number, nursing it along until it became the "typical" rate. And later, discussing the fossil Iguanodons found jumbled in a mine at Bernissart, Belgium, Milton morphed it into a functional synonym for the *maximum* value. "For their bodies to be rapidly buried would require rates of deposition thousands or even millions of times greater than the average of 0.2 millimeters per year proposed by uniformitarians."[9]

Except it wasn't uniformitarians who were proposing that rate—only Milton. So had he finally ended up talking himself into thinking his own scenario wasn't even his idea?

Milton's argument seemed especially surreal because natural processes are fully capable of dumping a lot more than "a few millimeters of sediment" on large obstacles now and then. I had just seen one example on television, where modern archaeologists had located the buried hull of a riverboat stranded on a Mississippi sandbar in the 19th century and abandoned as not worth the trouble to salvage. Bulldozers were required to remove the *meters* of sediment, which took place not in the river, or even at its edge, but on a farmer's field. For the Mississippi River had done more than just lay down mud quick enough to entomb the hull—the river had in the meantime completely shifted course, at which point the sedimentation process *stopped*.[10]

So the first half of Milton's logic about buried brontosaurs was wrong. What about the balance?

I knew most diplodocids were twenty-five meters or less in length, with most of that consisting of long thin necks and whiplike tails. Full skeletons of sauropods being quite rare, many museums have casts of the Carnegie Museum's famous *Diplodocus* (a lighter but longer eighty-foot sauropod cousin of *Brontosaurus/Apatosaurus*) rather than a specimen of their own to grace the dinosaur hall.[11]

But even if you had a fairly complete skeleton in the ground, it would only require two or three meters of sediment to cover a carcass plopped flat on its side. The only way it would require "tens of meters" would be if it were buried vertically—like a tent stake. Only I had never read of any examples of that, even given by creationists, let alone paleontologists.

And for good reason—there aren't any.

At this point curiosity got the better of me and I emailed Milton via the Mensa website to ask about his novel conclusions about sauropod burial. I included a reference to that Mississippi riverboat and specifically challenged his "tens of meters" claim.

Milton confidently replied that there was a "182-foot" (hence 60-meter) "Brontosaurus" on display at the London Natural History Museum. But a check of the museum listings indicated they actually had one of those Carnegie *Diplodocus* casts—thus wrong name and length. It took only a further twenty-four hours of email to confirm all this with the NHM paleontology department, whose Simone Wells dryly informed me that Milton's hallucinated specimen wouldn't even fit in the main gallery (which barely accommodates their *Diplodocus* as it is).[12]

All this suggested (i) Milton likely slipped an extra digit (or confused English measure for metric) somewhere in his notes. (ii) He knew so little about sauropod dimensions the figure didn't strike him as immediately suspicious (a 182-foot *Apatosaurus* would have been a record-holder listed in all the dinosaur books). Finally (iii) even though positively prompted by my skepticism, Milton never thought to fact check himself before repeating the mistake.

As for the catastrophe angle, Milton's reply didn't offer any evidence that articulated sauropod skeletons had ever been found perpendicular to the bedding plane. Instead, he responded with a completely different dinosaur example, claiming that the famous Bernissart *Iguanodon* skeletons were buried that way. He was simply repeating his book claim, where that example was the last of four instances of supposed catastrophic deposition that Milton had drawn secondarily from one of Henry Morris' creationist books.[13]

Now the world's leading authority on *Iguanodon* happens to be both alive and a compatriot of Milton's: British paleontologist David Norman. His excellent *Illustrated Encyclopedia of Dinosaurs* explained how these smaller (non-sauropods) were deposited, and it wasn't anything like the version Milton borrowed from Henry Morris:

> One rather misleading aspect of the way of life of *Iguanodon* relates to the discoveries at Bernissart. The concentration of skeletons at Bernissart has been used as evidence that these animals lived in herds, and in the case of Bernissart that they plunged into a ravine after being stampeded by a predator, or some other dramatic event. Unfortunately, appealing though the story is, it is certainly

> not what happened at Bernissart. Re-study of the material has shown that there was no ravine to fall into, the skeletons simply collected in a marshy or lake-like depression; furthermore there was no large herd, but rather there were separate phases of deposition, with carcasses being washed in and buried from time to time.[14]

Surely anyone wanting to discuss Iguanodons in the 1990s would want to start with David Norman. Yet Milton hadn't even mentioned him.

Except he had.

Milton had already cited Norman's book, but on a completely different matter (relating to bird evolution). Presuming that he had read Norman at some point (rather than obtaining even this item secondarily), it had apparently never occurred to him to look up "Iguanodon" in the index to see what Norman had to say about it.[15]

And with this oversight, Milton has obligingly shown us exactly how he could wander so far astray from the facts. Milton consistently began by limited reading, which he merged uncritically into his own treatment without calibrating any of it by the available literature. Add an absence of curiosity (or a surfeit of hubris) when challenged on his presentation of the facts, and Milton becomes an exemplar of how not to conduct reasoning.

While there is little doubt that Milton doesn't like Darwinism or uniformitarian geology, a problem comes in trying to figure out what Milton does believe, unambiguously or otherwise. He apparently thinks the earth is not many millions of years old, but whether it is as young as 100,000 or even 10,000 years is impossible to determine from Milton's text.[16] As for evolution, Milton never explained what he thought was going on in the past. At one point he hinted that quantum theory might offer the key to a "non-Darwinian" model of life, only to ridicule later on "half-baked speculations about aliens and quantum mechanics" he never specified.[17]

However confidently Milton appealed to scientific reasoning in making his case (including using the buttons on a pocket calculator) the result was a fog of self-imposed uncertainty.

And he isn't alone there.

When Christopher Toumey studied a North Carolina Young Earth creationist club, his relationship grew so friendly that they were "often asking for my professional opinions and personal feelings about creationism. I participated modestly by contributing my knowledge of the history of evolutionary and creationist thought, which they liked to hear about but lacked the curiosity to look up. I became by default the group's unofficial historian of creationism. This was a strange thing for me, an evolutionist explaining the history of creationism to creationists, but I was honored and pleased to make myself useful with my esoteric expertise."[18]

Lacked the curiosity to look up? What a dismal observation to make about a *study* group.

But isn't that exactly what Milton was doing with that 182-foot Brontosaurus at the British Museum? Or the local antievolutionist that got me started on this project, by invoking Milton's fossil expertise without realizing how unreliable his source was?

The daisy chain quality of Miltonian scholarship supplies a common pattern for the social process of antievolutionism that I experienced at the grassroots level. An activist (even one not consciously favoring YEC beliefs) wouldn't need to draw on Henry Morris directly—not so long as they relied on uncritical conduits like Milton.

Thus the "Foreward" Phillip Johnson wrote to a 1998 antievolution book by Hank Hanegraaff (popular radio commentator on the "Bible Answer Man" show) praised his scholarly contribution: "He exposes the specific wrong answers and provides lots of references to other literature." Which indeed Hanegraaff had, citing scientific heroes that included Duane Gish on the *Protoavis* matter to be discussed in Chapter Six.[19]

While Hanegraaff doesn't deny his YEC views, he rarely calls attention to them. But even when an author is unequivocally a Young Earth creationist, not everyone seems able to spot it. Take *The Collapse of Evolution* by Florida computer instructor Scott Huse. Even by creationist standards it is superficial twaddle, derivatively (and ineptly) recycling the weakest of YEC claims.[20]

Yet in "An Evolving Debate" online at PBS (May 8, 1998), Carl Herbster, president of the American Association of Christian schools, proposed:

> A public high school class should be exposed to the scientific evidence that contradicts evolution and that points to intelligent design. This can be done without directly dealing with religion. Several former evolutionary scientists have written scientific critiques of evolution, such as Michael Denton, Evolution: Theory in Crisis, and Scott Huse, The Collapse of Evolution. Just pointing out scientific evidence and problems should pass court scrutiny.[21]

And when Doug Bandow (a Fellow of the *laissez-faire* conservative Cato Institute) wanted to recommend books "demonstrating that religious faith does not mean checking one's mind at the church door," he included *The Collapse of Evolution*.[22] Eight years earlier Bandow had been just as enthusiastic about Johnson's *Darwin on Trial*. "Johnson lacks a technical background," observed Bandow, "but he makes up for that deficiency with his ability to deconstruct poor reasoning."[23]

Examples of Denton's scientific analyses and Johnson's deconstruction of them will be explored in the chapters to follow.

While Johnson, Herbster and Bandow show how smooth a road can run from faulty "primary" (actually secondary) YEC authors to their secondary (really tertiary) supporters in the Intelligent Design community, Milton's example tells us something else about the methodological dynamics of antievolutionism that the religiously grounded advocates do not. However much Milton might sound like Henry Morris, there was an important difference: "Let me make it unambiguously clear that I am not a creationist, nor do I have any religious beliefs of any kind. I am a professional writer and journalist who specializes in writing about science and technology and who writes about matters that I believe are of public interest."[24]

Which suggested the working premise for this book: the core problem with antievolutionism could not be religion, otherwise how would you explain the secular Richard Milton?

Of course religion enters into the picture, both demographically (most American antievolutionists are conservative Christians) and as a profound motivation for acceptable content (most notably the rejection of an animal origin for human beings). Readers unfamiliar with this context will find "A Brief History of Creationism" in Appendix I.

Religion further acts as a deep cultural well for apologetic methods long used to defend core doctrines, such as biblical inerrancy among traditional creationists. For example, the Christian apologetic practice of resting doctrine on "proof texts" finds its counterpart in efforts to disprove evolution by assembling a critical mass of quotes from evolutionists ("out of their own mouths") rather than discussing the data on which those quotes might have been based.[25]

Recognizing that religious conviction is not a synonym for faulty methodology frees us to examine the extent to which antievolutionism as a methodological enterprise follows a Miltonian path as a matter of preference, expedience, or necessity.

To find the commonality in the logic of antievolutionism, we must look to history.

When it comes to assessing the natural world and the extent to which physical processes account for it, there is an inevitable tension between what may be observed now and how that may relate to what happened in the past (or might in the future). Can we be absolutely certain that apples fell for Aristotle as they did for Newton and do for us when we drop one today? If they didn't, how then can physicists be so presumptuous to extrapolate their present experiments back through the eons to propose what Jupiter may have been doing umpteen million years ago? Or in the Einsteinian context of curving space-time, ramming advanced physics all the back to what positrons were up to during the early flash of the Big Bang?

These are far from academic questions in the creation/evolution debate. While Old Earth creationists (OEC) like Hugh Ross see the Big Bang as the ultimate verification of a supernatural starting point for the universe, Young Earth creationists are just as certain that such retroactive math is unscientific (and counter-Scriptural).[26] There is also a scatter of cosmological criticism in the scientific community that ultimately surfaces among the anti-Darwinism of David Berlinski in *Commentary* and Tom Bethell at *The American Spectator*.[27]

All of which suggests contributors in this area need to think carefully about the precedents they are setting when they offer arguments based on a difference of philosophical opinion about what limits ought to be placed on the power of inferential logic.

Milton set a disconcerting standard in a chapter of his book *Forbidden Science*, all too aptly titled “A Methodological Madness.” Here Milton explained that “someone who—before 1969—wished to entertain the hypothesis that the Moon was made of rocks like the Earth’s, held a view which was neither more nor less rational or scientific than one who held the green-cheese theory.”[28]

He means it.

Of course a healthy science ought to have no problem with empiricism. Had the lunar regolith turned out to be green cheese, there would have been a lot of astonished faces back at Houston, but they still would have had to deal with it. The practical problem comes when we move beyond lunar dairy products. While no one was seriously proposing in 1969 that the moon might possibly be made of green cheese, the age of the earth and universe and the evolutionary aspects of fossils are definitely hot topics in some quarters. And each of those issues depends on the presumption that it is possible to take data preserved from the past and draw reasonable inferences from them.

Milton failed to appreciate this distinction when he criticized paleontologist Robert Bakker for roughly estimating the time spanned by a Late Jurassic dinosaur deposit at about 10 million years. “Yet we are given the confident assertion concerning the number of dinosaur generations and the number of years to which this sequence is equivalent, with no solid physical basis. No other scientific discipline would be permitted to consider such procedures, but when paleontologists date rocks by means of fossils, they do so with the authority of Charles Darwin himself.”[29]

But replace “fossils” with “pottery fragments” and that’s exactly what archaeologists have been doing quite independently of Darwin. The principle of comparative dating even applies to the presence of pop-top beer cans in garbage dump stratigraphy, as evolutionary biologist Kenneth Miller dryly noted in his critique of creationism.[30]

Compare then the attitude of Henry Morris from 1963: “But in what way do fossils of dead animals provide evidence for evolution? Since they were deposited in most cases prior to human historical observations and records, it is obviously impossible to know for certain just how and when they lived and were buried.”[31]

Note that by “evolution” Morris meant more than just whether certain animals might be related by common descent. As a Young Earth creationist he included the whole doctrinal package, which contends that virtually all fossils were deposited only a few thousand years ago during Noah’s Flood, and not living (and dying) over many millions of years.

But in order to take this comprehensive position Morris had to ignore the whole paleontological subdiscipline of *taphonomy*. This was the field David Norman was using when he explained how the Bernissart Iguanodons came to be where they were. As anthropologist Laurie Godfrey noted, taphonomists “can recognize the telltale signs of postmortem gnawing, of trampling, of slow or rapid water transport, of oxidizing or reducing depositional environments, of physical and chemical weathering, of postdepositional deformation, and so on. They can tell you why no shoulder blades, vertebrae, hand bones, and foot bones may be represented in a deposit loaded with skulls, jaws, and occasional long bones of fossil vertebrates.”[32]

Exactly like a forensic expert accumulating evidence at a crime scene, taphonomists correlate observations about a past event with experience gleaned from present experiment. Dried blood spatters on a wall can tell about the nature of a crime only because experimenters have been able to determine empirically what happens to blood when it is splayed under varying conditions. Likewise, how a fossil animal could come to be found in a particular configuration is a reflection of the geological constraints seen to be working today.[33]

To reject these inferential journeys into the geological past is ultimately to deny the present observations on which those inferences were based. This is most obviously seen when Young Earth creationists defend the teaching that there was no animal carnivory until after the Fall of

Adam (or perhaps even the Flood).[34] Thus Ken Ham of Answers in Genesis pointedly cautioned: "The present food chain and behavior of animals (which was changed after the flood in Genesis 9:2-3) CANNOT be used as a basis for interpreting the Bible—the Bible explains WHY the world is the way it is!"[35]

Like Milton with Norman's Iguanodons, though, Ham directly referenced a paleontological source that explained in great detail why carnosaurs are known to have been eating meat. And like Milton, Ham managed not to mention any it.[36]

Are we getting a pattern?

When applied in a political context the antievolutionary methodology can get the Kansas State School Board in 1999. Creationists who briefly held a majority of seats decided it was time to revise their science standards to treat evolution as an unproven theory. But remember that for many creationists "evolution" overflows the boundary of common descent, and the creationist board members wanted also to excise explicit references to conventional geochronology and the Big Bang.[37] While the nominal sponsor of the revised standards was veterinarian Steve Abrams, former head of the state Republican Party, much as Milton had with Morris *et al* Abrams drew on local creationists for advice in wording the provisions. Thus was the actual text drafted by Tom Willis, a Young Earth creationist who serves as President of "The Creation Science Association of Mid-America."[38]

Controversy immediately erupted as evolutionists and culture critics despaired at how much of modern science could be so easily tossed out by a state school board.[39] Meanwhile antievolutionary apologists (including a broad swath of the Discovery Institute's Fellows) lined up to defend the standards, focusing on the anti-Darwinian side of the ruckus, while avoiding the Kansas boards' intimate connection to Young Earth creationism.[40]

Tom Willis' role in the Kansas affair was even more unsettling from an epistemological standpoint because he has also showed a surprising open-mindedness toward the scientific legitimacy of *geocentrism*.[41]

Now you'd think if anything were a settled scientific issue these days, it would be that the earth revolves around the sun. But there remains a small body of geocentric creationists, whose influence has been a persistent undercurrent in the antievolution debate.[42] Young Earth creationist Paul Taylor (someone who would agree with Henry Morris that there were dinosaurs on Noah's Ark) drew on British creationist Malcolm Bowden and Ohio college computer science teacher Gerardus Bouw without mentioning their geocentrism.[43] The Bowden scholarly daisy chain even extends into Intelligent Design territory, as Phillip Johnson came "to be suspicious of both the Java Man and Pekin [*sic*] Man fossil finds" from reading Malcolm Bowden.[44]

Ideas have consequences, and so do methods, especially when absorbed parasitically.

In order to believe today that geocentrism is a viable scientific concept, a great deal of careful data management is required, and that is only possible if some very selective ideas about the nature of inferential logic provide a philosophical scaffolding. Willis' behind-the-scenes role in the Kansas case may therefore tell us something about why the science standards he drafted drew a line in the epistemological sand as finicky as Milton had on lunar cheese. "There are two basic origins views; macro-evolution and intelligent design. These views are part of a whole class of Historical theories that do not qualify as empirical science. Origins views cannot be demonstrated, repeated, or falsified and no proof can be advanced that one view is superior to another in ensuring successful research, much less good citizenship."[45]

This uncompromising demarcation is shared by many of those defending the Kansas standards. For example, in "The Compelling Secular Necessity of the Kansas Board of Education's Amendments to Its Science Education Standards," creationist psychologist Paul Ackerman similarly stressed the incompatibility of history with an experimental method. "Historical questions such as the age of the earth or whether dinosaurs evolved into birds cannot be experimentally tested in the manner of, say, whether a particular vaccine will prevent a disease."[46]

The views of Morris, Willis and Ackerman are inevitable if you don't want science education treating the Big Bang as a physical reality, or stepping on theological toes by refusing to include Adam and Eve and the Flood in recent human history. That it also permits the exclusion of general evolution is simply a corollary, though one with which non-YEC antievolutionists are more than happy to agree. And that's because the idea that "historical" disciplines are somehow inaccessible to a science dependent on experimentation is a fairly common attitude in the general culture, even at the college level.[47]

This misconception found its way into an odd episode involving Phillip Johnson decanting evolutionary biologist Richard Lewontin criticizing Carl Sagan's *The Demon-Haunted World*, a work concerned with the persistence of superstition and irrationality in a modern world otherwise so capable of sound scientific reasoning. Lewontin's confusion began here:

> So why do so many people believe in demons? Sagan seems baffled, and nowhere does he offer a coherent explanation of the popularity at the supermarket checkout counter of the *Weekly World*, with its faked photographs of Martians. Indeed, he believes that "a proclivity for science is embedded deeply within us in all times, places and cultures." The only explanation that he offers for the dogged resistance of the masses to the obvious virtues of the scientific way of knowledge is that "through indifference, inattention, incompetence, or fear of skepticism, we discourage children from science." He does not tell us how he used the scientific method to discover the "embedded" human proclivity for science, or the cause of its frustration. Perhaps we ought to add to the menu of Saganic demonology, just after the spoon-bending, ten-second seat-of-the-pants explanations of social realities.[48]

For Lewontin, there is only one sure-fire guarantee against falling into belief in the supernatural (a deep basket which includes the God of Abraham along with tabloid extraterrestrials). It is nothing less than an "*a priori* adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counter-intuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door."[49]

Being an orthodox Marxist, that was one easy admission for Lewontin to make, since absolute materialism is a bedrock assumption for that ideology. But that authoritarian opening was all Phillip Johnson needed to get going, repeatedly citing Lewontin's remarks to support his own apologetic claim that "evolution is not a fact, it's a philosophy."[50]

Johnson fell into "proof text" mode when he characterized Lewontin's position:

> Lewontin laments that even scientists frequently cannot judge the reliability of scientific claims outside their fields of specialty and have to take the word of recognized authorities on faith. "Who am I to believe about quantum physics if not Steven Weinberg, or about the solar system if not Carl Sagan? What worries me is that they may believe what Dawkins and Wilson tell them about evolution."[51]

Lewontin was objecting to Sagan's including Richard Dawkins and Edward Wilson among the "best contemporary science-popularizers." He prefaced his Weinberg/Sagan point: "when scientists transgress the bounds of their own specialty they have no choice but to accept the claims of authority, even though they do not know how solid the grounds of those claims may be."[52]

Although Lewontin was not claiming that a scientific position was being reached solely as a philosophical statement in defiance of facts, Johnson was acting as if Lewontin had. And here Lewontin's imprecision was leading Johnson into trouble. That people outside a specialty might not devote sufficient time to comprehending the underlying logic of quantum physics or cosmology is not the same thing as saying that they would be unable to do so even if they put their mind to it. Or that members of the supposedly arcane discipline wouldn't be able to meet the layman somewhere in the middle by carefully explaining how every single step was arrived at, and how each amenable prediction comported to empirical confirmation.

A naturalistically inclined critic could fairly have called Lewontin on this point, objecting that the chain of reasoning leading to the acceptance of quantum theory or the immensity of the universe is just as solid as that backing up "descent with modification." These cornerstones have made the scientific cut because they generate specific predictions about the content of the observable universe—tests which each has successfully passed. For the *microcosmos* of quantum theory, the ghostly swirls in a cloud chamber verify the existence of a swarm of subatomic particles, precisely as the red-shifted spectra of distant galaxies have confirmed their yawning temporal recession on the *macrocosmic* scale.

And the discovery of intermediates like the therapsids discussed in part three of this book supports the evolutionary conception that *uniquely* proposed the prehistoric existence of so distinctive a fauna.

None of these links in their respective evidential chains requires acceptance "on faith" in the sense that one believes in the divinity of Jesus or the enlightenment of Buddha. Instead, Lewontin was justifying an expedient laziness, whereby absolutist materialism (rooted in some increasingly musty Marxist ideology) was permitted to replace direct understanding as a way of dealing with the content of other technical disciplines. If one is going to disbelieve in any proposed phenomenon (from miracles to Cold Fusion), it ought not to be because they are ruled nonexistent by philosophical decree—no matter what the evidence—but because there is a dearth of observation to support their reality. To do otherwise is to raise an unnecessarily rigid metaphysical firewall that puts empiricism on the wrong side.[53]

And this wrong side is also where Phillip Johnson has landed.

Remember that for his examples of "counterintuitive " explanations that might be "mystifying to the uninitiated," Lewontin did not select anything from his own field of evolutionary biology. He was highly critical of Dawkins and Wilson over in the rival sociobiology department, and cautioned that the current hoopla over gene therapy was unjustified on theoretical grounds. But neither of these constituted a repudiation of the general evolutionary concept of naturalistic descent with modification that an antievolutionist like Phillip Johnson is opposed to.[54]

Moreover, Lewontin began his piece by recalling how in 1964 he and Carl Sagan had first met when they debated a creationist in Arkansas. The topic they defended was "*Resolved*, That the Theory of Evolution is proved as is the fact that the Earth goes around the sun."[55]

Given Johnson's secondary reliance on the paleoanthropology of geocentrist Malcolm Bowden, his comment on Lewontin's point was ironic to the point of mirth: "How could the theory of evolution even conceivably be 'proved' to the same degree as 'the fact that the earth goes around the sun'? The latter is an observable feature of present-day reality, whereas the former deals primarily with nonrepeatable events of the very distant past. The appropriate comparison would be between the theory of evolution and the accepted theory of the *origin* of the solar system."[56]

Johnson's view was historically debatable, for we "observe" the sun "rising" on the horizon, exactly as it did in Aristotle's day when geocentrism was the accepted reality and heliocentrism a minority position. It wasn't immediately obvious that the earth wasn't stationary (the problem of conceptualizing inertia only began in Galileo's era, and later given formulaic rigor by Newton). Thus it took a lot of clever inferential thinking (including a revived heliocentric theory of ultimately superior explanatory power) to change the interpretation of what people "see."[57]

But Johnson also did not pursue his own analogy to the next step: is the naturalistic origin for the solar system (something Henry Morris or Tom Willis would strenuously object to) methodologically distinguishable from the reasoning underpinning that brand of naturalistic evolution Young Earth creationists and Johnson independently assail? More bluntly, why was it *evolution* that was "not a fact" here, rather than the quantum physics or stellar distances Lewontin actually gave as prime illustrations of concepts the materialist is supposed to accept in spite of their seeming injury to common sense?[58]

Well, jumping to those more direct conclusions would have sounded a trifle too like Henry Morris or Tom Willis, wouldn't it?

Johnson latched onto the antievolutionary option here with such exclusivity not because there is some logically identifiable (or defendable) way to distinguish the "fact" and "philosophy" of it that wouldn't also apply to abstruse physics or cosmology. He advanced his parochial interpretation because it is evolution—*and evolution alone*—that he wants out of the picture.[59]

That is the common problem with Henry Morris' Young Earth Creationism, Richard Milton's catastrophic geology, and Phillip Johnson's anti-Darwinism. All of them ultimately rest on an anti-historical premise: that a given theory of origins cannot have logical consequences amenable to observation and experimentation.[60]

This is a Trojan Horse for Intelligent Design, where the whole point has been that there are ways to "falsify" evolution. That's what Michael Behe's "irreducible complexity" and William Dembski's "specified complexity" are all about. Yet both of those approaches attempt to infer design by viewing existing systems in isolation. Fossil arguments play no role—which means *history* plays no role.[61]

There is a forensic dilemma when it comes to relating the fossil world to the present.

Microevolutionary processes are by their nature chiefly determined by observing the structure and behavior of living organisms. You follow how individual animals interact in the wild, or study how developmental mechanisms assemble a complete form from the instructions on a string of DNA. Whatever that data may be, they are still virtually instantaneous snapshots of what can go on within a laboratory setting or under the temporally restricted eye of field research that has only been looking for a few centuries. The one thing such research cannot completely embrace is the dimension of *time*, especially in increments of many thousands, millions, or billions of years. And yet it has to do that very thing. With no choice but to venture into what Henry Gee has dubbed "Deep Time," you have to recognize how it transforms and to some extent restricts the experimental and observational pallet.[62]

If you find a unique fossil, was it really so special at the time? Or had it actually been quite common, except that individuals were so small and perishable that there was little chance that any of them would ever get preserved? Maybe all of them usually lived over in the next county, but that habitat ended up pulverized by a glacier half a million years ago. Assuming then that this fossil was once a living organism (and it has only been in the last few centuries that this particular interpretation has become a scientific given) what all can you tell about its lost life? You can't take its temperature, you can't look at its gene sequence, you don't know how many brothers or sisters it may have had, or necessarily whether it ever reproduced. But you can surmise that it *had* a gene sequence, and there are precision tools like taphonomy to put constraints on the implications of the data being observed.

Deep Time is a historical venue, and yet most people haven't given up on understanding our slice of eternity, despite all the pitfalls. No one alive today ever met Caesar and Cleopatra, but no one seriously suggests they were fictional. Cleopatra is reputed to have had a child by Caesar, but there's no way to prove now that they ever made love. Though if they did, and Caesar whispered sweet nothings in her ear, we may reasonably surmise it had to have been in Greek, the only language they had in common.[63]

Interpreting human history would thus seem on a somewhat firmer footing that discerning how Sue the *T. rex* died in the Cretaceous, or whether she was a distant physical cousin of the fried chicken served up at a fast food franchise seventy million years later. Unlike our Roman on his Egyptian adventure, documented by historical inscriptions and coins, all we have in the fossil record is bunch of bones. There were no eyewitnesses to see the living animal, let alone chronicle the step-by-step transformation of some of its dinosaur cousins into chicken dinner.

And yet—while we may have documents galore on Caesar, what we don't have are any of his remains. As was the Roman practice with their dead, the slain Caesar was evidently cremated on a funeral pyre in the Forum. So in a physical sense the individual Caesar is less "real" for us now than Sue the *T. rex*. We can literally inspect the dinosaur bones, or at least parts of them, and infer some things about that once-living individual animal that is unavailable to us for the late Roman dictator.[64]

Deep Time is also not afflicted by something else that tags along with eyewitnesses. When Plutarch reported on Cleopatra's linguistic skills the possibility exists that he might have been misinformed or even fibbing. But when plumbing Deep Time the investigator can rule out mendacity as a contributing factor at the source. While scientists may stumble now and then in reading the forensic clues, they may at least rely on the principle that, behind it all, Nature is *not* an artifact.[65]

As the discipline of taphonomy indicates, the very existence of certain fossils in particular places and preserved in distinctive ways says things about the living event that produced that combination. The details have to matter, and at least one useful measure of how rigorous an argument is must be the degree to which those details surface in it. Guided by the objective principles of sound scholarship, all steps in a chain of reasoning must in principle be carefully and openly documented.

That this is the legitimate way to edge back along the ravines of Deep Time, step by inferential step, is the leitmotif for this book.

In documenting this distinction concerning three major macroevolutionary events (the origin of phyletic disparity in the Cambrian Explosion, and the subsequent diversification of amniotic vertebrates into birds and mammals) I hope to contribute fresh perspectives to a field already represented by an extensive critical literature. Philosophers, paleontologists and biologists have variously defended evolutionary reasoning and assailed the poor scholarship and incomplete arguments of creationist authors.[66]

I have learned much from these prior analyses, as the reader will see by my own citations. But there are also important examples that have been overlooked, and I've been genuinely puzzled as to why this has been so. Duane Gish's recent forays into discounting the evidence of Deep Time have been all but ignored by secular critics.[67] Nor has any prior treatment spotlighted the sizable scholarly oversights Phillip Johnson has displayed concerning the three macroevolutionary cases covered in this book.[68]

And of course none had the example of Richard Milton to suggest how the debate should be shifted away from the contentious cliché juxtaposition of Science (embodying methodological naturalism) and Religion (dependent on transcendental revelation and faith).[69]

While those issues are perfectly valid ones to explore (and I count myself firmly in the provisionally naturalistic camp represented by people like Arthur C. Clarke or the late Carl Sagan), focusing there too quickly obscures the methodological lesson suggested by the Milton case. The universe may indeed belong either to "God or Matter" as Phillip Johnson has put it.[70]

But such discussions are not facilitated if their proponents are inured to Miltonian scholarship and reasoning.

A renewed focus on basic scholarly method may not be a completely painless process for some in the creation/evolution debate. People often get used to framing arguments in certain ways, traveling along familiar ruts. For example, the atheist William Provine appears to be all too comfortable debating with his friend Phillip Johnson, since both actually share the same primary "God or Matter" division. Provine simply says *nay* to Johnson's *yea*.[71]

While it may be too glib to think that "common ground" exists somewhere between the polarities of Johnson and Provine, the scholarly methods approach may offer one potentially more fruitful alternative: the search for *solid* ground between competing alternatives.

Prologue

Whitworth College
November 1998

When I learned that Phillip Johnson was to attend a "Creation Week" symposium at Whitworth College, right in my Spokane, Washington, backyard, I had just begun writing the material that has resulted in this present volume. Although I'd already had several email exchanges with Johnson over the years, I was very anxious to make the most of this public opportunity to ask him as many questions as I could squeeze in on how he had arrived at his particular antievolutionary conclusions.

After all, an idea worth having is one worth defending.

I listened to Johnson's main address, which was a restatement of his philosophical stance that the creation/evolution debate was fundamentally a battle between methodological naturalists and those who are open to the action of God. Whitworth being a Presbyterian college (Johnson's own denomination), this was not an inappropriate approach to take.

But Johnson also specifically pilloried Stephen Jay Gould for having criticized his book *Darwin on Trial* only on niggling details. That caused me to squirm in my seat, for Gould had been far from vague when he chided Johnson for trying to concede the evolution of the unique mammal jaw as merely a "narrow point" rather than as a macroevolutionary smoking gun. The details of all this would end up in Episode Three of this book, but back in 1998 what I wanted to ask Johnson was how he could make that claim about the insubstantiality of Gould's review? If the fossils of the reptile-mammal transition didn't represent a *bona fide* macroevolutionary sequence, what would?[72]

In the question period that followed I finally got my chance to ask away. But what I wasn't getting were any real answers. Johnson couldn't be made to discuss even one specific, and I grew quite flustered as he stuck to his general philosophical defense that evolutionists only interpret the evidence as they do because they are in the thrall of a naturalistic dogma. Finally he ended the exchange by cautioning the audience that my evident annoyance was due to his treading on my evolutionary religion, and moved on to the next raised hand.

In one sense my confrontation with Phillip Johnson was a dry well. But in retrospect it revealed something after all. Here I was—obviously one of those unrepentant evolutionists, hammering away at him with my impolite questions. What would have been better than to have flattened my argument right then and there with some vaulting technical proficiency? An ideal strategy—that is, if you know the details. But if you don't, diving off the technical side of the board runs the risk of landing you in the shallow part of the pool.

Johnson did not remain around afterward to schmooze with the audience, but Stephen Meyer did, and I managed to pigeonhole him for some further questions. At that time a philosophy professor at Whitworth, Meyer was one of the organizers of the "Creation Week" event.[73]

I was struck by how no one in the audience seemed aware that Gould's review had not been as gauzy as Johnson intimated. Had I not raised it in my own question, the assembly would have been left with Johnson's version uncontradicted. I was equally interested in why Meyer had made no move to correct Johnson about leaving out the therapsid issue, but that didn't seem to concern him.

Anticipating a lot more substantive argument than I got from Johnson, I had brought a photocopy of a chart showing the major players in the reptile-mammal transition, by name and in chronological order. Showing this to Meyer, he said he'd never seen a chart like that. Which rather took my breath away. This wasn't a state secret. I'd unearthed it from the public library. What then was Meyer's excuse for his unfamiliarity with the major players in the origin of a whole vertebrate class?[74]

Finally I maneuvered around to a question I considered completely relevant to Meyer's own discipline, and my methodological concerns. Did he consider it *philosophically* legitimate for

Phillip Johnson to proceed as though he had successfully disposed of fifty-million-years worth of fossils representing the reptile-mammal transition without actually mentioning any of them?[75]

I never did get an answer.

Episode One

Bauplan

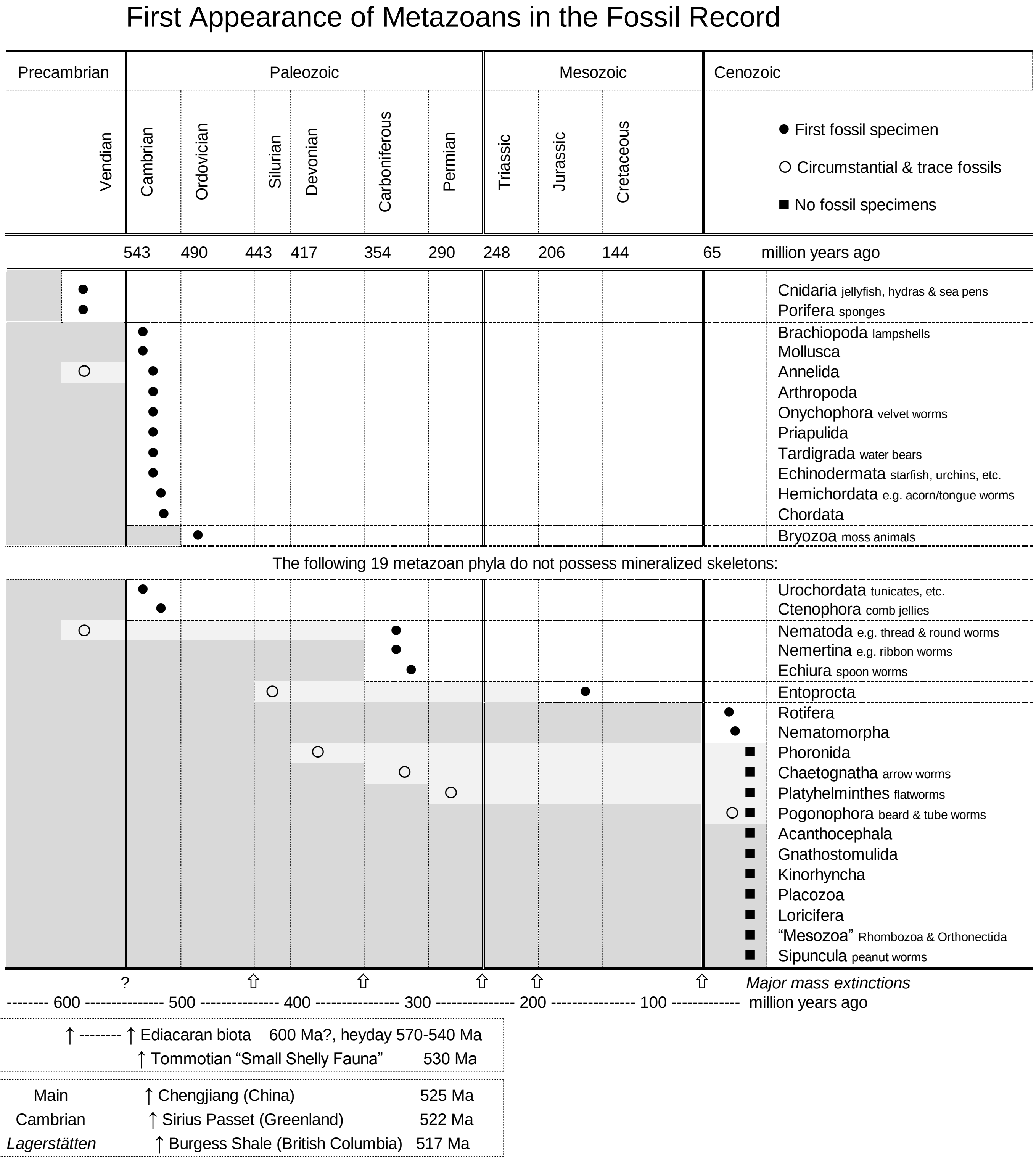


Figure 1. Main period dates per ucmp.berkeley.edu/help/timeform.html, with boxed Ediacaran, Tommotian and *Lagerstätten* chronology adapted from *bio.cc/Scientists/Dan_bolser/EARLYCAM.HTM*. The overall chart structure follows *ucmp.berkeley.edu/phyla/metazoafr.html*.

Chapter 1. The Cambrian Explosion

In science and scholarship *expertise* may be thought of as the knack of knowing when to ask relevant questions, and being able to tell whether you’ve got good answers. It relates to how you validate the assumptions of a deductive chain, or the conclusions of inductive reasoning, along with gauging how cogent the logical links are. Approached methodologically, all questions and answers therefore become diagnostic, revealing the attitude of the person asking or answering them.

In 1994 PBS aired a documentary by Randall Balmer called “In the Beginning: The Creationist Controversy.” Investigating the social and political context of the creation/evolution debate, it devoted little time to the scientific merits of either side, although Balmer clearly favored the evolutionary interpretation. Concerning the hot-button topic of whether evolution should be excluded in public school science education, and to what extent creationism ought to be actively included, Balmer interviewed the bane of textbook publishers, Mel and Norma Gabler of Texas.

Through several decades the Gablers have taken on the role of textbook fact checkers, diligently rooting out the perceived inaccuracies in history texts, such as the evident boner when one mistakenly attributed the end of the Korean War to Truman dropping an atomic bomb on North Korea. I entirely sympathize with their fury at such incompetent authorship. But the Gablers are not just apolitical scholarly nitpickers. Primed by a sincere religious conviction and technical naiveté, they decide what constitutes outrageous error based on their conservative ideology. So it was that they opposed the MACOS (Man: A Course of Study) project published in 1970, which endeavored to introduce 5th and 6th graders to the general concepts of modern evolutionary and social science thinking. The Gablers’ success in derailing the MACOS project was abetted in no small measure by the overweening arrogance of its planners, still blissfully unaware of the depths of conservative Christian unease over modern liberalism.[76]

The persistent activism of the Gablers has produced a grassroots organization that springs into action whenever textbooks appear that do not measure up to their standards. Their intervention at textbook acceptance hearings signal the opposition of a broad coalition that can translate if needed into a voting block come next board election. And because Texas is such a gigantic market, publishers are reluctant to print specialized works for other districts that can’t be sold in the Lone Star State. The result is that the local opposition spearheaded by the Gablers has enacted a *de facto* veto for the entire nation.[77]

Now when it comes to evolution, the Gablers do not favor banning its teaching. They advocate the “middle way” of requiring texts to characterize evolution as “only a theory,” not factually verified (or even verifiable). In the PBS program, Norma Gabler clearly stressed that “we’ve never asked for creation in the classroom. We’ve always asked that it be taught fairly.” Phillip Johnson has affirmed this view more generally when he stated that “creation scientists emphasized that they wanted to present only the *scientific* arguments in the schools; the Bible itself was not to be taught.”[78]

But what creationists mean by “fairly” translates into including in the science curriculum certain information they believe constitutes strong evidence against evolution. When Balmer asked for some examples, Mel Gabler replied with two. First, that “suddenly—I mean *suddenly*—here appear practically every life form at almost the same time, whether it’s a fish or algae or tree or whatever.” Then he said that the astronauts landing on the moon encountered much less lunar dust than the thick layer they were expecting, which meant the moon couldn’t possibly be all those billions of years old the scientists believed it was.

With one simple question and two short answers, we could now see exactly what the Gablers meant by “strong evidence” as well as how broadly they defined “evolution.” And with that, their laudable goal of expunging falsehood and distortion from school texts was compromised. For both of Mel’s examples were incontrovertibly *false*, and any “science” text that included them as statements of “fact” would be as grossly in error as that history book was with Truman’s Korean A-bomb.

That the Gablers showed no awareness of this spoke volumes about the nature of their scholarship, and suggests how potentially dangerous the educational (or political) manifestation of creationism can be.

The reasons why the Lunar Dust claim is absurd are given in Appendix II. But its importance in assessing the epistemology of grassroots antievolutionists like the Gablers is that it is a standard myth of Young Earth creationism that they were mixing into the discussion of “evolution,” exactly as Henry Morris did in his 1963 quote from the Introduction.[79]

We have to keep that distinction in mind when we consider Gabler’s other example, which was an allusion to the “Cambrian Explosion.” About 530 million years ago a bevy of new animals appeared—so many that antievolutionists think this bodes ill for any naturalistic theory that has new forms emerging incrementally from existing ones. But the Gabler’s inclusion of the Lunar Dust myth reminds us that Young Earth creationists carry additional conceptual baggage when it comes to the Cambrian.

For them there was no “530 million years ago”—only a historically recent Flood event that conventional science misinterprets as having taken place eons ago.

To discover how creationists like Mel Gabler could come to believe fish and algae and trees appeared at “almost the same time” requires looking at what they might have been reading in the Creation Science literature. Anyone shopping at a conservative Christian bookstore today, or on one of its many online counterparts, could find the YEC view of the world summarized in the paperback *What Is Creation Science?* by Henry Morris and Gary Parker. Originally published in 1987, it has been a mainstay of Creation Science education, and the back cover of a 1997 printing of the “Revised and Expanded” edition invited the reader with confident academic authority:

> Many Christians are not aware that a growing number of legitimate scientists now embrace the Genesis explanation of origins. In *What Is Creation Science*, two of the most respected members of that group have given us the benefit of their knowledge: Dr. Henry Morris, who has served on the faculties of five universities, and Dr. Gary Parker, a former evolutionary biologist. Their findings throw the brakes on the “evolution train.”[80]

Open the volume to see what these educators had to say about the Cambrian Explosion, and you would find a chapter on “The Fossil Evidence” written by Parker. An illustration showed a variety of marine animals, which the main text described this way:

> Take a look at Fig. 23. If you live near the seashore or like to visit marine aquaria, I’m sure most of the animals there are quite familiar to you. There are some jellyfish floating in the background. On the bottom you can find sea urchins and sea lilies, members of the starfish group; a couple of snails; sponges; lampshells; and members of the earthworm group. That large fellow stretched out along the right side is a nautiloid, a squid-like animal that is a member of the most complex group of invertebrate animals we know anything about (the cephalopod molluscs). The nautiloid belongs to the group of animals that has an eye somewhat like ours, as I mentioned in the first chapter.
>
> What does this illustration show? A picture of present-day sea life off the California coast or around some tropical island? No, not at all. It pictures not sea life today, but the “first” or simplest community of plants and animals to leave abundant fossil remains. This illustration shows life in the so-called “Age of Trilobites” (what I’ll later call the “Zone of Trilobites”).[81]

Parker has ever so gently led the reader to the sunny shores of Santa Barbara or Tahiti, and everything about the adjoining illustration reinforced that familiar image. The dozen creatures populating “Figure 23” were described by this caption:

> The simplest community of abundant fossils, the “Trilobite Seas” (Cambrian System), contains almost all the major groups of sea life, including the most complex invertebrates, the nautiloids, and the highly complex trilobites themselves (inset above). Darwin called the fossil evidence “perhaps the most obvious and serious objection to the theory” of evolution.[82]

Darwin, of course, didn’t have the last hundred years’ worth of paleontology to draw on, as Parker presumably had, to determine what marine specimens to remark on and how reasonably to do so.

Many of the major fossil beds known to the geology of Darwin’s day were European (the “Cambrian” period itself comes from the Latin name for Wales, where a detailed survey was undertaken in the 1830s). The Burgess Shale deposit in British Columbia which figures so importantly in the “explosion” debate was only being explored around 1910, a quarter century after Darwin’s death. And it was only in the 1970s that a major reevaluation of the Burgess fauna was undertaken—though that was still a decade before Morris and Parker wrote the original version of *What Is Creation Science?*[83]

But right from the start there was misdirection from Parker’s text, for in calling the scene the “simplest community of plants and animals” one has to ask, where were the *plants* he spoke of? The illustration didn’t show any, not even seaweed (which are not “plants” in the sense that word would commonly mean to a reader unfamiliar with technical taxonomy). The Plantae are one of five *kingdoms* of life, along with the bacterial Monera, the more complex Protoctista (which embrace a spectrum of unicellular organisms, from protozoa and diatoms to their multicellular offshoots, like seaweed), Fungi and our own Animalia.[84]

Among animals, the jellyfish and segmented worms were around long before the Cambrian, as Parker noted a few pages later. This meant they were holdovers rather than newcomers. Two other *phyla* (plural of *phylum*, the taxonomical subdivision within animals that reflect their different “body plans”) also originated before the Cambrian: the “sea cucumbers” and “beardworms”—though those latter were only isolated in Precambrian deposits since Parker wrote his chapter.

All this is relevant to the question of how many novel forms popped up in the Cambrian Explosion, rather than being evolutionary offshoots from things already knocking about.

Those forms aside, Parker’s tubular sponges, the bug-like trilobites, and the “lampshell” brachiopods that look superficially like clams, were all pretty much as advertised.[85]

But with the mollusks (a clam, snails, and the nautiloid) Parker began to stretch things. The earliest bivalves resembling modern clams, the sort Parker might trip over on the California shore, arrived only with the following geological period, the Ordovician. And the nautiloids didn’t appear until the *late* Cambrian, still tens of millions of years after the big “explosion.” During the Ordovician, nautiloids proliferated as major marine predators, when they did indeed look like the large one suggested by Parker’s Figure 23. Then there were Parker’s echinoderms (a starfish, the sea urchins, and crinoid “sea lilies”). Sea urchins in any guise are not known until the Ordovician again. And “starfish” and “crinoids” existed in the Cambrian only if you accept as stand-ins their extinct *evolutionary ancestors*, which belonged to entirely different classes (the taxonomical rung directly beneath phylum) from the more familiar ones those names are applied to today. The modern classes of starfish and sea lilies do show up later on—in the Ordovician period.[86]

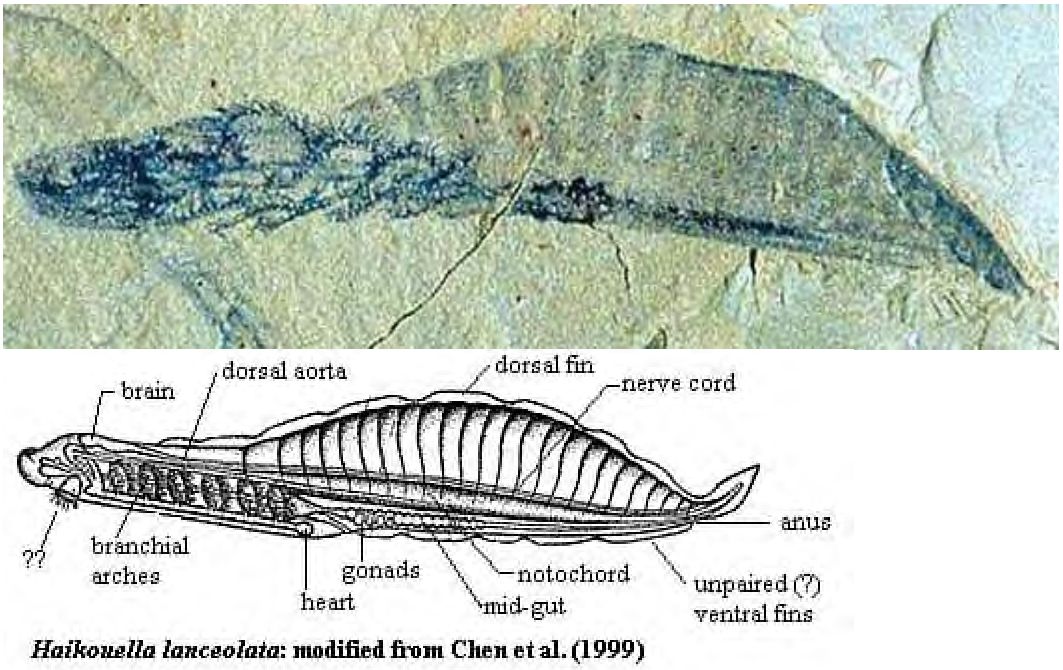
Could it be Parker has mistaken an illustration of fauna typical of that period as applying to the earlier Cambrian? This seems increasingly likely once we note a *twelfth* animal in Parker’s tableau—one not mentioned in the text, or in the caption. But swimming at the upper left corner of his Figure 23 was something labeled a “heterostracan fish.” The early jawless agnathan fishes do not join the fossil parade until the middle of the Ordovician period, and then only fragmentarily. The specialized *heterostracan* fishes, in fact, properly belonged to the even later Silurian and Devonian periods, around 70 million years after the Cambrian. Since Parker gave no sources for any of this (not even for the Darwin quote), there’s no way of pinning down at what stage his research went astray.[87]

There’s something else revealing about his illustration. Parker’s “heterostracan fish” resembled a plump trout or bass, except with all the fins missing. Unless the savvy reader picked up on that streamlined condition and checked into it, they would never discover just how un-fishlike the early agnathans were. (Parker certainly did nothing to direct them along that avenue.) The illustrations of a heterostracan in standard paleontological references reveal a creature nothing like any catch Parker would reel in from a pier at Fisherman's Wharf. Part of an overall group known as the ostracoderms ("shell skins") an example like *Anglaspis* was sheathed in massive overlapping dermal plates (ossified bony coverings distinctive of these early vertebrates). It looked rather like a swimming asparagus tip.[88]

Now if Parker were an *evolutionary* biologist (instead of a creationist one) he could have placed an ancestral agnathan in the Late Cambrian, since a 1978 paper by John Repetski identified a few of their characteristic dermal plates from that time.[89] Though without the corresponding soft tissue to guide a reconstruction, paleontologists have to be careful about how they go about resuscitating extinct animals in Deep Time, as evolutionary biologist Barbara Stahl appropriately cautioned in her 1985 book *Vertebrate History: Problems in Evolution*.[90]

Such limits can pose a challenge for the creationist, though, because they approach Deep Time with a dogma mandating that fossils appear "fully formed" (and by which they fail to recognize intermediates because they are expecting transitional features to be *nonfunctioning*, such as a fish with half a fin). But without an appreciation of the paleontological fine print, their idea of "fish" (or fins) may be far from the scientific understanding that evolutionists are using. So if Parker had heard about these Cambrian dermal plates when commissioning the illustration for his ICR collaboration with Henry Morris, he could very easily have misunderstood what it represented. We know that's possible because that is exactly what happened with several creationists who cited Repetski, such as Luther Sunderland (then an engineer at General Electric) who mutated those tiny dermal plates into a "fully developed" heterostracan.[91]

While Parker and Sunderland were vaulting ahead of the data, evolutionists were assembling the links in their own chain of reasoning.



***Haikouella lanceolata*: modified from Chen et al. (1999)**

Figure 2. The Early Cambrian chordate *Haikouella* fossil (top) & internal schematic (bottom), from *palaeos.com/Vertebrates/Units/01Chordata/010.200.html* & *010.200.html*.

Barbara Stahl explained that "If the ostracoderm ancestor of the jawed fishes ever comes to light, many workers believe that it might prove to be a heterostracan-like form of a very primitive type." Something like the living cyclostomes: hagfish (endearingly known as the "slime hag" for their characteristic excretions) and lampreys. Among the most primitive of living craniates (animals with head bones), the special characters of the cyclostomes "are similar to those of the ancient jawless fishes."[92]

As it happens, several new species of craniates have been recently discovered from special Early Cambrian deposits that preserved soft tissue with exceptional detail (more about the implications of that next chapter). And what did these earlier forms look like? Not "fully formed" heterostracan fish, which averaged several inches in length, and sometimes up to a foot. These specimens were at the very bottom of the scale, about an inch long (25-30 mm), and neatly followed the evolutionary cue sheet: *Haikouella* (Figure 2) resembled a *lamprey larva* while *Myllokunmingia* looked more like a rudimentary hagfish.[93]

All of which returns us to the question of how easily honest people like the Gablers could come to so misunderstand what was going on back in the Cambrian.

Gary Parker *never* said there were any fish in the Cambrian. His chapter only showed the reader a picture of one. And he singled out for his lone example a group just as anachronistic to the early Cambrian as a dinosaur would be to Victorian England. That he may have arrived at his depiction based on a misunderstanding of a source he didn't even bother to cite only compounds their methodological problem.

But Parker's primary sins were ones of omission. He said nothing about all the contemporary marine forms *not* found in those Cambrian waters: sharks, advanced fish, turtles, seals or dolphins. Nor mention what any Cambrian diver would have observed were they to poke their head above the waves: a landscape utterly devoid of complex life. There would be no plants or trees on the land, and likewise no insects, frogs, lizards or birds frolicking around them—let alone lions and tigers and bears.[94]

Need we scratch our heads then to see how the Gablers and their compatriots could come to sincerely believe what they do? They are only going on what they have been *given*—or, more correctly, what they have *sought out*. And what that selective diet regularly consists of is a mishmash of half-truths and outright falsehood.

So long as the creationist keeps to the ICR reading list, they are never exposed to vital contrary information, even inadvertently by citation. Thus in his 1994 book defending a diluvian origin for the Grand Canyon, geologist Steven Austin illustrated a "Reconstruction of pre-Flood ocean floor suggested by Paleozoic fossils." While asserting that the "assortment of different body plans is similar to modern oceans," what the reader was seeing was a virtually identical picture to Parker's Figure 23—again with no citations to back it up.[95]

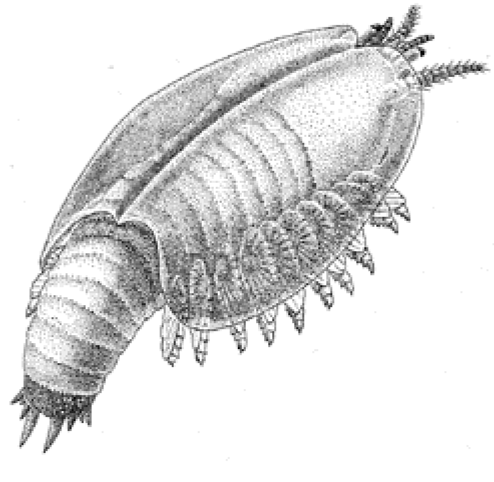


Figure 3. The early crustacean *Canadaspis perfecta* (length about three inches)—abundantly represented by over 4000 specimens in the Burgess Shale. Drawing by Marianne Collins, illustrated in Gould (1989, 163), reproduced online at the Smithsonian's Cambrian website *nmnh.si.edu/paleo/shale/pcanadap.htm* (though misspelled there as "Canadapsis").

Duane Gish's 1995 edition of *Evolution: The Fossils STILL Say No!* skipped even the picture show, but his faunal description was comparable to Parker's: "In Cambrian rocks are found fossils of clams, snails, trilobites, sponges, brachiopods, worms, jellyfish, sea urchins, sea cucumbers, swimming crustaceans, sea lilies, and other complex invertebrates."[96] While the anachronistic sea urchins and sea lilies remained, the nautiloids were absent, to be replaced by "swimming crustaceans" and "other complex invertebrates." Like Parker and Austin, Gish provided no sources. But his treatment could have reflected the newer information available by then from Stephen Jay Gould's popular *Wonderful Life* on the Burgess Shale specimens. The problem was the Cambrian "crustaceans" turning up in the Burgess Shale were *evolutionary ancestors* (illustrated in Figure 3), not modern crabs or lobsters as Gish's use of the familiar term might have led his readers to think.[97]

Even when the creationist literature waxes technical, a reader would have to dig beneath the surface to see whether everything was as stated. Since so much of the antievolution controversy turns on how organisms are classified and by what means physical intermediates might be identified, what Henry Morris had to say in his 1985 book *Scientific Creationism* is especially revealing. Like *What Is Creation Science?* it was intended as a provisional textbook, but was also made available in two editions: a seven-chapter version for a secular audience, excluding all Biblical references, and a General Edition with an eighth chapter that explains "Creation According to Scripture."

In the secular part, Morris outlined how the taxonomical facts of life documented **Systematic Gaps in the Fossil Record**:

> If evolution were true, one would suppose that the classification system itself would evolve over the ages. If all animals and plants are randomly changing, the categories of classification should likewise be changing. The fact is, however, that it has been the same since the beginning, even assuming the geological ages are as taught in orthodox geology. Note the following:
>
> 1. All kingdoms and subkingdoms are represented in the geologic record from the Cambrian onward.
> 2. All phyla of the animal kingdom are represented from the Cambrian onward.
> 3. All classes of the animal kingdom are represented from the Cambrian onward, except:
>   (a) Moss-corals (Ordovician onward)
>   (b) Insects (Devonian onward)
>   (c) Graptolites (Cambrian to Carboniferous)
>   (d) Trilobites (Cambrian to Permian)
> 4. All phyla of the plant kingdom are represented from the Triassic onward, except:
>   (a) Bacteria, algae, fungi (Precambrian onward)
>   (b) Bryophytes, pteridophytes (Silurian onward)
>   (c) Spermophytes (Carboniferous onward)
>   (d) Diatoms (Jurassic onward)
> 5. All orders and families (as well as kingdoms, phyla and classes) appear suddenly in the fossil record, with no indication of transitional forms from earlier types. This is true even of most genera and species.[98]

There were no sources for any of these assertions. Instead, Morris offered a string of "proof text" quotations from an assortment of evolutionists mentioning fossil gaps of one sort or another over the years. For example, there was a 1953 quote from paleontologist George Gaylord Simpson on the frequent absence of "completely continuous transitional sequences" at various taxonomical levels. The problem with that tactic is that Morris never got around to specifying whether an *almost* "continuous transitional sequence" might satisfy his concerns, or whether Simpson's book entertained anything like the sort of paleontological discontinuity that the ICR was defending. In point of fact, Simpson had not. Stressing how "there are usually many geologically brief interruptions of deposition, with or without erosion of some of the strata already deposited," Simpson showed how perfectly gradual evolution could seem saltational. He offered the example of the increase in the number of inner ribs on ammonites (a major Paleozoic shelled marine invertebrate predator) that had simply continued a smooth trend of incremental change begun long before the depositional gap.[99]

But even if Morris' representation of Simpson's view had been correct, was that Eisenhower era opinion still relevant to the paleontology available when Morris was writing in 1985?

That's what the creationist needed to defend. And that's where Morris was in big trouble.

What Morris had written was that everything appeared at the same time, except for all the things that didn't! The Precambrian bacteria started up *billions* of years ago, of course, while his Jurassic diatoms belonged to the same timeframe as Richard Milton's *Brontosaurus* (remember, Morris was "assuming the geological ages are as taught in orthodox geology"). Anyone unfamiliar with the terminology would have stayed that way throughout, for Morris made no effort to explain it.

As his own list acknowledged, the first two kingdoms are known to have arrived long before the Cambrian, and we saw from Parker and Austin's seascapes that also included the animal kingdom. Though evolutionists have no doubt Fungi go way back, their squishy nature makes it naturally difficult to establish just when (there are traces from the Ordovician). But Morris needed them to salvage the antiquity of the Plant Kingdom (relating to his first and fourth points), so lumped fungi together with the equally disparate bacteria and algae (also separate *kingdoms* in their own right). Thus you can understand how his collaborator Parker could go awry, and contribute to the confusion of the Gablers about when "algae" and "trees" appeared.[100]

Conventional plant fossils don't make their bow until comparatively late in the geological parade, well over 100 Ma after the Cambrian ended (in the Devonian period, about 400 Ma)—and not all at once. There are ten plant "divisions" (the botanical equivalent of zoological phyla).[101] Two refer to the mosses (Bryophyta) and the remainder to the vascular plants (Tracheophyta). The last division only showed up in the Cretaceous, about the time the iguanodontids were stomping about: the flowering plants (Angiospermophyta, a.k.a. Anthophyta)—an extraordinarily diverse ensemble conspicuously absent from Morris' outline.[102]

Now of course, were Morris accepting an *evolutionary* framework, he could argue that plants originated from some pre-plant form dating back into the Cambrian or before.[103] But as that is definitely *not* his position, saying as he did that all of the kingdoms were present "from the Cambrian onward" was wrong.

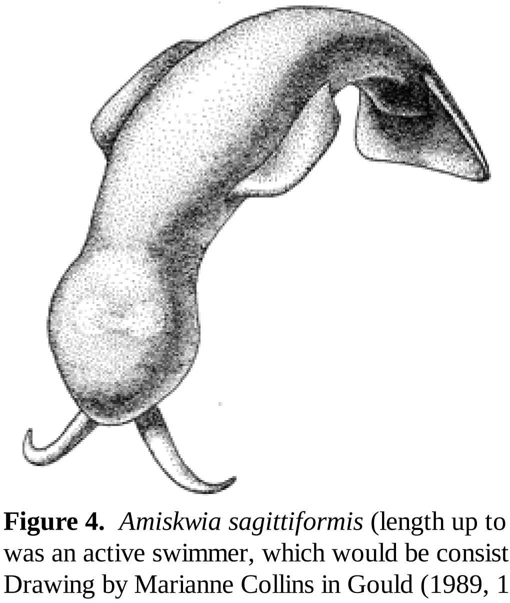


Figure 4. *Amiskwia sagittiformis* (length up to an inch). The dorsal and tail fins suggest it was an active swimmer, which would be consistent with its rarity in the Burgess Shale. Drawing by Marianne Collins in Gould (1989, 152), and online at the Smithsonian (*nmnh.si.edu/paleo/shale/pamisk.htm*).

Which leads to Morris' second claim, about there being no new animal phyla. That is a lulu for the same reason, for the only people who can say that with a straight face are *evolutionists*. That's because many of the metazoan phyla *don't* have a fossil record that extends back into the Cambrian (summarized in Figure 1 that began this *Bauplan* section). Still others are positioned there only because Cambrian fossils have turned up from that may be connected to those phyla *on evolutionary grounds*. So any creationist trying to elbow all of the phyla back into the Cambrian has to switch gears and deny the logic of their own position.

Depending on who's counting, there are around thirty-three currently living animal phyla.[104]

We've already seen four phyla originated before the Cambrian, and Parker alluded to another six Cambrian ones (including some dependent on *evolutionary* assumptions). What then of the remaining twenty-three?

The Cambrian apparently had "velvet worms" (Onychophora) and worms of phylum Priapulida. But the lone specimen from the Early Cambrian Burgess Shale, called *Amiskwia* (Figure 4) is more of a problem. It could have been a "ribbon worm" (Nemertina) or an "arrow worm" (Chaetognatha)—or something else altogether. Either way, at least one of those phyla gets banished from the Cambrian, and both are out if *Amiskwia* represented a new one.[105]

Then there are all the Conodonta teeth that litter the Cambrian—they only got a body in 1983 when an inch-long fossil of one finally turned up in a Lower Carboniferous shale in Scotland, revealing a wormy thing resembling a supremely primitive chordate. Newer fossil finds have clinched their chordate affinity, possibly relating to hagfish. Even with the Carboniferous example living 150 million years later, though, the conodonts still went extinct 200 Ma, thus allowing the exclusion of their potential 34th phylum from our living list.[106]

Early forms of the frond-like colonial graptolites are likewise known from Cambrian deposits, and because they are now perceived *on evolutionary grounds* to be ancestral Hemichordata (which include the worm-like pterobranchs and the "acorn" or "tongue" worms), that phylum has been eased back from the Ordovician into the Mid-Cambrian. But the bryozoan "moss animals" (Ectoprocta) are much harder to peg, and belie the standard creationist notion that living things fall into easily distinguished created categories. Appearing much like seaweed from a distance, on closer examination a bryozoan's "cells" turn out to be individual animals whose body cavities are interconnected like PVC piping (the white plastic tubing commonly used for American plumbing these days). Depending on how the sparse late Cambrian fossil examples are interpreted, the bryozoans *might* have lived then; during the later Ordovician the more familiar forms definitely show up.[107]

So that gives maybe five more phyla to add to the Cambrian brood, for a running total of fifteen. But the available fossil record on the remaining eighteen is less tractable.

The "peanut worms" (Sipuncula) were once thought to have inhabited the Cambrian too, but those specimens are now considered to be a form of priapulid. There are some Silurian burrows and tracings suspected to have been made by a "spoon worm" (Echiura). The comb jellies (Ctenophora) and the diminutive "water bears" (Tardigrada) have turned up in the Burgess Shale and other Cambrian sites. Unfortunately for Morris and Parker, the only known fossil representatives when they were writing were a single comb jelly revealed by X-raying some Devonian slate, and one tardigrade trapped in Cretaceous amber.[108]

The fossil record for comb jellies and water bears raises a warning apropos how difficult it may be to find fossils for small soft-bodied animals, especially if they lack mineralized parts to aid preservation. Comb jellies persisted for 300 Ma (from the Devonian right down to the present) without leaving *any* intervening fossil trace. And the water bears did likewise for a comparable time (Cambrian to the Cretaceous), followed by another fallow period during the Cenozoic. Unless their phyla were subject to repetitive creation events, it would appear that small, unshelled invertebrates are prone to going about their business in Deep Time without betraying their physical presence.

Fourteen more miniscule phyla remain to be dealt with. But just because they are tiny doesn't mean they are inconsequential, since many are parasitical. While evolutionists can trace the structural similarities of kinorhynchs or loriciferans back to primitive flatworms even without their fossil counterparts, creationists have no such naturalistic option. Take one of the more recently recognized ones, the microscopic worm-like hermaphroditic Gnathostomulida. They were only discovered in 1956 and accorded the phyletic accolade in 1969. Did they develop long ago, as evolutionists suspect, or was it possible these animals were *literally* created the day before their initial observance? By what "theistic realism" could *any* of these flimsy organisms be attributed *without fossil evidence* to an environment half a billion years ago? For foolish consistency's sake—ever the hobgoblin of tiny minds, as Emerson once said—these fourteen phyla will have to go.[109]

By using the same hairsplitting tactics creationists regularly employ to isolate the evolutionary implications of the fossil record, the most we could muster for the Cambrian animal farm were 15 of the 33 contemporary phyla—and even then several evolutionary ancestors had to be hijacked along the way.

Percival Davis and Dean Kenyon tripped over much the same hurdle in their creationist textbook, *Of Pandas and People*. This is noteworthy for the Intelligent Design movement, which has co-opted the book as though it represented a non-creationist assessment of the evolutionary issues. Copies were prominently displayed on a hall table at the 1998 Whitworth College "Creation Week"—and Michael Behe, Stephen Meyer and philosopher Alvin Plantinga were among the *Critical Reviewers*, *Editors* and *Contributors* for that 1993 2nd edition. But so too were others with a more YEC background, from Discovery Institute Fellows Paul Nelson and Nancy Pearcey, to Los Alamos National Laboratory geophysicist John Baumgardner, Bryan College paleontologist Kurt Wise, and Norman Geisler of the Dallas Theological Seminary.[110]

ID standard bearers like Stephen Meyer, Phillip Johnson and William Dembski have described the book's co-author Dean Kenyon always as only an advocate of "intelligent design," never as someone who might also be a Young Earth creationist.[111] Davis and Kenyon have reciprocated by shrouding their own YEC convictions under a mantel of ID rhetoric. Concerning the fundamental Flood Geology doctrine of a young earth, *Of Pandas and People* sufficed with astonishing understatement: one brief nod that design proponents "are divided on the issue of the earth's age."[112]

As though the geological yardstick of Deep Time were irrelevant to an assessment of evolutionary evidence that might depend on a temporal sequence.

Then again, Davis and Kenyon had trouble even when it came to compiling a chart.

To illustrate that "nearly all" animal phyla originated in the Cambrian, *Of Pandas and People* showed a "generalized schematic of the fossil record." This displayed 41 bars representing current and extinct phyla—solid segments indicated fossil representation while dotted lines meant the absence of a confirmed fossil trail. But as none of the bars were labeled, and no chronological scale was supplied other than "Present" at the top, and "Cambrian" and "Precambrian" at the bottom, everything about the chart seemed intelligently designed to make it as uninformative as possible.[113]

Had the Cambrian phyletic lines been labeled, there might have been a point to clustering them in some way, but as they were not identified there was no logic in sprinkling the ones with dotted lines among those without. Unless, of course, the idea was to camouflage how many interrupted lineages there were.

Not that organizing the lines more logically would have helped their case, for of the 30 phyletic bars descending from the "present" only 16 had solid sections suggesting fossil forms—and of those exactly *six* extended all the way back to the Cambrian. Apparently for Davis and Kenyon, "nearly all" was a heuristic concept that could range from 38% (those living phyla with fossil examples) down to 20% (when the non-fossil dotted lines were included). Ironically, this was *lower* than the roughly 50% value we have just established by a phylum by phylum evolutionary walkthrough.[114]

And just to show that this slip was not unique to YEC believers, antievolutionary biologist Jonathan Wells offered his own chart in *Icons of Evolution* to show how “The Cambrian explosion gave rise to most of the animal phyla alive today, as well as some that are now extinct. (Figure 3-4).”[115] Reproduced below, it filled the entire page forty:

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
Recent	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Permian	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Carboniferous	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Devonian	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Silurian	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	▨		▨	▨	▨
Ordovician	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	▨		▨	▨	▨
Cambrian	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨		▨	▨		▨	▨	▨
							▨				▨						▨	
Precambrian																		

The main caption (**FIGURE 3-4 Actual fossil records of the major living animal phyla**) appeared twice, once at the bottom of the chart, and again on the next page accompanying this detail: “One phylum (the sponges) and possibly two others appeared just before the Cambrian; two worm phyla appeared much later, in the Carboniferous; two phyla appeared midway through the Cambrian, and one in the Ordovician. For phylum names, see the notes to this chapter at the end of the book.”[116] There we learned what the letters stood for:

(a) Annelida (clamworms, earthworms, leeches)
(b) Arthropoda (insects, crabs, centipedes, spiders)
(c) Brachiopoda (lamp shells)
(d) Bryozoa (small aquatic animals with tentacle-ringed mouths)
(e) Chaetognatha (arrow worms)

(f) Chordata (tunicates, lancelets, vertebrates)
(g) Cnidaria (corals, jellyfish, hydras)
(h) Ctenophora (comb jellies, sea walnuts)
(i) Echinodermata (crinoids, sea urchins, starfish, sea cucumbers)
(j) Hemichordata (acorn worms)
(k) Mollusca (clams, octopuses, snails)
(l) Nematoda (eelworms, roundworms)
(m) Onychophora (small terrestrial worms with short legs)
(n) Phoronida (tube-dwelling marine worms with tentacles)
(o) Platyhelminthes (flatworms, flukes, tapeworms)
(p) Pogonophora (giant deep-sea tube worms)
(q) Porifera (sponges)
(r) Rotifera (small animals with a crown of cilia)[117]

Why Wells didn’t put this information into the chart up front is unclear. There was ample room either at the bottom of the caption—or at the bottom of the chart itself, had he not padded out the **Precambrian** rows, which were not to scale.[118]

The padding was just as heavy up at the top of the chart, where phyla were pushed back beyond the current fossil evidence or accepted early forms only assigned there on evolutionary grounds. Thus there are some possible (e) Chaetognatha found in the Kicking Horse Shale member of the Burgess Shale and the Maotianshan shales of Yunnan, China. Otherwise, the characteristic grasping spines of chaetognaths don’t show up until the late Paleozoic (though not with actual worms attached).[119] Evolutionists may likewise relate Precambrian traces to the (l) Nematoda—but while the available body fossils do belong to the Carboniferous (as Wells’ caption intimated) his chart nonetheless graphed them in the previous *Devonian*.[120]

Nor are there any known (n) Phoronida fossils. Some secrete tubes of agglutinated sediment, so trace fossils of that sort could be from phoronids—or from annelids or arthropods that make similar features. Some phoronids also bore into shells and rocks in distinctive ways. But the oldest of these holes is Devonian (not Cambrian).[121] The earliest (o) Platyhelminthes fossils are also trace examples—and dating to the Permian, not the Carboniferous (caption) or Devonian (chart).[122] The (p) Pogonophora could date to the end of the Precambrian, providing that thin tubular *sabelliditid* fossils were made by them. Tubes recognized as more like those of known pogonophorans don’t show up until the Oligocene (33-23 Ma), not the Cambrian 500 Ma earlier.[123] The first (r) Rotifera fossils are also known from the Oligocene—but not the Cambrian.[124]

Thus of Wells’ eighteen “major phyla” fully a third were problematic. Had he reflected this in his chart, there would have been a lot more bare patches:

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
Recent	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	
Permian	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	
Carboniferous	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨			▨	
Devonian	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		▨	▨			▨	
Silurian	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		▨				▨	
Ordovician	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		▨				▨	
Cambrian	▨	▨	▨			▨	▨	▨	▨	▨	▨		▨				▨	
							▨				▨						▨	

That still leaves unanswered how he arrived at his trimmed list of “major” phyla, since Wells offered neither criteria nor specific references. Why are the Chaetognatha, Ctenophora and Phoronida (with 100, 90 and 15 known species) accounted “major” phyla, while the Acanthocephala (1100 species), Tardigrada (600), Sipuncula (320), Echiura, Entoprocta and Kinorhyncha (150 each), or Gnathostomulida (100) are not?[125]

One cynical answer presents itself: as compared to Figure 1, including these “minor” phyla would have diluted still further Wells’ claim about how many of the extant ones could be physically tracked back to the Cambrian—or, if expedient, rammed there.

With *Of Pandas and People* and *Icons of Evolution* as tendentious corroboration, it is clear that Henry Morris was wrong again when he declared *all* animal phyla were present from the Cambrian onward.

If Morris’ take on the taxonomical record was bad enough with the three points examined so far, his contention No. 3 is in a wholly different category.

Saying that all animal classes are represented in the Cambrian is staggeringly wrong. Never mind the logical absurdity of making that blanket statement along with at least one prominent exception (the Devonian insects)—what about class *Amphibia*, *Reptilia*, *Aves*, and *Mammalia*? The whole range of terrestrial vertebrate life is missing! Nowhere has Morris (or any other creationist, for that matter) ever offered the slightest evidence that amphibians or reptiles or birds or mammals are known from Cambrian deposits. And for the same reason as Milton’s tent stake sauropods—there aren’t any.[126]

Had Morris written a history that insisted Henry VIII shot cruise missiles at Genghis Khan during the Battle of Marathon, one could easily imagine the Gablers descending on the publisher like avenging harpies. Yet when it comes to even the most blatantly false pronouncements of creationism like this one, it all wafts past their attention like dandelions on a summer’s breeze.

Our review of Morris’ taxonomical claims now leaves us with his remaining unqualified assertion that everything appeared “suddenly” in the fossil record, *always* without intermediates. This is the creationist equivalent of clear-cutting, for it is applied willy-nilly to the entire fossil record and is certainly the most ubiquitous item in the canon.[127]

This argument depends on *never* laying out any “map of time” to make the reader aware of the precise *what*, *when*, and *where* of things. If Parker’s Cambrian trilobites *had* evolved from something else, how much earlier would you expect to find their ancestors, and what should these have looked like? Formulating such standards is not some optional exercise conducted to while away spare time. It is essential for anyone (creationist or evolutionist) who hopes to be taken seriously when assessing whatever fossil evidence may have turned up from Deep Time.

Chapter 2. Lagerstätten

When I was a teenager in the 1960s, the *World Book Encyclopedia* view of the Cambrian was a laconic observation that shelled animals became common then. This was also the era when it was believed dinosaurs were lumbering sluggish reptiles who failed to make the cut once the plucky mammals arrived and began raiding their eggs.

Gary Parker reflected such popular understanding when he described the Cambrian period as the Age of Trilobites.

The mineralized shells of trilobites happened to fossilize fairly easily—and because they also molted frequently, the litter of their discarded carapaces could be used to calibrate any rocks in which they appeared. But paleontologists also knew that not all animals produced such traces, and Darwin thought this “artifact of preservation” could be hiding what had gone on before. If we were able to visit the Precambrian we would see soft bodied representatives of the later forms, going about their business to gradually evolve into what we see “exploding” in the Cambrian.

Creationists naturally don’t buy this argument, and focus on the discontinuity—though as seen last chapter, not always focusing *too* closely.

But the Cambrian Explosion is a real issue, and needs an explanation.

Paleontologists can trace all the extant phyla back to the Cambrian either by the direct fossil evidence or by evolutionary inference. As each phylum is recognized on the grounds of its characteristic body plan, it follows *Baupläne* originate early in the process, not in stages all through geological history like buds branching from extant phyletic roots. Was this phyletic “explosion” an actual expansion of animal diversity, and if so, was it also of so unprecedented a character that only a nonevolutionary explanation could account for it?

While the “modern era” of Cambrian interpretation was not begun by Stephen Jay Gould’s *Wonderful Life*, it was certainly popularized by it. Gould’s book explained how in the 1970s a new generation of paleontologists like Harry Whittington and Simon Conway Morris began to reexamine many of the fossils gathered from the Burgess Shale back at the turn of the 20th century, and realized a lot of reclassification was in order.

Figure 5. *Pikaia gracilens* (averaging 1.50 inches). Drawing by Marianne Collins in Gould (1989, 322). There is a somewhat less accurate depiction (minus tail fluke) online at the Smithsonian’s *nmnh.si.edu/paleo/shale/pamsci.htm* file.

Some of the Burgess specimens belonged to living phyla, such as *Eldonia*, a flattened jellied beanbag small enough to fit in your palm. At first mistaken for some form of jellyfish, more detailed study suggested it was an ancestral echinoderm. Among the arthropods, the slightly smaller *Canadaspis* (Figure 3) was an early crustacean, while *Sanctacaris* (illustrated in Figure 6) belonged to the chelicerates (that include the terrestrial spiders and scorpions)—though of course in neither case were these representatives typical of *modern* crustaceans or chelicerates. And there was *Pikaia* (Figure 5), a wormy character a bit over an inch long that briefly held the honor of being the first known chordate, until an even more primitive specimen (*Cathaymyrus*) was discovered in China from deposits dating about 8 Ma earlier. That productive Chinese locale would subsequently reveal such cousins as *Haikouella* noted last chapter.[128]

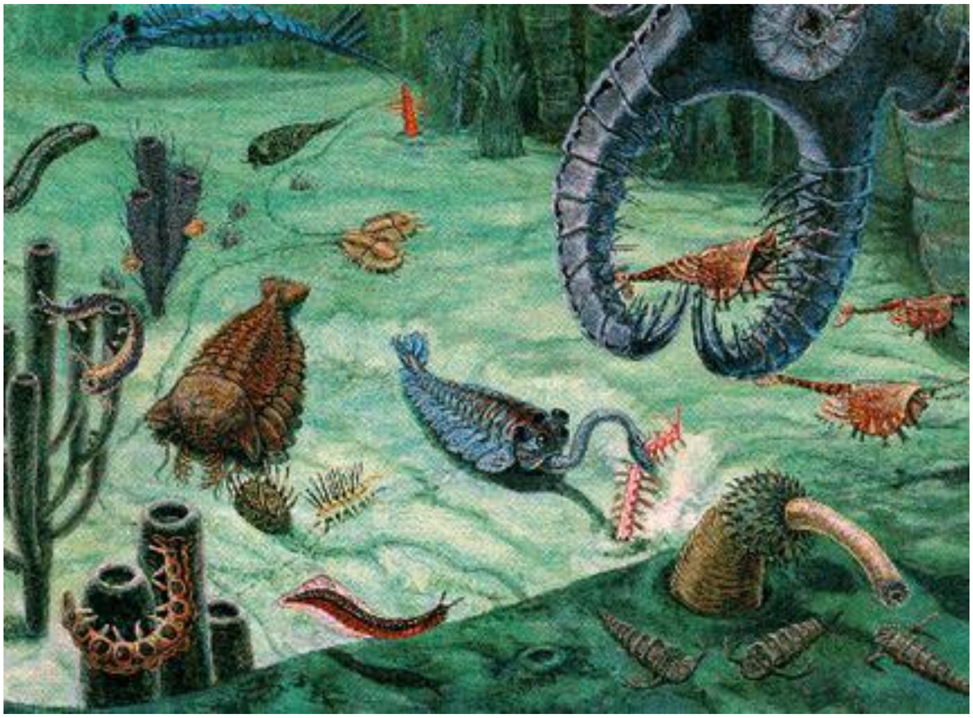


Figure 6. A composite Early Cambrian faunal assembly, the right half of a painting by D. W. Miller from Erwin *et al.* (1997, 135-136) illustrating the transition from Precambrian to Cambrian (image available online at the Smithsonian’s *nmnh.si.edu/paleo/shale/pamsci.htm*).

Near the sinuous *Halkieria* exploring at the upper left corner, one *Anomalocaris* (Fig. 7) patrols, while in the foreground another seizes one of the *Waptia* (Fig 28) trio swimming along the right margin. Toward the center background, three small brachiopods (*Lingulella*) live between the Chengjiang arthropod *Fuxianhuia* and the spiny sponge *Pirania* (with some *Nisusia* brachiopods attached). To their right, two *Naraoia* (Fig. 22) trilobites have grazed into one another—the lower one’s trail leading back to the “large” chelicerate *Sanctacaris* (about 3 inches long) nearing a pincushion *Wiwaxia* (Fig. 23) and the equally prickly velvet worm *Hallucigenia* (Figs. 13a-c).

Along the left margin are two branching stalks of the sponge *Vauxia*—one with a velvet worm *Aysheaia* (Fig. 14) prowling around the top, and the other nearer the ledge with a similarly positioned *Microdictyon* (a Chengjiang “lobopodian” distinguished by its tube-like walking appendage). Nearby, the chordate *Pikaia* (Fig. 5) swims toward three mollusc-like *Haplophrentis* (Fig. 15), one of which is about to become the meal of a looming *Ottoia* (Fig. 16)—a scenario directly supported by one fossil priapulid with the hyolith in its gut. Behind on the seafloor, the nozzle claw of *Opabinia* (Fig. 9) grips *Burgessochaeta*, a bristle worm relation of the annelid *Canadia* (Fig. 17).

While these taxa fell within the body plans known from living organisms, many (if not most) were so disparate they apparently represented hitherto unknown phyla. This revolution in interpretation was in full swing by the time D. W. Miller contributed a painting (Figure 6) for a 1997 article on the origin of animal body plans in *American Scientist*.[129]

The first impression you get from the new perception is that you’ve slipped into a science fiction movie. Aside from the trilobites (which have been known long enough for creationists to mention without gulping), almost *nothing* is familiar. There were so many vanes and spikes and carapaces combined with gilled appendages that paleontologists David Fastovsky and David Weishampel described the bestiary as “like a parts store for segmented organisms.”[130]

Indeed, the terror of the Cambrian seas turned out to have been a previously unknown creature that consisted of pieces formerly mistaken for separate animals. Putting them back together resulted in *Anomalocaris*, the giant of its day, which could get longer than a meter and looked like a segmented squid with shrimp tails parked by its circular mouth as grasping tentacles (Figure 7). It might have been an arthropod, or belong to an entirely new phylum—but trying to decide which when there are *no* living counterparts is no easy task.

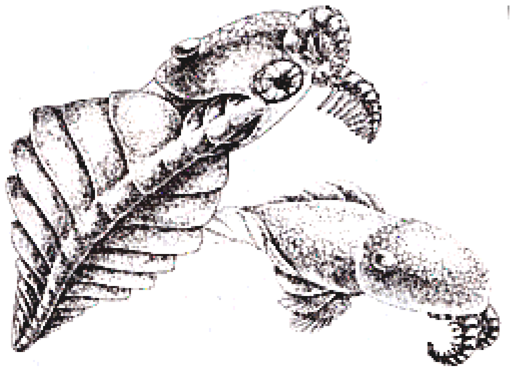


Figure 7. Two species of *Anomalocaris* (*A. nathorsti* left, *A. canadensis* right). Their length was about a yard, though Chengjiang relations grew double that (specimens are also found in Utah's House Range deposit and at Sirius Passet in Greenland). Drawing by Marianne Collins in Gould (1989, 203). See the Smithsonian's *nmnh.si.edu/paleo/shale/panomal.htm* for a similar depiction online.

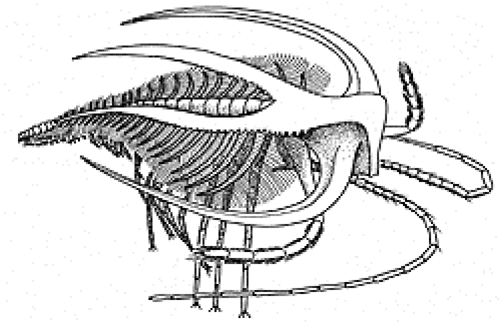


Figure 8. The "lace crab" *Marrella splendens* (length from 1/10 to 3/4 inches) is represented by over 15,000 specimens in the Burgess Shale. Drawing from the Smithsonian's online section on the Cambrian (*nmnh.si.edu/paleo/shale/pmarella.htm*). Cf. the still more vivid view by Marianne Collins in Gould (1989, 114).

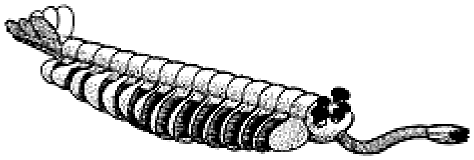


Figure 9. *Opabinia regalis* (body length about 3 inches, with one-inch proboscis). Image from the Smithsonian's *nmnh.si.edu/paleo/shale/popabin.htm* file. Cf. the drawing by Marianne Collins in Gould (1989, 126).

In fact, quite a number of the Cambrian oddities fall under the "arthropods of uncertain affinity" umbrella, like *Marrella* (Figure 8), a buggy thing about the size of your fingernail, with streamlined head spines, or the roach-sized *Alalcomenaeus* (resembling a centipede crossed with a tiny lobster). But others were so plainly *weird* they appeared to fall completely off the phyletic map, such as *Opabinia* (Figure 9) with its five doorknob-shaped eyes over a clawed mouth dangling from a hose.

There are two other characters in the Cambrian play that haven’t been introduced (the Ediacarans and the Tommotians), but they’ll elbow their way on stage when cued. The important thing to remember now is the overall pattern of change that is seen in the Cambrian. There were *ancestral forms* of modern phyla among a much larger ensemble of extinct *Baupläne* that seemed weighted to arthropods, a group that has long hogged the species showcase. There are over 300,000 extant beetle species, for example—compared to only about 4000 mammals (of which about a third are bats and rats).

What could have been responsible for this *particular* distribution of life: rarities (like chordates and *Opabinia*) nestled among herds of permutations on the arthropod parts store? If this had something to do with their DNA, did it reflect a purely natural process—or the agency of Intelligent Design?

Valid questions.

But to answer them, wouldn’t it be essential to address as many of the known details as possible? Identify who the players were, when they were appearing on the scene, and then explore all the available biological clues, with the goal of working out an explanatory scenario (natural or otherwise) to be defended?

Phillip Johnson’s *Darwin on Trial* presents the archetypal Intelligent Design version of this quest. Whereas Creation Science pretended the Cambrian was only the California coast minus the condos and land life, Johnson dispensed with all the Cousteau scenery and presented analogs of Henry Morris’ second and fifth taxonomical points—that all animal phyla appeared in the Cambrian without antecedents. Because Johnson explicitly cited Gould’s *Wonderful Life*, all the information contained in that resource was in principle available for his analysis. It is therefore useful to read Johnson’s account in its entirety, to see what he saw fit to offer—and what he omitted:

> The single greatest problem which the fossil record poses for Darwinism is the “Cambrian Explosion” of around 600 million years ago. Nearly all the animal phyla appear in the rocks of this period, without a trace of the evolutionary ancestors that Darwinists require. As Richard Dawkins puts it, “It is as though they were just planted there, without any evolutionary history.” In Darwin’s time there was no evidence for the existence of pre-Cambrian life, and he conceded in *The Origin of Species* that “The case at present must remain inexplicable, and may be truly urged as a valid argument against the views here entertained.” If his theory was true, Darwin wrote, the pre-Cambrian world must have “swarmed with living creatures.”
>
> In recent years evidence of bacteria and algae has been found in some of the earth’s oldest rocks, and it is generally accepted today that these single-celled forms of life may have first appeared as long ago as four billion years. Bacteria and algae are “prokaryotes,” which means each creature consists of a single cell without a nucleus and related organelles. More complex “eukaryote” cells (with a nucleus) appeared later, and then dozens of independent groups of multicellular animals appeared without any visible process of evolutionary development. Darwinist theory requires that there have been very lengthy sets of intermediate forms between unicellular organisms and animals like insects, worms, and clams. The evidence that these existed is missing, however, and with no good excuse.[131]
>
> [*At this point a note explained:*]
>
> The picture is clouded slightly by uncertainty over the status of the Ediacarans, a group of soft-bodied, shallow-water marine invertebrates found in rocks dating from shortly before the Cambrian explosion. Some paleontologists have interpreted these as precursors to a few of the Cambrian groups. More recent studies by a paleontologist named Seilacher support the view, accepted by Gould, “that the Ediacaran fauna contains no ancestors for modern organisms, and that every Ediacaran animal shares a basic mode of organization quite distinct from the architecture of living groups.” So interpreted, the Ediacarans actually demolish the standard Darwinist explanation for the absence of pre-Cambrian

ancestors: that soft-bodied creatures would not fossilize. In fact many ancient soft-bodied fossils exist, in the Burgess Shale and elsewhere.[132]

[*The main text body continued:*]

The problem posed by the Cambrian explosion has become known to many contemporary readers due to the success of Gould's book *Wonderful Life*, describing the reclassification of the Cambrian fossils known as the Burgess Shale. According to Gould, the discoverer of the Burgess Shale fossils, Charles Walcott, was motivated to "shoehorn" them into previously known taxonomic categories because of his predisposition to support what is called the "artifact theory" of the pre-Cambrian fossil record. In Gould's words:

> Two different kinds of explanations for the absence of Precambrian ancestors have been debated for more than a century: the artifact theory (they did exist, but the fossil record hasn't preserved them), and the fast-transition theory (they really didn't exist, at least as complex invertebrates easily linked to their descendants, and the evolution of modern anatomical plans occurred with a rapidity that threatens our usual ideas about the stately pace of evolutionary change).

More recent investigation has shown that the Burgess Shale fossils include some 15 or 20 species that cannot be related to any known group and should probably be classified as separate phyla, as well as many other species that fit within an existing phylum but still manifest quite different body plans from anything known to exist later. The general picture of animal history is thus a burst of general body plans followed by extinction. No new phyla evolved thereafter. Many species exist today which are absent from the rocks of the remote past, but these all fit within general taxonomic categories present at the outset. The picture is one of evolution of a sort, but only within the confines of basic categories which themselves show no previous evolutionary history. Gould described the reclassification of the Burgess fossils as the "death knell of the artifact theory," because

> If evolution could produce ten new Cambrian phyla and then wipe them out just as quickly, then what about the surviving Cambrian groups? Why should they have had a long and honorable Precambrian pedigree? Why should they not have originated just before the Cambrian, as the fossil record, read literally, seems to indicate, and as the fast-transition theory proposes?

An orthodox Darwinist would answer that a direct leap from unicellular organisms to 25 to 50 complex animal phyla without a long succession of transitional intermediates is not the sort of thing for which a plausible genetic mechanism exists, to put it mildly. Gould is describing something he calls "evolution," but the picture is so different from what Darwin and his successors had in mind that perhaps a different term ought to be found. The Darwinian model of evolution is what Gould calls the "cone of increasing diversity." This means that the story of multicellular animal life should begin with a small number of species evolving from simpler forms. The dozens of different basic body plans manifested in the Cambrian fossils would then be the product of a long and gradual process of evolution from less differentiated beginnings. Nor should the cone have stopped expanding abruptly after the Cambrian explosion. If the disconfirming facts were not already known, any Darwinist would be confident that the hundreds of millions of years of post-Cambrian evolution would have produced many new phyla.

> Instead we see the basic body plans all appearing first, many of these becoming extinct, and further diversification proceeding strictly within the boundaries of the original phyla. These original Cambrian groups have no visible evolutionary history, and the “artifact theory” which would supply such a history has to be discarded. Maybe a few evolutionary intermediates existed for some of the groups, although none have been conclusively identified, but otherwise just about all we have between complex multicellular animals and single cells is some words like “fast-transition.” We can call this thoroughly un-Darwinian scenario “evolution,” but we are just attaching a label to a mystery.[133]

Johnson has stuck fast to this position in the years since *Darwin on Trial,* adding nothing to it in his later books.[134] The Cambrian has remained a “mystery” for him, even though he already had at hand clues suggesting at least the outlines of a solution.

We may start with the *chronology*. What had been happening before, and for how long? Johnson mentioned the Ediacara biota only long enough to invoke Gould and Seilacher as authority figures to dismiss their relevance. Other antievolutionists have been as cursory, from Gish and the Morrises (Henry and son John) to Michael Denton.[135] Still more recently, Jonathan Wells’ *Icons of Evolution* declared that “Precambrian fossils consisted only of single-celled organisms until just before the Cambrian,” albeit with an Ediacaran interlude of “Multicellular organisms slightly older than the Cambrian.”[136]

First discovered in Australia in 1947, the Ediacara were later found worldwide (they are also referred to as the Vendian fauna, for the “Vendian Era” applied to the late Precambrian).[137] But just how “shortly before” the Cambrian *did* these Ediacara biota appear?

The Ediacarans showed up on stage about *fifty million years* earlier.[138]

That happens to be about how long it took mammals to develop from the reptiles—or for their eventual descendants (who made it through the Cretaceous mass extinction when the dinosaur competition didn’t) to diversify into whales, cheetahs, and human beings. It is a revealing omission that none of the antievolutionists diving into the Precambrian gave their readers a sense of the gigantic timeframe involved between the start of the Ediacaran and commencement of the Cambrian worlds.

Johnson and Wells further stumbled over what they had written only a few pages away.

Wells noted how the Cambrian Explosion “lasted a maximum of 5 to 10 million years. (Although 10 million years is a long time in human terms, it is short in geological terms, amounting to less than 2 percent of the time elapsed since the beginning of the Cambrian.)”[139]

Johnson parsed the sense of interval even finer in another explanatory footnote:

> Terms like “rapidly” in this connection refer to geological time, and readers should bear in mind that 100,000 years is a brief period to a geologist. The punctuationalists’ emphatic repudiation of “gradualism” is confusing, and tends to give the impression they are advocating saltationism. What they seem to mean is that the evolutionary change occurs over many generations by Darwin’s step-by-step method, but in a relatively brief period of geological time. The ambiguity may be deliberate, however, for reasons that will be explained in this chapter.[140]

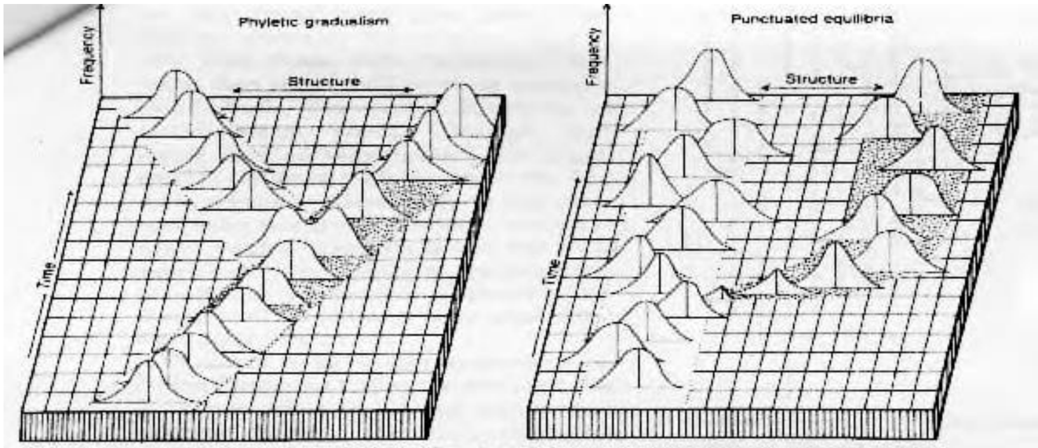
Like Milton’s “0.2 millimeters per year proposed by uniformitarians,” Johnson’s sense of what punctuationalists “seem to mean” had grown into the suspicion that their supposed “ambiguity may be deliberate.”

How true was this?

There are a *lot* of “100,000 years” to fill in “5 to 10 million years”—and even more when the span is extended back to the Ediacara biota. The existence of tens of millions of years of Precambrian metazoans strains Johnson’s glib characterization that Stephen Jay Gould’s view of Cambrian evolution involved “a direct leap from unicellular organisms.” Antievolutionary physicist Gerald Schroeder offered a similarly compressed treatment: “In a leap, life moved from single-celled protozoa and the amorphous Ediacaran clumps to multicellular complexity.”[141]

Within those millions of years, what were punctuationalists saying about what was going on?

Paleontologists Gould and Niles Eldredge proposed the “punctuated equilibrium” theory early in the 1970s to reconcile the observed pace and mechanisms of speciation with the tendency of organisms to remain relatively unchanged over most of their fossil duration. It had been discovered (particularly by the work of Ernst Mayr) that geographic isolation played an important part in the speciation process.[142] In the Phyletic Gradualism model, speciation flows along gradients of adaptation, where a species A turns into a new species B, even while a side branch might end up adapting into a form similar to the ancestral A. Punctuated equilibrium dispensed with the smooth flow and accepted the fossil data at face value: that A pretty much stayed A, while a geographically isolated subset fissioned off as the new B (Figure 10).[143]



Alternative models of evolutionary change

The classical view is of gradual change (left); more abrupt speciation (right) may instead be the major process. The graphs are drawn as frequency distributions of morphological structure. [Adapted from South African Journal of Science *76, 61 (1980)]*

Figure 10. Morphological change as envisaged under Phyletic Gradualism and Punctuated Equilibrium, illustrated in Roger Lewin (1980, 884). Although the speciation event leading to the two terminal forms is described as “more abrupt” under Equilibrium, its distinguishing feature appears to be a smaller distribution curve, edging off from the main line near the middle. The double-humped speciation point in the Gradualist model can just as easily be seen as representing partially isolated populations, which might involve the same dynamic of speciation in both models. If only a scattering of individuals from these shifting populations were preserved as fossils, of course, trying to discern which model better described their historic condition would be difficult. In both cases though, the time frame for capturing the *exact* speciation event would be narrow. One can compared the patterns in this figure with the variety of speciation modes noted by Simpson (1983, 126-127, 162, 172), as well as the information cited in note 153 below.

The pertinence of the debate between advocates of phyletic gradualism and punctuated equilibrium was not about the rates at which microevolutionary speciation takes place. Or even the pacing and modalities by which such speciation events might occasionally (though not necessarily—and by no means *inevitably*) cascade into broader macroevolutionary change.[144]

It is about how morphological change tracks against speciating branches, and the extent to which particular speciation events might be captured in the geological sieve, as Phillip Johnson must have been aware given his own sources.

While not referenced by direct footnoting, there were “Research Notes” at the end of *Darwin on Trial* listing the sources used for each chapter. There one read that “The basic description of punctuated equilibrium in the text is adapted from Gould’s ‘The Episodic Nature of Evolutionary Change,’ in *The Panda’s Thumb*.”[145] So in principle Johnson could have been familiar with this passage from Gould's book: "In describing the speciation of peripheral isolates as very rapid, I speak as a geologist. The process may take hundreds, even thousands of years; you might see nothing if you stared at speciating bees on a tree for your entire lifetime."[146]

On the contra-Punctuated Equilibrium side, Richard Dawkins' *The Blind Watchmaker* didn't dispute Gould's chronological schema, only the degree to which this constituted a rejection of neo-Darwinism (Dawkins explained why it didn't).[147] And yet another of Johnson's resources, the anticreationist anthology *Scientists Confront Creationism*, explained that Gould and Eldredge

> agreed that a perfect fossil record *would* document morphological intermediates between species, but they suggested that many of these would exhibit relatively brief and geographically limited existences. Indeed, Eldredge had such a near perfect record of the evolution of the Devonian trilobite *Phacops*. It was a record of stepwise evolutionary change in only two brief intervals during a span of eight million years! One such interval was recorded in a single easy-to-miss quarry in New York State. This quarry contained perfect intermediates between the geographically widespread mother and daughter species. In effect, due to the realities of an *imperfect* fossil record, most such intermediates will simply not be sampled.[148]

Had Johnson investigated further, he could have found this additional detail from Eldredge: "From my own work I can cite the trilobite genera (from the Lower Devonian of Bolivia): *Kozlowskiaspis—Metacryphaeus—Malvinella—Vogesina*, which are connected by a compelling array of intermediates."[149]

It didn't sound like Eldredge was saying that speciation events weren't preserved in the fossil record, or that the processes by which this took place were inexplicable by natural evolutionary means. And Eldredge has continued to reiterate this position, while Johnson has continued to ignore it. For example, in his 1995 book *Reinventing Darwin*, Eldredge offered:

> When lecturing to new audiences, I like to present myself as a "knee-jerk" neo-Darwinian, at least when it comes to the matter of adaptation and natural selection. It's true enough, and comes as something of a surprise to some who suppose that I will promulgate some wild new theory to supplant traditional canon. People tend to equate punctuated equilibria with some alternate notion of how evolutionary change—adaptive evolutionary change—occurs.
>
> But no rational evolutionary biologist feels that most change is not adaptive, or that adaptive change is not caused by natural selection. As we begin to see in the next chapter [titled "The Great Stasis Debate"], our fossil data imply that evolutionary change is rather more difficult and rare than generally suspected. And when it does happen, adaptive change comes rather quickly, at least when compared to vastly longer periods when species don't seem to change all that much.
>
> But what happens during those much briefer spurts? Adaptive change through natural selection, that's what—in the context, to be sure, of true speciation. And though our data frequently are too poor to demonstrate gradual change through selection, we do in fact have some documented examples of smooth transitions that are very much in agreement with natural selection.[150]

Johnson was familiar with this passage too, which he abstracted and merged with another section (slightly misquoted) pertaining to fossil stasis. "That is also why Niles Eldredge, surveying the absence of evidence for macroevolutionary transformations in the rich marine invertebrate fossil record, can observe that 'evolution always seems to happen somewhere else' and then describe himself on the very next page as a 'knee-jerk neo-Darwinist.'"[151]

Actually the "knee jerk" passage appeared forty pages earlier—a textual conflation consistent with a compression ratio that left out the substance of Eldredge's actual argument.

Davis and Kenyon’s *Of Pandas and People* made a similar mistake: “According to punctuated equilibrium, major evolutionary changes in small populations take place rapidly (say, in a few hundreds to several thousands of years) rather than slowly (that is, in millions of years) as conventional evolutionary theory holds.”[152]

But punctuated equilibrium wasn’t claiming that *major* evolutionary changes occur that quickly—only that the distinctly more modest episodes of *speciation* were capable of such comparative speed.

While the occurrence of natural speciation is a necessary precondition for macroevolutionary change, they are not interchangeable. It would not matter how long a newly fissioned species persisted in its fossil stasis. The naturalistic argument would only get in fatal trouble if it were impossible for the split to have occurred in the first place. Since that hasn’t been the position of Eldredge or other evolutionists, Johnson’s use of the punctuation argument falls into Henry Morris’ “proof text” category.

Had Johnson looked into the speciation branches rather than the lengths of the resulting static lineages, he could have learned that recent studies of fossil speciation rates suggest no single model is the “correct” one. Rather, various tempos come into play over the life of a lineage, including “punctuated anagenesis” and “coordinated stasis” where extinction and speciation ebb and flow together.[153] Gradualism and punctuation can even operate simultaneously in a species, as Patrick Doyle and Florence Lowry noted of the Late Miocene marine plankton *Globorotalia conomiozea*. While the main temperate population evolved gradually into *G. sphericomiozea* and finally into *G. puncticulata* over two hundred thousand years, the more isolated tropical branch rapidly split off yet another new species (*G. pliozea*) over only ten thousand years.[154]

Another of their planktonic examples was especially relevant to the fossil preservation issue:

> Their small size, abundance and widespread distribution make them useful subjects in evolutionary studies. The evolution of the genus *Orbulina* in the Miocene is an example of rapid change over a relatively short time span of 0.5 million years, in which all intermediate forms are known in an exceptionally complete stratigraphical sequence (Figure 4.7). Following this short, rapid burst, *Orbulina* remained unchanged to the present day, a span of 16 million years of stasis. Should the fossil record have been less complete, this event may have been represented by a sudden speciation event followed by a period of stasis.[155]

I discovered just how impervious Phillip Johnson’s conviction about static marine invertebrates was when I apprised him of the *Orbulina* quote in a 1998 email. His comment *in toto*: “Well, I see you don’t get it, and you aren’t going to get it. When you are in a Darwinian way of thinking, everything looks Darwinian—even stasis. You have to step outside before you can see the other side. Have a nice day.”[156]

If Johnson was unwilling to address even one counterexample to his giddy generality about speciation in fossil invertebrates, how much more of a hurdle would it be for him to make sense of a whole ecosystem of early Cambrian fauna? Or relate that to the potential precursor period stretching back tens of millions of years into the Precambrian? Especially when it comes to determining the extent to which the “explosion” might be closer to *Orbulina*-style speciation spooling out over those millions of generations, rather than a disconnected succession of typological stasis guided by Intelligent Design.

One of the important paleontological lessons that emerges from the debate over punctuated equilibrium is that the animals most likely to hog any single prehistoric group shot are the *local* stabilized majorities who have already undergone their speciation trips. Some may dominate the random sampling by the temporary success of sheer numbers, while others may do so on account of the prolonged persistence of their particular species.[157]

Since speciation is something many modern creationists theoretically accept as “variations within the type,” it is ironic how they fail to think through the consequences of this for the geological record, especially as the Burgess illustrated that selection factor so nicely. At the original site the most commonly found animal was *Marrella*, while *Alalcomenaeus* was one of the rarest—yet work along the mountainside twenty miles and *Marrella* was unknown, while *Alalcomenaeus* was prominent. Both animals existed and were abundant, *but not in the same place*, so if either one of those deposits had been lost to erosion the picture of Burgess “diversity” would have been very different.[158]

And I did say *mountainside*, which highlights how odd it was for Johnson to expound on science having “no good excuse” for the scarcity of Precambrian ancestors, when the Burgess Shale itself eloquently explained why. The Burgess exists for Johnson to mischaracterize only because it was crumpled like a throw rug during the process of continental drift and incorporated into the Rocky Mountains (a similar action scrunched later marine sediments up into the Alps and Himalayas).[159]

While Precambrian strata underlie most of Africa, Australia, the Americas, a good chunk of Antarctica and northeast Europe, plus bits of Asia, not much of it helps the Cambrian Explosion quest. There was no land life at the time, so terrestrial deposits would be irrelevant, as would any predating the Ediacara window. Even marine rocks of the right age wouldn’t be much of a find if it meant tunneling through a mountain or city to reach them. To shed light on whatever was happening during the transition from Precambrian to Cambrian, sediments would be needed from the coastal margins of the Rodinia supercontinent that was just rifting into smaller landmasses (like Laurentia and Baltica) as the Cambrian dawned (Figure 11).[160]

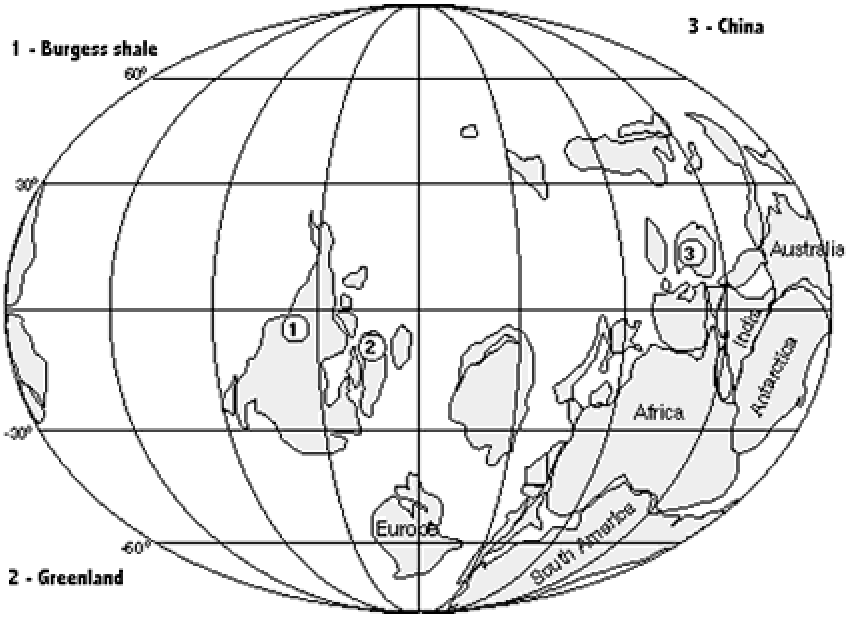


Figure 11. The Cambrian world, about 510 million years ago. Map from the Smithsonian’s *nmnh.si.edu/paleo/shale/p35ma.htm*. The three main *Lagerstätten* are indicated: the Burgess Shale (1) and Sirius Passet (2) on Laurentia, and Chengjiang (3) on the sprawling Gondwana. While these regions were tropical, Europe as the island of Baltica chills toward the South Pole. The main continents are drawn using their current boundaries for easier identification—though it is known that the center of Laurentia was the inland Sauk Sea (named for Sauk Center in Minnesota). Cf. Parker (2003, 80) on Cambrian continental illustration.

But those are the very deposits most likely to be devoured through plate subduction, and the oceans have had hundreds of millions of years since to further that disposal. Consequently, relevant Cambrian and Precambrian sites of any sort are not a dime a dozen. For example, the Cambrian continent of Laurentia was roughly North America turned 90° and positioned along the equator, with Greenland to the east and the Burgess Shale on the north coast. But for all that real estate there are just *thirteen* really useful sites, mostly along the same cordillera that snagged the Burgess beachfront property.[161]

Exactly the same situation applies in more recent slices of the geological column. Very few deposits are available for the Triassic Period, where Mesozoic strata are weighted to the later Cretaceous. And while there is an Early, Middle and Late Triassic, and an Early, Middle and Late Jurassic, there are so few deposits around 100 Ma that geologists have simply dispensed with the “Middle” and recognize only Early and Late Cretaceous.[162]

Not coincidentally, many of the most celebrated “fossil gaps” trumpeted by antievolutionists fall in windows like the Triassic, whose geological lacunae they never explain.[163] Thus Duane Gish decided *Protoceratops* “fails miserably as an ancestor for the horned dinosaurs” like *Triceratops* because “it should be found in geological formations such as the Middle or Lower Cretaceous, presumed to be older than the Upper Cretaceous.”[164]

As though there were a substantive “Middle” Cretaceous in which to look.

Darwin on Trial was therefore following in the broad but shallow footsteps of generations of creationists who think to comment on the fossil record without first getting a solid grasp on its geological reality. But when he singled out the Burgess Shale to “demolish” the notion that soft-bodied creatures wouldn’t fossilize, Johnson waded into some particular treacherous taphonomic ground. For the issue was not whether it was *possible* for such preservation to happen, but under what *circumstances* that takes place.

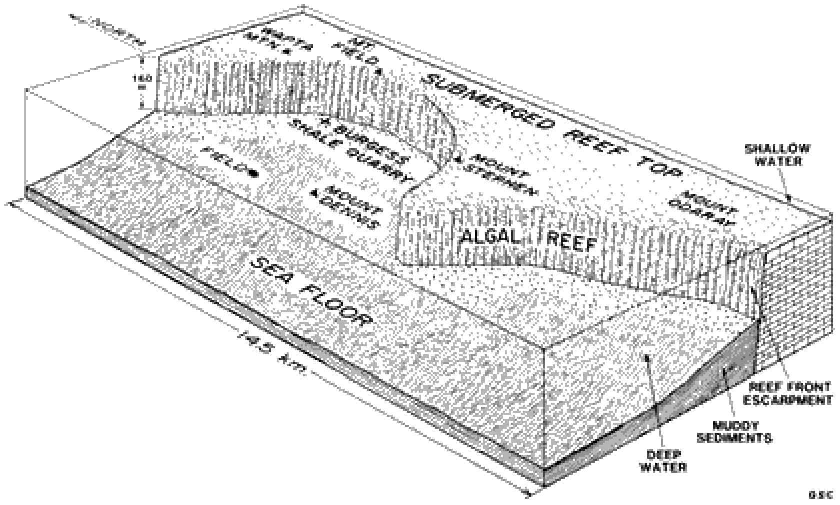


Figure 12. The Burgess Shale reef site as it existed during the Cambrian. Drawing from the Smithsonian’s *nmnh.si.edu/paleo/shale/preef.htm* (with the deposit date given there as 550 Ma rather than the more current recalibration of 517 Ma).

The Burgess Shale was once a reef site (Figure 12), where one day a massive landslide swept everything down slope to the anoxic bottom where decay was prevented. Such geological time capsules are so exceedingly rare that paleontologists have a special name for them—another datum Johnson didn’t bother to note.[165]

But Gould’s *Wonderful Life* did. Ironically enough, this was “on the very next page” after the passage Johnson had quoted on the Ediacaran matter:

> Paleontologists have therefore sought and treasured soft-bodied faunas since the dawn of the profession. No pearl has greater price in the fossil record. Acknowledging the pioneering work of our German colleagues, we designate these faunas of extraordinary completeness and richness as *Lagerstätten* (literally “lode places,” or “mother lodes” in freer translation). *Lagerstätten* are rare, but their contribution to our knowledge of life’s history is disproportionate to their

> frequency by orders of magnitude. When my colleague and former student Jack Sepkoski set out to catalogue the history of all lineages, he found that 20 percent of major groups are known exclusively by their presence in the three greatest Paleozoic *Lagerstätten*—the Burgess Shale, the Devonian Hunsrückschiefer of Germany, and the Carboniferous Mazon Creek near Chicago.[166]

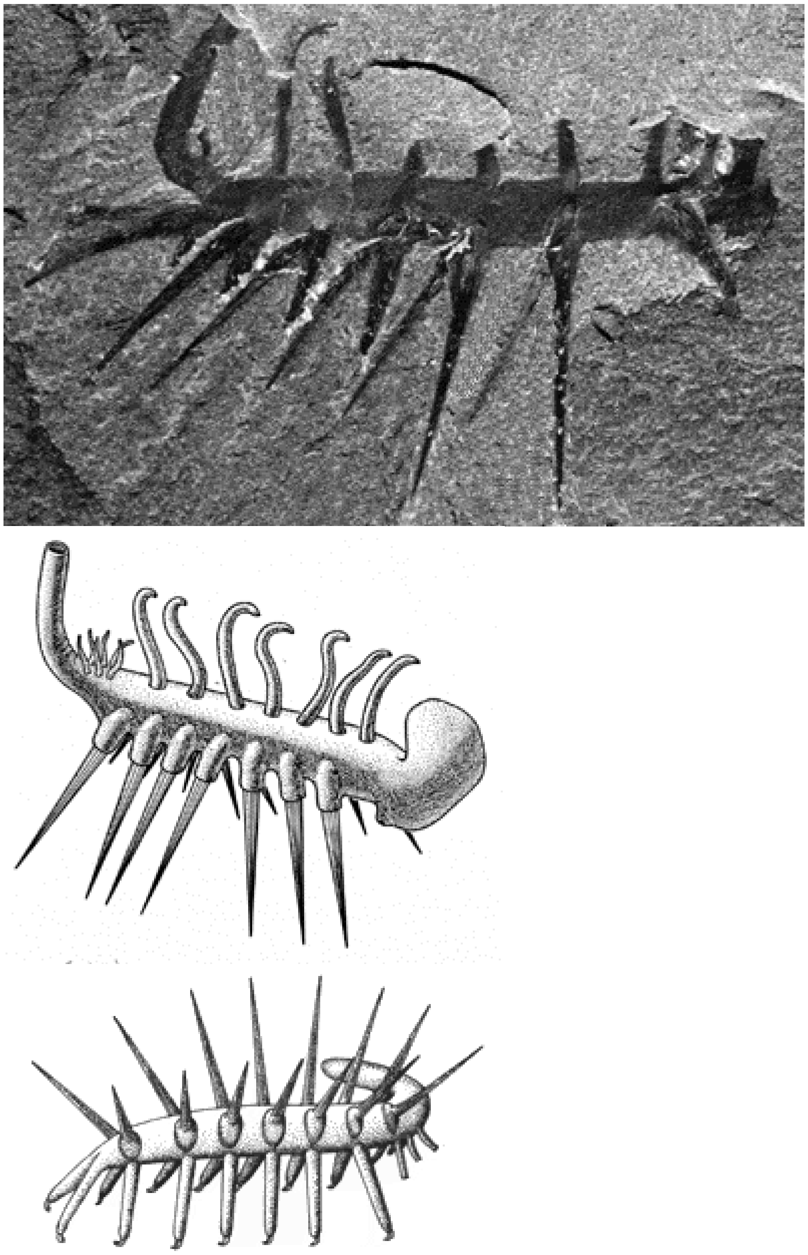


Figure 13. The onychophoran *Hallucigenia sparsa* (top and bottom) from the Burgess Shale (length about one inch), Smithsonian *nmnh.si.edu/paleo/shale/phallu.htm*. As recounted by Simon Conway Morris (1998a, 53-60), the name was chosen because it appeared like a strange hallucination, an animal that seemingly got around on its spiny paired legs while feeding with tentacles along the top. The illustration of *Hallucigenia* by Marianne Collins (middle) in Gould (1989, 114) followed Conway Morris’ initial description.

And this situation continues for other taxa and geological eras. We'll see in the second macroevolutionary episode on birds that practically all the relevant evidence stems from fossils preserved in *Lagerstätten*. Doyle and Lowry note still another example: "The oldest confirmed octopods are known from a Cretaceous conservation Lagerstätte in the Lebanon."[167]

The implication of this for creationist arguments on the fossil record cannot be overstated.

Some organisms are small, or lack mineralized parts that fossilize easily, or are not especially numerous. These are facts of nature. If such forms virtually require a *Lagerstätte* to be preserved, then they would be functionally *invisible* to the paleontological lens apart from Mother Lode deposits for that particular region and period. And even in cases where fairly conventional deposition could trap them, if subsequent terrestrial erosion or plate subduction devoured that burial site then again there would be so physical verification that the animal had once existed.

It would be one thing to have a splendid series of *Lagerstätten* in which fragile intermediates would have been reasonably preserved had they existed, and conclude from that objective situation that there is no physical evidence for the evolution of that organism. It is quite another matter to point to zones in the paleontological data where it is the physical record itself that is missing and act as if that were the same class of non-evidence.

That's exactly the mistake Johnson was making.

And it is a mistake that every other antievolutionist makes, for I literally know of no example where a major critic of evolution has ever even mentioned the geological context of a fossil ensemble, let alone highlighted the supremely relevant *Lagerstätten* parameter.

That includes Duane Gish rejecting as "incredible" the idea that Precambrian ancestors for Cambrian fauna would have been soft-bodied, and that such creatures would have rarely fossilized. This, even though Gish had quoted from the very page where George Gaylord Simpson had written (in 1949!) how "remarkable examples" of Cambrian deposits preserving soft parts were "so exceptional that the absence of such deposits in the pre-Cambrian would not be surprising."[168] And the Morrises continue the ICR tradition in their 1996 *Modern Creation Trilogy* series by stressing "the abundance of fossils whose soft parts have been preserved in the Cambrian rocks."[169]

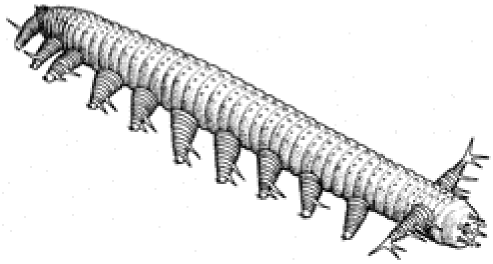


Figure 14. The onychophoran *Aysheaia pedunculata* (length around 2 inches), Smithsonian *nmnh.si.edu/paleo/shale/payshia.htm*. Cf. the version by Marianne Collins in Gould (1989, 169). Because it is often found together with sponge fossils, *Aysheaia* is believed to have lived on them parasitically (note its placement in Figure 6 earlier).

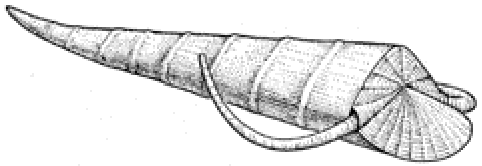


Figure 15. The tiny hyolith *Haplophrentis carinatus* (length 0.1 to 1.25 inches), Smithsonian *nmnh.si.edu/paleo/shale/phaplo.htm*. What the curved appendages near its lid shell did is uncertain, as there are no living hyoliths available to describe their behavior. They may have functioned as oars to advance along the seafloor, as static stabilizers against a current, or for something else altogether.

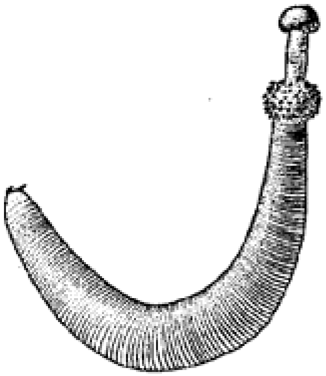


Figure 16. The priapulid worm *Ottoia prolifica* (length around 2 inches), Smithsonian *nmnh.si.edu/paleo/shale/pottoia.htm*. Cf. the version by Marianne Collins in Gould (1989, 295). The Smithsonian commentary noted that *Ottoia's* “relative immobility placed it in danger of being carried away and/or buried by any underwater mud avalanche from the cliff top,” possibly accounting for its abundance in the Burgess Shale.

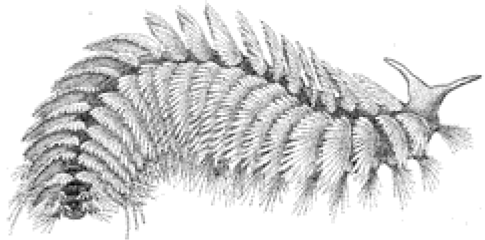


Figure 17. The polychaete annelid *Canadia spinosa* (length 1-2 inches), Smithsonian *nmnh.si.edu/paleo/shale/pcanadia.htm*, drawing by Marianne Collins in Gould (1989, 296). The Smithsonian commentary noted that “Sediment has never been found in the gut, suggesting that this worm may have been a carnivore or scavenger.”

Jonathan Wells joined this parade in *Icons of Evolution* when he specifically mentioned the three main Cambrian fossil beds (Burgess Shale, Sirius Passet and Chengjiang) without explaining that they were *Lagerstätten*.[170] Like Henry Morris & Son, Wells is also fond of selective authority quoting, as he demonstrated a few pages later when addressing the preservation issue:

> Did the ancestors of the animal phyla fail to fossilize because they were too small, or soft-bodied? The problem with this explanation is that microfossils of tiny bacteria have been found in rocks more than three billion years old. Furthermore, the Precambrian organisms found fossilized in the Australian Ediacara Hills were soft-bodied. “In the Ediacaran organisms there is no evidence for any skeletal hard parts,” wrote Simon Conway Morris in his 1998 book, *The Crucible of Creation*. “Ediacaran fossils look as if they were effectively soft-bodied.” The same is true of many of the organisms fossilized in the Cambrian explosion. The Burgess Shale, for example, includes many fossils of completely soft-bodied animals. “These remarkable fossils,” according to Conway Morris, “reveal not only their outlines but sometimes even internal organs such as the intestines or muscles.”
>
> So whatever the reason may be for the absence of ancestors, it is certainly not that they were small or soft-bodied. As geologist William Schopf wrote in 1994: “There is only one source of direct evidence of the early history of life—

> the Precambrian fossil record; speculations made in the absence of such evidence, even by widely acclaimed evolutionists, have commonly proved groundless." One such speculation is "the long-held notion that Precambrian organisms must have been too small or too delicate to have been preserved in geological materials." According to Schopf, this notion is "now recognized as incorrect."[171]

Wells artfully spliced together statements on two different subjects. Schopf was talking about the earliest preservation of single-celled prokaryotic organisms, not the circumstances under which all soft-bodied multicellular metazoans might be liable to successful fossilization. Indeed, at the bottom of the page Wells was quoting from, Schopf explained:

> Like Phanerozoic vascular plants, most prokaryotes have physically and chemically resistant cell walls; thus—despite their small size and "delicate" natures—they are potentially preservable by exactly the same processes (compression and petrification) as are fossil trees and plant parts. Two take-home lessons come to mind: (1) Even expert "conventional wisdom" can be mistaken; and (2) discovery of the "missing" Precambrian fossil record well illustrates that absence of evidence should not be regarded as evidence of absence![172]

Just because some small things can be preserved under certain conditions, doesn't mean that still larger ones organized differently will be caught in the same sieve. Which Wells ought to have noticed during the process of lopping off almost half of the animal phyla in constructing his Cambrian chart examined in the previous chapter.

A further illustration of how finicky some fossilization processes can be concerns phosphatization, whereby soft tissues are replaced with calcium phosphate. In this way the distinctive *embryos* of sponges and metazoans have turned up from the Precambrian Doushantuo formation in China (cherts and shales dating before 570 Ma). But there's a catch: it only works within a narrow range, for fossils up to about 2 millimeters.[173]

Using the same natural inference engine that Wells temporarily used to place phyla back in the past based on trace fossils, we may presume that the embryonic metazoans grew up to be something bigger. But whatever their adult forms were, they totally escaped preservation. These still could have been very tiny, smaller than *Marrella* or *Pikaia* from the Burgess Shale—but that would have been far too Brobdingnagian for capture by phosphatization.[174]

While Schopf was not talking about Ediacaran preservation in his short survey article, Conway Morris definitely was in his book. The sentences Wells quoted appeared in a paragraph that had explained how the Ediacara

> present an unsolved paradox in terms of their preservation. The problem is really twofold. First, in the Ediacaran organisms there is no evidence for any skeletal hard parts, similar for example to the calcareous exoskeleton of a trilobite. Ediacaran fossils look as if they were effectively soft-bodied. Yet these fossils most typically occur in sediments known as sandstones and siltstones. In normal circumstances these would be the least likely sediments in which a palaeontologist would expect or predict soft-part preservation to occur. The reason for this is rather straightforward: sandstones and siltstones tend to accumulate in areas of the sea floor that are quite turbulent and well oxygenated. Neither of these conditions is conducive to the fossilization of delicate tissues. By and large, soft-bodied fossils are found in fine-grained shales, as exemplified by the Burgess Shale.[175]

Thus the Ediacara biota stood out precisely because of the unlikelihood of their preservation. Conway Morris devoted the next pages to various theories as to how these particular organisms managed to buck the fossilization odds. He didn't favor the theory of Dolf Seilacher that the Ediacara were constructed from especially tough tissue, but looked more favorably on the idea that there weren't yet enough active scavengers or predators to dispose of the soft tissues before burial in the otherwise unpromising siltstones.[176]

Besides Wells evading the *Lagerstätten* issue, he was also stepping over an important clue to what might have been going on in the period leading up to the Cambrian Explosion: the advent of *predation*.[177]

Phillip Johnson could have known about this too, since Gould's *Wonderful Life* had explained that the Cambrian had not begun with the fauna of the big Explosion, but millions of years earlier with a different cast of characters: the Tommotian "small shelly fauna." Named after a spot in Russia where they were first found, these "tiny blades, caps, and cups of uncertain affinity" have been found all over the Cambrian world, but paleontologists are still uncertain whether they might have been some sort of ancestral mollusks or cephalopods.[178]

But whatever lived inside those diminutive shells (barely a few millimeters long) they affirmed three things. First, that organisms were going to the trouble of secreting the dead weight of a protective shell suggests the existence of active predators prior to the main Explosion. Indeed, there is evidence that one form of predator was active as far back as the Ediacaran period.[179] Second, that a whole ecology went about its business for millions of years without leaving any trace of what it was that might have been threatening the small shelly fauna (a confirmation of the *Lagerstätten* problem). And third, antievolutionists have shown no curiosity about any of this.[180]

Thus Wells wrote:

> British paleontologist Simon Conway Morris believes that at least some of the Ediacaran fossils were animals, but maintains that most of the many species appearing in the Cambrian did not have ancestors in Ediacara. "Apart from the few Ediacaran survivors," wrote Conway Morris in 1998, "there seems to be a sharp demarcation between the strange world of Ediacaran life and the relatively familiar Cambrian fossils."
>
> There are two other indications of multicellular animals just before the Cambrian: a "small shelly fauna," consisting of tiny fossils that are unlike any modern group, and trace fossils (burrows and tracks), apparently left by multicellular worms. But except for the latter, and possibly a few survivors from Ediacara, there is no fossil evidence connecting Cambrian animals to organisms that preceded them. The now well-documented Precambrian fossil record does not provide anything like the long history of gradual divergence required by Darwin's theory.[181]

There is peril in relying on authorities without fully comprehending the context in which their views were made. Much as Dr. Watson had when Holmes remarked about the dog *not* barking in the night, Johnson and Wells overlooked yet another provocative clue.

Those peculiar Ediacarans were *diploblastic* organisms—a technical way of saying they had two body layers, apparently sandwiched together something like fluid (or sand) filled air mattresses, with no evident body openings or internal organs. Not having internal organs restricted the Ediacarans to filter feeding off the byproducts of microscopic organisms or symbiotic bacteria. This contrasts sharply with the *triploblastic* structure of the Cambrian fauna and their descendants (like us) whose cells fold into a plethora of organ-filled cavities.

Although there are living diploblastic organisms (such as jellyfish and comb jellies), the general Ediacaran layout appears sufficiently distinct to warrant putting them on their own taxonomical siding.[182] But if Johnson and Wells were going to snatch one end of Seilacher/Gould and Conway Morris' inferential logic, it seemed remiss of them not to pocket the rest. For as it happens, the very Ediacaran anatomy being excluded from triploblastic ancestry also rendered them incapable of substantial locomotion, which meant any trails or burrows turning up in the Precambrian had to have been made by *something else*.[183]

Gould's *Wonderful Life* had discussed what that *something else* might have been:

> Seilacher does not believe that all late Precambrian animals fall within the taxonomic boundaries of this alternative and independent experiment in multicellular life. By studying the varied and abundant trace fossils (tracks, trails, and burrows) of the same strata, he is convinced that metazoan animals of modern design—probably genuine worms in one form or another—shared the earth with the Ediacara fauna.[184]

Jonathan Wells may have thought he could downplay the significance of all this by his brief reference to “multicellular worms” having made the early trace fossils. But because those organisms were triploblasts, their presence in the Precambrian zoo marked a profound transformation in underlying body plans, long before the Cambrian.

Because of the *Lagerstätten* factor, the existence of trace fossils takes on added importance as a calibrator for the Cambrian Explosion. Genetic studies have favored early divergence times for the phyla, sometimes many hundreds of millions of years before the Precambrian/Cambrian boundary. Of course, an individual gene may diverge well before it is expressed in a morphological package sufficiently distinctive and durable to show up in a paleontological context.[185]

But the farther back you push metazoan development, the earlier you position potential evolutionary offshoots, and that runs into the trace fossil problem. The more time you give them, the more likely it would be for any bottom huggers among them to traipse across the surface, or churn up the substrate in search of dinner—and such disturbances can be captured apart from *Lagerstätten*.[186]

Conway Morris made exactly this point in *The Crucible of Creation*, “that if an evolutionary radiation were to occur in an entirely soft-bodied group and we had no exceptional fossil preservation, then it would remain undetected and unobserved.” But skeletal species go hand in hand with trace fossils, which Conway Morris illustrated with a Lower Cambrian example suggesting “the digging activity of arthropods.” He could therefore “be fairly sure that any pre-Ediacaran animals would have been tiny, only a few millimeters long, and so inhabited a microbial world in the benthic realm on the seabed or as floating members of a planktonic community, perhaps similar to some living larvae.”[187]

Here was the inferential importance of the existence (or absence) of trace fossils that both Johnson and Wells sped past in their haste not to see complex metazoans prior to the Cambrian Explosion.

Figure 18. The Ediacaran frond *Charniodiscus arboreus* (length about 40 cm), South Australian Museum fossil specimen (SAM P19690), image from *peripatus.gen.nz/paleontology/Ediacara.html*.

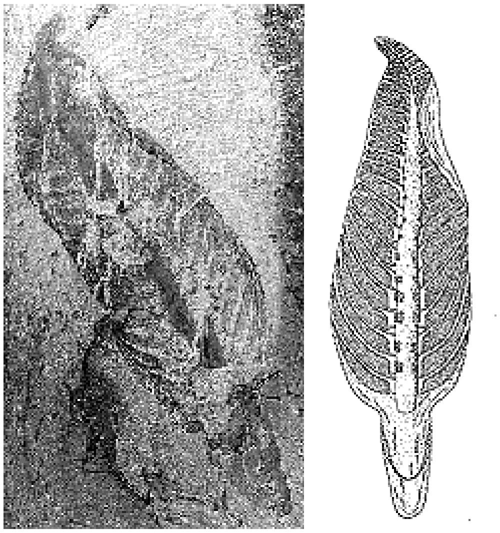
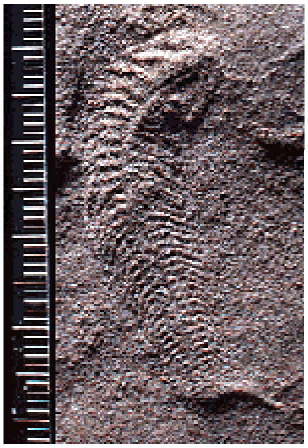


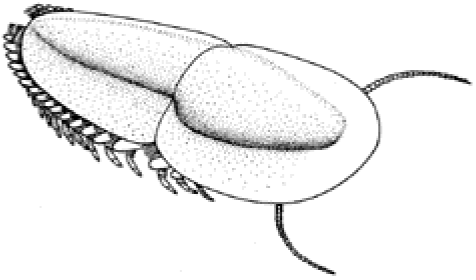
Figure 19. Left: *Thaumaptilon walcotti* (length ~20 cm), US National Museum fossil specimen (USNM 468028), *peripatus.gen.nz/paleontology/Ediacara.html*. Right: *Thaumaptilon* drawing, Smithsonian *nmnh.si.edu/paleo/shale/pthaum.htm*, commenting on “the numerous ‘branches’ projecting from the central ‘stem’ (axis). There are indications that the branches were connected internally to the axis by tiny canals. On the outside they were covered on one surface by thousands of tiny spots; possibly zooids (the individual elements of colonial animals). Note the fold showing us the alternate side which did not carry zooids.”

Figure 20. *Dickinsonia costata* (lengths ranging up to a meter). Yale Peabody Museum specimen (YPM 35467), *peripatus.gen/nz/paleontology/Ediacara.html*. “*Dickinsonia* has the distinction of being the only fossil to be described as a jellyfish, a coral, a sea anemone, an annelid worm, a polychaete worm, an arthropod, a bacterium, a protozoan, a member of a new phylum, a member of a new kingdom, and even an alien creature from outer space,” McMenamin (1998, 32).

Looking at those “few Ediacaran survivors” Jonathan Wells elected to quote Conway Morris on, the first was the frond-like *Charniodiscus* (Figure 18) which may have evolved into the primitive Cambrian sea pen *Thaumaptilon* (Figure 19). Indeed, Wells had to step past a reference to *Thaumaptilon* in the quote, where “wrote Conway Morris in 1998” occupied its text position in place of an ellipsis. The other example Conway Morris gave was *Dickinsonia* (Figure 20), including it among those Precambrian “fossils probably on the route leading to groups such as the arthropods and annelids.”[188]

Added to the information covered last chapter, five of the Cambrian metazoan phyla can lay fair claim to deep Precambrian fossil ancestry, and these are revealing ones.[189] All are organisms thought to have evolved early on, like the diploblastic jellyfish and triploblastic worms (annelids and their relations), along with rudimentary forms of the arthropods that would so hog the subsequent Cambrian zoo. We know now also that triploblastic embryos were among those phosphatized fossils that documented late Precambrian sponges, 40 Ma before the big Cambrian burst.[190]





Left **Figure 21.** *Spriggina floundersi* (length ~10 cm). Yale specimen (YPM 63257), *peripatus.gen/nz/paleontology/Ediacara.html*.

Right **Figure 22.** The Burgess Shale trilobite *Naraoia compacta* (length up to 1.5 inches), *Smithsonian nmnh.si.edu/paleo/shale/pnara.htm*. The large body shields obscured where the legs attached to the body, but the especially fine state of preservation permitted the fossil to be dissected in layers by Harry Whittington, whereby its trilobite affinity was established.

Sorting out whether some Precambrian animals might have been related to Cambrian ones concerns more than just getting the obvious details of the geological setting straight. Growth patterns are particularly revealing of phyletic affinity (as we’ll see next chapter with the echinoderms and early chordates). But just because the Ediacaran *Spriggina* (Figure 21) resembles a long eyeless soft-bodied trilobite—something like the Cambrian *Naraoia* (Figure 22) without the shell—doesn’t prove it as far as a trained paleontologist is concerned. Are its “segmentations” fixed body parts (invariant from one specimen to the next) or peripheral growth layers (somewhat in the manner of tree rings)? Making that call in the absence of *Lagerstätte* detail requires a sampling of individuals, especially of the same species, and hopefully including a range from juvenile to adult. And there we’re back at the geological roadblock. In this respect *Dickinsonia* tells the tale: paleontologist Mark McMenamin noted in 1998 that each of the four currently described species of this corrugated floor mat were known from only a sparse sampling of individuals. And it was the *best represented* of the Australian Ediacarans.[191]

Progress has been made at the other end, though, where imprecise taxonomy had to some extent overstated the phyletic disparity of the main Cambrian fauna.[192] Further specimens of the Cambrian predator *Anomalocaris* suggest affinities with the arthropods and even to the peculiar *Opabinia*.[193]

The curious early Cambrian halkieriids were once known only by the sclerites (calcareous plates) which covered their bodies. When in 1990 a full specimen was found in the Sirius Passet *Lagerstätte* of Greenland, *Halkieria* turned out to be a worm-like animal resembling a scale-studded shoe sole, though with small shells attached for some reason near either end. The characteristic arrangement of their sclerites link them to the polychaete worms, represented in the

Burgess by *Wiwaxia* (Figure 23), while *Halkieria’s* peculiar end shells led Conway Morris to suggest a potential relationship with the brachiopods.[194]

So long as antievolutionists wall the Cambrian off from the Precambrian, ignoring the specific taxa as well as the environment in which they lived, the pattern of evidence relating to their potential evolutionary ancestry remains off their analytical scope. And with no data set to account for, there is little incentive for antievolutionists to take the next step, and investigate the genetic and developmental mechanisms whereby that transformation might have taken place.

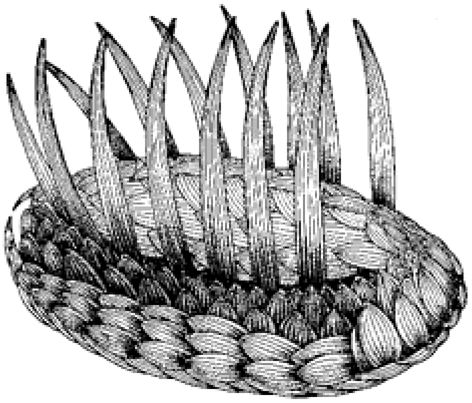


Figure 23. *Wiwaxia corrugata* (length 1/8 to 2 inches), Smithsonian image at *nmnh.si.edu/paleo/shale/pwiwax.htm*. Cf. the depiction by Marianne Collins in Gould (1989, 192). *Wiwaxia* may be a polychaete worm (though the Smithsonian commentary notes only that its body “resembles the slug, a member of the mollusk family).

Chapter 3. Patterns of Change

The picture of the transition from the Precambrian to the Cambrian that has been emerging over the last decade is one of a previously hidden world, of tiny “advanced” triploblasts living inconspicuously for many millions of years among the ruling Ediacaran air mattresses. Certainly being an aberrant diploblast must have had its advantages, even if it did drastically limit their range of movement, for they held Precambrian top billing for tens of millions of years.

Interestingly, the early period of their development coincided with a stupendously severe ice age (extending even into the *tropics*) that may have been triggered by a concentration of continental mass along the Equator.[195] As this hyperglaciation “Snowball Earth” waned in the last 20 million years of the Precambrian, the Ediacaran biota proliferated into their greatest diversity, possibly related to a facility for symbiotic relationships with bacteria in what was for them a congenial environmental window.[196]

A complete picture of the ecology of the Ediacaran world is missing, of course—there are no *Lagerstätten* available even to provide stray snapshots, as we have for the Burgess Shale and Chengjiang slices of the Cambrian. But if the “Garden of Ediacara” was even a bit like a modern rain forest, a lot of life may have been going on up in the canopy rather than on the surface. Any complex tiny triploblasts living among them may not at first have been able to adapt beyond a certain niche (many of the Ediacaran fronds could have tasted terrible, for example, because of the toxicity of their symbiotic bacteria). But conditions can change, and one of the factors that appears to have jumpstarted the Cambrian was a rise in oxygen levels, permitting an overwhelming expansion of those organisms whose diverging biochemistry and evolving visual acuity were capable of exploiting that new fuel to the max.[197]

Until the details of this world began to clarify, scientists had been viewing the Precambrian the wrong way around, as a *void* followed by a mysterious “explosion,” and antievolutionists have been wringing every ounce of mileage from this perception ever since.

But each precious scrap of information suggests what really took place during the Cambrian was a sweeping adaptive radiation following the collapse of the extensive Ediacaran ecosystem around 540 Ma.[198] This would relate the Cambrian Explosion to that pattern seen later in the history of life, especially among the vertebrates, where a mass extinction clears the deck of dominant lifeforms, opening niches that can be filled in a riot of adaptive evolution (Figure 24).[199]

When it comes to environmental niches, nature seems to abhor ecological vacuums as much as spatial ones. But the post-extinction successors do not arrive *instantaneously*. The mundane process of genetic mutation that fuels their natural selection is apparently *unguided*. So it takes some time for niche-filling macroevolutionary variations to appear. The result is a rebound that consistently stretches over *millions* of years. That’s why that Tommotian phase of the Cambrian was so significant—an interlude marking the *delay* attending a mass extinction.[200]

In his recent book on the Permian mass extinction paleontologist Michael Benton noted an interesting property of the post-mass extinction pulses:

> After mass extinctions, the recovery time, the time for diversity and ecosystem complexity to rebuild, is proportional to the magnitude of the events. Biotic diversity took 10 myr. to cover after major extinction events such as the Late Devonian, the Late Triassic and the KT. Recovery time after the massive end-Permian event was much longer: it took some 100 myr. for the diversity of families of plants and animals around the world to recover their pre-extinction levels.[201]

Whether delayed appearances like that would also be expected for an omnipotent creative intelligence (capable of creating whole galaxies *ex nihilo*) is another matter. Indeed, what ID may think of the necessity of restocking what amounts to a creationist game preserve after so many of the specimens inconsiderately drop dead is hard to tell, given that mass extinctions don’t rank very highly on their philosophical agenda. Though it would be interesting to learn what they would make of the *competence* of a designed global zoo recklessly falling apart.[202]

The question of what sparked these cycles of phyletic novelty is another instance where creationism and evolution part methodological company. If animals like the trilobites were an object of design, very little could be gleaned by studying possible Precambrian precursors like *Spriggina*, but if they came about by a naturalistic process of descent, tracing such a lineage would be most germane.

Was the explosion of disparity taking place because we’re looking at the very base of the genes that produce them? So many developmental switches starting in neutral that there was nowhere to go but *variation,* with practically every combination getting a chance on the stage?

Up until recently this was a theoretical question, since the developmental genes guiding living organisms hadn’t been identified. DNA turned out to operate on two levels, *structural* genes whose codon triplets specified strings of amino acids that were assembled into proteins that functioned as the physical nuts and bolts of the system—and *regulatory* genes that interacted with the DNA to turn coding segments on and off. Natural mutations could affect either or both of those two levels in ways that could be quite challenging to investigate.[203]

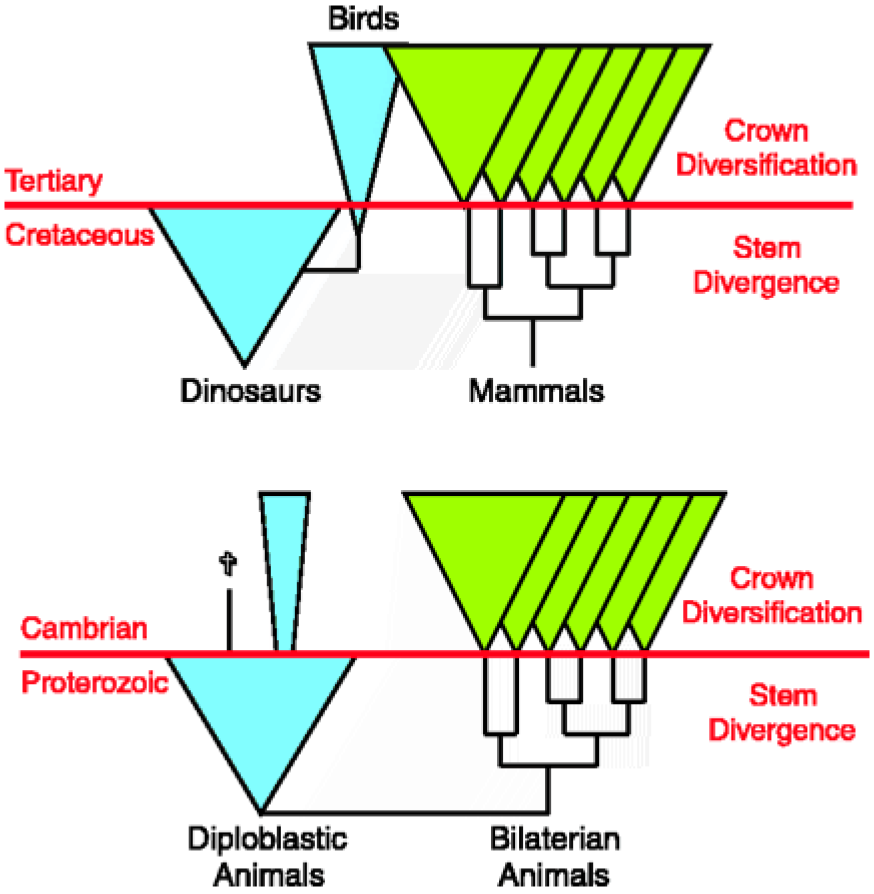


Figure 24. “Comparison of evolutionary dynamics across the Proterozoic-Cambrian and Cretaceous-Tertiary boundaries. The history of the terrestrial vertebrates, in which mammals radiated only after dinosaurs suffered mass extinction, may provide a framework for understanding the successive radiations of Ediacaran-grade and crown-group bilaterian animals,” Knoll & Carroll (1999, 2135).

Exploration of the regulatory side of the equation was picking up considerable steam by the time Gary Parker decided in *What Is Creation Science?* that genetic processes involved nothing beyond the “shuffling of existing parts, e.g. insects with legs where their antennas normally are, or with the extra pair of wings thanks to duplication of the second thoracic segment.”[204] This was an allusion to the *antennapedia* mutation in fruit flies (where legs are experimentally induced instead of antennae). Although two of Phillip Johnson’s sources (Gould and Dawkins) mentioned this too, *Darwin on Trial* didn’t pick up on the trail.[205]

Where the creationist Parker saw only a limited genetic mixing bowl, an evolutionist detects a vital clue to understanding fundamental development. Failing to yield at Parker’s barrier, biologists began to decipher the genes governing the placement of arthropod body parts. By the mid-1990s these *homeobox* genes were turning up all over the metazoan map, from insects and mammals among animals, all the way to plants (“types” not customarily accounted especially “similar” by creationists).[206]

The homeobox genes of a fruit fly and mouse are virtually identical sequences positioned in the same locations on their respective chromosomes, yet result in very different body plan effects. An insect’s skeleton is external, its body segmentation far more pronounced, so any changes to a fruit fly’s *HOM* complex will modify how wings and legs are to be attached. But mammals have experienced a few hundred million years of their own non-arthropod evolution, adding to that ancestral substrate considerable genetic modification for things like a vertebrate’s internal skeleton and musculature. During this adventure the mammalian *Hox* has undergone assorted gene doublings and duplications, and now exists in four copies on separate chromosomes (just as amphibians, birds, and worms have worked their own variations). When a mouse embryo expresses its primary *Hox* ensemble, it’s not to attach wing membranes or antennae, but to produce transient brain tissues, ultimately discarded in later development. Thus these regulatory genes are able to take on manifold functions, partners with structural genes in a billion-year-long evolutionary dance.[207]

Extraordinary information, one might think, worthy of discussion even from a creationist perspective. Yet (like *Lagerstätten*) antievolutionists have managed to avoid this subject with remarkable consistency.

Homeobox didn’t slow the Morrises’ *Modern Creation Trilogy*: “This is hardly an appropriate place to try to discuss all these terms and concepts. Even specialists in molecular biology are still trying to sort them out. A little seems to be known about many things, but not much is known about anything specific in this unique field of study.”[208]

Phillip Johnson continued to pen antievolutionary books, and cited works that discussed the developing homeobox field, but didn’t directly mention the matter himself. Instead, Johnson relied on Michael Behe’s *Darwin’s Black Box* to filter the biological issues for him. Unfortunately, Behe hadn’t discussed homeobox either.[209]

Nor did any of the ten contributors to the 1999 book *Three Views on Creation and Evolution* (which included commentary by Phillip Johnson).[210] Or the Discovery Institute luminaries William Dembski and Jonathan Wells in their recent books—a rather amazing omission in Wells’ case, given his Ph.D. in biology from Berkeley, and his citation of Conway Morris’ *Crucible of Creation* that had discussed homeobox in some detail.[211]

All of which puts an interesting scholarly perspective to this passage from Phillip Johnson’s 2000 book *The Wedge of Truth*:

> Is there an alternative to Darwinism? When Darwinists ask that question, they have in mind an alternative of the same kind, meaning a new scientific explanation that involves only law and chance. In that sense, I doubt there is an alternative. Many persons have tried to find such a theory by postulating innovative macromutations (perhaps in the so-called *hox* genes that are common to many distinct groups) or vaguely-defined self-organizing systems or chaos theory or new laws of physics.[212]

For this, Johnson's first reference to homeobox in nearly a decade of dedicated antievolutionary prose, there were no citations.

Although creationists seemed in no hurry to think about it, I expected evolutionists to hit on the implications of homeobox genes at once, and I was not disappointed. Joining Conway Morris was biologist John Avise commenting on the Cambrian: "Developmental alterations mediated by changes in regulatory genes almost certainly were involved in these evolutionary transformations."[213] Indeed, it wasn't difficult to find a score of scientific discussions relating the origin of phyletic disparity to changes in developmental homeotic genes.[214]

Mark McMenamin went still further for the Ediacarans, venturing a preliminary taxonomy based on a simple set of cell division rules, suggesting future lines of genetic research to resolve their relationship to contemporary fauna.[215]

And that synergistic way of thinking (relating the observations of fossil evidence to the mechanisms of cellular development) is why homeobox genes are so important to this issue, and their absence in the antievolutionary argument is so glaring. Homeotic genes govern the patterning of cell differentiation, front to back, side to side, start and stop. Anyone hoping to make sense of the pattern of life, whether favoring an evolutionary interpretation or defending a design option, couldn't avoid coming to grips with this evidence.

And yet that's exactly what antievolutionists weren't doing with homeobox. And its what they haven't been doing with developmental biology generally.

To see just how much is missing from the antievolutionary conceptual kit, consider this summary of the evolutionary side of the picture by Tim Berra in his 1990 criticism of creationism:

> Many biologists consider that some single-celled, flagellated (whiptailed) eukaryote is ancestral to all the multicellular plants and animals. These unicellular organisms show some plantlike features (many are photosynthetic) and some animal-like features (they are highly motile, and lack cell walls). Multicellular organisms most likely arose through the aggregation of single-celled organisms. Many such colonial forms exist today. This arrangement has the advantages of increased division of labor, coordination of activity, and interdependence among cells. Both botanists and zoologists trace the origin of their subjects to hollow, spherical, colonial flagellates that resemble an embryonic stage of the more advanced organisms. The Plant and Animal Kingdoms are both thought to have developed from such a common ancestor.
>
> Along the animal line, one of the earlier groups to evolve was the coelenterates (hydra, jellyfish, corals), which are postulated to have arisen via a larva-like stage, called a planula, which is a tiny ciliated, free-swimming, pear-shaped mass of two cell types with no left or right side, and no head or tail end. Most animal groups beyond the coelenterates are **bilaterally symmetrical**—they have left and right sides and head and tail ends. These animals, called the Bilateria, have the advantage of concentrating the sense organs in a "head" region and are more or less streamlined for active movement. They are thought to be derivatives of a planuloid ancestor that eventually gave rise to the flatworms and, ultimately, to the great diversity of the other invertebrate groups.
>
> A major division in the Animal Kingdom occurred soon after the development of bilateral symmetry. One of the two lines that followed from that division led to the animal group in which the blastophore (the external opening of the gut) of an embryo develops into a mouth. These animals, which include various types of worms, mollusks, and arthropods, are called Protostomia. The other line led to the group whose blastophore becomes an anus. These animals, called Deuterostomia, consist of the echinoderms (sea stars and their relatives), hemichordates (some marine worms), and the chordates (tunicates, amphioxus, and vertebrates, including humans).

> The echinoderms and the hemichordates have very similar ciliated larvae, and they probably share a common ancestor. Though the hemichordates and chordates share certain fundamental features, the hemichordates, until recently classified with the chordates, are now considered a separate group between the echinoderms and chordates. The prevailing view in zoology today is that both echinoderms and the chordates evolved from a common ancestor in the remote past. The evidence for this view rests chiefly on their similar embryonic organization and development, not their adult features.[216]

Echinoderms offer further clues to this phyletic origins debate: while their adult forms have evolved away from the bilateral body symmetry characteristic of hemichordates/chordates, they begin as bilateral embryos (later folding into a pentagonal disk that in turn develops into a five-sided juvenile). And while echinoderms have diversified into specialized adults as varied as the mammal gang, their developmental genes (such as Hox and Wnt) are turning out to be closely related to those of the chordates.[217]

But turn to the prominent antievolutionary literature (YEC or ID) and the reader discovers *none* of these topics. Not even in what Percival Davis and Dean Kenyon intended as an instructional creationist school text, *Of Pandas and People*.[218]

Paleontologist Chris McGowan thought this oversight remarkable enough in respect of Creation Scientists Morris and Gish, who were “both so concerned with demonstrating the absence of fossil forms that they have nothing to say about living animals.”[219]

But McGowan had plenty to say about living animals, devoting a whole chapter to it in his 1984 critique of creationism, *In the Beginning…* That account takes on added relevance when compared to the creationist silence on these matters (especially for Duane Gish, who cannot claim to have been unaware of the points raised in McGowan’s book). McGowan pointed out that when you study the variety of living forms (such as green alga like *Volvox* or the curious “slime molds”) discriminating between “plant” and “animal,” or even telling where single cells leave off and multicellularity sets in, can be quite a chore. “This, of course, flies in the face of Dr. Morris’s claim that there are no transitions between basic kinds—what could be more basic than plants and animals?” [220]

The developmental relationship between metazoan multicellularity and the aggregation of colonial animals has only been reinforced by recent discoveries in the genetics of the slime mold *Dictyostelium*. Living as individual amoebae in the soil, when faced with a food shortage some 50,000 *Dictyostelium* aggregate into a multicellular fruiting body with differentiated cell tissues, permitting spores to be deployed atop a millimeter-long stalk. The genes governing this transformation have turned out to be ones involved in multicellular construction (such as STATs, PKA and GSK-3). Indeed, as recently noted in the *Proceedings of the National Academy of Sciences*, “the initial aggregation is induced by the pulsatile secretion of a chemoattractant that turned out to be none other than cAMP, one of a few major second messengers in mammalian physiology.”[221]

This line of research further underscores an implication of Conway Morris’ linkage of *Charniodiscus* with *Thaumaptilon* that Jonathan Wells didn’t explore.

Surveying the current array of developmental genes now known to play a role among extant organisms, a common ancestor for the Bilateria could have been a comparatively streamlined model (possessing mesodermal layers along an anterior/posterior axis, with a two-ended gut and a central nervous system).[222] Combining such knowledge with the insights of Conway Morris and other paleontologists, Ruth A. Dewel of the University of Houston contends that most “bilaterian” features were gained in the shift from a colonial animal to a true metazoan. In this schema, *Charniodiscus*, *Yunnanozoon* and *Thaumaptilon* illustrate early splits in the multicellular story (Figure 25).[223]

Any one of these divides could have been explored by antievolutionists, but none have.

Take amoebae taxonomy. They have been difficult to group in part due to their sporadic employment of *mitochondria* as cellular engines.[224] It is well recognized today that biologist Lynn Margulis (once married to archetypal skeptic Carl Sagan, by the way) was correct when she popularized earlier theories that cellular organelles like mitochondria and chloroplasts are the remnants of formerly free-living organisms that were joined in an “endosymbiotic” relationship with nucleated cells. Organisms possessing mitochondria today (including our own Kingdom Animalia) only have them because their Precambrian bacterial ancestors experienced what amounted to a case of endosymbiotic indigestion.[225]

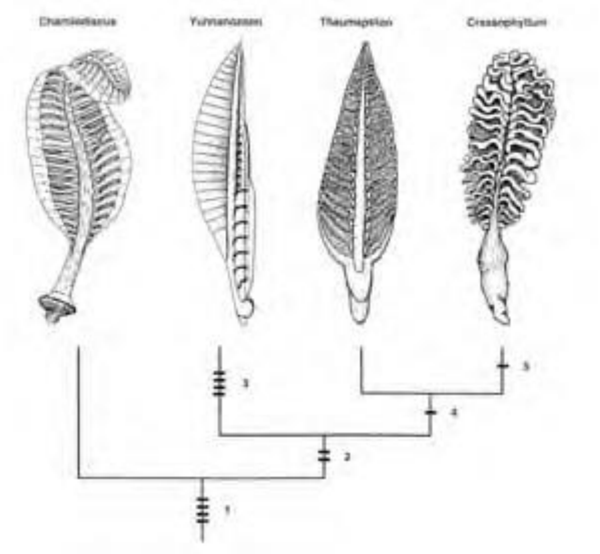


Figure 25. Possible relationship of *Charniodiscus*, the hemichordate *Yunnanozoon* (see note 93), cnidarians *Thaumaptilon* and *Crassophyllum cristatum*. Stem group position (1) represents the split into the frond-like Ediacarans and Subkingdom Eumetazoa (metazoans with tissues differentiated in a system of organs). Node (2) divides into bilaterians (3) and a coelenterate branch (4) into primitive Cambrian and later crown group cnidarians (5). Drawing from Ruth Dewel’s homepage (*www1.appstate.edu/dept/biology/dewelra.htm*).

Comparatively few antievolutionists mention mitochondria at all—but those who do successfully avoid exploring the implications of their endosymbiotic origin (which presupposes common descent at the deepest bacterial level). Examples again span the literature: from overt creationists like the ICR’s legal consultant Wendell Bird twenty years ago, through to the Discovery Institute cadre of Behe, Dembski, Johnson and Wells busily sandbagging the Wedge trenches today.[226]

Or consider what happened with Duane Gish concerning whether arthropods might be related to worms.

Chris McGowan had described at length how the “velvet worms” neatly fitted the bill as intermediates (worm-like internal segmentation and skin cuticle mixed with insect-like appendages and tracheal system). “If an evolutionist had to sit down at the drawing board and invent a hypothetical link between worms and arthropods, he could not do better than draw an onychophoran.” McGowan concluded with this jab: “Dr. Gish overlooks the onychophorans when he tells us that ‘not a single fossil has been found that can be considered to be a transitional form between the major groups, or phyla.’”[227]

Despite this prod from a critic we know he had read, Gish continued to overlook them in the 1995 updated version of his book. Just as *Dickinsonia* or *Spriggina* never made it into Gish’s exposition on the Cambrian Explosion, so the onychophorans were nowhere in evidence when he claimed “The Fossil Record of Insects Offers Remarkable Support for Creation.”[228]

But McGowan’s comment on designing an intermediate was even more ironic, since Gish also failed to mention something else he could have known about. Entomologists William Brown, Edward Wilson, and Frank Carpenter had described the sort of late Mesozoic ancestor they were expecting for wasps and ants. Their model was exactly confirmed in 1966 by the discovery of the

Cretaceous "wasp-ant" *Sphecomyrma*. Apparently when evolutionists successfully defined in advance both the characteristics and time frame for one of those supposedly nonexistent transitional fossils, this was something too inconsequential for Gish to bother his readers with.[229]

And there's more.

At exactly the time that Gish was not exploring the finer points of fossil or living insects, James Marden and Melissa Kramer were experimentally testing the theory that insect flight had developed from mayfly-like ancestors by incremental modification of their larval gills. They learned that even when the wings of stoneflies were physically reduced 75% (to the dimensions of the gill flaps *observed in early fossil insects*) they were nonetheless useful when it came to skating across the surface of ponds to escape predators. And frosting for this evolutionary cake has come from the genetic end: it turns out that the developmental genes *pdm* and *apterous* that guide insect wing formation also happen to be involved in generating the gills of their arthropod cousin, the brine shrimp *Artemia*. Curious, isn't it?[230]

And the genetic connections have continued to build up, such as the differentiating cascade of shared homeobox genes that figure in the development of onychophorans, crustaceans and insects (Figure 26).

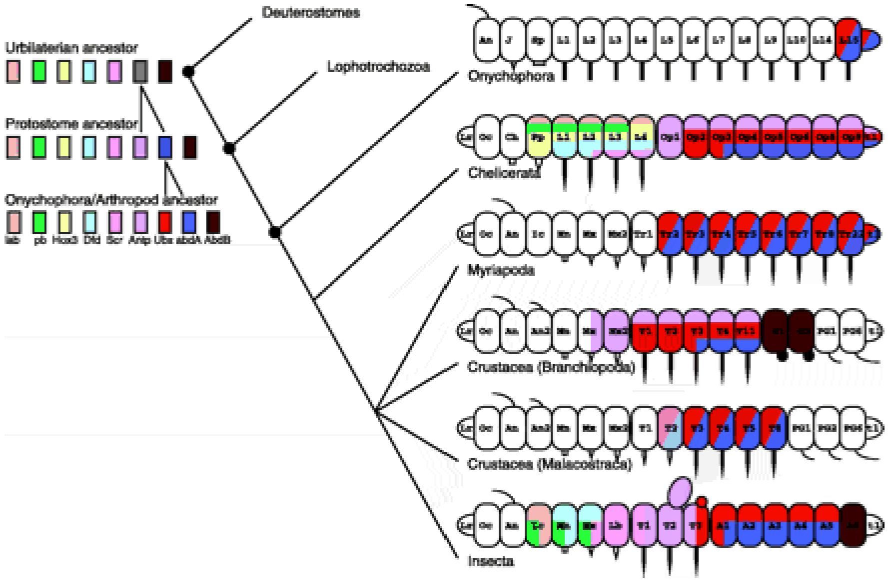


Figure 26. "Evolution of the onychophoran-arthropod clade and *Hox* gene regulation," from Knoll & Carroll (1999, 2134). "The last common ancestor of protostomes and deuterostomes possessed at least seven diverged *Hox* genes. The common ancestor of the protostomes possessed an additional central class gene that gave rise to the *Ubx* and *abdA* genes in the onychophoran-arthropod ancestor. The diversity of this clade has evolved around a conserved set of nine *Hox* genes."

Even a cornucopia of information cannot enter an imagination dedicated to the utilization of sources only as grist for "proof text" reasoning. That's why studying Duane Gish not discussing onychophorans or *Sphecomyrma* or the dynamics of early insect wings is so methodologically informative. Precisely because of his diligence in winnowing through the literature, Gish occasionally bounces over a pothole that knocks open the scholarly hood, permitting us a glimpse at the wheels of the tactical creationist mind at work.

A perfect example is what Gish had to say in 1995 about "The Great Gulf Between Invertebrate and Vertebrate." All you need to know up front are two background details Gish characteristically did not supply. First, geologist Arthur Strahler was drawing on the final leg of Chris McGowan's treatment of the origin of Cambrian metazoans, and the reason Strahler was doing this was to take Gish to task for *not* having discussed *Amphioxus* in the 1985 edition of his book.[231]

Thus all the remarks here about *Amphioxus* and *Pikaia* were added in riposte to Strahler’s unmentioned criticism:

> The idea that the vertebrates were derived from the invertebrates is purely an assumption that cannot be documented from the fossil record. On the basis of comparative anatomy and embryology of living forms, almost every invertebrate group has been proposed at one time or another as the ancestor of the vertebrates. The transition from invertebrate to vertebrate supposedly passed through a simple, chordate state, that is, a creature possessing a rod-like notochord. Does the fossil record provide evidence for such a transition? Not at all.
>
> Ommanney has thus stated:
>
> > How this earliest chordate stock evolved, what stages of development it went through to eventually give rise to truly fishlike creatures, we do not know. Between the Cambrian when it probably originated, and the Ordovician when the first fossils of animals with really fishlike characteristics appeared, there is a gap of perhaps 100 million years which we will probably never be able to fill.
>
> Incredible! One hundred million years of evolution and no fossilized transitional forms! All hypotheses combined, no matter how ingenious, could never pretend, on the basis of evolution theory, to account for a gap of such magnitude. Such facts, on the other hand, are in perfect accord with the predictions of the creation model.
>
> In contrast to the billions times billions of the transitional forms between invertebrates and vertebrates that must have lived and died as some invertebrate evolved into the fishes (believed by evolutionists to constitute the first vertebrates), and in contrast to the untold billions of fossil fishes entombed in rocks, evolutionists can describe only a single fossil chordate, *Pikaia*, which they suggest as being an intermediate. However, we still have chordates with us today. *Amphioxus* is a chordate that is very much a part of the modern world. As one of the defining characteristics, it has a notochord, a stiff, rod-like support above which is a nerve chord and below which is a simple digestive tube. There is no brain or real head in this creature. It has a series of gills that run down along the front of the body. Myotomes, which are a characteristic of chordates, are zig-zag bands of muscles and these extend the entire length of the body. It has a small tail fin and is a capable swimmer. Evolutionary biologists state that *Amphioxus* is a very primitive chordate, and thus must maintain that there has been little, if any, change in chordates since they are believed to have originated in the Cambrian, or even Precambrian “times.” Thus evolutionists would have us believe that while some chordate evolved into a fish, which evolved into birds and mammals, and lower mammals evolved up the ladder to humans, all under compelling changes in the environment, chordates have remained unchanged for at least 600 million years! Evolution is a strange phenomenon, indeed.
>
> Some evolutionists boastfully cite a fossil chordate, *Pikaia*, as an intermediate. One single fossil chordate as their “evidence” for the evolution of invertebrate into vertebrate! But if evolution is true, millions of undoubted intermediates showing the gradual evolution of fishes from its invertebrate ancestor should crowd museum shelves and be on display for any doubters to see. How desperate are evolutionists for the *most pitiful* little evidence they can find to bridge the monumental gap between invertebrates and vertebrates!

> The fossil *Pikaia* is found in the Burgess Shale of Canada. The Burgess Shale, in which is found a vast array of both soft-bodied and skeletonized invertebrates, every one of which occurs in a fully-formed state, and many in an amazing state of preservation, is assigned by evolutionists to the Middle Cambrian. If, as it is now maintained, the entire Cambrian can be compressed into a mere five million years, one can almost forget about "early," "middle," and "late" Cambrian. On an evolutionary time scale and tempo, there would be no essential differences in time between these divisions. It can certainly not be claimed that *Pikaia* is more primitive than *Amphioxus*. It had the notochord, nerve chord, and myotomes characteristic of chordates. Unlike *Amphioxus*, which has no real head, *Pikaia* had a distinct head. It had a caudal fin wrapped around the posterior end of the tail. Some suggest, however, that its breathing and feeding organs appear to be more primitive than those of *Amphioxus*.
>
> Thus, there you have him! A real fossil of a chordate, a possible intermediate between invertebrates and vertebrates. Enough to make any evolutionist swell with pride as he breathes a great sigh of relief! Now he has something to bridge the 100 million year gap (more of less) between invertebrates and fishes. Now he can slap the faces of those silly creationists with *real* evidence. Strahler, who has written a voluminous anti-creationist book, refers to *Pikaia* as "a winning ace"! Incredible! Not only should the fossil record produce billions times billions of fossils of creatures intermediate between invertebrates and vertebrates, but it should also produce a vast number of fossils that reveal the intermediates between the major classes of fishes as they diverged from the ancestral fish. As the next section documents, not one such intermediate has ever been found.[232]

As should by now be seen as a truly monotonous antievolutionary trend, Gish has begun with a chronological muddle. His reference to "the entire Cambrian can be compressed into a mere five million years" involved a bungled reading of work that had only dated the "explosion" part occurring over a few million years or so—not that the entire Cambrian covered that time.[233]

Gish's account had also turned the scholarly sequence of events around, giving the impression Strahler was offering *Pikaia* as an intermediate without reference to *Amphioxus*, thus allowing Gish to invite the animal onstage for his own purposes.

But the fact was that McGowan had put forward *Amphioxus* first as a plausible indicator of what a transitional chordate ought to have looked like. So it was certainly "Incredible!" that Gish thought he could safely leap from his prior position that there were no transitional fossil examples at all, to dismiss the specific one Strahler provided on the grounds it resembled the highly primitive living intermediate too closely!

To accomplish this trick Gish interposed the *ad hoc* condition that there had to be "billions times billions" of transitional forms. This argument slipped on the fact that the half billion years of *Amphioxus* ancestors one might suppose stretched back to the Cambrian were, apart from the Cambrian example itself, documented by no fossil record whatsoever—a point duly noted in Strahler's own account.

The numbers game Gish played with *Pikaia* was one born of desperate necessity, and required selectively bending his own rules. For only a few pages before invoking "billions times billions" of requisite fossils to squash the Cambrian chordates, he had laid down quite different standards: "a single intermediate" could settle the origin of flying insects, while "a few transitional forms" would suffice to establish that birds evolved from reptiles.[234]

Gish could charitably set the bar that low for them because he felt the candidates were lacking—but whenever the luck of the fossil draw changed the situation, either Gish shrank from the task (as with the onychophorans and *Sphecomyrma*) or arbitrarily upped the ante to mandate more.

And what if there should turn out to be *many* fossil intermediates? We'll see how that plays out in the section on the reptile-mammal transition.

Gish also labored a little too hard trying to decapitate poor *Amphioxus* for lacking the “head” that *Pikaia* supposedly had (both forms have swimming flukes at the other end, by the way). *Pikaia* had no more or less of a front end than *Amphioxus*. The modern lancelets have a tentacle-strewn mouth in front—where they are unusual is how the basic notochord runs the full length of their body (unlike the far more advanced vertebrates, where the notochord is a temporary embryonic feature ultimately submerged in the developmental process). Now *Pikaia* does have some pointy protuberances on its “head”—but then, so do onychophorans. As for how the Cambrian model stacks up against the later reflections, Conway Morris noted that, compared to any subsequent member of the Chordata phylum, *Pikaia* was “remarkably primitive.” Whether this paleontological expertise was one “boastfully” flaunted, I shall let the reader work out for themselves.[235]

Objecting to how little *Amphioxus* had “evolved” in the meantime engaged another straw man entirely of Gish’s own contrivance. The macroevolutionary transitions Gish himself noted (fish, birds, and mammals) were actually quite rare events in the history of life, standouts from a record of usually more modest evolutionary change. Horses, for example, took fifty million years to evolve from their smaller ancestors, as long a timeframe as the entire reptile-mammal transition (see Appendix III for the theoretical implications of the horse sequence). There is nothing in evolutionary theory that demands all organisms have to change continuously or necessarily. After all, bacteria and unicellular protoctists are still with us, even if a few of their ancient relatives may have veered off onto novel courses because of such processes as endosymbiosis.[236]

But why explore such wider horizons when it is so much easier to wave obsolete flags like the Ommanney quote? Since a 1964 Time-Life book couldn’t possibly be relevant to a discussion of the fossil origin of vertebrates once *Pikaia* landed on the table in the 1980s, the fact that Gish cited Ommanney at all indicated what a distorted role “scholarship” plays for the defense of creationism.[237]

Gish thus supplied a final irony to McGowan’s remarks about those who fail to appreciate the lessons of living animals, since at so many turns he couldn’t refrain from doing exactly that. By now well out of his depth, Gish didn’t even bother to tackle the conclusion of McGowan’s argument, which went beyond *Amphioxus* to recruit the third member of the Chordata brigade, the tunicates.

> Because it lacks a vertebral column, amphioxus cannot be described as a vertebrate, but it is obviously closely related to vertebrates, having more things in common with them than with any of the invertebrate animals. It is accordingly classified within the same major group as the vertebrates, the Phylum Chordata (meaning having a notochord), along with a number of other animals that have an affinity with the vertebrates.
>
> How should we interpret amphioxus? I regard it as a surviving member of a group of organisms from which the vertebrates evolved. I am not suggesting that amphioxus is the actual ancestor, of course, but only that the vertebrate ancestors were probably similar to amphioxus. Drs. Morris and Gish both discuss the transition from invertebrates to vertebrates, but they are both so concerned with demonstrating the absence of fossil forms that they have nothing to say about living animals. Perhaps they would dismiss amphioxus as being merely an unusual vertebrate and thus maintain that we still had not found a bridge across the invertebrate-vertebrate gap. Aside from the fact that it is *not* a vertebrate as it lacks a vertebral column, this is a reasonable argument in itself, except that amphioxus is not the only primitive chordate animal.
>
> Sea squirts look nothing at all like vertebrates, not even to the most imaginative mind. They are sac-like creatures often about the size of one’s thumb, and if you squeeze them you can squirt the water from their two spouts. You can often spot them at low tide, attached to rocks. Many of them look so uninteresting that they would easily be overlooked, but others, mostly the ones living together as colonies, are brightly colored and look most intriguing. They

are filter feeders, like amphioxus, and the bulk of their structure comprises an elongate bag, the pharynx, which is perforated by numerous slits. These are called gill slits, but it requires some stretch of the imagination to compare them with the gill slits of a fish. Have they got any convincing chordate features at all? None. Here we have a regular-looking invertebrate. However, the larva of the sea squirt looks just like a small tadpole, and possesses most of the features that we saw in amphioxus: a notochord, a hollow dorsal nerve chord, and a pharynx, usually with one pair of gill slits. Here is persuasive evidence for the invertebrate-vertebrate connection.

After several days of free swimming, the tadpole settles on the bottom and changes into a sea squirt, never to roam again. There is nothing unusual about this alternation between a free-swimming larva and a sedentary adult phase; the same happens in other organisms. The barnacle, for example, spends its adult life clamped to rocks along the seashore, but its larva is a small, shrimp-like creature which spends its time drifting along with the rest of the plankton in the upper layers of the sea. In fact, a large percentage of planktonic animals are the larvae of more sedentary parents, and the purpose they serve is dispersal.

We are used to seeing a close resemblance between young and adult individuals; small children, kittens, and puppies look like scaled-down versions of their parents, but this is often not the case among invertebrate animals. Butterflies no more look like caterpillars than barnacles look like their shrimpy larvae. If some relatively small changes occurred during development to prevent a larva from developing into the adult form, a major evolutionary change would be effected. We can imagine that such a change may have led to the origin of the first chordates, and if this seems to be stretching credibility, consider the alternation in body form that we see within the coelenterates.

The coelenterates have always been one of my favorite groups of invertebrate animals, mainly because they look so attractive. What could be more beautiful than a brilliantly colored anemone, tentacles surging with the tide, or a jellyfish, its transparent bell pulsating rhythmically, or a coral at the edge of a reef. There would seem a world of difference between a jellyfish and a coral, but the connection between them is clearly shown by their life histories. One of the types of coelenterates which we have not mentioned is the hydroid. Many of these look like small plants, and they are often misidentified as such when students first see them. They are usually found growing on seaweed, and when viewed under a microscope they are seen to comprise a number of tentacled structures which look like flowers. These are the polyps, or hydranths, and serve to gather food. Sometimes a second type of structure can be seen which bears small buds. These eventually become small jellyfish, called medusoids, which break free and swim off. Some of the medusoids are female and bear eggs; others, the males, shed sperm into the sea. The fertilized egg develops into a ciliated larva which, after a brief period of free swimming, settles on the bottom and develops into a new colony of polyps. There is therefore an alternation between the polyp phase and the medusoid phase.

In the jellyfishes proper the medusoid phase is the predominant one, and the polyp phase occupies but a relatively short part of the life cycle, serving only to bud off medusoids. Somewhat the reverse is true for the anemones, which have only a polyp phase, and no medusoid phase at all. Corals, which are essentially anemones that secrete a hard skeleton around themselves, similarly lack the medusoid phase. Which came first, jellyfish or anemones? For our purposes the answer is not important. What is important is that these two types of animals are interconnected—through the hydroid phase—and either one could have evolved from the other by a modification in the life cycle.

> This brief survey of living organisms has shown that the creationists are wrong when they say that there are no connections between the major groups of organisms. We have not been able to document connections between *all* major groups, but this is partly because they are not all interrelated. To put this another way, it is likely that multicellular organisms evolved more than once, and that some groups, for example the sponges, are probably side branches that did not lead anywhere.
>
> The fact that we cannot draw a firm line between plants and animals, or between unicellular organisms and multicellular ones, is difficult to reconcile with the creation model. Taken with the evidence for a link between the two major invertebrate groups (insects and worms), a link that is also documented by fossils, and between invertebrates and vertebrates, we have an overwhelming case for evolution. And we have not yet finished, for we have still to consider the fossil record.[238]

Take those tunicate larvae. The idea that modern chordates might have retained some of the characteristics of their juvenile state illustrates the developmental concept of *neoteny*. This “Peter Pan Syndrome” (as Linda Gamlin and Gail Vines put it) persists as a most evident trait in living salamanders:

> Like other amphibians, many salamanders have an aquatic larval stage. In some groups, however, development stops there and the adult stage fails to materialize. Instead the larva develops sexual organs and is able to breed. This phenomenon, known as pedomorphosis, is seen in the Mexican axolotl, which is sometimes kept as a pet. It grows up to 30cm long, and has small, weak limbs, but retains the larva’s tail-fin and external gills.
>
> Many other species of salamander share this trait, but to different degrees, and a small environmental change may determine whether the salamander develops into the adult form or not. Some that never become adults can be induced to do so by feeding them thyroid gland from a calf, which contains the hormone thyroxine. The fact that a mammalian hormone has such a specific effect on an amphibian points to the common evolutionary origin of all land vertebrates.[239]

But the process isn’t restricted to salamanders. There is a developmental argument that at least some of our human characteristics stem from our being an excessively neotenic ape.[240]

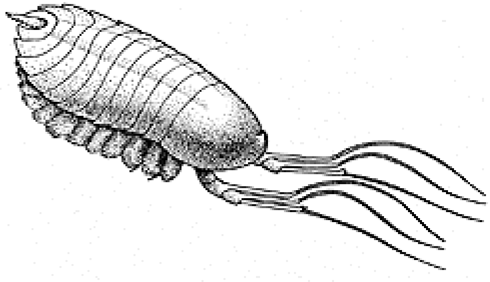
Homeobox genes, cell cleavage patterns, colonial multicellular aggregation, tunicate developmental biology—all these are highly relevant data to bring into the discussion of the origin of modern metazoan body plans. Yet *none* of this information has appeared in the antievolutionary literature. The closest biologist Jonathan Wells got to tunicates, for example, was to briefly list them among his “major phyla” as parenthetical members of the Chordata. He did not describe anything about them.[241]

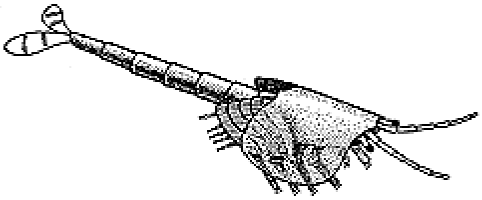
All of which begs some astonishingly obvious questions.

Never mind what evolutionists make of these subjects. How would these data fit into an antievolutionary framework that rejects common descent in favor of created “kinds” or “types”? Is a sea squirt the same “type” as its Chordata cousins? If so, then the origination of the Chordata phylum back in the Cambrian would obviously not have precluded an enormous amount of natural evolution since. But if a tunicate is *not* the same “type” as *Pikaia* (or *H. sapiens* half a billion years later) then whatever does this mean for the antievolutionary conception of what was going on?

It should make no theoretical difference to a creationist what “phylum” any of these Cambrian organisms were classed as, for their core concern could only be whether something like the abundant *Marrella* was a one-off “kind” or “type.” Likewise for all those forms that resembled *Alalcomenaeus*, such as *Actaeus*, *Emeraldella, Molaria*, and *Sidneyia*. Would a design framework accept or reject the view of the Smithsonian that *Leanchoilia* (Figure 27) was a spider-like form closely related to the chelicerates? Or that *Waptia* (Figure 28) was indeed of the crustacean "type"?[242]

We don't have answers to any of these questions, and for precisely the same reason that we don't know how old Richard Milton thinks the world is. Antievolutionists who wag fingers at the Cambrian Explosion don't merely fail to investigate its geological context. Or probe the relevant information on developmental biology and the latest findings in homeobox genes. They also fail to conceptualize their own position on the critical side of rigorous taxonomy, so that the issue of what constitutes a created "type" simply never comes up (see Appendix III).





Top **Figure 27.** *Leanchoilia superlata* (length ~2 inches). Drawing by Marianne Collins from the Smithsonian's website (*nmnh.si.edu/paleo/shale/pleancho.htm*). Cf. the dual depiction by Collins in Gould (1989, 185) showing the frontal appendages folded back for swimming (as *Leanchoilia* was apparently blind, these presumably served as a primary sensor).

Bottom **Figure 28.** The Cambrian crustacean *Waptia fieldensis* (length ~3 inches) from the Smithsonian's website (*nmnh.si.edu/paleo/shale/pwap.htm*). Although it appeared capable of swimming, the Smithsonian commentary notes its "weak jaw appendages" probably restricted it to a sediment sifting lifestyle. That bottom habitat would help explain its fairly abundant representation in the Burgess Shale.

In this respect the Cambrian Explosion as represented in *Darwin on Trial* was all too typical. Instead of working out where he stood on typology, Johnson's account was littered with turns of phrases that might well read nicely, but failed miserably to clarify (let alone advance) his own position. For example, whatever did Johnson mean by those "many other species that fit within an existing phylum but still manifest different body plans from anything known to exist later"? A phylum *is* a body plan, so how can something with the same "body plan" simultaneously have a different one?

Even stranger was Johnson's remark that, "If the disconcerting facts were not already known, any Darwinist would be confident that the hundreds of millions of years of post-Cambrian evolution would have produced many new phyla." As he didn't cite any Darwinists proposing such a thing, this notion could hardly be a statement of fundamental evolutionary principle.

Indeed, the idea that phyletic disparity could emerge from derived members of an existing phylum runs squarely up against the thrust of how phyla are identified in the first place. Take our own Chordata. Could it even be possible for a chordate to "evolve" in such a way that it would cease to be classified as one? Defining characters of that phylum include a *nerve cord* along a stiffening *notochord*, which means a descendant could only slip free of the distinction by *losing* what would seem rather indispensable features. So long as that notochord setup was retained, however varied its external appearance may become (whether sea squirt or Berkeley lawyer), the organism in question would *always* be pegged as a “chordate.”

This doesn’t mean that an enormous amount of change can’t occur within a phyletic framework. Brian Hall has called attention to the outmoded biological view that “the kinds of developmental differences that distinguish phyla and classes should differ qualitatively from the differences that distinguish species and genera.” Hall noted this was belied by empirical observation, such as the considerable developmental variations that had appeared in the sea urchin genus *Heliocidaris* over the last 10 to 12 million years. Although operating at only the genus level, the urchin’s changes were nonetheless “comparable to those that distinguish classes and phyla: determinate *vs.* indeterminate cell divisions, mode of gastrulation, and cell cleavage pattern.”[243]

Much the same situation applies to the trilobites. As observed in a recent textbook on invertebrate paleontology: “Trilobites are variously considered to be a phylum of the animal kingdom in their own right, albeit forming part of a larger group of arthropods, or as a subphylum of the Arthropoda. In both cases, the trilobites are gathered into a single class, subdivided at the order level. Classification is based largely upon shell morphology.”[244]

Such ambiguity is of course based on the fact that we don’t have living trilobites to better calibrate their phylogenic status. But enough is known to group them with spiders, crabs, and insects in the Arthropoda phylum because of shared external characteristics like segmented bodies and overt indicators of embryonic development represented by their prolifically shed carapaces.[245]

Such a broad umbrella might make the unwary forget just how distinctive each are in their own right, differing even to the number and character of their appendages. Which prompted this comment from Niles Eldredge invoking his specialty to criticize creationism: “Trilobites are as diverse and prolific as the mammals, and examples of evolutionary change are as compelling examples of evolution as any of which I am aware. Airily dismissing 350 million years of trilobite evolution as variation within a basic kind is actually admitting that evolution, substantial evolution, has occurred.”[246]

Compare all this to the studied vagueness of Johnson’s assertion that only “evolution of a sort” has taken place “within the confines of basic categories which themselves show no previous evolutionary history.” Did his discussion of the Cambrian mean that Johnson thinks phyla are such categories, within which only “evolution of a sort” happens?

If so, then he has just conceded the substantial changes among sea urchins, trilobites—or *Pikaia* to *H. sapiens*.

But as we’ll see in the sections on birds and mammals, where branches of the reptile class spawned the mammal and bird classes, that is precisely the magnitude of “change” that Phillip Johnson will *not* accept.

So which is it? Is modification within a phyletic “basic category” trivial or not?[247]

Even more importantly, is the pattern of life (fossil and living) even remotely compatible with the exigencies of a design option?

The sort of “chordates” that show up in the Cambrian were about the most primitive example of that phylum imaginable (resembling lamprey larvae and basal forms like *Amphioxus*). Had a putative Intelligent Designer selected a well-developed vertebrate member of the chordates for this debut instead—say, a sperm whale—its presence in the Cambrian would have given evolutionists severe migraines. That’s because evolutionary theory is not infinitely elastic. The same sort of inferential logic that puts constraints on the appearance of complex metazoans in the Precambrian based on the absence of trace fossils applies across the board. As whales betray their terrestrial origin in their anatomy, and because evolution works by natural modification of existing forms, putting a whale in the Cambrian would have pulled all their documented ancestry with them.[248]

But all this is only how the physical evidence has been negatively related to evolutionary theory. If design theories are to be taken seriously, shouldn’t the evidence also be positively related to their own theoretical concerns? There we have hit perhaps the largest snag in creationist epistemology. For antievolutionists don’t like thinking about such questions.

Once again Phillip Johnson’s rhetorical style comes through to illustrate the scale of the problem.

In his 1995 book *Reason in the Balance*, Johnson compressed his *Darwin on Trial* account into a comment that the Cambrian animals were “all complex multicellular organisms, with highly complex adaptations like the famous trilobite eyes. Where did these complex features come from? Before the Cambrian era, with a few exceptions, we have evidence of nothing but simple, unicellular life.”[249]

Besides the ease with which he crumpled tens of millions of years of Ediacaran diploblasts and triploblasts into “a few exceptions,” there remained the matter of *what* made those trilobite eyes so “famous” and whether their complexity posed some real challenge for evolution. Was this just “common knowledge”—something apart from genuine esoterica, like the street layout of Pompeii or the spin properties of neutrinos—so no explanatory references were warranted?

Discussions of this hobbyhorse are actually not all that common even in the creationist canon, raising questions as to how Johnson came by it. But one recent foray occurred in Scott Huse’s *The Collapse of Evolution*, abstracted and embellished from the account Duane Gish gave in his children’s book, *The Amazing Story of Creation from science and the Bible*. For Huse, the “famous” aspect of trilobite vision concerns the lenses arranged around their compound eyes:

> Although extinct now, the trilobite nevertheless speaks to us today concerning ingenious design and purposiveness in nature. Unlike the lens of a human eye, which is composed of living, organic tissues, trilobite eyes were composed of inorganic calcite. Consequently, many trilobite lenses have been preserved in the fossil record allowing paleontologists to study them. What they have discovered is truly impressive.
>
> Unlike human eyes which are composed of a single lens, trilobite eyes have a very special double lens design with anywhere from 100 to 15,000 lenses in each eye, depending on the subspecies. This special design allowed the trilobites to see underwater perfectly, without distortion. Implicit knowledge of Abbe's Sine Law, Fermat's Principle, and various other principles of optics are inherent in the design of these lenses. They appear to have been carefully designed by a very knowledgeable physicist. And indeed, the creationist would agree—they were.[250]

Huse should have shown some reluctance before attributing trilobite vision to the perfect divine hand.

Trilobites did indeed possess compound eyes with lenses composed of pure calcite—a novelty compared to their close evolutionary arthropod cousins, the insects, which use calcite and softer unmineralized cuticle. Unfortunately for the creationist argument, calcite crystal lenses also promote *double vision*, a “design defect” which later trilobites found a variety of ways to compensate for. Most of the solutions involved clustering the lenses in tight packs perpendicular to the eye’s surface, thus minimizing the inherent distortion. But it was only *after* the Cambrian, and thus tens of millions of years beyond their initial appearance, that those “famous” double-lensed schizochroal eyes appeared in *one* of the four major trilobite orders, Phacopida.[251]

Now consider the theoretical alternatives here.

The evolutionary option: the incorporation of magnesium atoms in the lower lenses resolved the phacopids’ long-standing vision problem by correcting the spherical aberration, and selection pressure guaranteed its spread—though *only* among those trilobites physically descended from them in that particular order.

Or the creationist view: it was divine design, end of analysis.

In asking where trilobite eyes “come from” Phillip Johnson delved no deeper than Gish/Huse did. All acted as though the design option was the obvious default, without ever defining what level of evidence would indicate trilobite vision had *not* been designed.[252]

As for working out the details, all the heavy lifting has to be done by the evolutionists, who are required to work out every jot and tittle of the process on their own.

A lot of work has already been done on the evolution of vision, but applying it to trilobite eyes is hardly easy. As the last trilobites trod the seafloor a quarter of a billion years ago, there are no living ones to examine. The odds of discovering the exact transitional species for particular innovations among fossil trilobites are remote—but even if they had been preserved this would not immediately resolve how their genetics and biology may have facilitated adaptations as the presence of magnesium atoms in their eyes. Without access to a time machine the only way in theory to *explicitly* account for trilobite eyes would be to somehow retrocalculate their ancestral genome, then model the results either by supercomputer simulation or cobble up copies through advanced genetic engineering. At the moment that’s a “Jurassic Park” fantasy ride.[253]

In the near term science is stuck with the painstaking study of existing visual systems and trying to work out the underlying processes from there. Study of the fruit fly’s chromosomes has revealed a few of the pertinent developmental genes (such as the insect *eyeless* and its assorted homologues). Shared sequences have been found relating to light sensation (*Small eyes* in mice, *Aniridia* in humans, and *Pax-6* in squid and flatworms) that guide the embryology that eventually manifests as their respective eyes. Indeed, *Pax 6* is so strikingly conserved and powerful a component that ectopic eyes can be generated on the bodies of fruit flies and frogs even when the gene used to do it is drawn from the other phylum.[254]

But these are by no means the blueprints for “eyes”—rather they are the upper level “master gene” switching mechanisms that appear to guide the expression of the as yet largely unknown concatenation of coding for the eyes themselves. It will take a lot more fundamental research like this before anyone should start looking for news bulletins on the origin of trilobite eyes.

Beyond these technical issues, though, lie some profound philosophical questions that emerge when the inference engine is directed at the proposition that a particular biological system is an object of Intelligent Design.

What does the trilobite eye example say about the quality or ingenuity of an engineer who began by introducing an inferior system, then spent millions of years trying out partial fixes before finally hitting on the “famous” remedy? Because the non-phacopids operated with the less famous vision for their remaining 200 Ma on earth, would this not suggest a designer curiously disposed to following evolutionary doctrine when it came to disseminating genetic novelty? What other reason could there have been for excluding the non-phacopids from this, especially since doing so only upheld the evolutionary view? And what about the family of Ordovician trinucleid trilobites that dispensed with eyes altogether?[255]

Some design advocates dismiss such questions as trying to “second guess” God’s intent, as Stephen Meyer put it to me at the Whitworth “Creation Week.”[256] But why would such an approach be *philosophically* illegitimate? As Philip Kitcher noted of the 17th century mathematician Leibniz: “For Leibniz, to invoke ‘design’ without saying what counts as good design is not only vacuous but blasphemous.”[257]

William Dembski acknowledged the philosophy of this point in 2001 by agreeing that questions about the morality, beauty, and intention of a designed object (along with the designer’s identity) “arise very quickly once design is back on the table for serious discussion.”[258]

So unless divine engineering is to be held to a *lower* standard than human contrivance (a novel position for those endeared to transcendental ethics) such potentially embarrassing judgmental inferences come with the territory.

Episode Two

Feathers

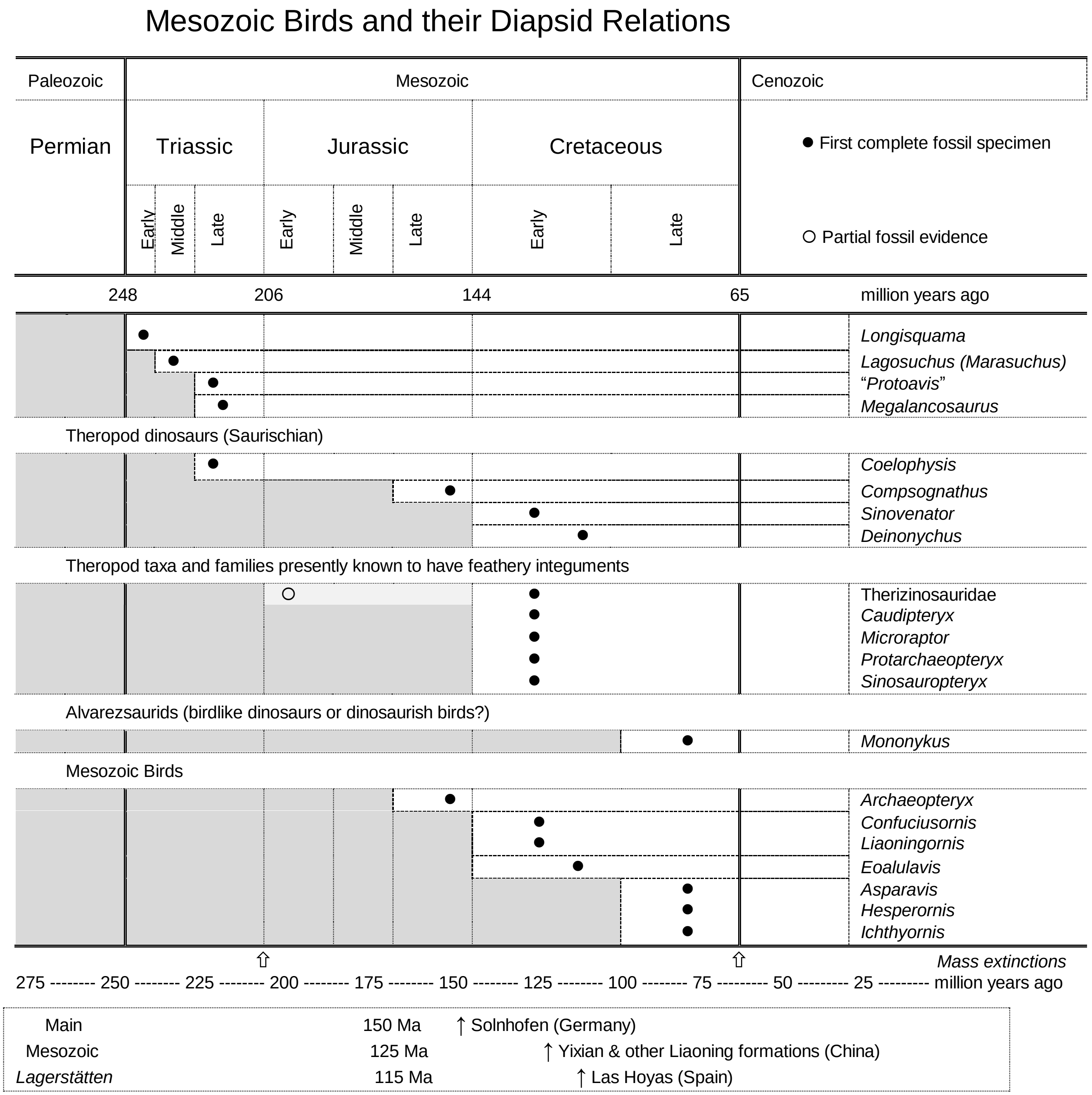


Figure 29. Main period and taxonomical dating from *dinosauricon.com*.

Chapter 4. Archaeopteryx

Going by the fossil snapshots of the Burgess Shale and Chengjiang, early chordates and craniates like *Pikaia* and *Haikouella* were peripheral figures in the Cambrian landscape, flitting among the plethora of arthropods and reef invertebrates. But half a billion years of climate change and descent with modification filled the seas with fish, and brought tetrapods onto the land, first as amphibians and eventually as reptiles. Such diversification shifts the parameters of the fossil inference game when it comes to Chordates.

The rarity of the conditions required for *Lagerstätten* (underwater landslides that bury fauna *en masse*, or anoxic lakes that minimize the decay of whatever sinks to the bottom) are less critical when it comes to preserving vertebrate bones or teeth. And unlike invertebrates like molluscs, whose hardy external casings tell precious little about what's going on inside the shell, vertebrates hang their inner parts from their highly visible (and diagnostically distinctive) skeletons. Because skeletons don't fit together willy-nilly, finding the right piece of a shoulder blade can tell a lot about the unpreserved parts that were once attached to it. This includes how the muscles were laid out, because vertebrate muscles happen to leave identifiable striations in the bones they are connected to.

All these differences in structural anatomy mean that the mundane operation of sedimentation is often sufficient to preserve forensically revealing fragments of Deep Time: from the occasional river flood drowning migrating herds to the gentle silting over of stray carcasses (such as the *Iguanodon* taphonomy that so eluded Richard Milton).

Post-Cambrian vertebrate evolution has obviously brought many more taxa on the fossil scene, along with a correspondingly enlarged body of paleontological literature pertaining to them. Whatever macroevolutionary tale they might have to tell would depend critically on the extent to which that information was recognized.

But remember the lessons of Milton and the Gablers, who put themselves at the mercy of their secondary redactors by not looking things up on their own. Without independent investigation, how ever would a reader be able to judge the confident certainty of statements like this from Duane Gish's 1993 book *Creation Scientists Answer Their Critics*:

> Evolutionists have employed clever tactics in their debates with creationists, both on platforms before live audiences and in their anti-creationist publications. In public debates, they rarely respond to the creationists' challenges concerning the immense gaps between microorganisms and complex invertebrates and between complex invertebrates and fishes, and, as mentioned above, in their publications, they either simply ignore these problems or offer stories which even they must realize lack credibility. Rather, they spend much time discussing a few disreputable claims concerning the existence of alleged transitional forms. These claims most often center around *Archaeopteryx*, a bird which, many evolutionists maintain, gives some indications of being intermediate between reptiles and birds; the so-called "mammal-like reptiles," supposedly showing a transition between reptiles and mammals; a few alleged intermediates between ape and man, such as *Australopithecus* and *Homo erectus*; and much less often, fossil horses.[259]

Gish's first two examples are of considerable interest to our topic, since they represent blatant instances of macroevolution—and slow ones at that. While the transition from australopithecine to Henry Morris is a blip of only three or four million years, the appearances of birds and mammals were far more leisurely. It took scores of millions of years for branches of the early reptilian amniotes to develop so far that they might be recognized as those new classes.

Moreover, as both birds and mammals are warm-blooded, to concede that either of them could be traced back into cold-blooded reptilian ancestors exceeds the load limit of creationism's microevolutionary box. Consequently whatever data might suggest such a biological connection must be either overlooked or suppressed.

This has been true from the start.

Progressive creationist Richard Owen proposed an unworkable theory of independent Archetypes rather than naturally evolving species related through common descent, as proposed by his contemporary, Darwin.[260] When the first specimens of *Archaeopteryx* (Figure 30) came to light in the early 1860s they straddled the boundary between any putative reptile and bird Archetypes. But Owen simply couldn't see it. He had no trouble spotting every avian feature in *Archaeopteryx,* but never compared the anatomy to any fossil reptile. His arch rival Thomas Huxley upheld his reputation as "Darwin's bulldog" by not merely redressing that oversight (catching Owen out on a "horrifying series of errors," as Pat Shipman recently put it)—but also directly relating *Archaeopteryx* to the Dinosauria, a group Owen had originally named.[261]

Creationists and their evolutionist critics have been reprising Owen *v.* Huxley ever since.

What emerges from this tale is the realization that *Archaeopteryx* is an exemplar for how antievolutionists approach the methodological issue of whether it is possible to identify a transitional form. Once people are able to convince themselves that a "reptilian bird" isn't *really* a "reptilian bird," the antievolutionary intellect appears permanently inoculated against the acceptance of any intermediate example. Tossing aside the far larger collection of transitional "mammal-like reptiles" (our third macroevolutionary episode) becomes then merely a matter of enthusiasm, not philosophy.

Figure 30. The third "Berlin" specimen of *Archaeopteryx lithographica*, *rainbow.1deo.columbia.edu.courses/v1001/soln15.html*. Noted for its especially fine feather impressions, the species designation reflects how the smoothly grained limestone matrix readily splits into thin slabs, highly suitable for lithographic printing plates.

Since most everybody on either side of the creation/evolution debate makes a point of saying something about *Archaeopteryx,* though, there is ample verbiage to draw on in documenting this phenomenon.

Gary Parker’s 1987 contribution to *What Is Creation Science?* has the advantage of being both typical and brief. Not only did he quickly highlight everything creationists consider important about the origin of birds, he also obligingly lunged into deep scholarly quicksand. The result is a creationist puzzle portrait of *Archaeopteryx* submitted, with complete sincerity, in spite of having half the pieces missing:

> *Archaeopteryx* is **the** showcase for evolution. There is one really photogenic specimen, the Berlin specimen, which is pictured in essentially all biology books. That specimen, along with a reconstruction in the same position, is shown in Fig. 25.
>
> At first, you may wonder what the fuss is all about. It has feathers, wings, and a beak, so it’s a bird. But look closer. It has teeth in the bill, claws on the wings, no breast bone with a keel, an unfused backbone, and a long, bony tail. These are all characteristics we normally associate with reptiles. What’s more, the existence of a creature like *Archaeopteryx* was predicted by evolutionists before any such specimen was found. What’s a creationist going to say to a “perfect example of evolution” like *Archaeopteryx*?
>
> Well, first of all, the reptile-like features are not really so reptile-like as you might suppose. The familiar ostrich, for example, has claws on its wings that are even more “reptile-like” than those of *Archaeopteryx*. Several birds, such as the hoatzin, don’t have much of a keel. No living birds have socketed teeth, but some fossil birds did. Besides, some reptiles have teeth and some don’t, so presence or absence of teeth is not particularly important in distinguishing the two groups.
>
> More importantly, take a look at the individual features of *Archaeopteryx*. Is there any clue as to *how* legs evolved into wings? No, none at all. When we find wings as fossils, we find completely developed, fully functional wings. That’s true of *Archaeopteryx*, and it’s also true of the flying insects and the flying mammals (bats).
>
> Is there any clue in *Archaeopteryx* as to *how* the reptilian scales evolved into feathers? No, none at all. When we find feathers as fossils, we find fully developed and functional feathers. Feathers are quite complex structures, with little hooks and eyelets for zippering and unzippering them. *Archaeopteryx* not only had complete and complex feathers, but feathers of several different types. As a matter of fact, it had the asymmetric feather characteristic of strong flyers.
>
> What about a lack of a keel? Actually, muscles for the power stroke in flight attach to the wishbone or furcula, and *Archaeopteryx* had “an extremely robust furcula.” As a matter of fact, a growing number of evolutionists, perhaps a consensus, now believe that *Archaeopteryx* was a strong flyer. Many now consider *Archaeopteryx* the first bird, and not a missing link between reptiles and birds (See Denton, 1985).
>
> Actually, the final piece in the *Archaeopteryx* puzzle (for the time being, anyway) has been put into place with the discovery in Texas of a quarry full of bird bones (“protoavis”), entombed in rock layers “deeper” than those which contain *Archaeopteryx* remains (Beardsley, 1986). What does that mean? It simply means that the *Archaeopteryx* specimens we have cannot have been the ancestors of birds, because birds already existed.
>
> Creationists, by the way, are not forced to decide whether *Archaeopteryx* was a bird or a reptile. Creationists believe that many separate and distinct types were created. Because of its unique combination of *complete, functionally integrated traits, Archaeopteryx* would qualify as a created type (unless it turns

> out to be a hoax, as Sir Fred Hoyle has been claiming!). For creationists, it's the created type that is the real unit in nature. The higher categories are products of human thought, and difficulties with fitting organisms into these human categories represent only problems with human imagination, not with the reality of created types.[262]

Parker started off by not following his own advice.

Far from treating *Archaeopteryx* as a complete, integrated package of traits, and grounding the animal firmly in the context of what lived before and after, Parker dismembered it like a holiday turkey and proceeded to wave its isolated features around the room, daring evolutionists to make sense of them.[263]

Of course *Archaeopteryx*'s wing can't tell you much by itself how it's own structure or feathers evolved. You'd need its immediate ancestors' developing wings to do that, and Parker was quick to affirm those were not available. But did Parker indicate whether there might be a really good geological explanation for why that was the case? "No. None at all."

So here is the first of Parker's missing puzzle pieces: the paleontological background for *Archaeopteryx*. Given what we saw in Chapter Two, it's not a completely unfamiliar tale. But as far as creationism is concerned, evidently it is one that has to be continuously retold.

Back in the Jurassic period, 150 million years ago, "Europe" consisted of a series of islands dotting the giant Tethys Sea that stretched between Africa and what then existed of Asia (the subcontinental raft of India was still parked down by Madagascar in the Southern Hemisphere). Eventually a chunk of one of those Tethyan islands ended up folded in a corner of Bavaria, providing one more *Lagerstätte* snapshot, the Solnhofen, in which the only known fossils of archaeopterygids are to be found.[264]

There are to date, exactly seven—plus one feather impression.

Now while Kent Hovind actually thinks there were just seven *Archaeopteryxes* alive in all pre-Flood history, most other creationists (YEC or OEC) have yet to venture an opinion here. But evolutionists would rate the idea as highly unlikely. Even though no fossils exist to prove it, they infer these early birds had parents—and string enough of those together, pretty soon you have ancestors. Naturally evolutionists expect that ancestral chain to have looked even *more* unlike later birds, and more like a linking reptile, than the archaeopterygids did. The problem with settling this side of the equation is that the odds of encountering their fossils are incredibly remote, since there are no other suitable *Lagerstätten* in the preceding Jurassic (or Triassic, for that matter). Add to that, small flyers are among the worst candidates for successful preservation in any event—as the sketchy fossil record for birds and bats confirms.[265]

But let's suppose luck was with the paleontologist, and some of the revealing evolutionary ancestors of *Archaeopteryx* successfully entered the fossil record. How likely would it be for them to make it all the way into a museum display case?

Like everything else, islands are subject to erosion, and the subsequent geologic history of the region hasn't helped there. When the African plate plowed into Europe tens of millions of years later, masses of real estate were mangled into the new Alps—resting as it does on the African plate, geologically speaking, Italy is not actually a part of Europe. The result of this collision was a lot of obliterated landscape.

Then consider the scouring action of several ice ages. Just think of all the debris that had to be removed from the sides to leave the distinctive Matterhorn sticking up afterward.

Even should the evidence have made it that far, there was still the lamentable likelihood of slightly-missed timing, with the vital clue eroding from some hillside centuries ago, to dissolve unnoticed into dust long before the 1860s, when living paleontologists began poking around the Solnhofen.

These are simply the bald facts of geology.

Yet of all those antievolutionary authors I have examined who have ventured opinions on *Archaeopteryx*, not one ever thought to examine the geological context of the Solnhofen. That includes the various ICR efforts by Henry and John Morris, Gary Parker and Duane Gish, along with orbiting YEC authors Ankerberg and Weldon, Wendell Bird, Davis and Kenyon, Hank

Hanegraaff, Scott Huse and Luther Sunderland. Likewise for Michael Denton, Alan Hayward, Cornelius Hunter, Phillip Johnson and Richard Milton, variously circulating around the conventional geological framework.[266]

Jonathan Wells continued this tradition by highlighting exactly the feature of the Solnhofen that precluded the preservation of earlier fossils, yet never made the connection:

> The Solnhofen limestone, in which all eight specimens of *Archaeopteryx* were discovered, is from the geological period known as the Upper (or Late) Jurassic, about 150 million years ago. This makes *Archaeopteryx* the earliest known bird—or at least, the earliest undisputed bird. Several specimens of it—especially the Berlin specimen—are also among the most beautiful fossils ever found. The Solnhofen limestone is so fine-grained that it is quarried for use in the printing process known as lithography, and it preserved *Archaeopteryx* in exquisite detail—right down to the structure of its feathers.[267]

The absence of such considerations as geological context from the antievolutionary canon inevitably colors the perceptions of the new cadre of Intelligent Design activists who draw on their work.

A case in point is Jonathan Wells' defender Casey Luskin, of the "Intelligent Design and Evolution Awareness (IDEA) Club" which started up at the University of California (San Diego) following a 1999 speech by Phillip Johnson. Luskin came to my attention because of a response he had written with another IDEA member, Nathan Gapper, to a speech by Eugenie Scott of the National Center for Science Education criticizing Wells' *Icons of Evolution*.[268]

Late in 2001 I emailed a variety of questions to Luskin, to explore how he had approached these issues methodologically.

Concerning Wells' *Archaeopteryx* claims, I specifically asked whether Luskin knew of anything "distinctive" about the Solnhofen that might bear on the issue of fossil preservation. Luskin accurately reflected the vacuum handed him by Wells by not recognizing its *Lagerstätte* character. When I later explained what that was, his comment was cheery and astonishing: "I am a geologist (I just finished my masters over the summer), and I find fossils, etc. quite interesting! I must admit I'd never heard the term Lagerstatten (or if I had, I'd forgotten it), so thanks for enlarging my vocabulary."

But enlarging one's vocabulary is a moot concern if it doesn't translate into an improved understanding of the nature of the paleontological problem.

Because of the vagaries of fossil preservation, *Archaeopteryx* is likely to remain an isolated example in the Jurassic landscape, and hence a forensic bottleneck. *Archaeopteryx* could have been very typical of what was going on in the Late Jurassic—or very unusual. But while there is simply no way to know how precisely diverse its family was, there is at least one measure of how generally diverse it probably *wasn't*.

Just like those trace fossils in the Precambrian, isolated feathers are more likely to be shed, and perhaps sporadically preserved, the more feathered animals there were (whether birds or their potential non-bird relations). Gregory Paul has noted that stray feathers do indeed show up in the following Cretaceous Period, and that this is a circumstantial clue that neither birds nor protoavians were particularly abundant prior to *Archaeopteryx*.[269]

As the earliest *preserved* bird, *Archaeopteryx* does tell us something relevant to the story. And it was something that Gary Parker didn't want to accept in his version. As far as he was concerned, *Archaeopteryx* was not merely a bird. It was a typologically conventional one. But in drawing on Michael Denton as the authority on the flight characteristics of *Archaeopteryx*, Parker slipped over into Miltonian scholarship. Although Parker hadn't bothered with any specific page numbers, he was correct on two points: Denton had discussed *Archaeopteryx*, which did have a large furcula.

From there it was downhill.

Denton cited one reference to affirm that *Archaeopteryx* was “capable of powered flight as a modern bird.” But being *capable* of flight specified nothing about how that ranked with hawks or hummingbirds. Nor had Denton quoted *any* contemporary scientists who doubted *Archaeopteryx* was a link between reptiles and birds, let alone that “many” did so. That Denton held that opinion was clear, but that’s not what Parker brought him on stage to say.

There is no reasonable doubt today that *Archaeopteryx* could fly. Its main feathers were asymmetrical, a distinction characteristic of feathers employed as an airfoil.[270] But to assess how well it could fly would require delving into the detailed physical anatomy. As it happens, here is where the fact that you can tell how vertebrate muscles are attached to their bones should have entered Parker’s argument.

While a bird’s pectoralis muscle used for downstrokes and level flight originates on the wishbone, attaching to the keeled sternum, the supracoracoideus used for takeoff and upstrokes involves only the keel and coracoid bone. Because *Archaeopteryx* lacked a massive sternum all its weaker flight muscles employed that enlarged furcula. Thus it could have flapped all right, but apparently wouldn’t have had enough thrust to pull off the ground from a standing position, as modern birds are able to do.[271]

Based on such evidence, the consensus view then (and now) was that *Archaeopteryx* was a fairly anemic flyer, and nothing in Denton suggested anything to the contrary. As Henry Gee put it more recently in *Deep Time*: “*Archaeopteryx* could have flown far more efficiently than a sack of potatoes, but may not have had the endurance or maneuverability of a modern bird.”[272]

That birds fly using feathers as an airfoil, unlike the fleshy membranes of a bat, is of course something that any theory of bird origins has to contend with. But assessing the significance of the evidence requires having all of it on the table, and here again Parker was leaving things out.

Here’s what Chris McGowan wrote about Henry Morris and Duane Gish when they tried to score the same points about the origin of feathers as Parker:

> Drs. Morris and Gish both ask why we do not find fossils with partly developed feathers, and I believe that the answer lies in the incomplete nature of the fossil record. The fact that feather impressions can be clearly seen in two of the five skeletons of *Archaeopteryx* might lead one to conclude that the preservation of such fine detail is not exceptional, but this is most certainly not true. First let us point out that we have only the knowledge of *some* of the feathers of *Archaeopteryx*, namely the largest ones: the primary (on the hand) and secondary (on the forearm) wing feathers, and the tail feathers. We have no knowledge at all of the numerous smaller feathers, called contour feathers, which fill in the gaps between the large wing feathers, and which clothe the body. Secondly, the feather impressions are so faint in two of the specimens of *Archaeopteryx* that they were overlooked and the specimens were initially identified as reptiles. Let us be in no doubt—feather impressions *are* rare in the fossil record, and even when they have been preserved they only give us information about some of the feathers. The only place left to search for evidence of the transition from scales to feathers is in the living world.[273]

Which brings us to a second puzzle piece missing from Parker’s account: why paleontologists link scales and feathers to begin with.

Although Parker never picked up on it, his purported source Michael Denton had briefly touched base there. “It is true that basically a feather is indeed a frayed scale—a mass of keratin filaments—but the filaments are not a random tangle but are ordered in an amazingly complex way to achieve the tightly intertwined structure of the feather.” For Denton, any “intertwined” feature that was “amazingly complex” was mystery enough for him, especially when he could slip in a slightly misquoted sentence from Barbara Stahl’s *Vertebrate History: Problems in Evolution*, to clinch the deal: “how they arose initially, presumably from reptiles scales, defies analysis.”[274]

Denton had not pressed on to the next page, however, where Stahl explained the specific reasons for her seemingly dismissive view:

> G. Heilman, who published an exhaustive discussion of the origin of birds in 1927, suggested that the scales of an arboreal avian ancestor lengthened in response to increased air pressure and then gradually frayed at the edges and metamorphosed into typical feathers as a result of friction generated between the air and the body of the leaping animals. Heilman's quaint, Lamarckian explanation is unacceptable today, but no other has been put forth. The problem has been set aside, not for want of interest, but for lack of evidence. No fossil structure transitional between the scale and feather is known, and recent investigators are unwilling to found a theory on pure speculation. Their supposition that feathers were derived from the scales of reptiles is based upon the fact that both are nonliving, keratinized structures generated from papillae on the surface of the body. Since reptiles and birds are closely related, it seems more likely that their papillae are homologous than that those of birds arose *de novo* and replaced the reptilian scale-producing tissues.[275]

Such information has not figured in the accounts of those creationists quote-mining Stahl (either directly or via Denton).

For example, Denton, Paul Taylor and Duane Gish were the ammunition Canadian creationist schoolteacher David Buckna marshaled in a 1995 exchange with critic Jeff Poling. The secondary nature of Buckna's scholarship showed when he offered Denton's slightly misspelled version of Stahl as though it was the original text. But Buckna clearly scored points for confident hyperbole: "Denton blows out of the water any notion that scales could evolve into feathers, given a million years, a zillion years, take your pick, since the structure of scales and feathers are ENTIRELY different. Jeff, have you ever seen pictures of scales and feathers taken with an electron microscope?"[276]

Buckna hadn't referenced this statement, but it appears to trace back to articles by Carl Wieland from the Answers in Genesis journal *Creation Ex Nihilo*, drawing in turn on a prior piece by David Menton, which featured optical (not electron) microscope pictures of a feather and scales. Since it is the embryological genetics of feathers and scales that was at issue, not the surface features of the finished forms, Wieland's pictures were about as relevant as comparing snaps of an adult fruit fly and Henry Morris to dispose of their shared homeobox gene kit.[277]

Wieland has updated his articles online at AiG, adding a 1996 authority quote gleaned from feather expert Alan Brush: "At the morphological level feathers are traditionally considered homologous with reptilian scales. However, in development, morphogenesis, gene structure, protein shape and sequence, and filament formation and structure, feathers are different."[278]

Wieland's use of this quote was characteristic creationist apologetics, for it depended on not explaining what Brush meant by those "different" scales.

What Brush had in mind has been clear from his writings: feathers developed from filament-forming "tubercule-like" features (similar to those seen in *dinosaurs and living reptiles*) rather than directly from a specifically "flat Archosaurian scale."[279] Brush has also joined with another feather researcher, Richard Prum, to isolate the developmental differences between tubular feathers and flat scales. Their work has affirmed the homology of scales and feathers at the deeper developmental level of the placode ("an epidermal thickening above a condensation of dermal cells").[280]

Just how closely feathers and "scales" are related has also been noted by French paleontologist Philippe Taquet: "This is so true that if you inject retinoic acid under the skin of the feet on chicken embryos, they'll grow feathers there where normally there are scales."[281] Interestingly, researchers Gopinathan and Jaishri Menon have recently noted that "retinoids are increasingly being implicated in morphogenesis, homeobox gene transcription, etc."[282]

That such work has failed to surface in the antievolutionary treatment of feather origins should by now not be particularly surprising. It is only a localized instance of the far broader failure to get a proper grip on *Archaeopteryx*‘s undeniably reptilian characteristics. Some years before Gary Parker’s dislocated account, Douglas Futuyma had stressed just how transitional *Archaeopteryx* was:

> *Archaeopteryx* isn’t an intermediate between reptiles and birds merely because it has teeth and claws. It is an intermediate because it occurs before any of the birds that have more “advanced” characteristics; because it has exactly the characteristics that the ancestors of the birds must have had if they descended from reptiles; because it occurs at the same geological times as the small theropod dinosaurs; and because it is almost identical to these dinosaurs in virtually every characteristic except its feathers. It has a long series of tail vertebrae, unfused back vertebrae, unfused limb bones, a rudimentary series of breastbones, solid limb bones, and innumerable other characteristics that are indistinguishable from other small reptiles of the time (see Figures 10 and 11, Chapter 4). It is classified as a bird because of only one characteristic—feathers. Use any other criterion, and it will be classified as a reptile. Organisms, especially extinct ones, don’t fall nicely into categories.[283]

Only from the confident high ground of creationist typology, Parker had thought they could. Up at that altitude it didn’t matter what features the archaeopterygid “type” possessed, because the creationist never gets around to defining the *type*. Presumably even if *Archaeopteryx* had sported antlers or spinnerets, all that would have been accepted as merely oddities of the created mosaic. But back down on terra firma, few creationists are willing to tolerate for long the idea that the archaeopterygids were, apart from their feathers, animals so reptilian their remains might readily be confused for one.

Because ultimately the fixed boundaries of “reptile” and “bird” cannot be defended when there are intermediates flapping around, the creationist has no choice but to categorize *Archaeopteryx* as either one or the other. Henry Morris expresses the conventional creationist position: “*Archaeopteryx* is a bird, not a reptile-bird transition.”[284]

But there are a few antievolutionists who swim against the typological current by trying to sequester *Archaeopteryx* on the reptile side. Richard Milton took that approach, as did *Of Pandas and People*, who tried a daring logical high dive from the opposite end of the board. Deciding *Archaeopteryx*‘s reptilian features set it “apart from birds” (with their “avian complex” of muscle attachment on the sternum and furcula), Davis and Kenyon concluded: “Clearly, the characteristics of *Archaeopteryx* are not predicted by Darwinism for a transition between reptiles and birds.”[285]

If a bird with reptilian features would not be expected by Darwinists claiming birds evolved from reptiles, Davis and Kenyon denied their readers the instructional pleasure of a description of what would.

Back over on the conventional Creation Science side, though, Duane Gish followed through on his treatment of the avian issue by darting out from behind a turn-of-the-century ornithologist to lob what he apparently thought was a particularly damaging evidential grenade:

> In reference to *Archaeopteryx*, *Ichthyornis*, and *Hesperornis*, Beddard stated: “So emphatically were all these creatures birds that the actual origin of Aves is barely hinted at in the structure of these remarkable remains.” During the nearly 100 years since the publication of Beddard’s book, no better candidate as an intermediate between reptiles and birds than *Archaeopteryx* has appeared. Not a single intermediate with part-way wings or part-way feathers has been discovered. Perhaps this is why, with the passage of time, *Archaeopteryx*, in the eyes of some evolutionists, has become more and more “reptile like”! In contrast to Beddard’s assessment of *Archaeopteryx*, some evolutionists today not only assert that this bird is undoubtedly linked to reptiles, but if clear impressions of feathers had not been found, *Archaeopteryx* would have been classified as a

> reptile. This is a gross misstatement, since no reptile has avian wings and the many other bird-like features possessed by *Archaeopteryx*.[286]

Since we have Chris McGowan's own remarks above about Solnhofen feather impressions, we know Gish had under his nose at least some of the relevant information that directly belied what he ended up writing.

Of the seven extant fossil skeletons (the last turning up in 1992), three of them (thus almost *half*) were indisputably classified at first as reptiles—and in each instance, the reason for this was precisely because their feather impressions were so faint. Both the "Eichstätt" specimen discovered in 1951 and the "Solnhofen" in the 1960s were originally described as the dinosaur *Compsognathus*, which *Archaeopteryx* closely resembles. The partial "Haarlem" (a.k.a. Teyler) was unearthed in 1855, before the feathered archaeopterygids were even recognized, and so was pegged then as some sort of pterosaur. As later more detailed studies took a second look, the feather impressions were duly spotted and all had been properly reclassified as archaeopterygids by the time Gish sat down in the 1990s to write about "gross misstatement."[287]

The inability of antievolutionists to acknowledge the taxonomical similarity between *Archaeopteryx* and at least some dinosaurs took on a comic opera cast with the late physicist Fred Hoyle's hoax theory, which Gary Parker had so obliquely alluded to.

In the early 1980s several critics of evolution (such as Hoyle and his mathematics colleague Chandra Wickramasinghe, and creationist Lee Spetner) claimed the London and Berlin *Archaeopteryx* specimens were actually 19th century forgeries concocted to bolster the new evolution theory. The irony for Gish's argument concerns how Hoyle *et al.* maintained the feathers had been carved onto otherwise perfectly genuine *Compsognathus* skeletons—thus tacitly affirming exactly the anatomical similarities Gish and other antievolutionists were so vigorously denying.

Subsequent study quickly blew the hoax idea to smithereens.[288] But it still surfaces every so often among antievolutionists. Some, like Duane Gish, Wendell Bird and Jonathan Wells, bring it up even while acknowledging the telling criticism.[289] And while Answers in Genesis currently lists the claim among "Arguments we think creationists shouldn't use," a few YEC diehards (including the venerable Morrises) still try to keep it flying.[290]

Then there's Stephen Meyer.

In an opening seminar of the 1998 Whitworth College "Creation Week," Meyer casually tossed off how doubt had been cast on the authenticity of the *Archaeopteryx* specimens. When I raised my hand to stop Meyer in mid lecture to challenge the specifics he executed an abrupt reverse, admitting only then that he didn't really think those claims were persuasive.

Left unanswered was the tiny philosophical question: if he didn't believe the forgery theory was sound, why did he bring it up in the first place?

Chapter 5. The Theropod Connection

While “reptile” is a rather broad term, *Compsognathus* is anything but, and that level of specificity brings us to a third (and rather chunky) piece missing from Gary Parker’s bird puzzle: exactly which reptiles do evolutionists think *Archaeopteryx* developed from, and *why* have they come to that opinion? Beyond that, to what extent are the Jurassic archaeopterygids related to modern birds at all?

The hot target here surfaced in 1969 when John Ostrom discovered an extraordinarily bird-like maniraptoran theropod, *Deinonychus*. Ever since, dinosaur paleontologists have been muscling in on the established bird watchers, eventually appropriating Class Aves for their own, raising professional hackles along with the anatomical controversy.

While scientists like Alan Feduccia or Larry Martin sandbag the traditional position, fervently challenging the particulars of the dinosaur theory, their views do not ultimately rescue the creationist case. This is because their “traditional position” happens to be that the reptilian features of *Archaeopteryx* derived not from the later dinosaurs, but from the equally reptilian *ancestors* of the dinosaurs, namely the archosaurs that included the extinct thecodonts (such as the arboreal Late Triassic *Megalancosaurus*) and the earliest crocodiles.[291]

Consequently, creationists have to be particularly wary how close they steer to this debate, lest they clue the reader in too much on the very thing they don’t wish to admit: paleontologists are trying to figure out which reptile ancestor best fits the bill because *Archaeopteryx* is so distinctively reptilian!

This obfuscation acts as a wave of natural confusion, rippling out among all the peripheral Creation Science authors who depend on the core sages (such as Morris and Gish) for their information.

That’s what happened with Scott Huse when he translated the opinions of Henry Morris into a ridiculous “Wanted” poster to highlight the seeming incongruity of intermediate forms: a “fishibian” (fish sprouting frog’s legs), an “amphitile” (legged snake), and the “repbird” (bird with snake grafted at the neck). Since no evolutionist contends birds evolved from *snakes*, the picture only illustrated the sort of juvenile excess some creationists are prone to when their sources are so removed from the actual science.[292]

Huse may have been straining for that frothy slapstick humor Duane Gish displayed in *The Amazing Story of Creation*, where children were shown a transitional whale consisting of a cow (replete with hooves and udder) whose hind quarters summarily dissolved into a fluked cetacean.[293]

But when targeting an adult audience, Gish puts on his serious face and endeavors to sound profoundly technical:

> It has been asserted that *Archaeopteryx* shares twenty-one specialized characteristics with coelurosaurian dinosaurs, indicating that birds had evolved from these, or very similar, dinosaurs. It spite of these similarities, there are two facts that would exclude *Compsognathus* as an ancestor of birds. *Compsognathus* and *Archaeopteryx* were contemporaries, both of which occur as fossils in the Solnhofen limestone, said to be Upper Jurassic, or about 150 million years in age. How can a parent be as young as its offspring? Furthermore, *Compsognathus* and coelurosaurian dinosaurs were saurischian, or lizard-hipped, dinosaurs. A proper reptilian or dinosaurian ancestor of birds should have had bird-hips. Coelurosaurian dinosaurs cannot be the ancestor of birds.
>
> Research on various anatomical features of *Archaeopteryx* in the last ten years of [*sic*] so has shown, in every case, that the characteristic in question is bird-like, not reptile-like. When the cranium of the London specimen was removed from the limestone and studied, it was shown to be bird-like, not reptile-like. Benton has stated that “details of the brain case and associated bones at the

> back of the skull seem to suggest that *Archaeopteryx* is not the ancestral bird, but an offshoot from the early avian stem.” In this same paper, Benton states that the quadrate (the bone in the jaw that articulates with the squamosal of the skull) in *Archaeopteryx* was single-headed, as in reptiles. Using a newly devised technique, called computed tomography, Haubitz et al. established that the quadrate of the Eichstätt specimen of *Archaeopteryx* was double-headed, and thus similar to the condition of modern birds, rather than single-headed, as stated by Benton.
>
> L. D. Martin and co-workers have established that neither the teeth nor the ankle of *Archaeopteryx* could have been derived from theropod (coelurosaurian) dinosaurs—the teeth being those typical of other (presumably later) toothed birds, and the ankle bones showing no homology with those of dinosaurs. John Ostrom, a strong advocate of a dinosaurian ancestry for birds, had claimed that the pubis of *Archaeopteryx* pointed downward—an intermediate position between that of coelurosaurian dinosaurs, which points forward, and that of birds, which points backward. A. D. Walker, in more recent studies, asserts that Ostrom’s interpretation is wrong, and that the pubis of *Archaeopteryx* was oriented in a bird-like position. Further, Tarsitano and Hecht criticize various aspects of Ostrom’s hypothesis of a dinosaurian origin of birds, arguing that Ostrom had misinterpreted the homologies of the limbs of *Archaeopteryx* and theropod dinosaurs.
>
> A. D. Walker has presented an analysis of the ear region of Archaeopteryx that shows, contrary to previous studies, this region is very similar to the otic region of modern birds. J. R. Hinchcliffe, utilizing modern isotopic techniques on chick embryos, claims to have established that the “hand” of birds consists of digits II, III, and IV, while the digits of the “hand” of theropod dinosaurs consist of digits I, II, and III.[294]

You may have noticed how Gish managed to keep clear of specifying what any of those twenty-one “specialized characteristics” might have been that Alan Charig claimed *Archaeopteryx* shared with dinosaurs. Since those features literally ran from head to toe, this was no peripheral omission.

Once again, we have some idea what Gish presumably was aware of because Chris McGowan had already passed through this area, describing thirteen anatomical features distinguishing reptiles from birds, involving the hip, chest and abdomen, the vertebral structure, hand, ankle and tail, and feathers. Of these, *Archaeopteryx* had exactly two avian elements (a wishbone and feathers)—all the remaining characteristics were specifically and uniquely reptilian.[295]

Moving to the technicalities, what proportion of Gish’s readers would know enough about reptile jaw quadrates or “otic regions” to make sense of such esoterica from their own experience? If they didn’t, Gish certainly wasn’t about to assist them, for “in every case” he sequestered the necessary background information.

Consider what might be pertinent in trying to evaluate the jaws of *Archaeopteryx*.

Its *size*, for one thing: the archaeopterygids were only about as large as a crow, and “Eichstätt” in particular was a juvenile. You could easily rest its diminutive skull in the palm of your hand, which made the lower jaw about the size of a short swollen toothpick.[296]

What Gish had brought up here was the tricky matter of just how much of a second bump was apparent on the tiny quadrate bone where the skull lined up with the jaw. While this could reveal something about how the jaw articulation was changing, why would that help the creationist argument? Recalling that “Eichstätt” was originally classified as a dinosaur, establishing that it had also begun to acquire a feature “similar” (though not yet identical) to the avian condition would only seem to buttress its status as a transitional form.

Gish had very carefully couched the debate to make Michael Benton and “Haubitz et al.” seem at loggerheads, when both were only trying to make sense of the facts of nature through careful observation. British paleontologist Alick Walker’s ear study (obtained secondarily via Peter Dodson) lands in the same misrepresented category.

The actual soft tissues of *Archaeopteryx* ears vanished long ago, of course, so what paleontologists have to look at is the conformation of the skull around where the ears used to be. And, indeed, the otic region of *Archaeopteryx* is a lot like modern birds—but that’s only because their proposed theropod dinosaur ancestors’ otic regions were a lot like modern birds, too. Either Gish didn’t know this, or he didn’t care to find out, or he didn’t think the reader needed to know about it.[297]

But the two “facts” Gish commenced with were no facts at all.

The first was merely the recapitulation of the mental block that shields creationists from the implications of what it means for organisms to be related by common descent—but documented by an inherently fragmentary fossil record.

No paleontologist contends *Compsognathus* was itself the “parent” of *Archaeopteryx*, only that their lineages shared a comparatively close relation—an idea that would seem reasonably supported by something that really was a fact, namely the aforementioned circumstance that several of their fossils had actually been confused for one another. That Gish thought he could score a serious technical point on such unstable ground highlighted how conceptually naïve the creationist view is. This argument in the fossil realm was the asinine equivalent of insisting distant cousins couldn’t be related if both were still alive.[298]

Gish had to reach even farther out for his second “fact.”

The earliest dinosaur finds had pelvic girdles shaped a lot like modern lizards and birds, and for that reason paleontology was stuck with the nomenclature of “lizard-hipped” saurischians and “bird-hipped” ornithischians (Figure 31).[299] But while dinosaurs started out with that pelvic arrangement, they didn’t *stay* that way, and paleontologists have since chalked up a remarkable variety of “exceptions” to the conventional framework. None of which seeped into Gish’s petrified schema.[300]

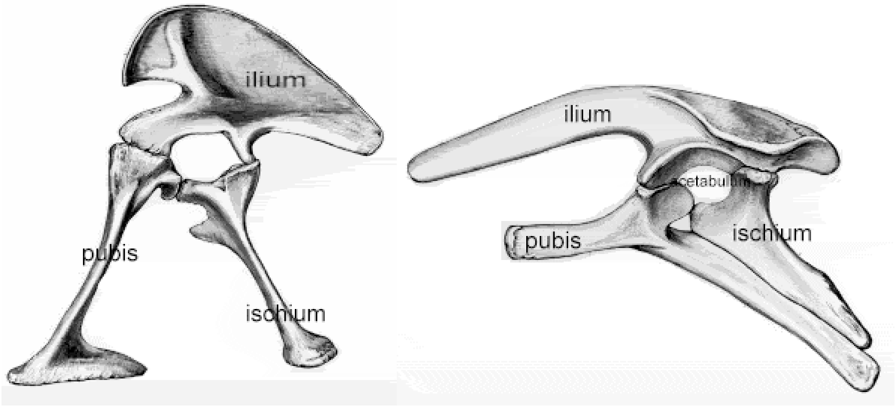


Figure 31. Typical dinosaur pelvic layouts: Saurischian (left, the large bipedal predatory theropod *Allosaurus*) and Ornithischian (right, the herbivore *Stegosaurus*), *users.tamuk.edu/kfjab02/dinos/VPDINOSAURS.htm* from 1896 drawings by O. C. Marsh; cf. the pelvic display of *Allosaurus* and *Stegosaurus* at the Smithsonian (*nmnh.si.edu/paleo/dino/allohip.htm & stegohip.htm*). While the overall shape was much the same for quadrupedal and bipedal saurischians, in bipeds the pelvis was shifted upward, putting the attached muscles under greater tension and permitting a springier step than that of their quadrupedal sauropod cousins, Norman (1985, 37). For ornithischians, although the body of the pubis is nestled alongside the ischium, the extension protruding to the right mimicked the overall configuration of the projecting saurischian pubis. This feature appeared in many of the larger ornithischians, including the partially bipedal hadrosaurs.

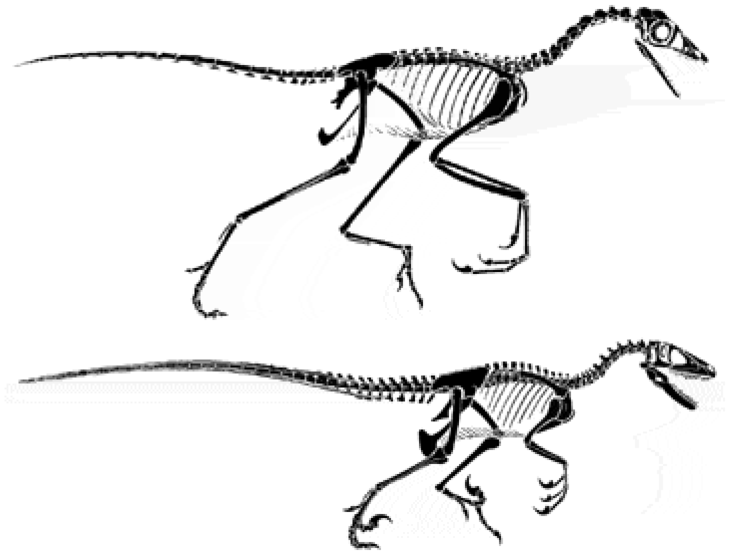


Figure 32. Skeletons of (top) *Archaeopteryx lithographica* (length about half a meter) and (bottom) *Deinonychus antirrhopus* (length about 3 m), illustrations from *rainbow.1deo.columbia.edu.courses/v1001/soln15.html* based on Gregory Paul’s reconstructions, Paul (1988, 354, 362-363). *Deinonychus*’s deadly sickle-clawed toes are clearly visible (a feature familiar to viewers of Steven Spielberg’s *Jurassic Park* movies where it’s predatory attributes were used to full dramatic effect—see also note 301).

The salient characters here were the dromaeosaurids, like Ostrom’s *Deinonychus,* which were “lizard-hipped” in name only. For a quarter of a century paleontologists had known these formidable saurischian predators (Figure 32) had backward-pointing pubic bones virtually identical to *Archaeopteryx*. So why didn’t Gish know it?[301]

In fact, just about the time Gish was putting his comforting pelvic certainties to paper, paleontologists Fastovsky and Weishampel were explaining the contrary: “in the history of dinosaurs, the pubis rotated backward three times: once in ornithischians, once in segnosaurs, and once in the dromaeosaurid-*Archaeopteryx*-Aves clade. It is significant that in modern bird embryos, the pubis initially points forward (the primitive condition) and rotates backward as the embryo develops.”[302]

Gish’s attempt to rout Ostrom’s pelvic interpretation with Walker’s 1980 observations tripped over yet another piece of recent information he already knew about.

In 1992 the seventh *Archaeopteryx* specimen was discovered (the “Solnhofer Aktien-Verein”) which Gish duly introduced the page before—but only because this new example happened to possess a bony sternum, which he reflexively translated as *bird*.[303] Of course, Gish didn’t muddy the waters by describing that item in detail—a wise caution, since it was quite a small sternum, and thus still a long way from the massive keel of living flying birds. This was evident from the illustration of it in Pat Shipman’s recent book on the archaeopterygids, about which specimen she had this to say:

> It provided three surprises, new features that significantly altered the view of *Archaeopteryx*. The skeleton is very small—even smaller than the Eichstätt specimen—but apparently adult. This has led Peter Wellnhofer, the German paleontologist who described it, to suggest that it represents a new species, *Archaeopteryx bavarica*. Apart from size, the specimen includes two new anatomical features: a bony sternum, which is unknown in any other specimen

> and is crucial for the attachment of flying muscles; and a set of bony, interdental plates that are preserved on the inner side of each lower jaw between all tooth positions. Similar interdental plates are found in two different groups that have been suggested as possible ancestors for *Archaeopteryx*: the theropod dinosaurs and a still more primitive reptilian group, the thecodonts.[304]

So the newest *Archaeopteryx* was beginning to acquire one more "bird-like" trait, and sported another reptilian aspect besides—isn't that what transitional fossils are supposed to do?

Gish was so intent on parading *A. bavarica*'s indistinct sternum he overlooked everything else, including its pelvis, which was clearly directed in the maniraptoran manner, just as Ostrom had so long insisted. It was yet another piece of evidence to cement the dinosaur-*Archaeopteryx* connection. But while real science works like that, discovering things, assessing them, and moving on, Gish was stuck wallowing in the creationist tar pit, trying to pull that obsolete data free.[305]

Richard Milton manifested a similar trait when he included a jab at *Archaeopteryx* in a 1995 article ("Battling the Suppression of New Ideas") slated for the British weekly *Times Higher Education Supplement*—which never reached publication, apparently due to the outraged intervention of Richard Dawkins.[306]

Milton fielded his paleontological expertise once again when he declared: "the candidate most favoured by neo-Darwinists is a small agile dinosaur called a Coelosaur [*sic*], and this is the explanation offered by most text books and museums." However, "such a descent is impossible because coelosaurs [*sic*], in common with most other dinosaurs, did not possess collar bones while 'Archaeopteryx', like all birds, has a modified collar bone to support its pectoral muscles."

The proper term here was *Coelurosaur*, not "Coelosaur"—as again Milton might have discovered had he paid closer attention to the one source he cited here, David's Norman's fine dinosaur encyclopedia.

Milton left off page numbers, though—a prudent oversight, given that Norman had explicitly stated: "The major problem of the lack of a 'collar-bone' or clavicle in theropods was shown not to be a problem at all, because several theropods did in fact possess clavicles (see page 47)."[307] Because of their sliver-like shape, theropod clavicles can easily be confused for ribs or gastralia (and vice versa). But by the mid-1990s when Milton was writing still more examples had turned up properly *in situ* to settle their identity.[308]

That the arguments of Milton, Gish and other critics of bird evolution snag on such minutia is the leitmotif of a movement plagued by ill-informed dilettantism.

This is doubly ironic for traditional Biblical creationism. However much they pay lip service to how marvelous be the works of creation, creationists devote precious little effort to actively studying them. In the creationist catalog of wonders, birds simply *are*, with furcula or without antlers, and the little things that trigger light bulbs over the heads of naturalists seldom engage their attention.

Like the presence of the "small shelly fauna" in the Early Cambrian, these are sometimes obvious things—that birds stand on their hind legs, for example.

From sparrow to penguin to emu, birds are obligatory bipeds, reserving their highly modified forelimbs either as airfoil, for paddling in the water, or complete inutility. Contrast that with the other two vertebrates known to have taken wing: those membrane flyers, the bats and pterosaurs.

Undeniably skilled at aerial acrobatics, bats nonetheless give their terrestrial background away the moment they hit the ground, as they clamber about awkwardly on all fours. Mammals, in fact, are so committed to four feet the exceptions can be counted on one hand (kangaroos and company, the kangaroo rat, and us).[309]

Pterosaurs are extinct, of course, but the available evidence suggests they too were primarily quadrupedal. A few specialized forms may have been able to amble on their hind legs, but no pterosaur had the dedicated anatomy suitable for the casual strolling facility of a flamingo.[310]

Bipedality is a very refined capability, involving musculature, balance, and all the neurological wiring to go with it. Consequently, there was the distinct evolutionary suspicion birds did not end up resembling bats or pterosaurs because they were descended from something that had already perfected walking on two legs.[311]

And here the archosaurs, especially their dinosaur descendants, had neon lights all around them, for they are the only prominent animal group in history other than birds to feature broad groups of habitual bipeds.

But merely walking on two legs wouldn’t have sufficed for most paleontologists if the detailed anatomy didn’t match, and that is where the dinosaur case really kicked into high gear. The feet of theropod dinosaurs showed the steady acquisition of features that birds eventually inherited as a done deal. The fifth toe was lost, the middle three pinched inward (fusing together in the embryo stage of modern birds), and the first digit shifted behind to provide the backward-facing claw that would eventually be adapted by birds for perching. There was also a characteristic sliver of bone (the “ascending process of the astragalus”) running up from the ankle as a stiffener, and which is still found to varying degrees in the drumsticks of living birds.[312]

Any one of these apparent resemblances would have been relevant to bring up concerning how homologous the ankle of *Archaeopteryx* was to those of dinosaurs. But Gish never even made it to that minimum threshold, thus setting an anemic precedent when he turned finally to the far more complicated subject of the avian hand (the dinosaur I-II-III versus bird II-III-IV digit problem).

Here was a collision of disciplines and techniques: the embryological analysis of developmental biologists against the paleontologists’ fossil evidence. As it also involves the controversy over whether birds evolved from dinosaurs or some other reptile, this brings the added potential for clashing egos, both professional and personal. The upshot is that dinosaur advocates think the ornithologists have got it wrong, and vice versa.[313]

Round One in the bout appears to be a technical knockout: all the scientific parties agree that theropod dinosaurs have probably retained fingers I-II-III, at least on the basis of the currently available paleontological material.[314] But there should be a caution inserted here that the fossil record for the origin of the Cretaceous maniraptoran dinosaurs is not terribly good. So there is the possibility that new fossils might turn up from the Jurassic to broaden the paleontological picture, tracing the reduction of a four-digit hand to the II-III-IV arrangement, thus resolving the matter without changing the embryological position at all.[315]

Round Two appeared to be shaping up as a technical knockout for the other side. Bird hands and feet develop five cellular *anlagen*. Four of those in the hand develop into finger buds, generated by a signal emitter positioned at the pinky spot (which can produce mirrored duplicates when the genes malfunction). The two digits on the end (III and IV) eventually fuse together as the carpometacarpal bones—the tough cluster that makes chicken wings such a raw deal for dinner. That leaves the next in line (digit II) to provide anchorage for the alula, an opposable feather flying birds use to enhance maneuverability.[316]

Tough times for the dinosaur theory?

That would depend first on what anlagen were present in the embryonic hands of *Archaeopteryx*, or the maniraptoran dinosaurs and their kin. These are unavailable for comparison.[317]

The issue would also turn on knowing exactly what determines *finger identity*.

It has been learned that avian wing development involves several interacting genes—including one in the *hedgehog* group (named because of the bristles it produced in fruit flies) dubbed *sonic hedgehog* (*Shh*) after the popular computer game character. Who says scientists don’t have a sense of humor?[318]

But the genetic reading mechanism is an insensate machine, and if a DNA reading “frame shift” occurred somewhere in that process there might have been a digital reassignment.[319] This proposal has been lent theoretical support by subsequent work on the avian foot (where the toes differ sufficiently in the phalanges to simplify identification). It turns out that bird toes are not specified from the start, by their sequence among the rough anlagen, but rather only acquire their specific structure afterward, following a cascade of *Bmp* (bone morphogenetic proteins) circulating in the interdigital tissue.[320]

We'll be hearing more from *sonic hedgehog* and *Bmp* in due course. But first we need to move on to Round Three, where we encounter one more vital piece missing from the creationist puzzle. A really big one this time, having to do with that hundred million-year wide chasm separating modern birds from *Archaeopteryx* and the Jurassic dinosaurs.

What happened in between?

Since *Archaeopteryx* looked so much more like a dinosaur than a bird, when did "normal" birds appear? Ones with keeled sternums, fused limb bones, and all that? This would seem a fairly obvious question. Yet the only time Gary Parker touched on this was to observe that "some fossil birds" had teeth. And that's all Duane Gish had to say about them, too: that the teeth of *Archaeopteryx* were "typical of other (presumably later) toothed birds."

Now wait a minute. Birds with *teeth*? Since when did birds have teeth? Never mind antlers, it doesn't seem to bother creationist theory in the least that *Archaeopteryx* was a toothed bird, as Henry Morris explained:

> Thus, *Archaeopteryx* is a bird, not a reptile-bird transition. It is an extinct bird that had teeth. Most birds don't have teeth, but there is no reason why the Creator could not have created some birds with teeth. Not all reptiles have teeth, though some do. The same is true of fishes, amphibians and mammals. Some have teeth and some don't. The same evidently was true of the original birds. For some reason, those that were created with teeth have since become extinct.[321]

Here is another of those surpassing "light bulb" moments that forever elude the creationist imagination. This one stays dim because they never get around to asking the right questions, or even posing the right riddles. Of course a Creator could make anything in any manner—that's the problem. It's easy enough imagining God making a bird with teeth, but why would one *without* teeth be made with teeth—or rather, the *genes* to make them? As was shown experimentally in 1980, chickens apparently still carry genes pertaining to reptilian teeth but normally don't express them because they have lost some of the genes to turn them on. Yet intervene in that process with the proper hormonal stimuli, as the experimenters did, and *voila*—"scarce as hen's teeth" was no longer strictly true.[322]

Now why should that be so?

An evolutionist has an answer: because all birds evolved from animals that had teeth, just as their ancestors had more than three fingers in their hand. But have creationists anything to remark about this? We may quote Gary Parker again: "No. None at all." The subject indisputably didn't come up in the assorted contemporary works examined, from Morris/Parker and Wendell Bird, to the late Luther Sunderland or (the often as late) Duane Gish. Nor Michael Denton, Alan Hayward, Cornelius Hunter, Richard Milton, Jonathan Wells (a biologist), or even Davis/Kenyon hoping to qualify as an instructional *science* text. And of course the derivative Scott Huse, Ankerberg/Weldon, or Hank Hanegraaff never got within a mile of it.[323]

There is one exception to this litany, but it's one of those that "proves the rule," courtesy of the redoubtable Phillip Johnson. In *Reason in the Balance* he disputed Stephen Jay Gould's argument that the false "thumb" of the panda (actually an extended wrist bone) indicated contingent adaptation. This is the "trilobite eye" problem again: whereas intentional design can start from scratch, natural evolution has to make do with what is at hand. But we're moving on from that issue, to the matter of technical imagination and scholarly stamina.

Here's how Johnson's Research Notes documented his jab at Gould:

> Steven [*sic*] Jay Gould's essay "The Panda's Thumb" is found in the collection by the same title (Norton, 1980). An update of Gould's basic argument was published by Kenneth R. Miller in *Technology Review* 97 (February 1994); 24. Miller cites the panda's thumb example, along with assorted deficiencies in the construction of the eye, "pseudogenes" that do not perform evident useful

> functions, and so-called hen’s teeth that have allegedly been produced by putting mouse tissue in contact with chicken epithelial cells. It would require an additional chapter to address these examples here, and the effort would distract readers from the main philosophical themes, so I will merely say that I look forward to discussing these examples before scientific audiences with the support of my very capable associates who have investigated them all.[324]

As we’ll see again in the third episode with the reptile-mammal transition, Johnson’s solicitude about not unduly distracting his readers appears to coincide precisely with topics not easily bent into a shape consistent with Intelligent Design.

But the fact remains Douglas Futuyma had written of this, as had Stephen Jay Gould in a work conspicuously titled *Hen’s Teeth & Horse’s Toes*—both of which Johnson cited in *Darwin on Trial*. So why wasn’t this intriguing datum remarked on when it came to the origin of birds? I suspect for the same reason the creationists listed above didn’t deal with it—because the subject *didn’t* routinely come up in the other anti-creationist literature.

Remember that creationism is methodologically a *reactive* enterprise, where the object is to plug holes in furtherance of a highly moral apologetic goal, not to understand the natural phenomena. All Johnson or Gish (who read Futuyma) or Hanegraaff (who read *Reason in the Balance*) had to do was miss the occasional spot where it was mentioned, and poof—it’s off the scope. Only when Miller brought the subject up again was a Pavlovian twitch elicited, prompting Johnson to offer it as a coming attraction, by which time he might be able to assemble a united front of “very capable associates” to do his thinking for him.[325]

Lost in all this peroration is the natural world science seeks to comprehend. Which puts us back with our unanswered question: when had there been birds with teeth? Well, as none of those creationist authorities seemed in any hurry to point out, all through the Cretaceous period—the age immediately following the Jurassic when the toothed *Archaeopteryx* lived.[326]

Duane Gish even let slip two of their names, *Ichthyornis* and *Hesperornis*, but only as windup for his jejune foray into “gross misstatement.”

What we’ve hit on here is the great blind spot creationists have when it comes to finding the meaning of things like *Archaeopteryx*—and, by extension, the entire fossil record. So obsessed with the absence of ancestral wings and feathers in one direction, they never turn around long enough to grasp the implications of *descendants* evolving from the other.

Discovered in the early 1870s, *Ichthyornis* and *Hesperornis* lived during the Late Cretaceous, about 70 million years after *Archaeopteryx*, along the extensive Niobrara seaway that made Kansas temporarily beachfront property. Apart from its teeth, *Ichthyornis* was very much like modern birds, featuring a well-developed sternum and fusing tailbones. *Hesperornis* meanwhile had adapted to an aquatic lifestyle, with diving capabilities something like loons today, and its teeth were the ones Gish almost discussed. In reiterating his claim a few pages later he scuffed tantalizingly close to the truth: “As already described, *Archaeopteryx* did not have reptile-like teeth, but teeth that were uniquely bird-like, similar to teeth found in a number of other fossil birds. As pointed out by Martin, Stewart, and Whetstone, *Archaeopteryx* and other toothed birds had unserrated teeth with constricted bases and expanded roots, while theropod dinosaurs, its alleged ancestors, had serrated teeth with straight roots.”[327]

What Gish overlooked was something dinosaurologist Gregory Paul had explained in his 1988 book, *Predatory Dinosaurs of the World*, namely that “the very conical, unserrated, and big-rooted teeth of *Archaeopteryx* are most like those of marine crocodiles, whales, and the toothed diving bird *Hesperornis*.”[328] In other words, the similarity was likely due to the adaptive dynamics of *diet*, in the same way the curved “rip a chunk and let it die” steak knives lining a tyrannosaur’s jaw indicated what manner of carnivore it was.[329]

Of course there are still a few creationist dogmatists who can’t even manage to get that bit straight, as seen earlier concerning the docile tyrannosaurs proposed to have inhabited Eden.[330]

For about a hundred years the record of fossil Cretaceous birds remained not much better than *Ichthyornis* and *Hesperornis*, with only one genus turning up from the critical Early

Cretaceous. But all that began to change in the 1980s, when the number of available specimens first doubled, then doubled again during the 1990s.

Meanwhile Phillip Johnson whistled through the dark in *Darwin on Trial*: "The new specimens have reptilian skeletal features which qualify them as possible intermediates between *Archaeopteryx* and certain modern birds. The evidence, however, is too fragmentary to justify any definite conclusions."[331]

Johnson did not append what he might consider fossil evidence that would not be "too fragmentary." In any event, he has precluded the opportunity of drawing any definitive conclusions himself because he hasn't brought the subject up since. An insufficient supply of capable associates, perhaps.

Nor have any of his fellow antievolutionists volunteered to fill that gap.

Not the books of Scott Huse (praised by Carl Herbster and Doug Bandow) and Richard Milton that appeared in 1997, or those of Hank Hanegraaff (with glowing Foreward by Phillip Johnson) and Ankerberg/Weldon following in 1998, or Cornelius Hunter's anti-Darwinian *opera* in 2001 and 2003. Jonathan Wells veered the closest in *Icons of Evolution* when he sported a chart on "Cladistic theory and the fossil record" that had several black bars representing "groups of extinct birds." But none of these Cretaceous birds were identified, and his text didn't explain anything about them.[332]

Had they thought to investigate this matter, creationists hoping these Mesozoic flyers might pose a problem for evolution would have been in for a shock.

The Early Cretaceous *Eoalulavis*, discovered in Spain in 1996, proved to be the earliest bird with an alula feather—only it was attached to the theropod digit I.[333] It would appear the Cretaceous birds were picking up right where *Archaeopteryx* left off. Step by incremental step, they were losing their theropod features: the specialized gastralia bones lining the belly wall, their tails, and eventually their teeth (though evidently not the genes for them). Concurrently, the keeled sternum got bigger, the forearm lengthened, and the fingers of their theropod hand embarked on that carpometacarpal fusion and possible developmental frameshift.[334]

What we're seeing with the physical evidence is only part of a larger biological process whereby birds at first could only fly by trading off the energy their theropod cousins could devote directly to growth, as in the early (and now extinct) enantiornithine birds that once proliferated in the Cretaceous.[335] By the time the dinosaur system fell apart 65 million years ago, though, birds had become *almost* modern. They appear to have lacked only one avian attribute, the complex of hollow pneumatic bones that work in conjunction with their lungs. Although theropods also had some hollow bones, which birds may have simply inherited, the full blown avian pneumatic system was one further adaptation that appears to have taken place after the Mesozoic.[336]

All this makes mincemeat of Henry Morris' claim about animals always appearing "fully formed" in the fossil record, without intermediates. Neither typical reptiles nor modern birds, *Archaeopteryx* and the later Cretaceous flock were simultaneously fully functional *and* intermediate. It's the creationist mythology that insists "transitional" forms have to look like Frankenstein monsters (Huse's idiotic "repbird"). Evolutionary theory sternly maintains the opposite: transitional forms *must* be functional. Wings and feathers couldn't have developed peripherally, only to suddenly gain utility, like flicking a light switch. And this difference in theoretical opinion is why the Cretaceous birds matter so much. Representing only some thirty genera sprinkled across 70 million years, what does it tell you that a random sampling of "birds" should turn up such a distinctively mixed flock?

Are evolutionists just exceptionally good at anticipating the creative output of God?

This issue of the consistent predictive power of evolutionary thinking came home to roost over feathers. For some time dinosaur paleontologists had been warming to the idea that feathers evolved in the more active theropods for thermoregulation, and were only later adapted as an airfoil. On this reasoning, Gregory Paul had depicted many of the small theropods in *Predatory Dinosaurs of the World* as feathered.[337]

All they lacked was fossil confirmation for the existence of feathered dinosaurs.

Even had these lived, of course, their successful preservation was a long shot. As Chris McGowan had noted (and the fossil record of *Archaeopteryx* continued to demonstrate), feathers were only likely to be preserved in the rarest of *Lagerstätten* circumstances. It was no coincidence then that the spectacular new Spanish Cretaceous birds were turning up in lithographic limestone, just as *Archaeopteryx* had in the Solnhofen. This was also the case for the finds coming from China.[338]

Ah, but evolutionists have that silent partner oddly committed to coming through for them in a pinch. Evidently feeling in an especially puckish mood back in the Mesozoic, and without consulting Henry Morris, the Creator decided what paleontologists really needed to perk up their day late in the 20th century were a few impressively feathered dinosaurs. So he planted some appropriately bird-sized ones in China, in triplicate.[339]

And many thanks, too, for they were just what Darwinists had in mind. *Sinosauropteryx* again resembled the “usual suspect,” our old friend *Compsognathus*—only this time covered with rudimentary feathers, short “downy filaments” with a central rachis and wildly fraying barbs.[340]

The other two were similarly transitional. Although the forelimbs of *Protarchaeopteryx* and *Caudipteryx* were not adapted for flying, they were nonetheless fully feathered with non-aerodynamic plumage, including symmetrical ones bearing the more familiar rachis-shafted configuration. Indeed, they looked surprisingly like the “hypothetical pre-bird” illustrations of John Ostrom, the ones Gary Parker offered in 1987 as examples of how evolutionists founded their conceptions on “faith, not facts.”[341]

Because these Cretaceous dinosaurs were contemporaries of the still-evolving early birds, they represent a revealing snapshot of what some theropods were up to while the birds were getting the hang of flying. Particularly puzzling is the phylogenetic position and behavior of the odd alvarezsaurids, which includes *Mononykus* with its weirdly shrunken forelimbs resembling those of a mole, and so possibly used for digging. Known from sporadic fossils in Asia and the Americas, at least one specimen (*Shuvuuia*) was feathered—but it’s still unclear whether they were early flightless birds or extremely birdlike dinosaurs.[342]

In any case, knowing that at least a few nonavian dinosaurs had genes for making feathers has enormous theoretical implications.

The “dino fuzz” appearing on these theropods precisely matched what Brush and Prum had deduced proto-feathers needed to have looked like based on the known developmental process of bird feathers. The existence of feathered theropods in the Cretaceous also jacked up the likelihood that their Jurassic ancestors could have had them too, and paleontologists will continue hunting for even earlier *Lagerstätten* snapshots to clarify the picture (though given the geological reality, don’t hold your breath).[343]

At the minimum, they raise provocative questions about whether “birds” branched from dinosaurs only once, or several times, and will certainly kindle frenzied debate as to why some feathered theropods took wing, while others remained grounded.[344]

Chapter 6. Protoavis

Speaking of being grounded, what about Gary Parker's secret weapon, that Triassic bird, *Protoavis*? If *modern* birds were truly flapping around 75 million years before *Archaeopteryx*, this would suggest the archaeopterygids and the Cretaceous birds that so resembled them were an evolutionary siding, an independent (and ultimately unsuccessful) stab at flight by a branch of the feathered archosaurs.

But would this instantly disprove the idea of bird *evolution*? Creationists act as if it did. For them, encounter "bird" and "before *Archaeopteryx*" in the same paragraph and Darwin's comeuppance is assured.

Time to pause for fact checking. Was this "final piece in the *Archaeopteryx* puzzle" a "modern" bird as Parker claimed? In fact, was *Protoavis* a "bird" at all? Every antievolutionist who has invoked *Protoavis* has glibly presumed that it was.

Answering these essential questions brings us once again to our recurring theme of *taxonomy*. How do you classify extinct organisms? How would you recognize an intermediate? And do those antievolutionists who wade into these debates show proper caution in evaluating provocative new evidence?

If *Protoavis* had been represented by beautifully articulated specimens trapped in lithographic limestone (feathers and all), that would be one thing. But "Protoavis" consisted of two extremely fragmentary examples extracted from the mudstone of the Dockum Formation in Texas, a deposit paleontologically notorious for disgorging misidentified bits and pieces. And its discoverer, Sankar Chatterjee, had a mixed reputation for making sweeping claims on the basis of preliminary information.[345]

All the controversy that swirled around *Protoavis* turned on the poor quality of the fossils and how they were to be interpreted.

On the taphonomic up side, mudstone would not likely have preserved feathers or feather impressions, so their absence was not necessarily a problem. Chatterjee claimed to have detected distinctive quill nodes on the bones, spots where the flight feathers of powerful flyers are attached. The skulls he found had a variety of bird-like characteristics, and he spotted holes on their hollow limb bones that suggested it had a pneumatic "flow-through" lung system like that of living birds. If these observations were valid, it would certainly be a legitimate contender for the ancestry of contemporary birds.

On the down side, however, was the fact that "Protoavis" was a disarticulated ensemble. Meaning there was no guarantee Chatterjee's fossils were even from the same species—which would capsize any anatomical generalizations made under the assumption that they were.[346]

But even conceding all that, *Protoavis* was by no stretch of the imagination a typical modern bird, since it still had teeth, a long reptilian tail, and had only the start of a keeled sternum. In overall appearance, both in the skeletal reconstruction put forward by Chatterjee himself, and one artist's vivid rendition of it, *Protoavis* looked pretty much like *Archaeopteryx*. In other words, still a reptilian bird, only earlier.[347]

All of which puts Gary Parker's treatment of this subject in the Richard Milton category of being oblivious to the content of his own sources. That's because much of this information (including an illustration of the fragmentary bones) appeared in the very first report on the find in the British journal *Nature* in 1986—which happened to be the only source Parker offered for his *Protoavis* argument. Showing neither equivocation nor caution, Parker conjured up that "quarry full of bird bones" in complete defiance of the *Nature* text.[348]

Parker's "jump the gun" readiness to accept *Protoavis* in 1987 as conclusive in spite of his own skimpy source material only sets a model for how the fossil has been handled since. Richard Milton offered no indication that he had examined any of the underlying issues when he pronounced that "true birds, essentially the same as modern birds, were flying happily in the skies of Texas" back in the Triassic.[349]

But all these are isolated discussions. From a scholarly point of view, though, it is considerably more revealing to follow repeated arguments, where the implications of parasitical or evasive citation are harder to conceal.

In this area, the extensive trail of breadcrumbs laid down by Duane Gish neatly fits the bill. In 1990 Gish dropped *Protoavis* alongside another proposed fossil bird in his children's book, *The Amazing Story of Creation*. The scholarly problem was that by then still more information had surfaced about how iffy Chatterjee's find was, such as the very skeptical discussion of it that appeared in Gregory Paul's *Predatory Dinosaurs of the World*.[350]

Whether Gish was simply unaware of this can't be decided on the basis of his citations or bibliography, because *The Amazing Story of Creation* didn't give any. Instead he decided *italics* could best substitute for description, and put his trained bird act through the paces:

> A few years ago, a paleontologist found the fossils of a modern bird and concluded, from the evidence, that it had lived at the same time as *Archaeopteryx*. *Archaeopteryx* cannot be the ancestor of birds, if modern birds and *Archaeopteryx* lived at the same time.
>
> More recently, paleontologists found fossils of a bird in Texas that is supposed to have lived 75 million years before *Archaeopteryx*. If evolutionary thinking is followed, this bird should be more *reptile-like* than *Archaeopteryx*. But it is more *bird-like* than *Archaeopteryx*! Creation scientists conclude that *Archaeopteryx* was not an *intermediate* between *reptiles* and *birds*, but was a *bird*, especially created by God and preserved for us in the fossil record.[351]

Gish sounded much like the account in Wendell Bird's *The Origin of Species Revisited*, which came out the year before and paired the same information in the same order.[352]

The first concerned Utah paleontologist James Jensen's discovery of several bird-like femurs (*not* a complete bird, modern or otherwise) among the fossil jambalaya at the Late Jurassic Dry Mesa Quarry in Colorado, roughly contemporary with the European *Archaeopteryx*. Since the legs of bipedal dromaeosaurids and birds were so alike, without the rest of the animal you couldn't tell whether you were looking at an early more advanced bird, or an ancestral maniraptoran.[353]

Creationists unfamiliar with this background naturally seized the bird side of the argument, such as Luther Sunderland, whose posthumous book also appeared just prior to Gish.[354] Farther along the creationist daisy chain, Scott Huse probably drew on Sunderland's version when he jumped his even broader conclusion in 1997, also sans citation, that "fossils of modern birds have been found in the same rocks as Archaeopteryx."[355]

When Gish touched on *Protoavis* next, in *Creation Scientists Answer Their Critics* in 1993, it was presumably clear Jensen's Jurassic "birds" weren't flying far, for he dropped them from his argument. Only now there was an even louder chorus of scientific doubt concerning Chatterjee's interpretation, which transcended the boundaries normally separating the two bird evolution camps. Don Lessem discussed it in his 1992 book, *Dinosaurs Rediscovered*—but more to our scholarly point, two short 1991 articles covered it: one in *Science* by Alun Anderson, and the other in *Science News* by Richard Monastersky.[356]

While the ever feisty Robert Bakker (one of the earliest modern boosters for the theory that birds are directly evolved from dinosaurs) was impressed with Chatterjee's fossil, Alan Feduccia (who ought to have leapt at a Triassic ancestor to trump the dinosaurian *Archaeopteryx*) considered it at most a peculiar reptile. Even Chatterjee's staunchest defender, paleontologist Larry Martin, didn't think *Protoavis* necessarily had feathers or could fly—which would have made it rather unusual were it the "modern" bird creationists were claiming.

The lethargy of his scholarship showing, all Gish added to his 1993 resources was one other 1986 account of the original find in *Science News*. That and the *Nature* piece Parker used were enough for Gish to flesh out his foregone conclusions. But a further measure of Gish's wishful thinking was reflected in his opening sentence—we already know what Gish had to say in his fuller argument two years later about the supposed "bird-like" nature of *Archaeopteryx*, so his opening salvo this time began with an objective dud:

> It might be noted here that every recent investigation of important structures in *Archaeopteryx* has shown them to be bird-like rather than reptile-like. Furthermore, a very recent find of fossil birds in Texas has greatly strengthened the case for the creationist side. Sankar Chatterjee and colleagues at Texas Tech University have discovered the fossil remains of two crow-sized birds near Post, Texas. These fossils were recovered from the Dockum Formation, allegedly 225 million years old. Therefore, these fossil birds are supposedly 75 million years older than *Archaeopteryx*. Evolutionists would, of course, expect that fossil birds 75 million years older than *Archaeopteryx* would be considerably more reptile-like than *Archaeopteryx*. Just the reverse is true, however! The fossil bird discovered by Chatterjee (named *Protoavis*, for "ancestral bird") had, for example, a keel-like breastbone, a skull entirely like that of modern birds, and hollow bones, in addition to all of the other bird-like features possessed by *Archaeopteryx*. A date of 225 million years for this newly discovered fossil bird would place it right at the time the dinosaurs supposedly first appeared, destroying a popular notion that birds had evolved from dinosaurs. In any case, rather than getting a fossil of a creature just emerging from its supposed reptilian ancestor, evolutionists got a bird even more bird-like, if anything, than *Archaeopteryx*, supposedly 75 million years younger. So much for the ancestral status of *Archaeopteryx*![357]

You'll notice Gish discretely left out any mention of the teeth and tail *Protoavis* had. But then, given how "bird-like" the reptilian *Archaeopteryx* has been for him, those oversights were only to be expected.

A master of the opportune omission, Gish proved no less addicted to it when he turned to *Protoavis* for the third time in 1995. Included among his citations now were the aforementioned 1991 Anderson and Monastersky pieces, which meant Gish was just catching up to where his research ought to have been in 1993. But since he did cite them, we could sit back and observe how he dealt with all those unpleasant opinions about *Protoavis*. Judgments like the one Feduccia made: "Calling this the original bird is irresponsible."[358]

Knowing the extent of what Gish was by then aware (assuming, of course, that he had read his own citations), what he had to say (and not) about Chatterjee's Triassic "bird" in *Evolution: The Fossils STILL Say NO!* was a model of circumlocution:

> Recent events cast even further doubt on *Archaeopteryx* as a transitional form. If the claims of Sankar Chatterjee prove to be valid, then certainly *Archaeopteryx* could not be the ancestral bird, and dinosaurs could not be ancestral to birds. Chatterjee and his co-workers at Texas Tech University claim to have found two crow-sized fossils of a bird near Post, Texas, in rocks supposedly 225 millions years old—thus allegedly 75 million years older than *Archaeopteryx* and as old as the first dinosaurs.
>
> If Chatterjee is right, his fossil bird is as old as the oldest fossil dinosaur. How could dinosaurs then be ancestral to birds? Chatterjee claims that the forelimbs, shoulder, hip girdles, and skull are definitely bird-like. His reconstruction also shows portals extending from the rear of the skull to the eye socket—a characteristic of modern birds not seen in any dinosaur—as well as a flexible neck, binocular vision, and a large brain, which are features of modern birds. In fact, Chatterjee claims that his fossil bird, which he has named *Protoavis*, is more bird-like than *Archaeopteryx*, since it has a substantial keel-like breastbone, or sternum, and hollow bones. If Chatterjee's analysis is correct,

> then obviously neither dinosaurs nor *Archaeopteryx* could be ancestral to birds. Furthermore, if birds really did evolve from reptiles of some sort, then a bird 75 million years older than *Archaeopteryx,* or 225 million years old, should be extremely reptilian. Chatterjee's *Protoavis,* according to Chatterjee, is just the opposite, even more bird-like than *Archaeopteryx.* Chatterjee finally published a scientific paper on *Protoavis,* but he included a description of the skull only. This publication, including his bold claim that *Protoavis* was a bird in the full sense of the word, has generated intense controversy. This controversy has been described in detail.[359]

Apart from a flurry of conditional "ifs" and a paltry concession to the "intense controversy" at the end (details of which he declined to share with his readers), Gish was sticking to his guns.

But that wouldn't account for that "substantial" keel-like breastbone *Protoavis* had in this third version. Had the fossils *grown* in the intervening two years? He certainly didn't get this datum from looking at either Chatterjee's reconstruction or the photograph of the original material, which showed a modest feature barely more "substantial" than the latest *Archaeopteryx* find (data Gish presumably knew about based on his own reference trail).[360]

The evolution of Gish's *Protoavis* triptych showed how Creation Science's most articulate defender was embarked on an almost hallucinatory disconnection from the grubby facts. And all this while paleontologists were discovering those genuinely impressive articulated Cretaceous birds that Gish did *not* discuss.

But the story gets even better, for Gish's *Protoavis* argument percolates through the antievolutionary daisy chain in an especially interesting way.

As it happens, Gish's footnote for Alun Anderson's article had misspelled his name, as "Alan" Anderson. While this may constitute evidence that Gish might not have read the original himself, it indisputably acts as a tracer for anyone haphazardly relying on *Evolution: The Fossils STILL Say No!* Such as Hank Hanegraaff, clearly in full Miltonian scholarly mode when *The Face that Demonstrates the Farce of Evolution* lifted Gish's 1995 version of *Protoavis* wholesale, complete with the misspelled footnote diligently copied from Gish's book.[361]

Phillip Johnson may not have paid the slightest attention to this portion of Hanegraaff's book when praising the references given by the Bible Answer Man, but that could be because *Protoavis* didn't play a particularly notable role in his argument.

Johnson had briefly alluded to the matter in *Darwin on Trial*: "A paleontologist named Chatterjee claims to have found fossil evidence of a bird he calls Protoavis, in Texas rocks estimated to be 225 million years old. Bird fossils substantially older than 145 million years would disqualify *Archaeopteryx* as a bird ancestor, but Chatterjee's claim has been disputed."[362]

As this observation was in one of Johnson's explanatory footnotes rather than in the main text, it may have been a late inclusion. There were no references, nor did Johnson elaborate on either the find or the dispute over its significance in his subsequent books.

And why should he? Johnson's approach to paleontology has not required any interaction with the data. Indeed, his preferred method has been to simultaneously concede the facts while rendering them harmless.

Compared to Creation Scientists bogging down on the anatomy of *Archaeopteryx*, Johnson's argument was one of breathtaking simplicity:

> *Archaeopteryx* is on the whole a point for the Darwinists, but how important is it? Persons who come to the fossil evidence as convinced Darwinists will see a stunning confirmation, but skeptics will see only a lonely exception to a consistent pattern of fossil disconfirmation. If we are testing Darwinism rather than merely looking for a confirming example or two, then a single good candidate for ancestor status is not enough to save a theory that posits a worldwide history of continual evolutionary transformation.

> Whatever one concludes about *Archaeopteryx*, the origin of birds presents many mysteries. Flight had to evolve, along with the intricate feathers and other specialized equipment, including the distinctive avian lung. Possibly birds did somehow develop from dinosaur predecessors, with *Archaeopteryx* as a way station, but even on this assumption we do not know what mechanism could have produced all the complex and interrelated changes that were necessary for the transformation.[363]

This approach in *Darwin on Trial* was only widening a defensive trench begun by Michael Denton.

Like Johnson, Denton argued that the acceptance of transitional forms was in the end a matter of ideological predilection, not a conclusion compelled by objective characteristics. "As evidence for the existence of natural links between the great divisions of nature, they are only convincing to someone already convinced of the reality of organic evolution."[364]

Denton could freely acknowledge the specifics of fossil sequences (even ones so extensive as that chronicling the reptile-mammal transition) because he promptly upped up the ante by requiring the preservation of internal organs before conclusive inferences could be drawn.[365]

Since we know how rare *Lagerstätten* are, that was one safe bet.

The problem with this attitude was that if applied rigorously it would demolish comparative anatomy as a discipline. Take a Pleistocene era fossil saber tooth cat, for instance. The message of its bones would say "mammal"—but without preserved organs how exactly would one go about *proving* that? Especially to someone ideologically committed to it *not* being a mammal. This is particularly relevant when we get closer to home, for without soft tissues to go by how would you know that fossil "humans" were *really* human? Denton's argument was just the sort of thing you'd expect from an armchair antievolutionist with no professional comprehension of (or philosophical inclination to find out) what it means to *do* paleontology.[366]

When Johnson spoke of "testing Darwinism" that consisted of simply imposing another hurdle as Denton had.

No longer would it matter what pattern was discerned in the fossils, or how many specimens you lined up to document it. Evolutionists would have to present their completed physiological package deal up front—a sort of paleontological analog to the exclusionary rule in jurisprudence.

The only difficulty with this is that natural sciences don't function that way. In fact, they *can't* function that way. Hypothesis formation starts with the available evidence and works out the inferences as you go, trying to resolve what you can with what you have.

By demanding just one more piece (and maybe one more besides) Johnson never does quite specify how much would be *enough*.

As a practical matter, feathers can be linked to reptilian scales by their very composition, so how far down in the genetic basement must science rummage before Johnson's "theistic realism" would allow those Cretaceous nearly-birds to start telling us something about their development? We can see the fossils, with their ever-enlarging sternums, to which muscles would have been attached, and for which a host of neurological control mechanisms would have been in play. Without the repeal of comparative anatomy, it sure looked like their flying capacity was evolving—must we know *exactly* how before the sequence can even be acknowledged?

Unless we can jump into the Wayback Machine and look at a living *Eoalulavis*, we're back at the trilobite eye problem again.

Johnson's dwelling on "mechanism" sounds ever so reasonable—that is, until you stop to remember that this is embedded in an argument that has consistently bypassed all the necessary detail. It has been evolutionists, not creationists, who have been examining the morphology of feathers, uncovering their genes and developmental processes. It has been paleontology, driven by the imperative of working out the true relationship of life on earth, which has amassed such a significant body of fossil evidence pertaining to that transformation, ignored *en bloc* by the antievolutionary movement.

Even more fundamentally, of all the many antievolutionary treatments of *Archaeopteryx*, not one described what "types" or "kinds" were involved, let alone the criteria for their comparison. Since many creationists theoretically concede speciation within a type, how then are they to exclude *from their own theoretical framework* the possibility that modern birds are merely variations on the "archaeopterygid type"—or the "feathered theropod type" for that matter?

You can be certain that no creationist is ever going to connect those dots, otherwise will have conceded a macroevolutionary transition. So the "types" and "kinds" have to be kept safely locked in the analytical tool shed, always polished, as never used.

This inability to conceptualize both their own argument and the criteria for accepting or rejecting a contrary position represents a core defect in the logic of antievolutionism. A new contender for record holder in this department would be the chapter Jonathan Wells devoted to *Archaeopteryx* in *Icons of Evolution*. While *Protoavis* came up briefly, Wells accepted its controversial character and didn't contend that it unseated *Archaeopteryx* from the lineage of birds.[367]

Instead, Wells switched the subject from ancestry to descendants. After noting that *Archaeopteryx* "had toothed jaws like a reptile, rather than a bird-like beak, and it had a long, bony reptile-like tail," Wells wrote:

> But there are too many structural differences between *Archaeopteryx* and modern birds for the latter to be descendants of the former. In 1985 University of Kansas paleontologist Larry Martin wrote: "*Archaeopteryx* is not ancestral of any group of modern birds." Instead, it is "the earliest known member of a totally extinct group of birds." And in 1996 paleontologist Mark Norell, of the American Museum of Natural History in New York, called *Archaeopteryx* "a very important fossil," but added that most paleontologists now believe it is not a direct ancestor of modern birds.[368]

Just as Gish had done above with the *Protoavis* "controversy," though, Wells never explained anything about those "many structural differences between *Archaeopteryx* and modern birds," so that his readers might judge for themselves how serious a problem this was. That would have required investigating the Cretaceous flock, of course—which as we saw last chapter, Wells also did not do.[369]

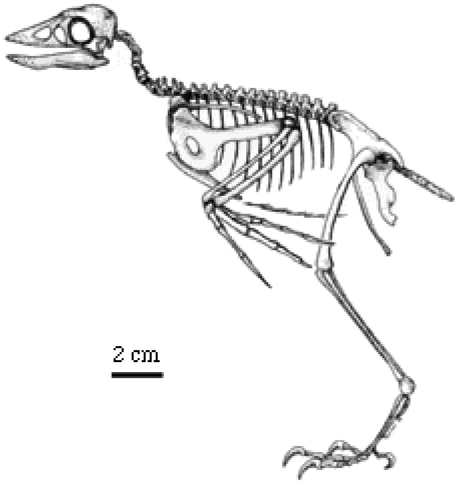


Figure 33. The Early Cretaceous enantiornithine bird *Confuciusornis sanctus*. Note the presence of a toothless beak and shortening tail, showing up somewhat ahead of the similar adaptations to appear in the rival ornithines. Illustration from *rainbow.1deo.columbia.edu.courses/v1001/clover16.html*.

The anatomical details are straightforward enough. *Archaeopteryx* has been included among the subclass Sauriurae with the earliest birds, the enantiornithines ("opposite birds") that dominated the Cretaceous. An example would be *Confuciusornis* (Figure 33) from the Yixian *Lagerstätte*, which dates from the same time as one of the earliest of the ornithines, the still-toothed *Liaoningornis*. The Enantiornithes differ from later birds chiefly in having a "triosseal canal" (a slot along the coracoid bone) and having the metatarsal bones of their feet fusing in the opposite direction (proximal to distal) from that of modern birds.[370]

To see whether this poses as big a problem for evolution as Wells wanted, consider a hypothetical fossil "bird" lacking a triosseal canal and frameshifting some regulatory genes so that the metatarsals reversed their fusion sequence. Given how Wells tried to use Martin and Norell's quotes, by his own logic wouldn't such a discovery have to be admitted as a legitimate candidate for bird ancestor?

But we know that the dearth of Jurassic *Lagerstätten* means that such a fossil might easily have escaped detection. So to clinch his argument, Wells would need to go a few steps further. He would need to define the limits within which he is willing to permit forms to vary (delving into coracoid genetics perhaps). Then relate that to the known fossil record (where birds objectively show a decline in reptilian characters over time) as well as whatever ID schema he thought might account for that record apart from descent with modification from some nonavian.

The result would be a chain of reasoning that would distance modern birds from *Archaeopteryx* and Enantiornithes because our hypothetical perfect ancestor could not in principle have been related to them.

I was understandably curious about whether that depth of reasoning was part of Wells' repertoire. After all, he might have had an encyclopedic grasp on the ins and outs of Mesozoic fauna and the relevant developmental biology that he simply neglected to include in his book—aimed at a general readership—but about which he could readily discourse if only suitably prompted.

There was one way to find out. On April 23, 2001 I wrote to Wells:

> Having read your recent book, *Icons of Evolution*, I am curious about the issue of how intermediate fossils are to be identified in the fossil record, that they might provide the proper testing of the record against either materialistic evolution or its various alternatives.
>
> In the case of birds, for instance, which are believed by evolutionists to have evolved from some manner of reptile, suppose that a perfect intermediate (or series of them) were indeed discovered in the fossil record. What would such forms look like in order to satisfy all sides in the debate? In what respects would a particular instance of such an intermediate differ, say, from existing fossils like *Archaeopteryx*?

Here is Wells' prompt reply of April 25th, in its entirety:

> I'm not sure I can adequately specify "how intermediate fossils are to be identified in the fossil record," though *Archaeopteryx* would be a very poor candidate in any case, since it lacks both the anatomical features and the stratigraphic (i.e. chronological) position to satisfy even those people who are determined to find intermediates between reptiles and birds.
>
> But even a near-perfect sequence would not decide the issue for or against materialistic evolution, as Berra's Blunder shows. A mere sequence of intermediates is just as compatible with intelligent design or separate creations as it is with materialistic descent with modification, as I point out in my chapter on homology. What we would need in addition to such a sequence would be a natural mechanism that produces it without the need for intelligent intervention. The principle mechanism proposed by neo-Darwinists—changes in genetic programs—doesn't fit the evidence. So the matter remains unresolved.[371]

But I hadn't asked him to defend *Archaeopteryx* as a suitable intermediate. I wanted to know whether he could explain in what way indisputable intermediates could be distinguished from *Archaeopteryx*. Repeating his mantra about the inadequacy of *Archaeopteryx* therefore committed a fairly rudimentary error in analytical logic. If you're claiming there are no Buicks in the junkyard, wouldn't you have to have some idea of what a Buick is supposed to look like? Otherwise, how would you know you weren't already looking at Buick parts?

You'll notice also that I had not stipulated a "near perfect" sequence. I had asked for his conception of *conclusive* evidence. With that substitution Wells demonstrated his agility at insulating his position rather than clarifying it.

But his reply did resolve one thing: Wells was trying to navigate through Deep Time without anything like a working roadmap. He did this by his reminder to me about how *Archaeopteryx* was in the wrong stratigraphic position to settle the issue of bird evolution.

In what possible sense could Wells have thought that claim true? *Archaeopteryx* predates all modern birds, and lived long after the origin of the archosaurs from which they might have been derived. Thus if there is one thing about *Archaeopteryx* that is incontestable, it is that it is *temporally* intermediate.

What Wells appeared to be doing in his letter was conflating his *Icons of Evolution* argument about how specific fossil examples (from *Compsognathus* to *Deinonychus*) might be nudged off the broad path from diapsids past *Archaeopteryx* to pigeons. He was very diligent about quoting sources to affirm that this or that taxa wasn't directly related to this or that subsequent animal. For example, that *Coelophysis* wasn't "considered ancestral to *Archaeopteryx* because, like *Compsognathus*, its features are not those one would expect in an ancestor."[372]

Of course Wells didn't explain what "features" (*plural*) would be expected in an ancestor. Or whether they would make any difference to him if such an animal were discovered.

Wells had cited two references for that claim: Robert Carroll's *Vertebrate Paleontology and Evolution* from 1988, and the 1998 book *The Mistaken Extinction: Dinosaur Evolution and the Origin of Birds* by Lowell Dingus and Timothy Rowe. Yet neither source had specifically excluded *Coelophysis* from bird ancestry. Indeed, the page numbers for Carroll referenced by Wells had missed the bird (ornithines) part completely, nabbing instead sections on theropods and a bit on *Ornithischian* dinosaurs.[373] In that venue, Carroll had mentioned *Coelophysis* briefly to contrast its pubic bone with the reverted arrangement among Ornithischians. Wells may also have inferred that *Coelophysis* was a more distant relative of birds from a chart in *The Mistaken Extinction* that put it on a side branch of the Theropoda node of a phylogenetic map of Aves origins.[374]

Any fossils in that group would be fairly representative of whatever specific taxon happened to have spawned the lineage to birds. And as you move up the phylogenetic branches, the relevant similarities of the members of each node become more like that of birds. That's what cladistic analysis is supposed to do: provide empirical underpinnings for a phylogenetic map of maximum parsimony.

Compsognathus belongs to a group farther up the map than *Coelophysis*, and consequently its features are more like that of birds. Which of course Wells knew: "One specimen of *Archaeopteryx* (collected in 1951) in which feathers were not immediately recognized was even misidentified as *Compsognathus* for several years."[375]

How could that be possible unless they were a lot alike?

Things like the ankle structure of birds, noted by 19th century anatomists. As Dingus and Rowe explained: "During growth, the 'solid' foot of adult birds begins with all the parts that remained separate throughout life in *Compsognathus*. Among reptiles, only *Compsognathus* exhibited this pattern, hence dinosaurs were the closest reptilian cousins of birds."[376]

Here is where biologist Wells needed to switch on the inferential engine and think *biologically*.

Since morphology is due to genetics, wouldn't the existence of a dinosaur so anatomically similar to *Archaeopteryx* that it was repeatedly confused for it mean that the group to which *Compsognathus* belonged possessed some genes very similar to it?

At this stage Wells might have paid attention to something else Carroll had to say about *Compsognathus*. It's one of the smallest dinosaurs—and small critters are harder to find in good condition. Indeed, *Compsognathus* is known from exactly two specimens (take note, neither of them with their hands preserved in pristine condition).[377] Connect that with something Dingus and Rowe had written: "The fossil record of theropods is not very good, probably because their hollow skeletons rarely withstood the dynamics of sedimentation and burial. Most known theropod skeletons are incompletely preserved, and gaps spanning tens of millions of years still punctuate our knowledge of theropod history."[378]

Was it then impossible for the genetic package of that group to have been inherited by relatives not trapped in the Solnhofen limestone, ones not hampered by whatever it was that distinguished *Compsognathus* from birds?

And while we're about it—what did distinguish *Compsognathus* from birds?

Again, Wells never said. But Carroll had: "There is great overall similarity to *Compsognathus*, but this genus is too late in time (as a direct contemporary of *Archaeopteryx*) and too specialized in the reduction of the manus to two digits. No other adequately known theropod appears to be an appropriate ancestor."[379]

That was it. The *Archaeopteryx* contemporary and lookalike *Compsognathus* lacked one finger.

As the number of digits in the vertebrate hand is modulated by alanine repeats in the *Hoxd-13* gene, the mutations required for *Compsognathus* to lose a finger would appear to have been comparatively modest.[380] Given also the ubiquitous tendency for dinosaurs to reduce the number of their fingers and toes, just how extraordinary would it have been for an ancestor of *Compsognathus* to have a third one, just like *Archaeopteryx*? We know that a relative of *Compsognathus*, the feathered *Sinosauropteryx*, did have three fingers—and subsequent evaluation of the original *Compsognathus* suggests it may have had the third digit too, but simply missed in its fragmentary state.[381]

Since neither the detailed paleontology nor the developmental angle ever arose in Wells' book, he didn't have to think about these things. But then, given his letter to me, would it have changed his mind if *Compsognathus* had had three fingers? You get three guesses.

Wells' Deep Time navigation skills failed again when he got around to dealing with the Cretaceous maniraptorans like *Deinonychus*:

> Ironically, once cladistics took over and similarity became the *only* criterion for relationships, paleontologists found that the most likely candidates for the ancestor of *Archaeopteryx* lived tens of millions of years *later*. It was no longer its contemporaneity with *Archaeopteryx* that ruled out *Compsognathus* as an ancestor, but the fact that it didn't have the right features. According to the cladists, the animals with the right features were bird-like dinosaurs that lived in the Cretaceous period, long after *Archaeopteryx* had become extinct. But then, in order to make bird-like dinosaurs the ancestors of birds, the fossil evidence must be re-arranged. (Figure 6-2)[382]

Everything about this passage is absurdly confused and inaccurate.

We'll skip over whether Wells was proposing that relationships be founded on *dissimilarity*. Instead, we have to wonder what Wells was thinking about *relationships*.

No paleontologist was saying something like *Compsognathus* couldn't be on the bird lineage because the maniraptorans were even closer to the root. Cladistic analysis was only suggesting that group to which *Compsognathus* belonged lay farther back on the line of descent than the maniraptorans. Saying that your father is your ancestor doesn't mean your grandfather isn't your ancestor too.

But the viscera of Wells' argument turn on the biostratigraphy of that Figure 6-2. That was the "Cladistic theory and the fossil record" chart mentioned in the last chapter, concerning Wells' lack of discussion of Cretaceous birds.[383]

Given the fact that all known *Archaeopteryx* fossils come from a single deposit, we have to wonder how Wells has divined when they went extinct. They have to have gone by the wayside before the present, and if they were average they probably fizzled out after a few million years (as virtually every species has).[384]

But if Wells is going to switch on that side of the inferential engine, he had better not forget the other side. When did *Archaeopteryx* first appear?

That too we can't know, since we only have the one Solnhofen slice.

But these questions apply just as readily to the maniraptorans. We know *Deinonychus* existed in the Early Cretaceous. But when did it *appear*? As Wells' own source of Dingus and Rowe reminded, the theropod record is poor. But it's not entirely absent. Those same authors had specifically noted evidence for "nonflying maniraptorans" living in the *Jurassic*.[385]

Why then didn't he put that as part of the bar representing "Extinct Bird-Like Dinosaurs" on his chart?

Perhaps Wells simply missed it in his haste to marshal authority quotes. But however it came about, this is the reverse of what Wells was doing with the Cambrian. Instead of trying to ram as many phyla as close to the Explosion as he could (minus documentation) he was now overlooking evidence that suggested maniraptorans were at the very least contemporaneous with *Archaeopteryx*.

What has confused Wells along with all of the antievolutionists in this area is something that should be obvious to anyone operating with a working map of Deep Time. The Cretaceous maniraptorans get illustrated because those are the fossils that have been found comparatively complete. That's true for most of the Mesozoic, where the bulk of the taxa date from the Cretaceous because that's where the deposits are.

But paleontology marches on, and the maniraptorans get pushed farther back with each new discovery.

In 2002 a basal troodontid (*Sinovenator*) turned up from the Early Cretaceous, whittling down that gap with *Archaeopteryx* to about 25 Ma. But even before *Icons of Evolution* appeared, a fragmentary therizinosaurid coelurosaur was found from the Early Jurassic (50 Ma before *Archaeopteryx*)—and at least one Cretaceous therizinosaur had been found with proto-feather integuments. Combined with its anatomy, the existence of feathers puts therizinosaurs fairly close to the stem group for birds.[386]

While it is always possible that the paleontological dust will eventually settle in a new direction, at the moment the witty summary of Fastovsky and Weishampel will suffice: "Birds are dinosaurs. And not all the dinosaurs have gone extinct; one group, the birds, survives. What did dinosaur meat taste like? A trip to Kentucky Fried Dinosaur, or a mouthful of Dinosaur McNuggets can answer that question!"[387]

Episode Three

Hair

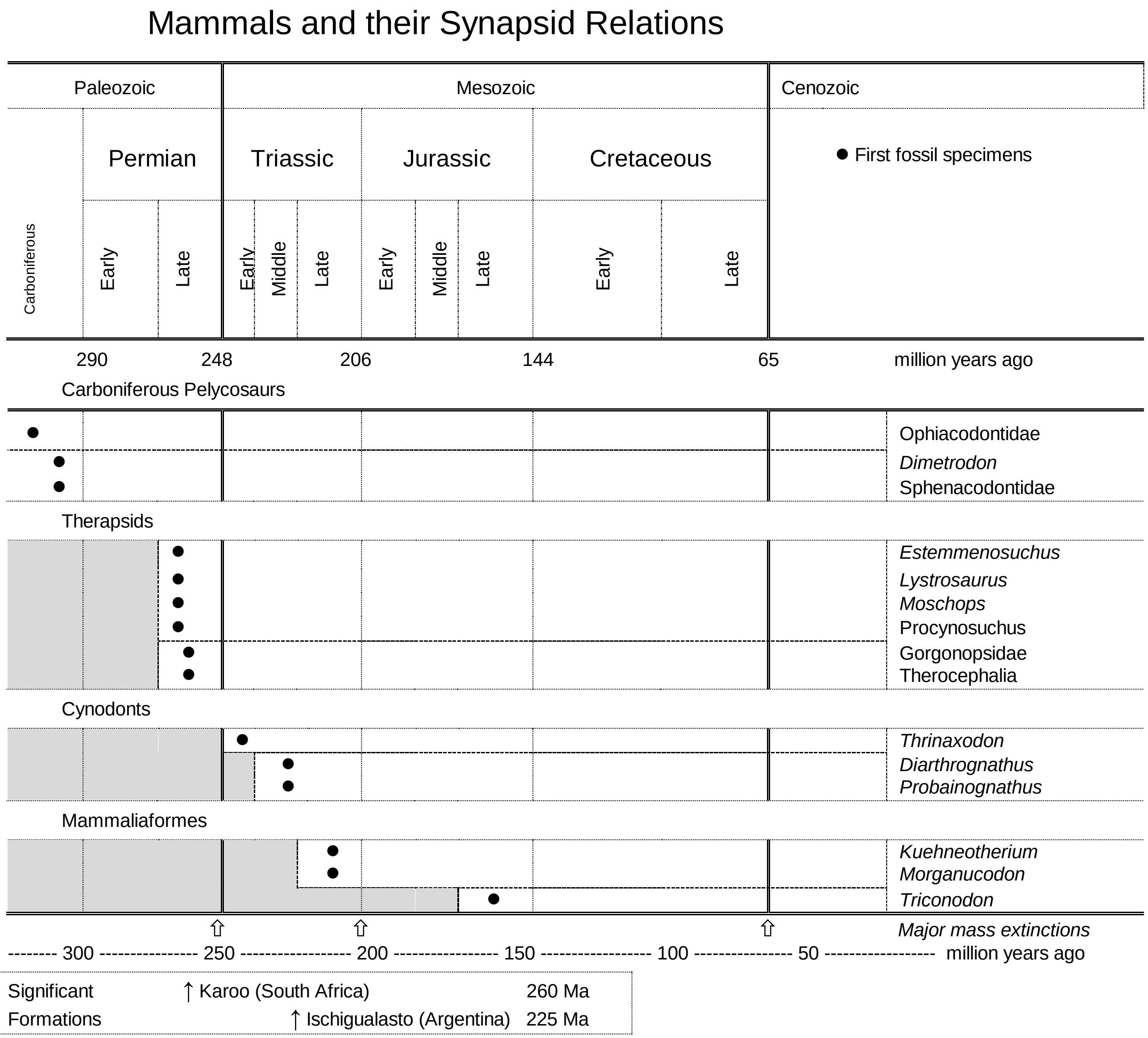


Figure 34. Main period and taxonomical dating from dinosauricon.com and Sidor & Hopson (1998).

Chapter 7. The Reptile-Mammal Transition

When Phillip Johnson insisted *Archaeopteryx* was only a “lonely exception to a consistent pattern of fossil disconfirmation” he stepped over a logical line. What would a “fossil disconfirmation” of Darwinian evolution (by which we mean “descent with modification” and “speciation through natural selection”) consist of?

In normal parlance this would be something that shouldn’t exist at all if Darwin’s theory of evolution were true—birds showing up in the Carboniferous period or a winged Pegasus appearing at any time. But that’s decidedly not what Johnson means by “fossil disconfirmation.” Here one might parenthetically note that he could hardly have presented concrete instances of true disconfirmation, for the fairly simple reason that (to date) there are none to give.

No, Phillip Johnson meant something very different by “fossil disconfirmation.” He was thinking exclusively about the absence of adequate intermediate series. But the failure to encounter something that ought to have existed is not the same thing as actively finding something that shouldn’t, and Johnson’s persistent confusion of the two is where the geological issues return to haunt Intelligent Design as much as Creation Science. We already know there are very good reasons why most fossils have never been preserved (such as the rock strata disappearing in the meantime through erosion). So unless Johnson wanted to venture some specifics, all his allusion to “fossil disconfirmation” represented nothing more than a comforting mantra.

Much like Michael Denton, Johnson seemed unaware of how paleontologists have been “testing” evolution at every dig. The next spade of earth could always turn up a genuine disconfirmation. But doesn’t that also allow for *confirmation* of the theory? Johnson seems not to have considered that possibility, or at least he never puts that spin on the history of paleontological discovery (which, as far as I can determine from his writings and my correspondence with him, he’s never substantively studied).

The vertebrate class to appear prior to Aves was our own Mammalia. While Darwinists believed mammals had evolved from some early reptile or amphibian, it wasn’t until well into the 19th century that the first fragments of intermediates started to show up—and not until the 20th century for the really hot evidence to be found. So does it not then count as some manner of “confirmation” that curious animals possessing exactly the right transitional characteristics to qualify as a mammal ancestor really had existed, just as the naturalistic theory expected? As Henry David Thoreau once remarked, some circumstantial evidence is conclusive—like finding a trout in the milk.[388]

Having examined how antievolutionists have approached the bird side of the diapsid equation in the previous Episode, we need to see if they do any better when it comes to the other macroevolutionary episode tracking back into class Reptilia. In the context of Johnson’s mantra, we need to know from creationists in what respect the proposed transitional mammal fossils “disconfirm” the evolutionary expectation.

Turning to *Darwin on Trial*, Johnson covered this extremely salient topic with about the same amount of text he devoted to the Cambrian Explosion:

> We come at last to the crown jewel of the fossil evidence for Darwinism, the famous mammal-like reptiles cited by Gould and many others as conclusive proof. The large order *Therapsida* contains many fossil species with skeletal features that appear to be intermediate between those of reptiles and mammals. At the boundary, fossil reptiles and mammals are difficult to tell apart. The usual criterion is that a fossil is considered reptile if its jaw contains several bones, of which one, the articular bone, connects to the quadrate bone of the skull. If the lower jaw consists of a single dentary bone, connecting to the squamosal bone of the skull, the fossil is classified as a mammal.

In this critical feature of jaw structure, and in some other features, various "therapsids" approach the mammalian characteristics so closely that in some cases they could be reasonably classified as either reptiles or mammals. Gould's vivid description brings out the importance of this:

> The lower jaw of reptiles contains several bones, that of mammals only one. The non-mammalian jawbones are reduced, step by step, in mammalian ancestors until they become tiny nubbins located at the back of the jaw. The 'hammer' and 'anvil' bones of the mammalian ear are descendants of these nubbins. How could such a transition be accomplished? the creationist asks. Surely a bone is either entirely in the jaw or in the ear. Yet paleontologists have discovered two transitional lineages of therapsids (the so-called mammal-like reptiles) with a double jaw joint—one composed of the old quadrate and articular bones (soon to become the hammer and anvil), the other of the squamosal and dentary bones (as in modern mammals).

We may concede Gould's narrow point, but his more general claim that the mammal-reptile transition is thereby established is another matter. Creatures have existed with a skull bone structure intermediate between that of reptiles and mammals, and so the transition with respect to this feature is possible. On the other hand, there are many important features by which mammals differ from reptiles besides the jaw and ear bones, including the all-important reproductive systems. As we saw in other examples, convergence in skeletal features between two groups does not necessarily signal an evolutionary transition.

Douglas Futuyma makes a confident statement about the therapsids that actually reveals how ambiguous the therapsid fossils really are. He writes that "The gradual transition from therapsid reptiles to mammals is so abundantly documented by scores of species in every stage of transition that it is impossible to tell which therapsid species were the actual ancestors of modern mammals." But large numbers of eligible candidates are a plus only to the extent that they can be placed in a single line of descent that could conceivably lead from a particular reptile species to a particular early mammal descendant. The presence of similarities in many different species that are outside of any possible ancestral line only draws attention to the fact that skeletal similarities do not necessarily imply ancestry. The notion that mammals-in-general evolved from reptiles-in-general through a broad clump of diverse therapsid lines is not Darwinism. Darwinian transformation requires a single line of ancestral descent.

It seems that the mammal-like qualities of the therapsids were distributed widely through the order, in many different subgroups which are mutually exclusive as candidates for mammal ancestors. An artificial line of descent can be constructed, but only by arbitrarily mixing specimens from different subgroups, and by arranging them out of their actual chronological sequence. If our hypothesis is that mammals evolved from therapsids only once (a point to which I shall return), then most of the therapsids with mammal-like characteristics were not part of a macroevolutionary transition. If most were not then perhaps all were not.

The case for therapsids as an ancestral chain linking reptiles to mammals would be a great deal more persuasive if the chain could be attached to something specific at either end. Unfortunately, important structural differences among the early mammals make it just as difficult to pick a specific mammal descendant as it is to pick any specific therapsid ancestors. This baffling situation led some paleontologists to consider a disturbing theory that mammals, long assumed to be a natural "monophyletic" group (that is descended from a common

> mammalian ancestor) were actually several groups which had evolved separately from different lines of therapsids.
>
> Turning mammals into a polyphyletic group would make therapsids more plausible as ancestors, but only at the unacceptable cost of undermining the Darwinist argument that mammalian homologies are relics of common ancestry. Whether mammals evolved more than once remains an open question as far as fossils are concerned, but the prestigious George Gaylord Simpson lowered the stakes considerably by deciding that a group could reasonably be considered monophyletic if it descended from a single unit of lower rank in the taxonomic hierarchy. Having arisen from the order *Therapsida*, the class *Mammalia* was acceptable as a natural unit.
>
> If one does not stop with the reptile-mammal transition but continues the attempt to provide a coherent account of macroevolution into the mammal class itself, it becomes immediately apparent that there is a great deal more to explain than the differences in jaw and ear bone structure between reptiles and mammals. The mammal class includes such diverse groups as whales, porpoises, seals, polar bears, bats, cattle, monkeys, cats, pigs, and opossums. If mammals are a monophyletic group, then the Darwinian model requires that every one of the groups have descended from a single unidentified small land mammal. Huge numbers of intermediate species in the direct line of transition would have had to exist, but the fossil record fails to record them.[389]

As with his discussion of the Cambrian Explosion, just about everything in this passage about evolution's "crown jewel" was either misleading or outmoded.

But before filling in the absent details, there's a lesson to be learned by following how far Johnson thought to press his case, and on what basis he proposed to do it. Just as Gish couldn't resist the urge to sound technical, Phillip Johnson lays claim to his own turf: "I am not a scientist but an academic lawyer by profession, with a specialty in analyzing the logic of arguments and identifying the assumptions that lie behind those arguments."[390]

In "explaining" the reptile-mammal transition Johnson ended up revealing how creationists can be so persistently opaque to the implications of fossil evidence. In that respect Johnson performed a real service.

From the starting block of the therapsids Johnson first conceded Gould's "narrow point" (which we'll return to) then made four claims.

First, the features weren't conclusive because they could be convergent. Second, Darwinism requires a specific line of descent, and evolutionists only offer an "artificial" one. Third, ancestry from the therapsids comes at the unacceptable price of mammalian polyphyleticism. And fourth, so much of mammalian metabolism was unaccounted for anyway. Johnson then sprinted on to whales and bats and opossums—all without ever having actually touched on a single nominal example of the reptile-mammal transition he was supposedly discussing.

Now the spot where Johnson would justify these claims would be in his Research Notes. Structurally speaking, *Darwin on Trial* didn't employ direct footnotes for documentation, where a specific assertion was linked to an equally distinct citation. Instead his source material was laid out in what amounted to parallel essays at the back of the book. There was nothing intrinsically inappropriate about this—unless what evidence he presented didn't square up with what he claimed for it. In the Cambrian and *Archaeopteryx* examples the Research Notes hadn't amounted to much, but with the reptile-mammal transition Johnson offered something seemingly more substantive:

> The discussion of the mammal-like reptiles is based upon Stahl (Chapter Nine), as well as the pertinent chapters in Futuyma and Grassé. The quote from Futuyma on this subject is from p. 85 of *Science on Trial* and the quote by Gould is from the "Evolution as Fact and Theory" essay discussed in Chapter Five. Following the example of other writers I have lumped the mammal-like reptiles

> together as "therapsids," avoiding the use of more specific technical terms—cynodonts, theriodonts, etc.—that would distract the general reader unnecessarily. The mammal-like reptiles are also sometimes called the *synapsida*, the subclass to which the group belongs. The essential point is that wherever one draws the line around the group of eligible ancestors for mammals, it contains a range of groups and numerous species, no particular one of which can be identified conclusively as ancestral to mammals. A quote from Grassé (p. 35) is helpful:
>
>> All paleontologists note … that the acquisition of mammalian characteristics has not been the privilege of one particular order, but of *all the orders of theriodonts*, although to varying degrees. This progressive evolution toward mammals has been most clearly noted in three groups of carnivorous therapsids: the Therocephalia, Bauriomorpha and Cynodontia, each of which at one time or another has been considered ancestral to some or all mammals.
>
> James A. Hopson of the University of Chicago is a leading expert on the mammal-like reptiles, and he argues the case for their status as mammal ancestors in his article "The Mammal-like Reptiles: A Study of Transitional Fossils," in *The American Biology Teacher*, vol. 49, no. 1, p. 16 (1987). Hopson is not testing the ancestry hypothesis in the sense that I do so in this chapter, but attempting to show the superiority of the "evolution model" to the creation-science model of Duane Gish. To that end he demonstrates that therapsids can be arranged in a progressive sequence leading from reptilian to mammalian forms, with the increasingly mammal-like forms appearing later in the geological record. So far so good, but Hopson does *not* present a genuine ancestral line. Instead he mixes examples from different orders and subgroups, and ends the line in a mammal (*Morganucodon*) which is substantially older than the therapsid that precedes it. The proof may be good enough to make Hopson's specific point, which is that for this example some form of evolutionary model is preferable to the creation-science model of Gish, but his argument does not qualify, or purport to qualify, as a genuine testing of the common ancestry hypothesis itself.[391]

It was again so considerate of Johnson to spare the reader that unnecessary distraction of "more specific technical terms."

Though this solicitude also evaded the considerable issue of what (if anything) distinguished that subclass of *synapsida* from their reptile cousins, and would that have any bearing on deciding whether the therapsids were genuinely related to mammals? If the idea really were to "test" the Darwinian hypothesis, wouldn't this be a necessary point to pin down? That he did not address this issue meant it was implicit to Johnson's argument that the taxonomical particulars of the animals involved had no bearing at all. And in that void, how then could it be possible to decide whether a feature like Gould's "narrow point" of the mammalian jaw was a matter of "convergence" or not?

By *convergence* evolutionists mean a feature not inherited from a common ancestor, but one that appears similar because the animals faced comparable conditions and so produced like results independently. The wings of bats, pterosaurs, and birds are therefore not *homologous* structures (though the bones in them would be, having come from their mutual tetrapod vertebrate ancestors).

There are plenty of examples of such physical convergence.

Dolphins resemble the extinct ichthyosaurs, and saber tooth carnivores have cropped up several times in mammal history, in both placental and marsupial guise. We've already touched on how diet effected the shape of teeth in dinosaurs and birds. Along that trail Johnson might have mentioned the Early Cretaceous notosuchian crocodiles of central Africa, which had similar dentition and side-mounted eyes as the therapsids.[392]

Because morphology is ultimately a reflection of deep developmental processes, convergence of adaptive features may be telling something very important about how certain genetic loci "hot spots" could channel change among parallel lineages. Work on the genetic side is beginning to identify the genetic players, as more organisms are fully gene sequenced.[393]

But Johnson was pressing a lot farther in his convergence argument, which becomes apparent the moment you step back from isolated features like tooth shape or body proportions to look at the complete animal.

The skeleton of an ichthyosaur is reptilian—only the hydrodynamic outline looks like a dolphin (something Barbara Stahl's *Vertebrate History* explained rather nicely).[394] While lifestyle can dictate a lot about the features an animal has, the internal structure still betrays its lineage. One doesn't have to *imagine* that a few "mammalian" traits could develop through convergence, since they objectively did with the notosuchians. But that actually undermines Johnson's case, because convergence doesn't ripple through the whole animal clear down to the last tooth.[395]

What then does comparative anatomy *mean* in the new regime of "theistic realism"? Judging by *Darwin on Trial*, absolutely nothing. For not one of Johnson's sources was used to directly support the idea that the features so characteristic of the therapsids were plausibly the product of convergence. How then did Johnson arrive at this judgment? Was he relying on his own paleontological expertise here? "As we saw in other examples…."

Ah, there was the snag: *what* other examples? A check through the text revealed Johnson hadn't actually given any "other examples" of convergent skeletal features, let alone ones relevant to the specific case of the therapsids.

Homology was briefly mentioned, but no specific examples were given. There was a quote by Gould on the Australian marsupials, but that didn't allude to their convergent members, either. Nor did any of the usual instances of fossil convergence turn up in that guise. The coverage of *Coelacanth* (a "living fossil" survivor of the crossopterygian fishes that include the rhipidistians considered close to the origin of land vertebrates) or the amphibian *Seymouria* did not actually put the argument in convergent terms. Finally, "convergent evolution" was not among Johnson's index topics.[396]

So how did Johnson come by this view?

One likely suspect is Michael Denton, who had used the *Coelacanth* example (which didn't use its bony fins for walking) to conclude "many quite separate groups of mammal-like reptiles exhibited skeletal mammalian characteristics, yet only one group can have been the hypothetical ancestor of the mammals. Again, as with the rhipidistian fishes, the similarities must have been in most cases merely convergence."[397]

Johnson could have cited Denton on this point, of course, though that wouldn't have helped his case. First, because Denton hadn't even explored the rhipidistian example adequately, where the anatomical relation to early land vertebrates is profound.[398] Nor did Denton do better with the second clause of his logic: using "convergence" in an invalid manner, applying it to collectively derived therapsid characteristics rather than to ones of truly independent origin. Just because lots of therapsids were inheriting variants of the ancestral pattern doesn't mean that a specific lineage leading uniquely to mammals hadn't done that too.[399]

But Johnson hadn't cited anyone for his convergence argument, let alone Denton. So was this a case of absorbing reading so thoroughly that you forget where you get your own argument?[400]

Not that Johnson fared better when he did offer references.

The sources in his Research Notes were all marshaled for his second proposition that the therapsid series failed to qualify as an authentic line of descent. But these were eggs in a very unstable basket. Having just elbowed *Archaeopteryx* aside because there were too few fossils, Johnson was now faulting evolutionists for having too many!

What exactly would the "correct" number of transitional fossils be to satisfy creationist sensibility here?

Futuyma certainly hadn't claimed there was no single line of mammalian descent, only that there were many potential candidates to choose from in working out what that might be. So was there now a Johnson Corollary to Duane Gish's venerable "no cousins" rule? No animal can have ancestors if there were cousins that resembled it?

Johnson sounded even more like Gish in his reliance on the Grassé book, which in characterizing modern Neo-Darwinism as the "myth of evolution" has been mined for authority quotes almost as frequently as the *oeuvres* of Stephen Jay Gould.[401] While he questioned the degree to which current biological theory had accounted for it, Grassé apparently harbored no doubt that general evolution had occurred (considering it "a fact and not a hypothesis").[402] And although evolutionists like Theodosius Dobzhansky had specifically criticized Grassé for being behind the technical curve here (not dealing with the gene duplications and endosymbiotic events that could generate new genetic information), Johnson stepped past that.[403]

But Johnson wasn't even getting the fossil issue straight.

That synapsids were related to mammals was a taxonomical datum recognized even by Archetypalist Richard Owen.[404] Unfortunately, fossils are not uncovered all at once—nor are the first ones dug up likely to be either complete or representative of their taxa. So while various therapsid groups have been perceived as possible *direct* mammal ancestors "at one time or another," this doesn't mean they're regarded in quite the same way now. As the fossil picture accumulates, a specimen that might legitimately qualify as a potential ancestor, *based on what was known at the time*, could turn out to belong on a siding once more examples turn up.[405]

That's how paleontology works, as we've already seen in the case of dinosaurs, where Ostrom's discovery of a more complete *Deinonychus* forced the reassessment of bird ancestry.

Johnson's invocation of Grassé's 1975 misgivings about "the myth of evolution" certainly paralleled Gish's reliance on Ommanney's 1964 *Time-Life* fish quote. But by not explaining on what basis those taxonomical changes had taken place, Johnson poised on the same scholarly razor as Gish on *Archaeopteryx*: either he was aware of contrary information and didn't care to explain it, or he didn't know anything about it and wrote from ignorance.

In Johnson's case we can rule out the ignorance defense because of that Hopson article, which had done a splendid job of laying out the current fossil evidence and the justifications for their relationship.

Johnson's one technical assertion here—that *Morganucodon* "is substantially older than the therapsid that precedes it"—was simply wrong (as Hopson's figures 3, 6 & 10 made plain).[406]

But that muddle only begged a more telling point: as the synapsids represented an evolutionary progression from one order to the next, how could it be possible for a "genuine ancestral line" to be traced from a basal amniote to mammals *without* passing through them in some way? The only circumstance under which you would stay locked in the same order would be if there *hadn't* been any macroevolution.

Maybe we need a second opinion.

Paleontologist Robert Sloan discussed the mammalian "line of descent" issue in an anthology on creationism. Because the contingencies of fossil preservation are appreciated and applied in paleontology, Sloan recognized that "Thankfully we do not have to have the first species of each of these groups to understand what happened; a slightly later species will do as well." Sloan then illustrated the acquisition of mammalian characteristics from the early synapsid Ophiacodonta order, through the Therocephalia order, and finally to the Cynodonta. From there he homed in (as Hopson also had) on the single cynodont family Chiniquodontidae. Known from the Mid-Triassic on by such forms as *Probainognathus* preserved in the Ischigualasto Formation of Argentina, this is a perfectly satisfactory link to the earliest recognized mammal family in the primitive subclass of Eotheria, the Morganucodontidae of the Late Triassic.[407]

As *Morganucodon* was the only suspect in this lengthy tongue-twisting parade Johnson deigned mention by name, whatever artificiality there may have been about them couldn't be separated from creationist wish fulfillment. We have no idea how Johnson or any other inspired critic of evolution would draw the typological line between the therocephalians *Alopecognathus* and *Ictidosuchus* (two examples on Robert Sloan's chart of mammalian evolution) because they have yet to get around to drawing one.

This is no small oversight, for it evades a quite fundamental conceptual issue separating the evolutionary and creationist worldviews (explored further in Appendix III). If common descent is a fact of nature, then the only true and reliable taxonomy will be one that accurately reflects the evolutionary phylogeny of the animals involved. In that case, it will never be possible for antievolutionists to construct a workable typology.[408]

Of course that hasn't stopped creationists from acting as though they had accomplished this essential task. Thus in the Epilogue added to the 1993 edition of *Darwin on Trial*, Johnson ingenuously stressed that microevolution was "change within the limits of a pre-existing type, and not necessarily the means by which the types came into existence in the first place. At a more general level, the pattern of relationships among plants and animals suggests that they may have been produced by some process of development from some common source. What is important is not whether we call this process 'evolution,' but how much we really know about it."[409]

Only when it comes to really *knowing* about that "pattern of relationships," Johnson wants not only to have his typological cake while eating it. He also wants to skip the inconvenience of actually having to bake it first.

Now criticizing Creation Science is not one of Johnson's favored subjects.[410] So it was particularly interesting to see him simultaneously challenge Hopson's schema and try to use it as a stick to beat back Duane Gish.

Johnson's whole argument consisted of casting doubt on the idea that mammals might have descended from therapsids—as well as keeping the therapsids from connecting up with more basal "reptilian" amniotes at the other end. Per Johnson's own finicky criteria, what then would remain of the "evolutionary model" to put up in evidence against ICR creationism? What might "some form" of evolution take without either "descent" or "modification" being a part of it? Here was another grandiose instance where Johnson employed terminology so imprecisely as to vitiate all meaning.

This argument was doubly strange if you knew what Gish's "creation-science model" had said about the reptile-mammal transition. Gish's apologetic was no bundle of "young earth" blather and theological quotations. Aiming for much the same secular triumph as Intelligent Design, the loonier facets of Creation Science geochronology have been kept carefully shrouded in the corner. Instead Gish put forward the same argument Johnson had. He concurred that evolutionists only offered a contrived line of descent and similarly stressed how mammalian features like the reproductive system were unexplained. So if "some form" of evolution really were sufficient to banish Gish to the metaphysical hinterlands, on what logical grounds wouldn't that apply to Johnson?[411]

Gish parted analytical company with Johnson in only two respects. His penchant for technical exposition meant Gish actually discussed some of the specific taxa. And he clearly recognized their profound threat in a way Johnson evidently didn't—the jaw-ear transition was no "narrow point" to be casually conceded. Having synapsids with dual jaw joints appearing just before the first true mammals looked far too much like macroevolution to let stand, so Gish vigorously denied the facts in a show-stopping display of scholarly legerdemain. To establish how perfectly ordinary and reptilian the "therapsid" jaw configuration supposedly was, Gish chose for his examples the synapsid features retained by two early *mammals* (*Morganucodon* and *Kuehneotherium*). But he disguised this awkward bit by temporarily relabeling them "mammal-like reptiles" for the duration of the trick. Creation Science taxonomy in action is a marvel to behold.[412]

But challenging the details of the therapsid jaw observed in the Middle Triassic *Probainognathus* and the Late Triassic *Diarthrognathus* required Gish to perform some particularly tight citational acrobatics:

> It is significant that similar claims concerning a double jaw-joint in *Probainognathus* and *Diarthrognathus* have been questioned. *Probainognathus* and *Diarthrognathus* are represented as being very close to the hypothetical direct ancestors of mammals. Concerning *Probainognathus* Kemp states:
>
> > A second much quoted feature of *Probainognathus* that relates it to mammals is the secondary contact between the dentary and the squamosal. In fact, there is some doubt whether there is actual contact between these bones (Crompton and Jenkins, 1979)….

> With reference to *Diarthrognathus,* Gow states:
>
> > The ictidosaur, *Diarthrognathus,* from the Clarens Formation (Cave Sandstone) (Crompton, 1958) is generally held to exhibit the expected morphological grade intermediate between cynodonts and mammals; more specifically, it is thought to have both reptilian and mammalian jaw-joint. However, several of Crompton's interpretations of the morphology of the lower jaw and its articulation with the skull were wrong; some but not all of these he has conceded in print (Crompton, 1972).
>
> Thus we see that the notion that there was both a mammalian and a reptilian jaw-joint in these two creatures has been challenged from within evolutionary circles. These creatures are all extinct—all that remains is extremely fragmentary fossil material. The manner in which these creatures are reconstructed and their function is visualized is often critically affected by preconceived notions of what should be expected. Evolutionists feel certain that reptiles evolved into mammals. This would have required the replacement of the reptilian jaw-joint. With extremely fragmentary and incomplete material available, it is thus possible that what is being "seen" is what one expected to see rather than what was really there. Finally, and this is conclusive, not a single intermediate between an animal with a powerful, fully functional reptilian jaw-joint and a powerful, fully functional mammalian jaw-joint has been found. All reptiles, whether *Morganucodon* [!], *Kuehneotherium* [!], or whatever, had a full complement of reptilian bones in the jaw and all mammals, fossil or living, have a single bone on each side of the lower jaw. No intermediates have been found.[413]

Gish was arguing *Probainognathus* lacked the rudiments for the secondary jaw solely because paleontologists Arthur Crompton and Farish Jenkins (via Kemp) had wondered whether it had made "actual contact" at that stage. Then he spun around to intimate the later *Diarthrognathus* couldn't have continued that process because (via Gow) the same Crompton was wrong, at least regarding those "several" anatomical points Gish did not describe.

Lost in this merry seesaw of authority quotes was any sense of the fossil reality or paleontological history. The skulls of *Probainognathus* and *Diarthrognathus* available to Gish in the early 1990s objectively showed the physical proximity of the bones involved. Moreover, when *Diarthrognathus* was found in 1932 (it got its present name in 1958) its jaw layout exactly fulfilled a prediction Robert Broom had made back in 1912, when he deduced what an intermediate jaw structure had to have looked like to link reptiles and mammals. As Richard Aulie put it in 1974, such a prediction "can be expected in evolutionary theory but not in the doctrine of special creation."[414]

All this made for further irony. Gish had ended up expressing sentiments remarkably akin to those of a certain Berkeley lawyer (the duality of the therapsid jaw being merely in the eye of the evolutionary beholder). Meanwhile, forget about finishing off Gish—Johnson neglected to conclude his own chain of reasoning, for he never did get around to documenting his third claim about the dire implications of mammalian polyphyleticism. But that oversight only brought the sorry parade full circle, for by the time of *Darwin on Trial* the issue was as dead as a doornail, in good measure due to those very fossils (like *Probainognathus*) Gish had at least mentioned but which Johnson pointedly hadn't.[415]

To add insult to injury, the ninth chapter of Barbara Stahl's *Vertebrate History*, on which Johnson had purportedly based his fossil treatment, had discussed that very point at length. One may chalk off the recurring cast of characters here (human and fossil):

> By the late 1960s, Crompton and his colleagues F. A. Jenkins, Jr., and J. Hopson had formed a new opinion concerning the origin of the Mammalia. They think now that the triconodonts, docodonts, symmetrodonts, pantotheres, and

> perhaps even the multituberculates can be traced to a single line which emanated from one specific family among the Therapsida and thus that class Mammalia is monophyletic in a much narrower sense than that understood by Simpson. Their definition of a mammal continues to depend on the presence of the dentary-squamosal jaw joint rather than the absence of the articular from the mandible. However, by requiring that a mammal possess teeth that are not repeatedly replaced, that are (or primarily were) differentiated posteriorly into premolars and molars, and that are (or were at some time in their history) characterized by a primary cusp set between accessory ones in front and behind, they have excluded from the class Mammalia the tritylodonts, the cynodonts with crowned molars, and *Diarthrognathus* and its immediate relatives.
>
> The conviction on the part of Crompton, Jenkins, and Hopson that the mammals did constitute a monophyletic group stemmed from studies of newly discovered Upper Triassic fossils and reexamination of others of approximately equivalent age. The new material, which came from red beds in Lesotho in southern Africa, consisted not just of teeth but of skulls and postcranial bones belonging to animals eventually named *Erythrotherium* and *Megazostrodon*. From the structure of their teeth these animals proved to be mammals, rather than reptiles like the majority of the forms at the site.[416]

Stahl went on to explain that their teeth fit into the enlarging pattern in which the earliest mammals were logically derivable from the basal therapsid group, hence the current rejection of polyphyleticism. So we're back with what Douglas Futuyma had been saying in the first place, that the earliest mammals and the last therapsids overlapped so precisely that only miniscule diagnostic features separated them. Why then wasn't this sinking in for Johnson?

When it came to appreciating this evolutionary "crown jewel" Johnson appeared to be nursing his own Gish-class "hallucinatory disconnection." Of his first three shots he had offered relevant citation for only one—and those hadn't lived up to the claims being made for them. Even apart from the available literature he cited, Johnson's other two charges were directly contradicted by his own primary source of Stahl.

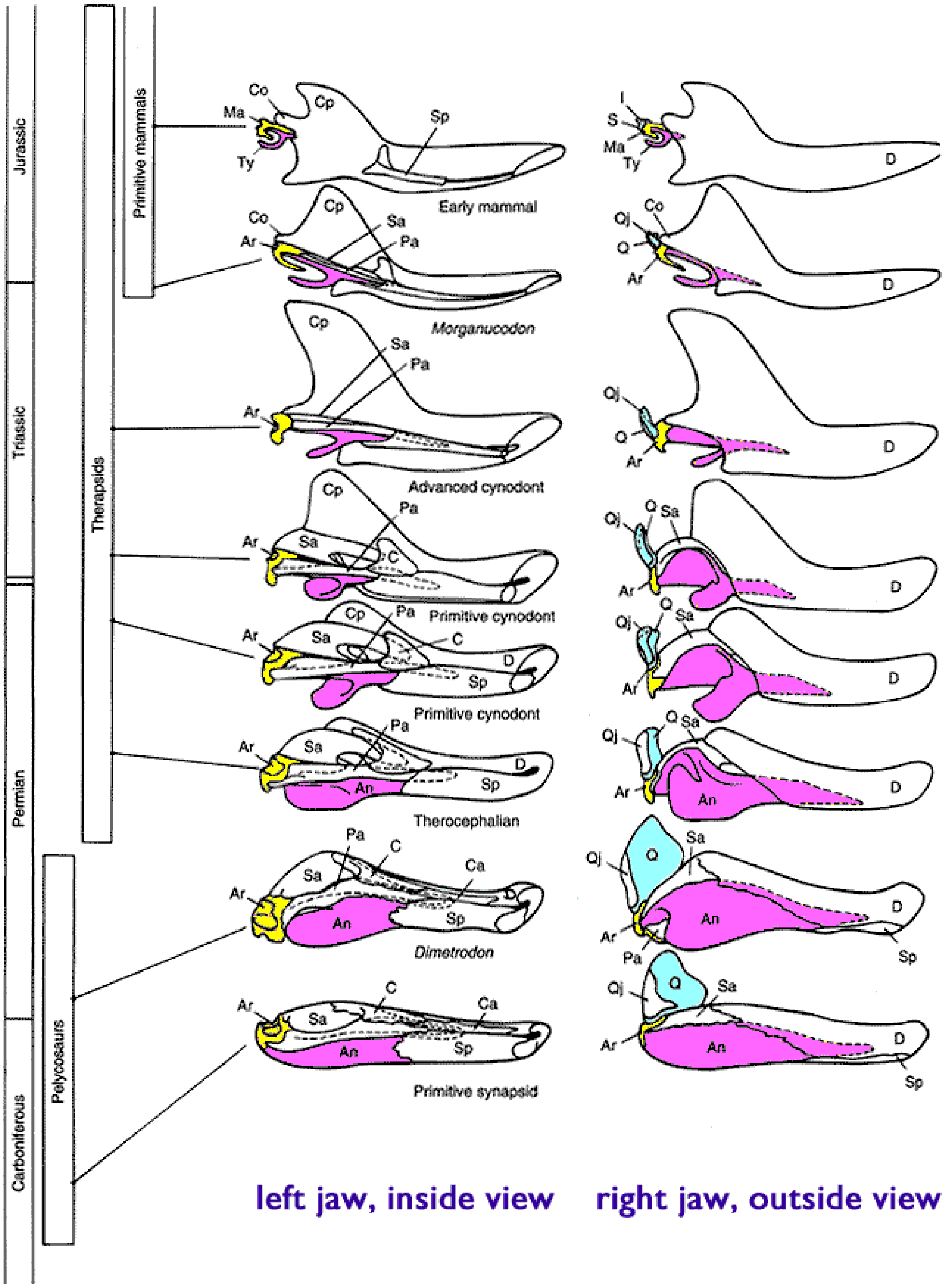
And, of course, we have those ghostly "other examples" hovering over the convergence claim, presumably reflecting his absorption of Michael Denton.

Looked at as a brief coming from someone professing special skill at "analyzing the logic of arguments," it wasn't so much that Johnson was approaching his subject with a biased eye, as that he wasn't approaching it at all. Little wonder how "narrow" the reptile-mammal obstacle appeared—from a mile away everything looks small, so why bother lugging around all that bulky scientific inference kit?

Johnson's fourth point was why.

That there are physiological distinctions between modern reptiles and mammals is obvious. Images of scaly crocodiles versus cuddly cats may jump to mind. But it is also true that there is considerable variety to both the "mammal" and "reptile" layouts. For example, the urogenital hardware differs significantly among the egg-laying monotremes, the marsupials and placentals, reflecting the diversity of tens of millions of years worth of diverging evolution. And crocodile hearts (intermediate between basal reptiles and the bird configuration) hints at how modern crocodiles are the less-adventurous remnant of a once more physiologically diverse lineage that included both sprinting and aquatic Mesozoic models.[417]

Next page **Figure 35.** Mammal jaw evolution schematic by K. V. Kardong, *Vertebrates: Comparative Anatomy, Functions, Evolution*, p. 274 (McGraw-Hill , 2000), images at Douglas Theobald's "29+ Evidences for Macroevolution (at *talkorigins.org/faqs/comdesc/section1.html*) or *daphne.palomar.edu/ccarpenter/reptile%20to%mammals.htm*. Abbreviations for shaded bones: An=angular, A =*articular*, I=*incus* (anvil), Ma=*Malleus* (hammer), Q=*quadrate*, Ty=*tympanic annulus*. Additional abbreviations: C=*coronoid*, Ca=*anterior coronoid*, Co=*dentary condyle*, Cp=*coronoid process*, D=*dentary*, Pa=*palatine*, S=*stapes*, Sa=*surangular*, Sp=*splenial*.


Jurassic
Triassic
Permian
Carboniferous
Primitive mammals
Therapsids
Pelycosaurs
Co
Ma
Ty
Cp
Sp
I
S
D
Early mammal
Ar
Sa
Pa
Qj
Q
Morganucodon
Advanced cynodont
C
Primitive cynodont
Primitive cynodont
An
Therocephalian
Ca
Dimetrodon
Primitive synapsid
left jaw, inside view
right jaw, outside view

But what sort of physiology would you expect a protomammal *ancestor* to have, and how would you go about detecting that condition in the fossil record? There are no Permian synapsids or advanced Triassic therapsids to look at, so everything about them has to be a matter of informed inference. Where do they fall on the spectrum between the biology of extant reptiles and that seen in a mammalian fur-ball?

It cannot simply be assumed that the "reptilian" metabolism of early diapsids or synapsids was interchangeable with their modern counterparts. That Johnson didn't think he even needed to investigate these questions suggested he considered the topic self-evident and settled. And that may be because he was relying once more on Michael Denton, whose view from the typological high ground was that "The possibility that the mammal-like reptiles were completely reptilian in terms of their anatomy and physiology cannot be excluded."[418]

But Denton had grounded this conviction not on a detailed examination of the many anatomical features (hair, more upright stance, etc.) that distinguished the later synapsids from their cousins, the anapsid and diapsid reptiles (information which Denton's source of Barbara Stahl had explained at some length).[419]

Instead, Denton singled out one blip of information: a 1968 comparison of the brain size of the mammal-like reptiles with an early mammal with a skull available for comparison, the Late Jurassic *Triconodon*, that suggested the reptile-mammal central nervous systems "were entirely reptilian." But *Triconodon* lived about *50 million years* after the Triassic mammals like *Morganucodon*, which were coming onto the paleontological scene at the very time Denton was writing (and thus as feasibly on Phillip Johnson's scope years later).

Those earlier fossils are the ones Denton should have been looking at. Unlike the far later *Triconodon*, the features of these earliest mammals (such as the jaw layouts shown in Figure 35) are so hard to disentangle from the late therapsids that the boundary between them has become almost arbitrary.

Chapter 8. Meaningless Concessions

While the Gould excerpt Phillip Johnson quoted was a perfectly adequate summary of the jaw-ear shift, it only covered the razzle-dazzle finale. It's the slower windup that puts the "reptile-mammal" tale of physiological evolution in perspective.

When basal amniotes first appeared over 300 million years ago they looked like slightly modified amphibians, their skulls composed of solidly fused bones with openings only for the eyes and nostrils. Those are the "without arch" *anapsids*, represented partially today by the plucky (but still considerably derived) turtles.

Interestingly, one of the amphibian characteristics absent in reptiles is a notch at the back of the skull, the otic arch, where amphibians have their external ears. This suggested the earliest amniotes might have been deaf. But computed tomography scanning of fossils of the Late Devonian *Ichthyostega* have recently revealed that at least that taxon found a way around that contingent inheritance, developing "a highly specialized ear, probably a hearing device for use in water."[420]

Now the idea of further descendants developing their hearing by the reconfiguration of the amphibian stapes bone (itself a modification of the hyomandibular bone in fish) underscores what Gould was saying about the last therapsids. Bone hijacking was an old vertebrate trick by the time the therapsids got into the game by rearranging parts of the jaw.[421]

This is the idea of "exaptation" (a neologism coined in 1982 by Gould and Elizabeth Vrba to cover what has otherwise been referred to as "preadaptations"). Anatomical features might develop in conjunction with some other function, only later to be *exapted* to new ends. That is how the blips of microevolution seen in each slice of Deep Time can sometimes cascade into macroevolutionary transformations.

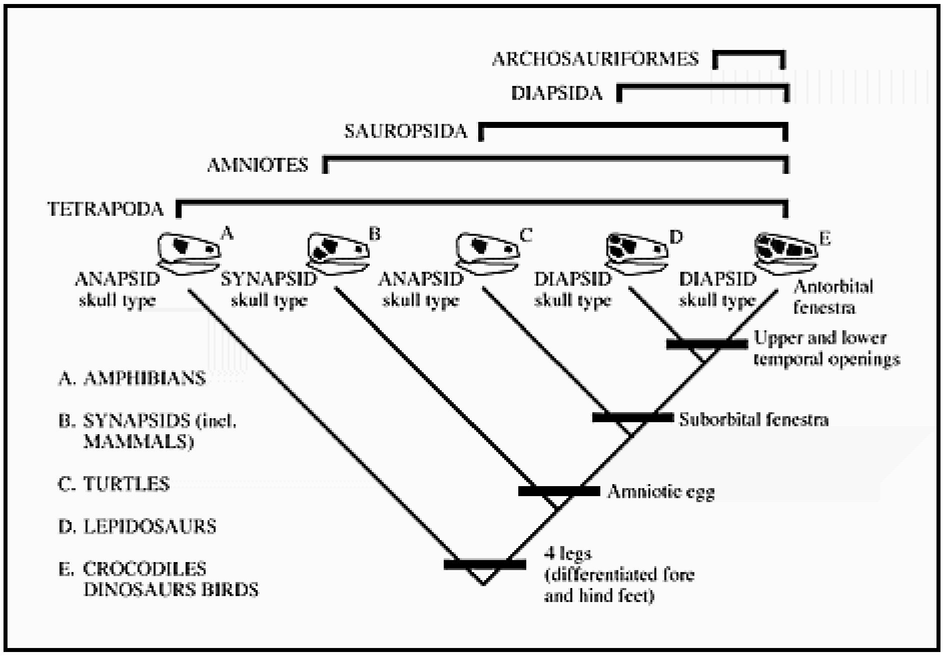


Figure 36. A cladogram of terrestrial vertebrate skull openings related to the acquisition of fundamental diagnostic features. Note **E**, the "antorbital fenestra" (opening ahead of the eye) that positions birds on the diapsid side well apart from **B**, the synapsids. Illustration from *rainbow.1deo.columbia.edu.courses/v1001/8.html*.

Such occurrences would be perfectly natural, but hardly inevitable, since a great number of cousins (including others we may presume never got caught in a fossil trap) would have gone their own directions. That was clearly the case with the synapsids, where not all of them accumulated a combination of hardware suitable for so fortuitous transformation as seen in the mammal lineage.

To navigate this particular thicket of past life you would need to pay attention to something that might seem far removed from ear evolution: the openings in the skull that allowed more complex jaw muscle attachments that added strength to the bite.

In this fundamental area there was an early split along two divergent paths (Figure 36). The "joined arch" *synapsids* had a single fairly small hole just behind the eye socket on either side of the head, while the "twin arch" *diapsids* featured a pair of holes—a larger one below and a smaller above, opening up more of the skull as anchoring struts. There were also the "wide arch" *euryapsids* with a single upper hole, represented by the aquatic ichthyosaurs and plesiosaurs of the Mesozoic, but the paleontological view these days is to regard them as variant diapsids that closed the lower opening.[422]

Because of those skull holes, amniote members can be traced through the fossil record with considerable precision. Which may be why creationists are in no hurry to point this out, since it makes it easier to compare their evolving traits. Like Phillip Johnson, Duane Gish had restricted his taxonomical definition to the synapsids.[423] But Henry Morris edged completely out on the limb to insist that no useful distinctions could be made:

> The fossil record throws very little light on the hypothetical evolution of amphibians into reptiles, or that of reptiles into mammals. All of them are four-legged vertebrates with similar skeletal structures and thus their fossilized remains provide little basis for distinguishing between them. Among animals living today, there are certain reptiles whose bony parts closely resemble those of certain reptiles whose bony parts closely resemble those of certain amphibians and others that closely resemble certain mammals. The external characters and appearance, as well as the physiological functions, of amphibians, reptiles and mammals, are all vastly different from each other, but these differences need not show up in the fossil record.[424]

Ah, but at least some of them *do* show up, and that's where that "pattern of relationships" Johnson glided past becomes so important. For it was among the synapsids—and *only* among that group—that the full suite of "mammalian" characteristics began to emerge. Faced with the competition of the dominant Permian therapsids, the diapsids weren't becoming even slightly "mammalian." Convergence on that scale simply wasn't possible for them, and the reptile diapsids spent the Permian being inconsequential. Whatever it was their distant synapsid cousins were doing so well, only they apparently obtained the genetic substrate to do it.[425]

Then came the Permian mass extinction, which decimated land life. Only a narrow remnant of the therapsid order squeaked through the Permian gauntlet into the Triassic. For a time they rebounded and did pretty well—the herbivorous *Lystrosaurus* had such a heyday a recent TLC cable documentary about them described it as "When Pigs Ruled the Earth."[426]

But the good times didn't last. As the supercontinent of Pangea coalesced the climate became less seasonal, which meant a near-mammalian metabolism grew correspondingly less advantageous. In that changing environment the diapsids (with their extra-snappy jaws) got a second chance, and the therapsids began to lose ground against the thecodonts and their later offshoots, the archosaurs.[427] Even as some of the therapsids were crossing the mammalian threshold they never regained their dominance against the archosaurs. By the time dinosaurs strode on the scene late in the Triassic, the true mammals were settling into a long period of hunkering down. It would be 150 million years before the mammals would get *their* second chance, after the K-T extinction cleared the playing field once again.[428]

The dinosaurs were another group with a curiously not-quite-reptilian physiology, from which that warm-blooded feathered cohort would appear to have emerged. So the reptile-mammal transition wasn’t occurring in a vacuum. It was one of *two* macroevolutionary shifts taking place, and making sense of it all required familiarity with that broader story. There was a metabolic arms race going on between the synapsids and diapsids, with thermostats being raised on one side and bipedal adaptations deployed on the other as each did their best in the ecological balancing act.[429]

For the synapsids, it meant a 50 million-year winning streak, in which all the taxa seemed to be cash players. The course seemed clear enough, as Robert Sloan pointed out:

> Each successive suborder of carnivorous mammal-like reptile has more mammalian characters than the preceding suborder. Later members of any suborder are more mammalian than early members of the same suborder. The earliest pelycosaurs differ from the most primitive and contemporary anapsid reptiles only in having a temporal opening, a feature which permitted them to snap their jaws shut faster. The latest cynodonts differ from the earliest mammals only in lacking two-rooted cheek teeth, and in having more than one set of replacement teeth, but do have teeth similar in shape to those of the first mammals.[430]

If the therapsids weren’t a transitional series, they were doing a pretty good impression of one. And Johnson’s readiness to slough everything off as convergent foible looked increasingly implausible the closer you approached the specifics.

Those “some other features” he so casually flicked a brow at, for example.

Since Johnson never got around to describing any of Hopson’s many examples, permit paleontologist Michael Benton to take a whack at it:

> The most important mammal-like reptile lineage of the Triassic was one that arose right at the end of the Permian. The early cynodonts were dog-sized animals such as *Procynosuchus* from the late Permian and *Thrinaxodon* from the early Triassic of South Africa. These therapsids were much more mammal-like than relatives such as the therocephalians and dicynodonts. In particular there are key changes in the skull. A secondary hard palate in the roof of the mouth separated it from the nasal passage, allowing the animal to eat and breathe at the same time; the teeth were differentiated into mammalian incisors, canines, and cheek teeth; the lower jaw was dominated by the dentary bone, which in earlier animals had been little more than a thin bedding plane for teeth, laid on top of a mosaic of larger components; and there was a wide arch of bone in the cheek region—the zygomatic arch—which flared outward to make room for stronger muscles controlling the bite of the lower jaw.
>
> During the Triassic, the cynodonts radiated into all sorts of carnivorous and herbivorous versions that achieved worldwide success. They show ever more mammal-like features, until they reach a point in the late Triassic where some forms are hard to classify either as reptiles or as mammals. The skull is even more mammalian, with the eye socket and single (synapsid) temporal opening fused and the dentary bone almost completing its takeover of the jaw. The skeleton shows evidence of an advanced upright posture, with both pairs of limbs tucked under the body instead of sprawling. Also, most of the Triassic cynodonts seem to have been endothermic, which means that they generated their own body heat, independent of their surroundings—they were “warm-blooded.” There is evidence in the snout region of nerves and blood vessels serving sensory whiskers; whiskers mean the presence of hairs on the body; hair means insulation of a warm-blooded body.[431]

Yes, the last of the therapsids were evidently *fur-balls*, as a glance at any recent illustration of one would have indicated (Figure 37). So unless Johnson was willing to invoke a whole new field of "theistic physiology," he needed to explain why the therapsids shouldn't be granted a metabolism more like that of a mammal than any living reptile.[432]

There was even evidence that the synapsid epidermis had been diverging from the ancestral amniote model for some time. The only trace of therapsid skin that has turned up comes from the Middle Permian dinocephalian *Estemmenosuchus* (one of many clunky looking animals knocking around in those days, such as its cousin *Moschops*, which looked like an overgrown grinning frog). But for a "random sampling" it was a dandy: embedded in its skin were *glands*, something unknown on the diapsid side of the fence, but entirely reasonable to expect from a group whose metabolism would eventually end up sweating through them for thermoregulation.[433]

That birds have feathers while mammals are covered in hair may represent the grandest of contingent splits in vertebrate history, reflecting what may have started out as the most trivial of differences. The skin of reptiles turns outward (evagination), while that of mammals folds inward (invagination).[434] Apply virtually the same set of genes to that variant in skin buckling (such as BMP receptor expression, *sonic hedgehog* and TGF-β2) and you get feathers on the reptile side and hair for mammals.[435]

Figure 37. The Triassic advanced cynodont *Diarthrognathus broomi* (subsequently renamed *Pachygenelius monus*). Painting at the Argentine Museum of Natural Sciences (selected image from *palaeos.com/vertebrates/units/410Cynodontia/410.500.html*), with a fuller segment in Czerkas & Czerkas (1991, 119).

How could anyone professing to be familiar with the fossil evidence approach that lengthy and consistent procession of increasingly and uniquely mammalian animals and *not* see a macroevolutionary event? It dwarfed the *Archaeopteryx* example, represented by only a scattering of fossils. To remove the "relevant suspects" in the mammal episode would mean not talking about everything that went on through the Permian and Triassic.

But then, that's exactly what Johnson tried to do, wasn't it? By leaving out both the larger paleontological background and the anatomical specifics, he tried to run the taxa through the same shredder Gary Parker had with *Archaeopteryx*. Only here he had a much longer series on his hands, and there wasn't going to be enough time. So he rolled out his resident evolutionary authority figure, Stephen Jay Gould, and tried to brazen it out with that truly flabbergasting concession that paleontologists might be right "in respect to this feature," as though isolated mammal-like ears were popping up in the fossil record like dandelions.

When it comes to the circumstantial evidence for macroevolutionary change, at what point are there enough trout in the milk?

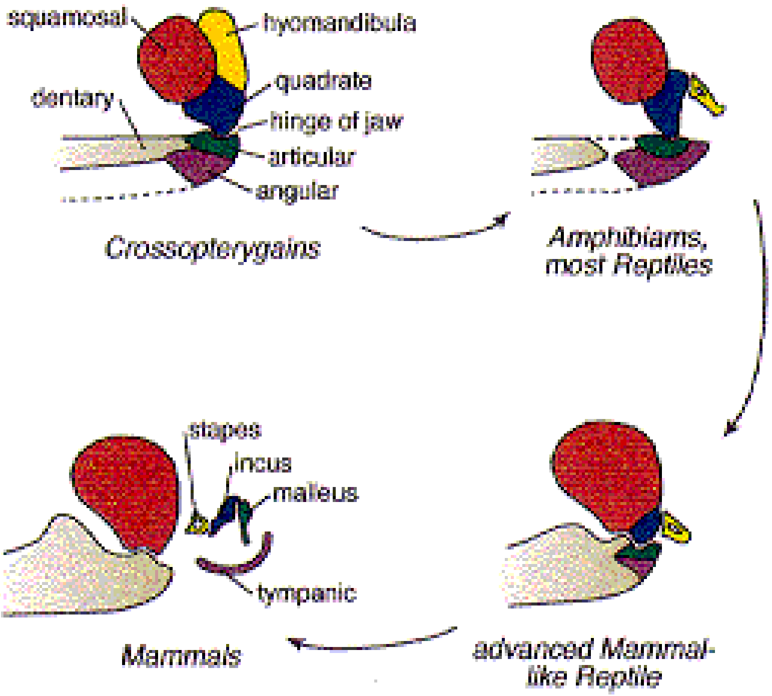


Figure 38. Evolution of the mammalian jaw and coopted ear structure, image at *uta.edu/biology/restricted/3452hske.html.* The crossopterygians were the bony-limbed fishes that included the living coelacanths. Incidentally, the German anatomist Karo Reichert noticed that the mammalian ear ossicles were embryonically homologous with the bones of the reptilian jaw in 1837, decades before Darwinian evolution entered the picture to better explain why that was so, Aulie (1974b, 25).

Look again at that jaw-ear conversion (summarized in Figure 38)—this time in a bit more detail than Johnson had with the Gould digest account. Right after the passage quoted above, Michael Benton had gone on to explain how intricate the confluence of adaptations were. The result didn't sound much like "convergence" in an otherwise unrelated lineage:

> The transition stage between reptile and mammal was marked by two further transformations in the skull. In reptiles, the jaw hinges between the articular bone in the lower jaw and the quadrate bone located low down at the back of the skull. In mammals, the joint is formed between the dentary bone in the lower jaw and the squamosal bone of the skull. For a while the transitional group, the advanced cynodonts, had both kinds of jaw joint, both of them functioning. The fossil record is good enough to display the whole sequence by which the dentary bone moved up inside the widening zygomatic arch until each end of the dentary's rough U-shape made light contact with the squamosal bone in the back corner of the arch. In a related sequence the "reptilian" jaw joint between articular and quadrate bones grew smaller, and these bones drifted closer to the new hinge point till the two were virtually in contact.
>
> Now came an extraordinary piece of evolutionary make-do-and-mend. Reptiles went on using the original articular-quadrate hinge; mammals did not need two sets of hinges, and the outer skull has lost them. In both animals the ear lies near the hinge. Reptile hearing uses a single ossicle (little bone) called the stapes, a thin rod that picks up vibrations from the inner ear inside the brain

> case. Mammalian hearing uses three ossicles to make a delicate instrument in the middle ear that transmits sound from the eardrum to a second membrane, the “oval window,” which connects with the inner ear. These three bones are, starting at the eardrum, the malleus, incus, and stapes—Latin for hammer, anvil and stirrup. We have already met the stapes. We first met the malleus and the incus as the articular and quadrate bones. They have shrunk and migrated, after all these hinges and structures were brought close together in the transitional reptile/mammals. It seems that there were twin forces at work to speed the shift; the jaw needed a better joint, and the nearby ear needed better machinery. The reptilian jaw made a third contribution when the angular bone traveled to become the mammalian ectotympanic, a C-shaped ossicle that holds the eardrum taut.[436]

The detail of Benton’s 1994 account may be compared to what *Of Pandas and People* was telling the creationist audience in the 1993 edition.

Declaring “there is no fossil record of such an amazing process,” Davis and Kenyon referred to an adjoining illustration that (quite correctly) explained how the reptile quadrate and articular bones were “located where the upper and lower jaws meet.” Unfortunately, what the figure intimated was the reptile layout was actually the intermediate *therapsid* configuration they just said didn’t exist (the picture clearly identified the quadrate and articular bones next to the stapes that conducted sound to the eardrum). The caption then went on to incorrectly suggest that “Darwinian theory” proposed that the quadrate and articular bones had become the incus and *stapes* (rather than the malleus). This anatomical confusion presumably inspired their inaccurate claim that “one of the bones had to cross the hinge from the lower jaw into the middle ear of the skull.” Because of this mistaken identification Davis and Kenyon were imagining that the bones had to jump inside the ear, when what was actually happening was a shortening of the stapes (a shared vertebrate auditory bone since the amphibians) that pulled the attached quadrate/incus and articular/malleus along with it.[437]

But the situation was even worse than antievolutionists downplaying the fact that, in spite of all the daunting odds, paleontologists had obtained the fossil evidence for this most amazing transformation. Corroboration for this “evolutionary make-do-and-mend” game has come from the other end of the spectrum—for it turns out that living mammals rehearse this ancient minuet in their own embryology.

The story starts with the neurulation process whereby vertebrates construct their central nervous system. A contemporary biology textbook told what takes place along the way:

> The story of neural crest cells is among the most amazing tales in all of developmental biology. When the neural plate involutes to form the neural tube during neurulation, and the neural tube detaches from the ectoderm, a series of cells is left over on either side. The cells are neither integrated into the neural tube nor taken up into the ectoderm. Instead, they set off on travels; colonize in various regions of the body; and give origin to a bewildering variety of cell types, tissues, and organs (Fig. 13-1).[438]

These include some rather disparate items common to all vertebrates, from the dentine-forming cells of the teeth to pigment cells found in bird feathers and mammal hair. But even more intriguing are some of the specific ways in which these initially undifferentiated neural crest cells have been pressed into service: the dorsal fins and gill arches of fish, and the sound-transmitting Meckel’s cartilage that link incus, malleus, and stapes within the mammalian inner ear.[439]

How the scaffolding comes together is wondrous.

While the gill arches are the source for the vertebrate jaw, the developmental loop is closed by what happens around that “sound-transmitting cartilage.” Mammalian embryos start out with a primary cartilaginous jaw joint hinged in the manner of fish, amphibians, and reptiles. But once the growing dentary and squamosal bones connect to form the secondary jaw, the primary disengages and the elements transfer to their new functions in the developing inner ear. This process is even more apparent among newborn marsupials, where the quadrate and articular only take up their auditory position after the dentary completes its post-natal growth. One may view all this either as still more frosting on the evolutionary cake, or as just another of those mysterious coincidences that so litter the creationist garden.[440]

At this point the basic rules of scholarly propriety kick in with a reminder: Hopson's article specifically mentioned this embryonic jaw data.

Since Phillip Johnson cited Hopson, we know he had this directly at hand, just as he had the content of Stahl's *Vertebrate History* to overlook. Which raises this pertinent question: if Johnson's purpose had been to properly "test" the evolutionary explanation for the therapsids why hadn't he addressed any of these points up front? Was he thinking that, if he didn't mention them, his readers wouldn't notice? Or was it like those "other examples" of skeletal convergence Johnson only thought he'd discussed—was he confusing intention for realization?

When it comes to the essence of pseudoscientific methodology it really doesn't matter.

The comprehensive incompetence of Phillip Johnson's account of the reptile-mammal transition underscores a rather glaring circumstance: that is the *only* treatment on the entire Intelligent Design side—just as Duane Gish's foray in *Evolution: The Fossils STILL Say No!* is the primary squib for Creation Science. It is therefore a statement of objective scholarship that the antievolution crusade has endeavored to dispose of a major macroevolutionary transition either by the juvenilia of Johnson and Gish—or by paying little or no attention to it at all.[441]

Perhaps the most striking feature about Johnson's treatment of the therapsids is that it was *not* a trimmed version of a technical argument, a "Gish Lite." Rather it was an absurdly inflated counterpart of Scott Huse, who at least had the virtue of brevity when he announced "There are no transitional forms between reptiles and mammals," and plowed on without further ado.[442]

There is something distinctive, though, about Phillip Johnson's contribution to the logic of creationism: his special honing of the *meaningless concession*, where conflicting facts that can neither be refuted nor accounted for are "conceded" or "accepted" tactically.

Creationists have long adopted that stance in respect of speciation, which they readily admit to in some theoretical sense but never apply systematically to the issue of created "kinds" or "types." And Michael Behe has blithely acceded to the other side of the Darwinist equation (common descent) without it otherwise impeding the thrust of his antievolutionary convictions.

But Johnson has elevated this approach to new heights, as we can see by tracing the journalistic flap over a book review.

The scientific literature didn't pay much attention to *Darwin on Trial* after it appeared, possibly under the assumption that it wasn't actually a work of science and so merited none. It did receive Doug Bandow's endorsement in William F. Buckley's conservative *National Review*, as well as considerable notice in *Christianity Today*.[443]

Lest the general public mistakenly believe Johnson's book offered information too hot for nervous evolutionists to handle, Stephen Jay Gould picked up the cudgel to defend Darwinian honor and composed a scalding review for *Scientific American*. Lighting into Johnson on both philosophical and technical grounds, towards the end Gould got around to what I considered the salient issue, Johnson's numbing concession on the therapsids:

> On page 76, he admits my own claim for intermediacy in the defining anatomical transition between reptiles and mammals: passage of the reptilian jaw-joint bones into the mammalian middle ear. Trying to turn clear defeat into advantage, he writes: "We may concede Gould's narrow point." Narrow indeed; what more does he want? Then we find out: "On the other hand, there are many important features by which mammals differ from reptiles besides the jaw and ear bones, including the all-important reproductive systems." Now how am I supposed to uncover fossil evidence of hair, lactation and live birth? A profession finds the very best evidence it could, in exactly the predicted form and time, and a lawyer still tries to impeach us by rhetorical trickery. No wonder lawyer jokes are so popular in our culture.[444]

Although a pretty short dollop as far as I was concerned, Gould had still affirmed the point that the jaw-ear transformation was no "narrow" one. Now that the battle was joined, how would Johnson respond to it? When *Scientific American* bluntly refused his rebuttal, Johnson presented his commentary in an Epilogue to the 2nd edition of *Darwin on Trial* in 1993, which depicted Gould's review as

> an undisguised hatchet job, aimed at giving the impression that my skepticism about Darwinism must be due to an ignorance of basic facts of biology. To that end Gould listed a string of objections about matters that had nothing to do with the main line of argument, and even invoked his own third-grade teacher as an authority on how to write chapter transitions. None of this would have impressed anyone who had read the book, but most readers of *Scientific American* would not have done so and would be likely to assume that Gould was describing it accurately. They were not likely to hear anything to the contrary, because the editors refused to print my response or any letters from readers, though I know they received many.
>
> Far from being discouraged by this treatment, I was elated. Most books are no longer news a year after publication; mine was apparently still enough of a menace to merit an all-out attack by America's most prominent Darwinist. Moreover, Gould on paper turned out to be much less formidable than the Gould many of my colleagues had anticipated. Everyone who was following the controversy assumed that Gould was the most formidable adversary I would encounter, and many were waiting to see if he would come up with a devastating response. That he could do no better than a hit-and-run attack was an implicit admission that he had no answer on the merits. As one biochemist friend wrote me in congratulation, "Judging by the howls of pain from the back pages of *Scientific American*, I think you must have struck a vital spot."[445]

If I may interject a personal observation, I was someone who had read *Darwin on Trial* before encountering Gould's purported "hatchet job" and so was particularly keen to see how well he handled the subject. At the time I thought Gould was being far too lenient with Johnson when it came to the therapsids.[446]

The reptile-mammal transition was so central to understanding whether macroevolutionary change has taken place that for Johnson to intimate this had "nothing to do with the main line of argument" was singularly obtuse. But where Johnson hit logical bottom was with what he had to say on that "narrow" therapsid point:

> Pending an unbiased review of the evidence that I hope to encourage, I accept the therapsid example for now as a rare exception to the consistent pattern of fossil disconfirmation of Darwinian expectations. My point was that any single example of this sort cannot be conclusive, and even this "crown jewel" of the Darwinian fossil evidence illustrates points on a putative "bush" rather than a specific ancestral line leading to an identified first mammal. That an army of researchers dedicated to finding confirmation for a paradigm has found some apparently confirming evidence here and there is not surprising. To evaluate the paradigm itself we have to consider also the mountains of negative evidence—like the absence of any pre-Cambrian fossil ancestors for the animal phyla. We also have to consider whether the accepted description of the therapsid sequence has been influenced by Darwinian preconceptions.[447]

When I inquired some years ago via email why paleontologists were so fond of the therapsid example, Johnson's reply was most certainly not that he accepted that example in even a provisional way. There was no hint that Johnson had incorporated any features of it whatsoever in his overall conception. Rather, he maintained that paleontologists were merely reinforcing their Darwinian philosophical convictions again.[448]

But the situation was even worse than that, since Johnson was in effect demarcating why I found the reptile-mammal transition so persuasive. To contend that I was impressed because my evolutionary presumption dictated it was the opposite of the truth—I had become convinced of evolution largely because of such evidence. I tried to explain that distinction to Johnson in our email exchange, and also brought the point up at the 1998 Whitworth meeting, to no avail. For Johnson, it was simply inconceivable anyone could arrive at an evolutionary sentiment because they were motivated by the quality of the supporting data. So my reflection on my own reasoning could not be true.

Johnson’s position grows stranger still when we recall how *Darwin on Trial* had allowed *Archaeopteryx* as the “lonely exception to a consistent pattern of fossil disconfirmation.” That’s his take on the origin of class Aves. In the space of a few years, and with *no new information* under his belt, solely for the purposes of his rebuttal to Gould the therapsids had been suddenly accepted (“for now”) as another “rare exception to the consistent pattern of fossil disconfirmation of Darwinian expectations.” That’s the origin of class Mammalia.

When it comes to vertebrate classes, and what has appeared over the last *quarter of a billion years*, Johnson apparently didn’t realize that he had just run out of “rare exceptions” to concede.[449]

Then again, Johnson’s concession of *Archaeopteryx* (“on the whole a point for the Darwinists”) was just as provisional as his “acceptance” of the reptile-mammal transition. In *Defeating Darwinism* he returned to his familiar redoubt: “The evolution-creation controversy is not about minor variations but about how things like birds come into existence in the first place.”[450]

But wouldn’t “the first place” for bird origins be back in the Jurassic? And wouldn’t that involve *Archaeopteryx*?

Now we can see how Phillip Johnson can deal so summarily with the macroevolutionary origin of birds and mammals (or anything else). He never stays in one spot long enough to feel the quicksand under his feet.

Chapter 9. Testing, Testing, One, Two, Three

From a methodological point of view it was especially revealing that Phillip Johnson's idea of responding to Gould's criticism of his take on the reptile-mammal transition consisted of moving to another subject. "To evaluate the paradigm itself we have to consider also the mountains of negative evidence—like the absence of any pre-Cambrian fossil ancestors for the animal phyla."

Johnson had jumped his own mark here by citing the absence of Cambrian ancestors as though their nonexistence (or existence, for that matter, for those that have turned up) invalidates the plausibility of the reptile-mammal transition a *quarter of a billion years later*. It is one of Johnson's pet logical complaints about naturalistic evolution that its proponents conflate agreement with modest microevolutionary change into proof of the larger atheistic metaphysical worldview. By skipping back to the Cambrian (an area where *Darwin on Trial* was considerably less conclusive than promoted) to avoid dealing with the therapsids, Johnson was practicing the very sin he accuses Darwinists of.[451]

The Pavlovian appeal to the Cambrian Explosion as a catch-all surrogate for macroevolutionary mystery has since become a standard mantra in the Discovery Institute anti-Darwinian road show, such as the presentation I saw by Stephen Meyer in an October 2001 class lecture at Whitworth College.

Meyer's DI compatriot Jonathan Wells also plays on it, as in the *Icons of Evolution* argument he condensed for *The American Spectator*:

> The fossil record shows the major groups of animals appearing fully formed at about the same time in a "Cambrian explosion," rather than diverging from a common ancestor. Darwin knew this, and considered it a serious objection to his theory. But he attributed it to the imperfection of the fossil record, and he thought that future research would supply the missing ancestors.
>
> But a century and a half of continued fossil collecting has only aggravated the problem. Instead of slight differences appearing first, then greater differences emerging later, the greatest differences appear right at the start. Some fossil experts describe this as "top-down evolution," and note that it contradicts the "bottom-up" pattern predicted by Darwin's theory. Yet most current biology textbooks don't even mention the Cambrian explosion, much less point out the challenge it poses for Darwinian evolution.[452]

If Wells was aware that there might be some good paleontological reasons for why early Cambrian metazoans might not be easily observed (a dearth of suitable *Lagerstätten*), he did not share this intelligence with his readers. But apart from that, Wells' *American Spectator* article had to literally step over most of subsequent macroevolutionary change. This is because the illustration Wells selected to exemplify how "Darwin's branching 'Tree of Life' has been seriously undermined by the fossil record and modern molecular biology" consisted of nothing apropos the Cambrian. Instead, it was a graphic from Kenneth Miller and Joseph Levine's textbook *Biology*, showing the great amniotic synapsid/diapsid split leading to reptiles, mammals, dinosaurs and birds.[453]

Now if there is one thing that *cannot* be said about the reptile-mammal transition (at least with a straight face), it is that its earliest members appeared "fully formed" without visible antecedents. The *Lagerstätten* issue could have played a role here, as only a handful of deposits are known from the Triassic (notably the Ischigualasto in Argentina, from whence *Probainognathus* comes) and none are *Lagerstätten* class.[454]

But in spite of that seemingly poor geological start, there are actually an amazingly large number of fossils involved. This is probably due to the fact that the reptile-mammal transition wasn't occurring as a sideshow among the synapsids (unlike the birds, where most dinosaurs, let alone diapsids, weren't turning avian), but among the dominant land animals of the Permian.

Consequently a lot more of the branches were active, raising the odds that stray bits and pieces would get preserved to document their passage.

Both of those macroevolutionary spurts took place over a very long time, and clearly followed exactly the pattern that Meyer and Wells insist *isn’t* seen: the distinctly Darwinian sequence of new forms starting out with “slight differences appearing first, then greater differences emerging later.”

It is just as hard to tell the earliest birds from dinosaurs (recall those taxonomically fuzzy alvarezsaurids) as it is to distinguish the first mammals from their advanced cynodont cousins. That Meyer and Wells have paid no attention to such things is one reason for being somewhat skeptical of their fecundity whilst lecturing on the panorama of fossil history, but Phillip Johnson’s lengthier print evasions don’t have the convenient out of extenuating ignorance.[455]

The final whistle stop in this sorry journey concerns the “unbiased review” of the evidence Johnson proposed to encourage—not undertake himself, mind you. His thinly veiled accusation that all the solid work (“apparently confirming evidence here and there”) of professional paleontologists up until then was tainted by their paradigmatic bias was already insulting. But beyond that lay the more fanciful hope that somehow the jaw articulations of therapsids might relocate if only one stared at them long enough with a sufficiently unbiased eye. [456]

Although Duane Gish had been sweating to that purpose for the last generation, Johnson paid no attention to that end of the argument. What he appears to have had in mind manifested a few years later in *The Creation Hypothesis*, a 1994 anthology assembled by Christian philosopher James Porter Moreland to promote the design argument as a viable, if not superior, alternative to the current mechanistic evolutionary view. In a glowing preface, Johnson ventured that work as “the beginnings of a great project to discover the truth” lying beyond the sterile confines of contemporary scientific naturalism.[457]

The contributions ranged from philosophical analysis by Stephen Meyer, and criticism of chemical origin of life theories by Walter Bradley and Charles Thaxton, to Hugh Ross explaining how the “anthropic principle” showed the physical constants of the universe were fine-tuned by a Creator especially to favor the existence of humanity. At the time I first read Moreland’s anthology I was giving the Intelligent Design movement every opportunity to make good on their case. Thus I was particularly interested in reading what creationist paleontologist Kurt Wise had to say about “The Origin of Life’s Major Groups.” If anyone were capable, through training and inclination, to show why the therapsids were not a proper evolutionary sequence, it would be him. There would be no reason for Wise to overlook relevant fossil evidence, or to suppress aspects that appeared supportive of creationist interpretation. Here was an ideal test case, where someone with all the necessary credentials was given the opportunity to take their best shot.

How did Wise do? Well, he never discussed the therapsids, for one thing. The closest he got was in a section on fossil transitions, though for all the amount of detail offered he appeared to know less about the subject than I did. For anyone looking for a creationist refutation of the evolutionary implications of the fossil record in general and the reptile-mammal transition in particular, this was a dismal failure. Recruited to the field for this most critical play, Wise thoroughly fumbled the ball:

> If macroevolution is true, then organisms have made many substantial transformations in the course of history. The preservation of these transformations might be expected in the fossil record. Series of fossil species like the horse series, the elephant series, the camel series, the mammal-like reptile series, the early birds and early whales all seem to be strong evidence of evolution. Another class of fossil evidence comes in individual *stratomorphic intermediates*. These are fossils that stand intermediate between the group from which they are descendent and the one to which they are ancestral—both in stratigraphic position and in morphology. They have a structure that stands between the structure of their ancestors and that of their descendants. However,

they are also found in the fossil record as younger than the oldest fossils of the ancestral group and older than the oldest fossils of the descendent group.

Stratomorphic intermediate species and organismal groups should be a common feature of the fossil record. And examples of stratomorphic intermediates do exist. Mammal-like reptiles stand between reptiles and mammals, both in the position of their fossils and in the structure of their bones. The same can be said of the anthracosaurs, which stand between amphibians and reptiles, and the phenacodontids, which stand between the horses and their claimed ancestors. In like manner, some fossil genera are stratomorphic intermediates in the group and most similar to the group from which they are supposedly descendent. Examples include *Pikaia* among the chordates, *Archaeopteryx* among the birds, *Baragwanathia* among lycopods, *Icythyostega* among the amphibians, *Purgatorius* among the primates, *Pakicetus* among the whales and *Proconsul* among the hominoids.

Once again, the existence of stratomorphic intermediate groups and species seems to be good evidence for evolution. However, the stratomorphic intermediate evidences are not without difficulty for evolutionary theory. First, none of the stratomorphic intermediates have intermediate structure, it's the *combination* of structures that is intermediate, not the nature of the structures themselves. Each of these organisms appears to be fully functional organisms of fully functional structures. *Archaeopteryx*, for example, is thought to be intermediate between reptiles and birds because it has bird structures (e.g., feathers) and reptile structures (e.g., teeth, forelimb claws). Yet the teeth, the claws, the feathers and all other known structures of *Archaeopteryx* appear to be fully functional. The teeth seem fully functional as teeth, the claws as claws, and the feathers as any flight feathers of modern birds. It is merely the *combination* of structures that is intermediate, not the structures themselves. Stephen Jay Gould calls the resultant organisms "mosaic forms" or "chimeras." As such they are really no more intermediate than any other members of their group. In fact, there are *many* such "chimeras" that live today (e.g., the platypus, which lays eggs like a reptile and has hair and produces milk like a mammal). Yet these are not considered transitional forms by evolutionists because they are not found as intermediates in stratigraphic position.

As a result, the total list of claimed transitional forms is very small (the above list is very nearly complete) compared to the total number of mosaic forms. The frequency seems intuitively too low for evolutionary theory. The very low frequency of stratomorphic intermediates may be nothing more than the low percentage of mosaic forms that happen to fall in the correct stratigraphic position by chance—perhaps because of random introduction of species by a Creator or the somewhat randomized burial of organisms in a global deluge.

Second, stratomorphic intermediates tend to be found in groups that we have already seen show a fossil-record order consistent with evolutionary order—that is, vertebrates and plants. They are absent among the groups of invertebrates. In some cases a series of intermediates cannot even be imagined. More often the imagined intermediates cannot have survived. Transitions from one major group of organisms to another are challenges to the ingenuity of even the most capable macroevolutionists.

Just as the more general order may be due to a pattern of a Creator's introduction or of the advance of a global flood, these few stratomorphic intermediates may be explainable in the same way. If, for example, the general order of the fossil record is due to introduction of organisms, then one might occasionally expect stratomorphic intermediates to have been created in the sequence between two groups. Likewise, on an earth that is zoned biologically, fully functional, structurally intermediate organisms are likely to be

> geographically located between the two groups they lie between structurally. An advancing global flood would then tend to land structural intermediates between the other two groups in the fossil record. Thus, whereas the mosaic nature of claimed "transitional forms" presents a challenge to evolutionary theory, that and the existence of stratomorphic intermediates *are* consistent with progressive creation and global deluge theories.[458]

So many questions are posed by the existence of synapsids and their near-mammalian kin, yet all Wise could muster was this gobbledygook, where intermediates now present a problem for *evolution* because they are drawn from fossil sequences that already appear evolutionary!

This measured exactly the limits of Wise's rhetorical desperation. Calling them "stratomorphic intermediates" explained nothing more about them than had Johnson's incantation of "convergence" and "artificial lines of descent." Wise even ended up trying the same stunt as Johnson, whittling down his description of the macroevolutionary candidates until they seemed "too low" to matter. But *Archaeopteryx* and the therapsids were not marginalia—they were the *only* vertebrate classes to originate since the reptiles. How could their example get any more comprehensive?

Adhering to a more literal Biblical creationism than Johnson, Wise sounded more like his fellow Flood believer Duane Gish as he carefully picked his way through the technicalities of the fossil witness list. He chose *Archaeopteryx*'s inherited teeth and claws to minimize rather than tackling the more demanding project of explaining how an evolutionary intermediate for a structure so refined as the mammalian jaw could avoid being "fully functional." Or how such a thing could have come about without looking identical to what was actually found in *Probainognathus* or *Diarthrognathus*.

Particularly ingenuous were the "mosaic" platypus and those literally *unimaginable* invertebrate intermediates.

Coincidentally, the same year *The Creation Hypothesis* came out, fellow paleontologist David Norman touched on this very point in his book *Prehistoric Life*. "Detailed study of living and fossil molluscs has led biologists and paleobiologists to hypothesize about the earliest mollusc ancestor. This archetypal mollusc was thought to have lived under a cup-shaped shell, to have crept about on a flat foot, and to have had a repeated series of gills running down the side of its body."[459]

Shells of just that primitive configuration, known as the monoplacophorans, existed at least as far back as the Middle Cambrian—though, shells being shells, it was not always possible to infer much about what was going on in the soft-bodied critters beneath. It would help if living examples of the monoplacophorans were available. And what a surprise: the mysterious designer *again* came through for evolution, for in recent decades living forms (such as *Neopilina*) have been dredged up from their deep water habitats to reveal the primitive mollusks dwelling inside. They turned out to match the theoretical evolutionary prototype quite closely.[460]

As for the monotremes, while obviously not "intermediate" in any temporal sense, was it true that evolutionists dismissed the morphological implications of the living monotremes on that basis? Judging by what Colbert and Morales "briefly" explained in *Evolution of the Vertebrates,* apparently not:

> It is pertinent at this place to mention briefly the monotremes, constituting the subclass Prototheria, known in the Australian fossil record from a single lower jaw with cross-crested molar teeth, of Cretaceous age and named *Steropodon*; from isolated lower molar teeth of Miocene age, named *Obdurodon*; and from Pleistocene materials. The teeth of *Steropodon* show resemblances to the teeth of *Obdurodon*, and may be compared with the vestigial teeth of the living Australian monotreme, *Ornithorhynchus*.
>
> This last mentioned genus, known by the popular names of platypus or duckbill, is one of three living monotremes, the other two being the spiny echidnas, or anteaters, *Tachyglossus* of Australia and *Zaglossus* of New Guinea.

> Superficially these monotremes are highly specialized, the platypus for a life in streams and in underground burrows along the banks, and the anteaters for a hedgehoglike existence in deep forests. In the duckbills the front of the skull and lower jaw are flattened into a ducklike beak for burrowing in the mud streams in search of worms and grubs. The teeth are shed and replaced by hard pads in the adults. The feet are modified as webbed paddles. The anteaters are protected by sharp spines that cover the body. In them the jaws are toothless and elongated into a long, tubular snout, with which they probe ant hills.
>
> In spite of these specializations the recent monotremes are basically very primitive mammals. They reproduce by laying eggs, which are hatched in burrows. The young are suckled on milk that is secreted, as mentioned above, by modified sweat glands that are homologous to the mammae or breasts in the higher mammals. The skeleton and soft anatomy show the persistence of various reptilian characters. For instance, the shoulder girdle is very primitive with a persistent interclavicle, large coracoids, and no true scapular spine. The cervical ribs are unfused. Various reptilian characters persist in the skull. The rectum and urinogenital system open into a common cloaca as in reptiles, not separately as in mammals. There are no external ears or pinnae as in most other mammals.
>
> The primitive shoulder girdle of the monotremes is closely comparable to the shoulder girdle of *Morganucodon*, the triconodont found in the Triassic fissure fillings of South Wales. The monotremes may have had their origins in docodont ancestors, in turn derived from morganucodont-like progenitors. On the other hand, some authorities feel that the monotremes may be included within the Theria, the subclass which embraces a majority of the mammals, rather than being isolated in a separate subclass, the Prototheria. However that may be, there is good reason to think that the monotremes represent an ancient line of descent from the mammal-like reptiles, continuing in an isolated corner of the world, where they have been able to survive as basically primitive mammals, with an overlay of certain specializations. In many respects the monotremes give us an excellent view in the flesh of mammals intermediate in their stage of evolution between the mammal-like reptiles and the higher mammals.[461]

What does it say about Wise’s scientific methodology that he thought he could dangle the duckbill without exploring any of this? Wise invoked the concept of animal mosaics as easily as Johnson did his “pre-existing types.” Both simply assumed they carried evidential force, and so laid no foundation for them. Of course, Wise carefully avoided describing what an evolutionary intermediate *would* look like that would satisfy him. The creationist calibration must always be retroactive.

Over on the ID side, Michael Denton got into a similar muddle while laying out his typological boundaries (see Appendix III for more on typology). He was willing to allow only three “somewhat anomalous” exceptions to exist: lungfish, the monotreme mammals, and the Onychophora (which we met in conjunction with arthropod evolution). The monotremes’ reproductive system and eggs “seem almost fully reptilian, while where they are mammalian, as for example in the construction of their middle ear, or in the possession of hair, they are fully mammalian.”[462]

Here is where Denton’s poor assessment of the reptile-mammal transition caught up with him. For the two “mammalian” traits Denton cited for the monotremes (ear layout and hair) were specifically those traceable back through the therapsids—those extinct forms Denton preferred to sequester on the *reptile* reservation.

Oh consistency, where art thou?

One final example from Phillip Johnson can conclude this examination of his approach to the reptile-mammal transition.

As is clear from his citation trail, Johnson has shown no interest whatsoever in familiarizing himself with the available technical literature. He prefers instead to draw ammunition from all the wrong places, popular accounts (newspaper reviews and general books) and occasionally from overt creationists (including Malcolm Bowden). Quite recently Johnson was apparently poking around the YEC *Answers in Genesis* website, where he spotted a paper by creationist John Woodmorappe claiming to have used "cladistic analysis" to demolish the validity of the reptile-mammal transition. Johnson later blithely recommended that work to his friend David Berlinski, who included it in his 2003 rejoinder to critics of one of his anti-Darwinian *Commentary* articles.[463]

That apologetic daisy chain caught my eye, since Woodmorappe (notable in the YEC community for a strained "feasibility study" on Noah's Ark) was arguably one of the least promising prospects to rely on.[464] When I examined Woodmorappe's paper, my suspicions were confirmed. Not only had Woodmorappe not done a "cladistic analysis"—his argument was a hodgepodge of miscalculated charts that carefully avoided detailing any of the data he was supposedly analyzing.[465]

But how ever could Phillip Johnson have spotted that, since not examining the details was exactly the problem with his own approach to the reptile-mammal transition?

Such recurring episodes are the inevitable product of a core methodology that has all too frequently measured resources not by the rigor of their content, but the extent to which aspects of them might reinforce a preconception. This mainspring of creationist motivation takes on further methodological importance because of how they look at the present state of science.

There is the negative issue of restoring science education by expunging what they hold to be a spurious evolutionary mythology. Phillip Johnson would be a perfect witness for that line of thinking.

But creationist activists at the grassroots have also been led to believe that genuine innovation awaits them in a refreshed scientific enterprise. No one represents this positive attitude more enthusiastically than the Discovery Institute, which openly stations their CRSC division (Stephen Meyer, director) in the vanguard of **Design Theory: A New Science for a New Century**:

> Materialistic thinking dominated Western culture during the 20th century in large part because of the authority of science. The Center for the Renewal of Science and Culture seeks, therefore, to challenge materialism on specifically scientific grounds. Yet Center Fellows do more than critique theories that have materialistic implications. They have also pioneered alternative scientific theories and research methods that recognize the reality of design and the need for intelligent agency to explain it. This new research program—called "design theory"—is based upon recent developments in the information sciences and many new evidences of design. Design theory promises to revitalize many long-stagnant disciplines by recognizing mind, as well as matter, as a causal influence in the world. It also promises, by implication, to promote a more holistic view of reality and humanity, thus helping to reverse some of materialism's destructive cultural consequences.[466]

The perception of modern evolutionary science as "stagnant" has been percolating through the creationist mindset for some time (from YEC authors Donald Chittick and Duane Gish through to the ID vanguard of Michael Behe and the theological ally J. P. Moreland).[467]

This is an understandable conclusion given the imperatives of their worldview. After all, if functional naturalism isn't really true, then the edifice built on such assumptions cannot be a sound one. "By their fruits shall ye know them," so to speak. Consequently all the busy activity of contemporary evolutionary science in biology or paleontology must really represent the fruitless wheel spinning of a failing materialist ideology.

Both sides of this equation (removing bad evolutionary thinking and replacing it with superior design arguments) are sustainable only because of the Miltonian methodology whereby they insulate themselves from too many of the intractable details. Only through such a method can creationists believe evolutionary science is a rotting corpse—or that their own design option is poised to ignite a scientific revolution.

In the end we must agree that there is a deadening failure of imagination involved in the debate over macroevolution, but evolutionists are not the ones suffering from it.

Certainly not E. O. Wilson *et al*. when it came to describing the Cretaceous “wasp-ant” *Sphecomyrma*. Nor dinosaur paleontologists as they correctly anticipated the existence of feathered theropods. Or Robert Broom when he deduced the exact jaw layout of reptile-mammal intermediates only found decades later. And evidently not invertebrate biologists when they again applied their feeble Darwinism to nature and successfully imagined some of the “unimaginable” and deduced the hitherto unknown internal anatomy of the primitive monoplacophorans.

With that we may suggest that Phillip Johnson’s persistent desire to “test” evolutionary theory is the complaint of someone who not only doesn’t like the way all the previous tests have turned out. He has convinced himself that all those tests hadn’t been made.

Evolutionary theory has been *tested*, and will continue to be so, by all the accumulating evidence of biology and paleontology. Refinements will determine whether certain aspects of the evolutionary process are ineluctable (like keratin integuments sprouting from some vertebrates)—or more contingent (such as the appearance of large-brained bipedal primates that communicate with grammatically structured acoustic signals).

But don’t hold your breath that any future discoveries are likely to overturn the overall scientific view that all living things are related by common descent, and have apparently come to their current conditions by natural processes rather than interventionist bursts of design.

Today’s testing concluded. Class closed.

Appendix I. *A Brief History of Creationism*

Although contemporary creationists tend to be politically conservative, the origins of the movement lie in the more radical progressivism at the beginning of the 20th Century, and how it reacted to geopolitical and cultural upheaval.

The disillusionment following the First World War was abruptly followed by such diverse threats as Bolshevism and a permissive Roaring Twenties morality that openly flaunted the Prohibition movement many of the creationists embraced. And if that weren't bad enough, the arts and physical sciences were also in convulsion, from modernist art and music to quantum theory and Einstein's relativity. The same progressive urges that had inspired many activist Christians to promote child labor laws and the income tax at the turn of the century, now saw in "modernity" much to save their children from.[468]

Darwinism specifically became the focus for that conflict in 1921 when William Jennings Bryan unexpectedly launched an anti-evolution campaign. Having run unsuccessfully for president three times as a leading Democrat in the populist movement, Bryan had recently served as President Wilson's secretary of state, only to resign in pacifist outrage over the administration's increasingly bellicose response to Germany's employment of unrestricted submarine warfare. It was during his later war relief work that Bryan came to believe German militarism (which many regarded as the primary cause of the war) was but the virulent outcome of an unyielding "survival of the fittest" evolutionary philosophy. Bryan and others feared that such a mentality, left unchecked, would only bring on more war and labor exploitation.

That the popular perception of evolution included the not-unfounded conviction that it was the willing tool of atheism drew religious organizations into Bryan's crusade, most notably the World's Christian Fundamentals Association (founded in 1918). Over the next few years many state legislatures were importuned to ban the teaching of human evolution in public schools. It was this effort that attracted the attention of the newly-formed American Civil Liberties Union, and their decision to challenge the constitutionality of a new Tennessee statute resulted in the famous 1925 Scopes "Monkey" Trial that put the issue of evolution on the front burner in America.[469]

While the ACLU defense lined up squads of scientists to argue the scientific legitimacy of evolution, the Tennessee prosecutors discovered to their chagrin there *were* no scientific witnesses to call to testify for their side. This forced an abrupt change in tactics, from one upholding the statute's validity on empirical merit, to one resting solely on the state's legislative authority to direct the content of public education. With *all* direct scientific courtroom testimony thus excluded (which meant a gaping hole in the defense's case), Clarence Darrow pulled the now-legendary maneuver of calling Bryan to the stand as expert on the only field remaining, namely the Bible. Darrow's withering cross-examination of Bryan on the peculiarities of Biblical exegesis elevated the proceedings to both farce and tragedy, for a week after the media circus concluded Bryan fell ill and died.[470]

The outcome was a draw for both sides. Scopes was duly convicted, but the ACLU was robbed of the opportunity to challenge the ruling at the federal level when the Tennessee high court overturned the conviction on a technicality. Press accounts of the proceedings painted creationism in very broad strokes, not only as retrograde defenders of religious bigotry, but as parochially *southern* ones. Though this was not representative of Bryan's movement initially, after Scopes the course of anti-evolution legislation shrank to a largely southern rural constituency.

In a pattern that would be replayed half a century later, the salient effect of all the publicity over the Scopes Trial was to induce a severe chill among textbook publishers. High school science books either downplayed or removed altogether references to evolution, including the one Scopes had used to trigger the Tennessee court challenge in the first place.[471] For this reason it was unnecessary to enforce any of these anti-evolution laws in the next decades, for no human evolution was actually being taught. This quiet spell lulled many in the scientific community into thinking that creationism had "gone away," when it had only dozed off.

Like Caesar's Gaul, 20th century creationism may be divided into three parts. God, of course, was always in charge, but the details of Genesis were open to considerable interpretation. The dominant view embraced by conservative Christians circa 1920 was what would eventually be known as the "Day-Age" theory. It accepted the basic outlines of conventional geology, and allowed fossils (including ancient man) to belong to past creation "days" of unspecified duration. For these Day-Agers, the "facts of science" were no problem at all.

But down in the trenches, significant changes were brewing. Presbyterian minister Harry Rimmer promoted the more specific requirement that the history of *human* life not exceed the confines of traditional Biblical teaching, though non-human fossils could still be ascribed to a Pre-Adamic age of indeterminate length. Referred to variously as the "Gap" or "Restoration" theory, this second side of creationist doctrine has enjoyed broad denominational appeal. Believers as disparate as C. L. Scofield (of the influential *Scofield's Reference Bible*) and Herbert W. Armstrong's Worldwide Church of God favored it, as did those "bad boys" of modern televangelism, Jimmy Swaggart and Jim Bakker. The Jehovah's Witnesses have embraced support for both the Day-Age and Gap views.

The distinctive third form of creationism sprang from the brow of Ellen White, founder of the Seventh-Day Adventists. Instead of passively accepting the standard geological framework, White insisted fossil life was actually the recent detritus of Noah's Flood (an event which "higher criticism" had supposedly banished as mythological fantasy), and so stuff the entire picture back into a Bishop Ussher-sized 6000-year chronological box. By thus reinterpreting the context of the fossil record, in one bold stroke White simultaneously resuscitated the theologically momentous deluge as a verifiable hydrologic event, and deftly pulled the rug from under evolution, which depended so heavily on the fossil sequence.

In 1923, self-taught "geologist" and Adventist convert, George McCready Price, tidied up White's Flood Geology for a more secular clientele in his book, *The New Geology*. Price, incidentally, was the lone "scientist" the Scopes prosecution could scrape up in 1925. Away in Europe at the time, though, he had to decline his spot in legal history. As for his arguments, mainstream science was still not impressed, including those evangelical scientists who founded the American Scientific Affiliation in 1941 when the American Association for the Advancement of Science (AAAS) began to seem too evolutionary for them. But all accepted the findings of uniformitarian geology, so *en bloc* dismissed Flood Geology as rank pseudoscience.

For those who wanted their Bible straight up, Flood Geology might have seemed ideal but for its Adventist associations. Flood Geologists also tended to regard Day-Agers as hopelessly spineless compromisers with standard geology. So for many years sectarian squabbling kept the three branches of creationism either at each other's throats, or glowering over their stout denominational fences. That this distinctly fringe view would eventually be taken up by most modern Biblical creationists may be credited to the unflagging enthusiasm of Henry Morris, a civil engineer whose study of Rimmer in the early 1940s led him to Price's book. Cleaving off any remaining Adventist connotations, Morris mutated Price's Flood Geology into the formidable doctrine of today's "Scientific Creationism."

All it took was the customary social crisis, this time after another World War.

Though we tend to view the 1950s with "Leave It To Beaver" nostalgia, beyond the surface conformity of the suburban tract lots lurked the paranoia of Joe McCarthy. With one well-aimed pelvic wiggle, Elvis Presley could send fundamentalist preachers into paroxysms of concern over modern "degeneracy," as pessimistic as their 1920s predecessors. When the Soviet Union was first into space with Sputnik, America's political leaders had also to deal with the unsettling prospect of perhaps being fatally behind on the Cold War learning curve. Amid the furious effort to revamp the high school science curricula that ensued, the Biological Sciences Curriculum Study (BSCS) duly reinstated all the evolutionary work that had piled up since Scopes' day, and with that stimulus the somnolent creationist movement perked up in a hurry.[472]

That 1920s fundamentalism might stem from a profound dissatisfaction with modern life was understandable. What was to prove so unexpected for secular science was how these same processes acted along entirely new demographic lines, one accompanying the growth of large metropolitan areas. "Scientific Creationism" was no longer a rural southern eccentricity, but this realization had yet to invade the cultural and scientific establishments. This misperception was further reinforced by the evocative 1950s hit play about the Scopes Trial, *Inherit the Wind*, brilliantly filmed in 1960 by the leading issues director of the day, Stanley Kramer, just as the seeds of the new creationism were being sown. Those who relegated creationism to somewhere between "monkey gland" medical quackery and Salem witchcraft were in for a shock.[473]

As noted by anthropologist Christopher Toumey, there was also a deep theoretical division between 1920s creationism and its 1950s Flood Geology reincarnation. Those earlier creationists had focused on the issue of *human* descent, and did not (at least in theory) necessarily preclude significant evolution for everything else. Their objections hinged on the seeming determinism of evolutionary postulates, and its proponents were usually clergy. The new creationism of Henry Morris was enamored of "scientific" geological exposition, and affirmed the "slippery slope" implications of Darwinist thinking by opposing *all* significant naturalistic evolution. In a fascinating about-face, though, it was now not the *determinism* of that process that so bothered them, but its supposed *randomness*.[474]

While the BSCS project woke creationists up, it took a legal decision to get them moving. In 1968 the Supreme Court struck down a 1929 Arkansas statute actively banning the teaching of evolution, passed in the waning days of the post-Scopes chill. With the country thrashing out the issues of school desegregation and the Vietnam War, anti-evolution laws seemed as anachronistic as doilies on Danish modern furniture. All save Justice Black thought such laws *ought* to be unconstitutional; they just had difficulty agreeing on *why*. Some felt the law vaguely worded, others that it infringed on educators' free speech, but the tack the court majority ended up taking was that it sought religious establishment.[475]

This ruling set up a constitutional hurdle that forced creationists to adopt an equally athletic legislative strategy, one promoting "equal treatment" for creation and evolution. Provided one were thorough enough, a seemingly Bible-free "creation model" might be offered as an equally scientific contender with the "evolution model." (That the results just happened to coincide *exactly* with the old Biblical creationism could be sidestepped as further indication of how "genuine science" served in the end to affirm scriptural truth.) Many creationists would have preferred no evolution be taught at all, of course, but given the new legal circumstances, at least this approach attached to any exploration of evolution an appropriate creationist riposte.

Others in the creation movement tackled this equivalence issue differently. When Dale Crowley of the National Bible Knowledge Association unsuccessfully sued the Smithsonian Institution in 1978 over its evolution exhibits, it was on the grounds that taxpayer money was being spent to promote the "religion" of evolution (atheism in its trendy new garb of "secular humanism"). In the "equal time" taffy pull, while one camp insisted how *nonreligious* Creation Science could be, their compatriots were simultaneously trying to haul evolution over the metaphysical wall to declare it just as *religious* as creation.[476]

Morris' role in this phase of creationism was significant, founding five of the eleven main creationist associations listed by Christopher Toumey.[477] Morris was among the seminal "Team of Ten" who founded the Creation-Research Society (CRS) back in 1966. He and Rev. Tim LaHaye established the Christian Heritage College, and with Kelly Segraves these three set up the Creation-Science Research Center there in 1970. Morris has also had a long, though unofficial, link with the Center for Creation Studies at Jerry Falwell's Liberty University. Finally, after a schism with Segraves over denominational neutrality and political activism (Morris favored retaining church affiliation and focusing on educational efforts), he established the influential Institute for Creation Research (ICR) in 1972, which serves as base of operations for the indefatigable Duane Gish.[478]

The high water mark for the YEC phase of anti-evolution legislation came in the early 1980s. An increasing activism among conservative Christians was invigorated by the more general conservative realignment going on in American politics. The Reagan administration sent encouraging signals to both abortion opponents and creationists, although neither sentiment translated into any substantive action at the federal level. While Jerry Falwell's "Moral Majority" duked it out with Norman Lear's "People For the American Way" in the public arena, efforts to affect the content of public school science education proceeded in about half the states.[479]

One of the first off the block was the 1981 "balanced treatment" act in Arkansas. Since it was the rejection of their 1929 anti-evolution statute by the Supreme Court that had started all this brouhaha, there may have been some haste in redressing the state's dishonor. The legislator who offered the bill manifested no familiarity with the scientific issues involved, and had simply copied the text from one proposed by creationist activist Paul Ellwanger, who in turn had relied on a draft concept by lawyer Wendell R. Bird. The law was promptly challenged, mainly by Arkansas clergy appalled at so bald an attempt to codify a narrow interpretation of Genesis in the public schools, as though it were the only rigorous alternative to evolution.[480]

In a turnabout of the Scopes era, the state's case now depended on demonstrating competent scientists accepted this particular category of creationism as sound science rather than sectarian mandate.

They had a tough time.

Mathematician Chandra Wickramasinghe was called to question the probability of life arising purely through random processes (which no evolutionist entertained by then), but in the process repudiated the very creationism being offered as the alternate model. When physical chemist, and creationist, Donald Chittick was asked whether he could accept a scientific fact which conflicted with the Bible, he would not commit himself. Given such testimony, the presiding Federal District Court judge found no reason to regard the law as any other than trying to further a religious purpose, and so ruled in 1982.[481]

A parallel effort in Louisiana resulted in a 1981 equal time statute similar to the Arkansas act, except it was even more deliberately worded to avoid triggering court disapproval. This survived all the way to the Supreme Court, which bluntly declared it unconstitutional in 1987, and signaled that mere packaging was not going to solve the problem.[482]

Since then creationists have tended to focus on either revising the curriculum at the grass roots school board level, or bypassing the public school process altogether by disseminating their information directly through home schooling or Christian academies, as they had done for many years. With that, the situation fell into a reprise of the 1920s cease fire, again abetted by some textbook publishers who turned circumspect about offending potential markets with inadequately veiled references to evolutionary thinking in their high school science texts.[483]

Just as evolutionists were gearing up to joust with Creation Science, though, along came the "Intelligent Design" movement to turn the tables.

In a way, it was the revenge of the American Scientific Affiliation approach to creation, which had never clutched at the deadening anchor of Flood Geology to begin with. Distracted by the glare of Henry Morris' fireworks, evolutionary writers were often too busy targeting the carrying capacity of Noah's Ark to notice the subdued emergence of religiously devout scientists and philosophers from the halls of academe. These new antievolutionists were holding up the Big Bang as the ultimate act of creation, while endeavoring to undermine the viability of naturalistic theories on the origin of life by challenging its very chemistry.

Of course, they still had to deal with that recalcitrant fossil record, and resolve its many evolutionary implications. Arguably the most influential work here was Australian molecular biologist Michael Denton's 1985 *Evolution: A Theory in Crisis*. While Morris and Gish were wallpapering over their Biblical convictions to appear innocuous enough for secular consumption, Denton restricted his arguments exclusively to scientific issues and evidence, and consequently impressed a lot of people for whom "Creation Scientist" was just a synonym for crank.[484]

Following Denton's lead, lawyer Phillip Johnson put *Darwin on Trial* in 1991, biochemist Michael Behe pried open *Darwin's Black Box* in 1996, only to supposedly find nothing inside, and in 2000 biologist Jonathan Wells claimed to have exposed the faulty *Icons of Evolution*.

Although ostensibly unconcerned with the Flood, and adept at composing extended paragraphs utterly devoid of scriptural citation, the substantive content of Intelligent Design is not far removed from traditional beliefs. In their 1991 study of Biblical creationism, sociologists Eve and Harrold delineated these core concerns:

> 1) *The origin of the universe.* Was the universe divinely created, or has it always existed, or did it come into existence without any supernatural cause?
> 2) *The age of the universe and of the earth.* Are they billions of years old, or only thousands?
> 3) *The origin of life.* Was life divinely created out of nothing, or did it result from chemical processes in the "primeval soup" of the early earth?
> 4) *Biological evolution.* Once it appeared, has life changed through a process of evolution (descent with modification), in which new species appeared while others became extinct, or have all the kinds of living things remained the same (with only minor changes within categories)?
> 5) *Human origins.* Did humanity evolve by a process like that posited for other life-forms, or were humans especially and distinctly created?[485]

Measured by this taxonomy, Intelligent Design would part company with Creation Science only over the second issue (the age of the earth and universe), and consequently could be awarded a solid 80% on the "creationism index." By comparison, a theistic evolutionist who believed God really had "rested" after launching the Big Bang and archaebacteria billions of years before would drop to only 40%, while Phillip Johnson's bête noire, Richard Dawkins, could pitch his metaphysical tent squarely at ground zero.

One thing the new Intelligent Design wing has not had time to develop is the broad subculture characteristic of traditional Biblical creationism. Toumey has studied that structure in detail, and has discerned three levels of participation. At the top is a core leadership that undertakes most of the research and writing, aided by an inspired cadre who relay the authoritative positions to the third tier, a receptive (and surprisingly passive) body of general sympathizers.[486]

That *passivity* is an important feature, for the rank and file creationist is apt to accept the pronouncements handed down to them with very little critical examination. When it comes to scientific criticisms of those views, however, they manifest exactly the opposite attitude, an unflinching *skepticism*. Though customary for those receiving revealed truth in a religious context, such hermetically sealed credulity is the very antithesis of the inquiring curiosity essential for the scientific process.

While those occupying the base of the creationist pyramid tend to reflect the attitudes of the population at large, the demographic mix of the upper two tiers is far more distinctive.

The picture of an activist creationist is one of a socially conservative white male Christian, usually a Protestant, and predominately Republican—thus contrasting with the often marked radical progressivism of their 1920s counterparts. Furthermore, the serious creationist is more likely to be a scientist than a professional theologian, and more often deriving from a technical background like engineering or computer science, than one of the life sciences where the fiddly bits of nature cannot be so handily avoided.[487]

The exceptions to this overall picture are rare enough to be noteworthy.

Eve and Harrold remarked how few Roman Catholics were involved in the creationist movement, citing Paul Ellwanger's involvement in the Arkansas legislative effort.[488] Michael Behe is a similar example from the Intelligent Design side, while political critics of evolution count among them Pat Buchanan and William F. Buckley (whose *National Review* magazine and *Firing Line* series on PBS gave early prominence to Phillip Johnson). Part of the reason for this may be because the church hierarchy still smarts from the last time it weighed in on matters scientific, the Galileo case. (In that instance it only took the church 350 years to get around to admitting it had been a little bit mistaken there). But a more likely factor is that Catholic scientific thinking has adapted itself to aspects of evolutionary thought for long enough that the institutional support a Duane Gish might rely on from an evangelical pulpit is less available to someone of that faith drawn to creationist explanations.

An analogous situation is found with the Mormon Church, another popular denomination conspicuously absent from the creationist tide. While polling data suggest individual Mormons are more likely to hold creationist views than the general population, only Melvin Cook has managed to play even a minor role, seldom emerging above footnote status in the creationist literature. With a far more recent experience of active persecution (including the martyrdom of founder Joseph Smith), and a practice of realistic political accommodation (abandoning polygamy as price for Utah's admission to the union), the leadership appears rather skittish about becoming embroiled in potentially contentious public debate. So however much the Book of Mormon's version of pre-Columbian events may diverge from the conventional view, in marked contrast to the strident anti-Darwinist crusade of Protestant creationists, there has been no comparable effort to promote it as an alternative for public school history consumption.[489]

Venturing farther afield, one encounters asterisks.

While religion editor of the Washington *Evening Star* William Willoughby unsuccessfully sued the National Science Foundation in 1971, trying to force it to spend as much money promoting creationism as it had the BSCS project. Subsequently he moved on to edit a Scientology magazine.[490] Native American creationism (which objects to the Bering Strait migration of their ancestors as strenuously as Henry Morris decries uniformitarian geology) is represented by Vine Deloria, Jr.[491] Michael Cremo and Richard Thompson's weighty *Forbidden Archaeology* defends a Hindu (Hare Krishna edition) conception projecting human activity far back through geologic time.[492] And Islamic fundamentalism has met conservative Christian creationism in a curious Turkish offshoot of Henry Morris' Institute for Creation Research.[493]

Whether other religions, from Buddhism to Sufi, can resist the temptation to weigh in on this subject, only time and good sense will tell.

A few antievolutionists profess no religious motivations at all, such as British neo-catastrophist Richard Milton, who exported his 1992 book, *Facts of Life*, to America in a 1997 edition, *Shattering the Myths of Darwinism*. Milton's side of the equation opens the possibility for a distinctly non-Christian New Age parapsychological antievolutionism that may not be at all to the liking of more conventionally religious advocates of Intelligent Design theory.[494]

This potential for schism hasn't had much time to arise, since the ID movement is barely a decade old, jump started on college campuses particularly by the many books and lectures of Phillip Johnson. There is an academic patina to the efforts of the Discovery Institute that Henry Morris' Creation Science never attained. But beneath Johnson's prodigious gifts as a rhetorical engineer lies the religious agenda of the Wedge campaign he began, whereby a consortium of opponents to the perceived obstacle of Darwinian naturalism may yet steer the debate toward Christian revival by "asking the right questions."[495]

This *Kulturkampf* aspect of the design movement readily draws on the substrate begun by more conventional creationism, whereby antievolutionary claims are embraced by people only marginally familiar with the relevant sciences. Just how far up the philosophical food chain this extends was illustrated when former Supreme Court nominee Robert Bork felt disposed to sideswipe evolution in his 1996 diagnosis of the ills of modern American society, *Slouching Towards Gomorrah*:

> The major obstacle to a religious renewal is the intellectual classes, who are highly influential and tend to view religion as primitive superstition. They believe that science has left atheism as the only respectable intellectual stance. Freud, Marx, and Darwin, according to the conventional account, routed the believers. Freud and Marx are no longer taken as irrefutable by intellectuals, and now it appears to be Darwin's turn to undergo a devaluation.
>
> The fossil record is proving a major embarrassment to evolutionary theory. Though there is ample evidence of evolution and adaptation to environment within species, there is not evidence of the gradual change that is supposed to slowly change one species into another. A compelling argument for why such evidence is missing is provided by the microbiologist Michael Behe. He has shown that Darwinism cannot explain life as we know it. Scientists at the time of Darwin had no conception of the enormous complexity of bodies and their origins. Behe points out that for evolution to be the explanation of features such

> as the coagulation of blood and the human eye, too many unrelated mutations would have to occur simultaneously. This may be read as the modern, scientific version of the argument from design to the existence of a designer.[496]

This passage exhibits in dehydrated form all the methodological delinquencies of the creationist worldview. There is the ubiquitous conflation of evolution with atheism and radical politics, with the presumption that once these annoying obstacles are elbowed aside the business of spiritual regeneration will proceed unimpeded. Just what bearing all this could have on substantive questions like dinosaur phylogeny or variations in genetic sequencing never occurs to Bork, who is in far too much a hurry sprinting for the light to offer adequate citation. His lone reference to *Darwin's Black Box* didn't help much, as Behe hadn't discussed the fossil record or the speciation process at all. In fact, in one of the more remarkable declarations in the antievolutionist canon, Behe actually agreed that all living things are apparently related by common descent—a notion more prosaically known as "evolution." That Bork could skip past this stupefying concession should not be unexpected, for Behe managed to sidestep all its implications rather gingerly himself.[497]

What effect Bork's cavalier conceits might have had on matters of creationist litigation had he been confirmed to the court is anybody's guess. We already have the example of Justice Scalia, who dissented from the 1987 ruling striking down the 1981 Louisiana "balanced treatment" law, and was joined in this opinion by Chief Justice Rehnquist. Neither jurist apparently discerned anything even remotely scientifically spurious about the "creation model" under consideration, giving one pause to wonder to what degree a grounding in basic scientific principles has penetrated American legal education.[498]

How much more difficult then for jurists unfamiliar with the details or methodology of science to assess the less overtly "creationist" efforts undertaken by the ID movement in Kansas in 1999 or in other states since (see Appendix III on some of the arguments from the Kansas affair).

Appendix II. *The Lunar Dust Myth*

The Creation Science claim that the moon does not possess enough surface dust consistent with it being billions of years old is one of the most conclusive illustrations of how easily creationists can repeat misinterpreted information.

The main source for the myth has been Henry Morris. Although he has sprinkled various versions of it through his books over the years, the most authoritative statement may be gleaned from the account in *Scientific Creationism*, since that work purports to serve as a preliminary *textbook* for the teaching of Creation Science in public schools. Here is the entire section on the "Influx of meteoric material from space" in that work:

> It is known that there is essentially a constant rate of cosmic dust particles entering the earth's atmosphere from space and then gradually settling to the earth's surface. The best measurements of this influx have been made by Hans Pettersson, who obtained the figure of 14 million tons per year. This amounts to 14×10^{19} pounds in 5 billion years. If we assume the density of the compacted dust is, say, 140 pounds per cubic foot, this corresponds to a volume of 10^{18} cubic feet. Since the earth has a surface area of approximately 5.5×10^{15} square feet, this seems to mean that there should have accumulated during the 5-billion-year age of the earth, a layer of meteoric dust approximately 182 feet thick all over the world!
>
> There is not the slightest sign of such a dust layer anywhere of course. On the moon's surface it should be at least as thick, but the astronauts found no sign of it (before the moon landings, there had been considerable fear that the men should sink into the dust when they arrived on the moon).
>
> Lest anyone say that erosional and mixing processes account for the absence of the 182-foot meteoric dust layer, it should be noted that the composition of such material is quite distinctive, especially in its content of nickel and iron. Nickel, for example, is a very rare element in the earth's crust and especially in the ocean. Pettersson estimated the average nickel content of meteoric dust to be 2.5 per cent, approximately 300 times as great as in the earth's crust. Thus, if all the meteoric dust layer had been dispersed by uniform mixing through the earth's crust, the thickness of crust involved (assuming no original nickel in the crust at all) would be 182 x 300 feet, or about 10 miles!
>
> Since the earth's crust (down to the mantle) averages only about 12 miles thick, this tells us that practically all the nickel in the crust of the earth would have been derived from meteoric dust influx in the supposed (5×10^{9}) year age of the earth!
>
> Another interesting calculation can be made by noting that river water carries about 0.75 billion pounds of nickel each year to the ocean and the ocean contains about 7000 billion pounds. Thus the nickel dissolved in the ocean's waters could have accumulated from river flows in slightly over 9000 years. Consequently the absence of the appropriate percentage of nickel arriving on the earth's surface from meteoric infall cannot be attributed to erosion and transportation to the ocean. The only possible way of accounting for the small amount of nickel found in the earth's crust and ocean seems to be in terms of an age for the earth of only a few thousand years.[499]

Just as "interesting" is to compare this with what Morris had to say in another book, *The Remarkable Birth of Planet Earth*. This was a short paperback done in 1972, only two years before the original edition of *Scientific Creationism*. Its back cover blurb preened that Morris was a "distinguished man of science" who "is thoroughly equipped to come to grips with his subject material." It gained considerable public distribution in 1981 when Jerry Falwell's "Moral Majority" crusade offered it gratis, via a mass media ad in *TV Guide*, as a tidy compendium of all the scientific evidence for creation.[500]

Regarding the meteoric dust example, Morris then had more terrestrial concerns: "There is no measurable accumulation of meteoric dust on the earth's surface, but present rates of influx of such dust from space would produce a layer 1/8 inch thick all over the earth in a million years and a layer 54 feet thick in 5 billion years."[501]

By reading more than one Morris we are tipped off to the numbers game he's trying to play, for how can the same influx rate produce layers 54 and 182 feet thick? He never stated his assumptions used in the 1972 calculation, but whatever they were he appears to have abandoned them by 1974.[502]

The standout feature of this earlier version, however, concerns how Morris referred to the arriving dust by thickness rather than weight. That was a blunder he would not subsequently make, as it left the reader to stop and think about what might happen to that 1/8 *millionth* of an inch of dust landing each year. It is difficult enough imagining grass clippings many millions of times larger remaining placidly on the driveway through the next heavy rain, so what made Morris think microscopic dust particles would be so obliging, and not have a substantial drift life of their own?

As Morris acknowledged, a great deal of any meteoric nickel filtering down from space would end up washed into the sea, but one has to peer around a magician's screen to see what's really going on. Certainly by the time the revised edition of *Scientific Creationism* appeared in 1985, no oceanographer believed the ocean floor remains *unchanged* over 500 million years, let alone 5 billion. It is known (by which I mean it has been *observed* and *measured*) that seafloor spreading and subduction occur. This serves eventually to conveyor-belt sediments back into the earth for recycling, where some might emerge millions of years later in surface crust by volcanic processes. Since a thorough comprehension of plate tectonics has never been up the Creation Science alley, the background information needed for the reader to arrive at an informed conclusion here has been withheld.[503]

All of these caveats pertained, of course, provided Morris' statements about the meteoric influx rate were factually correct. But it turned out Pettersson's measurements were based on readings taken from Hawaiian mountaintops (under the presumption these would be less subject to contamination by industrial nickel effluents) and ranged from 5 million to the 14 million tons Morris elected to quote. Pettersson himself considered the lower value the more likely one, since it made sense relative to what was then known about the nickel content of deep ocean sediments.[504]

Morris let the reader know absolutely none of this.

Even so, five million tons a year is a lot of dust, and billions of years of it settling on the lunar surface could pose a problem. Because scientists were (and remain) convinced the moon was formed that long ago, one of the first things NASA did was to put detectors in orbit precisely to settle the issue, well before they had to start drafting blueprints for landing pads. Fortunately, by the mid-1960s these space-based experiments made it abundantly clear Pettersson's preliminary values had indeed been way too high. Meteoric dust was being *concentrated* at high altitudes, not deposited there in a representative manner. The influx rate observed from orbit turned out to be only around 20,000 tons a year, a value 1/280 of the higher of Pettersson's ground-based observations, the one Morris unceremoniously latched onto.[505]

So in what respect was the Pettersson study the *best* measurement in 1974 when Morris set about compiling the *Scientific Creationism* text, or in 1985 when he supposedly revised it—let alone 1996, when the 20th edition appeared (from which the above quote was drawn)? By 1985 several evolutionary critics of creationism, such as Chris McGowan and Kenneth Miller, had picked up on this issue and called attention to the fact that NASA had far lower measurements in hand than Pettersson's 1960 work.[506]

But rather than cluttering up his main text with a discussion of the actual history of the matter, Morris' only adjustment was to amend his sole footnote to the meteoric dust passage:

> Hans Pettersson, 'Cosmic Spherules and Meteoric Dust,' *Scientific American*, Vol. 202 (February 1960), p. 132. More recent measurements indicate a much great [*sic*] influx of dust than Pettersson calculated, and thus a still younger age for Earth and the moon (see G. S. Hawkins, Ed., *Meteor Orbits and Dust*, published by NASA, 1976). Figures obtained by actual measurements in space as listed in this publication, yield 200 million tons of dust coming to earth each year.[507]

An internet check with NASA's publication catalog and email help line revealed the Hawkins report was printed not in 1976, but in *1967*, and consisted of 48 papers presented at a symposium held in August 1965. This meant the participants were just starting to grapple with the new space-based data then emerging from the Gemini phase of the Apollo program. Since Morris supplied no page numbers (out of 437), the reader was given no help in tracking down whether those numbers were accurate.[508]

But especially if they had been right, why then didn't Morris revise the 1985 text to reflect that, instead of retaining the dated 1960 Pettersson measurement as the *best* one? Well, if the true meteoric dust rate were 14 times higher than Pettersson's top value that presents some difficulties for Morris' oceanic concentration trick. If the sea contains 3.5 billion tons of nickel, and terrestrial erosion is only contributing 375,000 tons a year, at the same time meteoric dust is adding 200 million tons, by his own math Morris would have just "proven" the current amount took only 17 years to accumulate. So, unless some of that nickel was *going somewhere* or the influx rate was *wrong* (either of which would invalidate the whole calculation), applying the new value to the 1974 Morris logic would have the earth created sometime around the year 1957.[509]

The absurdities and evasions of the meteoric dust argument do not filter down to the substratum where the Gablers and other politicized creationists dwell, simply because the material they expose themselves to either continues to repeat it unchallenged or tactfully avoids the subject altogether.[510]

An interesting current example of the former (besides Morris himself) would be "Dr." Kent Hovind, an ebullient ex-high school (Christian) science teacher who regularly stomps the countryside lecturing church groups on the fallacies of evolution. In a 1996 video dealing with "The Age of the Earth" Hovind managed to thoroughly out-Morris the master by claiming one inch of lunar dust accumulates there every 10,000 years. That happens to be *16 times* Morris' "1976" rate, which was *14 times* Pettersson's top estimate, itself *280 times* the actual value. Those listening so raptly to Hovind's exposition on the tape were being supplied with an influx rate inflated 60,000 times. Being off by those four orders of magnitude was rather like saying you'd watered the lawn yesterday when Andrew Jackson was president.

As for the "studied silence" approach, Duane Gish continues to excel. In a 1992 appearance on a Northern Michigan University program, "Voices for Creation: Scientists Speaking Out on the Origin Issue," Gish claimed the moon ought to have 50 feet of dust on its surface were it as old as evolutionists thought. By this time he was presumably familiar with at least one relevant voice, paleontologist Chris McGowan, who specifically argued the contrary—yet the meteors did not descend into his 1993 book *Creation Scientists Answer Their Critics*.[511] If Gish accepted Morris' view as scientifically valid, it would have seemed a ripe target for one of his artfully convoluted rejoinders, noting how those silly evolutionists had got it wrong again. If he agreed with the criticisms, though, was this a case of not wanting to assail a fellow creationist? Doesn't it then matter to Gish whether the Morris might have included in a potential *school text* a "fact" that was empirically preposterous?[512]

Meanwhile, creationist physicist Donald DeYoung tried to straddle both sides of the fence, and got so tangled up putting spin on the history of space exploration that he completely missed the astrophysical implications of what he was talking about. In his 1989 book, *Astronomy and the Bible*, DeYoung stacked the deck this way:

> More recent measurements of dust-accumulation from space give results as much as a thousand times less than originally thought. The early estimate of sixty meters of lunar dust thickness, divided by one thousand, results in only about two inches of dust, in apparent agreement with the long-age view. Two creationist responses will be mentioned. *First*, the evolutionary view predicts a much greater influx of dust in the early stages of the solar system. The hypothetical cloud of dust that formed the sun and planets should have been much thicker in the past. Therefore a thick layer of moon dust is still predicted, and it is still missing. *Second*, the revised value of a much smaller dust accumulation from space is open to question. Scientists continue to make major adjustments in estimates of meteors and space dust that fall upon the earth and moon.
>
> Recent study of the problem can be briefly outlined:
>
> pre-1966 Estimates postulated great depths of lunar dust.
> 1966 Unmanned *Surveyor* probes landed on the moon, showing little dust and a firm surface.
> 1969 The first manned lunar landing (*Apollo 11*) showed just two to four inches of dust.
> post-Apollo Estimates of dust accumulation were reduced. Another view is that the thick lunar dust is actually present, but has been welded into rock by meteorite impacts.[513]

DeYoung clearly wanted to give the impression the influx rate was scaled down only *after* the thin layer of dust was found on the moon, and all that impeded this interpretation were the facts of the space program. More specifically, the *landing pads* on Surveyor, for they were just as dinky as the ones on the later Lunar Excursion Module. If the engineers designing them were under the impression the moon would be blanketed in a thick mantle of dust, why then did they make the feet so comparatively small?[514]

Evolutionist Tim Berra summed up the paucity of the lunar dust argument this way: "Creationists are aware of the modern measurements, but they continue to use the incorrect figure because it suits their purpose. Such is their honesty and scholarship. Do these people believe that the astronauts would have been allowed to land on the Moon if NASA thought they would sink into 100 feet of dust?"[515]

Instead of simply admitting creationism might actually have been mistaken about something, DeYoung performed the contorted defense of trying to drag in the early history of the solar system, and thereby marched right past one of the most exciting astrophysical discoveries of the late 20th century.[516] The intense bombardment believed to have occurred nearly 5 billion years ago was not so much raining *down* on the moon as *forming* the moon, and just how this took place was only figured out after geophysicists got their hands on actual lunar samples. These revealed both similarities and differences with terrestrial rocks that provided the final clues to the moon's origin. Both pre-Apollo theories turned out to be wrong. The moon was neither a captured satellite nor had it been produced along with the earth in an accretion disk or by fissioning off from the formative earth. Rather, after the earth had already grown to the point where heavier elements (especially iron) had begun settling into the molten core, a Mars-sized or better planetesimal slammed into it during the period of intense bombardment that characterized the formation of the solar system. This collision splattered off a mass of the lighter surface material, along with a sampling of the colliding body. It was from this distinctive debris that our moon was composed.[517]

Appendix III. *Falsification*

The antievolutionary revisions to Kansas' science education standards proposed in 1999 offered a particular approach to the issue of logical falsification. Although one may define terms in many ways, you only see what they actually mean when they are applied. And on close examination the guidelines being proposed by the Abrams/Willis group in Kansas carried far more than even the baggage of Young Earth creationism in their zeal to exorcise the specter of "macroevolution." As has been seen all through the antievolution controversy, their most serious problems were occurring at the very ground level of fundamental reasoning.

One place to start is with someone who thought the creationist standards were thoroughly in order. Someone outside the technical field, who might give us a *vox populi* take on the affair.

"The Phyllis Schlafly Report" for March 2001 complained how a newly elected school board had just put the evolution sections back into the Kansas science standards.[518] This turn of events did not sit well with the combative Mrs. Schlafly, who complained about the new board's "dumbing down science in order to promote evolution." Which was an ironic way to put it, given that her Eagle Forum's idea of sound scientific pedagogy includes lectures by "Dr." Kent Hovind (the bumptious Florida YEC evangelist whose doctorate was obtained from Patriot University, a diploma mill currently operating out of a suburban split-level in Colorado).[519]

In the original evolutionary version of the Kansas standards, 8th Graders learning about the HISTORY AND THE NATURE OF SCIENCE were told to "Display open-mindedness to new ideas." But the Willis revision didn't like that attitude, and replaced it with a call to "Learn about falsification." That consisted of a foray into analytical logic—or at least, the sort that Tom Willis could swear by:

> 10 1. Learn inductive reasoning and its limits.
>
> **Example:** If we saw on the road nothing but black cars, we might theorize that all cars are black. This is an example of inductive reasoning. Discuss the proposition. Can we prove that there are only black cars without actually seeing them all? No matter how many cars we see, we will never see them all, so inductive reasoning can never absolutely prove any general statement.
>
> 10 2. Learn deductive reasoning and its limits.
>
> **Example:** If we theorized that there were only black cars, we might plan on seeing black cars on our trip home from school. This is an example of deductive reasoning. On what is deductive reasoning based? The inductive reasoning that led to the theory or on *a priori* assumptions. Therefore, deductive reasoning can only be as valid as the assumptions or the inductive reasoning used to form the original theory.
>
> 10 3. Learn about falsification.
>
> **Example:** What would we accept as proof that the theory that all cars are black is wrong? How many times would we have to prove the theory wrong to know that it is wrong? Answers: One car of any color but black and only one time. No matter how much evidence seems to support a theory, it only takes one proof that it is false to show it to be false. It should be recognized that in the real world it might take years to falsify a theory.[520]

Now this argument was included in the standards solely because it was considered relevant to disposing of evolution—and apparently *only* evolution. As Phyllis Schlafly put it in her 2001 editorial, "Evolution can encounter difficulties with the falsification test."[521]

But is that true *only* of evolution? Or *even* of evolution?

Phyllis Schlafly was acting as if the analytical slide ran only one way. Why was it *evolution* that was the "all cars are black" hypothesis being exposed for refutation by the existence of (even one) non-black car? Why couldn't it be the other way around: *creationism* as the argument being compared to the available collection of cars? By framing the debate in one way and not the other, defenders of the Kansas standards were treating creationism as though it were the default position—the undisputed alternative to the specter of naturalistic Darwinism.

The very fact that the debate was being framed in this lopsided way disguised some even more fundamental problems with how the "logic" of falsification was unrolling in Kansas. The most obvious problem concerns the fact that finding one black car only works to falsify an extremely general statement like "all cars are black." It would hardly disprove the more qualified assertion that "most cars are black." For that, you'd have to determine the relative proportion of black and non-black cars. And things get even more complicated when you address *historical* questions, like "most cars *used* to be black." Now you have to recognize the record of previous car production and ownership—not the current distribution.

And, by the way, back in the early 1920s, when Henry Ford had cornered over half of American car sales, it may well have been true of many places that indeed most cars were black, that being the only color the Model T came in.

But there is something else decidedly screwy about the way the Kansas standards framed the falsification issue. While the existence of even one non-black car would certainly refute their caricatured proposition that "all cars are black," it would hardly allow you to conclude that all the *black* cars weren't **black**. Yet that's precisely what the standards were trying to do with evolution: using the existence of any "falsifying" evidence (if such there be) to permit the blanket rejection of the implication of all those black cars. And all without actually examining any of that "black car" evidence.

What Willis was doing in this section on "falsification" was committing a truly monumental category mistake: treating *observations* (that certain cars were black) as though they were *theories* about why the cars were that color. The mere discovery of non-black cars would not necessarily have any bearing on the validity of a theory about why the black cars were black. That would be true if and only if the mechanism being proposed to account for a car's blackness absolutely precluded the existence of non-black cars.

Translated into what the creationists really were exercised about, "macroevolution," the recognition that some animals might not have been related by common descent wouldn't inevitably negate the idea that others *were* related by common ancestry. This was the same clumsy logical mistake Phillip Johnson and Jonathan Wells made when they tried to invoke the purported mysteries of the Cambrian Explosion as a way to circumvent all the evidence of macroevolutionary change that they so pointedly did not discuss.[522]

There were at least two links missing in this antievolutionary logic chain.

First, some idea of the limits of speciation had to be appreciated. If it is impossible for species to split, then there is no way for larger macroevolutionary changes to emerge. If the antievolutionist wants to draw the line at speciation, then they have to account for the evidence of biogeography (the distribution of living things in time and space). As both Charles Darwin and Alfred Wallace independently discovered during their sojourns out in the wild, the pattern of endemic flora and fauna was wholly inconsistent with fixity of species.

Although most modern creationists accept speciation, it is in a general sense and rarely applied to specific instances. Consequently grassroots creationists are frequently confused on this subject, such as thinking speciation is synonymous with macroevolution.[523] As for biogeography, they have avoided this topic with amazing consistency, despite the persistent prodding of evolutionary critics who remind them of it.[524]

If the antievolutionist accepts that at least some natural speciation has occurred, but that this process cannot in principle support the overall concept of common descent with modification, then they are compelled by the logic of their position to identify the limits of natural modification. In the creationist parlance, they would need to clarify what they mean by created "kinds" or "types"—and illustrate by example how they would propose to categorize the range of life (living and fossil) on that basis.

Michael Denton has set the benchmark here, having conceded both speciation and that the horse sequence "is nothing like a perfect continuum of forms, the breaks are distinct and clear, but the overall sequential pattern is so obvious that no one seriously doubts that the modern horse has evolved from the primitive horses of the Eocene era sixty million years ago."[525]

Denton was wrong though: most antievolutionists do seriously doubt horse evolution, though not by applying a clear concept of speciation to the subject.[526] And while Denton accepted the horse sequence, he also airily dismissed it as "the exception which proves the rule" of typological stasis, whereby "nature cannot be arranged in terms of sequences and that where sequence does exist it is exceptional or relatively trivial." What Denton did not do was apply that equine yardstick to other fossil examples, particularly the reptile-mammal transition, where he would have had to detect some stage in the process that exceeded the boundary of horse-sized variation he had acknowledged as microevolution writ large. By not following through on the logic of his own concession, Denton's 1985 book fell into the broad antievolutionary tradition of not pressing too quickly to define a workable typology.[527]

A recent development has reinforced the problem facing typology. YEC creationists (such as Kurt Wise and Todd Wood, both of Bryan College in Tennessee) have tried to revive an older redefinition of the problem called "baraminology" (*baramin* being a Hebraic neologism for "created kind").[528] The new breed of baraminologists has instituted a proliferation of redundantly obfuscating terminology. There are "apobaramin" and "polybaramin" groupings of unrelated organisms that would include one or more "holobaramins" (preserved representatives of the actual created "baramin" type) within which there could be "monobaramins" (naturally related lineages) as subsets.[529]

But if two organisms are not in the same mono- or holobaramin then they would have to be both apo- and polybaraminic. Why then bother with two categories for unrelated forms at all?

Those caveats side, baraminologists Wood and his collaborator David Cavanaugh have tried to apply topological algorithms to morphological data sets, under the presumption that holobaramins would stand out by the discontinuities in their spatial plotting. But so far their work hasn't isolated even one unequivocal holobaramin, only evidence for monobaramins (i.e. groups related by common ancestry).[530] Of particular interest is the horse sequence, where Wood and Cavanaugh have actually confirmed its *monobaraminic* status.[531]

If all baraminology manages to do is disclose a plethora of open-ended monobaramins, this will pose no problem for Darwin. That's because such findings are completely consistent with the evolutionary conception, under which there would be no independently created holobaramins to identify.

Notes to the Introduction

[1] Milton's 1994 book *Forbidden Science* offered paranormal speculations that included a defense of Uri Geller's status as a legitimate psychic. Milton (1997) was a revision of the 1992 British edition, *Facts of Life*. Such a mix of interests is not surprising for a Mensa member. Articles by Glenn Jackson (etcsa.org/GJackson/PtsOfOrigin20010203.html) featured at the East Tennessee Creation Science Association proudly notes that "He is a lifetime member of both American Mensa and the Creation Research Society." Shermer (1997, 56-57) noted: "The IQ score has acquired nearly mystical proportions in the last half century, but I have noticed that belief in the paranormal is not uncommon among Mensa members (the high-IQ club for those in the top 2 percent of the population); some even argue that their 'Psi-Q' is also superior." But not always their sense of historical anachronism: the co-founder of Mensa, Australian barrister Roland Berrill, firmly believed that the occult tarot (largely a 19th century concoction) actually originated at a convention of adepts supposedly held in Morocco around 1200 AD. See Dummett & Mann (1980) for a comprehensive survey of gaming tarots (a 15th century Italian invention), and Decker *et al*. (1996) on the subsequent invention of the occult tarot.

Milton's paranormal interests and reliance on obsolete creationist material contributed to the largely unfavorable review of *Shattering the Myths of Darwinism* by Carl Wieland (1998) for the Young Earth creationist organization Answers in Genesis (review available at the AiG website, answersingenesis.org/home/area/magazines/tj/docs/tj_v12n2_Milton.asp).

Parenthetically, the content and philosophy of *Forbidden Science* was eerily like that of a project I collected notes for back in the early 1970s. My working title then was *Renaissance II: Towards a New Worldview*, but the more deeply I delved into the "facts" the less secure my positions became, until I shelved the whole thing as irremediably half-baked. In writing *Three Macroevolutionary Episodes* a quarter century later a lot of my old notes turned out to be quite useful, albeit in a very different context. Milton and I are also about the same age, so it is as though we were time twins, branching our separate methodological ways. Wither but for the grace of Providence (and sound Scholarship) go I, so to speak.

[2] There is an entertaining body of criticism of "The Mysterious Origins of Man" and "Dr." Carl Baugh at the talkorgins.org website. Baugh is among the few remaining YEC believers who accept that human footprints are preserved at the Paluxy River site in Glen Rose, Texas. Cf. the backspin by John Morris' Impact No. 151, January 1986 (icr.org/pubs/imp/imp-151.htm) and AiG ("Maintaining Creationist Integrity" at answersingenesis.org/docs2002/1011hovind.asp). A sampling of the voluminous critical literature on the Paluxy "mantracks": Strahler (1987, 462-470), Lockley (1999, 181-185), Pennock (1999, 216-221) and Kossy (2001, 184-189).

Baugh possesses a self-inflicted "doctorate" from an Australian mail order operation set up conveniently by his friend and fellow YEC believer, Clifford Wilson. Wilson (1972; 1974; 1976) vents criticism of Erich von Däniken and concern over demonic UFOs. Interestingly, the similar Wilson & Weldon (1978) ended up being the sole citation representing creationist thoughts on probability assessments of the origin of life in Dembski (1998, 55-56, 59-60).

Milton (1997, 267) and his alternativescience.com website remain insouciant over his involvement with the MOM special, praising NBC for its "rare and honorable exception" in bucking Darwinian orthodoxy by airing it. I discovered in my email exchange that not only was Milton unaware of the gossamer credentials of his fellow interviewees (like Baugh)—Milton didn't much care one way or the other.

Graham Hancock, who resembles a more gracious edition of Richard Dawkins, represents another facet of the antiestablishment subculture. Starting out as a journalist plying the African beat for the *Economist*, Hancock wrote on social themes like the AIDS epidemic and Ethiopian famine before Hancock (1992) decided the Ark of the Covenant was stored in an Ethiopian shrine. Bauval & Gilbert (1994), Hancock & Bauval (1996) and Hancock (2002) contend that Egypt and other cultures are far older than conventional archaeology supposes. John Anthony West (1993)

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popularizes the ideas of Alsatian philosopher and Egyptian buff Schwaller de Lubicz, who believed Egyptian civilization began 30,000 years ago from a legacy of Atlantean Sacred Science, and this further connects to the "scientific" astrology of West & Toonder (1970).

[3] On advancing "creationism as a much more scientific model of origins than evolutionism," LaHaye & Noebel (2000, 317n) recommend many works, starting with "all books published by the Institute for Creation Research;" along with Sunderland (1988) and "all works by Phillip E. Johnson on the subject of evolution." Finally, "for our atheist readers we recommend Richard Milton's *Shattering the Myths of Darwinism*. Milton is an atheist who sees through the myths of Darwin." Evangelist Tim LaHaye is responsible for the popular "Left Behind" series of novels depicting the horrific post-Rapture world leading up to Armageddon.

Milton also served as a "Commentator" for Eternal Productions' video *A Question of Origins* (advertised at morethanwords.net/origins.htm). "This video *exposes* the fallacies and complete ignorance of the theory of evolution to the point that **you will marvel** that the world still accepts and defends a theory that modern science has proved to be false." Among those contributing to this marvel were apocalyptic boosters Chuck Missler and Dave Hunt, the ICR fossil point man Duane Gish, and British creationist (and geocentrist) Malcolm Bowden (see note 43 below).

As of this writing, additional references to Milton are slim, but revealing. Mike Carrier's anti-Darwinian *Netwurking News* (at goodschools.com) has castigated Richard Dawkins for expressing unflattering opinions of Milton (cf. note 306 below, Chapter Five). Opaque biophysicist Cornelius Hunter (2001, 81, 182n; 2003, 37, 78, 155n, 158n) secondarily extracted a 1951 quote by George Gaylord Simpson on the proven solidity of evolution from Milton's 1997 revised book (though giving a publication date of 1992, which was of the original British version under a different title). And Native American creationist Vine Deloria (2002, 34, 52, 68-69) mentioned "popular science writer and critic" Milton "whose book *Shattering the Myths of Darwinism* is generally thought to have begun the intense modern debate about Darwin." By whom this was "generally thought" he didn't specify.

[4] See Milton (1997, 32-33, 42-45, 62-64, 87-94) on Cook and Velikovsky. Physicist Stephen G. Brush, "Finding the Age of the Earth: By Physics or By Faith?" in Zetterberg (1983, 296-349), abridged as "Ghosts from the Nineteenth Century: Creationist Arguments for a Young Earth," in Godfrey (1983, 59-71), and geologist Strahler (1987, 157-158) survey Cook and similar creationist arguments. Concerning plate tectonic info, see note 502 in Appendix II below.

In the early 1970s I went through a brief "Velikovsky phase" in my first years at college. For those unfamiliar with the episode, Velikovsky (1950) correlated catastrophic legends to the close approach of the planet Venus, which he believed was recently ejected from Jupiter and described by ancient observers as a comet. Although best known for his neo-catastrophism, except for Velikovsky (1955) the rest of his work was historical—Velikovsky (1960) even ventured an entertaining identification of the legendary Oedipus with the Pharaoh Akhnaton. But the focus of Velikovsky (1952; 1977; 1978) was on resolving the incredible chronological headache that resulted from his taking the much older *Admonitions of Ipuwer* as an Egyptian eyewitness to the cometary cataclysm going on during the Exodus.

[5] See Bauer (1984) on the apoplectic early scientific reactions to Velikovsky's theories, as well as a penetrating autopsy showing exactly where he went wrong—cf. also Plait (2002, 174-186). This may be contrasted with the "misunderstood genius" version of Velikovsky partisans De Grazia, *et al*. (1966) and Ransom (1976). Though Velikovsky would seem a ready ally for Biblical catastrophism (even supplying a physical explanation for the Exodus), he never defended the theological subtext that any of this was God's doing, so Creation Scientists have kept their distance, as indicated by DeYoung (1989, 48-49). Morris (1963, 64) briefly alluded to Velikovsky as part of "the recent revival of interest in catastrophism," as did Sunderland (1988, 126-127), while Morris (1972, 67) cited him on legends of divine warfare. Velikovsky emerged as a victim of "suppression" for Wendell Bird (1989, Vol. 2, 135, 489) apropos "Scientific Lack of Integrity by Many Evolutionists."

Velikovsky is easier to find farther out on the limb, from ancient astronaut believers Flindt & Binder (1974, 15-16) to the rambling lectures of Idaho apocalyptic Chuck Missler, interspersed

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with satanic UFOs and Great Pyramid codes. For the decidedly anti-Christian Deloria (1999, xiv), "My dissatisfaction with orthodox science began after reading *Worlds in Collision* by Immanuel Velikovsky." See also Deloria (1973, 48; 1974; 1995, 46; 1999, 339-353; 2002, 98-101, 201-202, 225-226n). The 1974 item (reprinted in the 1999 citation) referred to a piece in *Pensée* (a journal at Lewis and Clark College in Portland, Oregon, which took up the Velikovsky cause early in the 1970s, and on which I served one summer as their research assistant).

[6] Milton (1997, 79). Milton's catastrophist doppelganger Deloria (1995, 40) had an even looser grip on the finer points of stratigraphy. "We are told that dinosaurs lived 65 million years ago, and yet from Roy Chapman Andrews forward our scientists continue to find the dinosaur skeletons on top of the ground or very near the surface. So 65 million years of sediment apparently was insufficient to bury those monsters from our sight." Deloria might try tunneling in the Morrison Formation in Utah sometime, after which he might better appreciate why paleontologists tend to dig at the sections that have eroded surface exposures.

[7] Milton (1997, 23, 68-69). Extracts appear among the Milton quotes recommended at Paul Taylor's Eden Communications website (christiananswers.net/catalog/bk-shattering-quotes.html). Milton's numbers would have been less uniform when not rounded to a single decimal. *Palaeozoic*: Cambrian (.17), Ordovician (.19), Silurian (.26), Devonian (.23), Carboniferous (.22), and Permian (.12). *Mesozoic*: Triassic (.20), Jurassic (.24), and Cretaceous (.21). *Cenozoic*: Paleocene (.33), Eocene (.57), Oligocene (.53), Miocene (.58), and (if taken as beginning a million years ago) Pliocene (.42). By Milton's reckoning, 31,000 meters (19 miles) of sediment was involved. View that stack as a unit and the average over 500 Ma drops to only 0.06 mm annually—in other words, the farther back the spread was taken, the lower the average. This should have suggested to Milton (and Taylor appropriating his conclusions parasitically) not only how sporadic deposition was and how much was being recycled, but why dividing the thickness into the time was a mistake to begin with. But Milton (1997, 70) only recognized erosion in the abstract. "The study and interpretation of this sequence of sediments (the science of stratigraphy) is complicated by the fact that some of the beds have been laid down, only to be eroded again, giving rise to gaps in the sequence."

[8] Doyle & Lowry (1996, 340) used 1.7 mm per year (actually "17 metres per 10 000 years") to illustrate a hypothetical example of gradual sedimentation. An order of magnitude is a factor of ten, and Milton's tendency to misplace decimal points extended to an offhand observation about the lens defect in the Hubble telescope being "more than a centimeter out—that it was outside the range that anyone was mentally prepared to check on. Had it been a millionth of a meter out, it would have been spotted at once," Milton (1997, 50). The mirror had in fact been ground 2 microns too flat at the edges (1/50 the width of a human hair) because a laser used to position a "null test" lens had reflected off a paint chip, Fischer & Duerbeck (1998, 27). That resulted in the misalignment of the calibration lens by 1.3 mm—roughly an order of magnitude shy of "more than a centimeter."

[9] Milton (1997, 81, 84). For those readers familiar with the recent Disney cartoon feature *Dinosaur*, the main characters were Iguanodons. Had the entire Bernissart formation been deposited in one catastrophic go, by the way, it wouldn't have involved rates *millions* of times higher than his number, but at most 200,000 (another order of magnitude gaff, re the previous note). Which brings to mind Milton (1997, 90): "In North America an area of 200,000 square miles in Idaho, Washington State, and Oregon, known as the Columbia Plateau, is covered by lava to a depth as great as 5,000 feet (almost 1 mile). Uniformitarianism could never account for such beds. This quantity of lava exceeds by many orders of magnitude all the lava flows from all the world's currently active volcanoes." Gish (1978, 58; 1995, 49) is similar, and Huse (1997, 78) relied on another Gish book for the same misinformation. Neither Milton nor Gish offered any citations for this, but Velikovsky (1955, 89) may have been the source.

The Columbia Basalt actually covers less than a third of that area (about 63,000 square miles), with 42,000 cubic miles of lava erupting from a dike system 17-13 Ma (though some flows continued until 6 Ma), Mueller & Mueller (1997, 30-39) and Hill Williams (2002, 93-106). While some of the largest eruptions involved 500 cubic miles, the average flow was around 130. As the minor Hawaiian volcano Pu'u O'o erupted 1/50 cubic mile of lava over just a three year period in

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the 1980s, 500 cubic miles would require only around 7500 years. Keep that up for 5 million years and you get Mauna Loa (very much an active volcano), which on its own comprises 18,000-24,000 cubic miles of lava, Sieh & LaVey (1998, 192, 248, 257) and Jon Erickson (2000, 82). Cf. also Dvorak *et al.* (1992) on the magma dynamics of Kilauea.

[10] While the riverboat episode was shown on TV, other examples of rapid processes that can have long-term effects have been duly reported in the technical literature. For example, a few severe floods on the Nile (in 813, 816 and 820 AD) eventually cut off the once-thriving port city of Pelusium both from the sea and the river that once ran through it, Goodfriend & Stanley (1999).

[11] Museums with a *Diplodocus* cast include the Smithsonian in Washington D.C., and the Central Geological and Prospecting Museum in Leningrad (now St. Petersburg), Lambert & The Diagram Group (1983, 242-247; 1990, 235-237, 242-245, 260).

Just as the London Natural History Museum was formerly known as the British Museum, *Apatosaurus* is the diplodocid "formerly known as" *Brontosaurus* (except for mavericks like Robert Bakker, who stick by the old name out of habit). The genus name was changed in the late 1970s after it was realized the *Camarasaurus* skull being used as a stand-in for the missing head of *Apatosaurus* (which meant "deceptive reptile" due to its lack of preserved skulls) was unlikely for a diplodocid. Ironically, what was probably the real head had been known all along from nearby deposits, but had gone unrecognized for nearly a century. See Gould (1991, 86-93) or Fastovsky & Weishampel (1996, 250). Inaccurate creationist accounts of this nomenclatural shift include Paul Taylor (1987, 12) and Gary Parker in a 1996 creationist video ("Fossil Evidence for Creation") claiming the skull used was from *Apatosaurus*.

[12] See Lambert & The Diagram Group (1983, 244), and Gardom & Milner (1993, 24) or the 2002 *A&E* version of Conan Doyle's *The Lost World* for views of the display *in situ*. Milton (1997, 214) also alluded briefly (and without citation) to a "200-foot brontosaurus."

[13] Cf. Milton (1997, 94) with Henry Morris (1985, 98-99). Morris cited Edwin Colbert's 1965 *The Age of Reptiles* (p. 169) and his 1968 *Men and Dinosaurs* (pp. 141, 151 & 58) for four supposedly catastrophic depositions, with the *Iguanodon* example as the fourth. Milton offered the same quotes in the same order, citing Colbert directly (though not with page numbers as Morris had). While Morris' *Scientific Creationism* was in Milton's bibliography, it was not directly cited in the text.

Morris' first example, the Triassic period Ghost Ranch formation, was exactly as Colbert described it, a "local catastrophe" where small dinosaurs (chiefly *Coelophysis*) were trapped in a quarry 6 x 20 meters—about the dimensions of a typical suburban tract home. See Lambert & The Diagram Group (1990, 53) on *Coelophysis*, and Norell *et al.* (1995, 107-109), Benton (1996, 74-75), or Clive Coy, "Ghost Ranch," in Currie & Padian (1997, 277) on the formation. For comparison, one mass of sauropod bones in Wyoming (the sort of jumble a catastrophist would home in on) was not much larger: 14 x 20 meters—and the 4000 bones involved only around 20 animals. See Brent H. Breithaupt, "Howe Quarry," in Currie & Padian (1997, 355), as well as the excellent color photograph of part of the site in Norell *et al.* (1995, 86). Morris' next two examples represented floodplains: the Late Jurassic Como Bluff in Wyoming and the Late Cretaceous Red Deer River in Alberta. See Brent H. Briethaupt, "Como Bluff," and David A. Eberth, "Edmonton Group," in Currie & Padian (1997, 135-137, 199-203). Cf. Norell *et al.* (1995, 109): "a few years ago tens of thousands of caribou drowned while trying to cross a flood-swollen river in northern Canada. Along this river the bloated, decomposing bodies were stacked 3 meters high. Similar occurrences happen each year at river crossings during the annual migration of east African antelopes." See also Weber (1980, 10-13).

[14] Norman (1985, 32). The two main Bernissart deposition clusters suggest a shift in prevailing current at the site. An *Iguanodon* is about nine meters long, but again corpses would tend to be found on their side, where only about a meter would be required for burial. This might not have appeared obvious to Milton (1997, 84) when he recounted their measurements, because dinosaur dictionaries and encyclopedias don't customarily give the *width* of these animals. But this was easy enough to determine with the many scale replicas available—such as the collection from the London Natural History Museum. Even Strahler (1987, 380) was behind the curve here, relying on

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Edwin Colbert's presentation of the idea that the Bernissart specimens had fallen into a ravine. Taquet (1994, 37-41) discusses the site in relation to more recent findings.

[15] Milton (1997, 106) quoted Norman (1985, 193) on one point, the I-II-III versus II-III-IV digit problem relating to whether birds could be descended from dinosaurs (covered below in Chapter Five).

[16] Milton (1997, 19).

[17] Milton (1997, 230-233, 274).

[18] Toumey (1994, 211).

[19] Hanegraaff (1998, xi-xiv), variously citing Morris & Parker (1987), Sunderland (1988) and Gish (1995). Johnson's willingness to recommend a book provided it is sufficiently critical of evolution may be calibrated by his back cover bit for Hare Krishna creationists Cremo & Thompson (1993): "*Forbidden Archaeology* is a remarkably complete review of the scientific evidence concerning human origins. It carefully evaluates *all* the evidence, including the evidence that has been ignored because it does not fit the dominant paradigm. Anyone can learn a great deal from the authors' meticulous research and analysis, whatever one concludes about their thesis regarding the antiquity of human beings." Diehard Paluxy "mantrack" boosters Henry Johnson (omniology.com/K-ManInGeoCol.html) and Kent Hovind (as stated in a squabble with AiG, answersingenesis.org/docs2002/1011hovind.asp) also draw on Cremo & Thompson. And a third of the citations against human evolution in Deloria (1995, 66-72) were to *Forbidden Archaeology*, which work he described as "impressive."

One of the most "impressive" citations might be Cremo & Thompson (1993, 813-814) drawing on the supermarket tabloid *Weekly World News* (July 27, 1982) for some purported machined spheres from the Precambrian (Paul Heinrich explores the geological origin of these objects at Talk.Origins concerning "The Mysterious Origins of Man" show). Printed on cheap black-and-white stock, the *Weekly World News* is fond of proclaiming "new" apocalyptic predictions from Nostradamus, the Vatican archives, or the Dead Sea Scrolls. Periodically, imaginary survivors of the *Titanic* are rescued—in February 2001, it was a baby in a life preserver, mysteriously still a baby even after 89 years (the magazine intimated a time warp was involved). My fondest *Weekly World* bulletin occurred some years ago: the astonishing telescopic observation of a WWII-era B-17 bomber on the moon!

Forbidden Archaeology was published by the Bhaktivedanta Institute, and dedicated to Hare Krishna's founder, "His Divine Grace A. C. Bhaktivedanta Swami Prabhupãda." The "Hare Krishna News Network" site (krishna.org) dedicated to Prabhupãda's teachings includes the claim that NASA faked the Apollo moon landings. Part of their argument rested on secular Apollo deniers—a group who got a publicity boost in February 2001 via a special on the Fox network (whose "documentary" telecasts have seldom been burdened by either editorial discretion or taste). See Plait (2002, 155-173), Mackenzie (2003, 193-199) or the apollo-hoax.co.uk website for field guides to this surreal area—cf. also the rationalist attitude of Smith (2000, 16) and warnings of Oberg (2003).

Of relevance is how Prabhupãda's reasoning turned on *scriptural* authority, precisely like Henry Morris on the Genesis Flood. In "Man On the Moon—A Colossal Hoax that Cost Billions of Dollars," Prabhupãda (who died in 1977) declared that "The Vedic account of our planetary system is already researched, concluded, and perfect. The *Vedas* state that the moon is 800,000 miles *farther* from the earth than the sun. Therefore, even if we accept the modern calculation of 93 million miles as the distance from the earth to the sun, how could the 'astronauts' have traveled to the moon—a distance of almost 94 million miles—in only 91 hours (the alleged elapsed time of the Apollo moon trip)? This would require an average speed of more than one million miles per hour for the spacecraft, a patently impossible feat by even the space scientists' calculations." So much for those fuddy-duddy astronomers who reasoned centuries ago that the moon couldn't possibly be farther away than the sun and still cause *solar eclipses*. Judging by Rowley (1971, 117), Hare Krishna literature has considered space travel a waste of effort for some time, recommending instead that visitations to the planets be accomplished via Krishna Consciousness.

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[20] Huse (1997, 63) relied on YEC Randy Wysong for this deadly display of logic: "An ancient Mayan relief sculpture of a bird resembling the Archaeopteryx has been found. This indicates a discrepancy of about 130 million years. If the geologic column is correct, the two should never have met. Apparently, the geologic column is wrong." Huse's version has in turn been cited by "The Scholar's Lighthouse" (hislight.com/support/creation-evolution/mandino.html).

This ridiculous conclusion jump was inflated from an anonymous November 1968 *Science Digest* picture of a Mayan sculpture that showed a long-necked birdlike figure (p. 1) looking something like a heron. The Mexican archeologist who discovered it made the mistake of saying it had "a vague resemblance" to a reptilian bird, and that's all it took to set Wysong/Huse flying. Futuyma (1982, 179) and McGowan (1984, 107) criticized Henry Morris for repeating the claim—which was still in the 20th (1996) printing of Morris (1985, 122). All of which lends an ironic touch to Gish (1993, 73-74) when he affirmed the scientific sagacity of Henry Morris *et al.* and fumed over evolutionists like Futuyma and Niles Eldredge who regarded Creation Science as a gathering of incompetents and liars.

Another illustration of dated ineptness would be Huse's coverage of the Kanapoi humerus, a fragmentary arm bone dating about 4 Ma. His sole source was a 1981 ICR pamphlet (Impact No. 101, available at icr.org) by Gary Parker, which still affirmed the authenticity of the Paluxy River "man tracks" (re note 2 above). Evidently unaware that it consisted only of that arm bone, Huse (1997, 139) decided "there is evidence that people walked upright before the time of Lucy. This would include the Kanapoi hominid and Castenedolo Man. Obviously, if people walked upright before the time of Lucy, then she must be disqualified as an evolutionary ancestor." Morris (1985, 177) repeated the Castenedolo skull claim, as did Parker in Morris & Parker (1987, 160-161). But Old Earth creationist Hayward (1985, 146-148) reminded that "Castenedolo Man" was actually only 25,000 years old, and by the time of Gish (1995) and Morris & Morris (1996b) the mistaken fossil had disappeared from the ICR repertoire. Cf. the YEC version of Kanapoi and other fossils by Lubenow (1992, 170), absorbed in turn by Ankerberg & Weldon (1998, 244). Surveys of such "anomalous fossils" may be found at the Talk.Origins Archive, or by Weber (1981, 21) and Conrad (1982a), also available online at ncseweb.org. Schwartz (1999, 27-32) specifically details the problematic Kanapoi humerus.

As Huse's defective scholarship is fairly easy to document (such as his wholesale copying of Luther Sunderland discussed below in note 355, Chapter Six), Bandow's failure to spot any of this puts him behind even *Answers in Genesis*. As he did with Richard Milton in the same issue (note 1 above), Carl Wieland (1998a) reflected the wary AiG view of Huse when criticizing a British theologian (Douglas F. Kelly) for relying too heavily on him rather than keeping up with the ID authors Behe and Johnson. "Huse is a well-meaning creationist writer whose books we at *Answers in Genesis* ceased to stock years ago on account of their being more than occasionally sloppy and out-of-date" (review available at answersingenesis.org/docs/3983). That memo has apparently not made it through to other sectors of the YEC fringe. D. James Kennedy extolled *The Collapse of Evolution* on the back cover as "one of the best overviews on the subject currently available." Much of Huse's second chapter on Geology was devoted to YEC claims, and Chick Publications (a screwball anti-Catholic evangelism operation in California) excerpted a 1996 version to proclaim "Evolutionists are wrong! The earth is young" (chick.com/reading/books/174/evolvex.asp).

[21] The Herbster transcript was obtained from pbs.org/newshour/forum/april198/evolve5.html. While Denton's *Evolution: A Theory in Crisis* was a purely secular critique of evolution (see Appendix I), Herbster was apparently unaware of the extensive Biblical references offered throughout *The Collapse of Evolution*, accessible via a dedicated "Scripture Index" in Huse (1997, 214-215).

[22] Bandow's "Bedtime Christmas Readings" for December 1999 was obtained from cato.org/dailys/12-23-99a.html. In March 2001 I emailed Bandow asking whether he was familiar with the background of any of the books he cited. He replied that he "found them to be better argued and researched than the typical 'creation science' and young earth tracts, which aren't well-founded." Not that Bandow fared noticeably better with some of his other Yuletide recommendations in this area. While physicist Gerald Schroeder (1997) tried to correlate geology

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and cosmology via a logarithmic map to a Genesis timeline, Old Earth creationist (OEC) physicist Hugh Ross (1996; 1998) reprised his argument that modern physics proclaims the unique identity of God.

When it comes to their evolutionary opinions, though, Schroeder and Ross share a tendency for gossamer citation. Schroeder's part in the Ernst Mayr daisy chain is covered in note 142 below (Chapter Two). A comparable example is Walter Bradley, "Why I Believe the Bible Is Scientifically Reliable," in Geisler & Hoffman (2001, 175, 309n) picking up on Ross (1994, 141), reprised by Ross (1998, 55, 110) claiming that "religious relics date back only about eight thousand to twenty-four thousand years" and "art containing indisputable spiritual content just five thousand years. Thus the archaeological date for the beginning of spirit expression agrees with the biblical date." Ross' one source, Bower (1996), made no such claim. As Bower's subtitle explained: "Rock and cave art may offer insights into shamans' trance states and spiritual sightings," particularly in the interpretation of geometric shapes common to hallucinatory visual processing. That at least some prehistoric art was part of a shamanistic worldview ("a means of traveling to a supernatural world," as Paleolithic art expert Jean Clottes put it) is highly plausible. But this would apply all through the history of human artistic expression, 20,000 years and more ago—as Bower made plain. Where Ross obtained his 5000-year figure is anybody's guess (a decorated Irish passage tomb of that age was mentioned, but not as any spiritual benchmark).

[23] Bandow (1991).

[24] Milton (1997, 269).

[25] Examples of "saturation quotation" include Morris & Parker (1987, 2-26), Gish (1993, 367-386), John Ankerberg & John Weldon, "Rational Inquiry & the Force of Scientific Data: Are New Horizons Emerging?" in Moreland (1994, 270-293), and Bert Thompson (1995, 11-87). The weak underpinnings of creationist scholarship is illustrated by the persistence of the spurious Bounoure "Evolution is a fairy tale for adults" quote that Moreland (1994, 287, 331n), Hanegraaff (1998, 6, 161n) and Federer (1999, 61,722n) each cited secondarily from separate quote books. See E. T. Babinski ("Old, Out of Context Quotations from French Scientists Part 2" at talkorigins.org/faqs/cc/part12.html) for details on the Bounoure misattribution. Federer's lengthy *America's God and Country: Encyclopedia of Quotations* is a popular compendium of authority quotes (including Napoleon praising Jesus) extracted from likeminded secondary sources, which suggests how pervasive "proof text" thinking is in the conservative Christian milieu. Or among university press scholars, such as the parade of quotes sociologist Stark (2003, 178-192) deployed against the "Darwinian Crusade."

For a specifically theological application, the Dallas Theological Seminary's Norman Geisler affirmed "God's Moral Perfection" in "Why I Believe the God of the Bible Is the One True God," Geisler & Hoffman, (2001, 88-89) by Bible proof texts extolling God's perfection—not specific examples of God's morality in action. By this means he minimized ambiguous areas, such as the genocidal command to Saul in I Samuel 15:3: "Now go and smite Amalek, and utterly destroy all that they have, and spare them not; but slay both man and woman, infant and suckling, ox and sheep, camel and ass." Since God's perfect nature was established by proof text, such instructions could not be immoral. Consequently the Amalekites had to have been so wicked that even having them around would run the risk of moral contamination, thus justifying their absolute extermination. Hugh Ross (1998, 139) defends a similar position.

Geisler's reasoning on the Amalekites is brought to a wider audience via Lee Strobel (2000, 118-124)—cf. notes 34 below & 480 (Appendix I) on Geisler, antediluvian animal herbivory and End Time UFOs. Strobel (1998; 2000) are popular apologetics highly recommended in the conservative (and often YEC-friendly) evangelical subculture. Phillip Johnson on the back cover of *The Case for Faith*: "Lee Strobel asks the questions a tough-minded skeptic would ask and provides convincing answers to all of them. His book is so good I read it out loud to my wife evenings after dinner. Every inquirer should have this book." D. James Kennedy said the work "sets a new standard among existing contemporary apologetics." Strobel is also a welcome contributor to Hanegraaff's "Bible Answer Man" show done by the Christian Research Institute (equip.org), whose guests have included Phillip Johnson and William Dembski. Witham (2002,

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192-193) commented that Strobel atypically includes antievolutionism in his sermons as an associate minister.

[26] Ecker (1990, 202-203) briefly surveys Creation Science attitudes about advanced astrophysics, and Smoot & Davidson (1993) describe their part in the 1992 COBE satellite experiment that confirmed the subtle fluctuations in the cosmic background implied by the Big Bang model. Hugh Ross (1994; 1995; 1996; 1998) expounds on the significance of the Big Bang and the "anthropic" argument that the fine-tuned constants of the universe point to a Creator. Meanwhile, Chittick (1984, 99) offered this YEC expectation: "Present indications are that the big bang theory is in trouble and may soon be replaced." DeYoung (1989, 86-92) dismissed the evidence for galactic expansion, while a chart on "Chronological Discrepancies Between Scripture and Big Bang" reminded readers on the Scripture side that "Plants formed before the sun" and the "Sun formed on the fourth day, after the earth." The compartmentalized Wendell Bird (1989, Vol. 1, 411, 441-457) mentioned the "inhomogeneity" of cosmic background radiation apart from his dismissal of the microwave background and red shift findings supporting the Big Bang. Curiously, while "microwave background radiation" didn't make it into Bird's Vol. 1 index, "Rubik cube" did (with two mentions in the text, pp. 80 & 304).

Ankerberg & Weldon (1998, 262): "so many objections have been raised against the Big Bang that we find texts with bold titles like Eric Lerner's *The Big Bang Never Happened* (1991)." While Lerner (1991) did his best to defend Hannes Alfvén's plasma universe theory as an alternative to the Big Bang, in proposing a universe *trillions* of years old (if not eternal) Lerner's book offered slim support for the Creation Science young universe scenario. Adding insult to injury, Ankerberg & Weldon (1998, 262) cited Hugh Ross exactly once, for a quote that the universe wasn't eternal!

[27] Berlinski (1996a,b; 1998; 2001, 2002; 2003) questioned Big Bang cosmology as well as Darwin, while Bethell (1993; 1996; 1999a,b; 2000; 2001; 2002) mixed criticism of relativity theory with his anti-Darwinism. Re Bethel, see economist Brad DeLong on "Conservative Fear of Albert Einstein" (econ161.berkeley.edu/Comments/occasional/bethell.html) and John Farrell's "Did Einstein Cheat?" (archive.salon.com/people/feature/2000/07/06/einstein/) for commentary. Concerning the subculture of revisionist physics, Chris Hillman's "Some Scientifically Inaccurate Claims Concerning Cosmology and Relativity" (math.ucr.edu/home/baez/RelWWW/wrong.html) offers a concise guide. Bethell's enthusiasm for fringe physicists includes Tom Van Flandern (who is also convinced that the "face on Mars" is a *bona fide* clue to ancient civilizations on that planet). Van Flandern's technical claims crop up occasionally in the YEC debate, such as Walter Brown (1989a, 40; 1989b, 42) jousting with Jim Lippard (1989, 23).

[28] Milton (1994, 217).

[29] Milton (1997, 29). He wasn't even correct on this technical point, since the practice of identifying relative chronology by characteristic index fossils predated Darwin by a wide margin, Gohau (1990). In this Milton sounds very much like conventional YEC claims, such as Morris & Parker (1987, 237), Gish (1995, 46) and Morris & Morris (1996a, 48-49; 1996b, 287-298)—but also Deloria (1995, 179).

Criticism of the "circular reasoning" canard came up early in the creationism debate, such as by Futuyma (1982, 180), but the most amusing counterexamples stem from creationists who pay insufficient attention to their own paper trail. Thus Henry Morris (1985, 133) got so riled trying to prove rocks are not dated radiometrically, he let slip: "Many people believe the age of rocks is determined by study of their radioactive minerals—uranium, thorium, potassium, rubidium, etc.—but this is not so. The obvious proof that this is not the way it is done is the fact that the geological column and approximate ages of all the fossil-bearing strata were all worked out long before anyone ever heard or thought about radioactive dating." Ankerberg & Weldon (1998, 297, 300) likewise insisted that the geologic timetable was arrived at "by assuming that evolution is true and applying circular reasoning" three pages before stressing that creationist geologists had established it prior to Darwin.

[30] Miller (1999, 28-31).

[31] Morris (1963, 49).

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[32] Laurie Godfrey, "Creationism and Gaps in the Fossil Record," in Godfrey (1983, 195). Incidentally, Gish (1993) bypassed taphonomy in his tactically worded rejoinder to Godfrey and other critics of creationism. See Simpson (1983, 14-26) or Behrensmeyer (1984) on the general principles, and Wagner (2000) for comments at the genetic level. With straight face, Morris & Morris (1996b, 263) quoted Behrensmeyer (1984, 560, 561) about how rapid preservation needs to be to protect fossils, as though this meant Flood Geology conditions.

A rare example of a creationist venturing into this area would be Bernard E. Northrup's "Taphonomy: A Tool for Studying Earth's Biblical History." Presented at a Seattle Creation Conference in 1985, the revised 1997 online version (ldolphin.org/taphon.html) was a meandering rationalization of evidence that precluded a single Flood. Northrup ended up sounding a lot like 18th and 19th century catastrophists by positing several deluges plus three or more vaguely outlined non-aquatic disasters. Along the way he wondered whether Persian Gulf oil might be "so plentiful because they are formed from the animal, plant and human life-forms which the Noachic flood buried?" Northrup's arguments haven't been widely circulated, though several of his articles do show up on the reading list of a "Christian Life Training" website (clt.org.za/dwnld.html) under "Topics in Science and the Bible" that includes Berlinski (1998)! Cf. the criticism of Northrup's catastrophism at baby.indstate.edu/gga/pmag/northrup.htm.

[33] Babcock *et al.* (1998) explained the cascade of inference to be drawn by the discovery in Antarctica of a single crayfish claw dating back to the Early Permian. "The new discoveries show that the earliest Permian crayfish were distributed in high paleolatitudes of southernmost Pangea, where they lived in freshwater lakes fed by glacial meltwater. Modern crayfish habitat, used as a guide to crayfish temperature tolerance, indicates that summer temperatures of streams and lakes near the South Pole that supported the crayfish probably reached 10-20 °C during Permian-Triassic interglacial intervals." Bakker (1986, 105-116) presents a vivid description of dinosaur taphonomy at Como Bluff (re note 13 above). See also Anthony R. Fiorillo, "Taphonomy," in Currie & Padian (1997, 713-716) for more dinosaur applications, Demko *et al.* (1998) on how fossil plants "may reflect local hydrologic conditions rather than regional climate," and Carpenter *et al.* (2003) on what some fossil fish reveal about Late Cretaceous climate. Or Gaines & Droser (2003) inferring the paleoecological context of the "ptychoparii" trilobite *Elrathia kingii* (it was apparently a pioneer in a niche later exploited by other fossil organisms: "the exaerobic zone, at the boundary of anoxic and dysoxic bottom waters").

[34] Strahler (1986, 358) noted the position of Whitcomb & Morris (1961, 461, 464) that pre-Flood tyrannosaurs were herbivorous. Taylor (1987, 25-27) and Gish (1992, 69-71) are more recent examples aimed at educating children (abetted by an absence of references). Gish (1990, 71) on *T. rex*: "It is supposed that his main diet consisted of other dinosaurs, but it also may be that these teeth and claws were used to eat tough roots and bark, etc." Lee Strobel (2000, 126) casually quoted Norman Geisler on the original herbivory of animals in Paradise without recognizing its relation to this issue.

[35] Ham (1998, 127n). Beneath the text was a "**CREATION**WISE" cartoon that underscored the evangelical concerns of AiG. Frame one showed a beaming youth saying, "THE BIBLE IS **100% TRUTH**, FROM START TO FINISH!" Later (as a student at "LIBERAL U") he declares, "THE BIBLE HAS SOME MYTHS, BUT IS MOSTLY TRUE!" As an adult he says, "THE BIBLE HAS LOTS OF MYTHS AND SOME TRUTH." The last frame shows him as an older man, tossing the Bible away with the cry, "HOGWASH!" The main caption reads: "SAD BUT TRUE—THIS KIND OF EVOLUTION DOES HAPPEN!"

[36] Ham (1998, 145-146, 148-151) obliquely referencing Currie & Padian (1997). Entries in that volume that Ham had to repress would include Joshua B. Smith, "Cleveland-Lloyd Dinosaur Quarry," P. Martin Sander, "Teeth and Jaws," Aase R. Jacobsen, "Tooth Marks," William L. Abler, "Tooth Serrations in Carnivorous Dinosaurs," and Anthony R. Fiorillo & David B. Weishampel, "Tooth Wear," in Currie & Padian (1997, 126, 717-724, 738, 740-743, 743-745). Larson & Donnan (2002, 213): "We know *T. rex*'s punchlike teeth could neither strip leaves from trees nor crush and process fruits and berries. They had only one use, and that was to cut through flesh and bone. We know what happened to Sue's dinner after she ate because we found the acid-etched tail vertebrae of an *Edmontosaurus* in her stomach contents, along with other digestive tract material."

See also Abler (1999) on *T. rex*'s dental tool kit and Rogers *et al.* (2003) on an apparently cannibalistic theropod from Madagascar.

[37] Full texts of the various drafts are available with comparisons at sunflower.com/~jkrebs. Jack Krebs is a high school math teacher and a Board Member of the Kansas Citizens for Science (kcfs.org), formed to combat the creationist revisionists. The full Markup Version of Draft 5 (sunflower.com/~jkrebs/KS%20Sc…ds/Standards%20-%20versions/5th-Aug.html) that Krebs compiled highlighted the complete original text, all of the 1999 excisions, as well as the various passages inserted by the writing team.

[38] William K. Piotrowski briefly noted Willis' role in the Kansas case in a Fall 1999 piece, "The Kansas Compromise," for *Religion in the News* at The Leonard E. Greenberg Center for the Study of Religion in Public Life at Trinity College in Hartford, Connecticut (available at trincoll.edu/depts/csrpl/RINVol2No3/Kansas%20Compromise.htm). Though Piotrowski did slip a cog *en route* when he described Phillip Johnson as "an engineering professor." The "Happy Heretic" Judith Hayes (2000, 191-192) also commented on the role the CSAMA played in drafting the Kansas standards. Willis himself appeared online for the *Washington Post* (August 23, 1999, washingtonpost.com/wp-srv/national/zforum/99/nat082399.htm) to answer questions on the controversy, during which he affirmed the complete scientific accuracy of Young Earth creationism and reminded how God "clearly forbade teaching evolutionism: 'Thou shalt not bear false witness.'"

[39] See Dalton (1999), Gould (1999b), Pollitt (1999) in *The Nation* (reprinted by the National Coalition Against Censorship at ncac.org/cen_news/cn75kathpollitt.html), Leif Robinson (2000), Zimmer (2001c, 334-336) and Hochschild & Scovronick (2003, 187). Further online items: Chris Colin ("The devolving of evolution" at salon.com/books.it/1999/08/25/evolution) and "Sabotaging Science: Creationist Strategy in the '90s" by People For the American Way (pfaw.org/issues/education/creationist-strategy.pdf).

[40] The Discovery Institute (discovery.org) is a Seattle-based conservative think tank, founded by Bruce Chapman (who ran unsuccessfully for Governor of Washington some years ago). Much of DI is devoted to promoting regional trade and economic development, but also a cultural renewal in which anti-Darwinism has come to play a significant part. DI Fellows comprise a roster of the Intelligent Design movement: Michael Behe, David Berlinski, Michael Denton, Phillip Johnson, Stephen Meyer, Nancy Pearcey and Jonathan Wells, with many of them weighing in on the Kansas case. The design wing of the DI has actively cooperated with antievolutionary campaigns around the country to reform science education, such as with the Texans for Better Science Education (strengthsandweaknesses.org).

The collection of articles at the Access Research Network (arn.org) on "Kansas School Removes Evolution from State Competency Tests" is representative, where not one of the antievolutionary ones listed took note of the Big Bang issue. Parenthetically, Witham (2003, 116) noted that ARN emerged in 1991 from a "Students for Origins Research" group that began in the mid-1970s as "a creationist fellowship." That background was not belied by the Kansas case articles. Nancy Pearcey's "The Sky is Not Falling: Did Kansas Ban Evolution?" (from the Fall 1999 *Jubilee* magazine) confused word count for content: "Contrary to hysterical reports, the board did not ban evolution from the classroom. In fact, the new guidelines substantially *increase* coverage of the topic." Pearcey's article is also available at Phyllis Schlafly's eagleforum.org (see Appendix III for more on Schlafly's perspective). Jonathan Wells played a similar numbers game in "Ridiculing the Kansas School Board is Easy, But It's Not Good Journalism," for the *Daily Republic* of Mitchell, South Dakota (October 14, 1999). More recently, Witham (2002, 238-239) took the "increased evolution" teaching line in his coverage of the Kansas affair, but did not mention Willis' role.

Returning to the ARN articles, Mark Hartwig discoursed on "Evolution Controversy not Caused by Religious Fanatics" in the *Montgomery Journal* (August 25, 1999) without spotting Willis. Likewise Phillip Johnson (1999), Michael Behe's "Teach Evolution and Ask Hard Questions" in the *New York Times* (August 13, 1999), or the DI's director Jay Richards apropos "Darwinism and Design" for the *Washington Post* (August 21, 1999). Two pieces appeared via the

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Kansas City Star (September 7, 1999). John T. Altevogt ("Hugh Hasn't a Clue about Kansas") berated Hugh Downs for criticizing the Kansas standards on the falsification issue (see Appendix III for further details). Jim Sullinger ("Debate over Evolution Hits Home in One County") reported on the controversy generally, and did not challenge the declarations of ID proponents distancing themselves from creationism. More peripherally, Linda Gorman ("Defying Darwin") repeated many of the ID mantras for the *Colorado Daily* (September 7, 1999)—such as that macroevolution has "little support for it in the fossil record."

Perhaps even more revealing is how some Young Earth creationists downplayed the Big Bang issue at their own websites. For example, according to John Morris at the ICR, the Kansas vote had removed "only the harmful philosophy of materialism and its attendant, unsupported history of the evolutionary development of the Kansas school students from lower forms of life." John Morris (1999, 2), available also at icr.org/pubs/af/pdf/af9910.pdf. Morris decried both "the arrogance of the elitist scientific organizations" and the "predictable and vicious" response of the media to the Kansas vote. Morris kept the YEC aspect out of the picture when he mentioned the Kansas case again in the *Acts & Facts* "President's Column" for March 3, 2001.

[41] Willis confirmed his conviction that an orbiting earth was not an established fact of science in an interview for *New Scientist*, Holmes (2000, 42). *En passant*, a 2001 IMPACT piece (No. 332) by Henry Morris ("EVOLUTION IS RELIGION—NOT SCIENCE") quoted bits of Appleyard (2000, 45) and Scott (2000, 47) from that same issue, so he could have in principle been aware of Willis' geocentric proclivities whilst castigating evolutionists for promulgating humanistic propaganda. In *The CSA News* for March/April 2000 (csama.org/2000003NL.HTM) Willis explained, "both the observations and the Bible indicate quite strongly that the earth does not move," and that "For those of us interested in good science, the question remains, 'Is this principle valid?'" The only possible honest answer for Willis is that "Not one shred of evidence supports the notion of cosmological uniformity, and many support the notion that, not only is the 'principle' balderdash, but the Earth is actually the center of the universe." Willis concluded his CSA treatise: "The purpose of this essay is not to assert that geocentrists, or anyone else is right. I do not know who is right, though I strongly suspect that, as He promised, God will 'confound the wisdom of the wise.'"

[42] Numbers (1992, 106, 237-238, 243-244). A belief that the Bible required Ptolemaic cosmology remained surprisingly popular among certain conservative American religious denominations into the 20th century, such as the Missouri, Wisconsin and Norwegian Lutheran synods. Geocentrism also circulated in the background at George M. Price's "Religion and Science Association" and Walter Lang's "Bible Science Association" (BSA) in the 1930s. Numbers described the "codependent relationship" that endured for many years between the BSA and the Creation Research Society, who overlooked their geocentric elements because they avidly disseminated CRS material. BSA members also actively helped Nell Segraves prepare creationist textbooks for California starting in the late 1960s, and geocentrist Paul Ellwanger played a notable role in the 1980's "equal time" legislation effort. Ellwanger and R. G. Elmendorf represent a retrograde band of Roman Catholic geocentrists (see users2.ev1.net/~origins/menu-helio.htm). The BSA has a spin-off organization, the "Twin Cities Creation Science Association" (tccsa.freeservers.com/history.html), and remains active itself revamped as "Creation Moments." Interestingly, when I accessed creationmoments.com/ on August 21, 2003, their "Featured Product of the Day" was Behe's *Darwin's Black Box*.

Toumey (1994, 128-130) described how disconcertingly open-minded members of the BSA were even in the mid-1980s to lectures by Bouw and other geocentrists. That was the period when Tom Willis and the Discovery Institute's Nancy Pearcey were there. Cf. Brown (1989a, 44) and Gardner (1997, 17; 2000, 16). Pearcey's Foreward to Phillip Johnson (2002, 7) briefly alluded to her stint as "a contributing editor for the *Bible-Science Newsletter*, an unabashedly creationist publication (now defunct)." Her current Discovery Institute role included joining Michael Behe, Phillip Johnson and Stephen Meyer to brief several Republicans and congressional staff on ID positions, Applegate (2000). Nothing of her prior YEC work appears to be preserved online, though Paul Taylor (1995, 71) contains this secondary reference: "Astronaut Neil Armstrong

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reportedly said his greatest fear in landing on the Moon was the expected thick layer of dust. [Nancy Pearcey, 'The Age of the Earth: Does Mother Nature Tell?', *Bible-Science Newsletter*, Vol. 25, No. 2 (Minneapolis, Minnesota: Bible-Science Association, February 1987), p. 9.]" The bracketed material was in Taylor. See Appendix II for a fuller treatment of the Lunar Dust Myth that Pearcey was helping to promote.

[43] Taylor (1995, 34-35, 53, 90-94, 97-99) citing Bouw and Bowden. Bouw promotes geocentrism via the Association for Biblical Astronomy (www2.baldwinw.edu/~gbouw/), along with the conservative political agenda of the Constitution Party (a.k.a. the "Taxpayers Party," with its recurrent presidential candidate Howard Phillips). Thus Eve & Harrold (1991, 129-130) understandably plot Biblical geocentrism on the extreme right wing of creationism.

Bowden's "Creation Page" website affirms that "there is evidence that the earth is NOT moving around the sun, but either the aether is moving around the earth carrying the planets with it, or the earth is spinning on its axis. The most likely model is that the aether is rotating around the earth as calculations show that if it did not, it would rapidly collapse upon itself" (ourworld.compuserve.com/homepages/bowdenmalcolm/homepage.htm).

[44] Johnson (1991, 175). Johnson may have been unaware of Bowden's geocentric side when he cited him, but even those who do attend to that aspect don't fully appreciate the implications of his methodology. With unintended irony, "TJ" complained at Answers in Genesis that "Bouw fails to apply the same rigorous standards that he applies to the heliocentric theory to his own pet model" (answersingenesis.org/home/area/magazines/tj/docs/TJv15n2Geocentrism.asp)—as though YEC believers weren't loaded with their own double standards.

[45] Quotation from Draft 4a, obtained via the Krebs resource per note 37 above.

[46] Ackerman's article was obtained from the YEC "True Origin" website (trueorigin.org), which considers itself as balancing the evolutionary position of talkorigins.org. While encouraging students to "identify assumptions, use critical and logical thinking, and consider alternative explanations," Ackerman did not identify which alternatives he had in mind, or in what way critical thinking would be permitted to evaluate them. Ackerman subsequently joined the Kansas "Intelligent Design Network" (IDnet, at intelligentdesignnetwork.org) which has campaigned alongside the Discovery Institute and local antievolutionists in several (so far unsuccessful) bids to extend Kansas-style science standards to other states, such as Ohio. Kansas sponsor Steve Abrams continued to press this view of testability in January of 2001 when the newly elected board commenced to restore the evolutionary picture (the Kansas State Board of Education meeting minutes at ksde.org/commiss/bdmin/Jan01mins.html).

[47] See Alters & Nelson (2002, 1895) surveying student misconceptions about evolution, and Cleland (2001) explaining why "the claim that historical science is methodologically inferior to experimental science cannot be sustained." More generally, creationists (particularly those who rely on secondary sources for their authority quotes) can have some odd ideas about what "evolution" supposedly teaches. For example, the "Six Strange Teachings of Evolution" (at pathlights.com/ce_encyclopedia/10mut07.htm) believes that evolutionary theory involves inevitable progressivity and perfection.

[48] Lewontin (1997, 29). His negativism received criticism from several fellow scientists in letters to *The New York Review of Books* (6 March 1997), noted by Segerstråle (2000, 346)—see also Miller (1999, 185-191). Interestingly, Segerstråle (2000, 42-47) comments on Lewontin's uncompromising attitude about how ideological assumptions supposedly lead to "bad science." Lewontin evidently excludes his own ideology from that equation, by the way—cf. Alcock (2001, 20), representing the evolutionary psychology position often opposed by Lewontin.

Segerstråle highlighted the example of Louis Agassiz, whom Lewontin retroactively decried as a "liar" for incorrectly believing that the skulls of blacks closed up faster than whites. Agassiz's touchy racism has been noted by Gould (1980, 169-176; 1981, 44-45) or Wolpoff & Caspari (1997, 85-92), but it is a tricky methodological point whether a scientist can be thought of as *lying* when they profess "scientific" opinions that subsequent investigation refutes. The case of psychologist Cyril Burt is relevant. Gould (1981, 234-239, 273-296) noted that Burt could be perfectly reasonable so long as he wasn't defending his particular obsession (that intelligence was

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largely inherited). Burt's posthumous reputation wasn't helped, though, when he was found to have fudged intelligence test data, writing several papers with imaginary "co-authors," Kohn (1986, 52-57)—though Matt Ridley (2003, 75) noted that one of the suspect co-authors did eventually turn up. For Miltonian lagniappe, Burt also served as a president of Mensa.

[49] Lewontin (1997, 31). He recalled when "at the time of the moon landing, a woman in rural Texas was interviewed about the event, she very sensibly refused to believe that the television pictures she had seen had come all the way from the moon, on the grounds that with her antenna she couldn't even get Dallas. What seems absurd depends on one's prejudice. Carl Sagan accepts, as I do, the duality of light, which is at the same time wave and particle, but he thinks that the consubstantiality of Father, Son, and Holy Ghost puts the mystery of the Holy Trinity 'in deep trouble.' Two's company, but three's a crowd."

[50] Johnson (1997, 81). Johnson (1998a, 69) hit the same theme in an essay reprinted from *First Things* (November 1997): "Lewontin eventually parted company with Sagan over how to explain why the theory of evolution seems so obviously true to mainstream scientists and so doubtful to much of the public." Lewontin's "views on the relation of evolutionary theory to atheism" surfaced again in Phillip E. Johnson, "Reflection 2," in Moreland & Reynolds (1999, 267-271). Bethell (1999b, 20) and Colson & Pearcey (1999, 96) are similar (see also note 58 below).

[51] Johnson (1998a, 70), drawing on Lewontin (1997, 30-31). Incidentally, Johnson ran perilously close to colliding with his own logical caboose here, since Lewontin was effectively agreeing with him that Richard Dawkins and E. O. Wilson were extrapolating their genetic views beyond the evidence. But then Lewontin and Wilson have been going at it for some years, turning on occasion into farce, as with the 1981 "Nabi" episode, when the Lewontin and Wilson camps lobbed pseudonymous letters and editorials at one another in *Nature*, Segerstråle (2000, 184-188). See also note 221 (Chapter Three).

[52] Lewontin (1997, 30).

[53] Ironically, minister Barry Lynn (of Americans United for the Separation of Church and State) arrived at a similar conclusion unprompted during the 1997 "Firing Line" evolution debate on PBS, after both Phillip Johnson and William F. Buckley lobbed Lewontin's materialist revelation at him. Neither explained the background context for the quote, however, and Lynn (evidently unaware of its provenance) swallowed their baited hook by criticizing Lewontin for supposedly suggesting that unflinching materialism was a prerequisite for a belief in *evolution*. Rounding out the antievolution side at the debate were Michael Behe and David Berlinski. The evolutionary opposition consisted of Lynn, Ken Miller, philosopher Michael Ruse and anthropologist Eugenie Scott (of the National Center for Science Education).

Some miraculous phenomena would clearly be amenable to an empirical test. For example, if a soldier's lost leg were restored after a visit to Lourdes, it would go way beyond hard-nosed skepticism not to chalk that one up as a genuine miracle. But that empirical sword cuts both ways, which is why it is useful for a skeptical mindset. There aren't any such indisputable miracle cases at Lourdes—indeed, one 19th century visitor dryly remarked how he saw so many crutches, but no wooden legs. From that observation one can legitimately infer that if there is a miraculous healing process going on, the agency responsible for it has refrained from doing so in an unequivocally miraculous manner.

While miracles fall on the supernatural/theological side of the question, Cold Fusion belongs to the realm of hard science. The Close (1991), Taubes (1993) and Cromer (1993, 160-167) autopsies predate Richard Milton (1994, 33) enthusing that "prototype ten Kilowatt cold fusion heating devices are already under test and are likely to find their way to market in the near future." As of late 2003 there are still no home CF generators on the shelves at Sears, though there may be an interesting phenomenon lurking amidst the hyped data, Close (1991, 342) and Arthur C. Clarke (1998, 1533; 1999, 527-528, 537) with Fairley & Welfare (1998, 6). The coverage by physicist Park (2000, 12-27, 92-98, 118-124) noted the "go public first" attitude of the Utah experimenters Stanley Pons and Martin Fleischmann. There was also a religious angle, as "many Utah Mormons were convinced that the discovery of cold fusion came directly from God to rescue the state from serious economic problems." Cold Fusion appeals to certain conservative technophiles, from Dixie

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Lee Ray (the nuclear physicist one-term Washington governor) to the paranoid political extremism of Lyndon La Rouche, Helvarg (1994, 228-229). There is a thriving subculture promoting the impending wonders of this technology, complete with conventions (noted by Bruce V. Lewenstein's "The Cornell Cold Fusion Archive" at wpi.edu/Academics/Depts/Chemistry/Courses/CH215X/coldfusion.html).

[54] Lewontin (1997, 29): "The prevention or cure of metabolic and developmental disorders depends on a detailed knowledge of the mechanisms operating in cells and tissues above the level of genes, and there is no relevant information about those mechanisms in DNA sequences. In fact, if I know the DNA sequence of a gene I have no hint about the function of a protein specified by that gene, or how it enters into an organism's biology." Genetic systems simply cannot be viewed as fixed blueprints independent of the organism's environment, Lewontin (2000a,b), David Moore (2001) or Dusheck (2002). Cf. Griffiths & Neumann-Held (1999) on the hierarchy of factors affecting "the evolutionary gene." Ironically, antievolutionist Bethell (2001) hit some of the same marks, which were duly picked up as postings on the apologetic daisy chain by the Discovery Institute (discovery.org) and thence to the YEC Bible-Science Association (creationsafaris.com/crev04.htm).

[55] Lewontin didn't reprise the "absolutely compelling arguments" of the 1964 debate, as Johnson (1997, 68) duly noted. Their debating foil was apparently Henry Morris—cf. Witham (2002, 215-215). Lewontin (1997, 28): "Sagan and I drew different conclusions from our experience. For me the confrontation between creationism and the science of evolution was an example of historical, regional, and class differences in culture that could only be understood in the context of American social history. For Carl it was a struggle between ignorance and knowledge, although it is not clear to me what he made of the unimpeachable scientific credentials of our opponent, except perhaps to see him as an example of the Devil quoting scripture."

[56] Johnson (1998a, 68). Cf. Stark (2003, 177) on Richard Dawkins making the same evolution/heliocentrism comparison.

[57] The earliest version of the Copernican model was actually *less* accurate than Ptolemaic geocentrism, and remained that way until Kepler overcame the longstanding religious and philosophical bias toward circles being more "perfect," and realized orbits were elliptical. Even more ironically, a factor playing a role in Kepler's epiphany was a job he'd once done calculating the volume of wine barrels, which made him familiar with the mathematics of their elliptical shape, James Burke (1985, 150-151) from his *The Day the Universe Changed* series. Cf. Owen Gingerich, "The Copernican Revolution," in Ferngren (2002, 95-104).

[58] Nancy Pearcey's Foreward to Johnson (2002, 13) made the same logical jump as Johnson when she highlighted Lewontin's "stunning admission." And a 2000 essay for *World Magazine* by J. Budziszewski (reprinted at the "True.Origin Archive") did likewise. Pearcey and Budziszewski did not clarify whether they thought modern cosmology or quantum physics were but chimeric materialist illusions.

[59] Johnson (1995,12) skirted closest to this problem when he repeated his position that antievolutionary critics like himself need not propose a detailed theory of their own, and that evolutionary theory was a philosophical system based on naturalism rather than firmly on evidence (see also note 382, Chapter Six). Johnson (1995, 91-93) returned to this argument, commenting on a lengthy quote from the "very atheistic" physicist Steven Weinberg (1992, 247-248) criticizing his view. The scholarly problem consisted of how Johnson had surgically removed just one sentence from the Weinberg passage, which turned out to be the meat: "There never was a time when the calculations based on Newton's theory of gravitation or any other theory were in perfect agreement with all observations." In other words, if evolution were to be rejected on the grounds that some aspect of nature had not yet been carefully accounted for (rather than being accepted because it accounted for so much else), that principle would apply to fields other than evolution. Evidently the prospect of several centuries of physical science imploding under the deadening pressure of Johnson's Theistic Realism was a topic he did not have a ready answer for—and which he didn't especially want his readers to notice, either. So *snip*, and out went the inconvenient sentence.

Weinberg (1992, 91-106, 169-170) specifically touched on the fuzzy edges of Newtonian cosmology. See also Harold I. Brown (1986) or Barrow (2000, 115-122). Of relevance are Albert (1986), Sonleitner (1986) and Sokal & Bricmont (1998, 64-71) on the limits of Karl Popper's falsification view as applied by Creation Science or in science generally (see also Appendix III). There is even some circumstantial evidence that Newton tidied up a few minor variables *a posteriori* to better conform his calculations to later observation, Kohn (1986, 36-39).

Newton's acceptance in Europe was not instantaneous, with the Germans hanging on until after the 1720s, and the French filtering things through a secularist sieve, Ronald L. Numbers, "Cosmogonies," in Ferngren (2002, 234-244). One theoretical problem concerned how Newton's calculations required the simplification of gravitational interaction to two bodies (comparatively small earth orbiting really big sun, for example). Trying to calculate precisely what would happen when more than two bodies ran into one another (especially if they were of more similar mass) was not simply difficult—it was *impossible*. Cf. Wolfram (2002, 972-973). Had Phillip Johnson lived in the 17th century and been ill disposed to the magical mechanistic force of "gravitation" that Newtonians were proposing to govern the entire universe, the inherent insolubility of the "three body problem" could have been invoked as a justification to reject Newtonian theory generally.

[60] Philosopher Robert Pennock (1999, 210) contends that Intelligent Design proponents like Johnson "are relativists about natural human knowledge, and they therefore think science is rotten to its core because it claims that its naturalistic method can discover objective empirical truths. Their strategy, therefore, is to be quiet about the specifics of their own alternative and to seek out scientific discontents, inciting them to a political revolution—an overthrow of scientific naturalism itself—claiming that conditions will be improved once 'theistic realism' is the ruling paradigm and 'theistic science' is in control of knowledge. This is the classic postmodernist approach, for which truth is just politics." Walter Olson detects a similar pomo strain to ID in "Dark Bedfellows" (January 1999, at reason.com/9901/co.wo.darkbedfellows.shtml). See also note 495 below (Appendix I). Cf. Witham (2003, 128) disingenuously noting that Phillip Johnson "employed a deconstructionist tactic 'playfully' in his early writings on Darwinism, but ended up switching to garden-variety scholarly analysis." Just how "garden-variety" Johnson's scholarship has been will be documented in due course.

[61] Evolutionary ripostes to Behe (1996; 1998; 1999a,b; 2000; 2002) on "irreducible complexity" have not always been detailed, tending to reinforce creationist convictions that he is "on to something" after all. Dorit (1997), Alters (1999, 103), Schick & Vaughn (1999, 178) and Eldredge (2000, 139-140) were cursory. Avise (1998, 237n), Hellman (1998, 200n), Davies (1999, 280n), Harold (2001, 266n) and Dennett (2003, 128n) dismissed Behe to peripheral footnotes—though Dennett referenced his longer 1997 commentary, "The Case of the Tell-Tale Traces: A Mystery Solved; a Skyhook Grounded" (at ase.tufts.edu/cogstud/papers/behe.htm). More substantive technical and analytical criticism were given by Coyne (1996), Cavalier-Smith (1997), Kenneth Miller (1999, 130-164), Pennock (1999, 263-272) and Thornhill & Ussery (2000). Cf. also Shanks & Joplin (1999) with rejoinder by Behe (2000), Pigliucci (2001), and the assorted Internet coverage (most notably at the Talk.Origins Archive).

The "specified complexity" logic of Dembski (1998; 1999; 2002a,b) is that mathematical analysis can establish the designed character of information systems like DNA. But so far he has not shown how (or whether) his formulae can be applied to actual DNA (such as being able to differentiate gene duplications or mutated pseudogenes from putative designed sequences). Like Behe, criticism of Dembski has begun online, but because his works are so recent there hasn't yet been much print coverage. One item concerns Dembski's application of the "No Free Lunch Theorem" of Wolpert & Macready (1997) on the limits of applicability of evolutionary algorithms to model life. The co-author David Wolpert complained Dembski misunderstood and misapplied it ("William Dembski's Treatment of the No Free Lunch Theorems is Written in Jello" at talkreason.org/articles/jello.cfm).

[62] Gee (1999) is primarily an investigation of how cladistic analysis operates to sort out the decidable issues in evolutionary thinking (see also note 408, Chapter Seven). Interestingly, the

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founder of cladistic analysis concurred with the principle that "macroevolution" ultimately consisted of microevolutionary processes, Hennig (1966, 225).

[63] Besides her Greek, Cleopatra was the first (and last) of the Ptolemaic line to speak Egyptian. She also reportedly knew Aramaic, Ethiopian, Hebrew, Median, Parthian, Syriac and Trogodyte (a tongue spoken by neighbors of the Ethiopians), Michael Grant (1972, 34, 63, 256n, 258n).

[64] See Larson & Donnan (2002) on the forensic analysis of *Sue* the tyrannosaur, along with enough legal squabbles to rival the Kennewick Man flap covered by Morell (1998a,b), Holden (1999a,b; 2000c; 2004), Thomas (1999) and Downey (2000). Many viewers of PBS and cable may also be reminded of the historical range of criminal forensic pathology documented by shows in 2002 that dealt with Ötzi the "Ice Man." Found in the Alps in 1991 after a thaw exposed the body, the fellow possessed a copper axe and some well-made arrows, Roberts (1993), Sjøvold (1993), Annaluisa Pedrotti, "Ötzi: The Ice Man," in Forte & Siliotti (1997, 114-119). Following the discovery of a flint arrowhead embedded in the mummy's shoulder, though, the possibility arose that Ötzi may have been the victim of foul play. See Dickson *et al.* (2003) for follow-up, and Holden (2003) re Müller *et al.* (2003) on the isotopic evidence suggesting the Ice Man migrated from a home restricted to a few valleys in the southern Italian Tyrol.

[65] This would apply particularly to the Creation Science notion of "creation with apparent age." Arguably the single dumbest idea in all their canon, it is applied cosmologically to defuse the implication of galaxies being millions of light years away (and therefore millions of years old, otherwise we wouldn't be seeing them, due to the speed of light). See Henry Morris (1963, 56-58) or Morris & Morris (1996a, 19; 1996b, 316) for variations on the theme. Cf. Price (1980) on the slippery (and selective) slope of YEC "omphalos" reasoning (so-named for the 19th century antievolutionary apologist Philip Gosse who claimed the geological record was simply created to look old, much as Adam was presumably created with a navel).

Because modern astronomy documents events in deep space (such as supernovae and colliding galaxies), the Creation Science version represents the equivalent of Adam showing up in Eden in a wrinkled business suit, wilted boutonniere in place, with an expired library card in his wallet. I must confess some personal satisfaction when I described this "library card" metaphor to Stephen Meyer at the 1998 Whitworth "Creation Week" (detailed further below). Meyer doubled over in laughter and asked if he might borrow the story. I was happy to oblige—though if he has, I do hope he attributed the source correctly.

[66] Valuable criticism can still commence with biologist Futuyma (1982), paleontologist McGowan (1984) and geologist Strahler (1987). Other notable critical works include Kitcher (1982) and Berra (1990), while the somewhat duplicative Godfrey (1983) and Zetterberg (1983) employed the anthology approach, as did David Wilson (1983), Montague (1984), Hanson (1986), and Ruse (1988). McIver (1988b) provides a penetrating annotated bibliography of the antievolutionary literature, while the dictionary by Ecker (1990) is useful for quick research on spot topics. McKown (1993) and Tiffin (1994) illustrate the archetypal "secular humanist" response, though a bit on the repetitive side. Lloyd Bailey (1993) faults creationism's analytical credentials on the home turf of Biblical exegesis. Eldredge (1982) has recently been marginally revamped as Eldredge (2000) to reflect the newer Intelligent Design mutation, as has Ruse (2000) and Pigliucci (2002). Pennock (1999) tackles the subject from a philosophical standpoint, and cell biologist Kenneth Miller (1999) from the biochemical end—both devote several chapters to dissecting the views of Michael Behe and Phillip Johnson. Sonder (1999) summarized many of the issues as part of a general science series for young adults, but did not deal with the Intelligent Design phase.

And then there is Raztsch (1996), whose equivocal "plague on both your houses" approach coyly left the door propped open for the potential scientific credibility of the "creation hypothesis." In a related vein, Ferngren (2002, 277-288, 335-344) reprinted a 1986 essay on Biblical creationism by Ronald Numbers, while having Intelligent Design advocate William Dembski pick up the more recent ID thread. In this way "design" theory could be held at arm's length from its more overtly doctrinal cousins, who are not only very much active at the turn of the millennium, but also share a host of methodological conceits with their academic counterparts in the ID movement.

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[67] For example, philosopher Robert Pennock (1999, 153, 334) briefly alluded to Duane Gish's *Creation Scientists Answer Their Critics* (1993) and *Evolution: The Fossils STILL Say NO!* (1995) but did not delve into any of the revealing specifics. From a scholarly methods angle, you can hardly ask for more relevant material than responses to criticism or revised treatments purporting to address newer data, since they add to the paper trail documenting the author's applied methodology.

[68] Stephen Jay Gould's 1992 review of *Darwin on Trial* is the only example I know of where Johnson's section on the reptile-mammal transition was singled out for criticism (re note 444, Chapter Eight).

[69] The Science/Religion debating field is actually a fairly broad one, with many shades of opinion on how the two sides relate (if at all). Segerstråle (2000, 399) discerned a tripartite approach on the evolutionary side: "separation, confrontation, and merger." Stephen Jay Gould and John Maynard Smith would represent the first position, Richard Dawkins and (to some extent) Carl Sagan the second, and E. O. Wilson (sort of) for the latter. Segerstråle (2000, 376) similarly discerned three "basic strategies among evolutionary biologists when it comes to" tackling values. "The first strategy is to keep science separate from values." Dawkins represents that approach. "The second strategy actively connects science with values: you criticize science you don't like or you do scientific research that corresponds to your values." Many of the politically motivated critics of sociobiology are to be found there. "The third also connects science with values, but in a more intricate and proactive way: it involves choosing or developing theoretical approaches with seemingly desirable social implications." She noted Gould and Richard Lewontin among the third group. Interestingly, E. O. Wilson appears to be oscillating between the first and third approaches.

[70] Johnson (1997, 125).

[71] Provine's 1994 debate with Johnson at Stanford University on "Darwinism: Science or Naturalistic Philosophy" is available at the Access Research Network website (arn.org). Cf. Witham (2002, 22-24). Kenneth Miller (1999, 189) has noted the curious Provine-Johnson isomorphism, and paleontologist Eldredge (2000, 135, 137, 148, 153, 206n) added the unapologetic atheist Richard Dawkins to the line. Ruse (2001, 98-110) comments on the anti-Darwinian side of fellow philosopher Alvin Plantinga—cf. Witham (2003, 210-211) positioning Plantinga as an evolutionist. Much as Johnson does, creationists Morris & Morris (1996a, 97-101) find Ruse and Provine useful foils—but tack them onto a far more restrictive target than Johnson's broad Wedge strategy to unseat Darwinian naturalism by uniting religious antievolutionists. Thus Morris & Morris (1996a, 106-107) show utter disdain for Old Earth creationist "compromisers" like Hugh Ross (1994). Farther out in the apologetic hinterlands, a Catholic site (familylifecenter.net/html/combat-campus-curses.html) offers Johnson's debate with "William B. Provide" [*sic*] on the "RESOURCE LIST TO COMBAT CAMPUS CURSES."

Parenthetically, Ruse (2001, 219) noted an ironic polarity to the debate over morality and ethics, as "the most conservative Augustinian thinker" crossed paths with Darwinism: "Both Darwinian and Christian are worried about being locked into actions by fate or blind law or something of this nature. And both Darwinian and Christian can find ways forward, showing that the concerns are genuine but that real solutions lie at hand, ready to be taken. Darwinian and Christian have much to learn from each other on this, as on earlier problems." Cf. also Miller (1999, 208-213) on the weak scientific underpinnings of the "Faustian bargain" of ontological materialism, and Pennock (1999, 189-194) on the difference between ontological versus methodological naturalism.

Notes to Prologue

[72] I had already attempted to cover this ground in email correspondence with Johnson. He not only refused to think in such terms, he positively advised against doing so, on the grounds that it plays into Darwinist hands by focusing on individual examples instead of looking at the "evidence as a whole." Just how anamorphic Johnson's "big picture" vision really is will be explored in due course, but the creationist track record is already painfully clear. Kenneth Miller (1999, 99): "I

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have never read, nor do I ever expect to read, an explanation of any event in natural history in which the explanation of design is correlated with actual events."

[73] Meyer subsequently left Whitworth to take up a permanent post as director of the Discovery Institute's Center for Science & Culture. The National Center for Science Education has been tracking the rather interesting evolution of how the DI has represented their subsidiary Center (see ncseweb.org/resources/articles/4116_evolving_banners_at_the_discovery_8_29_2002.asp). It started out as "Center for the Renewal of Science & Culture" in November 1996 with a website banner drawn from Michelangelo's famous creation depiction in the Sistine Chapel, where God touches Adam's outstretched finger. Around October 1999 the image was revamped to show a DNA helix in place of Adam. Two years later God & DNA exited the scene, to be replaced by an eye-shaped spiral nebula taken from the Hubble telescope—and that image remains as the Center's title was shortened to just "Center for Science & Culture." The NCSE tartly looked forward to the future evolution of the Center's name, with the removal of the "superfluous word" *Science*.

[74] The chart was in Robert E. Sloan, "The Transition between Reptiles and Mammals," in Zetterberg (1983, 270). Meyer served as an advisor on the antievolutionary textbook Davis & Kenyon (1993), whose account of the reptile-mammal transition left much to be desired. See notes 407 (Chapter Seven) & 437 (Chapter Eight) for further context on the Sloan chart and *Of Pandas and People*.

[75] Nor has Johnson expanded on this topic. Here are the entire discussions in his subsequent books. *Reason in the Balance*: "Because of this way of thinking, even the notorious discrepancies between the facts of the fossil record and Darwinian expectations do not matter so long as there is *some* evidence (*Archaeopteryx*, Lucy, the 'mammal-like reptiles') that can be interpreted to fit the paradigm—and the critics are unable to propose a credible mechanism for evolution by big jumps. If the contest is between Darwinism and 'we don't know,' Darwinism wins," Johnson (1995, 107). *Defeating Darwinism*: "I've long been fascinated by the conflicting messages Darwinists provide concerning the fossil evidence. On the one hand, they proudly point to a small number of fossil finds that supposedly confirm the theory. These include the venerable bird/reptile *Archaeopteryx*, the 'whale with feet' called *Ambulocetus*, the therapsids that supposedly link reptiles to mammals, and especially the hominids or ape-men, like the famous Lucy. These examples, all from vertebrate animals, are pressed very insistently on me in debates as proof of the 'fact' of evolution and even of the Darwinian mechanism," Johnson (1997, 59-60). He then went on to claim a similar problem with *invertebrate* evolution (re note 151 below), which consisted of his misunderstanding the point of Eldredge (1995). See my posting "A Tale of Two Citations" at talkreason.org for further details. References on the whale issue are given in note 248 below. Concerning the "small number" of fossils documenting macroevolution, for the reptile-mammal transition that would be 400 genera, involving thousands of specimens, which happened to be the dominant land animals of the Permian period, Robert E. Sloan, "The Transition between Reptiles and Mammals," in Zetterberg (1983, 264).

Notes to *Chapter 1* (The Cambrian Explosion)

[76] John R. Cole, "Scopes and Beyond: Antievolutionism and American Culture," in Godfrey (1983, 25-28), considers the MACOS case even more illustrative of the political qualities of modern antievolutionism than the BSCS project (see Appendix I).

[77] Schafersman (1982), Larson (1985, 123-4, 129, 139-140) and Ravitch (2003, 92-95, 105-107). The Gablers have not restricted their direct campaigns to Texas, as noted by Stanley L. Weinberg, "Creationism in Iowa: Two Defense Strategies," in Hanson (1986, 63-64), and Ruth Brown (2002, 125-126, 257-258). Ravitch noted the ironic similarity of the Gablers' confrontational method to that of radical feminists! Cf. Gould (2002, 989).

[78] Johnson (1991, 6). Cf. the creationist Bergman (1979) extolling the virtues of "equal time" teaching in public schools with critic Edwords (1981, 23-29) on how committed Creation Science has actually been to this seemingly Bible-free approach.

A recent "equal time" case concerns Danny Phillips, a Denver high school student who objected to the evolutionary content of a PBS video shown in his science class. Johnson (1997, 34-35) cast Phillips in a heroic mode, as someone bucking the Darwinian orthodoxy. "Danny has a special interest in truth, however, and because his father is pastor of a church that has an interest in questioning evolutionary naturalism, Danny knew that this claim of molecule-to-man goes far beyond the scientific evidence." One may compare that treatment with David Hill's coverage of the school board response in "Counter Evolutionary" for Education Week's Teacher Magazine in 1996 (edweek.org/tm/vol-08/03evol1.h08). Like many Biblical antievolutionists, Danny didn't want "creationism" taught in the schools, only a fair presentation of "factual science." But Hill thought the fifteen-year-old's statements were "somewhat disingenuous," since Danny felt insulted by evolutionary theory because it "contradicts God's creation of the world." In order for Johnson's characterization of the Phillips case to stand up, it would be appropriate to establish that Phillips had not entered the debate rejecting "evolutionary naturalism" *a priori* on theological grounds.

[79] See note 31 above in the Introduction. "The Mel Gablers Educational Research Analysts" (members.aol.com/TxtbkRevws/bio_othr.htm) mixes Intelligent Design "Biology Resources" Denton (1985); Johnson (1991; 1995; 1997), Davis & Kenyon (1993) and Behe (1996) with three YEC "organizations offering scientific materials" (the Institute for Creation Research, Answers in Genesis, and Creation Moments). Such conflation naturally filters through conservative Christian education, as in El Paso, Texas where the principal of Immanuel Baptist School and a senior at Faith Christian Academy both offer supposed inaccuracies in radiometric dating as ammunition against evolution, Martinez (2004, 4D). The article is also available at the newspaper's website (elpasotimes.com/stories/living/20040123-72033.shtml).

[80] The back cover summary is from the 16th (1997) edition of Morris & Parker (1987). Regarding the co-authors' academic history, Numbers (1992, 193, 197, 213, 288) notes Morris was an instructor at Rice Institute (Austin, Texas) during the 1940s, prior to obtaining a doctorate in hydraulic engineering from the University of Minnesota in 1950. He headed the civil engineering department at Southwestern Louisiana Institute (now the University of Southwestern Louisiana) before administering the larger civil engineering program at Virginia Polytechnic Institute 1957-1963 (until his YEC views garnered notice by his fellow academics and a new administrator let him go). Parker's 1973 Ed. D. degree from Ball State University related to biology and geology. The Institute for Creation Research website (icr.org) lists Parker's subsequent teaching career as Eastern Baptist College, Dordt College, Clearwater Christian College, Christian Heritage College, and the ICR's own Graduate School.

One of those "legitimate scientists" Morris & Parker may have in mind presumably includes San Francisco State University biologist Dean Kenyon, whose introduction to *What Is Creation Science?* lauded the authors for their "superb ability to avoid undisciplined speculation and to keep their reasoning in close conformity with the actual facts of nature," Morris & Parker (1987, iv). Although Morris & Morris (1996c, 178) state obliquely that Kenyon "had become a creationist, partially through reading creationist books," Morris & Parker (1987, 52) noted more directly that Kenyon became a convert in the 1970s after reading Whitcomb & Morris (1961). *The Genesis Flood* was a seminal work in the Creation Science revival of Flood Geology. That Kenyon could be impressed by its geological absurdities offers one measure of how careful his methodology is in the creationism venue.

Kenyon almost testified at the Arkansas creationism trial, but was apparently dissuaded by creationist lawyer Wendell Bird, Edwords (1982a, 43). That connection may be the root for Kenyon's equally enthusiastic preface to Bird (1989, Vol. 1, xv-xvi), where he described that wandering monstrosity as both "clearly organized" and "of great merit." John Ankerberg & John Weldon, "Rational Inquiry & the Force of Scientific Data: Are New Horizons Emerging?" in Moreland (1994, 330n) took these remarks as evidence that Kenyon "has extensively reviewed the scientific case for creation and accepts it as legitimate." But Bird's two-volume critique of evolution was three times longer than it needed to be on account of stupefying redundancy: extensively summarizing conclusions before repeating them in the main text, then reprising the same material a third time.

See note 111 below on the ID side of Kenyon's contribution to antievolutionism.

[81] Morris & Parker (1987, 126). A scholarly note on the book's slapdash organization: Parker's reference to eyes in "the first chapter" was not accurate. Henry Morris wrote the first chapter, titled "The Vanishing Case for Evolution" (though the page headings rendered it as "The Vanishing Case for Evolution Science"). Parker mentioned eyes in the book's second chapter, which was the first contributed by him. There may have been some introductory text removed in the revision process, since the Contents on page xv listed itself as occurring on page xvii. There was also supposed to be an Index of Names following the subject index, but the copy I bought had forgot to print it.

[82] Morris & Parker (1987, 127).

[83] Simpson (1983, 73-78) would be typical of how evolutionists interpreted the Cambrian phyla when Morris and Parker were writing.

[84] The "Kingdom Protoctista" of Margulis & Schwartz (1988, 77) "is defined by exclusion: its members are neither animals (which develop from a blastula), plants (which develop from an embryo), fungi (which lack undulipodia and develop from spores), nor prokaryotes. They comprise the eukaryotic microorganisms and their immediate descendants: all nucleated algae (including the seaweeds), undulipodiated (flagellated) water molds, the slimes molds and slime nets, and the protozoa." The "five kingdom" system (devised by famed Cornell ecologist Robert H. Whittaker) was well known among biologists by the time Morris and Parker set about revising their various texts.

[85] Morris & Parker (1987, 129) re Precambrian jellyfish and annelids. Spoon worms (phylum Echiura/Echiurida) are listed as Precambrian fauna in Emiliani (1992, 669). Beardworms (Pogonophora—or, since 1987, Siboglinidae) lack a mouth, digestive canal, or anus, and employ symbiotic bacteria to digest the nutrients their tentacles gather; hitherto unknown beardworm species discovered living around hydrothermal vents derive nourishment directly from the excretions of chemosynthetic bacteria colonizing their outer tissues. See Margulis & Schwartz (1988, 238-239) for general beardworm taxonomy, Gamlin & Vines (1986, 69, 154) or Emiliani (1992, 443) on recent finds, and McHugh (1997; 2000) and Boore & Brown (2000) suggesting beardworms and spoon worms may not be phyla, but rather derived annelids. Fortey (2000b) offers the big picture on trilobites.

[86] Knoll (2003, 189-190): "Crown group echinoderms appear only later in the Cambrian, or even in the Ordovician, depending on how one interprets a handful of mid-Cambrian fossils." (A "crown group" consists of the last common ancestor for a given lineage of living taxa, as opposed to a "stem group" that would include extinct forms.) For general accounts of Cambrian and Ordovician fauna see Lambert & The Diagram Group (1985, 46-77, 205-206) or Emiliani (1992, 446-481), with Simpson (1983, 73-75) providing a broad overview of higher taxa in chart form. Droser *et al.* (1996) describe recent paleontology concerning the Ordovician radiation.

Regarding echinoderm evolution and diversity, Emiliani (1992, 470), Doyle & Lowry (1996, 212-213) and Gee (1999, 73-78) supply the broad details, and Dornbos & Bottjer (2000) relate early echinoderms to changes in the way their seafloor substrate was mixed. Also a recent *American Zoologist* symposium: Blake *et al.* (2000) re Blake (2000), Hotchkiss (2000), Hrincevich *et al.* (2000), Knott & Wray (2000), Mah (2000), Mooi & David (2000) and Vickery & McClintock (2000). Guensburg & Sprinkle (2001) argue that the crinoid clades evolved well back in the Cambrian "apparently from an edrioasteroid ancestor." A Middle Ordovician specimen, the "starfish" *Edrioaster bigsby* (class Edrioasteroidea) illustrated in Emiliani (1992, 470), resembled a flattened baseball, with the five "arms" wrapped around it like seams. For comparison, the early "crinoid" *Gogia* (class Eocrinoidea) shown in J. John Sepkoski Jr., "Foundations: Life in the Oceans," in Gould (1993, 58) had long tendril arms set on a low body, but still differed from the later true crinoids in the way its pored plate sutures were laid out.

[87] See Lambert & The Diagram Group (1985, 76-77) on the agnathan fishes, Stahl (1985, 25-35) for more detail on the two main groups (Osteostraci and Heterostraci), and Forey & Janvier (1993) for the implications of recent finds.

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[88] Stahl (1985, 32) or Rich *et al.* (1996, 346) illustrated *Anglaspis*. Cf. Ellis (2001, 84-85). Incidentally, the summary of heterostracan diversity by Radinsky (1987, 36-38) cautions how little is known of their internal anatomy.

[89] Repetski (1978).

[90] See Stahl (1985, 34-35, 71-75) on mid-1980s Cambrian fossil fish and the challenges of evaluating the evolutionary implications of dermal bones.

[91] Sunderland (1988, 81, 103) repeats the creationist insistence that intermediate forms would not appear "fully formed" but rather would be "developing and not fully functional." Up until his death in 1987, Sunderland frequented scientific symposia armed with a recorder to document supposedly incriminating evolutionary pronouncements, McIver (1988b, 263-264). In that capacity Sunderland duly quizzed evolutionists David Raup and Donald Fisher on Repetski's findings, and took their agreement as confirmation of his own misperception about what manner of vertebrate fish inhabited the Late Cambrian, Sunderland (1988, 53, 72, 74). Wendell Bird (1989, Vol. 1, 214), Austin (1994, 146) and Morris & Morris (1996b, 299) also relied on Repetski, without clarifying what sort of fish were involved.

[92] Stahl (1985. 45). Cf. Radinsky (1987, 36-38) reconstructing the features of an ancestral chordate based on evolutionary assumptions. See Malcolm W. Brown's 1992 report, "Evidence of Bone Shows Vertebrates to be Far Older Than Once Believed," in Wade (1998, 108-110), Margulis & Schwartz (1998, 231), Gee (1999, 69-73), Zimmer (2000a), Ellis (2001, 78-80, 86-87) and Parker (2003, 202-203). Fossil hagfish were unknown until one turned up from 330 Ma, Martini (1998). The details of lamprey developmental biology continue to be clarified, as reviewed in the new study by Richardson & Wright (2003). For the genetic side of the lamprey connection to the evolution of early vertebrates, see Neidert *et al.* (2001), Force *et al.* (2002) and Irvine *et al.* (2002), with Salaneck *et al.* (2001) on a possible early neuropeptide receptor preserved in the lamprey genome, relating to Wraith *et al.* (2000).

[93] Holland & Chen (2001, 145-148), Shu *et al.* (2003b), Mallatt *et al.* (2003) and Shu & Conway Morris (2003) offer differing perspectives on *Haikouella* and *Myllokunmingia* described respectively by Chen *et al.* (1999) and Janvier (1999) on Shu *et al.* (1999). Illustrations of both taxa may be seen online at palaeos.com. Incidentally, Wells (2000a, 270) cited Chen *et al.* (1999) and Shu *et al.* (1999) for "recent reports of Chengjiang fossils," but did not discuss the taxa or their significance in his text. Another Early Cambrian agnathan (*Haikouichthys*) further clarifies the primitive stem-group craniates, Shu *et al.* (2003a). *Haikouichthys* may actually be the same species as *Myllokunmingia*, as noted at the University of Bristol (palaeo.gly.bris.ac.uk/Palaeofiles/Lagerstatten/chngjang/animalia.html).

Further research has also refined the "Yunnanozoan" group to which *Haikouella* and *Myllokunmingia* have been attributed. Based on a first specimen, *Yunnanozoon* was thought to be a very primitive chordate, Gould (1995) re Chen *et al.* (1995), and Dzik (1995). But subsequent finds undermined that identification, leading Shu *et al.* (1996) to rank it as more likely a rudimentary hemichordate. Cf. Conway Morris (1998a, 132, 136-137) on Gould's "hyperbolic" acceptance of *Yunnanozoon* as an "unambiguously identified chordate."

At Answers in Genesis, Tas Walker (2000) was insouciance itself when he offered Shu *et al.* (1999) to show "that fish appear suddenly in the fossil record along with all the other kinds of animals." Walker inferred that "one of the fossils resembled a young lamprey which is parasitic on other fish. This means that although fossils of other fish are not found until later, they must have been alive at the same time." Although modern lampreys are adapted to a parasitical lifestyle, this is no guarantee that *Haikouella* was. By describing it as a "young lamprey" rather than a larva-like one would also keep the reader from thinking about the developmental implications of this relationship. There happens to be a considerable evolutionary literature on the concept of neoteny and heterochrony (see notes 239-240, Chapter Three).

[94] Microbial colonies appear to have expanded onto coastal and river shorelines by 1200-1000 Ma, Prave (2002). But the first signs of animal life on the land don't come until long after the Cambrian Explosion. For example, tracks of some "large, amphibious arthropods, possibly euthycarcinoids,"

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are known from the Cambrian-Ordovician boundary, MacNaughton *et al.* (2002). Physical fossils for the slender burrowing euthycarcinoids occur later still, in the Triassic, Rich *et al.* (1996, 221).

[95] Austin (1994, 140). Two slightly positive aspects: the picture was not identified as a Cambrian ensemble, and the "fish" swimming in the heterostracan position was somewhat more accurately rendered (the bony plates were more prominent).

[96] Gish (1995, 54).

[97] See Gould (1989, 161-163) on the early crustacean *Canadaspis*, and also the references in note 128 below. Gould (1989, 25): "The Burgess Shale includes, for example, early representatives of all four major kinds of arthropods, the dominant animals on earth today—the trilobites (now extinct), the crustaceans (including lobsters, crabs, and shrimp), the chelicerates (including spiders and scorpions), and the uniramians (including insects)." Someone reading this passage at too fast a clip might have missed the implication of what Gould meant by "early representatives" of those groups.

[98] Henry Morris (1985, 79).

[99] Morris (1985, 80) citing Simpson (1953, 360). The ammonite example was on the following page of Simpson's book. Similarly Simpson (1944, 105): "When the record does happen to be good, it commonly shows complete continuity in the rise of such taxonomic categories as species and genera and sometimes, but rarely, in higher groups." The next ten pages were devoted to explaining those higher level gaps, which Simpson (1944, 115) noted "systematically correspond with the structural breaks" in the fossil record. Duane Gish (1993; 1995) failed to quote this passage, even though Gish (1993, 129-130) quoted Simpson from the following page on putative fossil gaps—though with a typo giving the page number as 105, ironically. Cf. also the analytical details offered by Simpson's "The History of Life," in Tax (1960, 123-152).

[100] Similarly ambiguous terminology figures in Froede (1999) for the *CRS Quarterly* (available at creationresearch.org/crsq/articles/36/36_3/plantfossils.html). Margulis & Schwartz (1988) and Emiliani (1992, 666-671) reflect phyletic data available to late 1980s creationists; newer views from the 3rd ed. of *Five Kingdoms* will be noted as warranted, such as those Ordovician fungi fossils, Margulis & Schwartz (1998, 347).

[101] See Gamlin & Vines (1986, 45-66) on the vast diversity of "lower" plants and trees, Simpson (1983, 80-83) for an older example noting the sequence of plant group appearances, and Graham *et al.* (2000) on current evolutionary views. Hardy plant spores have been found earlier than fossil plants, but recently some spore-containing plant fragments have been found from the Ordovician period (475 Ma), Kenrick (2003) re Wellman *et al.* (2003), helping to bridge the record to the more prominent "megafossils" of the Late Silurian (425 Ma). Cf. Gary Parker in Morris & Parker (1987, 165) with paleontologists Rich *et al.* (1996, 373-374) apropos showing caution over fragmentary pollen data, and C. Brown (2002, 104-105, 112n) on other antievolutionary plant claims.

[102] Sorting out the angiosperm radiation is made harder because it didn't happen all at once (the earliest forms even lacked petals), Crepet (1998), Friedman & Floyd (2001) and Klesius (2002). Cf. Gamlin & Vines (1986, 59-66), David L. Mulcahy, "Rise of the Angiosperms," in Eldredge (1987, 21-26), Michael Benton, "Dinosaur Summer," in Gould (1993, 152-157), Rich *et al.* (1996, 534-541), James F. Basinger, "Mesozoic Floras," in Currie & Padian (1997, 422-433), Ayala *et al.* (2000) re Dilcher (2000), and Zanis *et al.* (2002). Genetics suggest a pre-Cretaceous origin, Li (1997, 164-167), while an odd primitive Chinese angiosperm hints at an Asiatic herbaceous source, Sun *et al.* (1998; 2002) and Stokstad (2002b). However, its Late Jurassic dating is problematic, Swisher *et al.* (1999) and Barrett (2000); Palmer (1999, 136-137) treats it as Cretaceous. See Krizek & Meyerowitz (1996), Doebley & Lukens (1998), Alvarez-Buylla *et al.* (2000), Lawton-Rauh *et al.* (2000), Crepet (2000) on Barkman *et al.* (2000), and Coen (2002) on angiosperm developmental genetics (such as the MADS-box and *cyc* genes). For comparison, Zhou & Zheng (2003) discuss a Cretaceous gingko intermediate, and Nishiyama *et al.* (2003) explore the implication moss genes have for land plant evolution.

Antievolutionists have preferred quote mining rather than exploring the details of plant biology, such as Gish (1978, 154; 1990, 36; 1993, 85-87; 1995, 336-337), Morris (1985, 86-87), Gary Parker in Morris & Parker (1987, 135), Bird (1989, Vol. 1, 233-234), Johnson (1991, 179), Taylor

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(1995, 106) and Ankerberg & Weldon (1998, 215). Cf. Laurie R. Godfrey, "Creationism and Gaps in the Fossil Record," in Godfrey (1983, 201-202) on Gish. Gish (1993, 82-84, 89-91) also pounced on Kenneth Miller (1982, 9), reprinted in Zetterberg (1983, 258), after he mistakenly interpolated a phrase into Corner and then castigated Gish for having not quoted it correctly! Gish did not note how quickly Miller acknowledged and corrected the gaff (and never repeated it), re Miller's exchange with creationist Robert Kofahl in the Summer 1982 issue of *Creation/Evolution* (pp. 40-43), available online at ncseweb.org. This may be compared to Gish's continued resiliency in repeating factual mistakes long after being called on their scientific accuracy, as chronicled by Joyce Arthur for *Skeptic* magazine (Vol. 4, No. 4, 1996, pp. 88-93)—available at holysmoke.org (a *very* unflattering website criticizing the ICR view of the universe). Cf. Witham (2002, 216-219).

[103] Trying to piece together what the common ancestor of plants and animals was like is one of the most challenging of forensic puzzles. The current evidence suggests much of plant and animal developmental mechanisms originated independently in the two lineages, Meyerowitz (2002). On a broader front, the creationist focus on animals tends to obscure just how diverse the rest are, Roger Lewin (1997, 56-60), Gupta (1998) or Schäfer *et al.* (1999). The prokaryotic Monera (organisms lacking a central nucleus to store their cell DNA) embraces a very ancient split in life as dramatic as the development of the nucleated eucaryotes. The Archaebacteria (which thrive in the sort of hostile anaerobic conditions common on the early earth) also show as much genetic differences with the true bacteria as the two do with the Eucaryotae. All this came at first as something of a shock to scientists, though it really shouldn't have. Such splits represented the accumulated development of bacterial processes over twice as long as the roughly 1.7 billion years it took for the most rudimentary of eucaryotes to go from unicellular model to overconfident Creation Scientist. The new genetic information occasioned a substantial rearrangement of the bacterial phyla in the 3rd ed. of Margulis & Schwartz, as well as sparking a significant debate on whether Archaebacteria represent a third domain of life, Harold (2001, 20-25). See also Woese (1998) versus Mayr (1998), with Margulis *et al.* (2000, 6954-6955) supporting Mayr's defense of the traditional two domain view—cf. Ryan (2002, 172-174) for perspective.

[104] McMenamin (1998, 253) counts 37 living phyla, including another recently discovered wee beastie, the Cycliophora. Margulis & Schwartz (1998, 210) didn't recognize that one (it has not been properly described), but hit the same number by splitting arthropods into Chelicerata, Mandibulata & Crustacea, and chordates into Urochordata, Cephalochordata & Craniata. All are still traceable back to the Cambrian, though, so don't affect our cataloguing exercise.

[105] Margulis & Schwartz (1988, 190-191, 242-243) considered *Amiskwia* a likely nemertine, while Emiliani (1992, 474-475) put it down as a chaetognath, and Margulis & Schwartz (1998, 239) now only place it provisionally as a nemertine. Gould (1989, 210) thought it might be a new phylum, and the Gore (1993, 128) illustration is labeled "Unclassified." Describing a possible Early Cambrian chaetognath that has recently been discovered, Chen & Huang (2002) noted that *Amiskwia* could have been some form of mollusk. See Margulis & Schwartz (1988, 232-233) and Rich *et al*. (1996, 194-196) for the onychophorans; Margulis & Schwartz (1988, 220-221) for the priapulids.

[106] See Gamlin & Vines (1986, 94), Emiliani (1992, 475) and Rich *et al.* (1996, 338-340) on the conodonts, with Janvier (1995) noting the chordate connection supported by Purnell (1995) and Gabbott *et al.* (1995). The conodonts appear to have had eyes, which would be of relevance to the evolution of chordate vision—though the fossil evidence is not yet unequivocal (see palaeos.com/Vertebrates/Units/030Conodonta/030.000.html). Cf. Donoghue & Purnell (1999) on how the assessment of conodont paleoecology turned on whether the animals regularly shed the diagnostic parts that were fossilized.

[107] See Margulis & Schwartz (1988, 244-245) and Emiliani (1992, 475-479) on the hemichordates. The bryozoans had been grouped with the mainly sessile Entoprocta as phylum "Bryozoa," but more recent anatomical analysis has led to their being split into separate phyla. See Gamlin & Vines (1986, 71), Margulis & Schwartz (1988, 204-205, 210-211), and Emiliani (1992, 488-489). Rich *et al*. (1996, 142-152) show how varied the bryozoan body plan has been through fossil

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history. Gould (1998a, 60; 1998b, 52) favored an Ordovician dating for the Bryozoa, which would make it the only animal phylum possibly diverging after the Cambrian.

[108] See Margulis & Schwartz (1988, 182-185, 222-225, 228-229) on the comb jellies, water bears, peanut and spoon worms, with Margulis & Schwartz (1998, 226, 285, 297) for the newer information. Conway Morris (1998a, 107-109) described the Cambrian comb jellies, which differed from their modern counterparts in having 24 or more comb rows (aggregates of their external propulsive cilia), compared to the 8 in contemporary ctenophores.

[109] Per Margulis & Schwartz (1988, 174-175, 186-189, 192-209, 212-213, 230-231), the "minor" 1980s animal phyla: Entoprocta, Gastrotricha, Gnathostomulida, Kinorhyncha, Loricifera, Nematoda, Nematomorpha, Phoronida, Placozoa, Platyhelminthes (flatworms), Rotifera—and three subsequently wrinkled ones: Mesozoa (split into two phyla, Rhombozoa and Orthonectida), Acanthocephala (possible descendants of the Burgess Shale priapulid worms), and Pentastoma (parasites now regarded to be highly modified crustaceans), Margulis & Schwartz (1998, 232-237, 247, 273-275). Gamlin & Vines (1986, 69) noted the problematic character of the gnathostomulids—until the Carboniferous example turned up to settle conodont affinity, those teeth common in Cambrian shale were thought possibly to be theirs, Margulis & Schwartz (1988, 192).

As for how not inconsequential many of these are, the parasitical nematodes are possibly the most abundant animals on earth, with 80,000 described species (and perhaps a million altogether) living in too many places it's better not to think much about, Margulis & Schwartz (1998, 242). One particular species, *Caenorhabditis elegans*, is a model organism for biologists, as its transparency and comparative simplicity permit study of such processes as cell death (apoptosis) that underlie normal multicellular growth. Interestingly, *C. elegans* was thought to exhibit the developmentally curious property of "eutely" (where individuals have the same total number of cells), but this has recently been challenged, Cunha *et al.* (1999). See Emiliani (1992, 441) for an evolutionary attribution of the nematodes to the late Precambrian, and Ruiz-Trillo *et al.* (2002) on recent genetic evidence suggesting nematodes are basal bilaterians (in an otherwise polyphyletic Platyhelminthes).

[110] Davis & Kenyon (1993, iii). Baumgardner is a mix of traditional evangelical YEC (see youngearth.org/baumgardner.htm) and a quite accomplished technician (his TERRA program is widely used to model the earth's mantle). Cf. the discussion of Baumgardner at icr.org/research/jb/debatehighlights.html with the oblique coverage Witham (2002, 240) gave to Chandler Burr (1997). See notes 34 & 40 of the Introduction on Geisler and Pearcey; Wise's arguments on evolution are covered in Chapter Nine. Incidentally, Wise studied at Harvard under Stephen Jay Gould (which must have been an educational experience for them both). Brilliant and enthusiastic, his iconoclastic career is described in Numbers (1992, 281-282); see also Kenneth Miller (1999, 173-174, 187) and Witham (2002, 52-53, 103-107).

One scholarly trail provides further context for the critical contributors to *Of Pandas and People*. Paul Nelson and John Mark Reynolds represented the YEC position in Moreland & Reynolds (1999). In their "Conclusion" to Moreland & Reynolds (1999, 98) they noted "in the 1994 *Proceedings of the International Conference on Creationism*, six creationist scientists, all with relevant terminal degrees, presented a paper entitled 'Catastrophic Plate Tectonics: A Global Flood Model of Earth History.' This paper provides a new theoretical way of understanding the flood of Noah and its impact on the geological record. It solves many problems, while providing a huge amount of room for future research." Nelson & Reynolds revealed no details of its content or the identities of the authors. But the Creation Science Fellowship of Pittsburgh (website at csfpittsburgh.org) sponsoring those conferences indicated they were Wise, Baumgardner, Steven Austin, physicist Russell Humphreys (of Sandia National Laboratory), geologist Andrew Snelling, and atmospheric scientist Larry Vardiman (who appeared on an idiotic 1993 CBS program on the quest for Noah's Ark). Austin, Snelling, and Vardiman are presently among the "resident faculty" at the ICR (with Duane Gish, Henry and John Morris, biologist Kenneth B. Cumming, and physicist Donald DeYoung).

A further sign of the crossover market for Intelligent Design and conventional YEC beliefs is the new Brazos division of Baker Book House, venturing into ID territory with Dembski & Kushiner (2001) and Hunter (2001; 2003). Long a stalwart of traditional apologetic publishing, from Youngblood (1986) to Geisler & Hoffman (2001) and Webber (2002), Baker House is also responsible for such benchmarks of creationist thinking as Morris (1963), DeYoung (1989), Lubenow (1992) and Huse (1997).

[111] Stephen Meyer consistently describes Kenyon only as an "intelligent design" believer, from his December 6, 1993 *Wall Street Journal* piece (apologetics.org/articles/scopes.html) and "The Methodological Equivalence of Design & Descent" in Moreland (1994, 82) to a chat on Chuck Missler's radio show (June 21, 2000). Ankerberg & Weldon (1998, 100), Colson & Pearcey (1999, 74) and Witham (2002, 162-166; 2003, 103, 117-118) are similar.

In a 1996 article ("What Every Theologian Should Know about Creation, Evolution, and Design" available at the Access Research Network website, arn.org), William Dembski said Kenyon ("not a rube or ignoramus") abandoned his Darwinian beliefs "not for religious but for scientific reasons." Although during his evolutionist phase Kenyon co-authored *Biochemical Predestination*, it is unclear to what extent Kenyon simply switched absolutist gears, as many a political convert has over the years when decamping to the opposing side (like Jane Fonda assimilating the views of her various husbands).

Johnson (1995, 29-30) mentioned Dean Kenyon as an example of an ex-evolutionist convert to "intelligent design" who suffered persecution after raising challenging questions in his San Francisco State University lectures. Drawing partly on Cohen-Kiraly (1997), Johnson (1997, 49-50, 124) put a similar "inquiring minds" spin on the case of an Ohio physics teacher, Mark Wisniewski, called on the carpet in 1996 for including Creation Science material in a unit contrasting competing views on the origin of life and the universe. Tucked away in Johnson's endnotes was a newspaper report that half of Wisniewski's students ended up thinking the creationist positions were more plausible. Since he expressed no concern over this outcome, Johnson apparently regarded this as a sign of progress. Incidentally, the 1998 International Conference on Creationism included Kenyon's "Teaching a Balanced View of Biologic Origins in a Secular University" along with several papers by Wisniewski: "Creation in the Public Schools: Learning by Experience" and a reprise of "The Worldview Approach to Critical Thinking" (given at the 1994 meeting).

[112] Davis & Kenyon (1993, 92).

[113] Davis & Kenyon (1993, 95).

[114] Frank Sonleitner informed me (personal communication in 2004) that the first edition of *Pandas* had depicted the fossil record of the phyla with solid lines only. Presumably Davis & Kenyon were apprised of this inaccuracy and filled in the dotted sections for the 2nd edition—but didn't perform a similar recalibration with their "nearly all" phyletic conclusion. Interestingly, it turned out that Davis & Kenyon (1988, 95) had included three phyla (one extant and two extinct) with a Precambrian fossil presence, but the 1993 version performed a retroactive extinction by removing the first line and deleting the Precambrian segment from the two extinct phyla. Short dotted segments were shown for a dozen more extinct phyla alluded to generally in the text, but those examples were likewise dropped from the 1993 chart and the caption moved up to fill the space. See Sonleitner (1991; 1994) for surveys of the errors and misrepresentations in the various editions of *Pandas*.

Over on the ID side, the latest Discovery Institute slide show on the Cambrian Explosion (which I saw presented by Stephen Meyer to one of his philosophy classes in October 2001) now acknowledges that half of the phyla aren't preserved in the Cambrian. Meyer was willing to infer the rest as parasites of known ones (which may be compared to Tas Walker at Answers in Genesis, note 93 above), but left out the naturalistic logic whereby phyletic candidates were represented by evolutionary ancestors.

[115] Wells (2000a, 39).

[116] Wells (2000a, 41).

[117] Wells (2000a, 271-272).

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[118] Since Recent to Cambrian is 540 Ma, each row would be about 68 Ma—but that couldn't be right, as the Permian would date 140 Ma (100 Ma off). Wells had of course left out the entire Mesozoic, which needed two rows besides the blank one preceding the Permian. But even at 68 Ma/row, the whole chart would represent only about 2.4 billion years, shy of the formation of the earth by a further 2000 Ma. Wells (2000a, 36) had a schematic of geological history that noted the formation of the earth as "currently dated at about four and a half billion years ago" but otherwise gave no dates.

[119] See wikipedia.org/wiki/chaetognatha.

[120] See note 109 above on the nematodes. Cf. also Sven Boström's nematode lecture information at abo.fi/fak/mnf/biol/mni/lec_bost.htm.

[121] Phoronida data obtained from ucmp.berkeley.edu/brachiopoda/phoronida.html.

[122] See ucmp.berkeley.edu/platyhelminthes/platyhelminthes.html.

[123] See ucmp.berkeley.edu/annelida/pogonophora.html. Piotr Mierzejewski includes some possible pogonophoran tubes in a survey of Ordovician and Silurian microfossils (see graptolite.net/ultra.html), though this still falls short of the Cambrian.

[124] See ucmp.berkeley.edu/aschelminthes/aschelminthes.html.

[125] Species numbers drawn from the catalog at www2.austincc.edu/sziser/worldspecies.html.

[126] An obvious case of evasion concerns Duane Gish: although McGowan (1984, 102) alluded briefly to Morris' taxonomical excesses, Gish (1993) did not discuss it. Morris & Morris (1996b, 299) now hedge their bets with "most of the classes of the animal kingdom appear in the Cambrian rocks" and "practically *all* the animal classes and phyla are found in *all* the geologic 'ages'."

[127] Ecker (1990, 15-18) summarized what Scientific Creationism has made of "abrupt appearance" references from mainstream evolutionists.

Notes to *Chapter 2* (Lagerstätten)

[128] Conway Morris (1998a, 103-104, 130-131, 173). Though Valentine *et al.* (1999, 854) characterize *Eldonia* as an organism "of uncertain affinity." Other Chinese specimens of possible early chordates have been discovered, Enserink (1999) and Ellis (2001, 80-83)—references for *Haikouella* and company are in note 93 above.

[129] Erwin *et al.* (1997, 135-136). Cf. the *National Geographic* illustrations, Gore (1993, 122-123, 128-129), and the still more recent depictions in Palmer (1999, 62-65).

[130] Fastovsky & Weishampel (1996, 71).

[131] Johnson (1991, 54). His Research Notes did not specifically reference Dawkins (1986, 229) for the quote. Gish (1995, 56-57) similarly quoted Dawkins.

[132] Johnson (1991, 54-55, 167), drawing on Gould (1989, 58-60, 311-314).

[133] Johnson (1991, 55-56), quoting Gould (1989, 271-273). Cf. the YEC review of Gould's book by Brown & Coffin (1990).

[134] The Johnson (1993b) update of *Darwin on Trial* did not revise the Cambrian text. Johnson (1995, 87, 228) summarized the problem and referred the reader back to the fuller account in *Darwin on Trial*. Johnson (1997, 60) sufficed with an allusion to "the 'Cambrian explosion,' where the basic animal groups all appear suddenly and without evidence of evolutionary ancestors."

[135] Like Johnson, Gish (1993, 116) relied on Gould for Seilacher's take on the Ediacarans, which Gish (1995, 56) coalesced into the bald claim that paleontologists Levinton (1992), Gould, and James W. Valentine "stated unequivocally that they could not possibly have been ancestral to any of the Cambrian animals." Morris & Morris (1996b, 59-60, 282) is similar. Denton (1985, 187) briefly noted that "several new types of organisms which were not known one hundred years ago have been discovered in the Burgess Shale and at Ediacara, in rocks of Cambrian and late pre-Cambrian age: however, none of these discoveries have thrown any light on the origin or relationships of the major animal phyla."

[136] Wells (2000a, 37). Vaguer still, Cornelius Hunter (2001, 69) didn't mention the Ediacara biota at all when declaring: "In a geological moment, the fossil species went from small worm-like

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creatures and the like to a tremendous diversity of complex life forms, including virtually all of today's modern designs."

[137] Mark McMenamin (1998). Cf. Ellis (2001, 25-31) and Knoll (2003, 163-177).

[138] Gould (1989, 59) ventured 100 Ma for the gap, while Gould (1998a, 58) charted the newer values. Both Johnson and Wells cited *Wonderful Life* in other contexts. Wells (2000a, 270) further referenced Grotzinger *et al.* (1995) "On the dating of the Ediacaran assemblage"—but didn't mention any of those dates directly in his text. Erwin (1999, 620) positions the distinctively Ediacaran forms around 570 Ma, with an increase in diversity after 550 Ma. Further references on Ediacaran chronology: Martin *et al.* (2000) and Kerr (2000).

[139] Wells (2000a, 39).

[140] Johnson (1991, 52).

[141] Schroeder (1997, 89).

[142] Mayr (1963; 1970) laid out the principles of "allopatric" speciation based on geographic isolation. Mayr (2001a, 174-187) represents his latest survey—see Coyne (1994), Futuyma (1994), Gould (1994b), Schilthuizen (2001, 13-14, 19-22, 27-28, 53-58, 97-98) and Lenormand (2002) on Mayr's influential contribution to current views on speciation.

Mayr played a curious part in an authority quote daisy chain. Citing Horgan (1992) and Rennie (1994), Schroeder (1997, 127) declared that Mayr "has come to admit that the origin of our species is a 'puzzle' (to use his word) that may never be solved. The link that leads directly to *Homo sapiens* is missing." Rennie's interview with Mayr had not mentioned human evolution. Horgan's survey of current trends in science, and the extent to which fundamental discoveries remain to be made (primarily in physics) mentioned Mayr *once*. "All that remains, Mayr contends in *One Long Argument*, a book published last year, are 'puzzles.' Some of these puzzles, he concedes, particularly historical ones such as the origin of life or of *Homo sapiens*, are extremely difficult and may even resist a final, satisfying explanation. But however they are resolved, Mayr argues, they will not force any significant changes in the underlying paradigm of Darwinian evolution," Horgan (1992, 20). Horgan was stretching Mayr's position—which Schroeder might have noticed had he read *One Long Argument* instead of Horgan's abstraction. Mayr (1991, 25): "today this derivation is not only remarkably well substantiated by the fossil record, but the biochemical and chromosomal similarity of man and the African apes is so great that it is puzzling why they are so relatively different in morphology and brain development." Cf. Mayr (2001a, 235-256) on human evolution.

The conservative culture critic Rabbi Daniel Lapin (1999, 54) subsequently escalated the Horgan-Schroeder misapprehension: "In his recent book, *The Science of God*, Schroeder quotes [*sic*] Harvard professor emeritus of zoology, Ernst Mayr, who has been a noted authority and advocate of Darwinian evolution. After many years of study Mayr had the intellectual honesty to admit that we may never solve the puzzle of the origin of species." Since Mayr all but defined allopatric speciation, he was probably the last person to invoke as a source of mystery here. For contrast, Lapin (1999, 53) lauded those "courageous men" Phillip Johnson and Michael Behe for driving "six-inch, titanium steel nails" into "the coffin of Darwinian evolution."

Hunter (2001, 10, 177n) riffed off Mayr (1988, 170) more directly as the sole reference for Hunter claiming that Darwin "was motivated toward evolution not by direct evidence in favor of his new theory but by problems with the common notion of divine creation." Mayr had drawn no such connection. As the chapter on Darwin in Mayr (1988, 169-183) indicated, Darwin had seen things during his trip on HMS *Beagle* that empirically suggested a naturalistic process of common descent (see Appendix III below). It was this evidence, and not merely philosophical conceit, that generated those "problems" for creationist theories of nature.

[143] See Eldredge (1991a, 34-58) or Gould (2002, 745-1024) on punctuated equilibrium and Sonleitner (1987), Schwartz (1999, 320-330), Richard Morris (2001) or Shermer (2001, 97-116) on the controversy. That PE is less revolutionary than it sounds is seen in Levinton & Futuyma (1982), Simpson (1983, 171-176), Dawkins (1986, 223-252), Berra (1990, 48-50) and Kenneth Miller (1999, 111-121). Gamlin & Vines (1986, 18-19) and Whitfield (1993, 178-181) illustrate this regarding the remarkably detailed 4.5 million year showcase of fossil invertebrates at Lake Turkana in Kenya.

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[144] I have found no signs that evolutionists are befuddled when it comes to the rate of speciation *per se*. For example, the *Journal of Evolutionary Biology* "shop talk" on Wu (2001a,b) by Bridle & Ritchie (2001), Britton-Davidian (2001), Mallet (2001), Mayr (2001b), Orr (2001), Rieseberg & Burke (2001), Rundle *et al.* (2001), Shaw (2001), van Alphen & Seehausen (2001) and Vogler (2001). Of far greater relevance than the rate of speciation is the means by which species identity is assessed (including genetic, behavioral, morphological, and reproductive isolation). Sites & Marshall (2003) survey various methods and their applicability to living examples.

[145] Johnson (1991, 168).

[146] Gould (1980, 184). Similarly Eldredge & Tattersall (1982, 59): "Speciation can occur very quickly. In perhaps a few hundred years, new reproductively isolated species can form." Eldredge (1995, 99) reminded his readers of the position that he and Gould had taken: "As against five to ten million years of stasis, we claimed that evolutionary change—tied up in speciation events—happens rather quickly. Here we are at the smallest level of resolution of geological time often (but not always) possible with the fossil record. Even tens of thousands of years are usually difficult to decipher in the fossil record. So our estimates of time required for speciation events were much hazier than out estimated average durations of species. I came up with the figure 'five to fifty thousand years,' which was consistent with some of the events we believed we had some direct data on from our own studies." This may be compared to the "per-lineage diversification rate of 0.77-1.75 per million years" playing out as some South African plants diversified "very rapidly" a few million years ago, Klak *et al.* (2004).

Following speciation in the wild requires patience: the PBS *Scientific American Frontiers* series reported on the *twenty years* a scientist observed spider behavior in the American Southwest, and was just now documenting the behavioral changes that appear to be fissioning one species. Cf. also Strahler (1987, 397-400) and the talkorigins.org/faqs/faq-speciation listing, Nagel & Schluter (1998) on sticklebacks, Grieg *et al.* (2002) on yeast. It was thought for a time that speciation might be induced by a genetic "bottleneck" without having to fiddle with the whole competitive environment, but nature is not so easily nudged. See Meffert (1999, 707-708) and Schilthuizen (2001, 63-72) on Rice & Hostert (1993), Templeton (1996) and Rundle *et al.* (1998), as well as the misidentified *Nereis* worm saga in Weinberg *et al.* (1992) and Rodríguez-Trellis *et al.* (1996). Rice & Hostert is excerpted in Mark Ridley (1997, 174-186).

[147] Dawkins (1986, 242) touched on the issue of pacing in terms of morphological change, highlighting an argument by G. Ledyard Stebbins. A mouse-sized species accumulating body mass in increments too small to be easily measured by scientists could get as large as an elephant in 60,000 years—still too fast for certain fossilization. Incidentally, the standardized quantification of speciation rates in terms of "darwins" and "haldanes" has recently come into practice, per Hendry & Kinnison (1999). These suggest that the change observed in the fossil record are within the ranges measurable in living organisms. Whether there are also higher level constraining rules to speciation hasn't been established. For example, tentative attempts to correlate speciation rates to changes at the molecular level, Barraclough & Savolainen (2001), or Webster *et al.* (2003; 2004) *contra* Brower (2004) and Witt & Brumfield (2004).

[148] Laurie R. Godfrey, "Creationism and Gaps in the Fossil Record," in Godfrey (1983, 206). Cf. Niles Eldredge & Michelle J. Eldredge, "A Trilobite Odyssey," in Eldredge (1987, 61-68). Eldredge (1995, 147): "In my *Phacops rana* lineage, I found two apparent instances of speciation, each involving only minor amounts of anatomical change." For Eldredge, a shift in the number of eye lenses in the animal was "minor"—but that was also over a quite short time span, which Eldredge (1995, 121) related to how most speciation bursts would not be captured in the fossil record. Thus "minor" shifts from one related species to another could still add up to major changes in the long term. Some idea of what degree of genetic interactions may have been going on in the trilobite lens example is suggested by Hafen *et al.* (1987) on mutations in the *sevenless* gene that eliminates the UV-sensitive form of retinular (R-cell) photoreceptors in *Drosophila*.

[149] Eldredge (1981, 19). *Metacryphaeus*, *Malvinella* and *Vogesina* are illustrated in Eldredge (1991a, 110-115), along with *Bouleia dagincourti*, a "specialized member of the *Malvinella* group" that "evolved so far as to actually converge on *Phacops*-like species."

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[150] Eldredge (1995, 55-56).

[151] Johnson (1998a, 73), reprinting a November 1997 article he had written for *First Things*, a journal defending conservative religion, philosophy and cultural concerns. In a 1998 email responding to my inquiries on the nature of speciation, Johnson likewise tossed off the Eldredge quote and added, "Yet Eldredge describes himself on the next page as a 'knee jerk neo-Darwinist.'"

Johnson's first use of the "never seems to happen" quote appears to have been in his 1995 review of Daniel Dennett's *Darwin's Dangerous Idea*. As reprinted in Johnson (1998a, 63), Johnson remarked that "Whatever is motivating Eldredge to give all that fervent lip service to Darwinism, it obviously is not anything he has discovered as a paleontologist." Johnson also used the "never seems to happen" line in Letter 6 (December 6, 1996) of a PBS exchange with Ken Miller (pbs.org/nova, with a plethora of links on the net, as at talkorigins.org). Johnson (1997, 60-61) fielded a fuller version of the quote, drawn from Eldredge (1995, 95), but transposing and replacing several words ("seems never" turning into "never seems," and replacing "organisms" and "someplace" with "fossils" and "somewhere").

[152] Davis & Kenyon (1993, 86).

[153] Doyle & Lowry (1996, 82-85, 214-215, 321, 341-343), Kerr (1997) and Douglas H. Erwin & Robert L. Anstey, "Speciation in the Fossil Record," in Mark Ridley (1997, 244-254)—cf. also Simpson (1983, 160-161). Doyle & Lowry concluded that eight cases of microevolutionary change in fossil invertebrates (Ordovician trilobites, Silurian graptolites, Carboniferous rugose corals, Jurassic bivalves and ammonites, Cretaceous echinoids, and bryozoans) were about evenly split between phyletic gradualism and punctuated equilibrium. They also noted distinctive features of the Miocene-Pliocene bryozoan *Metrarabdotos* covered in Jackson & Cheetham (1990; 1999), summarized by Kerr (1995) and also by Gould (2002, 784-789, 843-845, 867-870). The static branch species tended to have overlapping geographical ranges (a prediction of the punctuation model). However, the study period (3.5 to 8 Ma) had sampling horizons separated by intervals running from 20,000 to a *million* years, thus not ruling out more gradual intermediate change were the record less coarsely graded.

Punctuated equilibrium also plays its part at the bacterial level, as Gould (2002, 808-810, 931-935) noted of Lenski & Travisano (1994), Elena *et al.* (1996) with commentary by Mlot (1996), and Papadopoulos *et al.* (1999).

[154] Doyle & Lowry (1996, 86-87). The Miocene Period ran from 23 Ma to 5 Ma.

[155] Doyle & Lowry (1996, 84). Figure 4.7 tracked one species of *Globigerinoides*, followed by three transitional species of *Praeorbulina*, and concluding with two species of *Orbulina*. The main morphological change involved a shift from a clustered group of spheres to a single round shape, Doyle & Lowry (1996, 283).

[156] Right about this time Michael Denton and Michael Behe were burnishing Johnson's reputation on the dust jacket of *Objections Sustained*. Denton declared that "Professor Johnson combines a broad knowledge of biology with the incisive logic of a leading legal scholar to deliver a brilliant and devastating attack on the whole edifice of Darwinian belief." And Behe hailed Johnson as "our age's clearest thinker on the issue of evolution and its impact on society." Two years after reading of *Orbulina*, Johnson replied to a questioner on Hank Hanegraaff's "Bible Answer Man" show (December 2000) that marine invertebrates showed only "change within the type, there's no change of one thing step by step into something completely different." What Johnson was expecting to see within the available time frame in those "lots and lots of fossils" Hanegraaff did not ask.

[157] Tudge (1996, 102-106) explained how population size figures in the pace of evolution, where genetic factors slow down the rate of allele flow in those large populations most likely to show up in the fossil record.

[158] See Gould (1989, 224) for distribution of the Cambrian examples, and Levinton (1992) on how preservation rates affected understanding of the Cambrian Explosion. Similarly, the paleoecological analysis of Gaines & Droser (2003) on *Elrathia* (note 33 of the Introduction) noted that it was "the most familiar and abundant trilobite in North America, but it occurs at only a few localities in the Middle Cambrian Wheeler Formation of Utah."

Emiliani (1992, 444) characterized the Cambrian by the appearance of 10 major phyletic players. Then as now, the arthropods played a significant role, along with mollusks, brachiopods, echinoderms, and hemichordates; as well as the protoctist foramanifera and radiolaria (both microscopic marine plankton). The extinct archaeocyathans were early coral-like animals whose secreted casings looked like nested ice cream cones, the hyolithans were early beardworms, and the extinct conodonts we now know to be primitive chordates.

[159] Such slices of oceanic crust beached on land are called "ophiolites." Not all are found at high altitude, though—San Francisco Bay and Puget Sound are cluttered with pieces of islands and ocean snagged on the continental margin by plate movement. See Jon Erickson (1996, 50) for worldwide ophiolite distribution.

[160] Lambert & The Diagram Group (1988, 184-191), Dalrymple (1991, 127) and Jon Erickson (2000, 7, 195) map an assortment of Precambrian deposits. See Dalziel (1995), Jon Erickson (1996, 9-13; 2000, 13-14), McMenamin (1998, 176-185), Karlstrom *et al.* (2000), J. Murphy *et al.* (2000), Hartz & Torsvik (2002), Powell & Pisarevsky (2002), Harlan *et al.* (2003) and Torsvik (2003) on the developing picture of Rodinia and Precambrian continental drift.

[161] Conway Morris (1998a, 118).

[162] Lambert & The Diagram Group (1990, 222) show the global distribution of all Mesozoic deposits, which are concentrated primarily in the western United States, and David B. Weishampel, "Dinosaur Distributions," in Weishampel *et al*. (1990, 63-139) provide a comprehensive survey (a source available to Duane Gish). The main vertebrate-bearing Mesozoic deposits in Colbert & Morales (1991, 211-212) show none in North America for the middle of the Triassic (representing about 10 Ma not available)—and only six major sites cover Asia for the entire Triassic. Christine Janis, "Victors by Default" in Gould (1993, 174) pointed out the dearth of Triassic sites when trying to work out the early evolutionary history of the monotreme mammals.

[163] Concerning fish evolution, cf. Morris (1985, 82), Wendell Bird (1989, Vol. 1, 213-214) and Duane Gish (1978, 75; 1995, 81) with Lambert & The Diagram Group (1985, 78), Stahl (1985, 145-146, 176-177, 213-221). Colbert & Morales (1991, 76) list few relevant Ordovician and Silurian deposits, with the situation improving with the Devonian (when the fish classes duly show up "fully formed"). Or the Mesozoic pterosaurs and marine reptiles as described by Denton (1985, 167, 169), Gish (1995, 100-109) or Schroeder (1997, 30-31) may be contrasted with the criticism of McGowan (1984, 158-160) and Strahler (1987, 430-433). On the technical side, McGowan (1991, 232-235), Motani *et al.* (1996), Chris McGowan, "A Transitional Ichthyosaur Fauna," Olivier Rieppel, "Introduction," and Robert L. Carroll, "Mesozoic Marine Reptiles as Models of Long-Term, Large-Scale Evolutionary Phenomena," in Callaway & Nicholls (1997, 61-78, 107-119, 468-473), and Motani (2000). See Wellnhofer (1991, 40-45, 60-64, 85-86), Kevin Padian, "Pterosauromorpha," in Currie & Padian (1997, 617-618), or Monastersky (2001) on pterosaurs.

Spencer G. Lucas, "Marine Reptiles and Mesozoic Biochronology," in Callaway & Nicholls (1997, 427): "Restricted geographic distribution is the single greatest problem facing those who will use the marine reptile record for Mesozoic biochronology. Most marine reptiles lived in both epeiric seas and oceanic basins, or at least some must have crossed those basins. Yet, most of the marine rock record exposed on the continents is that of relatively shallow epeiric seas, not of abyssal oceanic sediments. This means a relatively high percentage of marine reptile fossils will never be found. For the Mesozoic prior to the Middle Jurassic, subduction has eliminated virtually all the oceanic crust, and during this interval epeiric seas were at a minimum during the Pangaean lowstand. Therefore, the Triassic and Early Jurassic record of marine reptiles must be less complete than that of the later Mesozoic." Michael Benton, "Four Feet on the Ground," in Gould (1993, 112) similarly noted that "nowhere in the world do ocean crusts predate the mid-Jurassic."

[164] Gish (1995, 122). Drawing extensively on Answers in Genesis and the ICR, Charles Creager Jr. (genesismission.4t.com/transition/reptiles-mammals.htm) questioned why there "are no references to fossils from the mid Cretaceous" and posed: "Could it be that relevant fossils that are classified as the mid Cretaceous didn't fit their evolutionary assumptions?" Creager's degree is in physics from Bob Jones University.

Gish's evasive coverage of ceratopsid evolution may be compared to Glut (1982, 77, 172), Norman (1985, 131), Lambert & The Diagram Group (1990, 46, 77-78), Peter Dodson & Philip J. Currie, "Neoceratopsia," in Weishampel *et al.* (1990, 595, 598), or Czerkas & Czerkas (1991, 205). Gish could have known about much of the relevant information, having cited Dodson & Currie from Weishampel *et al.* (1990, 610) on a tactical point. Maps in Dodson (1996, 12, 207) indicate the pivotal ancestral taxa *Montanoceratops* and *Bagaceratops* are each known from only single horizons. The chart of main Asiatic Cretaceous sites in Colbert & Morales (1991, 211) shows nine for the Late Cretaceous, but only one for the Early Cretaceous.

[165] The exact mechanism accounting for the fine preservation of the Burgess Shale is still a matter of debate, as noted by Conway Morris (1998a, 15n). Rapid burial in a toxic environment ("depleted in oxygen and perhaps rich in hydrogen sulphide") clearly played a part, but there still would have been bacteria to decompose the carcasses. One possibility discussed by Conway Morris was that the particular clay disrupted the bacterial enzymatic processes.

[166] Gould (1989, 61). Briggs (1991), Doyle & Lowry (1996, 36-41), Sutcliffe *et al.* (1999) discuss prominent *Lagerstätten* and the circumstances of their formation. The glossary in Conway Morris (1998a, xvii) notes there are two classes of *Lagerstätten*: "conservation" (where fine detail is preserved, as in the Burgess Shale) and "concentration" (fossil graveyards, cave fissure fills, etc.) that provide broader samplings of ancient diversity.

[167] Doyle & Lowry (1996, 173).

[168] Gish (1993, 118-119; 1995, 67). Simpson (1949, 18) was quoted by Gish (1993, 117-118; 1995, 55, 66).

[169] Morris & Morris (1996b, 60-61). Their claim rested on a quote from paleontologist Derek Briggs (1991, 139): "From the beginning of the Cambrian the number of known sites displaying significant soft-part preservation exceeds 60, and for each of these major sites there are many minor ones." Unfortunately for the Morrises' gloss, that "60" referred to all the prime sites covering the half billion years *from the Cambrian on*, as a chart in Briggs (1991, 132) made plain. Briggs highlighted only *six* major deposits for the Cambrian proper (four in North America, and two others in Australia and China). Briggs (1991, 140) noted that "at least another 27 sites also yield some Burgess shale taxa"—but one should take care to reflect on that use of "some."

[170] Wells (2000a, 38-39). The concept of *Lagerstätten* also failed to make it into the brief Cambrian jab in Schroeder (2001, 120-121).

[171] Wells (2000a, 44-45), quoting Conway Morris (1998a, 2, 28) and Schopf (1994b, 376). Wells (2000a, 263, 270-271) was also familiar with Gould (1989) and Levinton (1992) who discussed the preservation issue (re note 158 above).

[172] Schopf (1994b, 376-377). Special things can happen with bacteria when living in an environment free of competing predation, by the way, as the photosynthetic cyanobacteria once did for over two billion years. Growing into vast layer cake colonies many feet across, incorporating other prokaryotes (such as green and purple bacteria) in their own mini-ecology, these *stromatolites* spread across the seafloor like a forest of stone hassocks. That is, until around 800 Ma, when *something* happened to end their heyday. Today a few may be found in harsh niches (such as an especially saline bay in Australia) where potential grazers can't get at them—but these modern stromatolites are only a few inches wide. See Simpson (1983, 70-71), Gamlin & Vines (1986, 150-151), Margulis & Schwartz (1988, 48), Eldredge (1991a, 182-184), Rich *et al.* (1996, 82-91) and Conway Morris (1998a, 21, 25-26) for stromatolite descriptions and illustrations.

[173] Bengtson & Zhao (1997), Bengtson (1998), Xiao *et al.* (1998; 2000), Gould (1998a), Juan-yuan Chen *et al.* (2000), Zimmer (2001b, 96-97) and Knoll (2003, 146-149). Recently some of the mechanisms of phosphatization have been clarified by experimental mineralization of invertebrate eggs, Martin *et al.* (2003). Interestingly, the sponges (believed to be very ancient indeed) were especially difficult to isolate in the Precambrian, as noted by McMenamin (1998, 37-39)—though embryonic and tissue fossils from around 580 Ma have since turned up from China, Kerr (1998a) on Li *et al.* (1998). Mazumdar & Banerjee (1998) suggest the "rapid proliferation" of siliceous sponges in the Early Cambrian reflected a "major change in seawater chemistry due to advanced

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availability of nutrients, leading to progressive evolution of siliceous biological forms and phosphatic shelly faunas." See also note 178 below.

[174] Erwin & Davidson (2002, 3029) note that while a small bilaterian ancestor "could potentially be preserved and recovered in association with acritarchs [microscopic fossil cysts of uncertain affinity], the latter have a fairly tough coating, compared, for example, to those of delicate swimming marine larvae. Both acritarchs and algal remains are frequently recovered by acid maceration techniques that are likely to destroy fossils with less resistant coatings. The exquisitely preserved Doushantuo embryos demonstrate the atypical conditions required for preservation of material lacking a durable coating."

In an October 2001 class lecture on the Cambrian I attended at Whitworth College, Steve Meyer cited some of the phosphatization work much as Wells did Schopf, to suggest that metazoan ancestors would have been necessarily preserved had they existed.

[175] Conway Morris (1998a, 28). Cf. Fortey (2000b, 136-140), Schopf (2000), Parker (2003, 173) and Wright *et al.* (2003) on the limitations of fossil preservation (such as sand grain size re Ediacaran specimens). Holland & Patzkowsky (1999) describe how such factors affect computer modeling of fossil diversity, and Kempe *et al.* (2002) note new microscopy techniques being applied to microfossil analysis.

[176] Preservation of many of the Ediacara may have been due to their being sand-filled in life, prompting Jerzy Dzik (1999) to argue that "The rise and fall of the Ediacaran faunas thus seems to be partially preservational artifacts. The range of its occurrence is a result of two successive evolutionary events: the origin of an internal hydraulic skeleton enclosed by a strong basement membrane, and the appearance of decomposers with abilities to disintegrate such collagenous sheaths."

[177] See McMenamin (1998, 258-261) or Parker (2003, 250-254) on the predatory interpretation of the Cambrian Explosion, Nedin (1999) on the specific case of *Anomalocaris*, and Hickman (2001) on the evolution of defensive shell development among gastropods.

[178] Gould (1989, 59-60). Norman (1994, 38-40) described early interpretations of the "small shelly fauna." Palmer (1999, 58-61) illustrates early Cambrian life, and further pictures are available at palaeos.com/Paleozoic/Cambrian/Tommotian.htm. Kouchinsky *et al.* (1999) note cnidarian embryos are associated with the first appearance of shelly fossils in Late Precambrian Siberia. The "fully biomineralized" remains of a meter-sized Proterozoic cnidarian (or poriferan) reef-hugger from around 549 Ma prompted Wood *et al.* (2002) to infer that "large, modular metazoans with biologically controlled mineralization appeared some 15 million years earlier than previously determined." Molecular evidence also suggests to Delgado *et al.* (2001) "that Late Proterozoic fossils possessing a mineralized tissue homologous to [vertebrate] enamel might be found in the future."

[179] The calcareous tubes of the sessile colonial coral-like Ediacaran *Cloudina* show tiny bore holes suggesting an otherwise unknown predator. Conway Morris (1998a, 154) and Parker (2003, 256-257) advance the predatory view (Parker spelling the taxon as "Claudina" by the way), while McMenamin (1998, 164) favors the contrary. Dzik (1994) suggests the "small shelly fossils" environment was disrupted by "the evolutionary diversification and ecologic expansion of infaunal detritus feeders."

[180] For his presentation of the creationist Cambrian mystery at the Whitworth "Creation Week," visiting lecturer Paul Chien (a biologist from the University of San Francisco) displayed a collection of Chinese specimens he had collected. Although one was a Tommotian shell, Chien did not call attention either to their pertinence regarding the preservation of early Cambrian life, nor allude to any of the proposed Precambrian ancestral candidates. Afterward I attempted to bring these matters up, but even then he wouldn't engage the data.

As for the YEC side, the 1974 edition of Gish's *Evolution: The Fossils Say NO!* flatly denied the existence of any Precambrian metazoans, noted by Futuyma (1982, 188) then Strahler (1987, 401-403). Whereupon Gish (1995, 55-59) revamped the text: (i) removing the obsolete statement, (ii) siphoning a misreading of Gould and others to declare the Precambrian fauna unrelated to later forms, then (iii) delicately cleaning up after himself by the refined revisionism of suggesting only

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evolutionists had been mistaken here. Nothing about the actual fauna attracted the Creation Scientist's attention.

[181] Wells (2000a, 38), quoting Conway Morris (1998a, 30).

[182] Norman (1994, 32-38) discusses various interpretations of the Ediacara biota, and why it is not easy to decide what was going on among organisms so unlike contemporary forms. McMenamin (1998) thinks most of the odder Ediacarans were unrelated to contemporary forms—cf. Walker (2003a, 257-258n). Monastersky (1998, 112-113) noted Seilacher's controversial take on the Ediacaran biota has modified through the years. For an online survey of the technical side of this debate, see peripatus.gen.nz/paleontology/Ediacara.html.

[183] Identifying trace fossils requires both skill and caution, as Seilacher *et al.* (2000) illustrate concerning a turbidity feature previously misidentified by paleontologist Preston Cloud. Trace fossils show a rise in complexity toward the end of the Precambrian, accompanied by an increase in the "bioturbation" of the seafloor sediments with which some of these metazoans would have interacted, Droser *et al.* (1999) and Jensen *et al.* (2000). Noting that the current conservative estimate for the appearance of bilaterian animals is about 550 Ma (roughly 15 Ma before the Cambrian), Droser *et al.* (2002) examine how the dynamics of sedimentation can effect the detection of trace fossils. For the early Cambrian, at least, fairly low sediment mixing increased "the likelihood of recording shallow-tier trace fossils in muddy sediments."

[184] Gould (1989, 312-313). The accumulation of information may be seen by comparing Norman (1994, 38), skeptical of Precambrian burrowing creatures, with Knoll (2003, 170-171). See Brasier (1998), Kerr (1998b,c) and Ellis (2001, 43-44) on the possible triploblastic trace fossils described by Seilacher *et al.* (1998), and Rasmussen & Bengtson *et al.* (2002) for more recent finds. Controversy attends Seilacher *et al.* because of uncertainty over the dating of the Vindhyan Supergroup formation in India. Crystals found in the rock date around 1600 Ma, Rasmussen & Bose *et al.* (2002) and Ray *et al.* (2002), while other fossils found there suggest a deposition about a billion years later (presumably incorporating the older crystals in the sediments). Discussions of the geological issues may be seen online at iisc.ernet.in/~currsci/dec25/articles9.htm and articles11.htm.

[185] Feder *et al.* (2003) note a million-year delay before a certain species of North American fruit fly used an ancestral shift in genetic material to adapt to a geographical adjustment in a host plant. Neanderthal mitochondrial DNA also appears to have diverged several hundred thousand years before morphologically distinct Neanderthals appear in the fossil record, per data in Krings *et al.* (1997; 1999). Cf. Knoll (2003, 200-204).

Natural variations in DNA (both nuclear and mitochondrial) are used to "date" divergence times for various organisms, but some caveats are in order. Coding for the amino acids that govern three-dimensional protein folding are the most revealing, for example, Balter (1997, 1034), but reversals at a given nucleotide locus can distort cladograms based on only a few variables, as Strauss (1999) cautioned regarding the mitochondrial "clock." It has also become clear that phylogenies based on a limited number of genes are less accurate than those incorporating a broader data set, Gee (2003) re Rokas *et al.* (2003). Cf. the antievolutionary spin Balter's report got by Hunter (2003, 57).

An obvious point that may get overlooked here: one way rough molecular dating of phylogenies might have favored Intelligent Design over evolution would have been if the genetic divergences were being clocked as taking place *after* their evident morphological packages had shown up in the fossil record. But as molecular clocks tend to overestimate phyletic branching rather than underestimating it, the molecular data so far fail to lend ID much support.

Recent papers on the big Deep Time phyletic split include Wray *et al.* (1996), Francisco José Ayala *et al.* (1998), Valentine *et al.* (1999), Medina *et al.* (2001), Erwin & Davidson (2002), Rodriguez-Trelles *et al.* (2002) and Benton & Ayala (2003). Wells (2000a, 46-48, 274-275) presents an ID spin on the three Wray, Ayala and Valentine papers. A comparison example: molecular data on fungi and green algae suggest those genes at least were differing as far back as a billion years, Pennisi (2001) re Heckman *et al.* (2001). This is some 250 Ma before their fossil appearance among land plants (cf. note 101 above). But it is debatable whether this translates into

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fungi and green algae appearing that far back as morphologically distinct forms, as other gene divergence times fall within the 425-490 Ma window, Sanderson (2003). Cf. also Pawlowski *et al.* (2003) using genetic data to infer "that a large radiation of nonfossilized unilocular [single-chambered] Foraminfera preceded the diversification of multilocular lineages during the Carboniferous."

[186] Based on an analysis of fourteen formations (including ten Early Cambrian and one Precambrian), Droser *et al.* (2002) concluded that in such settings, "even in the earliest Cambrian strata, trace fossils are relatively common." The Early Cambrian examples only extend a few centimeters into the sediment, however. "Animals that mix sediment, in general, do not leave well defined discrete trace fossils," but they do leave a homogenized layer in their wake—such deposits are virtually absent from the Early Cambrian. The absence of penetrating burrows until the Manakayan phase of the early Cambrian (see note 200, Chapter Three) suggested to Erwin (1999, 621) that animals lacked the internal coelom cavity required for such features. The situation changes for the Middle Cambrian, however, as burrows penetrate deeper in layers characterized by considerable mixing.

[187] Conway Morris (1998a, 141-142, 144).

[188] Conway Morris (1998a, 28-30)—see also McMenamin (1998, 207). Valentine *et al.* (1999, 854) classify *Dickinsonia* among the quilted Ediacaran biota, and Knoll (2003, 168-169) remains skeptical of its annelid affinity.

[189] Emiliani (1992, 432) indicated 68% of the Ediacara biota were apparently Cnidaria/Coelenterates (jellyfish, etc.), 22% annelid worms, and 10% unknowns; Doyle & Lowry (1996, 120) included also soft corals (pennatulaceans). See Palmer (1999, 54-57) for a recent illustration of the Vendian seaworld. The Precambrian distribution further suggests any potential arthropods among them were as peripheral as the chordates were to be in the Cambrian. But a rare Lower Cambrian English *Lagerstätten* has also revealed basal crustaceans that refresh the position that the "explosion" was less sudden than it appeared based on the available scattershot of *Lagerstätten*-class deposits, Fortey (2001) re Siveter *et al.* (2001). See also the exchange of technical caveats in the December 7, 2001 issue of *Science* (p. 2047) by Graham E. Budd, Nicholas J. Butterfield & Sören Jensen, with rejoinder by Dieter Waloszek, Mark Williams & Richard A. Fortey. Similarly, medusae are known occasionally to wash ashore in mass strandings, but fossil examples of this are exceedingly rare. Therefore the discovery of "hundreds of decimeter-sized impressions of medusae" in a Late Cambrian shoreline deposit in Wisconsin allows paleontologists to infer "that large soft-bodied pelagic organisms were abundant in Cambrian seas," Hagadorn *et al.* (2002).

[190] See note 173 above for references. Incidentally, Knoll & Carroll (1999, 2130) noted embryos resembling the egg case ornamentation and odd cleavage geometry of arthropods, but these could be due to other metazoan sources.

[191] See McMenamin (1998, 32-37, 146-147) on the pros and cons of *Dickinsonia* and *Spriggina* in relation to annelids and arthropods (also note 188 above). Doyle & Lowry (1996, 231) compared Cambrian trilobites to *Spriggina*, while Norman (1994, 36) noted Seilacher's contrary interpretation of it as a sessile filter feeder, with its "head" actually an anchoring foot. The rare Russian Ediacaran *Bomakellia* may also be related to the arthropods, though on the basis of the present fragmentary evidence McMenamin is unconvinced. A half-inch-long Ediacaran "prototrilobite" pictured in Monastersky (1998, 105) may represent an eyeless grazing ancestor to the hard-shelled Cambrian trilobites, Parker (2003, 257-259).

[192] Briggs *et al.* (1992) and Gee (1992)—cf. Peter Ward (1994, 21), Conway Morris (1998a, 207), Jablonski (1999, 2116) and Ward & Brownlee (2002, 18, 40-42) on post-Cambrian diversification. On this topic, Frank Sonleitner called my attention to how DeHann & Wiester (1999) had given a figure of 50 animal phyla originating in the Cambrian. As seen from the dates of the technical literature just cited, the creationists had apparently relied too heavily on early preliminary reactions to the fossils from the 1970s and '80s rather than subsequent analyses.

On a related matter, Phillip Johnson missed the gist of Gould's comment on the "cone of increasing diversity." Gould (1989, 46-49) stressed that while the *disparity* of life has dropped, its

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diversity has increased: ever more variation on the few surviving body plans. Though qualified demurs may be found in Wills & Fortey (2000, 1148-1150), and Newman (2001) re the extensive new catalog of Alroy *et al.* (2001), Kerr (2003a) notes the general pattern of increasing diversity still holds per Jablonski *et al.* (2003). Cf. also the charts of rising numbers of families in Benton (2003, 129, 131), and Andrew Smith (2003) on Crampton *et al.* (2003). Vertebrates highlight Gould's point: swimmers from hammerhead sharks to blue whales; three independent fliers (pterosaurs, birds and bats); and that frisky primate clan (even if some of its present members do have difficulty comprehending subtle distinctions).

[193] Chen *et al.* (1994), with partial demurs by Briggs (1994), and further remarks by Conway Morris (1998a, 183-184), particularly focusing on the presence of lobopods (tube-like walking appendages) versus jointed legs, and specialized characters like tail fans. Parker (2003, 78-79) noted newer fossil finds suggest the curious *Hallucigenia* and *Microdictyon* were velvet worms.

[194] Norman (1994, 40), Conway Morris (1998a, 185-194). Conway Morris suggests a halkieriid-like form could have shortened until the two shells drew together, though he cautioned that the origin of the distinctive brachiopod tenticular lophophore filter feeding mechanism remains unresolved. Bryozoans have a similar, but evidently unrelated feature, as noted by Margulis & Schwartz (1988, 211). Conway Morris (1998b) got into a feisty debate with Gould (1998b) in *Natural History*, wrestling over the halkieriid-brachiopod connection en route. Cf. Ellis (2001. 31-44). Fortey (2000b, 142-145) thought Conway Morris (1998a) had gone over the top on Gould: "I have never encountered such spleen in a book by a professional; I was taken aback." Apparently adding fuel to the heat of the exchange with the materialist Gould was Conway Morris' own firm Christian convictions, Witham (2003, 179-182). The Conway Morris/Gould tiff might have joined the pantheon already occupied by the celebrated Cope/Marsh "dinosaur wars" at the turn of the century, noted by Fastovsky & Weishampel (1996, 124-125) and Hellman (1998, 121-140). But Gould's death terminated his end of the seesaw, leaving the quite temperate Gould (2002, 1159) as his final word.

Notes to *Chapter 3* (Patterns of Change)

[195] See Kaufman (1997), Kaufman *et al.* (1997), Kennedy *et al.* (1998; 2001a), Hoffman & Schrag (2000), Ward & Brownlee (2000, 102-155), Sarah Simpson (2001), Condon *et al.* (2002), Leather *et al.* (2002), Lubick (2002), Knoll (2003, 206-215), Poulsen (2003), Gabrielle Walker (2003a,b) on the developing "snowball earth" scenario and assessments of its severity. Jon Erickson (1991, 124) illustrates the Precambrian glacial distribution on the continents as presently located. Runnegar (2000) re Hyde *et al.* (2000) suggest patches of open equatorial water provided refuges for developing early aquatic life—cf. Corsetti *et al.* (2003) on a persistent Neoproterozoic microbiota. The Precambrian carbon cycle appears also to have been more sensitive to loss of shallow-water environments, as planktic calcifiers had not yet evolved, Archer (2003) re Ridgwell *et al.* (2003).

The Paleozoic climate shift has prompted much speculation, including Joseph Kirschvink of Cal Tech on a possible 90-degree slide of the earth's surface relative to the rotational axis during the Cambrian, Kirschvink *et al.* (1997). For comparison, YEC geology can accept an ice age occurring during the tumult following the Flood, but not a plethora of earlier glaciation indicative of extended time frames—see, for example, the cavils of Hughes (1979).

[196] Charts noting Ediacaran diversity appear in Grotzinger *et al.* (1995, 603) and Knoll & Carroll (1999, 2131). The largest known Ediacaran frond (*Charnia*) grew nearly 2 meters in length, and in various species appears to have persisted over as much as 30 Ma (between 595 and 565 Ma), Narbonne & Gehling (2003). McMenamin (1998) favors the symbiotic model for much of Ediacaran life. Steiner & Reitner (2001) argue that some Ediacaran biota were colonial prokaryotes rather than individual organisms. The overlapping tiers of Ediacarans is consistent with their being primarily suspension feeders, Clapham & Narbonne (2002). Such tiering turnover appears to have been at work throughout the Cambrian, triggering "a cascade of ecological

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evolution, including the rise of bilaterian animals in high-tiering levels during the Ordovician radiation of the Paleozoic fauna," Yuan *et al.* (2002).

Based on the prevalence of distinctive cap carbonate deposits during this period, Kennedy *et al.* (2001b) "infer that during times of low-latitude glaciation, characteristic of the Neoproterozoic, gas hydrates may have been in greater abundance than at any other time in Earth history." The Ediacaran heyday may have been related to such shifts in ocean chemistry, or even have contributed to that chemistry via a feedback loop unidentifiable in the fossils themselves.

[197] See Fenchel & Finlay (1994) on the triggering role of oxygen, and Parker (2003) on the vision angle. Changes in trace mineral circulation in the Proterozoic ocean may also have facilitated the biological nitrogen cycle, Kerr (2002b) re Anbar & Knoll (2002). See Emiliani (1992, 413-445), Doyle & Lowry (1996, 121-124, 375-379), McMenamin (1998), Schopf (1999, 252-265), Knoll & Carroll (1999, 2135), and Eldredge (2000, 42-47) on Precambrian paleoecology.

[198] The change to a mass extinction view of the Precambrian was underway by Simpson (1983, 139), with Gould (1998a, 65) or Kerr (2002c) as recent expositions. For contrast, other than a single sentence mentioning the possibility of a "previously unrecognized" Precambrian mass extinction, Gish (1995, 56) thought no more about it.

Grey *et al.* (2003) note the Acraman bolide impact (c. 580 Ma) may have contributed to a mass extinction event. Incidentally, the apparent disappearance of reef communities of *Cloudina* figures in calibrating the Precambrian turnover because of what it tells about shift in ocean chemistry, such as the fact that their preservation "is best in limestone, and the shells are mostly obliterated where the carbonate is dolomitized," Hofmann & Mountjoy (2001). The oceanic anoxia separating the siliciclastic-dominated Precambrian to the carbonate-dominated Cambrian is consistent with a mass extinction event, Corsetti & Hagadorn (2000), and the disappearance of *Cloudina* and other fauna around 542 Ma "strengthen hypothesis invoking mass extinction within terminal Proterozoic ecosystems," Amthor *et al.* (2003). Similarly, rising sea levels and alteration of "thermocline and shelf geometry" appear to have played a part in the "recurrent extinctions of shallow-shelf communities throughout the Late Cambrian," Perfetta *et al.* (1999).

[199] A sample of mass extinction views: Gore (1989), Eldredge (1991b), Jon Erickson (1991), Raup (1991), Whitfield (1993, 182-187), Glen (1994), Peter Ward (1994; 2000), Palmer (1999, 90-91, 126-129, 196-197), Ward & Brownlee (2000, 157-188), Gibbs (2001), Jablonski (2001), Kerr (2001), Zimmer (2001c, 143-186) and Becker (2002). Finney *et al.* (1999) and Murphy *et al.* (2000) explore the special qualities of the Ordovician and Devonian events—cf. Ellwood *et al.* (2003; 2004) *contra* Racki & Koeberl (2004) on the latter event. Erwin (1996), Hoffmann (2000) and Benton (2003) cover the intense Permian crash that decimated even the usually imperturbable insects, and Quigg *et al.* (2003) suggest how subsequent "changes in ocean redox state strongly influenced the evolution and selection of eukaryotic phytoplankton since the Proterozoic era."

There is probably no single cause for a mass extinction. Least likely is Raup and Sepkoski's iffy "Nemesis star" theory that the sun has a dark stellar companion that periodically orbits dangerously close—see Robert Ehrlich (2001, 102-121) or Benton (2003, 138-140) for critical comment. Parker (2003, 293-295) notes arguments relating mass extinctions to the solar system's movement in and out of dust-laden spiral arms. Asteroid impacts are the hot catastrophic contender, particularly for the K-T event that correlates with the giant Chicxulub crater on the Yucatan peninsula, Carlisle (1995)—and contributed a nice oil reserve, Nishimura *et al.* (2000). Dingus & Rowe (1998, 11-104), Courtillot (1999, 119-134) and Lubick (2001) place this in the larger context of the many competing theories. Just how physically severe the K-T fireball was remains a point of dispute, Belcher *et al.* (2003). A possible terminal Triassic impact event, Walkden *et al.* (2002), may have contributed to the rise of dinosaurs, as covered by Kerr (2002a) and Thulborn (2003) re Olsen *et al.* (2002; 2003), and again by Kerr (2003b) on Basu *et al.* (2003).

Another serious culprit (especially if coinciding with a major impact) may be magmatic plume breaches. Spun off by plate subduction, these normally spawn volcanic chains like the Cascades or Hawaiian Islands. But three of the big five mass extinctions are associated with extensive volcanism: the Siberian Traps in the Permian, the Central Atlantic Magmatic Province for the Triassic, and the Deccan Traps of India at the end of the Cretaceous. For views pro and con, see

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Malcolm W. Browne, "New Clues to Agent of Life's Worse Extinction," in Wade (1998, 73-79), Courtillot (1999), Olsen (1999) re Marzoli *et al.* (1999), and Kerr (2003c) on Ravizza & Peucker-Ehrenbrink (2003). Volcanic gas emissions (notably carbon dioxide and sulfur, but also chlorine and fluorine) have been implicated in the collapse of marine ecosystems, Malcolm W. Browne, "Mass Extinction of Permian Era Linked to Gas," in Wade (1998, 80-85). The global warming effect of increased volcanism is suggested by plant turnover at the Triassic-Jurassic boundary, McElwain *et al.* (1999), and Benton (2003) sees a global warming plunge in oxygen levels during the Permian as a major factor in that mass extinction.

These flash points aside, about 95% of all extinctions occur as a sort of natural background level, Raup (1994, 6760). Fastovsky & Weishampel (1996, 388-390) note, though, there appears to be a general *decline* in this background rate at the *family* level—all the more interesting, given the increasingly sparse nature of the fossil record the farther back in time one samples.

[200] The delayed character of the Cambrian fuse is indicated also by the fact that the Cambrian did not actually start with the Tommotian. The Cambrian period began about 544 Ma with an even earlier phase called the Manakayan (also spelled *Manykaian*) which lasted some 14 Ma. The progress of paleontology is indicated by Gould (1994a, 17), who noted that it contained only the most fragmentary of fossil examples, to Erwin (1999, 622) indicating Tommotian taxa (molluscs, brachiopods and echinoderms) trace back some 15 Ma into the Manakayan. There are also arthropod trace fossils from some Ecdysozoan (cf. note 216 below).

[201] Benton (2003, 153). The K-T extinction offers a useful measuring stick, where the earliest mammals found after the crash are the least like contemporary models, and the rebound was slow (25 Ma for the Carnivora to achieve dominance, for instance) and circuitous, Christine Janis, "Victors by Default," in Gould (1993, 170-185, 194). See also Erwin (1998; 2001) and Jablonski (1998). Interestingly, Miller & Foote (2003) note that marine taxa surviving mass extinctions "were unusually long-lived geologically"—though "this effect was limited to the post-Paleozoic, suggesting differences in the dynamics of Paleozoic versus post-Paleozoic diversification." Cf. Prokoph *et al.* (2000) identifying periodic patterns to the evolution of planktic foraminifera following mass extinctions.

[202] Miller (1999, 102) hit on the same analogy from another direction, with a zoo's "lion and the lamb" exhibit requiring a continual supply of replacement lambs. Johnson's misunderstanding of the extinction debate has been of long standing. Johnson (1991, 57): "A record of extinction dominated by global catastrophes, in which the difference between survival and extinction may have been arbitrary, is as disappointing to Darwinist expectations as a record of sudden appearance followed by stasis." He stressed this supposedly anti-Darwinian extinction in a 1994 Stanford debate with William Provine (available at arn.org), recommending David Raup of the University of Chicago as his scientific source. By Johnson (1995, 83) this had hardened (without references) into: "many authorities now attribute extinctions primarily to freakish catastrophes, rather than to the hypothetical Darwinian process by which ancestors are supposedly being supplanted continually by better-adapted descendants." Johnson repeated his claim on Hank Hanegraaff's "Bible Answer Man" show in December 2000 that "the dinosaurs, and indeed perhaps all extinctions, were brought about by catastrophic event."

But just because there were severe dieoffs didn't mean a lot of gradual "Darwinian" extinction hadn't been going on the remaining 95% of the time. And Johnson could have been aware of this, having reviewed Raup (1991) for *The Atlantic* (February 1992), reprinted in Johnson (1998a, 41-47). It was Raup who pioneered the notion of "background extinction rates," and the mass extinction graph in Raup (1991, 80-85) offered a clue that not everything was necessarily taking place at the clusters—cf. Peter Ward (2000, 265) and note 199 above.

[203] A range of DNA coverage may be found in Futuyma (1982, 136-141), Gamlin & Vines (1986, 24-25, 28-30), Edey & Johanson (1989), Benjamin Lewin (1994, 100-106, 149-155, 202-225, 711-717), Li (1997), Huynen & Bork (1998), Rutherford (2000), Yanai *et al.* (2001), Theißen (2002) and Watson & Berry (2003). Viruses and bacteria can trade genes directly without sexual reproduction, Whitfield (1993, 188-191).

Kitcher (1982, 97) noted the frequent creationist "charge that mutations are rare depends on confusing the mutation rate per locus (of the order of 1 mutation per 100,000 loci) with the rate per zygote [fertilized egg] (of the order of 1 mutation per zygote) or the rate per population (of the order of 1 billion per population)." Yeast DNA (where most genes are functional) is especially resilient: 70% of experimental random insertions had no overt effect at all, Lewin (1994, 707). Cf. Li (1997, 177-196), Yang & Nielsen (2000), Kumar & Subramanian (2002), Itoh *et al.* (2002) and Forster *et al.* (2002) on mutation rates and site sensitivity.

[204] Morris & Parker (1987, 150). By himself, Henry Morris (1985, 72-73) didn't get so far as Parker in recognizing just what the replication process actually does with DNA.

[205] Gould (1983, 187-198) and Dawkins (1986, 230-231), works cited on other matters by Johnson (1991, 164-165, 172). Watson & Berry (2003, 224-227) note the considerable amount of research effort required to discover such mutations.

[206] See Whitfield (1993, 192-193), Krumlauf (1994), Benjamin Lewin (1994, 1173-1178), McGinnis & Kuziora (1994), Gould (1994e; 2002a, 1095-1155), Lumsden & Krumlauf (1996), Müller (1996, 206-216, 243), Li (1997, 292-297), Axel Meyer (1998), Coen (1999, 101-130), Maynard Smith & Szathmáry (1999, 120-122), Schwartz (1999, 33-38, 338-377), Carroll (2000), Duboule (2000) on Greer *et al.* (2000), Mayr (2001a, 108-112), Wray (2001), Panganiban & Rubenstein (2002), and Wagner *et al.* (2003).

[207] Gamlin & Vines (1986, 168): "The 60-amino-acid protein chain that the homeobox produces differs by only one amino acid between the fruit fly and the frog *Xenopus*. This extremely small degree of difference in the amino acid sequence is a clear indication that the protein is of critical importance in the developmental process." Wada *et al.* (1998), Murakami *et al.* (2001) and Kudoh & Dawid (2001) illustrate regulatory genes as developmental guides rather than explicit blueprints, such as Irx4 re chicken and mammal hearts. "The roles that Irx4 plays in regional specification within the heart tube is reminiscent of the functions of other *Iroquois* family members in regionalization of the *Drosophila* wing discs, eye disc, and neural precursor domain in *Xenopus*," Bao *et al.* (1999, 1163).

Beyond the considerable challenge of identifying which genes are involved in these processes, there is still the matter of figuring out why and how they do what they do. The preliminary character of work in this area is reflected in Fisher & Méchali (2003). Cf. Arias (1994) re Warren *et al.* (1994), Stauber *et al.* (2000; 2002) on insects, J. Chen *et al.* (1997) or Tsiantis (2001) re plants, Stollewerk *et al.* (2003) on the role of *Notch* in vertebrate and arthropod segmentation, Bayarsaihan *et al.* (2003) on the vertebrate-specific hox variant *Homez,* and Anand *et al.* (2003) on *Hoxc8* divergences in fish and mammals.

[208] Morris & Morris (1996b, 241)—cf. the rarified assessment of Paul Taylor (1995, 30-31, 85-87).

[209] Mayr (1991, 158, 181) highlighted *homeobox* and included it in his glossary of evolutionary terms—the revised edition of Johnson (1993b, 208) cited Mayr's book on another matter (cf. Schroeder and Lapin on Mayr, note 142 above). Johnson (1998a, 57-66) criticized Daniel Dennett's *Darwin's Dangerous Idea* on issues other than the allusion to homeobox in Dennett (1995, 353). Johnson (1998a, 54-56) cited Behe on his biochemical challenge to Darwinism. Sounding like Gary Parker from a decade earlier, Behe (1996, 40-41) had dismissed the *antennapedia* mutation as too trivial a change to bother with, without connecting it to the by then extensive literature on homeobox (notes 206-207 above). One may contrast biochemist Behe's response time here with how quickly Gould (1994e) picked up on the implications of homeotic genes.

[210] Moreland & Reynolds (1999) fielded philosophers Reynolds and Paul Nelson (of the Discovery Institute) for the YEC position, Bible scholar Robert C. Newman for the OEC side, and physicist Howard Van Till for Theistic Evolution (or as Van Till insists on describing it: "Fully-Gifted Creation"). Commentary was by Phillip Johnson, engineers Walter Bradley and Richard Bube, theologians Moreland, Vern Sheridan Poythress and John Jefferson Davis.

[211] Dembski (1999, 174-183) offered a generalized account of genetics, but missed homeobox there and in Dembski (2002a)—though Conway Morris did arise peripherally in Dembski (2002a, 376-377n). Wells (2000a, 73-77) touched on developmental genes only insofar as they play multiple

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roles in varied structures—thus supposedly refuting the general concept of homology (physical structures inherited from a common ancestor). The issue is of course whether developmental complexes might be retained just as well, even when eventually manifested in non-homologous structures. Thus concerning Laufer *et al.* (1997) and Rodriguez-Esteban *et al.* (1997), two sources cursorily referenced by Wells (2000a, 284), Gaunt (1997) noted that "the whole of this signalling pathway may be largely conserved between insects and vertebrates." See also notes 214 & 254 below. Although the term never appeared in Wells' main text, it did arise *en passant* when Wells (2000a, 41, 272) extracted a quote on the abrupt appearance of Cambrian phyla from "Jeffrey H. Schwartz, 'Homeobox Genes, Fossils, and the Origin of Species,' *Anatomical Record (New Anatomist)* 257 (1999), pp. 15-31." Cf. Conway Morris (1998a, 148-151; 2000b).

[212] Johnson (2000, 141-142).

[213] Avise (1998, 230n).

[214] Mark Ridley (1997, 262-268, 319-326) included Slack *et al.* (1993) and Wray *et al.* (1996) in the Oxford Reader series. See also Kenyon (1994), Valentine (1994), Carroll (1995), Erwin *et al.* (1997, 135-136), Panganiban *et al.* (1997), Maynard Smith (1998), Erwin (1999), Knoll & Carroll (1999), Schwartz (1999), Valentine *et al.* (1999), Damen *et al.* (2000), Peterson & Davidson (2000), Shimeld & Holland (2000), Wills & Fortey (2000), Holland & Chen (2001), Kollmar *et al.* (2001), Zimmer (2001c, 117-128), Gould (2002, 1155-1173), Newman & Müller (2002), Schierwater & Desalle (2002), and Knoll (2003, 193-199).

In the course of his dismissal of evolutionary relationships Wells (2000a, 274, 284, 291) cited the Wray, Panganiban and Slack papers. Here is Wells (2000a, 76) parsing Panganiban: "In all these animals [annelids, arthropods, echinoderms, onychophorans and vertebrates] *Distal-less* is involved in the development of appendages, yet the appendages of these five groups of animals are not structurally or evolutionarily homologous. 'These similarities are puzzling,' noted the biologists who reported them in 1997, because the 'appendages have such vastly different anatomies and evolutionary histories.'" What Wells did not include was their conclusion: "The most straightforward explanation for these observations is that the last common ancestor of the protostomes and deuterostomes had some primitive type of body wall outgrowth, e.g., a sensory or perhaps a simple locomotary appendage, and that the genetic circuitry governing the outgrowth of this structure was deployed at new sites many times during evolution." See note 216 below for more on the protostome/deuterostome matter.

[215] McMenamin (1998, 226-235). Cf. Thomas *et al.* (2000) on the theoretical dynamics of "Skeleton Space."

[216] Berra (1990, 80-81); the boldface highlighted key concepts. The Protostomia/Deuterostomia split is revealed at the embryonic level in cell cleavage, Gamlin & Vines (1986, 88-89), Müller (1996, 14), Raff (1996, 38-47) or Mayr (2001a, 50-57). While the protostomes follow a distinctive spiral cleavage sequence, the deuterostomes proceed radially, consistent with a very early separation for the genetic coding defining these two divergent developmental pathways. See Shankland & Seaver (2000) and Irvine & Martindale (2001) on annelid Hox expression re spiral cleavage. Valentine (1997) considers deuterostomy the ancestral bilaterian condition, with radial cleavage part of that developmental process—though cf. de Rosa (2001, 855). In turn, Halanych & Passamaneck (2001) discuss the hypothesis that the "protostomes" may represent two separate lineages: the Ecdysozoans representing such species-prolific groups as nematodes and arthropods, and the Lophotrochozoans (such as annelids, mollusks, and lophophorates). Primitive chordate relations like tunicates follow bilateral cleavage; other deuterostomes undergo further embryonic divergence (such as distinctive rotational twists in mammals).

[217] Wray & Raff (1998), Martinez *et al.* (1999), Arenas-Mena *et al.* (2000), Cameron *et al.* (2000), and Ferkowicz & Raff (2001). Lowe & Wray (1997) and Hinman *et al.* (2003) investigate the regulatory genes conserved in echinoderms over the last 500 Ma, as well as some of the modifications to them that have contributed to their subsequent morphological diversity. Concerning Lowe & Wray's analysis, Richardson & Chipman (2003, 19) offered the broader theoretical observation that "even highly constrained systems can undergo radical alteration."

Regarding paleontological diversity, cf. Dominguez *et al.* (2002) on a curious gilled Carboniferous fossil.

In the "missing the forest for the trees" department, the obtuse Tom Bethell (2000) took issue with Eugenie Scott's remark "that embryos are more similar than the mature bodies" by noting that sea urchin embryos "vary dramatically, though their mature forms closely resemble one another." Bethell offered no citations. Similarly Wells (2000a, 291-292): "Recent embryological research on worms, insects, and sea urchins reveals many instances in which organisms in the same group differ more in the early stages of development than in later ones. Von Baer's laws [of conserved stages in embryonic growth] are no more true for invertebrates than for vertebrates. For example, see R. A. Raff, G. Wray, and J. J. Henry, 'Implications of radical evolutionary changes in early development for concepts of developmental constraint,' pp. 189-207 in L. Warren and H. Kopworski (editors), *New Perspectives in Evolution* (New York: Wiley-Liss, 1991)." One may note Wells' reliance on a 1991 resource here, rather than more recent work by some of the same authors reflecting improved understanding of the underlying genetic processes.

[218] As evidenced on the unapologetic YEC side: Henry Morris (1963; 1975; 1985), Chittick (1984), Morris & Parker (1987), Paul Taylor (1995), Morris & Morris (1996b), Gish (1978; 1990; 1993; 1995), Huse (1997), Muncaster (1997) and Hanegraaff (1998). Likewise Hayward (1985), Wendell Bird (1989), Davis & Kenyon (1993), Ross (1994; 1995; 1996; 1998), Milton (1997), Lambier & Stevenson (1997), Schroeder (1997; 2001), Ankerberg & Weldon (1998) or Moreland & Reynolds (1999) straddling the Old Earth/Young Earth fence. Nor did Ratzsch (1996) allude to it when discussing creationist misunderstanding of evolutionary thinking. Over in Intelligent Design, the issue did not arise in Denton (1985; 1998), Johnson (1991; 1993b; 1995; 1997; 1998a; 2000), Moreland (1994), Behe (1996) or Dembski (1999; 2002). Wells (2000a, 51, 94-97) and Hunter (2001, 22) skated past the topic in near misses—both authors cited Berra (1990) on other matters, incidentally.

[219] McGowan (1984, 76).

[220] See McGowan (1984, 69-70). Ingram (1998, 67-76) describes *Volvox* (with its comparatively recent evolution, during the last 30 Ma), and Zimmer (2002a) relates it to the origin of multicellularity. Cf. Pfeiffer & Bonhoeffer (2003) re such work as Velicer *et al.* (1998). Concerning the slime molds, Gamlin & Vines (1986, 43) characterized their cooperative aspects as "one of the most remarkable phenomena of the natural world." On the taxonomy, Margulis & Schwartz (1988, 90-91, 110, 133) employ "Protoctista" rather than "Protista" re phyla Euglenophyta (some 800 species) and Chlorophyta (*Gonium* and *Volvox* among 7000 species). Margulis & Schwartz apropos Chlorophyta: "Most botanists agree that somewhere in this extremely diverse group lie the ancestors of the plants." They listed four phyla for the slime molds: the "cellular slime molds" (Acrasiomycota, covering two classes) described those alluded to by McGowan.

[221] Segel (2001, 3639), commenting on Marée & Hogeweg (2001), who modeled the *Dictyostelium* transformation process. See Brown & Firtel (1999) on the other genes, and Lynch & Conery (2003) for perspective on "novel substrates for the secondary evolution of phenotypic complexity by natural selection" generated by nonadaptive processes among prokaryotic organisms whose "enormous long-term effective population sizes" otherwise restricts their opportunities for complex evolution.

[222] Erwin & Davidson (2002). Ledent & Vervoort (2001, 767) note the "Urbilateria" would appear to have possessed homeobox genes (including at least seven *Hox* and several *Pax*), primary intercellular signaling pathways EGF, Hedgehog, Notch and TGF-B, and at least 35 *bHLH* genes generating the "basic Helix-Loop-Helix" proteins involved in cell determination, differentiation and growth. Thornton (2001) and subsequent experiment by Thornton *et al.* (2003) also suggest that steroid receptors "diversified from a primordial gene before the origin of bilaterally symmetric animals, and that this ancient receptor had estrogen receptor-like functionality." Cf. Shubin (2002) on limb patterning mechanisms and De Tomaso & Weissman (2004) on protochordate allorecognition. A related topic concerns Geoffroy St. Hilaire's 1822 suggestion that arthropods and chordates are structurally only inversions of the other's organization—an idea which has been

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revived now that the actual genetics is becoming known, Gould (2002, 1116-1122) re De Robertis & Sasai (1996), Bang *et al.* (2000) and Gerhart (2000).

[223] References re Ruth Dewel are given in the caption to Figure 25. For a competing interpretation, Dzik (2002) contends that the Precambrian "sea-pens" (such as *Thaumaptilon* and *Rangea*) do not reflect a colonial body plan, but more "probably sedentary ancestors of the ctenophores."

[224] Bapteste *et al.* (2002) suggest the amitochondriate protists *Mastigamoeba* and *Entamoeba* belong with *Dictyostelium* in a new Subphylum Conosa. Concerning how the various living eukaryotes may be related based on recent analysis of their ribosomal RNA, cf. the chart in Roger Lewin (1997, 67) with the more recent discussion by Barrier *et al.* (2001).

[225] A survey of the progress of the biological acceptance of the endosymbiotic theory may contrast Gamlin & Vines (1986, 156-158) with a listing of microbiology milestones in Tortora *et al.* (1995, 9) honoring Margulis under the year 1981 apropos the endosymbiotic "Origin of eucaryotic cells." See also de Duve (1995, 162-166; 1996), Stansfield *et al.* (1996, 361-365), Dawkins (1998, 225-231), Kurland & Andersson (2000), Mayr (2001a, 45-48), Zimmer (2001c, 111-115), Itoh *et al.* (2002), Ryan (2002), Palenik (2002) re Martin *et al.* (2002), and Knoll (2003, 123-137). Cyanobacteria appear also to have lent cellulose synthase to plants, Nobles *et al.* (2001). On a still deeper level, Gupta (1998), Martin & Müller (1998), Maynard Smith & Szathmáry (1999, 59-78), Margulis *et al.* (2000), Bell (2001), Hartman & Fedorov (2002), and Lurquin (2003, 141-151) explore the contenders for the endosymbiotic origin of eukaryotes.

[226] Behe (1996, 189) kept endosymbiosis at arm's length with this brief comment: "Symbiosis theory may have important points to make about the development of life on earth, but it cannot explain the ultimate origin of complex systems." Both Behe (1996, 26, 278n) and Johnson (1998a, 101-107; 2000, 72) have preferred to selectively invoke Margulis as an authority figure for her criticism of Dawkins-style Neo-Darwinism, drawing on Mann (1991) and Brockman (1995). Such takes may have led Witham (2003, 176) to paint Margulis' "symbiogenesis" as "a small chink in the neo-Darwinian armor." Wells' *Icons of Evolution* and Hunter's *Darwin's God* and *Darwin's Proof* skipped the subject of mitochondrial endosymbiosis altogether—cf. Henry Morris doing the same in "A House Divided" (BTG No. 134a, February 2000, at icr.org/pubs/btg-a/btg-134a.htm). Interestingly, Wells (2000a, 265) peripherally referenced Schwartz & Dayhoff (1978), though without noting its content, which included Schwartz & Dayhoff (1978, 398) explicitly noting how their preliminary analysis of genetic data lent support to the endosymbiotic origin of mitochondria and chloroplasts. Cornelius Hunter had to step over far more recent material, though, as both his books referenced Zimmer's 2001 work (see previous note for the Zimmer reference, and note 260 below in Chapter Four on Hunter's citation).

Farther afield, while Gordon Mills (1998) gymnastically mentioned mitochondria minus endosymbiosis, Dembski (1999, 176; 2002, 319) continues to dub symbiosis "speculative" without reference to any of its concrete examples, like mitochondria. The compartmentalized narrative in Bird (1989, Vol. 1, 100, 210) fielded both evasions, including a critical authority quote by Philip Whitfield—ironic given his impending agreement with the theory, Whitfield (1993, 28-29). The creationist school text *Of Pandas and People* (on which Behe and Mills served as advisors) did not allude to Margulis or symbiosis at all in the brief jabs at mitochondrial dating methods, Davis & Kenyon (1993, 111-112, 122). A creationist attempt to refute endosymbiosis theory (Don Batten's "Did cells acquire organelles such as mitochondria by gobbling up other cells?" at answersingenesis.org/docs2/4341_endosymbiont.asp) misrepresented Doolittle (2000, 94).

[227] The section on onychophorans in McGowan (1984. 73-74) cited p. 74 of the 1973 version of Gish's *Evolution? The Fossils Say No!* Cf. Gish (1978, 64). Denton (1985, 110) sidelined the onychophorans as "really a mosaic of characteristics drawn from the two distinct groups."

Kenneth Clarke (1973, 112-113, 172-173) started the evolutionary chain with the Early Cambrian onychophoran *Aysheaia*, which closely resembles a prototypical arthropod based on the anatomy of living insects. Thence to the early multilegged Myriapoda—and finally the first Monura insects in the Carboniferous (with vestigial legs behind their main six ones). Margulis & Schwartz (1988, 232) described the morphology linking the onychophorans to both annelid worms and arthropods. Cf. Jerzy Dzik, "Early diversification of organisms in the fossil record," in Pályi *et al.*

(2002, 219-248), noting along the way that "an almost complete transition from round worms to arthropods was documented with Cambrian fossils." For Clarke and Margulis & Schwartz, the interesting thing about modern onychophorans was how they had adapted to an exclusively terrestrial lifestyle (also a characteristic of adult insects and spiders).

Recent genetic studies have begun to work out the finer points of arthropod phylogeny. Mitochondrial DNA genes for ribosomal and transfer RNA (used in the construction of proteins) suggest insects and crustaceans are closely related, Roger Lewin (1997, 72), and Margulis & Schwartz (1998, 301) repositioned the onychophorans as "highly modified chelicerates or are related to chelicerates, crustaceans, and insects." Thomas (2003) re Nardi *et al.* (2003a,b) further indicate the primitive wingless springtails (Collembola) thought basal to insects may have diverged from the arthropod line prior to crustaceans, though not without methodological caveats by Delsuc *et al.* (2003). See also Abzhanov & Kaufman (1999a,b; 2000), Akam (2000) and Budd (2002) on insect developmental biology.

[228] The section on insects in Gish (1995, 69-73) touched the same points as Gish (1990, 55-56) had for the kids—cf. Morris & Morris (1996b, 117-119).

[229] In theory Gish (1993, 67-69, 108, 207; 1995, 26, 345) and Morris & Morris (1996b, 18, 118) could have known about the 1960s wasp-ant prediction via Futuyma (1982, 55), whose book they cited in other contexts—the same may be said for Johnson's *Darwin on Trial* and Hunter's *Darwin's God* and *Darwin's Proof*. Futuyma (1986, 341) illustrated *Sphecomyrma* as a textbook example, and the 1998 National Academy of Sciences evolution guidelines highlighted the prediction in Chapter 2 (the full text of which was available at this writing at nap.edu/readingroom/books/evolution98). Cf. Hölldobler & Wilson (1990, 23-27), Schultz (2000) on Grimaldi & Agosti (2000), and Henry Cooper (2001) on Mesozoic ant evolution. Hölldobler & Wilson's *The Ants* garnered a Pulitzer Prize for general nonfiction (noteworthy for a weighty 600-page technical read).

Denton (1985, 136) inadvertently stumbled over the *Sphecomyrma* issue when he affirmed: "But surely no purely random process of extinction would have eliminated so effectively all ancestral and transitional forms, all evidence of the trunk and branches of the supposed tree, and left all remaining groups: mammals, cats, flowering plants, birds, tortoises, vertebrates, molluscs, hymenoptera, fleas and so on, so isolated and related only in a strict sisterly sense." Fossil ancestors for mammals and birds were hardly imaginary, nor was *Sphecomyrma* (linking two of the Hymenoptera, the wasps and ants). And at the risk of sounding petty, I do have to wonder where and under what circumstances Denton would propose science recover an adequate fossil representation for *fleas*. Fleas do have "a questionable Cretaceous record in Australia," Rich *et al.* (1996, 235), but are otherwise no more likely to turn up in the available strata than any other soft-bodied animal of their miniscule size.

Incidentally, though not mentioned in *Evolution: The Fossils STILL Say NO!* Wilson did crop up once in Gish (1993, 145)—not regarding his entomology specialty, however, but only as ammunition in a political firefight over the claims of sociobiology. Wilson attributes Stephen Jay Gould's criticisms to Marxist ideology and prejudice—views reprised by Edward Wilson (1975, vi) in his preface to the 2000 reprint of *Sociobiology*. See Segerstråle (2000) for background on their extended infighting (cf. also note 51 of the Introduction). And just to complete a curious circle, Wilson's current status as ecological activist recently drew the interest of Tom Bethell in *The American Spectator*. Along the way, Bethell (2002, 55-56) blithely dismissed the significance of *Sphecomyrma* (which he didn't mention by name) as not being of much importance to the credibility of Darwinian processes.

[230] Marden & Kramer (1994) and Marden (1995), with commentary by Kaiser (1994), Heinrich (1996, 5-11) or Shipman (1998, 160-173). See Averof & Cohen (1997) on the genetic connection. Carroll *et al.* (1995) suggest wings developed outside the homeotic framework, only later coming under its regulation—cf. Gould (2002, 1165-1169), noting also Warren *et al.* (1994). Michael Thomas *et al.* (2000) relate the new findings to stonefly phylogeny. Re the fossil evidence, Tudge (2000, 289-290): "One ancient and extinct order, Palaeodictoptera, does have fixed lobes extending from the **nota** (the dorsal plates of the armour in each thoracic segment) that may be wing

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precursors"—Rich *et al*. (1996, 231-232) illustrates an example, *Stenodictya lobata*. Exactly how early winged insects appeared is unclear from the fragmentary evidence, but a recent reevaluation of a partial fossil (a mandible from 400 Mya Scotland) relates its features to derived insect characters, Engel & Grimaldi (2004).

Extant insects run the gamut from winged and partially winged forms to wingless ones—and even instances where wingless taxa have apparently been able to switch old programs back on to secondarily re-evolve wings, as Whiting *et al.* (2003) noted of stick insects. Two primary flight muscle systems are known in insects, nicely illustrated by Gamlin & Vines (1986, 205). The basic one in dragonflies moves the wings directly, while the musculature in later wasps, bees and beetles shifted to change the shape of the thorax instead, allowing faster wing beats. Kenneth Clarke (1973, 175-178, 218-224) represents the thinking of a generation ago, when the connections were just being drawn between primitive living forms (mayflies and stoneflies) and the early flying insects. Kingsolver & Koehl (1985) also noted how proto-wings could have played a thermoregulatory role before being co-opted for flight, work summarized by Gould (1991, 145-151).

[231] Strahler (1987, 404-405), citing McGowan (1984, 76).

[232] Gish (1995, 74-76). There were three footnotes for this section. "E. G. Conklin, as quoted by G. E. Allen, *Quart. Rev. Biol.*, 44:173 (1969)" and Romer (1966, 12) were referenced in the first paragraph about invertebrates proposed as vertebrate ancestors. The quotation was from "F. D. Ommanney, *The Fishes*, Life Nature Library (New York: Time-Life, Inc., 1964), p. 60"—and has been used at least as far back as Gish (1978, 66). Finally, Gish drew "a winning ace" from Strahler (1987, 405). For those enamored of scholarly minutia, it may be noted Strahler didn't say "a winning ace" exactly: "McGowan follows his winning ace lead with the king, hoping to take a second quick trick." And although Strahler added *Pikaia* to the argument as a fossil example to clinch McGowan's case, technically the "ace" being referred to was *Amphioxus*.

[233] See Gould (1994a, 16-17) on the dating issue. Gish (1995, 46, 59-60) repeated the mistake, and did so once more in his 1998 debate with Massimo Pigliucci (re note 259 below). The calibration of Phanerozoic periods has been an ongoing process, and involves more than just improved radiometrics. McGowan (1984, 103) noted that, "As progressively older fossils were found, the base of the Cambrian got pushed further back, so that Precambrian fossils, by definition, could not exist." My old 1958 *World Book Encyclopedia* thought the Cambrian covered 80 Ma (starting 490 Ma), but by the 1980s the Cambrian was pushed clear back to 600 Ma. The gradual refocusing of dates may be tracked in Lambert & The Diagram Group (1988, 190), Emiliani (1992, 446), Benton (1996, 19), Doyle & Lowry (1996, 5) and Courtillot (1999, 2). The most recent shift of the beginning of the Cambrian to 544 Ma (with the Tommotian phase coming at 530 Ma) involved a 5% change from the previously accepted figure of 570 Ma (when the Cambrian was thought to cover 65 million years). But the start of the subsequent Ordovician has also shifted to 500 Ma—meaning the span from the small shelly fauna to Parker's "heterostracan fish" still covers about 40 Ma.

[234] Gish (1995, 71, 130).

[235] Conway Morris (1998a, 104-106) described *Pikaia* in an interesting chapter using the literary device of an alien submersible investigating Cambrian sea life. Cf. Conway Morris (2000) with Wells (2000a, 275), whose Research Notes included the paper but without any of its content surfacing in the main text. See Gamlin & Vines (1986, 91), Strahler (1987, 406), Whitfield (1993, 88) or Palmer (1999, 66-67) on *Amphioxus* (a.k.a. *Branchiostoma*). Holland & Holland (1999) note the utility of *Amphioxus* as a molecular and developmental crosscheck for identifying homologous features in other animals. Ruvinsky *et al.* (2000), Horton *et al.* (2002), Satoh *et al.* (2002) and Luke *et al.* (2003) survey the divergence and dispersal of its T-Box and NK homeobox genes in vertebrate evolution. More specifically, *Amphioxus*' *Hox* genes represent an ancestral layout, Gee (1994) re Garcia-Fernàndez & Holland (1994), while Minguillón *et al.* (2003) identified an ancient gene family preserved in the otherwise considerably derived amphioxus genome. The "Evolution and Development Group" at the Max Planck Institute for Molecular Genetics in Germany (molgen.mpg.de/~amphioxus) note ongoing research, and an online lecture by

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Bill Jackman (biology.uoregon.edu/classes/Bi355f99/lectures/lecture7.html) is useful for background context. Cf. also Kim *et al.* (2000) on gene expression in the horn shark. For some historical perspective on how far this research has advanced from thinking of twenty years ago, the hemichordate pterobranchs were seen as rudimentary chordates by such works as Stahl (1985, 36-41) until their simple "notochord" was determined to be an unrelated structure, Margulis & Schwartz (1988, 244).

[236] Gish's simplistic idea is belied by a study of living examples, where the environment and competition constrain the adaptive avenues open at any given time. Tudge (1996, 96): "Every creature in the wild has to keep many balls in the air. Thus, an impala might in theory evolve tremendous fleetness of foot, but if it did, it might thereby sacrifice some of the strength of shoulder and weight of horn needed to beat off rivals in the fight for mates. It might on the other hand develop an enviable ability to digest coarse vegetation. But if it did, it would come into competition with zebras, or acquire a huge belly that would compromise its fleetness. In short, the real impala in the real world has to compromise, and its present size and shape allows it to balance one need against another." Dawkins (1986, 242-246) and Dennett (1995, 290-291) affirm that Darwinian evolution is not governed by "constant speedism" impelling relentless change.

[237] Earlier, Gish (1993, 127) stated "The transition from invertebrate to vertebrate supposedly passed through a simple chordate stage. The fossil record, however, fails to provide any evidence for this." He then offered the Ommanney quote, but made no mention of McGowan's intermediate points, or to *Pikaia*, by then hardly a paleontological secret. Neither did Morris & Morris (1996b, 62-63) mention the available data or context when they fielded Ommanney.

[238] McGowan (1984, 76-78). Whitfield (1993, 88-89), Norman (1994, 50-54), Müller (1996, 66-68) and Fastovsky & Weishampel (1996, 73-75) note the tunicate-vertebrate connection. Of the sea squirt's sessile transparent baglike adult form, Jolly (1999, 281) dryly observed: "After settling, with no more decisions to make, it eats its brain (like an associate professor getting tenure)." See Greenfield (1996, 12-13) for general data on brains and nervous systems in various organisms—including an illustration of the tunicate transition. Cf. Mineta *et al.* (2003) on genes recruited for the central nervous system in planaria. Identifying Cambrian tunicates have been tricky, though a firm one finally turned up, Jun-Yuan Chen *et al.* (2003) contra Shu *et al.* (2001).

Gamlin & Vines (1986, 68, 72-73, 93) illustrate the tunicates (ascidians), and how similar invertebrate body plans grade from the diploblastic coelenterates (cnidarians) and ctenophores (comb jellies) to the primitive triploblastic platyhelminths (planaria/flatworms). Buss (1999) re Stoner *et al.* (1999) cover protochordate colonial reproduction. Pennisi (1996) re Swalla & Jeffery (1996) examine tunicate tail development genes, and simplified forms of vertebrate genes in its genome relate to cell signaling and development, Pennisi (2002b) on Dehal *et al.* (2002). Also an *American Zoologist* issue on how *Hox* figures in: Hinman & Degnan (2001) on tunicates, Finnerty (2001) on cnidarians, Saló *et al.* (2001) on flatworms, and Burke & Nowicki (2001) on vertebrates. *Hydra* offers further clues to the early split in metazoan development: Hobmayer *et al.* (2000) on WNT signaling molecules; Bode (2001) on *Cnox* genes guiding its axis formation; Hongmin Sun *et al.* (1997; 2001; 2002) and Miller *et al.* (2000) on *Pax* gene evolution.

[239] Gamlin & Vines (1986, 101). See Gould (1977a, 63-74; 1977b; 2002a, 1037-1051), Raff (1996, 254-291), Zimmer (1998, 172-173), David Moore (2001, 193-204)—and Voss & Shaffer (1997) and Voss *et al.* (2001) on axolotl genomics. Cf. Mabee *et al.* (2000), Chipman *et al.* (2000) and MacDonald & Hall (2001) on the challenges of detecting heterochrony (differential juvenile development) in fish, anurans and mice, Richardson (1995), Jeffery & Bininda-Emonds *et al.* (2002), Jeffery & Richardson *et al.* (2002) and Kathleen Smith (2002) on the broader developmental and phylogenetic implications of heterochrony; and note 245 below for some fossil examples. Work to identify the genetic details is just beginning, such as the identification of *let-7* RNA and *lin-14*, Pasquinelli *et al.* (2000) and Reinhart & Ruvkin (2001).

[240] See Futuyma (1982, 102-103), Gould (1983, 370), Matt Ridley (1993, 326-329, 342-343), Stanley (1996, 157) and Schwartz (1999, 126-161) explore the concept that humans are actually an especially neotenous ape. Gould (1981, 113-122) noted how the idea of human neoteny was mangled in the racist recapitulationism of Haeckel and others before 1920. Johanson & Edey

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(1981, 43) contrast juvenile skulls in humans, chimpanzees, and the australopithecine Taung Child; see also Lambert & The Diagram Group (1987, 88-89).

[241] See the Chapter One listing (re note 117). Interestingly, Richards (1992, 163-164) noted how Vladimir Kovalevsky pointed out the ascidian larvae connection to Darwin as early as 1867. Wells (2000a, 91, 288) cited both Richards (1992, 169-174) and Richardson (1995), but only as part of criticism that Darwin accepted more of Ernst Haeckel's theories than Stephen Jay Gould thought, and that biology textbooks unjustifiably reprinted a fraudulent embryo drawing Haeckel concocted to support his ideas. Cf. Richardson & Keuck (2002) on Haeckel's recapitulationist theories, and how they relate to what is currently known about developmental processes. Denton (1985, 125) similarly slid past the tunicate issue when criticizing uncertainties in evolutionary taxonomy. Cf. Goldstein & Harvey (1999), Adoutte *et al.* (2000), Gascuel (2000), Le *et al.* (2000), King & Carroll (2001), Lee (2001), Medina *et al.* (2001), Posada & Crandall (2001) and Simon *et al.* (2002).

[242] Compare Gould (1989, 210-211, 220-221), Conway Morris (1998a, 181-183) and Budd (2002) variously exploring Cambrian taxonomy (relating *Leanchoilia*, *Sanctacaris*, *Fuxianhuia*, *Canadaspis* and other taxa).

[243] Hall (1992, 131), citing such work as Henry & Raff (1990) and Wray & Raff (1990; 1991). Former Young Earth creationist Glenn Morton (2001) called attention to much the same point via Vacelet & Boury-Esnault (1995, 335) concerning the phyletic placement among the sponges of the curious carnivorous Cladorhizidae; cf. the commentary by Kelly-Borges (1995).

[244] Doyle & Lowry (1996, 222).

[245] Trilobite carapaces molted from larvae to adults (such as *Olenellus* adapting to increasing water temperature and higher oxygenation in the early Cambrian) illustrate the principles of neoteny and heterochronic development, Fortey (2000b, 175-181, 218-233) and Sam Gon's trilobite website (aloha.net/~smgon/ordersoftrilobites.htm). See also Richardson & Oelschläger (2002) and Richardson & Chipman (2003) on phalange development in aquatic vertebrates (fossil and living).

[246] Eldredge (2000, 122-123), reprising comparable text in Eldredge (1982, 118). Trilobite diversity may be seen in Rich *et al.* (1996, 192-212) or the many plates in Fortey (2000b). Cf. Ellis (2001, 44-51). As far as I have been able to determine, no creationist has ever paid any attention to this trilobite evidence (including the specific speciation chain cited in notes 148-149, Chapter Two). That would include Gish (1993, 229-249, 251-366) criticizing Eldredge and Godfrey. More recently, Woodmorappe (2001b) skipped such matters in reviewing Eldredge's revamped *The Triumph of Evolution*. By the way, Woodmorappe also recommended Gish as someone who "ably refuted" Eldredge.

Hunter (2001, 26-27, 68, 70-71, 76-79, 101, 149, 179-182n, 187n; 2003, 38, 54, 76-77, 104, 115, 155n, 157-158n, 161n) may take honors here for evading the most information. Restricting his outings to selectively quoting Eldredge (1980, 50) and Eldredge & Gould (1988) on the absence of "gradual change" in trilobites, Hunter freely mined Godfrey and both of Eldredge's anticreationist books for ancillary quotes without spotting the statements that belied his characterization of Eldredge's stance on whether anti-Darwinian "discontinuities" existed in the trilobite fossil record. Incidentally, Eldredge's 1980 article related trilobite evolution to biogeography (a salient topic Hunter has similarly skipped, re note 524, Appendix III), and the 1988 item was not a technical paper but a response to Maynard Smith (1987) deploying Sheldon (1987) to dispose of punctuated equilibrium. Cf. Gould (2002, 872-874).

[247] Idiosyncratically, ID boosters DeHann & Wiester (1999) got so caught up by the phyletic primacy argument that they appeared to accept sub-phyletic development as natural evolution! (See also the section on baraminology in Appendix III.)

[248] Whales are air-breathing mammals, whose developmental biology includes embryonic teeth and hair and a capacity to generate hind limbs now missing from the living animal—all of which suggests a terrestrial origin. See Conrad (1982b), Edwords (1982c, 5), Futuyma (1982, 199), Strahler (1987, 441), Ecker (1990, 205), Bille (1995, 138) and Zimmer (1998, 148). Fossil whales supported an evolutionary appearance, Lambert & The Diagram Group (1985, 198-199) and Stahl (1985, 486-492), Thewissen & Bajpal (2001, 1041-1042), with modern whales only appearing in

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the fossil record in the Miocene: the sperm whale 23-25 Ma, and the Humpback only 10-11 Ma, Sara-Heimlich-Boran, “Cetaceans,” in Waller (1996, 396-397). Legged intermediates substantially predate that time, around 50 mya: Gould (1994c), Gingerich (1994), John Noble Wilford, “How the Whale Lost Its Legs and Returned to the Sea,” in Wade (1998, 143-148), Zimmer (1998; 2001c, 135-141), Luo (2000), Chadwick (2001) and Haines (2001, 36-41, 60-99). Parenthetically, the short Wilford article transposed letters and so consistently misspelled the legged whales *Rodhocetus* as “Rhodocetus.” Not even the New York *Science Times* is perfect! Technical papers include Gingerich *et al.* (1983; 1990; 1994; 2001), Thewissen & Hussain (1993), Thewissen *et al.* (1994; 1996; 1998; 2001), Thewissen & Madar (1999), Thewissen & Bajpal (2001) and Spoor *et al.* (2002).

Evasive antievolutionary accounts of whales may be found in Hayward (1985, 44-45), Gish (1995, 198-206), Paul Taylor (1995, 43), Morris & Morris (1996b, 77-78), Milton (1997, 133), Ross (1998, 50-52) and Hunter (2001, 21-22, 33, 48, 67, 76, 91, 106). Denton (1985, 93, 170, 174-175, 216-218) inspired Johnson (1991, 178-179), both quoting creationist Douglas Dewar describing the absurdity of whales evolving from a land ancestor. In 1935 Dewar helped found the “Evolution Protest Movement” in Britain with a group of like-minded eccentrics to combat Darwinism’s purported goals of moral degradation (promoted by psychoanalysis), human extinction (via birth control), and political revolution (through communism), Numbers (1992, 145-152). Not all that dissimilar panic buttons from those being pressed by Phillip Johnson three score years hence.

Incidentally, the criticism of whales in *Darwin on Trial* was a rare instance where a technical citation was given: Johnson (1991, 178) intimating that Gingerich *et al.* (1990) didn’t know their business when they detected the vestigial legs on some early whale fossils. YEC Don Batten (1994) at Answers in Genesis (aig.smartbusiness.org/docs/1344.asp) also impugned their technical expertise. Michael Behe similarly cited whales in a sophomore class he taught (though parsed via newspaper accounts rather than the original literature)—see Behe’s 1994 response to a 1992 debate on “Darwinism: Science or Philosophy” held at Southern Methodist University in Dallas (reprinted at the Leadership U website). Behe (1996, 181) glanced past whales, but did not discuss any of the new fossil finds. Although reminded by Ken Miller in the 1996 PBS letter exchange (referenced in note 151, Chapter Two) and again at the 1997 PBS Firing Line debate, apart from a single mention in *Defeating Darwinism* (quoted in note 75 of the Introduction), Phillip Johnson has avoided discussing the new whale fossils.

[249] Johnson (1995, 87). His Research Notes offered no trilobite resources.

[250] Huse (1997, 27), referencing Gish (1990, 104), which itself did not provide any citations (incidentally, Gish did not mention any specific number of lenses involved). While neither Gish (1993; 1995) nor Henry Morris (1985) offered the trilobite lens example, Gary Parker declared (without references) that trilobites “had extremely complex eyes—the math to understand the lens structure was not even worked out until the middle of the last century,” Morris & Parker (1987, 126). Creationist physicist Hayward (1985, 48-49) also extolled the trilobite eye, as did John Jefferson Davis, “Response to Howard J. Van Till,” in Moreland & Reynolds (1999, 229-230), and Hunter (2001, 71; 2003, 115). Raup (1991, 34-35) would be an instance of an evolutionist bringing up the subject.

[251] See Doyle & Lowry (1996, 223-230), Fortey (2000a; 2000b, 84-119) or Parker (2003, 216-224) on the specifics of trilobite vision. R. Chapman (1969, 544-553) describes the calcite lenses in insects, and Bushbeck *et al.* (1999) explore the closest insect analog to trilobite vision.

That Huse would be unaware of such base data was not unexpected. Like Ankerberg & Weldon (1998) and Hanegraaff (1998), *The Collapse of Evolution* was a monument to slipshod secondary citation. Characteristically, D. James Kennedy extolled Huse’s work on the back cover as “one of the best overviews on the subject currently available.” But even those familiar with the information have glossed over it, such as the section on trilobites in Austin (1994, 144-145) provided by Walter R. Barnhart, Marcia L. Folsom, and Kurt P. Wise.. Although aware that insect lenses produced blurred vision and that only some trilobites had the schizochroal lens system, they concluded this was evidence of “an exceedingly brilliant designer!”

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[252] Eldredge (2000, 144-146) commented on a taxonomical aspect of designed objects—that they are often hard to organize into the sort of tidy hierarchical nests so characteristic of nature. Much as I have a penchant for playing cards, Eldredge happens to be "an expert in the history of design of the coronet," and that field manifests exactly the opposite characteristic of a Darwinian system. Unlike those "famous" trilobite eyes, coronets are definitely the product of intelligent design—which means improvements can be made without any deference to where the idea might have come from originally. The resulting murky taxonomy is exactly what doesn't happen in a Darwinian framework of "descent with modification," where changes are *inherited* rather than *copied*. Arduini (1987) argues similarly.

[253] Computer modeling of "paleogenetics" is barely able to manage simple protein folding, and even things that would seem comparatively easy to calculate (like the hydrodynamic properties of a shark's tail) can tax the system. Tackling the trilobite eye is much like demanding that meteorologists chart the course of tornadoes months in advance—and that in a field where the relevant physical processes are already identified and quantified.

Nilsson & Pelger (1994), excerpted in Mark Ridley (1997, 293-301), modeled how lensed eyes could develop incrementally over a few hundred thousand generations (a geological eye blink). While the stages from photoreceptive strips to retina and lens are observed in living animals, such as Arendt *et al.* (2002) on polychaetes, organisms that don't develop appropriate neurological connections fail to progress to the complex system of mammals and cephalopods. Although Dawkins (1994; 1995, 78-83) covered Nilsson-Pelger, Behe (1996, 36-39) challenged the older Dawkins (1986, 77-81) by effectively demanding all the point mutations involved. Meanwhile, Keith Ward (1996, 121-124) accepted Nilsson & Pelger's argument, but thought such mutations could only have been guided by divine thought. The criticisms of David Berlinski (2002, 34; 2003) prompted my own commentary posted at Talk Reason (and Berlinski's reply).

[254] Barinaga (1995) re Halder *et al.* (1995), Onuma *et al.* (2002)—cf. Watson & Berry (2003, 195-202). Similarly, Neumann & Nuesslein-Volhard (2000) note how *hedgehog* homologues governing retinal patterning among fruit flies and zebrafish "supports a common evolutionary origin of the animal visual system." Carol Kaesuk Yoon, "The Wizard of Eyes: Evolution Creates Novelty by Varying the Same Old Tricks," in Wade (1998, 174-178) and Pennisi (2002a) report on the latest discoveries and thinking in the field. Oakley (2003) suggests that the emerging picture of eye evolution as a process of replication and divergence of modules independently recruited over time fits in with what has been learned about other simpler developmental variations, such as the generation of butterfly wing eyespots covered by Beldale *et al.* (2002). See also Roush (1997) re Shen & Mardon (1997), Callaerts *et al.* (1999), Pineda *et al.* (2000) and Oakley & Cunningham (2002) on related research, Bromham (2002) on a *Pax* puzzle, and von Mering *et al.* (2003) on techniques being developed to identify genetic modules.

Remarking on such work as Halder *et al.* (1995), Wells (2000a, 74, 283-284) slid past the point of such research by asking, "If genes control structure, and the developmental genes of mice and flies are so similar, why doesn't a mouse embryo develop into a fly, or a fly embryo into a mouse?" Wells did not consider the obvious: that those shared genes have branched onto different chromosomes and have accreted their own suite of specialized regulatory triggers.

[255] On the topic of vestigial vision, McMenamin (1998, 133) and Ellis (2001, 10) note the shrimp *Rimicaris* living around geothermal vents. Like many deepwater animals, it has lost its ancestral eyes. But as maintaining just the right distance from the deadly cauldron is the difference between a successful meal and becoming shrimp brochette yourself, some species have developed photoreceptive strips along their sides to sense their proximity to the vent. One species has even generated a cornea over the sensor membrane. See also Van Dover *et al.* (1989) and Pelli & Chamberlain (1989). Cf. Land (2002) re Jinks *et al.* (2002) on a deep-sea crab's degenerate "naked retina" adapted for hydrothermal proximity sensing.

[256] Johnson (1995, 90) danced around the matter, never saying whether "bad design" could be objectively inferred from the characteristics of living or fossil life, nor to what extent "purpose" plays a role in natural phenomena currently held to be mechanistic. See also Behe (1996, 223-225) trying to counter Miller (1994, 29-30) on the design issue, and Cornelius Hunter (2001; 2003)

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wringing every ounce of mileage from his complaint that evolution is a religious doctrine that erroneously tries to tell God how he would have done things.

[257] Kitcher (1982, 138)—though cf. Witham (2003, 50), reminding that Voltaire's *Candide* was a satire on Leibniz's Panglossian view that we did indeed live in "the best of all possible worlds." Kitcher went on to note the example of *coprophagy* in rabbits, where they eat some of their own feces because the bacteria to break down cellulose are secreted too far along the intestinal tract to be reabsorbed. The rejoinder in Gish (1993, 227) focused on the yucky aspect, deciding it was only the rabbit's opinion that mattered when it came to calling this disgusting—but he did not address the microbial secretion problem that indicated inadequate foresight if rabbits were considered to be objects of design.

[258] William Dembski's "Teaching Intelligent Design: What Happened When? A Response to Eugenie Scott" is available at discovery.org.

Notes to *Chapter 4* (*Archaeopteryx*)

[259] Gish (1993, 129). Gish's confidence concerning how badly evolutionists supposedly do in debates with his brand of creationism may be compared with Edwords (1982b), who noted that evolutionists do quite well provided they prepare themselves properly (particularly familiarizing themselves with the creationists' apologetic kit bag). Cf. also Tarzia (1990, 14).

Gish's August 12-13, 1992 debate with Hugh Ross, moderated by a befuddled James Dobson is available at the Talk.Origins website; cf. Ruth Brown (2002, 174-180) on Dobson's influential Family Research Council. Because Ross and Gish share beliefs in Biblical inerrancy and antievolutionism, their exchange focused on the YEC/OEC controversy, with Gish effectively steering the topic away from areas he could not substantively defend. Other run-ins with Gish are recounted by philosopher Michael Shermer (1997, 127-136) and biologist Massimo Pigliucci (pf.bio.utk.edu/skeptic/Debates/gish.html on a 1998 exchange). See also note 102 (Chapter One) re Joyce Arthur.

[260] Zimmer (1998, 20-21). Owen's vertebrate "Archetype" was "a lampreylike thing" (ironically paying homage to the basal character of the primitive craniates) that "was the blueprint that God referred to as He guided the history of life." Owen struggled in vain to figure out how the turnover seen in the fossil record actually occurred, but never went beyond proposing "secondary laws he simply called 'creative acts.'" Personality clashes melded with social conservatism in Richard Owen, a "borderline case because he really did believe in evolution of some sort, but he thought he needed to attack Darwin's theories uncompromisingly, in part owing to his enmity with Huxley," Mayr (1991, 100-101). Cf. Edey & Johanson (1989, 86-88), Michael White (2001, 128-130) and Zimmer (2001c, 44, 50-52). Meanwhile, Christian apologist Hunter (2003, 77) thought "Owen's idea of archetypes was reasonable but his mixing of God and evolution was not." Hunter offered few details and no sources here, but presumably drew on Edey & Johanson and Zimmer's 2001 book, referenced variously by Hunter (2001, 188n; 2003, 157n). See also note 404 below on Owen's evasive phylogenetic turnabout on the reptile-mammal transition.

Gould (2002, 312-329, 1070-1076) contrasted the "European formalism" of Owen's Platonic Archetype with the British "functionalist" tradition (represented, ironically, by both Rev. Paley and Charles Darwin). See Ritvo (1997) for the fascinating philosophical and social background to the struggles going on in 19th century natural science as it tried to make sense of the overload of new taxonomical data before evolutionary theory sorted everything out. Denton (1985) represents the most recent (and equally unsuccessful) attempt to revive the leaden pre-evolutionary views of Cuvier and Owen.

[261] Dingus & Rowe (1998, 134-138) and Shipman (1998, 29)—cf. Benton (2003, 30-33) on Owen and the Dinosauria. Owen's penchant for acrimonious debate long preceded his run-in with Huxley over *Archaeopteryx*. In the 1830s, "the brilliant and irascible" Owen adamantly refused to believe that the platypus laid eggs, Ritvo (1997, 14). Antievolutionist Louis Agassiz (the first to recognize

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the existence of an Ice Age) had a similar foil in American William Rogers, Witham (2002, 16-17, 214).

[262] Morris & Parker (1987, 135, 137-138); Parker's Fig. 25 was as advertised, though its provenance was not specified. Earlier Henry Morris (1985, 84-85) had made similar points, and was cited by Huse (1997, 89); Gish (1995, 129-141) took four times as long to touch the creationist bases, and was a source for Ankerberg & Weldon (1998, 221) and Hanegraaff (1998, 34-39). Cf. Gish (1978, 82-86). For illustrations of the currently known archaeopterygid specimens (seven animals and one feather) and the history of their discovery, see Fastovsky & Weishampel (1996, 298-299), Dingus & Rowe (1998, 116-121), and Shipman (1998, 16, 21-45).

[263] Incidentally, Parker's ostrich and hoatzin examples got the two a bit backward. As a flightless bird, ostriches naturally have only rudimentary wings, and consequently reduced need for flight muscle anchorage. It is the small South American hoatzin that possesses notable wing claws like *Archaeopteryx*, but only in its embryo and chick stage, losing them in maturity. Gish (1995, 138-139) pressed the claw point further by mentioning (without references) several other clawed birds, as though the popularity of the feature somehow disposed of a reptilian ancestry for birds. Canadian creationist schoolteacher David Buckna made similar claims in a 1995 online exchange with Jeff Poling (dinosauria.com/jdp/evol/three.htm). Frank Sonleitner kindly forwarded to me an extensive survey of several thousand North American birds by Fisher (1940) that indicated vestigial claws on one or more digits is fairly common (though often not noticed because they are partially buried in the bird's flesh).

Apropos an earlier version of Gish, McGowan (1984, 123, 125) noted that he had "entirely missed the point that the young Hoatzin, in retaining a primitive reptilian feature which other birds lose just before leaving the egg, is showing us its reptilian pedigree." Cf. Gish (1978, 82-86). A distinction also missed by Richard Milton (1997, 108): "no evidence as to what creatures they are descended from and hence what precisely the claws are vestiges of has been produced." See Stahl (1985, 370) or Feduccia (1999b, 108-110) for comparison of the embryonic and adult hoatzin wing. Recent analysis suggests the hoatzin's claws haven't been retained vestigially all the way from the Mesozoic archaeopterygids, but represent how old developmental modes may be revived for a new adaptation: to assist the chick in crawling from the nest, Shipman (1998, 195-197).

[264] See Hartmut Haubold, "Solnhofen Formation," in Currie & Padian (1997, 676-677) for its geology, fauna and paleoenvironment, and Benton (1996, 88-89) for a summary of the Jurassic landscape with map.

[265] Frank Sonleitner alerted me to Hovind's idiosyncratic stance on archaeopterygid diversity (noted in the AiG criticism of Hovind, cited in note 2 of the Introduction). Stahl (1985, 362) notes the obstacles facing the preservation of fossil birds. While Johnson (1991, 79) was aware "birds pursue a way of life that ensures that their bodies will rarely be fossilized," Johnson (1991, 53-54) failed to apply that insight to bats. Nor did Denton (1985, 213-216), Henry Morris (1985, 84), Gish (1990, 58-59) or Davis & Kenyon (1993, 102). Gish (1993, 330) dismissed on principle the identification of fossil bat teeth that Laurie R. Godfrey, "Creationism and Gaps in the Fossil Record," in Godfrey (1983, 199) indicated their early evolution from insectivores. Gish (1995, 187) later insisted "The paucity of the fossil record of bats cannot be used as an excuse by evolutionists, since we do have many fossils of bats. The fossils of bats recovered at Messel were the most numerous of fossil creatures discovered at that site." He cited Storch (1992, 96), which actually said "fossil bats are normally rare, but at Messel they outnumber other mammals, probably because they were often caught above the Messel lake when it released gases." This referred to something else Gish didn't explain—that Messel functioned like the Cameroon lake that killed thousands of villagers through natural releases of carbon dioxide. Cf. Haines (2001, 56-58) and Parker (2003, 177-178).

Conditioned to observe stasis, creationists seldom venture beyond the echolocation of the earliest known bats, as I learned from geologist John Wiester at the 1998 Whitworth "Creation Week." When he brought up bats in a conversation, I asked what he knew of their fossil record. This turned out to be only the basic examples featured in the creationist literature—an interesting circularity, given that Wiester was another of the critical reviewers of Davis & Kenyon's *Of Pandas*

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and People. The earliest fossil bats were very tiny, palm-sized as indicated in Case (1982, 435-436), and belonged to three extinct families—of the eighteen living families, only seven have fossil representatives adequate for identification (an eighth is problematic), Hill & Smith (1984, 182-221) and Fenton (1992, 4-5). Their flight anatomy and echolocation systems vary enough that one branch was thought possibly related to primates—Linnaeus had initially classified bats that way, Simpson (1983, 211). See Hill & Smith (1984, 33-39) or Thomas H. Kunz & Elizabeth D. Pierson, "Bats of the World: An Introduction," in Nowak (1994, 7) on the debate. Roger Lewin (1997, 76), Lin & Penny (2001), Springer *et al.* (2001) and Teeling *et al.* (2000; 2002) affirm bat monophyly while supporting the convergent development of echolocation. Cf. creationist Hunter (2003, 56-57) on the Teeling paper.

[266] Main sources: Henry Morris (1985), Denton (1985), Hayward (1985), Morris & Parker (1987), Wendell Bird (1989), Sunderland (1988), Gish (1990; 1992; 1993; 1995), Johnson (1991), Davis & Kenyon (1993), Huse (1997), Milton (1997), Ankerberg & Weldon (1998), Hanegraaff (1998) and Hunter (2001; 2003).

[267] Wells (2000a, 112-113).

[268] Luskin and Gapper's "Icons Haven't Lost Their *Touch*" was obtained from the ARN website.

[269] Paul (1988, 63, 66). Chatterjee (1997, 132-135) surveys fossilized feathers and feather impressions. Though cf. note 337 below (Chapter Five).

[270] Robert Bakker (1975) entertained the idea that *Archaeopteryx* might have been a grounded runner, but Bakker (1986, 318-332) reversed his opinion based on the evidence of the feather shapes, and returned to viewing *Archaeopteryx* as an arboreal flyer. In contrast, creationists Davis & Kenyon (1993, 105-106) acknowledged the aerodynamic configuration of its feathers yet couldn't make up their minds whether it could fly. Their equivocation probably related to their odd view of *Archaeopteryx* as unrelated to birds (re note 285 below).

[271] See Fastovsky & Weishampel (1996, 294-298) and Shipman (1998, 72-81, 217) for avian flight anatomy in relation to *Archaeopteryx*. Paul (1988, 217) compares the "partially developed" muscle system of *Archaeopteryx* to that of birds and the small dinosaur *Coelophysis*. The seventh *Archaeopteryx* specimen discovered in 1992 had a slightly more robust sternum, though still far from fully avian, Shipman (1998, 45).

[272] Gee (1999, 179). Paul (1988, 218) considered the flying ability of *Archaeopteryx* "was still on the crude side." The dynamic analyses of Speakman (1993) and Speakman & Thomson (1994) doubted its ability for sustained flapping, and Bock (2000, 480) regards *Archaeopteryx* as a glider. See also Shipman (1998, 250-273) for further discussion of the flying issue. Denton (1985, 175-178, 199-212) focused on the metabolic rate of birds and the proposed evolution of feathers. A sample of evolutionary sources writing on *Archaeopteryx* at that time: Lambert & The Diagram Group (1983, 52-53), Simpson (1983, 180-182), McGowan (1984, 110-126) and Norman (1985, 191-194).

[273] McGowan (1984, 119). Bock (2000, 480, 484) notes a similar dearth of available fossil data.

[274] Denton (1985, 209), citing Stahl (1985, 349), which read: "how they arose initially, presumably from *reptilian* scales, defies analysis" (italics added to highlight the difference). What Denton found so "amazingly complex" were the *barbules* that main a flight feather's shape. These represent another differentiating keratin layer, splitting from the main *barbs* that form the fluffy part of a feather—just as the barbs are the offshoots of the scale-like central rachis rib. The barbules are slightly curled, and so tend to snag on ones from the adjacent barb. Of course, none of the aerodynamic constraints that make barbules so useful (and therefore liable to natural selection) apply to the feathers a bird does *not* use for flying, as McGowan (1984, 119-120) noted of contour and surface feathers of the flightless penguin. Cf. Prum (1999, 302) and Prum & Brush (2002, 266) with the more cautionary Feduccia (1999b, 130). Contrast also the illustrations in Stahl (1985, 351) or Gamlin & Vines (1986, 112) with the stylized barbule depiction in Gish (1992, 67), arrayed with all the regularity of a chain link fence. That Gish could have known of more accurate views may be inferred from his invocation of Lucas & Stettenheim (see next note)—one illustration reprinted in Prum (1999, 293), Prum & Williamson (2001, 33) and Prum & Brush (2002, 263).

Very little research has been done so far, though, on the developmental genetics of barbule generation, as noted by Prum & Brush (2002, 291).

[275] Stahl (1985, 350). Prum & Brush (2002, 285) stressed that theories on the *how* or *why* of feather evolution had to be based on an accurate understanding of *what* happened first—and this only became possible recently with notable improvements in the fossil record and comprehension of the biological mechanisms involved in feather development. Gish (1995, 135-136) made a valiant effort to disconnect feathers from scales, citing "A. M. Lucas and P. R. Slettenhein [*sic*], *Avian Anatomy: Integument* (Washington, DC: GPO, 1972)" for several differences between them (tossing in mammal hair for good measure). Gish did not mention that feathers and hair are both composed of keratin—nor did he address any of McGowan's feathery points. Parenthetically, Gish had been misspelling Stettenheim's name at least since his 1989 ICR IMPACT piece (No. 195). Pressing on, Gish (1992, 66) informed his child readership: "The idea that feathers evolved from frayed-out scales is pure fantasy."

Cf. Prum & Williamson (2001) on feather growth, correcting some of the errors in earlier studies (including a few in Lucas & Stettenheim's 1972 classic). The more current Stettenheim (2000) is relevant, introducing an *American Zoologist* symposium on feather evolution that included Homberger & de Silva (2000), Menon & Menon (2000) and Sawyer *et al.* (2000) on the microanatomy, epidermal biology and homologous gene expression of birds and other amniotes. Other contributors included Bock (2000), Maderson & Alibardi (2000), Maderson & Homberger (2000), Maderson *et al.* (2000), Wolf & Walsberg (2000), and the aforementioned Brush (2000) on various theories of feather evolution. The dinosaur connection drew a lively debate: Geist & Feduccia (2000), Martin & Czerkas (2000), Ruben & Jones (2000) and Tarsitano *et al.* (2000) *con*, somewhat offset by Dodson (2000) and Sumida & Brochu (2000). Shipman (1998, 148-159), Feduccia (1999b, 127-130) and Tudge (2000, 516-518) also air the issues.

[276] The Buckna-Poling exchange reference per note 263 above. Stahl was briefly quoted by Taylor (1995, 104).

[277] Wieland (1988; 1994), available at answersingenesis.org/docs/1201.asp & 1352.asp.

[278] Brush (1996, 140). The Brush quote surfaced at a German-language ID site (mpiz-koeln.mpg.de/~loennig/mendel/anhang2/Vogelfeder.html) while other quotes from Brush appear at darwinismrefuted.com/natural_history_2_04.html (similarly detached from the technicalities of Brush's argument). Keratins come in a variety of forms, with the basic α-keratin composing mammalian hair, as well as the reticulate scales of birds and the outer sheath of their feather buds. 90% of feathers consist of the modified β-keratin, also expressed generally in reptile and avian epidermal cells, the beak covering (rhamphotheca) and claws, as well as their scutellate leg scales, Maderson & Alibardi (2000), Stettenheim (2000, 465-466, 469) and Prum & Brush (2002, 290). The specific form of β-keratin in feathers (ϕ-keratin) differs slightly in having a repeated tripeptide, Brush (2000, 635)—this is the "biochemically different" aspect Wieland and other creationists have picked up on. See Molloy *et al.* (1982), Koltunow *et al.* (1986), Presland *et al.* (1989) and Whitbread *et al.* (1991) on relevant keratin genes and their expression—with Gregg *et al.* (1984) suggesting "feather-like keratin genes may have evolved from a scale keratin gene by a single deletion event."

[279] Brush (2000, 633). The developmental structure of feathers has affected the debate over Feduccia (1999b, 86-88, 93-96, 133-135) and Jones *et al.* (2000) interpreting the vaned spines of the curious Triassic reptile *Longisquama* as proto-feathers. Rather than representing a rival bird ancestor to displace theropods, it more likely reflects an alternate example of pre-avian reptile "feathers," as variously noted by Machalski (2000), Maderson & Alibardi (2000, 527), Reisz & Sues (2000), Stettenheim (2000, 474), Stokstad (2000a) and Sumida & Brochu (2000, 490-492). See also the Letters to *Science* (March 9, 2001) by Michael Benton, Richard Prum, Unwin, Jones, Rubin & Martin, and Prum & Brush (2002, 267, 282-283). One may view *Longisquama* illustrated as a glider in Wellnhofer (1991, 177).

[280] Prum & Brush (2002, 267-269, 284-285). In one of the more tendentious entries in this limited YEC field, Michael Matthews ("*Scientific American* admits creationists hit a sore spot" at aig.gospelcom.net/docs2003/0313sciam.asp) bypassed the many technical details reprised by Prum

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& Brush (2003) to baldly invoke Brush (1996) "to refute the scale-to-feather transition." As a YEC believer, Williams is also certain that "Dinosaurs did not precede birds, according to God's eyewitness testimony."

[281] Taquet (1994, 197). Zou & Niswander (1996), Crowe & Niswander (1998) and Widelitz *et al.* (2000) examine the signaling paths that transform scutellae into feather filaments and buds.

[282] Menon & Menon (2000, 551).

[283] Futuyma (1982, 188-189). The figures were line drawings of the skeletons of *Archaeopteryx*, a pigeon, and an early theropod dinosaur, the small Triassic *Coelophysis*, Futuyma (1982, 76-77); the bird illustrations were taken from those still used in Colbert & Morales (1991, 186). The dinosaur connection runs all the way to the basement. Lessem (1992, 269): "Dinosaur eggs are much like bird eggs in their microscopic structure, enough to make the two difficult to distinguish, as opposed to the markedly different structures in the eggs of lizards, turtles, geckos, and crocodiles." Cf. Carpenter (1999, 98, 138), Chiappe & Dingus (2001, 79-86) and Chatterjee (1997, 124).

[284] Morris (1985, 85). Huse (1997, 150) is similar. Gish (1995, 129-141) provided the source material for Ankerberg & Weldon (1998, 221): "despite all the claims that *Archaeopteryx* is a transitional form between reptile and bird, that is simply not the case."

[285] Milton (1997, 106-108) and Davis & Kenyon (1993, 105-106).

[286] Gish (1995, 141), citing "F. E. Beddard, *The Structure and Classification of Birds* (London: Longmans, Green and Co., 1898), p. 160." Gish (1978, 84) was similar.

[287] Futuyma (1982, 75) also remarked on the misclassification of the archaeopterygids. See Fastovsky & Weishampel (1996, 298-299) or Dingus & Rowe (1998, 116-120) for a current overview, and Shipman (1998, 40-44) for more detailed coverage of the reclassified specimens ("Haarlem" by John Ostrom in 1970, "Eichstätt" in 1973 by F. X. Mayr, and finally "Solnhofen" by Günther Viohl in 1988). Citing Wellnhofer (1988) & Shipman (1989), Gish (1995, 132) briefly mentioned Viohl's undertaking: "The sixth specimen was found, or recognized as such, in a private collection in Solnhofen in November 1987." So either Gish had no idea of the significance of what he was reading (incompetence), or he *did* understand it all, and went ahead with his bald statement anyway (duplicity). Neither approach ranks very highly on the scholarship index. Incidentally, viewers of Steven Spielberg's dinosaur sequel *The Lost World* will recollect *Compsognathus* as the nasty little pack hunters that overwhelmed one straggler when the big game safari turned sour. See Wellnhofer (1990, 74-75) for skeletal comparisons of *Archaeopteryx* and *Compsognathus*, and Briggs (1991, 136) for fleshed out illustrations.

[288] McIver (1988b, 121, 277-278), Lippard (1989, 26) dueling with Brown (1989b, 47-48), and Berra (1990, 41) cover the matter from the creation/evolution direction—Shipman (1989; 1998, 141-148), Fastovsky & Weishampel (1996, 301), Dingus & Rowe (1998, 121-123) and Feduccia (1999b, 38-39) cover the issue more generally.

[289] Duane Gish (in a 1989 ICR IMPACT piece, No. 195) and Wendell Bird (1989, Vol. 1, 218) both offered the hoax theory. Gish suggested "it would be a devastating blow to evolutionists" if it were true, though citing the criticism of Charig *et al.* (1986). Bird was similarly hit-and-run: "Hoyle and his colleagues even argue that *Archaeopteryx* was neither reptile or bird—but instead a forgery—although Charig* and others have disagreed sharply." (Bird thoughtfully marked the presence of an evolutionist's opinion with an asterisk, which in this instance also referred to the late Alan Charig, curator of the British Natural History Museum, and therefore keeper of the London *Archaeopteryx* specimen.) Wells (2000a, 114) is similar to Gish and Bird on Hoyle, and as brief. For contrast, Clausen (1986) was quite circumspect about the hoax theory when reporting on it the YEC Geoscience Research Institute journal *Origins*.

[290] Morris & Morris (1996b, 67-68) and Harrub & Thompson (2001).

Notes to *Chapter 5* (The Theropod Connection)

[291] See Renesto (1994), Feduccia (1999b, 86-87, 89, 133-135), Geist & Feduccia (2000, 669-673) and Tarsitano *et al.* (2000, 682) on *Megalancosaurus*. Kevin Padian & Luis M. Chiappe, "Bird

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Origins," in Currie & Padian (1997, 72) represent a minority interpretation of it as actually an *aquatic* form.

Kevin Padian & Luis M. Chiappe, "Bird Origins" in Curie & Padian (1997, 71-79), Fastovsky & Weishampel (1996, 294-321), Dingus & Rowe (1998, 107-194) and Sumida & Brochu (2000) describe why the shift to a dinosaur origin took place. Shipman (1998, 96-138) and Mayr (2001a, 65-68, 226-227) discuss the dissenting opinions (with Shipman still concurring with the dinosaur theory as the most likely explanation and Mayr being more skeptical). Gee (1999, 245n) categorized Feduccia as reflecting the "traditional, scenario-based view of bird origins" that has been especially hard-hit by cladistic analysis—cf. Dodson (2000) and Sumida & Brochu (2000, 494). Although Feduccia (1999b) has accommodated somewhat to cladistics, Padian & Horner (2002) note how Feduccia remains wedded to a "typological" way of thinking. In explaining "Why Ornithologists Should Care About the Theropod Origin of Birds" in *The Auk*, Prum (2002) noted how many ornithologists had not been properly acquainted with paleontological evidence and methods.

[292] Below that wanted poster, Huse (1997, 89) cited only Morris (1985, 85) to support: "There are no connecting evolutionary links between reptiles and birds. Archaeopteryx was once highly acclaimed as such a link but has since been acknowledged by paleontologists to have been a true bird." Not that snakes would have evolved directly from amphibians, of course—but rather from a legged reptile ancestor (such as Mesozoic marine mosasauroids), Lee & Shine (1998, 1444) and Lee *et al.* (1999). Cf. also Ellis (2001, 151-159), Wiens (2001) and Wiens & Slingluff (2001). Living boas and pythons still retain remnant hind limbs, Berra (1990, 23) or Whitfield (1993, 99), and homeobox plays a significant role in that process too, Cohn & Tickle (1999)—cf. Gould (2002, 1171-1173) and Matt Ridley (2003, 32-34).

With ironically bad timing, just as Huse's "Wanted" poster went up, middle Cretaceous legged marine snakes slithered by to claim it: *Pachyrhachis*, *Haasiophis*, and *Podophis*. See Fraser (1997) on Caldwell & Lee (1997), John Noble Wilford, "Legged Snakes? First Reliable Evidence Is In," in Wade (1998, 134-136), Greene & Cundall (2000) on Tchernov *et al.* (2000), and Coates & Ruta (2000). Cf. also Jenkins & Walsh (1993) on legged caecilian fossils. Incidentally, here Gish (1995, 112) set his fossil specimen bar low: "If just a few fossils of the intermediate stages between lizards and snakes could be found, that would be sufficient to trace the origin of snakes back to the ancestral lizard, or whatever reptile proved to be the ancestor." It will be interesting to see whether future editions of Gish will be revised to demand more than just "a few" intermediates.

[293] Gish (1990, 45). Futuyma (1982, 181) reported of a 1981 lecture: "Gish proudly showed a home-drawn cartoon of a Holstein cow transforming itself, by a series of clearly ridiculous stages, into a whale—and triumphantly announced that this slide makes evolutionists furious. I was indeed angry—not at the triumph of creationist analysis, but at such a blatant caricature of evolutionary principles. He could as well have read from a textbook that animals are descended from the same ancestors that gave rise to plants, and then shown a cartoon of an oak tree being transformed into a man." See also Edwords (1982c, 3-4).

[294] Gish (1995, 133-134), derivatively absorbed by Hanegraaff (1998, 34-36, 173-174n). The crux of Gish's argument had been offered before, in his 1989 ICR IMPACT article (No. 195), "As a Transitional Form Archaeopteryx Won't Fly." Gish's 1995 references began with "A. J. Charig, *A New Look at Dinosaurs* (London: Heinemann, 1979), p. 139" for the 21 reptile characters. Paragraph two: "K. N. Whetstone, *Journal of Vertebrate Paleontology* 2(4): 439 (1983)" applied to the London specimen, Benton (1983, 99) for the quote, and finally "B. Haubnitz et al., *Paleiobiology* 14(2): 206 (1988)." Paragraph three cited Martin *et al.* (1980) from *The Auk*, and "Martin, in *Origins of the Higher Groups of Tetrapods* (Ithaca, New York: Comstock Publishing Association, 1991), pp. 485-540)," then "A. D. Walker, *Geological Magazine* 117:595 (1980)" and "S. Tarsitano and M. K. Hecht, *Zoological Journal of the Linnaean Society* 69:149 (1980)." Items like *The Auk* piece being cited by Benton (1983), Gish may have acquired them secondarily. The last references were definitely secondary: "A. D. Walker, as described by Dodson, *Journal of Vertebrate Paleontology* 5(2): 178 (1985)" and "J. R. Hinchliffe, as described by Dodson, *Journal of Vertebrate Paleontology* 5(2): 178 (1985)." Parenthetically, there was some irony to Gish's

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trying to impress the reader with the weight of "modern isotopic techniques"—this from someone who has consistently rejected radioactive principles when applied to the age of the earth.

[295] McGowan (1984, 116-117).

[296] The type specimen data in Paul (1988, 352) lists the skull length for "Eichstätt" as 39 mm (about 1½ inches), that of the subadult Berlin *Archaeopteryx* as 45 mm (1¾ inches). As for attending to matters of proportion, in a 1985 debate with Gish, Philip Kitcher relied on Kenneth Miller for a slide illustrating the evolution of the mammal jaw, based apparently on information in "E. F. Allin, *Journal of Morphology* 147:430 (1975)." Gish (1993, 92) criticized this in part because, "by not drawing them true to scale, they were made to appear more similar to one another than is actually true." Gish didn't explain why a skeletal feature in one animal couldn't be regarded as the natural evolutionary progression of another that differed only in respect to size. Feduccia (1999b, 81-82) similarly drew on Haubitz *et al* to keep the theropod theory at bay.

[297] Small theropods in general have birdlike braincases—in some respects even more so than *Archaeopteryx*, Paul (1988, 198-199). See Lawrence W. Witmer, "Craniofacial Air Sinus Systems," in Currie & Padian (1997, 155-156) for the finer points. The skulls of birds (fossil and living) have a characteristic skull opening in front of the eye, placing them taxonomically among the archosaurs, Fastovsky & Weishampel (1996, 305)—though the twin diapsid openings at the back of the skull have been lost, as noted by Feduccia (1999b, 82).

[298] Ratzsch (1996, 43) included the idea that related species can't coexist on his list of "popular creationist misunderstandings" of evolutionary theory.

[299] In modern reptiles the pubis and ischium are splayed out roughly at right angles, while in birds the pubic bone is bent backwards, nestled parallel to the ischium. Simpson (1983, 44, 181) most clearly illustrates the basic layouts for the two dinosaur groups, as compared to modern reptiles and birds.

[300] Gish (1995, 116) referred readers back to his own children's book, *Dinosaurs by Design*, for a description of dinosaur pelvic arrangement. Gish (1992, 65) juxtaposed the saurischian *Struthiomimus* (which no evolutionist places on the direct avian line) with the visually similar ostrich. Squatting behind them both, the ornithischian *Ankylosaurus* was described (accurately enough) as "more like a low-slung tank than a graceful airborne bird." Gish then sprang his selectively baited trap: "In fact, all of the dinosaurs that had long slim legs, small lightweight bodies, and in general appearance looked somewhat like birds, were lizard-hipped. On the other hand, the dinosaurs that were bird-hipped were otherwise all wrong to be the ancestors for birds. These facts are difficult to understand for those who assume evolution is true, but they surely don't present any problems for scientists who believe in creation!" What may prove a problem more difficult to understand is how Gish managed to miss *seven families* of long-legged bipedal ornithischians (the Triassic Heterodontosaurids and Fabrosaurids, the Jurassic Hypsilophodontids and Dryosaurids, and the Cretaceous Pachycephalosaurids, Homalocephalids, and Psittacosaurids). As illustrated in Lambert & The Diagram Group (1990, 150-152, 160-162, 169), these lightly built dinosaurs resembled neither ankylosaurs nor tanks. Consistently oblivious to the limitations of his creationist sources, David Buckna apparently riffed off Gish's account when he made similar claims about ornithischians looking "more like low-slung tanks than graceful birds" in his 1995 debate with Jeff Poling (dinosauria.com/jdp/evol/six.htm).

[301] The reverted pubis is clearly visible in the skeleton of *Deinonychus antirrhopus* illustrated in Norman (1985, 58-59), as well as Paul (1988, 362-363), which also shows its much smaller relative, *Velociraptor mongoliensus*. Trivia buffs may take note that in Paul's proposed reclassification of the theropods, *Deinonychus antirrhopus* became *Velociraptor antirrhopus*, and because author Michael Crichton drew on Paul's work for *Jurassic Park*, that was what everybody called the man-sized predators rampaging in the book and film.

[302] Fastovsky & Weishampel (1996, 309), a point noted also by Diego Rasskin-Gutma, "Pelvis, Comparative Anatomy," in Currie & Padian (1997, 539-540). Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 76-77) or Dingus & Rowe (1998, 159-172, 191) describe the general evolution of the theropod pelvis. A useful illustration in Norman (1985, 37) showed how the related muscle attachments facilitated dinosaur locomotion. While the saurischian

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arrangement provided adequate muscle tension for quadrupedal sauropodomorphs, twist the layout up slightly in a bipedal carnosaur, and the spread put added spring to the step. This format was evidently so dynamically useful the larger bipedal ornithischians ended up evolving an imitation, with the front of their pubis extending until positioned just like the "lizard-hipped" theropods.

As for the segnosaurs, these were a curious group of Cretaceous theropods only poorly known until recent discoveries in China clarified them somewhat as an apparently herbivorous offshoot, Dale A. Russell, "Therizinosauria," in Currie & Padian (1997, 729-730). Czerkas & Czerkas (1991, 222) thought the shift in pubic arrangement in segnosaurs reflected the modification of their digestive system coming from their new lifestyle, something like that of a giant ground sloth. Their possible relationship to birds is discussed in Chapter Six.

[303] Gish (1995, 132), ironically citing Svitil (1994b) on the new *Archaeopteryx* (which had noted the evidence supporting its ability to perch in an arboreal mode, but also reconfirmed its similarities to theropods).

[304] Shipman (1998, 45). See also Feduccia (1999b, 77) and Elžanowski (2001).

[305] Nor was the actual shift in the pubic bone in Ostrom's interpretation all that drastic, as a comparison of the older Heilmann version shown in Stahl (1985, 369) with the Ostrom layout in Norman (1985, 192) indicates. As noted by Benton (1990, 211-212) the debate was not so much about the *shape* of *Archaeopteryx*'s pubis but its *orientation*—whether the pinched U-shaped bone pointed down or more overtly backward relative to the pelvis. Cf. Paul (2002, 55).

[306] I encountered Milton's article (with coverage of the Dawkins fracas) at the home page for the syndicated radio Laura Lee Show. Besides Milton, lauralee.com sported several of his fellow commentators from "The Mysterious Origins of Man" special (re note 2 of the Introduction). Graham Hancock and John Anthony West respectively dealt with re-dating and finding secret buried chambers beneath the Sphinx, and Michael Cremo proposed "Rethinking Human Origins." Other MOM alumni: David Childress expounded on the acoustic levitation of Tibetan monks (Lee herself reported on her party levitation experiments) and Rand Flem-Ath waxed forth on Atlantis in Antarctica. Farther out from the MOM orbit, Lee's website offered a hodgepodge of New Age beliefs: UFO researchers, John Hogue's Nostradamus prophecies, Uri Geller's Mind Power, astronaut Edgar Mitchell's Noetic Science, von Däniken's ancient astronauts, a smattering of Velikovsky supporters, and Michael Drosnin's Bible codes. All of which rubbed cyberspace shoulders with Intelligent Design, as there was a link to Michael Behe's *Darwin's Black Box*.

[307] Norman (1985, 193).

[308] See Kevin Padian, "Pectoral Girdle," in Currie & Padian (1997, 532-534) for a survey of dinosaur clavicles, Norell *et al.* (1997) on the discovery of a *Velociraptor* wishbone, and Webster (2000, 28) on the first tyrannosaur furcula (from the spectacular "Sue" specimen).

[309] The fossil record only magnifies this. One small rabbit-sized mammal did try out the theropod layout (long tail balancing the body on the hips like a teeter-totter) about 50 million years ago, but what had proven so effective for dinosaurs was evidently a washout for mammals, since it spawned no successful lineage, Storch (1992, 66-67).

[310] See Wellnhofer (1991, 155-158), Kevin Padian, "Pterosauria," in Currie & Padian (1997, 615), Unwin (1999), Geist & Feduccia (2000, 669-670), Monastersky (2001, 94), and Unwin & Henderson (2002) on the debate over pterosaur quadrupedality.

[311] One can approach this from several angles, since scientists interested variously in bats, birds and pterosaurs readily compare their specialty with the anatomy of the other two. Compare Hill & Smith (1984, 50-51), Shipman (1998, 41-44), and Wellnhofer (1991, 178-183). Unwin (2003) re Witmer *et al.* (2003) note how pterosaur endocasts reveal clues about their flying skills and neuroanatomical handling package.

[312] See Fastovsky & Weishampel (1996, 295-296, 300-301, 305-306), Kevin Padian, "Bipedality," and Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 68-70, 77-78), Dingus & Rowe (1998, 185-186, 210-211) or Sumida & Brochu (2000, 492)—and Martin *et al.* (1980, 88-89) or Feduccia (1999b, 75-77) for objections. Interestingly enough, the example Padian & Chiappe chose for a living bird's astragalus was that of the hoatzin. Excellent illustrations in Paul (1988, 182, 189) show the development and function of the astragalus. From the embryological

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end, Futuyma (1982, 48-49) and Dingus & Rowe (1998, 214-215) noted that when early bone fusion in chicken embryos was interrupted experimentally, the full complement of reptile bones developed instead. McGowan (1984, 123): "if birds were created independently, why should this structure not be a single bone through all stages of its development, instead of being formed from the fusion of three separate elements?"

[313] Shipman (1998, 126-128) provides a nice overview for the digit controversy, including the dissents of Larry Martin, Alan Feduccia, Samuel Tarsitano, and Max Hecht. Czerkas & Czerkas (1991, 93) were among the few in the dinosaur field who thought the digit issue sufficient to exclude dinosaurs from the avian line (favoring a Triassic thecodont origin, particularly in light of Chatterjee's *Protoavis*, which they accepted as described by its discoverer). Recall also Richard Milton's use of the issue (note 15, Introduction).

[314] How the archaeopterygids' hand relates to the Cretaceous maniraptorans, and from them to earlier theropods, may be seen in Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 75-76) or Padian & Chiappe (1998, 42), and Dingus & Rowe (1998, 179, 190-191, 213-215). Fastovsky & Weishampel (1996, 296) concur that the fossil evidence supports the I-II-III arrangement for both dinosaurs and birds. Stahl (1985, 349, 370) would be a paleontological reflection of the biological view that the initial condensations II-III-IV in the avian hand end up as digits I-II-III (as illustrated by the embryonic and adult hoatzin). Concerning depictions of *Archaeopteryx*, Martin & Czerkas (2000, 690) offer some caveats on how the digits ought to have appeared in the cover illustration of *Scientific American*'s February 1998 issue, featuring Padian & Chiappe (1998).

[315] Though Feduccia (1999b, 70-72) remains unconvinced, another element linking *Archaeopteryx* with the maniraptoran dinosaurs is the latter's distinctive wrist bone called the semilunate carpal. Named for its crescent moon shape, it allowed the sort of flexing required later for avian flapping. So if all birds really did have fingers II-III-IV and all theropods I-II-III, then going strictly on the fossil evidence the maniraptoran *Archaeopteryx* would be knocked from the "bird" perch Gish had prepared for it. No wonder he chose his words so carefully, comparing birds only to theropods on this point, otherwise *Archaeopteryx* might fly the coop!

[316] Hinchcliffe (1997) on Burke & Feduccia (1997), Feduccia (1999b, 68-70, 382-385), Larsson & Wagner (2002) and Kundrát *et al.* (2002). Incidentally, Ham (1998, 77) and Pat Robertson's CBN.com (December 8, 1997) cited Burke & Feduccia as disqualifying the evolution of birds from dinosaurs, as though they were the only suspects in the bird-reptile paternity suit. Cf. the commentary by Gregory Paul (dinosauria.com/jdp/archie/paulfed.html).

[317] Cf. Holden (2000a) with the coverage by Wells (2000a, 130-132, 299) on some highly problematic dinosaur DNA.

[318] See Müller (1996, 190-193) or Riddle & Tabin (1999) for surveys of general avian wing development and the relevant genes.

[319] Wagner & Gauthier (1999), with Sumida & Brochu (2000, 492-493) and Prum (2002, 7-9) commenting on the implications for the theropod origin of birds.

[320] Hagmann (2000) re Dahn & Fallon (2000), and Litingtung *et al.* (2002). Prum (2003b, 554-555) related such findings to the frame shift issue, responding to the contrary Feduccia (1999a; 2002, 1189-1191). Cf. Feduccia's similar exchanges with Frietson Galis, Jacques van Alphen & Johan Metz in the June 2002 issue of *Trends in Ecology & Evolution* (p. 256) concerning Galis (2001) & Galis *et al.* (2001), and Feduccia (2003a) & Larsson & Wagner (2003) re Galis *et al.* (2003).

[321] Henry Morris (1985, 85). The opening sentences of this paragraph were quoted re note 292 above. Similar sentiments surface in Sunderland (1988, 78, 87), Wendell Bird (1989, Vol. 1, 283n), Gish (1990, 60; 1995, 138) and Hanegraaff (1998, 173-174n).

[322] Kollar & Fisher (1980). Futuyma (1982, 48), Gould (1983, 182-184) and Dingus & Rowe (1998, 223) noted this research, though Zimmer (1998, 172-173, 265) cautioned it was hard to replicate. Tooth buds are part of the migrating neural crest cells (re note 438, Chapter Eight), but only recently have the genes governing the avian side begun to be isolated, YiPing Chen *et al.* (2000), Narayanan *et al.* (2001) and Mitsiadis *et al.* (2003).

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[323] The main role call is as listed in notes 266-267 above (Chapter Four). All discussed *Archaeopteryx* and bird evolution without noting this experimental induction of teeth. The stab at *Archaeopteryx* in Hunter (2001, 66, 75-76) was brief but revealing, since he specifically quoted from p. 48 in Futuyma (see note 395 in Chapter Seven below) where tooth induction was mentioned. Hunter could plead ignorance on this subject either by admitting to poor vision or a severe defect in short-term memory.

[324] Johnson (1995, 228), re: Gould (1980, 19-26). Gould's first name was correctly spelled in the body of the text, Johnson (1995, 90). Gish (1993, 443) and Wells (2000a, 294-295, 297) also cited works (Futuyma and Dingus & Rowe, re note 322 above) that specifically mentioned chick tooth induction.

Incidentally, Davis & Kenyon (1993, 119-122) mentioned panda thumbs, though not in relation to haphazard design. Because giant pandas (as bears) were difficult to distinguish from the smaller red panda (exceptionally large raccoons) they decreed comparative anatomy to be inconclusive when it came to identifying evolutionary homologies such as the reptile-mammal transition. They did not explain that bears (Ursidae) and raccoons (Procyonidae) are anatomically similar allied families in the miacid-fissiped wing of order Carnivora—see Lambert & The Diagram Group (1985, 166-167). Miller (1994) is also available online at millerandlevine.com/km/evol/lgd/index.html.

[325] That lawyer Johnson used "so-called" and "allegedly" in his description suggests what line of defense he may have had in mind. Whether he intended to press on and harangue the journal *Science* for publishing such presumably unsubstantiated information remains to be seen.

[326] Davis & Kenyon (1993, 105) veered the closest, acknowledging that *Archaeopteryx* had teeth "like some later fossil birds such as *Hesperornis* of the Cretaceous Period."

[327] Gish (1995, 138), again citing Martin *et al.* (1980). Cf. Thomas Huxley's 1876 view of *Hesperornis* and *Ichthyornis* in Huxley (1893, 93-100), and the more current contrarian Feduccia (2002, 1191-1193). Feduccia reprises the sort of tooth argument that creationists are fond of quoting, and that confluence extends to the underlying methodology. Although replete with tooth illustrations, Feduccia's treatment was selective, skirting past even his own marginal comments—such as acknowledging the occurrence of non-serrated teeth among some dromaeosaurs, but dismissing that as being "atypical of theropods." From a developmental perspective, however, it would be the *existence* of such variation that would undermine his position, not the extent to which such novelties were *typical* of their clade.

[328] Paul (1988, 213). Gish could have consulted Lambert & The Diagram Group (1985, 140-141), Stahl (1985, 378-383), or Colbert & Morales (1991, 186-187). Shipman (1998, 258-261) describes the probable habitat and shorebird characteristics of *Archaeopteryx*.

[329] Lessem (1992, 86) quoted Larry Martin about the crocodile ancestry for birds being strengthened because he knew of no comparably configured dinosaur teeth. But there was a group from the first half of the Cretaceous (*Baryonyx* and *Spinosaurus*) that did have crocodile-style jaws and teeth, evidently reflecting a piscivorous diet (*Baryonyx* had undigested fish scales in its ribcage). See Paul (1988, 271), Lambert & The Diagram Group (1990, 134-135, 207), or Norman (1991, 158); Taquet (1994, 189-193) described the paleontological detective story more fully. The "Geographica" section of *National Geographic* (December 1998) reported on a third apparently related genus found by Paul Sereno, which he named *Suchomimus* ("crocodile mimic"). Incidentally, Lessem (1992, 214) mentioned *Baryonyx*, but not in connection to Martin. Upstaging all this, YEC Gish (1992, 81) invoked *Baryonyx* as the dragon slain by St. George!

[330] See notes 34-35 above (Introduction).

[331] Johnson (1991, 78). His Research Notes cited a sentence from the preface to Stahl (1985, viii) that referred to new Early Cretaceous true bird finds further isolating *Archaeopteryx* (which lacked the powerful keeled sternum regarded at that time as the primary bird diagnostic feature). Johnson also cited Wellnhofer (1990) and a *New York Times* report of Paul Sereno's Chinese bird discoveries, but did not elaborate their contents. Paul (1988, 68, 219) discussed some of the 1980s finds that would have been available to Johnson's capable phalanx. Incidentally, Wellnhofer's reference to the Cretaceous birds was only briefly at the end—the main subject of the article was a

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thorough coverage of the six *Archaeopteryx* specimens then available, and how their anatomy alone established its status as a true intermediate between birds and reptiles.

[332] Wells (2000a, 120-121, 296-297). See notes 19-22 in the Introduction for the Huse and Hanegraaff glee clubs. Hunter's superficial discussion of *Archaeopteryx* in *Darwin's God* (re mote 323 above) did not mention other Mesozoic birds, nor did he do so in his duplicative second book, *Darwin's Proof*.

[333] Padian (1996) on Sanz *et al.* (1996), and Chiappe (1998, 31). Cf. Zhang & Zhou (2000, 1956-1957). Interestingly, *Rahonavis* (a Late Cretaceous bird from Madagascar) appears to have possessed sickle-shaped maniraptoran-style foot claws, Sampson *et al*. (1997, 24-26), Forster *et al.* (1998) and Krause (2000, 54)—though with demurs by Geist & Feduccia (2000, 666-667).

[334] For surveys of the latest finds, Chiappe (1995a,b) and Luis M. Chiappe, "Aves" in Curie & Padian (1997, 32-38), and Padian & Chiappe (1998) are at the cutting edge. More general coverage may be found in Fastovsky & Weishampel (1996, 314-321), Dingus & Rowe (1998, 212-228), or Ackerman (1998). Of the 34 catalogued Mesozoic bird fossils, *Archaeopteryx* dated from 1861, 5 were added in the 1870s, but nothing more turned up until 2 in the 1970s. The 1980s added 7, with the remaining 19 all discovered in the 1990s. On the genetic side, Richardson *et al.* (1998, 154) spotlighted some of the developmental processes that may have contributed to the reduction of tail vertebrae in birds. Incidentally, Wells (2000a, 289) cited the Richardson paper in his take on Haeckel's embryo drawings (see note 241 in Chapter Three above).

[335] The growth/flight energy tradeoff matter is proposed by Schweitzer & Marshall (2001, 323-325). Feduccia and Larry Martin maintain only a few Cretaceous birds were directly related to modern ornithurines, whose punctuated burst of diversity took place later, in the Tertiary, Stock (1995) and Feduccia (1995; 2003b); cf. Dingus & Rowe (1998, 230-231, 235-240), Mindell *et al.* (1999, 147-149), Tudge (2000, 520-545), and Prum & Brush (2002, 269) re Zhang & Zhou (2000). The discovery of *Asparavis* (a primitive ornithurine from Late Cretaceous Mongolia) sheds light on the transitional phase, Stokstad (2001a) on Norell & Clarke (2001).

Fragmentary fossils suggest the orders Charadriiformes (auks and sandpipers) and Procellariiformes (albatrosses and petrels) evolved prior to the K-T extinction, along with some diving birds and maybe loons, Feduccia (1999b, 165, 402-403). Most avian orders appear not to have diversified until the Tertiary, Bleiweiss (1998). Chiappe & Dyke (2002) survey current evidence. 60% of living birds belong to the later Passeriformes (perching birds that cover a stupendous range from Darwin's finches to myna birds). Genetic studies now play a role, as Roger Lewin (1997, 78-80) noted of the affinities of Australian birds, or García-Moreno *et al.* (2003) supporting "a traditional avian taxonomy." Cracraft (2001) proposes a Cretaceous Gondwanan origin for modern birds, while Dingus & Rowe (1998, 246-262) related bird proliferation (twice as many species as mammals) over the last 100 million years to their spread through the Pacific island system. Feduccia (1999b, 24) likewise noted how the shorebird *Archaeopteryx* was found among the islands of the Tethys Sea.

[336] See Liem (1988, 754-755) on avian lung and air sacs in extant birds, and Britt *et al.* (1998) tracing early pneumatic openings in *Archaeopteryx*. As to what happened in between, the fossil record of early Tertiary birds (which are functionally like recent birds) involves only a few deposits, Feduccia (1999b, 166). Dating roughly 50-48 Mya, though, these fall millions of years after the K-T extinction. The issue of avian breathing relates not only to anatomy, but also to the presence of an adequate thermal engine. On the theoretical side, Schweitzer & Marshall (2001) offer a detailed sequence of evolutionary steps for theropod endothermy (warm-bloodedness) and bird evolution, starting with some quite simple point mutations in four bases leading to changed hemoglobin receptivity to the "effector" proteins that trigger oxygen release. Cf. Golding & Dean (1998, 362-363) on the point mutations that allow the hemoglobin of various bird species to extract more oxygen for high altitude flying. By the way, living birds have a broader thermostatic range than mammals, including toleration for body temperatures higher than any known mammal could stand.

For the critical side, Feduccia (2002, 1187) cites Morell (1996) concerning "a mountain of evidence" that "has been marshaled against endothermy in dinosaurs during the last three decades." This concerned chiefly bone histology (where hole spacing relates to activity that in turn may

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indicate underlying metabolism). Cf. Chinsamy & Elzanowski (2001) on avian & theropod bone histology. Interestingly, pterosaurs (neither dinosaurs nor birds) appear to have developed some similar bone features convergently, Larson & Donnan (2002, 294-301). But there is more to the argument for endothermy than just the structure of their bones. Dinosaurs are known from a broader range of habitat than conventional reptiles (including the polar circles, which still would have been cool enough during the Mesozoic for ponds to freeze in winter). Evidence continues to accumulate supporting endothermy, such as Fricke & Rogers (2000) differentiating the latitudinal range of dinosaurs from Late Cretaceous crocodiles. While Bakker (1986) was an early defender of dinosaur endothermy, dinosaur/bird advocates Fastovsky & Weishampel (1996, 328-355), Kevin Padian, "Physiology," in Currie & Padian (1997, 552-556) and Dingus & Rowe (1998, 224-227) actually favor a metabolic mix: functionally endothermic predatory theropods versus large herbivores managing quite well on ectothermy (cold-bloodedness).

On the YEC front, Ham (1998, 77) cited the critical Ruben *et al*. (1997) as disproving the avian dinosaur theory, despite the cautions against just such a conclusion by Gibbons (1997b) in the same *Science* issue; cf. Parker (2003, 73-74). Cf. Dalton (2000d), Stokstad (2001b) and sciencemag.org/cgi/content/full/291/5505/783a on the inferences drawn concerning a problematic *Thescelosaurus* "heart" fossil of Fisher *et al.* (2000).

[337] Paul (1988, 123-124) explained the feather rationale for dinosaurs. Those so depicted ranged from the protodinosaur *Lagosuchus* and ornithischian dinosaur *Dryosaurus*, to a flock of saurischians: *Coelophysis*, *Compsognathus*, *Elaphrosaurus*, *Avimimus*, *Ornithomimus*, *Ornitholestes*, *Garudimimus*, *Oviraptor*, *Troodon* (a.k.a. *Stenonychosaurus*), and *Deinonychus* (which Paul termed *Velociraptor*). Ironically, having feathers appear too early on too many taxa (especially as far back as the lagosuchids in the Triassic) runs the risk of violating Paul's own observation on the forensic absence of feather impressions (re note 269 above, Chapter Four). This would be particularly true for *Compsognathus*, preserved in the same deposit as *Archaeopteryx* apparently without any feathers attached; illustrations of the Bavarian type specimen (original and a cast) appear in Norman (1985, 42) and Paul (2002, 101). A putative quilled psittacosaur tail has been found, Steghaus-Kovac (2002)—though smuggled from the same problematic region as the faked *Archaeoraptor liaoningensis* covered re note 385 in Chapter Six. If confirmed, this would put some integumentary structures on the ornithischian side of the dinosaur fence, and would help justify Paul's 1988 rendition of *Dryosaurus*. See Gee & Rey (2003, 102) for how the quills might have related to the living *Psittacosaurus*.

More recently, *Troodon* was shown feathered in Palmer (1999, 118), Larson & Donnan (2002, 315-319) explained the rationale for a feathered *T. rex* chick, and virtually all the small theropods in Gee & Rey (2003) were shown with some degree of plumage. Cf. Brush (2000, 631-632) and Sumida & Brochu (2000, 496-497). See Wolf & Walsberg (2000) and Ruben & Jones (2000) for the pros and cons of the insulation theory of feather origins, and Padian (2001) on how it fits into the larger cladistic picture of how flight developed.

[338] See Chiappe (1998) for the Spanish finds, and Stokstad (2002c) on a recent Chinese example described by Zhou & Zhang (2002).

[339] See Ackerman (1998), Padian & Chiappe (1998, 44-45), and Shipman (1998, 274-277). Horgan (1997, 22) and Shipman (1998, 276-277) noted the snap reaction of Alan Feduccia and Larry Martin was to doubt the features were related to feathers—understandable, given the dearth of competitive bipedal archosaurian candidates (see also the next two notes).

[340] Phillip J. Currie, "'Feathered' Dinosaurs," in Currie & Padian (1997, 241), Chen *et al.* (1998), with commentary by Unwin (1998). Dissenters John Ruben and Larry Martin think *Sinosauropteryx*'s "feather-like structures" are akin to the frayed collagenous fibers seen in the tail of living sea snakes and monitors, Feduccia (1999b, 375-378). See also Ruben & Jones (2000, 592-593). Over on the creationist front, Ham (1998, 77) invoked the commentary on the debate by Gibbons (1997a) to dispose of all the Chinese feathered theropods, evidently unaware this particular dispute only concerned the strange *Sinosauropteryx* filaments.

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[341] Morris & Parker (1987, 139), or Hanegraaff (1998, 38-39) secondarily—cf. *Caudipteryx* and *Sinosauropteryx* shown in Ackerman (1998, 74-75, 82-83). Chuck Colson also disparaged news reports on feathered theropods—see the criticism at angkor.com/cityrain/colson.shtml.

On the scientific side, contra Ji *et al.* (1998) and Padian (1998), Feduccia (1999b, 132, 394-398) maintained "no feathered dinosaur has ever been found" and that they were really flightless birds ("Mesozoic kiwis"). Similar views are expressed by Geist & Feduccia (2000, 668), Martin & Czerkas (2000, 690-691). Feduccia (2002, 1188) cited Jones & Farlow *et al.* (2000) who argued that the body proportions of these taxa were like that of flightless birds rather than theropods. Cf. Paul (1988, 357-360; 2002) and Gould (2000). A third *Caudipteryx* specimen favors the theropod view, Normile (2000), and additional "integumented" Chinese theropods have turned up in the Jurassic/Cretaceous boundary (125-147 Ma): Xu *et al.* (1999a,b; 2001), Norell (2001), Sues (2001) on Ji *et al.* (2001), and Norell *et al.* (2002). See Prum & Brush (2002, 276-280; 2003) for an overview of the current evidence.

All this provoked some interesting exchanges. For example, Prum (2003b, 553-554) wryly noted how Feduccia (2002, 1196) had gone from arguing that dromaeosaurs were unrelated to birds to claiming now that they were actually feathered flightless birds that only convergently resembled dinosaurs! Meanwhile, Feduccia (2002) was reprised without qualification at harunyahya.org/mediawatch_s_american_dino_bird_error.html (a Turkish creationist site discussed further in Appendix I) criticizing Prum & Brush (2003).

[342] The range of scientific opinion on *Mononykus* is reflected in Norell *et al*. (1993), Novacek *et al.* (1994, 67), Taquet (1994, 224), Andors (1995, 72), Dingus & Rowe (1998, 215-217), Feduccia (1999b, 90, 399), and Gee (1999, 108-109). Ironically, Norell in the dino/bird camp considers *Mononykus* a probable bird, while anti-dino/bird ornithologist Storrs Olson found the forelimbs so odd that he considered it a dinosaur, Svitil (1994a), and Feduccia (2002, 1191) proclaims the alverezsaurids were theropods having "nothing to do with birds." If that were true, this poses a problem for the anti-dino/bird argument Feduccia champions, because a chemical analysis of the feathery filaments of *Shuvuuia* showed the decay products distinctive of β-keratins, the telltale feather proteins, Schweitzer *et al.* (1999).

Incidentally, due to the rules of priority the spelling of *Mononykus* was changed early on when it was discovered a beetle had already claimed it. That happenstance allows the dated character of several creationist accounts of *Mononykus* to be traced. Two 1993 articles in the creationist journal *Creation ex nihilo* (published by "Answers in Genesis," founded by Ken Ham and Gary Parker) latched onto the odd "mole" feature, which Ham (1998, 76, 139-140) used to claim "Mononychus" couldn't be a "Birdosaur" because it "was only a 'mole.'" Morris & Morris (1996b, 69-70) misspelled the name as "Monoychus"—including twice in a direct quote from Monastersky (1993, 245), where the original *Mononychus* spelling had been used. Harrub & Thompson (2001, 30) did get the spelling right when also relying on the Monastersky piece. Like Ham and Harrub & Thompson, the Morrises fixed on the curious limbs, concluding sarcastically: "Possibly, birds evolved from moles instead of reptiles!" All these were peculiar opinions to field, given their source material. A reconstruction of the full skeleton was available to look at in the Monastersky article, while Ham had that and the current spelling at hand courtesy of Norell *et al*. (1995, 134-135), a work elsewhere cited by Ham.

[343] A current summary of which dinosaurs have been identified with feathers and how they appear to relate phylogenetically to birds may be seen at origins.tv/darwin/dinobirds.htm.

[344] Norman (1985, 43) and Paul (1988, 41) have offered the African ground-hunting flightless secretary bird as a good model for the lifestyle of small theropods. Based on the new feathered theropod findings, Norell (1998) thinks the scales are tipped in favor of the "ground up" cursorial theory favored by Ostrom (1979), as opposed to the rival "trees down" arboreal view. Shipman (1998, 273) arrived at the same provisional conclusion on the basis of her study of *Archaeopteryx*. Homberger & de Silva (2000, 566-570) caution that bird evolution need not have been restricted to such an either/or model. A range of views: Morell (1993) on Feduccia (1993), Burgers & Chiappe (1999), Geist & Feduccia (2000), Tarsitano *et al.* (2000) and Wong (2002).

The recent discovery of the tiny *Microraptor* has stirred up this pot however, Stokstad (2000b) re Xu *et al.* (2000), with some taxonomical analyses suggesting that the maniraptorans might be derived from the avian stock after all (see dinodata.net/Dd/Namelist/Tabm/M157.htm). *Microraptor* may have been an arboreal dromeosaurid, and recently fossils have turned up with feathers on front and hind limbs, as well as its tail. Thus it could have been a glider, like a dinosaurian flying squirrel. See bbc.co.uk/1/hi/sci/tech/1058475.stm (December 6, 2000), *New Scientist* (newscientist.com/bews/news.jsp?id=ns9999244) and Academic Press' "Daily inScight" (apnet.com/inscight/12062000/graphb.htm) for the arboreal argument, and Stokstad (2003) & Prum (2003a) re Xu *et al.* (2003), and Padian (2003) on the new "four-winged" finds.

Jonathan Sarfati assembled the obligatory creationist rejoinder ("New four-winged feathered dinosaur?" at answersingenesis.org/docs/2003/0128feathered.asp) which Chuck Missler instantly incorporated into the K-House eNews for January 28, 2003 (available at khouse.org). While the *Microraptor* specimens surveyed by Xu *et al.* reopen the theoretical possibility that protobirds could have had an arboreal stage, it more obviously indicates how varied feathered theropods could get (just as in mammals there are "flying" squirrels as well as fully flying bats). Of relevance to the arboreal/cursorial debate is the recent experimental support for the behavioral and aerodynamic viability of the cursorial approach to general bird flight, Pennisi (2003) re Dial (2003). All of which does supply some ironic backspin to the flippant creationist cartoon contributed by Dave Anderson to Sunderland (1988, 84) and Gish (1990, 55). Intended to ridicule the cursorial flight evolution model, it showed a featherless theropod wearing a tiny parachute hurling itself off a cliff in a "Leap of Faith," only to end dangling on a limb protruding from the rock below.

Notes to *Chapter 6* (*Protoavis*)

[345] Although an inventive theorist and gifted field worker, Chatterjee has at times shot from the hip. For example, for only the slimmest of reasons, he claimed the allosaurs and tyrannosaurs were independently evolved from thecodont ancestors, bypassing the theropod dinosaurs, Paul (1988, 194). For a history of the formation where the *Protoavis* remains were found, see Phillip A. Murry & Robert A. Long, "Dockum Group," in Currie & Padian (1997, 191-193).

[346] Until Chatterjee describes the rest of his sadly mashed fossils in peer-reviewed literature, paleontologists are wary of taking *Protoavis* seriously. This is true across the board: Fastovsky & Weishampel (1996, 298), Luis M. Chiappe, "Aves," in Currie & Padian (1997, 32), Dingus & Rowe (1998, 192), Shipman (1998, 112-113), as well as Feduccia (1999b, 38, 398-399). Interestingly, birdlike tracks have turned up from the Triassic, Melchor *et al.* (2002), but whether something like Chatterjee's critter or some other early dinosaur made them is as yet unclear.

[347] Chatterjee's composite skeletal reconstruction was reprinted in Norman (1991, 200) and a photograph of one of the fragmentary specimens appeared in Lessem (1992, 88)—both are in Beardsley (1986) and Feduccia (1999b, 37, 39). Czerkas & Czerkas (1991, 95) featured a painting of several *Protoavis* restored per Chatterjee's view in their Triassic landscape. Chatterjee (1997, 43-81) reprised his evaluation of *Protoavis* (though distinctly shy about the attendant criticism). But the interesting datum for the creationism debate is how Chatterjee's *The Rise of Birds* unequivocally endorses the theropod ancestry of birds (a publisher's excerpt is available at press.jhu.edu/press/books/titles/sampler/chatjee.htm). Even more ironically, a cladogram in Chatterjee (1997, 223) doesn't even dislodge *Archaeopteryx* from its basal position, identifying *Protoavis* instead as a derived form. (The paleontological disadvantage of this position, of course, is that it generates "ghost lineages" as hefty as those afflicting the thecodont theory of Feduccia *et al.*) Perhaps sensing that *Protoavis* is still too evolutionary for his YEC tastes, Henry Johnson (omniology.com/ProtoavisPseudo-Avis.html) dismisses it as "purely a religious icon!" representing "Chatterjee's faith in the metaphysical macroevolutionary dogma." Which is not that dissimilar from the position of Phillip Johnson.

[348] Parker's reference was to Beardsley (1986).

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[349] Milton (1997, 108). Compare this with the equally cursory YEC version of Paul Taylor (1995, 42, 104).

[350] Paul (1988, 122-123, 187-188, 251-252), where *Protoavis* presented a "very big problem." Unlike Parker or Gish, Paul had actually examined Chatterjee's fossils. The quill nodes were far from obvious to him, and it also apparently had four toes, very much like the early bipedal dinosaur *Herrerasaurus*, which had bird-like hips besides and lived back in the Triassic. Apart from its bird-like skull, the rest seemed a less convincing intermediate than the later *Archaeopteryx*. Paul therefore placed it provisionally as some form of herrerasaur—whether a purely terrestrial one or a flying foray off the direct bird line, he couldn't tell. "It is difficult to say more because the fossils are incomplete and jumbled, need more work, and await publication," Paul (1988, 252). See Paul (1988, 113) for a comparison of the four-toed foot of the Late Triassic biped *Lagosuchus* (literally "rabbit-croc"), a member of the "paleodinosaurians and herreravians" he thought *Protoavis* might belong to, with the three-toed foot of its early theropod contemporary, *Coelophysis*. That "bird mimic" dinosaurs also existed underscored the need for adequate fossil information to rule out convergence of an isolated feature. Paul (1988, 403) summarized that "*Avimimus* is about as birdlike as 'Protoavis' in the head 'if not more,' very much so in the arm, hand and leg, and less so in the pubis. It is heady and unsettling stuff—as early as the Triassic and as late as the Cretaceous there existed taxa that were so avian looking, yet so archaic and disparate in other ways."

[351] Gish (1990, 60-61). Gish's 1987 IMPACT piece (No. 171, "Startling Discoveries Support Creation") appears to be his first treatment of *Protoavis* (though not by name, which is why a site search at icr.org for "Protoavis" failed to turn up anything). Gish offered the find as yet another sign that "new leaks" were springing in the "rotting theory" of evolution.

[352] Wendell Bird (1989, Vol. 1, 219). Gish (1978, 87) cited a brief *Science News* report (September 24, 1977, p. 198) on Jensen's discoveries—though misprinted as p. 128. Jensen's find was also used by Francis Hitching's *The Neck of the Giraffe*, which Hayward (1985, 43) relied on secondarily for the claim that "a true bird" lived at the time of *Archaeopteryx*.

[353] The context of Jensen's find and the fossil bed itself are covered by Kevin Padian & Luis M. Chiappe, "Bird Origins," and Brooks B. Britt & Brian D. Curtice, "Dry Mesa Quarry," in Currie & Padian (1997, 78, 196). Dingus & Row (1998, 213) regard the femurs as suggesting the presence of nonflying maniraptorans.

[354] Sunderland (1988, 87). While Bird had been content to stand pat with describing Jensen's fossils as a "fairly modern bird," Sunderland muddled the facts more thoroughly. Although *Science News* explicitly tagged them as Upper Jurassic, Sunderland displaced them to *early* Jurassic rocks. This confusion probably resulted from the article noting the first recognized birds occurred that much later. That meant the Late Cretaceous *Ichthyornis* and *Hesperornis*—unfamiliar with that context, Sunderland evidently mistook this for a reference to the Late Jurassic *Archaeopteryx*, and so dragged Jensen's find back another 60 Ma. Sunderland also exaggerated that Jensen subsequently found "the remainder of the skeleton," when the account only mentioned "two connected shoulder bones," not necessarily from the same animal. In a 1992 appearance on a Northern Michigan University video, "Voices for Creation: Scientists Speak Out on the Origin Issue," Gish praised Sunderland as "one of our finest spokesmen."

Similar source inflation occurred more recently in a mid-1990s piece by young earth creationist Jon Covey (creationinthecrossfire.com/Articles/Archaeopteryx.html, "Archaeopteryx: The Trump Card of Evolution"). Claiming that "Bones of a modern bird were found in the same geological strata as *Archaeopteryx* by James Jensen," Covey cited only a short summary in *Science* (January 20, 1978, p. 284) that had stationed several cautionary caveats around the lone problematic femur that had been found. Also typical of creationist "scholarship" is the fact that it apparently didn't occur to Covey that he might need to check whether there had been any relevant developments on this point in the many years since the 1970s.

[355] Huse (1997, 150). Like Sunderland (but unlike Bird or Gish) Huse did not mention *Protoavis*. Although Huse had not explicitly referenced Sunderland (or the Bird or Gish books, for that matter), telltale clues in his bibliography establish he had read *Darwin's Enigma*. While Huse (1997, 209-213) was hardly comprehensive, failing to list all footnoted resources, a quarter of that

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bibliography duplicated Sunderland (1988, 184-188). Among them were obscure items Sunderland used to support his own arguments (notably involving mammal evolution), but which Huse never cited at all. Two were to a 1978 book and its review by Lombard (1979) in *Evolution*. Huse's citations exactly matched the listings in Sunderland, right down to the jumbled name and inaccurate date of "1980" for the Lombard piece (see note 424 in Chapter Eight). Huse is thus a splendid example of scholarly parasitism, albeit an indiscriminate and untidy one.

[356] Anderson (1991) and Monastersky (1991). Lessem (1992, 86-101) covered the *Protoavis* flap and Chatterjee's maverick career. There's no denying the rancor of this debate was directly related to the tussle between the archosaur and dinosaur bird evolution theories, which have taken on much the same epic scope as the Hatfield/McCoy dispute. Kevin Padian in particular regarded the *Protoavis* case as outright paleontological misrepresentation, Lessem (1992, 99). Dinosaur advocates tended to support the cursorial theory of bird origins, and quickly highlighted the "road kill" character of Chatterjee's Triassic fossil, while thecodont backers who preferred an arboreal origin for birds were willing to forgive *Protoavis* some of its faults and take Chatterjee's interpretation at face value, such as Czerkas & Czerkas (1991, 90-95)—though that was before the revolutionary new dinosaur/bird finds, Sloan (1999, 100-102).

[357] Gish (1993, 132-133). Gish's unqualified stance may be contrasted with the tempered account of *Protoavis* in Sylvia and Stephen Czerkas' *Dinosaurs*. They reminded the reader of its reptilian teeth and tail, and cautioned that hollow bones "are found in many pseudosuchians, early crocodilians, and some dinosaurs. The function then should be associated with behavior, rather than flight," Czerkas & Czerkas (1991, 92). The avian pneumatic aspect would presumably have built on that existing anatomy, whether of thecodont or dinosaur origin.

[358] Alun Anderson (1991).

[359] Gish (1995, 137). There were three footnotes. The first paragraph cited Beardsley (1986), Monastersky (1991) and Anderson (1991). Gish's second note was to "Sankar Chatterjee, *Philosophical Transactions of the Royal Society*, London B., 332:277-349 (1991)." Paragraph three cited Zimmer (1992)—which was a glib citation indeed, given how thoroughly Zimmer had covered the problematic features of *Protoavis* that Gish kept so under wraps. It was also interesting Gish padded the original press account with Monastersky and Anderson, rather than including them with Zimmer's critical *Discover* one, where they would have been more relevant.

[360] Gish's familiarity with some of the relevant material per notes 303 (Chapter Four) and the previous note. Gish may have fallen back onto an earlier prose rut, since his 1987 IMPACT piece (No. 171) had mentioned the "substantial keel" of Chatterjee's find.

[361] Hanegraaff (1998, 35, 174n). Johnson's comments on Hanegraaff per note 19 (Introduction). "Alan" Anderson has been cited by Harrub & Thompson (2001, 30-31) and their rejoinder to Rennie (2002) at apologeticspress.org/docsdis/2002/dc-02-sa13.htm. For comparison, fellow YEC believer Jon Covey (cited in note 168 above) did manage to spell Alun's name correctly in his reprise of the *Protoavis* story.

[362] Johnson (1991, 78).

[363] Johnson (1991, 79).

[364] Denton (1985, 195).

[365] Denton (1985, 180-182). Wendell Bird (1989, Vol. 1, 220-221) followed Denton's reasoning.

[366] I brought this comparative anatomy example up with Phillip Johnson in a 1998 email exchange, but he didn't remark on it.

[367] Wells (2000a, 114, 294).

[368] Wells (2000a, 116, 295-296), citing "Larry D. Martin, ' The Relationship of *Archaeopteryx* to other birds,' pp. 177-183 in M. K. Hecht, J. H. Ostrom, G. Viohl, and P. Wellnhofer (editors), *The Beginnings of Birds* (Eichstätt: Freunde des Jura-Museums, 1985), p. 182; John Schwartz, 'New Evolution Research Ruffles Some Feathers,' *The Washington Post* (November 15, 1996), p. A3 (quoting Mark Norell)."

[369] See the text re note 332 (Chapter Five).

[370] Feduccia (1999b, 4, 142-145) illustrates the bone variations in enantiornithines, and Hou *et al.* (1995; 1999), Gibbons (1996) re Hou *et al.* (1996), and Shipman (1997) on the recently discovered

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flock. Uncertainty about the Jurassic-Cretaceous boundary in China has carried over into a dispute about dating *Confuciusornis* and *Liaoningornis*, Horgan (1997), Luis M. Chiappe, "Aves," in Currie & Padian (1997, 32), Dingus & Row (1998, 212), and Ackerman (1998, 89, 93). Cf. Ji *et al.* (1999) on the biostratigraphy of Chinese pterosaurs. Opponents of the dinosaur theory like Feduccia preferred to stick with the original Late Jurassic identification (145 Ma), which also pulled early ornithines like *Liaoningornis* far enough back to render them virtually contemporary with *Archaeopteryx*. But subsequent work has supported an Early Cretaceous dating (125 Ma), Swisher *et al.* (1999) or Barrett (2000), and Feduccia (2002, 1193) accepts an early Cretaceous dating for *Confuciusornis*.

[371] See note 211 (Chapter Three) on Wells' homology argument. His reference to "Berra's Blunder" concerns Tim Berra (1990, 118-119) who had used the gradual changes in the Corvette sports car as a familiar way to indicate how "selection" can produce "descent with modification" over time. Johnson (1997, 62-63) mistook this as an attempt to illustrate *natural* selection—and Pennock (1999, 260-261) subsequently turned the tables by arguing that Johnson had indeed been tilting at a "straw man." Wells (2000a, 68-70, 281) reprised Johnson's argument.

The essence of the Corvette example concerns the nature of classification, which may be applied to intentionally designed objects (from cars to furniture) along with natural processes (geological strata or nebulae); cf. Edey & Johanson (1989, 51-52) on Coke bottles as well as the references in notes 252 (Chapter Three) and 408 (Chapter Seven). The point that ought to have been at issue was how incremental modifications in a temporal sequence allow for meaningful taxonomical arrangement (especially when organized via cladistics). What one does with that information afterward is another matter—though Phillip Johnson of all people has shown no enthusiasm for wrestling with the observed pattern of fossil change and explaining where the natural workings of speciation and developmental modification fail to account for them (from dinosaurs to synapsid reptiles). Instead, in the Research Notes on the Berra point, Johnson (1997, 126) disported that "I was at first stunned to learn that many evolutionary scientists do not understand the difference between common design and naturalistic evolution, even after I have explained it to them."

[372] Wells (2000a, 295), citing Carroll (1988, 290-292, 303) and Dingus & Rowe (1998, 181-183). Cf. Duane Gish's application of the "no cousins" rule when it came to *Compsognathus* and *Archaeopteryx* in the passage quoted in Chapter Five (re note 294).

[373] The discussion of bird evolution appeared in Carroll (1988, 338-347).

[374] Dingus & Rowe (1998, 181).

[375] Wells (2000a, 115). One may note Duane Gish's similar pronouncement (re note 286, Chapter Four). Dingus & Rowe (1998, 185) specifically noted that *Compsognathus* was among the basal forms of the Tetanurae, the next node up the bird phylogenetic map from the Theropoda to which *Coelophysis* belonged. Scholarly marginalia: there were *two* misidentified fossils (see the text in Chapter Four re note 287), a point noted by both of the sources Wells (2000a, 295) cited: Shipman (1998, 44-45, 115) and Dingus and Rowe (1998, 120, 138). Wells may have been less than attentive here, though, since he gave the wrong second page number for Dingus & Rowe ("185" instead of 138).

[376] Dingus & Rowe (1998, 212).

[377] Carroll (1988, 291). The relevant fossil particulars of *Compsognathus* are summarized at dinosauricon.com/genera/compsognathus.html. See also Paul (1988, 297-299; 2002, 54-55).

[378] Dingus & Rowe (1998, 182).

[379] Carroll (1988, 340). He noted also that the reduced hand of *Compsognathus* possessed only two phalanges per digit.

[380] Some reviews and relevant literature pertaining to limb formation and differentiation: Goodwin (1994, 147-161), Sordino *et al.* (1995), Averof & Patel (1997), Kondo *et al.* (1997), Shubin *et al.* (1995; 1997), Gibson-Brown *et al.* (1998), Schwartz (1999, 339-345), Tabin *et al.* (1999), Laurin *et al.* (2000), Ruvinsky & Gibson-Brown (2000), Tudge (2000, 389-397), Wagner & Chiu (2001) and Capdevila & Belmonte (2002). Since Wells (2000a, 284) cited Shubin *et al.* (1997) and Tabin *et al.* (1999), some of this developmental information was familiar to him. The Tabin *American*

Zoologist paper was part of a symposium report that included Erwin (1999) and Holland & Holland (1999)—see notes 214 & 235 of Chapter Three.

[381] See dinosauricon.com/genera/compsognathus.html.

[382] Wells (2000a, 121). Wells' take on how cladistics affects the contemporaneity issue may owe a lot to Alan Feduccia, whom Wells (2000a, xiii) listed among "Those who assisted me with technical details." See Feduccia (2002, 1196-1197) for his version of the contemporaneity argument, and Prum (2003b, 552) noting the irony that Feduccia's argument requires an even longer string of "ghost lineages" to span the gap between *Archaeopteryx* and its putative Triassic ancestors. Feduccia's views have been absorbed by creationists, of course (see notes 316 & 341, Chapter Five). But Feduccia (2002, 119) more directly parallels antievolutionists like Phillip Johnson (1995, 12) or even Stark (2003, 177) in his methodologically questionable assertion that critics of a theory (such as the dinosaur origin for birds) are not obliged to offer a comparably explicit alternative. About which Prum (2003b, 551) commented: "What Feduccia rejects as the irrational demands of phylogenetic zealots are actually the baseline requirements of all sciences, from astrophysics to zoology."

Johnson reprised his position on theory formation in his online debate with Ken Miller (referenced per note 151, Chapter Two): "I'm not proposing another theory; I'm explaining why I'm not convinced by yours." David Berlinski expressed similar views in the 1997 "Firing Line" evolution debate (re note 53, Introduction), as did Lee Spetner in a 2000 email joust with Edward Max (available at both trueorigin.org & talkorigins.org). Or Richard Milton in "The Mysterious Origins of Man" special (re note 2, Introduction): "Some people have said to me, how can you criticize the theory if you can't—if you don't have something to replace it with. Well, I don't accept that. If the emperor hasn't got any clothes on, then the emperor hasn't got any clothes on. It's not my fault. It seems to me that if Darwinism is wrong, then somebody's got to point the finger." Paul Taylor (1995, 48) similarly quoted "Evolutionist" lawyer Norman MacBeth.

[383] Text re note 332 (Chapter Five).

[384] For example, Fastovsky & Weishampel (1996, 361-364, 367, 369, 370-372, 375, 379) catalog the fossil sites relevant to the appearance and evolution of dinosaurs, noting the typical fossil dinosaur genera appears to persist for 4-8 Ma.

[385] Dingus & Rowe (1998, 213). See note 353 above, plus Kevin Padian & Luis M. Chiappe, "Bird Origins," Philip J. Currie, "Theropoda," and David J. Varricchio, "Troodontidae," in Currie & Padian (1997, 78, 734, 750) on dromaeosaurid and troodontid teeth from the Late Jurassic. Cf. Dodson (2000, 506, 509).

Another of Wells' sources, Shipman (1997, 28) noted how a 90 Ma dromaeosaurid had been found able to tuck arms up like a bird. "The discovery shows that the bird-like folding mechanism existed in nonflying dinosaurs and could have evolved prior to flight." Wells (2000a, 299) had cited Shipman only for some critical comments by Martin and Feduccia concerning a 70 Ma maniraptoran *Bambiraptor* which had been depicted as feathered in one reconstruction. Cf. Holden (2000b), variously cited by Wells (2000a, 297-298). But then Wells has preferred to dredge up controversy rather than mining information. Wells (2000a, 123-126) heralded the *Archaeoraptor* hoax, where a Chinese fossil merchant had spliced together two fossils to make a chimerical bird-dinosaur that made it all the way to a feature in *National Geographic*, Sloan (1999). See Dalton (2000a-c). *National Geographic* commissioned a thorough independent autopsy, Simons (2000)—cf. Kevin Padian in a November 2000 piece, "Feathers, Fakes and Fossil Dealers: How the Commercial Sale of Fossils Erodes Science and Education" (at palaeo-electronica.org/2000_2/editor/padian.htm). Stephen Czerkas' role in promoting *Archaeoraptor* as a perfect intermediate between birds and dinosaurs was ironic, given his earlier support for *Protoavis* (note 356, Chapter Six). The bird part of the chimera is of paleontological interest, Zhou *et al.* (2002), but the dromeosaurid tail segment turned out to be even more exciting: from a *Microraptor*, Stokstad (2000c) and bbc.co.uk/1/hi/sci/tech/1248079.stm (plus note 344 above, Chapter Five).

Given the embarrassing aspects of this story I fully expected creationists to pounce on the "Piltdown bird." Besides Wells promptly including it in *Icons of Evolution*, March 2000 saw

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Steven Austin weighing in for the ICR (IMPACT No. 321) and Nancy Pearcey did likewise in *Human Events* (March 10, 2000). Austin and Pearcey's pieces were ironic, for they illustrated how little they grasped the lessons of the *Archaeoraptor* episode (failure to do the proper homework first). Both played "jump the gun" newspaper paleontology over a *USA Today* interview (February 1, 2000) with Chinese paleontologist Zhonge Zhou, casting doubt on a recent pterosaur fossil discussed by Ji *et al.* (1999). See Kevin Padian's commentary (paleo-electronica.org/2000_2/editor/padian.htm). Farther along the apologetic daisy chain, the "Twin Cities Creation Science Association" (tccsa.freeservers.com) picked up on Pearcey's contribution, joining a dated piece by Ian Taylor defending the *Archaeopteryx* hoax theory discussed at the end of Chapter Four.

[386] See Xu *et al.* (2002) on *Sinovenator*, Zhou & Xu (1998) and Xu *et al.* (1999a) on the therizinosaurids, and Prum & Brush (2002, 278-279) on the framework of bird ancestry.

[387] Fastovsky & Weishampel (1996, 321). Cf. Wells (2000a, 123) grumping: "The claim that birds are dinosaurs strikes most people—including many biologists—as rather strange. Although it follows from cladistic theory, it defies common sense. Birds and dinosaurs may be similar in some respects, but they are also very different." The Research Notes for this section, Wells (2000a, 297), spared his readers the demographic survey about "most people" considering birds as dinosaurs to be "rather strange"—or any references to any biologists sharing that opinion, let alone that "many" did so. (Recall Gary Parker's invocation of Denton's "many" scientists per note 262, Chapter Four.)

Notes to *Chapter 7* (The Reptile-Mammal Transition)

[388] See Aulie (1974a,b; 1975) for an excellent summary of the discovery and interpretation of fossils in the reptile-mammal transition. Thomas Huxley proposed an amphibian origin for mammals, but the discovery of the Permian reptiles from the Karoo deposit in South Africa tipped the scales in favor of a reptile lineage. Parenthetically, Richard Milton (1994, 158) quoted the Thoreau line in a chapter called "A Trout in the Milk" suggesting modern scientists are too willing to dismiss radical physical theories (like cold fusion) as suspect. Cf. note 53 above (Introduction).

[389] Johnson (1991, 75-78). Hunter (2001, 77, 182n) presented a condensed argument along the same lines as Johnson, including the Futuyma quote and the accusation that tracing lines of descent is vitiated by an abundance of candidates. "In fact, with evolution we must believe that across the reptile-mammal transition organisms evolved so rapidly that they appear fully formed and diverse in the fossil record, that there are large gaps between the reptiles and the mammals, and that convergent evolution must have occurred many times." Hunter cited a variety of paleontologists for this passage, such as Romer (1966, 184-185) and Carroll (1988, 377, 397-398), but didn't quote any of them, nor mention any specific taxa or features. Thus he bypassed the detailed taxonomical characters Romer (1966, 184) offered to support the general point that "In the varied therapsid types, we span nearly the entire evolutionary gap between a primitive reptile and a mammal." Romer did mention a late Triassic "evolutionary 'no-man's-land,' a time when the mammals were occurring. Unfortunately, our knowledge of this transition is still poor." But that was 1966—Hunter was writing in 2001, and therefore had even less excuse than Philip Johnson for overlooking the progress of paleontological discovery in the decades since.

On the citation trail, lawyer Ashby Camp's "Reappraising The 'Crown Jewel'" in the Creation Research Society's *Creation Matters* (September/October 1998, available at creationresearch.org and reprised at trueorgin.org) fielded a very similar argument as Hunter, but with specific quotes attached. Source parallels include an obscure secondary attribution of George Gaylord Simpson from a 1972 Time-Life book *Life Before Man* that appeared in Hunter's notes (but without the quote Camp used). Hunter (2003, 8, 41) listed Camp among those to whom "I am indebted," and reprised the *Darwin's God* reptile-mammal conclusions without further references. Hunter's ID and Camp's YEC also rub shoulders as links at ARN's "Response to the PBS Evolution Project (arn.org/pbs_evolution0901.htm). And just to complete this clubby daisy chain, Michael Behe,

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William Dembski, Phillip Johnson and Stephen Meyer populate the dust jacket of *Darwin's God* with praise.

[390] Johnson (1991, 13).

[391] Johnson (1991, 173-174), citing Futuyma (1982, 85), Pierre Grassé's *Evolution of Living Organisms*, 1977 English edition, and Gould's essay in his collection *Hen's Teeth and Horse's Toes*. Incidentally, the ellipsis in Johnson's quote of Grassé (1977, 35) excised a reference "(e.g., see Crompton, 1963)" and was incorrectly placed (belonging between "paleontologists" and "note"). The second sentence was also a quote from Crompton, and should have been in quotation marks. The next paragraph in Grassé is relevant for having been omitted: "The shaping of the mammalian form, which lasted from 50 to 60 million years, occurred in a smooth and gradual manner. The evolutionary tendencies present in *all* the theriodont lines are: in the mandible, the upper end of the dentary extends posteriorly into a flat process which, in mammals, is called the coronoid process, while the lower end is prolonged horizontally. The postdentary bones (angular, articular, prearticular, supraangular) undergo a strong reduction." Grassé went on to discuss the "long and gradual" acquisition of homeothermy (a.k.a. endothermy, warm-bloodedness) in "a great many therapsids, if not in all."

Davis & Kenyon (1993, 100) made the same points about Hopson (1987), and also used the Futuyma quote—but incorrectly capitalized "therapsid," suggesting they may have derived the quotation secondarily. Incidentally, *Darwin on Trial* was listed as recommended reading, Davis & Kenyon (1993, 89). For contrast, Eldredge (2000, 191n): "Paleontologist James Hopson of the Field Museum of Natural History in Chicago has been especially eloquent in expressing the fruits of his research on the evolution of mammals from mammal-like reptiles, providing one of the best antidotes to the tired old creationist claim that the fossil record reveals no transitions between 'major kinds.'"

[392] See Czerkas & Czerkas (1991, 181) for the notosuchians and Janis (1994) on the sabertooths. Whitfield (1993, 176-177) explains "primitive" versus "derived" traits in classification; cf. Simpson (1983, 196-200), Dawkins (1986, 100-107), Gamlin & Vines (1986, 13, 78, 81, 95, 126), Shubin (1998) re Clack (1998), or Mayr (2001a, 222-226). Huey *et al.* (2000) note the very rapid convergence of wing length in a species of fruit fly only introduced in the Americas a few decades ago (the shift was predicted as a correlation of latitude, but the segment of the wing doing the lengthening turned out to be different than its Old World counterparts).

[393] Convergence has appeared in viruses and mitochondria, Bull *et al.* (1997) and Mindell *et al.* (1998). Richardson & Brakefield (2003) re Gompel & Carroll (2003) and Sucena *et al.* (2003) note the convergent tendency of pigment patterns and hair distribution in fruit flies.

[394] Stahl (1985, 293-295).

[395] Futuyma (1982, 46, 48) pointed out that the Tasmanian "wolf" has the marsupial dental layout of three premolars and four molars, while placental canines have four premolars and only two molars. See also Carroll (1988, 435-439) on Australian marsupials. Simpson (1961b, 91): "in the classical case of *Thylacinus* and *Canis*, the resemblances, although many and detailed, are all related to a particular pattern of predatory adaptation, and in characteristics not related to that adaptation the animals are quite different." Benton (1990, 250-251) also relates such convergences to lifestyle: "even though a kangaroo looks very different from a deer or antelope, it lives in roughly the same way!" But while Denton (1985, 178), Davis & Kenyon (1993, 117) and Milton (1997, 192-193) all noted the correspondences between the skulls of North American placental wolves and the marsupial Tasmanian thylacines, none mentioned the diagnostic traits that otherwise distinguished them.

Denton waxed how "Anyone who had been privileged to handle, as I have, both a marsupial and placental dog skull will attest to the almost eerie degree of convergence between the thylacine and placental dog." Indeed, "in gross appearance and in skeletal structure, teeth, skull, etc," they were "so similar in fact that only a skilled zoologist could distinguish them." Frank Sonleitner found this argument especially glib, forwarding to me a contemporaneous publication from Denton's own Australian backyard, Archer & Clayton (1984, 588, 643-647), which noted the many diagnostic features unique to marsupials that separated the two taxa. These ran from the specialized tarsal

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bone in the foot to a host of distinctive features in their skulls. Besides the obvious dental differences, one item was especially apparent even to yours truly (a certified non-zoologist): the telltale holes in the palate found in all the Australian marsupials but in no placental mammal.

A similar distance from applied taxonomy dogged Hunter (2001, 29-31; 2003, 46-48, 123-124) claiming such convergences violate the idea that evolution is unguided and are better explained by special creation. Incidentally, since Hunter (2001, 48, 180n; 2003, 95, 160n) specifically cited Futuyma pages 46 & 48 (for quotes on the implausibility of God having designed living systems with the quirky patterns observed), his omission of the diagnostic aspect may be chalked up to either obtuseness or evasion. The generalizations of antievolutionary criticism may be compared to the level of detail in Rubidge & Sidor (2001) on convergent episodes in therapsid evolution.

[396] Johnson (1991, 65, 70, 74-75, 190).

[397] Denton (1985, 181).

[398] The two orders Dipnoi (lungfish) and crossopterygians (coelacanths and their extinct rhipidistian relatives, such as *Eusthenopteron*) in the subclass Sarcopterygii share with basal amphibians (like *Ichthyostega* and *Acanthostega*) bony limbs, specialized vertebrae, and a two-part cranium with internal nares and unique teeth. Radinsky (1987, 78-81) compared the structural layout of *Eusthenopteron* with early amphibians, noting how relevant muscle transformations were traceable in the fossils. A further sampling of resources: Lambert & The Diagram Group (1985, 86-87, 90-93), Colbert & Morales (1991, 64-69), Michael Benton, "The Rise of the Fishes," in Gould (1993, 79-83), Ahlberg *et al.* (1996), Rich *et al*. (1996, 367-371) or Samantha Weinberg (2000, 98-102, 195-203). Right about the time Johnson was relying on Denton, further fossils had accumulated to show that the earliest amphibians had internal fishlike gills, unlike the external ones of modern amphibian (as in the tadpole phase), Coates & Clack (1991). Such work prompted Miller (1999, 40): "*The first amphibians looked more like fish than any amphibian species that would follow them in the next 380 million years*."

[399] Denton's logic may be compared to Gish (1995, 87) shanghaiing Forey (1988, 729): "Evolutionists point to the presence of the fish-like tail fin as evidence that *Ichthyostega* is a descendant of rhipidistian fish, but as Forey points out, such ideas are flawed because fish-like tails are characteristic of the general group of vertebrates with jaws (Gnathostomata)." While a fishy tail couldn't be a simple derived rhipidistian feature, it was a flight of Aristotelian humor indeed for Gish to suggest early amphibians couldn't have evolved from any fish line because their tails were too generally fish-like. Gish also intimated the evolutionary apple cart was somehow upset by recent finds suggesting that early amphibians were able to walk reasonably well. Cf. Lebedev (1997), John Noble Wilford, "Early Amphibian Fossil Hints of a Trip Ashore Earlier Than Thought," in Wade (1998, 111-114), Daeschler & Shubin (1998), Gee (1999, 46-66) or Ellis (2001, 130-138), with Westenberg (1999) or Palmer (1999, 78-79) for a few handy visuals. Incidentally, Gish (1995, 83-92) excised confused bits in Gish (1978, 76-77) on early amphibian anatomy that had been criticized by McGowan (1984, 150-158) and Strahler (1987, 408-412).

[400] There are other instances where Johnson appears to rely on others for heavy lifting. Johnson (1995, 165-166) drew on Eger (1988, 298) for a quote from Kitcher (1982, 175-176) on the perils of antievolutionary science education, making it sound as though Kitcher was being unjustifiably finicky in excluding them. Like Hanegraaff with Gish on *Protoavis* (note 361, Chapter Six), Johnson reprised Eger's version (complete with ellipses) that had gutted Kitcher's specific examples of how difficult YEC pseudoscience would be to address in a classroom. Another parasitical chain (again with telltale copied ellipses) occurred when Johnson (2000, 111-117) filtered Pinker (1997a,b) via Ferguson (1998) on the degree to which modern instances of infanticide might reflect some of our evolutionary history. Cf. Ferguson (2001) with Pinker (2002, 129-133) briefly alluding to Ferguson and Intelligent Design.

[401] Cf. Johnson (1991, 18-19, 27, 158-159) with Gish (1993, 60; 1995, 8-9). Gish's favorite Grassé quote was a fairly innocuous one about how evolutionary theory ought to depend on fossil evidence (Grassé was a zoologist, not a biologist). This Gish (1993, 114, 337, 371; 1995, 25-26, 352) repetitively cited in a quote war with those who approached evolution from the living biology end, such as Mark Ridley. That snippet of Grassé (and a statement on the supposedly mysterious

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origin of insects) turned up variously in Morris & Morris (1996b, 49, 57, 117, 302), Ankerberg & Weldon (1998, 210, 216) and Hanegraaff (1998, 171-172n). Hayward (1985, 24-28) also devoted a considerable amount of space to Grassé's misgivings about orthodox Neo-Darwinism, while Wendell Bird (in a 1987 ICR *Impact* pamphlet, No. 173) and Bert Thompson (1995, 26) sufficed with fast jabs. Still more superficially, Henry Morris (1963, 91-92) picked up on Litynski (1961) which secondarily referenced French science writer (and UFO buff) Aimé Michel on Grassé and other French scientists supposedly doubting the explanatory primacy of "natural selection." Gary Parker invoked Grassé for the misleading claim that genetic mutations were inevitably deleterious, Morris & Parker (1987, 111). In a 1994 radio sermon D. James Kennedy characteristically expanded Grassé's views into the assertion that most French scientists didn't accept evolution at all.

[402] See E. T. Babinski ("Old, Out of Context Quotations from French Scientists, at talkorigins.org/faqs/ce/3/part11.html) quoting Grassé. Cf. Witham (2003, 26-27).

Some interesting historical background on French views of evolution has been noted by Bowler (1983, 107-117). Late 19th century French naturalists continued the abstract morphological tradition of Cuvier and were slow to adopt the field study approach exemplified by Darwin and Wallace. There was also a teleological streak to French thinking that conflicted with the trial and error focus of orthodox Darwinism, and laboratory biologists like Louis Pasteur and Claude Bernard further regarded the history of organisms as a highly speculative enterprise to begin with. Consequently the French have been on the periphery of evolutionary thinking for some time (just as the Soviets were isolated from genetic theory due to Lysenkoism). Ironically, although there was a current of neo-Lamarckianism in French "transformism" (they long resisted adopting the Brit term "evolution"), it was mainly the "American School" of evolutionists who attempted to revive inheritance of acquired characteristics early in the 20th century.

[403] Johnson (1991, 158-159) suggested Darwinists rejected Grassé's argument "against the weight of the evidence" solely because they found it "disturbing." He based this view on quotes nipped from the beginning and end of Dobzhansky's review of Grassé's book in *Evolution* (admiring Grassé's eminence in zoology and acknowledging that the synthetic theory had not explained everything). It wasn't immediately easy to check up on this, since Johnson's Research Notes neglected not only to indicate the date or page numbers—he forgot even to identify the journal! But Johnson did supply the reference when he revisited his argument in an April 1992 address ("Darwinism's Rules of Reasoning") given at the Southwestern Anthropological Association in Berkeley (obtained online from id.ucsb.edu/fscf/library/johnson/DRR.html).

Concerning where "the weight of the evidence was," Johnson had to overlook Dobzhansky (1975, 376) from the paragraph after the first one he quoted: "Grassé adheres to a surprisingly old-fashioned conception of the relation between the genotype and the phenotype." Offering the processes of intracellular symbiosis and gene duplication, Dobzhansky (1975, 377) noted that "Grassé does not mention this [duplication] even as a possibility, because to do so would mean a recognition of mutations as differentiation agents." Which only underscores how Johnson has also failed to deal with endosymbiosis and novelty through gene duplication.

[404] See Benton (2003, 209-210), or Aulie (1974a,b) for more detail. Owen was a major figure in synapsid paleontology (naming such groups as Cynodontia) and by 1880 his work brought him to effectively accept that mammals had evolved from reptiles through them. Although Owen balked at the natural selection mechanism, he perplexed Darwin and others by advocating that the succession of forms nonetheless followed a creation purpose via some as yet unspecified but still completely natural impetus. Such a vague "progressionism" lives on among creationists, whereby God is seen to have contrived a meandering turnover of incrementally advanced forms that just coincidentally mimics the Darwinian alternative. A recent exposition of this view would be the Unification Church's "From Evolution Theory to a New Creation Theory—Errors in Darwinism and a Proposal from Unification Thought" (an anonymous work "Under the Supervision of Sang Hun Lee" at tparents.org/library/unification/books/evoltheo-0a.htm). To what extent church member Jonathan Wells supports such views remains unclear, as he has not to my knowledge alluded to this side of his philosophy in print.

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[405] Cifelli (2001, 1214-1218) surveys the shifts in interpretation of synapsid and early mammal phylogeny based on the improving fossil collection; cf. Rubidge & Sidor (2001) and Luo *et al.* (2002). The overall fossil representation of Jurassic mammals remains sparse, however, as noted by Rauhut *et al.* (2002) concerning the first specimen found in all of South America.

[406] Hopson (1987, 19, 21, 24). The Mammalia (of which *Morganucodon* is a member) was graphed as only extending slightly into the Late Triassic (about 205 Ma on Hopson's chart). The synapsid group shown as its close sister taxon (Ictidosauria) extended about five million years farther back into the Triassic. *Probainognathus* preceded them both cladistically and chronologically, about 230 Ma. And so on back through the taxa. "In fact, given the known imperfections of the fossil record, the correlation between degree of advancement toward mammals and time of appearance is surprisingly high," Hopson (1987, 24). Likewise Radinsky (1987, 7-8) on the congruence of a cladistic assessment with the fossil sequence.

[407] Robert E. Sloan, "The Transition between Reptiles and Mammals," in Zetterberg (1983, 263-277), the quote occurring on page 269. A chart on page 270 illustrating the skull changes involved was the sort that could easily rouse the ire of a creationist unfamiliar with the context. A gorgonopsid (not held by evolutionists as a direct mammal ancestor) nonetheless was useful in showing the increasingly mammalian snout of synapsid reptiles at an early stage in the process, when the jaw elements were still essentially reptilian. Cf. the cladogram in Kemp (1982, 297) illustrating "a series of branching points, each one of which represents a hypothetical ancestral form," with Rubidge & Sidor (2001, 456-459, 465-467) on current taxonomical views of the orders Sloan listed. A forensic note: "The unsatisfactory state of gorgonopsian taxonomy has been the single largest impediment to a broader understanding of this group's evolution. Indeed, gorgonopsians possess such a stereotyped cranial morphology that ontogenetic changes appear to have been used to identify species and even genera," Rubidge & Sidor (2001, 465). Whenever an extinct group of animals varies little (or so much that it may not be monophyletic when more fossils turn up) it can complicate working out relationships to other forms (from the predatory "carnosaurs" among theropod dinosaurs, to whether the dog-like mesonychids are closely related to whales).

[408] Darwin stressed that proper taxonomy had to be based on the genealogy of common descent, as explored by Padian (1999). In recent years, framing nomenclature to reflect a taxon's correct evolutionary phylogeny has become common (as I was reminded rather bluntly by one of the critical reviewers for this chapter, commenting that, strictly speaking, "reptiles" apply only to the diapsid branch of the amniotic family, and not to the synapsid ancestors of mammals). Wells (2000a, 286) veered close to this point when he wrote "Cladists object to calling reptiles a class, because they do not consider them a natural group (i.e., one containing a common ancestor and all its descendants)."

Gould (2002, 605): "Many evolutionary biologists have failed to recognize that the so-called cladistic revolution in systematics rests largely upon this insistence that species (and all taxa) be defined as discrete historical individuals by branching (leading to the rule of strict monophyly)—and not as classes with 'essential' properties by appearance (leading to the acceptance of paraphyletic groups). Many biologists reject (and regard as nonsense) the cladistic principle that no species name can survive the branching off of a descendant—and that both branches must receive new names after such an event, even if the ancestral line remains phenotypically unchanged. But this counterintuitive rule makes sense within cladistic logic—for cladists define new entities only as products of branching (the word *clade* derives from a Greek term for *branch*). A transforming species that does not branch cannot receive a new name even if the final form bears no phenotypic resemblance or functional similarity to the original ancestor. Thus if such extensive transformation occurs unbranched lineages, a cladist, by failing to designate a truly different anatomy with a distinctive name, retains the technical individuality of species at the price of a severe assault against legitimate intuition."

Dawkins (1986, 275-284) and Dodson (2000, 506-508) offers similarly wary comments about cladism. Indications of how the technique laid out by Hennig (1966) has been applied and developed over the years may be seen in Simpson (1983, 169-170), Gamlin & Vines (1986, 32-33),

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Whitfield (1993, 176-177), Fastovsky & Weishampel (1996, 51-54. 61-63, 70, 90), Conway Morris (1998a, 176-180), Eldredge (2000, 202-203n) or Tudge (2000, 33-62). See also devbio.com/chap22/link2205.shtml for a useful set of online links to this field. Lee (1998), Sereno (1999) and Hudson & Coyne (2002) discuss related technical issues (such as the difference between "crown" and "stem" groups, how "nodes" figure in cladistics, and the effect different definitions have on the interpretation of genetic loci data). Cf. Hagen (2003) on the role of statistical reasoning in systematic biology.

[409] Johnson (1993b, 157-158). Left dangling was what he meant by "some process of development." If a physical lineage was involved, was there direct manipulation at the genetic level? Or didn't animal "types" reproduce in the way known today? There are real conceptual consequences attached to any process of physical descent which creationists have yet to think much about. Though Johnson (1993c, 39) did intimate in a *First Things* exchange with theistic evolutionist Howard Van Till (1993) that "it does not necessarily follow that we are referring to the ordinary process of reproduction that we observe in today's world, where ancestors give birth to descendants very much like themselves." (Their debate is also available online via the Talk.Origins website.)

[410] Johnson fails to discuss the subject even when he brings it up himself, as the Eger/Kitcher episode demonstrated (note 400 above) as well as his oblique coverage of the Kenyon case (note 111, Chapter One).

[411] Gish (1995, 150-157). The more condensed Gish (1990, 61-64) stressed the differences between reptiles and mammals for kids. Whether Johnson and Gish might self-destruct like matter + antimatter if ever they were locked in the same debating room together would be both entertaining and instructive to discover. Given his agility in outmaneuvering Hugh Ross, I doubt Johnson's waving Hopson at Gish would slow the veteran Creation Scientist down much.

[412] Gish (1995, 167-169). Unfortunately one of the scientific sources Gish quoted bungled the illusion by blurting out that *Morganucodon* was a mammal. Further confusion was added when Gish mentioned that *Morganucodon* was "also called *Eozostrodon*," which wasn't precisely so; early fragmentary finds were originally classified under the genus *Morganucodon*, but since then the animal gained its own separate status, as explained by Stahl (1985, 412-413). Subsequent classification has created a "Mammaliaformes" category for these highly transitional forms, as reflected in Rowe (1996, 651) and Wyss (2001) on Luo & Crompton *et al.* (2001). Wendell Bird (1989, Vol. 1, 221) tried a similar gambit with early mammals as Gish had, though with leaner detail.

[413] Gish (1995, 170-171), citing Thomas Kemp (1982, 271) and "C. E. Gow, *Paleontologia Africana* 24:15 (1981)." Kemp was Gish's main source for his chapter on the reptile-mammal transition. Interestingly, in criticizing the earlier editions of Gish's book, Strahler (1987, 413-414) cited Kemp at length, suggesting Gish may have picked up on Kemp by reading Strahler (other more telltale instances of Gish's selective parasitism will be examined next chapter). Cf. also Hopson (1987, 25) on earlier instances of Gish's "authority quote" gymnastics.

[414] Frank Sonleitner drew my attention to the Broom prediction recounted with illustrations by Aulie (1974b, 25-27). Three quarters of a century after Broom's dead-on prediction, creationist Sunderland (1988, 91) was all confidence: "But there is no convincing scenario that can even be conceived for getting the jaw bones across the jaw joint." Cf. Stahl (1985, 408-410, 445-446) for *Probainognathus* and *Diarthrognathus* skulls, Rubidge & Sidor (2001, 457) on those of related taxa, and McGowan (1984, 137-138), Hopson (1987) and Luo *et al.* (2002, 19-20) for phylogenetic context.

[415] See Luo *et al.* (2002, 5-6) for a current affirmation of mammalian monophyly. Gould (1992, 121) took Johnson to task for tilting at the "rotted windmills" of obsolete issues: "He attacks Simpson's data from the 1950s on mammalian polyphyly (while we have all accepted the data of mammalian monophyly for at least 15 years). He quotes Ernst Mayr from 1963, denying neutrality of genes in principle. But much has changed in 30 years, and Mayr is as active as ever at age 87. Why not ask him what he thinks now?" Johnson's entire rejoinder was that, "These quotations (pp. 77, 89) are placed in historical context to show how prestigious Darwinists dealt with or

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anticipated issues at the time," Johnson (1993b, 209). It may be noted Johnson hadn't actually *quoted* Simpson, only abstracted his position; nor were there any appropriate references even for that in the Research Notes. One may compare this with the similar scholarly hijinks Gerald Schroeder and Daniel Lapin have played with Ernst Mayr on the subject of speciation (note 142, Chapter Two).

[416] Stahl (1985, 410-411). The triconodonts and docodonts were orders in the Eotheria subclass; symmetrodonts, pantotheres, and multituberculates were primitive marsupial orders. Cf. Colbert & Morales (1991, 228): "In recent years many students of this problem have tended to favor the monophyletic origin of the mammals, with the cynodont genus, *Probainognathus*, selected as representative of what the ultimate mammalian ancestor may have been like. This concept is based upon the evidence of numerous fossils collected in recent years, and as Crompton and Jenkins have shown, logically replaces the polyphyletic theory for mammalian origins which was based upon limited fossil materials." See Lambert & The Diagram Group (1985, 150-157), Stahl (1985, 412-419), Colbert & Morales (1991, 234-240), Rich *et al.* (1996, 519-523) and Hu *et al.* (1997)—and Hunter & Jernvall (1995), Jernvall (2000), Polly (2000) on Jernvall *et al.* (2000), and Salazar-Ciudad & Jernvall (2002) on mammalian tooth diagnostics and developmental genetics. Stokstad (2002a) and Weil (2002) re Ji *et al.* (2002) describe an important new fossil clarifying aspects of the early eutherian radiation.

[417] See Lambert & The Diagram Group (1985, 156) or Colbert & Morales (1991, 241) on the urogenital variants. Recent fossil finds have extended the record of marsupials back another 50 Ma well into the Cretaceous (125 Ma), Cifelli & Davis (2003) re Luo *et al.* (2003). Cf. Dunbar & Barrett (2000, 74) on primate specialties. Romer (1970, 411) and Lambert & The Diagram Group (1990, 178) illustrate the heart configurations—cf. Ellis (2001, 159-166), Schweitzer & Marshall (2001, 322, 326) and Zimmer (2001a). The Romer example is interesting in that Denton (1985, 113-114) selectively drew on one of his illustrations, but excised sections and text that did not support his typological conclusions. For broader context: Burggren (2000) catalogs the broad diversity of vertebrate hearts, and Zimmer (2000b) notes recent thinking on their underlying evolutionary development. Norman (1994, 183-185) contrasted the hearing, lungs, and reproductive systems of birds and mammals, showing the various advantages and drawbacks each inherited from their divergent paths along the diapsid/synapsid divide. The preliminary heterochronic analysis of Jeffery & Bininda-Emonds *et al.* (2002, 299-300) suggests "that heart development was already moving earlier in ontogeny before the modern groups of amniotes diverged," supplying "initial conditions that were subsequently 'exapted' (sensu Gould and Vrba 1981) in the lineages leading to endothermic birds and mammals."

[418] Denton (1985, 180). Surpassing Denton and Johnson in faux detail, Hoyle & Wickramasinghe (1993, 158-159) dismissed the synapsid ancestry of mammals on the grounds that "the genetic material of a mammal is grossly different from that of a reptile." What *genetic* material this might be, they did not elaborate. At least Hoyle and Wickramasinghe were getting marginally closer to the data. Frank Sonleitner (personal communication) called my attention to their earlier 1980s theory that both birds and mammals had somehow originated from infection by space bacteria attending the K-T extinction event—a melodramatic notion fatally compromised by the fact that both classes had appeared many tens of millions of years earlier.

[419] Stahl (1985, 397-399).

Notes to *Chapter 8* (Meaningless Concessions)

[420] Clack *et al.* (2003). Norman (1994, 106-109) described the absence of the otic arch and the task of distinguishing the earliest amniotes from amphibians. Cf. the context-free Morris & Morris (1996b, 64) on amphibians and reptiles. It should be noted that the available record of Devonian tetrapods has been restricted by the exigencies of the fossil record to deposits in Greenland. Recently, though, a jaw from an *Ichthyostega*-like tetrapod has been found in Belgium from 365 Ma, Clément *et al.* (2004).

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[421] Strahler (1987, 415-416) noted this point in his discussion of the mammalian ear. There is a general trend among synapsids for a reduction in the number of skull bones, as catalogued by Sidor (2001). An email from Frank Sonleitner called my attention to a pertinent living example of reptilian jaw audition described by Gans & Wever (1972). Although the legless amphisbaenid "worm lizards" lack external ears, they hear via a flap of skin on the lower jaw (acting as a tympanum) that transmits sound to the inner ear by a long cartilaginous extension of the stapes crossing the jaw joint.

[422] This basic information routinely pops up in scientific discussions of reptile origins, such as Lambert & The Diagram Group (1985, 101), Gamlin & Vines (1986, 105), Colbert & Morales (1991, 109), Norman (1994, 110-111), Fastovsky & Weishampel (1996, 84-88), or Michael J. Benton, "Reptiles," in Currie & Padian (1997, 637-642).

[423] Gish (1995, 151). This was not a notable improvement over Gish (1978, 81).

[424] Henry Morris (1985, 83). McGowan (1984, 140) remarked that Morris' second sentence "makes no sense to me." Morris offered no specific examples or citations for his position, and the reptile-mammal transition did not come up again in either *Scientific Creationism* or *What Is Creation Science?* Morris & Parker (1987, xiii) claimed their 300-page effort was only a "survey of the field" that couldn't address everything—and with that effortless crumple the reptile-mammal transition joined biogeography and defined "kinds" in the Creation Science wastebasket.

The reptile-mammal transition leaked into Morris & Morris (1996b, 65-66) via a spate of misfired authority quotes. For example, in a statement from Chatterjee (1983, 115) on how simple jaw articulation could no longer be used to distinguish reptiles from mammals, a handy ellipsis marked where the Morrises nipped out the section where the meaning of that was explained: the existence of synapsids *intermediate* in jaw form. Parenthetically, this was our *Protoavis* Chatterjee, digging in the same Dockum group in Texas. The Morrises also quoted the last sentence from Roger Lewin (1981): "The transition to the first mammal, which probably happened in just one or, at most, two lineages, is still an enigma." This is a reference to the monophyletic debate—which was ironic, since Lewin's piece was about a major mammal evolution conference, part of the process that by the mid-1990s had resolved the "enigma" Lewin was referring to. But flimsiest was this quote from a monograph review by Lombard (1979, 1230): "Those searching for specific information useful in constructing phylogenies of mammalian taxa will be disappointed." The problem was that Lombard was not saying anything about the quality of the mammalian fossil record—rather, he was *criticizing* the author of the monograph (who was Gerald Fleischer, not "Tom S. Kemp," as the Morrises misidentified him in their reference note) for not supplying such "specific information." Sunderland (1988, 91, 181n, 186) also mined the Lombard quote, correctly identifying the book's author at least, but inverting the reviewer's name (as "R. Eric Lombard") and misdating it to 1980.

Cf. Stark (2003, 184, 395n) similarly mining Szathmáry (1999) reviewing the theory of Schwartz (1999) that changes in homeobox gene regulation could provide a general theory of speciation. To support the claim that "it is taken for granted among the leading biological scientists that the origin of species has yet to be explained," Stark quoted the reviewer (whose name he slightly misspelled as "Szathmaŕy") that Schwartz had not "in general" provided a solution to the species problem. Stark missed the details of Szathmáry's review: that while Schwartz had offered evidence for "the component processes" of his theory, he had not shown cases of speciation actually following it, nor discussed contrary examples of gradual evolution that would not have required Schwartz's model. See also note 142 (Chapter Two) on antievolutionists misunderstanding Ernst Mayr's role in clarifying the speciation process.

[425] Not unexpectedly, McGowan (1984, 133-137) laid out fourteen diagnostic reptile and mammal skeletal features, involving the teeth, jaw and skull, vertebrae and ribs, pelvic arrangement and limb bones. Of those, the transitional cynodonts scored 5 reptilian elements, 4 intermediate features, and 5 mammalian ones. No diapsid reptile would garner such a mixed rating. Strahler (1987, 418) reprinted the McGowan information in his own discussion. Robert E. Sloan, "The Transition between Reptiles and Mammals," in Zetterberg (1983, 271) listed 22 traits and charted their progressive appearance in the various therapsid groups.

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[426] Cf. Michael Benton (2003, 21-23, 224-227) on the paleontological advice he gave the producers of the documentary.

[427] See also Peter Ward (2000, 80, 91) on the lystrosaurs' fleeting success. Because mammal evolution starts with the Permian synapsids, but doesn't reach its apotheosis until after the extinction of the dinosaurs, the subject often gets fragmented. Modern dinosaur paleontologists tend to integrate them, however, since their respective ups and downs are now seen as related. Czerkas & Czerkas (1991, 34-119) gave a very nice overview of the Permian and Triassic worlds, with excellent illustrations that serve as reminders of the living ecosystems involved that might otherwise be forgotten in the flurry of discussion about this species or that genera. For a more taxonomically oriented background, Rich *et al*. (1996, 406-420, 516-533) is concise.

[428] The earliest true mammals were exceptionally small—the skull of the Late Triassic *Morganucodon* specimen shown to scale in Czerkas & Czerkas (1991, 118) was barely an inch long. Palmer (1999, 106-107) illustrates a range of these diminutive early mammals. Christine Janis, "Victors By Default" in Gould (1993, 171-172) described the adaptive advantages of small size in a dinosaur world. Exploiting the ecological niche of wide-eyed nocturnal miniature scampering insectivore carried mammals through the long dinosaur preeminence, and the hearing skills they honed would eventually come in handy for some early mammal spin-offs, the acoustic-navigating bats and cetaceans.

[429] A graph in McGowan (1991, 132) may well be the outer frame for the macroevolutionary picture. While metabolic rate generally rises with body mass, there are some revealing discontinuities. Unicellular ectotherms operate at roughly 20° C and cluster around the upper end of their range. Multicellular ectotherms (including fishes, amphibians, reptiles and invertebrates) run at about that temperature, but their line starts back a bit, overlapping the unicellular line like a roof shingle. In other words, being multicellular gets more "bang for the buck" from comparable body mass. The multicellular line extends up until another state change clicks in with the endothermic mammals and birds. Only that overlap is even more pronounced, reflecting their higher running temperature of about 39° C. See Kathryn Brown (2001) on Gillooly *et al.* (2001) concerning recent discoveries on metabolic base lines, and Kozlowski *et al.* (2003) endeavoring to relate such scaling to larger properties of metazoan cell size and number and genome size (including noncoding DNA).

[430] Robert E. Sloan, "The Transition between Reptiles and Mammals," in Zetterberg (1983, 276). The increasingly coordinated grinding and chewing teeth of mammals came at a price. "It is impossible to take full advantage of an interlocking teeth design if its precision is disrupted by the continuous replacement practiced by cynodonts and present-day reptiles. So early mammals have only two sets of replacing teeth, like ourselves," Christine Janis, "Victors By Default," in Gould (1993, 172). Manatees have retained the knack for tooth replacement, suggesting a target for future paleogenetic analysis (assuming the gentle ecologically threatened sirenians can escape extinction in the meantime). Ellis (2001, 176-182) describes sirenian diversity.

[431] Michael Benton, "Four Feet on the Ground," in Gould (1993, 111-112). Fastovsky & Weishampel (1996, 81) note secondary palates have appeared in varying forms in other tetrapods. Regarding posture, it's important to remember that the diapsid dinosaurs developed their own distinctive arrangement, especially among the larger quadrupeds, where the front knees bowed out, as in the ceratopsians (though not without vocal demurs by Robert Bakker and Gregory Paul). See Czerkas & Czerkas (1991, 212, 217-219) or Dodson (1996, 270-279).

[432] Rich *et al*. (1996, 416, 419) neatly display the evolution of paleontological illustration, since the newer ones for the current edition include a furred *Thrinaxodon,* along with older holdovers showing *Cynognathus* with reptilian skin, compared to the hairy depictions in Lambert & The Diagram Group (1985, 134-135) and Czerkas & Czerkas (1991, 73-74). *Thrinaxodon*'s near-mammalian metabolism may be deduced from its anatomy, which included a ribcage shortened for a muscular diaphragm to assist breathing, Czerkas & Czerkas (1991, 69-70). The ribcage configuration is evident in the full skeletal illustration of *Thrinaxodon* in Futuyma (1998, 149), who indicated their probable endothermy, and inferred presence of hair per Kemp (1982, 247-251). As

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Gish cited Kemp's book (note 413 above, Chapter Seven) he could have known of the hair argument.

There had been some suspicion dinosaurs may have checked out in part because they didn't have a diaphragm—which they wouldn't have needed during most of the Mesozoic because the atmospheric oxygen level was higher (up around 30%, judging from air trapped in Cretaceous amber). When that began to change late in the Cretaceous (possibly due to pollutants from the Deccan Trap eruptions), the theory speculated dinosaurs couldn't adapt to the lower 21% value. Recently a juvenile theropod fossil has turned up from the mid-Cretaceous (110 million years ago) with preserved organs that includes a diaphragm like that of crocodiles, Ruben *et al.* (1999) with commentary by Wuethrich (1999). Although supporting the idea of a dinosaurian metabolism unlike that of living tetrapods, it doesn't yet resolve their resilience to changing O_2 levels.

[433] Czerkas & Czerkas (1991, 51, 54-55, 57), with illustrations of *Estemmenosuchus* and *Moschops*. It is also interesting to note that birds have developed a few glands of their own, especially for preening, Stettenheim (2000, 467-468); Menon & Menon (2000) describe how the avian lipid secretion system differs from mammalian analogs. Hillenius (1994) and Ruben & Jones (2000, 588-590) note further circumstantial evidence indicating the increasing synapsid metabolic rate as they approached the mammalian phase.

[434] Oster & Alberch (1982). Cf. Prum & Brush (2002, 289) on how such contingent differences participate in (and constrain) the generation of evolutionary novelties like feathers. Other initial genetic variants between early diapsids and synapsids could have involved only slight shifts in the expression pattern of regulatory genes—such as *Hoxc8* which relates to the number and placement of cervical and thoracic vertebrae, explored by Belting *et al.* (1998) re chickens and mice. Cf. also the differential development of sex determination chromosomes in birds and mammals, Fridolfsson *et al.* (1998), Fridolfsson & Ellegren (2000) and Ellegren & Carmichael (2001).

[435] Ting-Berreth & Chuong (1996), Jung *et al.* (1998), Morgan *et al.* (1998), Foitzik *et al.* (1999), Jiang *et al.* (1999) and Kulessa *et al.* (2000). *Shh*, *Bmp* and retinoic acid all play roles in determining axial symmetry, Tsukui *et al.* (1999). More specifically, Harris *et al.* (2002, 160) note "that the anterior-posterior expression polarity of Sonic hedgehog (*Shh*) and Bone morphogenetic protein 2 (*Bmp2*) in the primordia of feathers, avian scales, and alligator scales is conserved and phylogenetically primitive to archosaurian integumentary appendages." For related research, see Gould *et al.* (1995), Noveen *et al.* (1995), Chia-Wei Chen *et al.* (1997), Noramly *et al.* (1999) and Cahoon-Metzger *et al.* (2001) on feather budding, and Duboule (1998) re Godwin & Capecchi (1998), Kishimoto *et al.* (2000), Sinha & Fuchs (2001) or Zhao & Potter (2001) concerning mammals. Research on the human side tends to relate to hair loss and how to stop it, Ben-Ari (2000). In the course of such work several variant forms of human hair keratins have turned up, Langbein *et al.* (1999; 2001).

[436] Michael Benton, "Four Feet on the Ground," in Gould (1993, 112). Similarly Radinsky (1987, 141-149) or Benton (1990, 228-231). Concerning illustrations, Hopson (1987, 18) used the cynodont *Thrinaxodon* and the modern opossum *Didelphis*. Benton, in Gould (1993, 96) and Norman (1994, 119) compared the early synapsid *Dimetrodon* with *Thrinaxodon* and the mammal *Morganucodon*. Colbert & Morales (1991, 230-233) chose the Late Permian therapsid *Lycaenops*, the advanced cynodont *Diarthrognathus*, and the opossum. Gamlin & Vines (1986, 107) showed reptile, therapsid, and mammal skulls, but did not specifically identify the species represented. Romer & Parsons (1986, 530) tracked the process back still further, showing the layouts of sarcopterygian fishes, early amphibians and therapsids. Futuyma (1998, 150) follows this layout, adding for confirmation the *Morganucodon* configuration (cf. note 398, Chapter Seven, on the sarcopterygian relation to early amphibians).

[437] Davis & Kenyon (1993, 120). Cf. Sunderland's similar jaw-jumping claim, note 414 above. Gish (1995, 164-166) had no ear layout pictures, restricting the illustrations to *Dimetrodon*, *Sphenacodon* and *Theriognathus*—all examples well back on the therapsid line of descent, rather than later forms relevant to the actual jaw-ear shift. (Had he cared to misidentify them, at least we knew Gish had a couple spare "mammal" labels.)

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[438] Müller's Fig. 13-1 explained the internal placement of the derivative features described in the body of the text, Müller (1996, 237-238). Testaz *et al.* (2001) is an illustration of recent work exploring the genetics of neural crest cell development.

[439] Although aware of the developmental aspects of the middle ear canals, Morris & Parker (1987, 64) missed the connection to the vertebrate jaw—as did Hanegraaff (1998, 203n) who relied on Parker secondarily, or Muncaster (1997, 7) with no references at all. The summary in Gish (1990, 86) veered closest: "The so-called gill slits in the embryo are in reality pharyngeal pouches that develop into the lower jaw, parts of the middle ear and certain glands." Cf. Gould (2002, 1108-1109) re Raff (1996, 343) on embryological neural crest rhombomeres migrating to form the pharyngeal arches, and MacDonald & Hall (2001) on issues of developmental timing.

[440] I thank Frank Sonleitner (personal communication) for calling my attention to the delayed character of marsupial jawbone growth. Since McGowan (1984, 139) and Hopson (1987, 18) mentioned the embryonic data, 1990s creationists (certainly Gish and Johnson) could theoretically have been aware of it. See Gould (1990) for some history, and Müller (1996, 129-131) or Rowe (1996) on the technical details. Kenyon (1994, 178), Pennisi (1999, 577), Shigetani *et al.* (2002), and Koentges & Matsuoka (2002) re Depew *et al.* (2002) track the progress of research into the genetics of vertebrate jaw evolution. A fossil sample of Meckel's cartilage has recently been found in several Cretaceous mammals, Wang *et al.* (2001). Cf. also Luo *et al.* (1995) and Luo (2001) on the evolutionary implications of current fossil data relating to the structure of the inner ear.

[441] The cursory treatments of Denton and Bird, the duets of the Morrises & Parker, and the coverage in Davis & Kenyon have already been noted. Sunderland (1988, 91-92) dismissed the mammal-like reptiles *sans* examples. YEC bumpkin Paul Taylor (1995, 43, 284) relied on Johnson (1991, 77-78)! Without otherwise commenting on it, Bert Thompson (1995, 214) obliquely listed "Mammal-like reptiles" (under the Carboniferous!) in a chart supposedly "based primarily" on Gould (1993). Meanwhile, Chittick (1984), Hayward (1985), Ross (1994; 1998), Hanegraaff (1998) and Wells (2000a) never mentioned them—nor (apart from the Wise ricochet noted below) did any of the antievolutionists in Moreland (1994) or Moreland & Reynolds (1999). The subject did arise when theology professor John Jefferson Davis took aim at respectively Young and Old Earth creationism: "Response to Paul Nelson and John Mark Reynolds" and "Response to Robert C. Newman," in Moreland & Reynolds (1999, 81, 139). Behe (1996) and Dembski (1999) avoided fossils altogether. As for the kabalistic physicist Gerald Schroeder, because he has decided the Bible classifies birds as reptiles he accepts *Archaeopteryx* as the only intermediate form. Otherwise, Schroeder (1997, 95) was certain that "In the entire fossil record, with its millions of specimens, no midway transitional fossil has been found at the basic levels of phylum or class." Relying solely on British Flood Geologist A. J. White, Milton (1997, 199) was more specific, announcing that "No fossil remains have been found" for mammal ancestors, even though "recognizing a transitional skeleton ought to be straightforward if, as Darwinists claim, mammals evolved from reptiles." See Numbers (1992, 327-328) on White's infighting with other British creationists less enamored of his Biblical literalism.

It is not unreasonable to suspect peripheral critics like Thompson or Milton overlook the therapsids because their limited reading never encounters the evidence directly. But as Gish acknowledged, this is hardly due to evolutionary shyness. Examples specifically targeted at creationism are Kitcher (1982, 110-114), Robert E. Sloan, "The Transition Between Reptiles and Mammals," in Zetterberg (1983, 263-277), McGowan (1984, 127-141), who devoted a whole chapter to it, and Strahler (1987, 413-420). Of critics of creationism in the 1980s I was able to survey firsthand, only Eldredge (1982), Godfrey (1983), Wilson (1983) and Hanson (1986) didn't feature some material specifically on the reptile-mammal transition. And, of course, the data existed independently of whether any critic of creationism elected to mention it, thus providing a dandy measure of creationist *curiosity*.

[442] Huse (1997, 89). No citations were offered to support Huse's statement, but he was presumably drawing on his wholesale mining of Luther Sunderland's bibliography (per note 355 above, Chapter Six).

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[443] Bandow (1991). The *Christianity Today* reaction began with the favorable review by Woodward (1991) that August. When the nominees for best Christian books of the year were listed in November (p. 40), *Darwin on Trial* was among those 45 listed on "Contemporary Issues." The April 6, 1992 issue (p. 41) announced that Johnson's work had tied for runner-up as Book of the Year (losing to a work critical of evangelical feminism). When Buckley welcomed Johnson on his PBS *Firing Line* series, they deconstructed some poor reasoning of their own in a leisurely round of softball questions-and-answers. It was through that interview that I first heard of Johnson and his book (at that time a dedicated *Firing Line* viewer, I've never been able to take Buckley so seriously since).

[444] Gould (1992, 120). While the presence of therapsid hair can be reasonably inferred, as noted above, the physical preservation of the hair itself would require a *Lagerstätte*. Regarding pterosaurs, recent finds suggest at least some of them had furred bodies as well, Wellnhofer (1991, 103-104, 163) or Monastersky (2001, 90, 102)—though Feduccia (1999b, 377-378) is doubtful. Even trapped in lithographic limestone, lactation and live birth would be extremely difficult to identify in any fossil.

[445] Johnson (1993b, 160-161). The full version of Johnson (1993a) appeared in the American Scientific Affiliation's *Perspective on Science and Christian Faith*, and is available both at the ASA website (asa3.org) and at Leadership U (leaderu.com/real/re9203/watchmkr.html).

[446] Gould similarly missed pressing home the therapsid point when he appeared on CNN's "Crossfire" series with Jerry Falwell in August 1999 (occasioned by the Kansas Board of Education's decision to remove evolution from their test curriculum). Since there was no indication that either moderator (Bill Press and Mary Matalin) or Falwell (or most of the audience) would have been aware of such macroevolutionary evidence, this would have been an excellent venue to acquaint the larger audience.

[447] Johnson (1993b, 208-209).

[448] Indicating more his own political interests than a measure of paleontological epistemology, Johnson's email likened the acceptance of the reptile-mammal transition by evolutionists to Marxists seizing on the exploitation of a few factory workers as confirmation of their general ideology.

[449] The original text of Johnson's *Scientific American* rejoinder fired both barrels at once: "The therapsid reptiles and Archaeopteryx are rare exceptions to the general absence of plausible transitional intermediates between major groups, which is why it is important to understand that even these Darwinist trophies are inconclusive as evidence of macroevolution." Johnson (1998b, 30) continues to claim that the reptile-mammal transition was some isolated phenomenon in the macroevolutionary history of life.

[450] Johnson (1997, 52). The "minor variations" concerned those seen in Darwin's Finches on the Galápagos Islands, where researchers like the Grants have documented abrupt shifts in morphology that could account for speciation there over only a few centuries. His 1997 remarks represent the latest installment in a chain that began with Johnson (1991, 25-27) re Futuyma (1982, 119), and expanded by Johnson (1995, 57, 71-73) dismissing Chadwick (1994) concerning the Pulitzer-winning Weiner (1994b). Johnson (1997, 87) was succinct: "Finch beak variation in no way denies that only God can make a bird." Although Pennock (1999, 103) remarked on Johnson's missing the point of Weiner's book, Johnson (2000, 47-48) did not specifically comment on that in his reprise of the "cyclical variation" argument. Milton (1997, 146-150), John Morris at the ICR website (BTG No. 72b), and Wells (2000a, 159-175, 307-312) field similar views, all reacting to Weiner. Morris evidenced his sloppier Creation Science scholarship, though, by describing Weiner's work as "a best-selling novel entitled, *The Beak of the Finches*." Cf. Gish (1995, 29) and Morris & Morris (1996b, 239).

See Larson (2001), Peter Grant (1991), Peter Grant & Grant (1992; 1994; 1997; 2002a,b), and B. Grant & Grant (1996) on the Galápagos and their finches. Mayr (1991, 5, 18-19) noted that the first islands' birds to fly the "fixed type" coop were a trio of mockingbirds (Darwin thought they were varieties until John Gould classified them as distinct species). Morphological studies relate the finches to several genera within a group of seed-eating birds, such as the West Indian

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Melanospiza richardsonii and the more common *Volatinia jacarina* of Central and South America noted by Weiner (1994a, 221). Morris & Morris (1996b, 238) did not mention any of the suspects when they cited Grant (1981, 661) on the finches, nor did Wells (2000a, 159, 162, 164) reflecting Grant (1991). Phillip Johnson, Richard Milton, the Morrises and Wells notwithstanding, genetic analyses have pressed the paternity suit through to the grassquilt genus *Tiaris*, Freeland & Boag (1999), Sato *et al.* (1999; 2001) and Burns *et al.* (2002).

Notes to *Chapter 9* (Testing, Testing, One, Two, Three)

[451] Johnson (1993b, 167) succinctly stated his position in the Epilogue to *Darwin on Trial*, and often repeated it at the 1998 Whitworth "Creation Week" symposium. Yet Johnson relied on this very distinction when defending Cambrian uniqueness in his June 18, 2001 "Weekly Wedge Update" at the Access Research Network website, where he argued there that "evidence that a gradual increase in animal diversity may or may not have occurred *after the Permian extinction* could have no bearing on whether the initial appearance of the animal groups hundreds of millions of years earlier was sudden or gradual." The *italics* were Johnson's. William Dembski snagged on this issue in a 2002 piece lampooning what he deemed "Evolutionary Logic" (arn.org/docs/dembski/wd_evolutionary_logic.htm), claiming (without example) that evolutionists referenced "irrelevant" sources, such as when "discussing the evolution of vertebrates and the article you cite is on the evolution of organisms in a completely different phylum or even kingdom."

[452] Wells (2000b, 21-22). A 2000 paper by Wells, "An Evaluation of Ten Recent Biology Textbooks And Their Use of Selected Icons of Evolution Evaluated" (available at the ARN website) gave many D's and F's for their coverage of such matters as the Cambrian Explosion. There were no quotations from any of the texts to clarify (or justify) the grades given, but I expected Wells would expand on his argument in *Icons of Evolution*. Unfortunately, Wells (2000a, 249-258) relegated the subject to a condensed appendix summary, leaving the ARN piece as his primary view. According to Wells, a text would earn a D on "Darwin's Tree of Life" thus: "assumes the truth of universal common ancestry without questioning it (and may call it a 'fact'); mentions the Cambrian explosion in the body of the text (briefly mentioning it in a note at the end of the chapter, without explaining what it is, is not sufficient), but does not discuss the problem it poses for Darwinian evolution." Wells gave the 1998 edition of Douglas Futuyma's *Evolutionary Biology* a D on this point—curiously so, since even the previous edition, Futuyma (1986, 325, 328), had specifically noted in the main text how the fauna "all appear fully formed, without intermediates connecting one phylum to another," and that this constituted "one of the great problems of evolution." Futuyma then cited several competing views on what might be going on.

[453] One should keep this pictorial incident in mind, as "bait and switch" is a persistent feature of Discovery Institute thinking on prehistoric life (where bacterial gene sequences may act as a stand-in for metazoan variations, just as the Cambrian Explosion substitutes for much later amniote diversification). But this needn't be the result of a conscious choice to be evasive, only a failure to conceptualize what a "type" or "kind" involves, or what a Darwinian "branching tree of life" would look like at the evidential level.

[454] See Raymond R. Rogers, "Ischigualasto Formation," in Currie & Padian (1997, 372-374). The site is part of a very small slice of Triassic time available in the region, as indicated by the stratigraphy chart in Fernando E. Novas, "South American Dinosaurs," in Currie & Padian (1997, 679).

[455] Though there is a case to be made for simple ignorance. Johnson (1991, 71) claimed that "Most of the evidence relied upon by today's Darwinists was known to Darwin's great contemporary, the Swiss-born Harvard scientist Louis Agassiz." Agassiz was born in 1807 and died in 1873. But almost all the strong evolutionary cases in the fossil record have turned up since then, from dinosaur taxa to the mammal-like reptiles at the turn of the century, to those Cretaceous birds and intermediate whales in the 1990s. For instance, see Stahl (1985, 399) on Agassiz apropos the

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fragmentary early mammal finds. And modern evolutionists do seem to pay a lot of attention to that DNA stuff, something else unknown in Agassiz's day.

[456] In a similar vein, Johnson (1993b, 157): "One thing I am not doing is taking sides in a Bible-science conflict. I am interested in what unbiased scientific investigation has to tell us about the history of life, and in particular about how the enormously complex organs of plants and animals came into existence."

[457] Phillip E. Johnson, "Foreward," in Moreland (1994, 8). For contemporary comparison, the Moreland anthology was roughly comparable in size to the sixteen contributions to a 1994 National Academy of Sciences colloquium on "Tempo and Mode in Evolution." But when it came to the range of paleontological and biological data being addressed, the Moreland fluff stood out in stark contrast to Ayala *et al.* (1994), Clegg *et al.* (1994), Doolittle & Brown (1994), Fitch & Ayala (1994a,b), Gould (1994d), Hartl *et al.* (1994), Hudson (1994), Knoll (1994), Lenski & Travisano (1994), Maizels & Weiner (1994), McHenry (1994), Niklas (1994), Popadic & Anderson (1994), Raup (1994), Schopf (1994a) and Valentine (1994).

[458] Kurt Wise, "The Origin of Life's Major Groups," in Moreland (1994, 226-228). The single citation was to "S. J. Gould and N. Eldredge, 'Punctuated Equilibria: The Tempo and Mode of Evolution,' *Paleobiology* 3, no. 2 (1977): 115-51." Farther off the deep end, Huse (1997, 148) averred: "Evolutionists insist that the duck-billed platypus is an evolutionary link between mammals and birds." Huse has been fielding this canard at least since the 1983 edition of his book (per the skeptical commentary at member.cox.net/ardipithecus/evol/lies/lie028.html). Cf. note 523 (Appendix III) on *vox populi* misunderstandings of what evolutionary descent entails (from both the creationist and evolutionist camps).

On the scholarly reference front, Ankerberg & Weldon (1998, 219) used only Wise's "stratomorphic intermediate" argument to dismiss the reptile-mammal transition, not even mentioning lawyer Phillip Johnson's account. YEC Paul Nelson & John Mark Reynolds, "Conclusions," in Moreland & Reynolds (1999, 97) also cited the article in *The Creation Hypothesis* ("a splendid book"), noting Wise "has a stronger knowledge of the contemporary geological record than many of his old earth critics." That Young Earth creationists like Nelson or Ankerberg were happy to see Wise included in the Moreland anthology only underscored the significance of why he was there at all. Like George McCready Price's invitation to be an expert witness at the Scopes trial, Wise was their only choice—there aren't any other creationist paleontologists. As for Wise's particular contribution, a parenthetical note: for those unfamiliar with lycopods (club mosses), Wise's reference sequence was presumably not to suggest they were morphologically intermediate between birds and amphibians. The Late Silurian *Baragwanathia* is not considered much of an intermediate form these days, as Rich *et al*. (1996, 374-375) noted; the Middle Silurian *Cooksonia* is regarded as more representative of primitive plants. See Lambert & The Diagram Group (1985, 38-39) for a summary of early vascular plant evolution, especially showing the change in leaf configuration, and Ryan (2002, 146-158) for an endosymbiotic perspective on *Cooksonia* and company.

[459] Norman (1994, 59).

[460] Margulis & Schwartz (1988, 216-218). Cf. Lambert & The Diagram Group (1985, 54), Eldredge (1991a, 101-102), Rich *et al*. (1996, 239) or Ellis (2001, 54-55). The evolution of the cephalopod body plan from a monoplacophoran-like ancestor apparently involved recruiting existing *Hox* genes in novel contexts, Patricia Lee *et al.* (2003). How creationists will work around the monoplacophorans remains to be seen. Morris & Morris (1996b, 114) mentioned *Neopilina* only as a "living fossil." They didn't figure in Gish (1995, 63, 68) when he cited several scientific studies to the effect that modern mollusk shells are "intimately integrated" with their internal anatomy to have evolved, but didn't elucidate what that entailed. Gamlin & Vines (1986, 76) explained that body coverings restrict gas exchange, meaning gills and an oxygen distribution system have to exist for that to work, but those features are known in their unshelled cephalopod cousins.

See Whitfield (1993, 84-86) for the general evolutionary reasoning behind the view that mollusks (shelled and unshelled) ultimately derived from a basic body plan, itself a variant on the

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flatworm layout. That the metazoan molluscs trace back to the Precambrian has recently been supported by over 35 new fossil specimens of *Kimberella* found in Russia, Fedonkin & Waggoner (1997). Based on earlier less detailed material from Australia, the unshelled animal had formerly been taken for perhaps a jellyfish, though McMenamin (1998, 238) still considers the new finds "no animal at all but rather a series of cell families spread out across a bedding plane surface." Cf. Erwin & Davidson (2002, 3023-3024). Walker (2003a, 213-215) notes newer evidence relating trace fossils to *Kimberella*, which would suggest a more complex metazoan locomotion for it.

[461] Colbert & Morales (1991, 240-241). Subsequent discoveries have pushed monotreme origins back to "an australosphedian clade endemic to Gondwanan landmasses" during the Jurassic and Early Cretaceous, Luo & Cifelli *et al.* (2001). Cifelli (2001, 1217-1218) and Luo *et al.* (2002, 17-19) cover the larger issues of monotreme phylogeny. Recently John Jefferson Davis, "Response to Robert C. Newman," in Moreland & Reynolds (1999, 139-140) picked up on Colbert & Morales' observations on the intermediate character of the monotremes. Similar views are presented in Stahl (1985, 436-438), and McGowan (1984, 140-141) noted that the monotremes' metabolism is also intermediate, running below marsupials, in turn under the placental rate. Not that monotremes have remained evolutionarily static, as Gould (1991, 269-293) recounted in two illuminating essays on the senses and brain anatomy of the living platypus and echidna. The monotremes appear to have originated prior to the mammalian Y sex chromosome falling under regulation of the SPY gene around 170 million years ago, Zimmer (2002c) on work reflected by Marshall Graves (2002). Cf. John & Surani (2000) on monotreme genetics, and Disteche (1999) re Carrel *et al.* (1999), and Vogel (1999) re Lahn & Page (1999) on the dynamics of the X and Y chromosome (issues of relevance to tracing human origins).

Incidentally, Gish (1995, 150) cited an earlier edition of Colbert (one containing the quoted monotreme anatomical information) but did not allude to it when he attempted to sidetrack the platypus on the grounds that it lived too late to be a mammal ancestor. Gish (1995, 179) now reads somewhat more accurately, "The fossil record of these creatures is extremely scanty and restricted to Australia." Though as Gish (1995, 114, 199) cited Lee (1994) and Gould (1994c) from the next issues of *Natural History*, he could theoretically have been aware of Michael Archer (1994), which reported on the latest monotreme fossil finds (including some 62 Ma teeth from early Cenozoic Patagonia). Platypus fossils remain rare though, Hall (1999, 213-214). Concerning an earlier edition of Gish that noted no monotreme fossils were then known, Strahler (1987, 458) suggested: "Let the creationists continue to search for living dinosaurs in the Congo basin and let the mainstream paleontologists continue to search for fossils of monotremes in Mesozoic and younger strata. Let's see who succeeds first!" No extant African dinosaurs have turned up, however, and Gish (1995) did not comment on the prescience of Strahler's wry challenge. Cf. Fairley & Welfare (1998, 35-38) on African dino lore. Meanwhile, Morris & Morris (1996a, 209-210) referred to "the numerous native accounts of a brontosaur-like animal in the swampy interior of the Congolese rain forests," and cited for this nugget: "See *Science* (November 1980), p. 6-7." Although the back cover blurb pronounced the volume "fully documented," there was a snag here: *Science* is a *weekly* journal, meaning there is no "November 1980" issue—and no such article appeared there during the month in question anyway. Just in case the Morrises had left off "Digest" from the citation, I checked *Science Digest* too—but nothing there either.

[462] Denton (1985, 109-110).

[463] See the March 2003 *Commentary* Letters (p. 24), Berlinski citing Woodmorappe (2001a). Cornelius Hunter (2001, 40-41) has also taken a whack at the evolutionary use of cladism, claiming that independent analyses of molecules could not provide "strong support" for common descent because the technique could also be applied to objects, like cars, obviously not related in a genealogical sense. Hunter reasoned hypothetically that "data from automobiles disguised as molecular data" would be fitted into an imaginary evolutionary framework—and even "given random, uncorrelated data," the evolutionist would merely waffle "that the maximum parsimony model was a bad assumption because the molecular evolution was too fast." Hunter's presumption that designed systems would mimic the hierarchical relationships of natural lineages remains to be seen (cf. note 252 above, Chapter Three). The steel, plastics and paints used by given car

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manufacturers would not possess differential mutations that track independently to common origins, as natural molecules tend to do. New components would be restricted to makers and particular model years, showing the same cladistic values no matter how the models were shuffled to fit an "evolutionary" framework. As for purely random data sets, Hunter did not seem aware that cladistic studies already take into account such comparisons—for example, Fedorov *et al.* (2003) checked against literally tens of thousands of random sets to measure the significance of intron placement in relation to ancient gene boundaries.

[464] Woodmorappe's 1996 book *Noah's Ark: a Feasibility Study* is currently out of print, but informative exchanges exist between Woodmorappe (rae.org/pagesix.htm) and critic Glenn Morton (at calvin.edu/archive/evolution/199607/0167.html). Although Morton is a devout Christian (but ex-creationist), Woodmorappe started off by declaring that "Morton is attacking the very Word of God" and quoted Martin Luther fulminating about similar "criminal monsters" who attacked Scripture. Whether such umbrage falls under the same category as Luther's considerable anti-Semitism, as noted by Hill & Cheadle (1996, 20) or Walters (2001, 55-61), is debatable. But it does suggest how ill prepared Woodmorappe is to permit other interpretations of the Bible, let alone temper his particular Noachian conclusions by contrary evidence.

[465] My Talk Reason criticism of Berlinski was alluded to above in note 75 (Prologue), and our correspondence on those issues (and David's considerable and persistent support) ultimately resulted in this present volume. Which may be chalked up as another of the ironies of life.

[466] The text is presented as the concluding sentiment at discovery.org/crsc/ (as of this writing, August 2002). See note 73 of the Prologue on the group's name change.

[467] Chittick (1984, 115): "Rejection of creation and acceptance of evolution started a general moral decline, and it has affected science as well. Science began to die." Gish (1993, 43-44) offered medicine as one of three instances where "evolutionary theory has retarded progress in science"—that may be compared to Nesse & Williams (1998) on Darwinian medicine. Muncaster (1997, 6) went so far as to declare that "informed microbiologists now almost unanimously <u>reject</u> *Macro*evolution." (What, he's conducted a survey?)

Over on the ID side, Behe (1996, 231) promises that "intelligent design will be a useful tool for the advancement of science in an area that has been moribund for decades." Such exuberance presumably inspired Hunter (2003, 122) to insist that "evolutionary theory, not ID, stifles research." J. P. Moreland, "Response to Robert C. Newman," in Moreland & Reynolds (1999, 143): "Various Christian and non-Christian scholars have claimed that evolutionary theory is in a period of crisis precisely because it is a dead-end research program if judged by its fruitfulness." Moreland's resources for this consisted of Denton (1985) and Moreland (1994), which coincidentally just spanned the time between when Denton described the implausible whale intermediates and their unfortunate discovery in Pakistan by those "dead-end" evolutionary paleontologists (see note 248, Chapter Three).

Notes to Appendix I (*A Brief History of Creationism*)

[468] Larson (1985, 30-39; 1997, 33-39). See also Gould (1991, 416-430) on "William Jennings Bryan's Last Campaign." Further fueling the disquiet of postwar Biblical traditionalists was the fact that "higher criticism" of the Bible had begun among *German* scholars, thus allowing the conflation of pacifist xenophobia with fears about materialist assaults on the godly American way of life. Although the German element has understandably faded in importance in the decades since, conservative Christian analysts like Thomas & Farnell (1998) continue to relate the practice of Biblical criticism to underlying evolutionary presumptions.

[469] Larson (1997) is the new benchmark for the Scopes trial, garnering a Pulitzer Prize; Larson (1985, 58-72), Ecker (1990, 173-176) and Randy Moore (1998a,b) provide condensed coverage.

[470] An ironic twist to the timing of Bryan's death: Larson (1997, 38-39) noted that "the aging Commoner moved to Miami for his wife's health and got in on the ground floor of the historic Florida land boom of the early twenties. Although publicly he played down his profits, the

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spectacular rise in land prices made Bryan into a millionaire almost overnight." Bryan did not live into the following year 1926, when a devastating hurricane burst the Florida real estate bubble (giving another meaning to "Inherit the Wind"). Bryan's arguments track positions that have remained perennial creationist favorites, as noted by Pigliucci (2002, 19-27, 303-325) commenting on Bryan's final antievolution speech, reprinted *in toto* as an appendix.

[471] See Grabiner & Miller (1974), John R. Cole, "Scopes and Beyond: Antievolutionism and American Culture," in Godfrey (1983, 22-23), Larson (1985, 84-88), Eve & Harrold (1991, 27) and Randy Moore (2001a). The downplaying of "evolution" in American science education extended into mid-century, as Gould (1999a, 139) and Kenneth Miller (1999, 10-11) recalled from personal experience. Cf. the 1961 essay by paleontologist George Gaylord Simpson, "One hundred years without Darwin are enough," excerpted in Mark Ridley (1997, 369-378), with Randy Moore (2001b; 2002).

Incidentally, Gould (1991, 428-429) noted the Scopes textbook, *Civic Biology* (1914) by William Hunter, made the "egregious claim that science holds the moral answer to questions about mental retardation, or social poverty so misinterpreted." Larson (1997, 23) likewise reminded that the view of "Darwinism" being promoted in early 20th century American biology texts "was decidedly anthropocentric and heavily laced with the scientific racism of the day." Alas, it took a lot longer to expunge those faulty interpretations from social science and popular culture than to excise references to Darwinian evolution.

[472] Toumey (1994, 23-24) describes the 1950s milieu. The BSCS project is still very much active, by the way, as noted by Witham (2002, 74-79).

[473] During this period arch-skeptic Martin Gardner (1957, 123-139) dissected Price and Rimmer as one might extinct life forms. Coming himself from a deeply religious background, Gardner had been impressed by Price in his youth, but that failed to survive a dose of college level geology. Ravitch & Finn (1987, 66) noted that a disconcerting 62.8% of students surveyed didn't know what the Scopes trial was about. Unfortunately, they still might not get an accurate picture if all they relied on was *Inherit the Wind*, since both play and film took considerable dramatic liberties with the trial, Moore (1999e). William Jennings Bryan being a Day-Age believer, the fictional Brady's affirmation of literal 24-hour creation days was clearly an exaggeration. Likewise, the fairly sympathetic views Drummond on the defense expressed towards the Bible as philosophy contrasted with the uncompromising atheism and determinism of the real Clarence Darrow. All this has proved grist for social conservatives, such as one website (bible.ca/tracks/textbook-fraud-scopes-trial-inherit-wind.htm) which labeled the film "Intellectual Pornography!"

The chapter Johnson (1997, 24-36) devoted to setting the record straight on the historical inadequacies and larger social impact of *Inherit the Wind* was only somewhat less effusive. Johnson (1997, 121) cited Larson (1997) as his primary source, along with the shorter Iannone (1997). Like Johnson, Iannone dissected the play's content without relating it to its historical context (the conformist 1950s McCarthy era). Incidentally, Iannone offered Phillip Johnson as her primary defense for the contention that "the proof for Darwin's theory remains spotty." Both Iannone and Johnson skirted the thorny topic of Biblical analysis, not venturing which Scripture (if any) being thrashed over by "Brady" and "Drummond" qualified as historically valid. As for the sort of pseudoscientific arguments actually offered by Price or Rimmer back in the 1920s, Johnson has consistently restricted his commentary to such vagaries as "some creationists really have made crazy arguments," Johnson (1997, 41).

[474] Toumey (1994, 49). Like it or not, stochastic (random) effects pervade biological processes—see Smolen *et al.* (1999), Azevedo & Leroi (2001) contrasting McAdams & Arkin (1997) and Britten (1998), or Fedoroff & Fontana (2002) re Elowitz *et al.* (2002). Interestingly, a deterministic orderliness can emerge from the underlying genetic "noise" via "stochastic focusing," Paulsson *et al.* (2000) and Berg *et al.* (2000). See also Kepler & Elston (2001), Swain *et al.* (2002) and Sasai & Wolynes (2003) on theoretical modeling. The downside: such leaky randomness can also be exploited by pathogens or otherwise lead to disease, Arkin *et al.* (1998) and Cook *et al.* (1998).

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[475] See Ecker (1990, 79), Shermer (1997, 154-172) and Randy Moore (1998c,d; 1999a) on Epperson *v.* Arkansas; Larson (1985, 98-119) also covers the state adjudications leading up to the federal case. Larson noted Black's rural Alabama Baptist background may have influenced his differing opinion. Sharing the populist Democratic tradition with Bryan, Black had been elected to the Senate with strong support of the KKK (whose very long list of things they didn't like included evolution). Cf. Hamburger (2002, 422-434, 454-476). Larson (1997, 250-257) further relates the case to the Scopes mythos, noting that Abe Fortas ("a working class Jewish boy growing up in the Baptist citadel of Memphis") was a high school student during the 1925 Dayton trial. "Fortas dearly wanted to decide the Epperson case, and did so as one of his last majority opinions before a financial scandal forced him from the bench," Larson (1997, 254).
[476] Toumey (1994, 49).
[477] Toumey (1994, ix).
[478] Besides the comprehensive account in Numbers (1992), see Eve & Harrold (1991, 120-135) for clear passage through the forest of creationist organizations, in and out of the Morris preserve.
[479] See Eve & Harrold (1991, 146-160) for a general survey, and Lloyd Bailey (1993, 202-204) for a short catalogue of specific state efforts.
[480] See Edwords (1982a), Ecker (1990, 133-138) and Randy Moore (1999b) for a discussion of the court challenge, McLean *v.* Arkansas. McKown (1982) explores the role of Wendell Bird's convoluted definitions in the Arkansas case, and Eldredge (1982, 86-87; 2000, 93-94) compares Bird's 1978 ICR summary of Creation Science beliefs with the very similar language of the Arkansas Act 590. Participants on both sides have offered commentary, from philosopher Michael Ruse, "A Philosopher's Day in Court," in Montague (1984, 311-342) to Gilkey (1985), a liberal theologian with considerable misgivings about the proposed law's implications for religion. Gilkey and Hanson (1986, 189-213) included the full texts of the statute along with Judge Overton's ruling, and the ruling solo appeared in Wilson (1983, 206-222) and Montague (1984, 365-397). Although affirming literal Biblical creation at the trial, Donald Chittick (1984, 253) discussed neither the details nor the ruling except to castigate the news media for its "distortions" of the case (none of which he enumerated). He referred the reader instead to "a fairly thorough documentation of this" by another of the creation witnesses, Dr. Norman Geisler of the Dallas Theological Seminary, in his book *The Creator in the Courtroom*. The Geisler is currently out of print, though McIver (1988a, 2; 1988b, 85) suggests it is useful but flawed.

Geisler achieved some notoriety at the trial when he revealed UFOs were "a satanic manifestation in the world for the purpose of deception," and that he had gleaned this intelligence from that authoritative compendium, *Reader's Digest*, Gene Lyons, "Repealing the Enlightenment," in Montague (1984, 358), and Gilkey (1985, 76-77). Cf. McIver (1987, 9). Creationist physicist Robert Gentry (1986) sprinkled discussion of his and other testimony through his book, which is primarily a defense of his "polonium halo" claim for a young earth.
[481] Larson (1985, 160). Of those testifying for the creation model, Berra (1990, 134-136) noted half were members of the Creation Research Society (five in number, including Chittick). Wickramasinghe's better-known antievolutionary colleague is the late physicist Sir Fred Hoyle, whose barricading of Steady State cosmology from the encroaching Big Bang hordes is also pressed into service by Young Earth creationism. Rather disingenuously, Morris & Morris (1996b, 190) remarked that Wickramasinghe "was even willing to testify for the creationist side at the creation law trial in Arkansas in 1981." There were no references, and the Morrises did not explain to their readers that Wickramasinghe did not support the ICR version of creationism.
[482] The Edwards *v.* Aguillard case is discussed in Ecker (1990, 72-76) and Randy Moore (1999c,d). Larson (1985, 147-163) wrote prior to the 1987 Supreme Court ruling, but did describe the concurrent Arkansas and Louisiana legislative efforts in some detail, including Wendell Bird's more active involvement in the latter case. Cf. also Ruth Brown (2002, 226-233) on creationism efforts in Tennessee.
[483] Stuart Hughes (1983) and Eve & Harrold (1991, 9-10).
[484] While Denton (1985) was primarily a defense of what turned out to be an unworkable typological conception of life, Denton (1998) has moved to the more general "anthropic" argument

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that the universe was fine-tuned for human life. This grades into a Platonic streak, whereby Denton & Marshall (2001) and Denton *et al.* (2002) investigate how protein folding reflects inevitable constraints. It remains to be seen whether such mechanistic properties will provide much comfort for the religious members of the design movement looking for signs more distinctive of a beneficent Designer.

[485] Eve & Harrold (1991, 3).

[486] Toumey (1994, 240-245).

[487] Toumey (1994, 231-237), who noted that Jerry Falwell entertained a career in engineering before heeding the call to evangelism. See also Ecker (1990, 77-79), and John W. Patterson, "An Engineer Looks at the Creationist Movement," in Zetterberg (1983, 151-161). Numbers (1992, 233) related why horticulturist Walter Lammerts expelled compatriot R. Laird Harris from the Creation Research Society in the mid-1960s as a heretic: "Harris not only opposed the majority view of a literal six-day creation but, worse yet, earned his living mainly as a theologian, a professional type Lammerts held in low esteem." Interestingly, Boyer (1992, 304-305) identified a similar science/engineering background and aversion to theologians among recent prophecy writers. Eldredge (1982, 16-17) recognized the populist streak underlying modern creationism, though that feature has followed an exclusively conservative trajectory in the decades since. While populists from the left and right are perfectly capable of intersecting over specific issues (as Ralph Nader and Pat Buchanan did recently in their surreal joint opposition to free trade legislation), antievolutionism appears not to be a unifying theme for those intractably suspicious of Big Business or Big Government.

[488] Eve & Harrold (1991, 126, 132).

[489] Numbers (1992, 308-314). "An official church position on the age of the earth (or the processes by which it was created) does not exist," according to Newell (2000, 14), and Witham (2002, 176-177) notes BYU teaches evolution. Cf. Ruth Brown (2002, 76).

[490] See Eve & Harrold (1991, 145, 201-202n) on the Willoughby matter. Awash in controversy over its paranoid abhorrence of ex-Scientologists and mainstream psychotherapy, so far the Church institution hasn't ventured into the creationist fray, although a series of cable channel commercials for Hubbard's books (caricaturing a shrill evolutionary lecturer) aired some years ago hints there is nothing doctrinal to stop them. Gardner (1957, 263-280) described the therapeutic inadequacies of Hubbard (1950), and there is a litany of criticism of its religious mode: Paulette Cooper (1971), Godwin (1972, 76-99), Evans (1974, 17-134), and for meringue, Randi (1980, 246-248). Rowley (1971, 42) described Scientologists he encountered back then as "people very on the ball, people very efficient, people always smiling in a forced way, people ludicrously nasty, people charming, suspicious, likable, touching, beautiful."

[491] Deloria (1973; 1974; 1995; 1999; 2002).

[492] Cremo & Thompson (1993). See note 19 (Introduction) for more on their book and Phillip Johnson's connections to it.

[493] "Harun Yahya" is the pseudonym of Turkish creationist Adnan Oktar. Although originally inspired by the ICR, the harunyahya.org website has kept up with the times by incorporating Michael Behe in his fusillade of antievolutionary arguments, to the glorification of Allah (see also note 341, Chapter Five, concerning Alan Feduccia). There is also a more unsettling element of anti-Semitism and Holocaust revisionism to Harun Yahya, as noted by Michael Hopkins at talkorigins.org/faqs/organizations/harunyahya.html. Taner Edis, "A World Designed by God: Science and Creationism in Contemporary Islam," in Kurtz *et al.* (2003, 120-124) puts Oktar and his followers into a social and political context: conservatives as upset at the secular thrust of Turkish public policy as their American creationist counterparts. Oktar has also benefited from support by Islamists in the Education Ministry. This *Kulturkampf* aspect has been the chief interest of Harun Yahya, which has paid scant attention to Flood Geology or affirming Genesis accounts.

There is a scattering of Young Earth creationist offshoots around the world, noted by Strahler (1987, 472), Numbers, "The Creationists," in Ruse (1988, 248), Numbers (1992, 323-335), MacKenzie (2000, 38), Koenig (2001) and C. Brown (2002, 110). The listing of 100 "Creation Science Organizations" by Scott Huse (1997, 174-183) had 71 for the United States and 21 for

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Britain, Canada, Australia, New Zealand and South Africa—the remaining 8% were represented by one each for Brazil, Germany, India, Korea, Mexico, Netherlands, Spain and Sweden.

[494] This is a pitfall which William Dembski briefly took note of when appearing on Hank Hanegraaff's "Bible Answer Man" radio show in August 2001, commenting on UFO believers who pick up on ID reasoning. To forestall such things was why Dembski staked out his Christian position in *Intelligent Design* (a 1999 book offered as a contribution bonus by Hanegraaff's ministry).

An example of what Dembski could be worried about would be the website of fledgling British antievolutionist Tim Harwood. His website (closed at the time of this writing, but originally at geocities.com/Area51/Rampart/4871/index.html) might have seemed conventionally ID by recommending Denton (1985), Johnson (1991) and Behe (1996). But the presence of UFOs and Milton (1997) signaled a different set of priorities. Harwood embraces Rupert Sheldrake's morphogenetic fields, by which "consciousness" somehow guides the course of macroevolution rather than stuffy adaptive micromutations. See Sheldrake (1998; 1999, 301-317; 2001; 2002) on how he views the potential importance of "morphic fields" in understanding the organization of life, and van Genderen *et al.* (2002a,b) for critical takes. Interestingly enough, Denton (1998, 365, 440n) offers Sheldrake along with Lyall Watson's highly dated *Supernature* as suggesting "that life may be more than our current science admits." Which would presumably include Watson (1973, 49-68) on the "scientific" astrology of Michel Gauquelin (1967; 1970; 1983). As for Phillip Johnson's Wedge plan to soften up recalcitrant materialists for Christian revival, Harwood seems an unlikely prospect (in a recent email to me, he described Johnson's religious goals as "misguided").

The weird Raelian cult (prweb.com/releases/2002/11/prweb50443.php) also wholeheartedly endorses ID theory—though the "designer" they have in mind is extraterrestrial. Aliens informed their leader "Rael" in 1973 that he was actually God's second effort at personal procreation, and thus Jesus' half-brother (though Jay Leno thought the robed former racecar driver resembled more "a pimp on the Jetsons"). See Pennock (1999, 234-242, 250, 276) for a comparison of the Raelian movement with creationism. The Raelians' plan to engineer a successor race to humans briefly brought their "Cloneaid" operation into the news late in 2002 when its CEO Brigitte Boisselier claimed they had successfully cloned a human baby.

[495] See Barbara Forrest's "The Wedge at Work: How Intelligent Design Creationism Is Wedging Its Way into the Cultural and Academic Mainstream" (at talkreason.org/articles/Wedge.cfm), a reprint with updates of her chapter in *Intelligent Design Creationism and Its Critics* (MIT Press, 2001). The Wedge agenda has been gradually dribbled out in Johnson (1993c; 1995; 1997; 1998a,b; 1999; 2000; 2002). But addressing Rev. D. James Kennedy's "Reclaiming America for Christ Conference" in 1999, Johnson more explicitly acknowledged the evangelical thrust of the Wedge campaign (aired later on Kennedy's Coral Ridge Ministry radio program in March 2000). Most problematic on the ID ecumenical landscape may be Michael Behe (Roman Catholic) and Jonathan Wells (a minister in the Unification Church)—denominations not held in high esteem by evangelical Protestants orbiting D. James Kennedy or Hank Hanegraaff. Cf. Pigliucci (2002, 44-45) on Wells.

[496] Bork (1996, 294). In his highly critical 1997 review of Behe's book for *Boston Review* 21(6):28 (available online at bostonreview.mit.edu/br21.6/orr.html, with responses by Behe, Phillip Johnson, and others) evolutionary biologist H. Allen Orr remarked: "Revealing his expertise on such things, Bork misidentifies Behe as a 'microbiologist,' not a biochemist." The review may also be found online at the "Talk.Origins Archive" website (talkorigins.org), a most useful clearinghouse for information on the creation/evolution controversy, with many links to sites pro and con. Interestingly, the anthropically-minded physicist Stephen Barr (2003, 110) identifies Behe as a "molecular biologist."

[497] Behe (1996, 5), where he stated "I find the idea of common descent (that all organisms share a common ancestor) fairly convincing, and have no particular reason to doubt it." He then thought no more about it. As *Darwin's Black Box* appeared the same year as Bork's own book, doubt may

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be raised about just how thoroughly the Supreme Court nominee could have digested its technicalities before deploying its "compelling argument" against evolution.

[498] See Strahler (1987, 528), McKown (1993, 153-155) and Randy Moore (1999d, 179) on Scalia, and Ecker (1990, 74) regarding Rehnquist. While the Rehnquist court inherited some rather flexible precedents when it came to separating church and state, Norman Redlich, "The Religious Clauses: A Study in Confusion," in Herman Schwartz (2002, 99-114), their application in the creationism venue has suffered from the limited understanding of the dissenting Justices. Gould (1991, 450-460) noted that Scalia's dissent was founded "in large part, upon a misunderstanding of science"—specifically, a persistent conflation of "evolution" with "how life began," rather than as the study of what has happened to life once it did appear (by natural or supernatural means).

While Wendell Bird (1989, Vol. 2, 445) quoted the Scalia/Rehnquist dissent with evident approval, fellow lawyer Phillip Johnson (1997, 54, 125) went beyond favoring Scalia's view to offer a Bork-style complaint about "the 'Darwin fish' bumper stickers" on their cars. Johnson expressed similar umbrage later that year when he waved one of the Darwin tetrapods about during the "Firing Line" evolution debate. Ditto Johnson (2000, 82): "Why else would persons who want to mock the Christian fish symbol choose to decorate their automobile bumpers with a fish with legs?" Farther afield, the protagonist of Christopher A. Lane's 1999 creationist novel *Tonopah* (Zondervan press, p. 144) characterized a "Celebrate Diversity" bumper sticker and the Darwin medallion as "statements against Christianity—against God himself."

By way of historical context, the "Darwin fish" appeared when literal Creation Science criticisms of evolution were at their height, and the people most likely to be campaigning for equal time for creation in public schools were conservative Christians liable to sport the fish symbol. The satirical quality of the Darwin tetrapod reminds me of a bumper sticker many years ago, advocating the ultimate in geographic self-determination: "Reunite Gondwanaland" (the southern half of the Pangea supercontinent, since fragmented into South America, Africa, Australia, and Antarctica). The creation/evolution bumper sticker war has continued apace, Johnson or Lane notwithstanding. A creationist one labeled "Survival of the Fittest" shows a larger fish explicitly labeled "Jesus" devouring the Darwinian rival—and one on "Survival of the Forgiven" has an "IXΘYE" fish about to swallow the fleeing (and obviously disconcerted) "Darwin" critter. There are also medallion versions where the fish is identified variously as "Jesus," "IXΘYE," or "Truth."

Notes to Appendix II (*The Lunar Dust Myth*)

[499] Henry Morris (1985, 151-153).

[500] A copy of the magazine ad may be seen on p. 37 of the Summer 1981 issue of *Creation/Evolution* (available online via ncseweb.org).

[501] Henry Morris (1972, 92).

[502] Since 182 feet is about 55 meters, Morris' 54 "feet" may have come from conflating English and metric. This may be compared to Richard Milton's brontosaur dimensions noted in the Introduction.

[503] NASA's Space Geodesy Program keeps track of both plate movement and land elevation changes, with current readings available online via lupus.gsfc.nasa.gov/vlbi.html. Cf. Tanya Atwater, "When the Plate Tectonic Revolution Met Western North America," in Oreskes & Grand (2001, 259-260). A typical technical article in this field would be Antonelis *et al.* (1999) on Pacific-North American plate motion.

The details of plate tectonics can be found in almost any contemporary geology source, such as Emiliani (1992, 234-253). Oreskes & Grand (2001) assemble a concise history of the development of plate tectonics, told from the perspective of the scientists involved. Strahler (1987, 200-214) covers it in relation to creationist theories. For perspective, the fastest plate motion is several centimeters a year, about the rate your fingernails grow. Since the earth's surface area remains a fixed value, it is possible at least to infer the extent of what pieces are missing from any given geological epoch. A map of the Cretaceous earth in Dingus & Rowe (1998, 54), for example,

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indicates about half of the seafloor has been lost since then via subduction (see also notes 162-163 above, Chapter Two).

Without bothering with scientific citation, Henry Morris (1985, 128, 156) held out hope that the pendulum was starting to swing back again, and geology would abandon continental drift after all. Morris & Morris (1996b, 269-273) have persuaded themselves that the pendulum has indeed swung, confidently declaring that "the whole concept of plate tectonics now is under a cloud." Cf. Deloria (1995, 39-40): "Inconsistencies abound, but we are so brainwashed by science that we do not even ask the relatively simple questions about ordinary things. We have shifting continents attached to sliding gigantic 'plates' and we also have continents rising and falling to allow for the deposition of limestone and marine sediments. Exactly how both processes can occur at once is not clear, and it is only our trained belief that an infinite amount of time has passed that allows both processes to be held as literal truths." Deloria (2002, 96, 106-107) has backpedaled somewhat on this theme.

[504] Pettersson (1960).

[505] Relevant space experiments didn't stop in the 1960s, of course—but recent data, such as from the orbital Long Duration Exposure Facility (LDEF) platform, simply confirm the low rate. Because only particles smaller than 10^{-7} grams can drift down intact, rather than being burnt up in the atmosphere, the amount of meteoric dust that actually makes it to the surface is lower still. Dalrymple (1991, 207-208) estimates 88 x 10^4 kg (970 tons) of meteoric material is deposited this way earth each year, a value physically confirmed by deep-sea sediment cores.

[506] McGowan (1984, 87), Kenneth B. Miller, "Scientific Creationism versus Evolution: The Mislabled Debate," in Montague (1984, 41-45). A typographical error in Miller left minus signs off two exponential values, but the context made the omission evident. See also Awbrey (1983) and Shore (1983)—and cf. Strahler (1987, 143-145) and Pennock (1999, 221-224) with old-earth creationist physicists Hayward (1985, 141-143) and Ross (1994, 105-106).

[507] Henry Morris (1985, 152). Interestingly, the critique of old earth dating in Morris & Morris (1996b, 320-335) did not include the meteoric dust claim—but the section in *Scientific Creationism* where it was discussed did come up among the sources recommended apropos "the *scientific evidence for recent creation*" (p. 332).

[508] The Talk.Origins Archive summary (matson-vs-hovind.html, p. 6) indicates the 200-million-ton figure was a secondary miscalculation. As for Morris' evident transposition of Hawkins' "1976" report date, it was interesting Duane Gish was able to spot such things in evolutionary text. When biogeologist Preston Cloud criticized the remarks on the suddenness of the Cambrian Explosion Gish made in a pamphlet "Have You Been Brainwashed?" Gish (1993, 124) objected that he should have cited "my more authoritative book, *Evolution? The Fossils Say No!*" Gish noted that "the book was available to Cloud at the time is obvious, since he included a reference to it in this publication (p. 141), erroneously giving its publication date, however, as 1937."

[509] The presumed river influx rates for a variety of elemental ocean constituents were given in a short list in Henry Morris (1985, 154), and more extensively in a chart of the "Indicated Age of the Earth" in Morris & Parker (1987, 288-291), where Morris' own *Scientific Creationism* was cited on the meteoric dust entry to suggest the age of the earth was "too small to calculate" and creationist Harold Slusher supplied that surface dust dated the moon to only 200,000 years. To further confound the issue of sources, Morris & Parker (1987, 266) cited a 1970s evolution textbook (not currently in print) which *mentioned* the meteoric dust accumulation problem, though without stating whether any arguments were offered critical of it nor what rates were involved. The influx values were all over the map (from 500 million years for volcanic crust formation down to 100 years for aluminum); Hayward (1985, 145) noted that the value given for the age of the earth derived from plutonium decay (80 million years) was actually just the *half-life* of a plutonium isotope. Instead of concluding how unreliable such datings are without knowing all the biological and transport processes that might affect the calculation, Morris attributed this range to the error of "uniformitarian assumptions" and forged ahead to conclude they indicated a young earth, Morris & Parker (1987, 286). Kenneth Miller (1999, 64-66) reminded readers just how absurd the Creation Science position is on this dating game.

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[510] Wendell Bird (1989, Vol. 2, 334) and Paul Taylor (1995, 17-18, 70-72) juggled both opinions at once, sidestepping the flimsy underpinnings of the lunar dust claim. Snelling & Rush (1993) bit the bullet for "Answers in Genesis" by rejecting all efforts by fellow YEC believers to prove a young earth or moon via dust influx rates (their piece is available at the AiG website: answersingenesis.org/home/area/magazines/tj/moondust(v7n1)/moondust.asp). Despite such caveats, though, the Lunar Dust claim is still repeated at the grassroots level, as recently as in the "public comments" section on the Working Draft (September 4, 2003) of the Minnesota Academic Standards Committee's proposed science curriculum (available at this writing via education.state.mn.us).

[511] McGowan (1984) was in Gish's bibliography, but he cited it only once, Gish (1993, 163), for a quote concerning the argument that evolution somehow violates the 2nd Law of Thermodynamics.

[512] There may have been an element of "mutual admiration society" here. Morris contributed a Foreward to Gish (1993, vi) in which he stressed that "no one is better qualified" to respond to evolutionists than Gish. "His opponents cannot produce scientific evidence for evolution for the simple reason that there isn't any!" Gish (1993, 13) in turn described Morris as one of the "voices of scientific reason."

[513] DeYoung (1989, 33-34).

[514] In the 1992 video appearance, Gish referred to the "very wide" pad design, and Kent Hovind strolled even further along this virtual path by claiming in his 1996 video that NASA put *giant* landing pads on the LEM to prevent it from sinking in.

[515] Berra (1990, 131-132). About the only scientist expecting the Apollo lander to sink into a morass of dust was Thomas Gold, a brilliant loose cannon in the tradition of Fred Hoyle. See Freeman Dyson's glowing Foreward to Gold (1999, ix).

[516] Henry Morris (1985, 31) tagged along close behind: "Finally, the moon landings have permitted man actually to study the composition and structure of some of the materials from at least one extra-terrestrial body. Enough has been found now to permit the firm conclusion that the earth and its moon are of vastly different structure and therefore could not have the same celestial evolutionary 'ancestor.'" And Morris in Morris & Parker (1987, 266): "The Earth and Moon have been found to be so different in physical composition that they could not possibly have had a common origin."

[517] Hartmann & Miller (1991, 44-57), G. Taylor (1994) and MacKenzie (2003) describe the detective process of discovering the actual origin of the moon, and Musser (2001) comments on recent developments. DeYoung (1989, 27) dismissed the collision theory and insisted the origin of the moon "remains a mystery to secular science." Nearly a decade later, Morris & Morris (1996b, 230) were manning the same trench: "Even the earth's moon is still of unknown origin, despite NASA's various *Apollo* missions." On the following page they opined: "The physical and chemical composition of the moon is very different from that of the earth, however, and it is difficult to see how the moon could have come from the earth, even as the result of such a hypothetical giant collision." Such an attitude was not unsurprising, given their indifference to the scientific literature linking lunar composition to the early earth's outer crust.

Notes to Appendix III (*Falsification*)

[518] The Eagle Forum's online *Education Reporter* (eagleforum.org) for that same month offered a similar treatment. According to an August 2, 2000 Associated Press report on the primary, creationist board member Linda Holloway was surprised at her loss, which she attributed to the successful "propaganda" of her opponents. Main sponsor Steve Abrams did retain his seat, however.

The Kansas debate briefly spilled over into the national presidential campaign, with pro-creationist conservatives freely favoring equal time for their pet, such as Gary Bauer, Pat Buchanon, Steve Forbes, Allen Keyes & Howard Phillips. Not unexpectedly, former Vice President Dan Quayle endorsed the Kansas move—but so did then Vice President Al Gore.

Though in Gore's case, this may have owed something to his Tennessee background, a state not unfamiliar with the educational ramifications of teaching evolution (as noted in Appendix I). The main point for frontrunners George Bush and Al Gore was to support local control and equal time—but as Gore was coming from the liberal camp, where antievolutionism is rare, it was Gore's position that garnered raised eyebrows from the scientific community, prompting Gore to indulge in some backpedaling. Among the also-rans, John McCain favored teaching evolution while stressing the need for local control, leaving Bill Bradley alone in favoring Darwin with no strings attached. See issues2000.org for position statements from the various contenders.

Incidentally, Phillip Johnson (2000, 78-79) referred to the presidential candidates' endorsement of local authority to allow creationism to be taught along with evolution, highlighting Gore's vacillating position—but not dwelling on any of the more overtly pro-creationist sentiments of the other candidates and their supporters. For example, Larry Bates and his son Chuck (fcci.org), who host seminars on the (perpetually) impending economic collapse. Their talk show "Unraveling the New World Order" appears on many conservative Christian radio stations, and in the summer of 2000 they were expressing electoral angst as George Bush had just selected Council on Foreign Relations member Dick Cheney for Vice President. "W" was also listening too freely to Henry Kissinger (someone with "the spirit of antichrist" upon him). But they were planning to overlook these dire influences and support Bush anyway, since Democrat Gore was "evil incarnate." These attitudes may be calibrated against a range of creationist politics: from Hugh Ross (1998, 169-172) opposing world government to LaHaye & Noebel (2000, 271): "The bottom line? *No humanist is fit to hold office*." Cf. Ecker (1990, 61, 110-112, 149-150, 167-169, 177) and Bailey (1993, 42-42) on some of the political diatribes that have circulated through the creationist worldview over the years.

[519] Schlafly's "Monthly Update" for November 2001 noted an interview with Hovind, and the "Eagle Forum Collegians Weekly Internet Newsletter" (October 3, 2001) described in glowing terms Hovind's September 24th lecture before their club at Truman State University in Kirksville, Missouri. Hovind's "Dr." designation was not provided with quotation marks. Though in March 2002 "Eagle Forum University" offered a course on *Evolution Fallacies*, most of the Eagle Forum's state affiliate websites do not concern themselves directly with evolution. But the Tennessee chapter (tneagleforum.org) is explicitly YEC, devoting a section to the "Creation/Evolution Debate" that offers as its only resources web links to the Institute for Creation Research and Answers in Genesis (but not, ironically enough, to Hovind's own drdino.com).

Because Hovind makes his mark by lecturing and debating (usually in church venues), not by writing or publishing, most criticism of Hovind is online, such as at "No Answers in Genesis" (home.austarnet.com.au/stear/default the website). Hovind is so far off the map that even Answers in Genesis has taken aim at him: "Maintaining Creationist Integrity" (answersingenesis.org/docs2002/1011hovind.asp). I first encountered Hovind's oeuvre when analyzing one of his videotapes, and wrote him in 1997 asking him to defend one transparently preposterous claim. Hovind correctly reported the amount of hydrogen being burned off by the sun annually, but claimed that if the earth were billions of years old, the sun would have so much more mass it would have ballooned out to the earth's orbit, incinerating everything. Hovind had neglected to perform the simplest calculation, which would have shown that even after four billion years the amount lost would have been trivial compared to the sun's total mass. His reply danced around these issues with such dervish-like agility that I identified a whole category of creationist logic in his honor: "Willing neither to defend his position, nor abandon it."

[520] This is the version in the A8 draft of June 26, 1999 (obtained from Jack Krebs' website, re note 37 of the Introduction). The revised Draft 5 adopted in 1999 deleted the explanations of inductive and deductive logic.

[521] Schlafly quoted only the final 1999 version that removed the lead-in examples (though her text differed slightly and included a redundant ellipsis inserted between two sentences). The text replaced by the car color example had brought the methods issue home to topical controversies: "Share interpretations that differ from currently held explanations on topics such as global warming and dietary claims. Evaluate the validity of results and accuracy of stated conclusions." Schlafly

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quoted the 2001 text example (though not the "open-mindedness" lead-in) without indicating whether she ever considered the "validity" or "accuracy" of Tom Willis or Kent Hovind.

[522] See specifically notes 451-453 in Chapter Nine on the Cambrian evasion.

[523] Creationism's 19th century antipathy and 20th century acquiescence to speciation was noted by John A. Moore, "Creationism," in Zetterberg (1983, 122). Gary Parker illustrates Creation Science's ambivalence on this point by rejecting that variation within species can produce new ones, while citing the Galápagos finches (which involve separate species) as examples of mere variation within the type, Morris & Parker (1987, 84, 89). And Toumey (1994, 220) noted how the North Carolina study group he followed relied on an ICR slideshow that equated "macroevolution" with *speciation*. Similar confusions plague ID exemplar Davis & Kenyon (1993, 19, 88) who downplayed speciation as a microevolutionary triviality before regarding the origin of species as representing the appearance of "new life forms." Phillip Johnson (2000, 131) has not thought about the problem apart from exclaiming that, "it is only Darwinists who think that what evolutionary theory needs to explain is primarily *speciation*."

Hank Hanegraaff showed his still looser comprehension in a September 2003 posting at equip.org: "So while you might be able to breed a Chihuahua with a Great Dane and get a new species of dog, you can't breed two dogs and get a cat, a mouse, or a whale." Likewise Stark (2003, 178) claimed that interbreeding only occurs within a species, "but not across species (no dog/cats or horse/cows)." Stark offered no more sources for this claim than Hanegraaff, which is not in fact true. Hybridization can both fuse and split species, as explored by Peter Grant & Grant (1994; 1997), Weiner (1994a, 198-200), Xu (2000), Schilthuizen (2001, 14-20, 28-31, 89-90; 2002), and Zimmer (2002b) on Peter Grant & Grant (2002b). Some 10% of living bird species occasionally crossbreed (duck and geese lead with about half their species hybridizing). Underlying Stark and Hanegraaff's confusion was a failure to appreciate what taxonomical level was involved: cats and dogs aren't merely different species, they fall into different families. What neither Hanegraaff nor Stark conceptualized was how present cats would have developed by incremental speciation from closely related species. Cf. Gish (1993, 309) similarly parsing Simpson (1961b, 90) on hybridization.

[524] See Joel Cracraft, "Systematics, Comparative Biology, and the Case against Creationism," in Godfrey (1983, 183-184), Strahler (1987, 365-366) or Ecker (1990, 42-43). To fit the full range of biogeography into a creationist framework functionally requires attributing "creation with apparent ancestry" to the designed organisms, which puts field creationism into the same omphalos category as "creation with apparent age" (re note 65, Introduction) used by YEC to dismiss theologically unpleasant cosmological findings.

The closest any major creationist has got to the topic is Gish (1993, 213-215) misrepresenting Kitcher (1982, 51-52). Morris & Morris (1996b, 237) played coy: "For some reason, the geographical distribution of animals and plants is often cited (and has been, since before Darwin's time) as an evidence of evolution." Although the index listing for "biogeography" indicated pp. 237-240, their short squib terminated at the top of 239. While claiming that migration of created "kinds" could account for the observed distribution of Australian marsupials or dinosaurs, they offered only Galápagos finches as evidence, which they treated as though they were a single species interfertile with their mainland cousins.

On the ID side, biogeography has so far continued to resist their curiosity, as noted in the critical review by Peterson (2002, 18). Examples may start with Denton (1985, 33-34) acknowledging the importance of biogeography (then doing nothing with it). Johnson (1991, 151) devoted only one sentence to it. And in his keynote presentation at a 1992 Southern Methodist University symposium on "Darwinism: Science or Philosophy" (available at the "Leadership U" website, leader.com) Johnson said it would only "confuse matters" to discuss biogeography further, as this supposedly only illustrated "the kind of evolution nobody disputes." He didn't elaborate what that might involve, though the context suggested what Johnson had in mind was the allowable "microevolution" that he and his fellow Intelligent Design advocates have persistently failed to rigorously define.

Biogeography also failed to make the cut in Wells (2000a) or in any substantive sense in Hunter (2001; 2003). Hunter (2001, 97-98, 113) had a brief section on "Biogeography" and alluded to a comment from Michael Ruse—but skipped the larger issue of why isolated islands invariably possess restricted inhabitants (no large endemic vertebrates on Hawaii, for example). In Hunter's case, he could have known this side of the subject via his referencing of Cracraft's article on it in the Godfrey anthology, Hunter (2003, 158n). Besides his failure to discuss the meat of biogeography, Hunter missed the Ediacara biota, differential cell cleavage, endosymbiosis, *Sphecomyrma*, bird tooth induction and the details of the reptile-mammal transition (notes 136, 218, 226, 323 & 389 above). All of which renders the sentiments of Hunter (2003, 150) particularly ironic: "There is an abundance of evidence for all sorts of discredited ideas. What is important is not the implications of the positive evidence, but the implications of all the evidence taken together."

[525] Denton (1985, 93), with Denton (1985, 85-86, 182-186) additionally on speciation and horses. Creationist Sarfati (1999) comes closest to Denton's concession by regarding them all as variations "within the equine (horse) kind."

In one sense, the appearance of horses in the fossil record isn't particularly "macroevolutionary" when compared to the origin of amniotes, mammals or birds at the class level. No new bones were brought into play from the ancestral mammal kit, and no radical new attributes comparable to cetacean echolocation. The horse line did get larger over time (though many of its cousins didn't) and the teeth changed in size, surface conformation and root length (though not in their number or overall layout) relating to shifts in diet. Although deeply crowned teeth coated in dental cement could wear down slowly enough to withstand the rigors of grazing, such development appears to have been somewhat unidirectional, not always adjusting back to a grazing approach, Morell (1999) re MacFadden *et al.* (1999), and Janis *et al.* (2000). What was happening at the genetic level during these shifts isn't yet known, though Tucker *et al.* (1998) identify some of the component processes in tooth specification. Research is similarly preliminary when it comes to how dental cementum is formed in mammals, Diekwisch (2001). Concerning horses, cf. "Coronal Cementogenesis in the Teeth of the Horse" given by Sahara *et al.* at the 2003 meeting of the International Association for Dental Research (abstract at iadr.confex.com/iadr/2003Goteborg/techprogram/abstract_28489.htm). Terling *et al.* (1998), Weiss *et al.* (1998), Lézot *et al.* (2000) and Smid *et al.* (2004) identify some of the hormonal and genetic players in cementogenesis, which includes the homeogene Dlx-2, part of an ancient gene family among vertebrates, Stock *et al.* (1996).

Such work may be contrasted with the vacuous apologetic glossing of Sarfati (1999) on the Tucker and MacFadden papers. One other notable feature of horse evolution is their reduction and eventual loss of side toes (with the final shift apparently taking place in the transitional genus *Dinohippus*). While the fossils cannot show exactly how tendons and musculature were shifting in coordination, at least some of the process is observable today, as McGowan (1984, 142-148) noted the appearance of side toes in the embryos of living horses.

Gould (1991, 166-181; 1996, 57-73; 2002, 580-581, 905-908) has repeatedly returned to the evolutionary lessons of the horse sequence, explaining the background context of material heavily filtered in creationist accounts. Although now over forty years old, Simpson (1961a, 229-267) is still an exceptionally clear and concise summary of the major trends and branches in horse evolution—though with one minor caveat concerning the brain of the starting taxon, *Hyracotherium* (then called *Eohippus*, "Dawn Horse"). Simpson drew on a 1948 paper on horse skull endocasts by Tilly Edinger that suggested it had a comparatively primitive mammal brain, more like its condylarth ancestors. That observation turned out to be ironically all too true, as a 1960s reappraisal by Leonard Radinsky suggested that Edinger had mistakenly used an Eocene condylarth for her "Eohippus" sample. Additional *Hyracotherium* fossils turned out to have had brains of considerably greater sophistication, more on a par with the descendent *Mesohippus* (see the December 1993 "Florida Fossil Horse Newsletter" of the Florida Museum of Natural History at flmnh.ufl.edu/ponyexpress/pony2_4/Pe24.htm).

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[526] Although Ratzsch (1996, 89-90) wrote as though most creationists accepted horses as allowable speciation, counterexamples are abundant. Morris & Parker (1987, 131-132), Wendell Bird (1989, Vol. 1, 223-225), Gish (1978, 157; 1993, 129-131; 1995, 189-197), Paul Taylor (1995, 42-43), Morris & Morris (1996b, 73-76), Huse (1997, 144-146) and Young Earth creationists Bert Thompson & Brad Harrub in an online rejoinder to Rennie (2002) at apologeticspress.org/docsdis/2002/dc-02-sa13.htm. Likewise Milton (1997, 99-104) and Stephen Meyer in person when I asked about them at the 1998 Whitworth "Creation Week." When Kenneth Miller brought up the horse example in the 1997 "Firing Line" debate, David Berlinski complained that the evidence for it posed a terrible trouble for evolutionists. Miller pressed him to explain why, but no paleontological details were forthcoming—cf. Berlinski (1996b, 20). The equivocal Hunter (2001, 66-67, 76-77, 94, 110-111) was also lean on specifics. The horse section in Wells (2000a, 195-207) contributed to Witham (2003, 167-168) claiming that evolutionary fossil sequences were "either misleading or fraudulent." Interestingly, Johnson (1991) and Hanegraaff (1998) skipped the equine matter.

As for the popularity of these views, in February 2004 the parent of an elementary student in Helena, Montana, complained that one of the school's library books on *Horses* (by Juliet Clutton-Brock) referred to their evolution. She asked either that the book be removed from the library, or the offending two pages be physically excised (Laura Tode, "Smith School parent wants book removed," at helenair.com/articles/2004/02/25/helena/a1022504_05.txt).

[527] Denton (1985, 185). Typology appeared to be still in the definitional stage when Siegfried Scherer discoursed on "Basic Types of Life: Evidence for Design from Taxonomy?" at the 1996 Mere Creation Conference (abstract at origins.org/menus/abstratcts.html). More theoretically, creationist efforts to define "kinds" by hybridization (as covered at grisda.org/origins/23106.htm) would functionally preclude a typology of extinct forms.

[528] Numbers (1992, 124-133) recounted the baramin saga concerning the Adventist-dominated Deluge Geology Society through the 1940s. YEC biologist Frank Lewis Marsh coined the term but allowed so much internal speciation that it smacked of "evolution" to prickly DGS co-founder George M. Price. The baramin concept has bumped along behind the scenes in Biblical circles, such as Paul Taylor (1995, 28).

[529] Wayne Frair (2000) summarized "the first scientific baraminology conference" (held in August 1999 at Liberty University) for the *Creation Research Society Quarterly Journal* (creationresearch.org/crsq/articles/37/37_2/baraminology.htm). Not surprisingly, it affirmed that claims from Scripture about life have "priority over all other considerations" (e.g., requiring the special creation of human beings). Baraminological terminology is also explained by Wood *et al.* (2003) and Richard Paley (objective.jesussave.us/baraminology.html).

Baraminologists such as Frair, Walter ReMine, Kurt Wise and Todd Wood seem stuck on the same common categories (dog, cat, turtle, sunflower) as Henry Morris or Duane Gish. Although mentioning Wise's "paleobaramin" category "for the older organisms" (meaning the extinct 99% of species), Frair managed to sidestep fossil clues. Thus he cited Hirayama (1998) without delving into its content: the discovery of the earliest fossil sea turtle that extended the sparse fossil record of chelonioids back 10 million years. This new Early Cretaceous find had the salt gland adaptation of a marine form, but retained the movable digits found in ancestral freshwater turtles. Frair's accompanying figure of "a very generalized representation for all living and extinct marine turtles" was rather too generalized to tell how the holobaramin lines were to be drawn regarding such early specimens. Frair offered tentatively that the total number of holobaramins would turn out to be "probably in the low thousands," suggesting a lot of families will be ranked as holobaramins (except of course for people, where only our species will do). Which is about where Marsh was half a century before.

[530] Wood & Cavanaugh (2001) and Cavanaugh & Wood (2002) determined that a group of sunflowers apparently were related (as a monobaramin) but couldn't say how far up the phylogenetic ladder their holobaramin went. This posed a theoretical problem, as even these plants showed a range of photosynthetic systems (C_3, C_3-C_4 intermediate, and C_4) that had to be submerged in an initially perfect created type. Consequently Cavanaugh and Wood decided the

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genes for all the systems had to have been designed in, providentially anticipating the Flood whereby the sunflowers would be prompted to evolve (within their holobaramin, whatever that may be) the variant photosynthetic pathways. Wood (2002) reprised this line of reasoning, with a condensed version in a September 2003 ICR *Impact* pamphlet (No. 363).

Just how much data the baraminological view would have to somehow account for here (involving biogeography, endosymbiotic inheritance, gene duplications, positive Darwinian selection and other issues) may be sampled in Kim & Jansen (1995), Helariutta *et al.* (1996), Ku *et al.* (1996), Marshall *et al.* (1996), Bremer & Gustafsson (1997), Clegg *et al.* (1997), Drincovich *et al.* (1998; 2001), Kim *et al.* (1998), Panero *et al.* (1999), Bremer (2000), Lai *et al.* (2002), Remington & Purugganan (2002), Tausta *et al.* (2002), Yang *et al.* (2002; 2004) and Rieseberg *et al.* (2003).

[531] Wood & Cavanaugh (2003, 4-5). As *Hyracotherium* was very similar to several contemporaneous taxa of comparable phylogenetic import (such as *Homogalax* at the base of the tapiroid superfamily), per Radinsky (1969), capping the equid type may prove a challenge for baraminology. Cf. George Gaylord Simpson, "The History of Life," in Tax (1960, 123), noting how *Homogalax/Hyracotherium* represent "not only the common parent of horse and tapir but also the common ancestor of two major divisions (suborders) of mammals."

References

Numbers in parentheses at the end of listings indicate notes in which the source was referenced.

Journal abbreviations:	*APP*	*Acta Palaeontologica Polonica*
	ABT	*The American Biology Teacher*
	AS	*The American Spectator*
	AZ	*American Zoologist*
	C/E	*Creation/ Evolution*
	DB	*Developmental Biology*
	E&D	*Evolution & Development*
	GR	*Genome Research*
	JEB	*Journal of Evolutionary Biology*
	JEZ	*Journal of Experimental Zoology*
	JME	*Journal of Molecular Evolution*
	MBE	*Molecular Biology and Evolution*
	NG	*National Geographic*
	NH	*Natural History*
	PNAS	*Proceedings of the National Academy of Sciences*
	SA	*Scientific American*
	SI	*Skeptical Inquirer*
	SB	*Systematic Biology*
	TREE	*Trends in Ecology & Evolution*

Abler, William L. 1999. “The Teeth of the Tyrannosaurs.” *SA* **281** (Sep.): 50-51. (36)

Abzhanov, Arhat, and **Thomas C. Kaufman.** 1999a. “Novel regulation of the homeotic gene *Scr* associated with a crustacean leg-to-maxilliped appendage formation.” *Development* **126** (15 March): 1121-1128. (227)

———. 1999b. “Homeotic genes and the arthropod head: Expression patterns of the *labial, proboscipedia,* and *Deformed* genes in crustaceans and insects.” *PNAS* **96** (21 Aug.): 10224-10229. (227)

———. 2000. “Crustacean (malacostracan) Hox genes and the evolution of the arthropod trunk.” *Development* **127** (1 June): 2239-2249. (227)

Ackerman, Jennifer. 1998. “Dinosaurs Take Wing.” *NG* **194** (July): 74-99. (334, 339, 341, 370)

Adoutte, André, Guillaume Balavoine, Nicolas Lartillot, Olivier Lespinet, Benjamin Prud’homme, and **Renaud de Rosa.** 2000. “The new animal phylogeny: Reliability and implications.” *PNAS* **97** (25 April): 4453-4456. (241)

Ahlberg, Per E., Jennifer A. Clack, and **Ervins Lukševics.** 1996. “Rapid braincase evolution between *Panderichthys* and the earliest tetrapods.” *Nature* **381** (2 May): 61-64. (398)

Akam, Michael. 2000. “Arthropods: Developmental diversity within a (super) phylum.” *PNAS* **97** (25 April): 4438-4441. (227)

Albert, Leon H. 1986. “‘Scientific’ Creationism as a Pseudoscience.” *C/E* **6** (Summer): 25-34. (59)

Alcock, John. 2001. *The Triumph of Sociobiology.* Oxford: Oxford University Press. (48)

Alroy, J., C. R. Marshall, R. K. Bambach, K. Bezusko, M. Foote, F. T. Fürsich, T. A. Hansen, S. M. Holland, L. C. Ivany, D. Jablonski, D. K. Jacobs, D. C. Jones, M. A. Kosnik, S. Lidgard, S. Low, A. I. Miller, P. M. Novack-Gottshall, T. D. Olszewski, M. E. Patzkowsky, D. M. Raup, K. Roy, J. J. Sepkoski Jr., M. G. Sommers, P. J. Wagner, and **A. Webber.** 2001. “Effects of sampling standardization on estimates of Phanerozoic marine diversification.” *PNAS* **98** (22 May): 6261-6266. (192)

Alters, Brian. 1999. “What Is Creationism?” *ABT* **61** (Feb.): 103-106. (61)

Alters, Brian J., and **Craig E. Nelson.** 2002. "Teaching Evolution in Higher Education." *Evolution* **56** (Oct.): 1891-1901. (47)

Alvarez-Buylla, Elena R., Soraya Pelaz, Sarah J. Liljegren, Scott E. Gold, Caroline Burgeff, Gary S. Ditta, Lluís Ribas de Pouplana, León Martínez-Castilla, and **Martin F. Yanofsky.** 2000. "An ancestral MADS-box gene duplication occurred before the divergence of plants and animals." *PNAS* **97** (9 May): 5328-5333. (102)

Amthor, Joachim E., John P. Grotzinger, Stefan Schröder, Samuel A. Bowring, Jahandar Ramezani, Mark W. Martin, and **Albert Matter.** 2003. "Extinction of *Cloudina* and *Namacalathus* at the Precambrian-Cambrian boundary in Oman." *Geology* **31** (May): 431-434. (198)

Anand, Sanjay, Wayne C. H. Wang, Dennis R. Powell, Stacey A. Bolanowski, Jian Zhang, Christina Ledje, Aruna B. Pawashe, Chris T. Amemiya, and **Cooduvalli S. Shashikant.** 2003. "Divergence of *Hoxc8* early enhancer parallels diverged axial morphologies between mammals and fishes." *PNAS* **100** (23 Dec.): 15666-15669. (207)

Anbar, A. D., and **A. H. Knoll.** 2002. "Proterozoic Ocean Chemistry and Evolution: A Bioinorganic Bridge?" *Science* **297** (16 Aug.): 1137-1142. (197)

Anderson, Alun. 1991. "Early Bird Threatens Archaeopteryx's Perch." *Science* **253** (5 July): 35. (356, 358-359)

Andors, Allison V. 1995. "*Diatryma* Among the Dinosaurs." *NH* **104** (June): 68-72. (342)

Ankerberg, John, and **John Weldon.** 1998. *Darwin's Leap of Faith: Exposing the False Religion of Evolution*. Eugene, OR: Harvest House Publishers. (20, 26, 29, 102, 111, 218, 251, 262, 266, 284, 401, 458)

Antonelis, Kyle, Daniel J. Johnson, M. Meghan Miller, and **Randy Palmer.** 1999. "GPS determination of current Pacific-North American plate motion." *Geology* **27** (April): 299-302. (503)

Applegate, David. 2000. "'Intelligent Design' Goes to Washington: Evolution Opponents Brief Congress." *SI* **24** (July/Aug.): 7-8. (42)

Appleyard, Bryan. 2000. "You asked for it." *New Scientist* **166** (22 April): 44-45. (41)

Archer, David. 2003. "Who Threw That Snowball?" *Science* **302** (31 Oct.): 791-792. (195)

Archer, Michael. 1994. "Mammals Eggstraordinaire." *NH* **103** (May): 48-49. (461)

Archer, Michael, and **Georgina Clayton**, eds. 1984. *Vertebrate Zoogeography & Evolution in Australasia*. Marrickville, Australia: Hesperian Press. (395)

Arduini, Francis J. 1987. "Design, Created Kinds, and Engineering." *C/E* **7** (Spring): 19-24. (252)

Arenas-Mena, César, Andrew R. Cameron, and **Eric H. Davidson.** 2000. "Spatial expression of *Hox* cluster genes in the ontogeny of a sea urchin." *Development* **127** (1 Nov.): 4631-4643. (217)

Arendt, Detlev, Kristin Tessmar, Maria-Ines Medeiros de Campos-Baptista, Adriaan Dorresteijn, and **Joachim Wittbrodt.** 2002. "Development of pigment-cup eyes in the polychaete *Platynereis dumerilii* and evolutionary conservation of larval eyes in Bilateria." *Development* **129** (1 March): 1143-1154. (253)

Arias, Alfonso Martinez. 1994. "Insects take a homeotic test." *Nature* **372** (1 Dec.): 408. (207)

Arkin, Adam, John Ross, and **Harley H. McAdams.** 1998. "Stochastic Kinetic Analysis of Developmental Pathway Bifurcation in Phage λ-Infected *Escherichia coli* Cells." *Genetics* **149** (August): 1633-1648. (474)

Aulie, Richard P. 1974a. "The Origin of the Idea of the Mammal-like Reptile." Part 1 of 3. *ABT* **36** (Nov.): 476-484, 511. (388, 404)

———. 1974b. "The Origin of the Idea of the Mammal-like Reptile." Part 2 of 3. *ABT* **36** (Dec.): 545-553. (388, 404, 414 & Fig. 38)

———. 1975. "The Origin of the Idea of the Mammal-like Reptile." Part 3 of 3. *ABT* **37** (Jan.): 21-32. (388)

Austin, Steven A., ed. 1994. *Grand Canyon: Monument to Catastrophe*. Santee, CA: Institute for Creation Research. (91, 95, 251)

Averof, Michalis, and **Stephen M. Cohen.** 1997. "Evolutionary origin of insect wings from ancestral gills." *Nature* **385** (13 Feb.): 627-630. (230)

Averof, Michalis, and **Nipam H. Patel.** 1997. "Crustacean appendage evolution associated with changes in Hox gene expression." *Nature* **388** (14 Aug.): 682-686. (380)

Avise, John C. 1998. *The Genetic Gods: Evolution and Belief in Human Affairs*. Cambridge, MA: Harvard University Press. (61, 213)

Awbrey, Frank T. 1983. "Space Dust, The Moon's Surface, and the Age of the Cosmos." *C/E* **4** (Summer): 21-29. (506)

Ayala, Francisco J., Ananías Escalante, Colm O'hUigin, and **Jan Klein.** 1994. "Molecular genetics of speciation and human origins." *PNAS* **91** (19 July): 6787-6794. (457)

Ayala, Francisco J., Walter M. Fitch, and **Michael T. Clegg.** 2000. "Variation and evolution in plants and microorganisms: Toward a new synthesis 50 years after Stebbins." *PNAS* **97** (20 June): 6941-6944. (102)

Ayala, Francisco José, Andrey Rzhetsky, and **Francisco J. Ayala.** 1998. "Origin of the metazoan phyla: Molecular clocks confirm paleontological estimates." *PNAS* **95** (20 Jan.): 606-611. (185)

Azevedo, Ricardo B. R., and **Armand M. Leroi.** 2001. "A power law for cells." *PNAS* **98** (8 May): 5699-5704. (474)

Babcock, Loren E., James W. Collinson, Molly F. Miller, John L. Isbell, and **Stephen T. Hasiotis.** 1998. "Paleozoic-Mesozoic crayfish from Antarctica: Earliest evidence of freshwater decapod crustaceans." *Geology* **26** (June): 539-542. (33)

Bailey, Lloyd R. 1993. *Genesis, Creation, and Creationism*. New York: Paulist Press. (66, 479, 518)

Bakker, Robert T. 1975. "Dinosaur Renaissance." *SA* **232** (April): 58-72, 77-78. (270)

———. 1986. *The Dinosaur Heresies: New Theories Unlocking The Mystery of the Dinosaurs and Their Extinction*. 1988 pb ed. New York: Zebra Books. (33, 270, 336)

Balter, Michael. 1997. "Morphologists Learn to Live With Molecular Upstarts." *Science* **276** (16 May): 1032-1034. (185)

Bandow, Doug. 1991. "Fossils and Fallacies." *National Review* **43** (29 April): 47-48. (23, 443)

Bang, Ranhy, Rob DeSalle, and **Ward Wheeler.** 2000. "Transformationalism, Taxism, and Developmental Biology." *SB* **49** (March): 19-27. (222)

Bao, Zheng-Zheng, **Benoit G. Bruneau**, **J. G. Seidman**, **Christine E. Seidman**, and **Constance L. Cepko.** 1999. "Regulation of Chamber-Specific Gene Expression in the Developing Heart by *Irx4*." *Science* **283** (19 Feb.): 1161-1164. (207)

Bapteste, Eric, Henner Brinkmann, Jennifer A. Lee, Dorothy V. Moore, Christoph W. Sensen, Paul Gordon, Laure Duruflé, Terry Gaasterland, Philippe Lopez, Miklós Müller, and **Hervé Philippe.** 2002. "The analysis of 100 genes supports the grouping of three highly divergent amoebae: *Dictyostelium*, *Entamoeba*, and *Mastigamoeba*." *PNAS* **99** (5 Feb.): 1414-1419. (224)

Barinaga, Marcia. 1995. "Focusing on the *eyeless* Gene." *Science* **267** (24 March): 1766-1767. (254)

Barkman, Todd J., Gordon Chenery, Joel R. McNeal, James Lyons-Weiler, Wayne J. Ellisens, Gerry Moore, Andrea D. Wolfe, and **Claude W. dePamphilis.** 2000. "Independent and combined analyses of sequences from all three genomic compartments converge on the root of flowering plant phylogeny." *PNAS* **97** (21 Nov.): 13166-13171. (102)

Barr, Stephen M. 2003. *Modern Physics and Ancient Faith*. Notre Dame, IN: University of Notre Dame Press. (496)

Barraclough, Timothy G., and **Vincent Savolainen.** 2001. "Evolutionary Rates and Species Diversity in Flowering Plants." *Evolution* **55** (April): 677-683. (147)

Barrett, Paul M. 2000. "Evolutionary consequences of dating the Yixian Formation." *TREE* **15** (March): 99-103. (102, 370)

Barrier, Marianne, Robert H. Robichaux, and **Michael D. Purugganan.** 2001. "Accelerated regulatory gene evolution in an adaptive radiation." *PNAS* **98** (28 Aug.): 10208-10213. (224)

Barrow, John D. 2000. *The Book of Nothing: Vacuums, Voids, and the Latest Ideas about the Origins of the Universe*. New York: Pantheon Books. (59)

Basu, Asish R., Michail L. Petaev, Robert J. Poreda, Stein B. Jacobsen, and **Luann Becker.** 2003. "Chondrite Meteorite Fragments Associated with the Permian-Triassic Boundary in Antarctica." *Science* **302** (21 Nov.): 1388-1392. (199)

Batten, Don. 1994. "A Whale of a Tale? (*Ambulocetus*)." Answers in Genesis ("*Creation ex Nihilo*") *CEN Technical Journal* **8** (1): 2-3. (248)

Bauer, Henry H. 1984. *Beyond Velikovsky: The History of a Public Controversy*. Urbana, IL: University of Illinois Press. (5)

Bauval, Robert, and **Adrian Gilbert.** 1994. *The Orion Mystery: Unlocking the Secrets of the Pyramids*. New York: Crown Trade Paperbacks. (2)

Bayarsaihan, Dashzeveg, Badam Enkhmandakh, Aleksandr Makeyev, John M. Greally, James F. Leckman, and **Frank H. Ruddle.** 2003. "*Homez*, a homeobox leucine zipper gene specific to the vertebrate lineage." *PNAS* **100** (2 Sep.): 10358-10363. (207)

Beardsley, Tim. 1986. "Fossil bird shakes evolutionary hypothesis." *Nature* **322** (21 Aug.): 677. (347-348, 359)

Becker, Luann. 2002. "Repeated Blows." *SA* **286** (March): 76-83. (199)

Behe, Michael J. 1996. *Darwin's Black Box: The Biochemical Challenge to Evolution*. New York: The Free Press. (61, 79, 209, 218, 226, 248, 253, 256, 306, 441, 467, 494, 497)

———. 1998. "Molecular Machines: Experimental Support for the Design Interface." *Cosmic Pursuit* **1** (Spring): 27-35. (61)

———. 1999a. "God … Sort Of." *First Things* (June/July): 42-45. (61)

———. 1999b. "Darwin's Hostages." *AS* **32** (Dec.): 32-36. (61)

———. 2000. "Self-Organization and Irreducibly Complex Systems: A Reply to Shanks and Joplin." *Philosophy of Science* **67** (March): 155-162. (61)

———. 2002. "The Challenge of Irreducible Complexity." *NH* **111** (April): 74. (61)

Behrensmeyer, Anna K. 1984. "Taphonomy and the Fossil Record." *American Scientist* **72** (Nov.-Dec.): 558-566. (32)

Belcher, Claire M., Margaret E. Collinson, Andrew C. Scott, Arthur R. Sweet, and **Alan R. Hildebrand.** 2003. "Fireball passes and nothing burns—The role of thermal radiation in the Cretaceous-Tertiary event: Evidence from the charcoal record of North America." *Geology* **31** (Dec.): 1061-1064. (199)

Beldade, Patricia, Kees Koops, and **Paul M. Brakefield.** 2002. "Modularity, individuality, and evo-devo in butterfly wings." *PNAS* **99** (29 Oct.): 14262-14267. (251)

Bell, Philip John Livingston. 2001. "Viral Eukaryogenesis: Was the Ancestor of the Nucleus a Complex DNA Virus?" *JME* **53** (Sep.): 251-256. (225)

Belting, Heinz-Georg, Cooduvalli S. Shashikant, and **Frank H. Ruddle.** 1998. "Modification of expression and *cis*-regulation of *Hoxc8* in the evolution of diverged axial morphology." *PNAS* **95** (3 March): 2355-2360. (434)

Ben-Ari, Elia T. 2000. "Hair Today: Untangling the biology of the hair follicle." *BioScience* **50** (April): 303-307. (435)

Bengtson, Stefan. 1998. "Evolution: Animal embryos in deep time." *Nature* **391** (5 Feb.): 529-530. (173)

Bengtson, Stefan, and **Yue Zhao.** 1997. "Fossilized Metazoan Embryos from the Earliest Cambrian." *Science* **277** (12 Sep.): 1645-1648. (173)

Benton, Michael J. 1983. "No consensus on *Archaeopteryx*." *Nature* **305** (8 Sep.): 99-100. (294)

———. 1990. *Vertebrate Palaeontology: Biology and evolution*. London: Unwin Hyman. (305, 395, 436)

———. 1996. *The Penguin Historical Atlas of Dinosaurs*. London: Penguin Books. (13, 233, 264)

———. 2003. *When Life Nearly Died: The Greatest Mass Extinction of All Time*. London:

Thames & Hudson. (192, 199, 201, 261, 404, 426)

Benton, Michael J., and **Francisco J. Ayala.** 2003. "Dating the Tree of Life." *Science* **300** (13 June): 1698-1700. (185)

Berg, Otto G., Johan Paulsson, and **Måns Ehrenberg.** 2000. "Fluctuations in Repressor Control: Thermodynamic Constraints on Stochastic Focusing." *Biophysical Journal* **79** (Dec.): 2944-2953. (474)

Bergman, Jerry. 1979. "The Attitude of University Students Toward the Teaching of Creation and Evolution in the Schools." Geoscience Research Institute *Origins* **6** (2): 60-70. (78)

Berlinski, David. 1996a. "The Soul of Man Under Physics." *Commentary* **101** (Jan.): 38-46. (27)

———. 1996b. "The Deniable Darwin." *Commentary* **101** (June): 19-29. (27, 526)

———. 1998. "Was There a Big Bang?" *Commentary* **105** (Feb.): 28-38. (27, 32)

———. 2001. "What Brings a World into Being?" *Commentary* **111** (April): 17-23. (27)

———. 2002. "Has Darwin Met His Match?" *Commentary* **114** (Dec.): 31-41. (27, 253)

———. 2003. "A Scientific Scandal." *Commentary* **115** (April): 29-36. (27, 253)

Berra, Tim M. 1990. *Evolution and the Myth of Creationism: A Basic Guide to the Facts of the Evolution Debate*. Stanford, CA: Stanford University Press. (66, 143, 216, 288, 292, 371, 481, 515)

Bethell, Tom. 1993. "Doubting Dada Physics." *AS* **26** (Aug.): 16-17. (27)

———. 1996. "A New Beginning." *AS* **29** (Sep.): 16-17. (27)

———. 1999a. "Rethinking Relativity." *AS* **32** (April): 20-23. (27)

———. 1999b. "The Evolution Wars." *AS* **32** (Dec.): 18-20. (27, 50)

———. 2000. "No Time for Science." *AS* **33** (Dec.): 27. (27, 217)

———. 2001. "A Map to Nowhere: The genome isn't a code, and we can't read it." *AS* **34** (April): 51-56. (27, 54)

———. 2002. "That's Life: The Evolution of Edward O. Wilson." *AS* **35** (March/April): 54-58. (27, 229)

Bille, Matthew A. 1995. *Rumors of Existence: Newly Discovered, Supposedly Extinct, and Unconfirmed Inhabitants of the Animal Kingdom*. Surrey, BC: Hancock House. (248)

Bird, Wendell R. 1989. *The Origin of Species Revisited: The Theories of Evolution and of Abrupt Appearance*. 2 vol., 1991 reprint. Nashville, TN: Regency. (5, 26, 80, 91, 102, 163, 218, 226, 266, 289, 321, 352, 365, 412, 498, 510, 526)

Blake, Daniel B. 2000. "The class Asteroidea (Echinodermata): Fossils and the base of the crown group." *AZ* **40** (June): 316-325. (86)

Blake, Daniel B., Daniel A. Janies, and **Rich Mooi.** 2000. "Evolution of starfish: Morphology, molecules, development, and paleobiology. Introduction to the Symposium." *AZ* **40** (June): 311-315. (86)

Bleiweiss, Robert. 1998. "Fossil gap analysis supports early Tertiary origin of trophically diverse avian orders." *Geology* **26** (April): 323-326. (335)

Bock, Walter J. 2000. "Explanatory history of the origin of feathers." *AZ* **40** (Sep.): 478-485. (272-273, 275)

Bode, Hans R. 2001. "The role of Hox genes in axial patterning in hydra." *AZ* **41** (June): 621-628. (238)

Boore, Jeffrey L., and **Wesley M. Brown.** 2000. "Mitochondrial Genomes of *Galathealinum*, *Helobdella*, and *Platynereis*: Sequence and Gene Arrangement Comparisons Indicate that Pogonophora Is Not a Phylum and Annelida and Arthropoda Are Not Sister Taxa." *MBE* **17** (Jan.): 87-106. (85)

Bork, Robert H. 1996. *Slouching Towards Gomorrah: Modern Liberalism and American Decline*. New York: Regan Books. (496)

Bower, Bruce. 1996. "Visions on the Rocks." *Science News* **146** (5 Oct.): 216-217. (22)

Bowler, Peter J. 1983. *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decades around 1900*. Baltimore, MD: Johns Hopkins University Press. (402)

Boyer, Paul. 1992. *When Time Shall Be No More: Prophecy Belief in Modern American Culture*. Cambridge, MA: Belknap Press (Harvard University Press). (487)

Brasier, Martin. 1998. "From deep time to late arrivals." *Nature* **395** (8 Oct.): 547-548. (184)

Bremer, Kåre. 2000. "Early Cretaceous lineages of monocot flowering plants." *PNAS* **97** (25 April): 4707-4711. (530)

Bremer, Kåre, and **Mats H. G. Gustafsson.** 1997. "East Gondwana ancestry of the sunflower alliance of families." *PNAS* **94** (19 Aug.): 9188-9190. (530)

Bridle, J. R., and **M. G. Ritchie.** 2001. "Assortative mating and the genic view of speciation." *JEB* **14** (Nov.): 878-879. (144)

Briggs, Derek E. G. 1991. "Extraordinary Fossils." *American Scientist* **79** (March-April): 130-141. (166, 169, 287)

———. 1994. "Giant Predators from the Cambrian of China." *Science* **264** (27 May): 1283-1284. (193)

Briggs, Derek E. G., Richard A. Fortey, and **Matthew A. Wills.** 1992. "Morphological Disparity in the Cambrian." *Science* **256** (19 June): 1670-1673. (192)

Britt, Brooks B., Peter J. Makovicky, Jacques Gauthier, and **Niels Bonde.** 1998. "Postcranial pneumatization in *Archaeopteryx*." *Nature* **395** (24 Sep.): 374-376. (336)

Britten, Roy J. 1998. "Underlying assumptions of developmental models." *PNAS* **95** (4 Aug.): 9372-9377. (474)

Britton-Davidian, J. 2001. "How do chromosomal changes fit in?" *JEB* **14** (Nov.): 872-873. (144)

Brockman, John, ed. 1995. *The Third Culture*. New York: Simon & Schuster. (226)

Bromham, Lindell. 2002. "Searching for Pax in hydromedusa." *TREE* **17** (Jan.): 11-12. (254)

Brower, Andrew V. Z. 2004. "Comment on 'Molecular Phylogenies Link Rates of Evolution and Speciation' (II)." *Science* **303** (9 Jan.): 173. (147)

Brown, C. Mackenzie. 2002. "Hindu and Christian Creationism: 'Transposed Passages' in the Geological Book of Life." *Zygon* **37** (March): 95-114. (101, 493)

Brown, Harold I. 1986. "Creationism and the Nature of Science." *C/E* **6** (Summer): 15-25. (59)

Brown, Jason M., and **Richard A. Firtel.** 1999. "Regulation of Cell-Fate Determination in *Dictyostelium*." *DB* **216** (15 Dec.): 426-441. (221)

Brown, Kathryn. 2001. "All Fired Up: A Universal Metabolic Rate." *Science* **293** (21 Sep.): 2191. (429)

Brown, R. H., and **Harold G. Coffin.** 1990. "Burgess Shale Re-Examined." Geoscience Research Institute *Origins* **17** (1): 33-37. (133)

Brown, Ruth Murray. 2002. *For a "Christian America": A History of the Religious Right*. Amherst, NY: Prometheus Books. (77, 259, 482, 489)

Brown, Walter T. Jr. 1989a. "Brown Responds to Lippard." *C/E* **9** (Fall): 35-48. (27, 42)

———. 1989b. "A Second Response to Jim Lippard." *C/E* **9** (Winter): 34-54. (27, 288)

Brush, Alan H. 1996. "On the origin of feathers." *JEB* **9** (Jan.): 131-142. (278, 280)

———. 2000. "Evolving a protofeather and feather diversity." *AZ* **40** (Sep.): 631-639. (275, 278-279, 379)

Budd, Graham E. 2002. "A palaeontological solution to the arthropod head problem." *Nature* **417** (16 May): 271-275. (227, 242)

Bull, J. J., M. R. Badgett, H. A. Wichman, J. P. Huelsenbeck, D. M. Hillis, A. Gulati, and **I. J. Molineaux.** 1997. "Exceptional Convergent Evolution in a Virus." *Genetics* **147** (Dec.): 1497-1507. (393)

Burgers, Phillip, and **Luis M. Chiappe.** 1999. "The wing of *Archaeopteryx* as a primary thrust generator." *Nature* **399** (6 May): 60-62. (344)

Burggren, Warren. 2000. "And the Beat Goes On: A Brief Guide to the Hearts of Vertebrates." *NH* **109** (April): 62-65. (417)

Burke, Ann C., and **Alan Feduccia.** 1997. "Developmental Patterns and the Identification of Homologies in the Avian Hand." *Science* **278** (24 Oct.): 666-668. (316)

Burke, Ann Campbell, and **Julie L. Nowicki.** 2001. "*Hox* genes and axial specification in vertebrates." *AZ* **41** (June): 687-697. (238)

Burke, James. 1985. *The Day the Universe Changed*. Boston: Little, Brown & Co. (57)

Burns, Kevin J., Shannon J. Hackett, and **Nedra K. Klein.** 2002. "Phylogenetic Relationships

---

and Morphological Diversity in Darwin's Finches and Their Relatives." *Evolution* **56** (June): 1240-1252. (450)

Bushbeck, Elke, **Birgit Ehmer**, and **Ron Hoy.** 1999. "Chunk Versus Point Sampling: Visual Imaging in a Small Insect." *Science* **286** (5 Nov.): 1178-1180. (251)

Buss, Leo W. 1999. "Slime molds, ascidians, and the utility of evolutionary theory." *PNAS* **96** (3 Aug.): 8801-8803. (238)

Cahoon-Metzger, Sharon M., Guoying Wang, and **Sheryl A. Scott.** 2001. "Contribution of BDNF-Mediated Inhibition in Patterning Avian Skin Innervation." *DB* **232** (1 April): 246-254. (435)

Caldwell, Michael W., and **Michael S. Y. Lee.** 1997. "A snake with legs from the marine Cretaceous of the Middle East." *Nature* **386** (17 April): 705-709. (292)

Callaerts, P., A. M. Munoz-Marmol, S. Glardon, E. Castillo, H. Sun, W.-H. Li, W. J. Gehring, and **E. Salo.** 1999. "Isolation and expression of a *Pax-6* gene in the regenerating and intact Planarian *Dugesia(G)tigrina*." *PNAS* **96** (19 Jan.): 558-563. (254)

Callaway, Jack M., and **Elizabeth L. Nicholls**, eds. 1997. *Ancient Marine Reptiles*. San Diego, CA: Academic Press. (163)

Cameron, R. Andrew, Gregory Mahairas, Jonathan P. Rast, Pedro Martinez, Ted R. Biondi, Steven Swartzell, James C. Wallace, Albert J. Proustka, Brian T. Livingston, Gregory A. Wray, Charles A. Ettensohn, Hans Lehrach, Roy J. Britten, Eric H. Davidson, and **Leroy Hood.** 2000. "A sea urchin genome project: Sequence scan, virtual map, and additional resources." *PNAS* **97** (15 Aug.): 9514-9518. (217)

Capdevila, Javier, and **Juan Carlos Izpisúa Belmonte.** 2000. "Perspectives on the Evolutionary Origin of Tetrapod Limbs." *JEZ* **288** (15 Dec.): 287-303. (380)

Carlisle, David Brez. 1995. *Dinosaurs, Diamonds, and Things from Outer Space: The Great Extinction*. Stanford, CA: Stanford University Press. (199)

Carpenter, Kenneth. 1999. *Eggs, Nests, and Baby Dinosaurs: A Look at Dinosaur Reproduction*. Bloomington, IN: Indiana University Press. (283)

Carpenter, Scott J., J. Mark Erickson, and **F. D. Holland Jr.** 2003. "Migration of a Late Cretaceous fish." *Nature* **423** (1 May): 70-74. (33)

Carrel, Laura, Amy A. Cottle, Karrie C. Coglin, and **Huntington F. Willard.** 1999. "A first-generation X-inactivation profile of the human X chromosome." *PNAS* **96** (7 Dec.): 14440-14444. (461)

Carroll, Robert L. 1988. *Vertebrate Paleontology and Evolution*. New York: W. H. Freeman & Co. (372-373, 377, 379, 389, 395)

Carroll, Sean B. 1995. "Homeotic genes and the evolution of arthropods and chordates." *Nature* **376** (10 Aug.): 479-485. (214)

———. 2000. "Endless Forms: The Evolution of Gene Regulation and Morphological Diversity." *Cell* **101** (9 June): 577-580. (206)

Carroll, Sean B., Scott D. Weatherbee, and **James A. Langeland.** 1995. "Homeotic genes and the regulation and evolution of insect wing number." *Nature* **375** (4 May): 58-61. (230)

Case, Gerard R. 1982. *A Pictorial Guide to Fossils*. New York: Van Nostrand Reinhold Company. (265)

Cavalier-Smith, Tom. 1997. "The blind biochemist." *TREE* **12** (April): 162-163. (61)

Cavanaugh, David P., and **Todd Charles Wood.** 2002. "A Baraminological Analysis of the Tribe Heliantheae *sensu latu* (Asteraceae) Using Analysis of Pattern (ANOPA)." *Occasional Papers of the Baraminology Study Group* (online journal at www.bryancore.org/bsg/) No. 1: 1-11. (530)

Chadwick, Douglas H. 1994. "Evolution, Right Before Their Eyes." *New York Times Book Review* (22 May): 7. (450)

———. 2001. "Evolution of Whales." *NG* **200** (Nov.): 64-77. (248)

Chapman, R. F. 1969. *The Insects: Structure and Function*. New York: American Elsevier Publishing Company, Inc. (251)

Charig, Alan J., Frank Greenaway, Angela C. Milner, Cyril A. Walker, and **Peter J. Whybrow.** 1986. "*Archaeopteryx* Is Not a Forgery." *Science* **232** (2 May): 622-626. (289)

Chatterjee, Sankar. 1983. "An Ictidosaur Fossil from North America." *Science* **220** (10 June): 1551-1553. (424)

———. 1997. *The Rise of Birds: 225 Million Years of Evolution*. Baltimore, MD: Johns Hopkins University Press. (269, 283, 347)

Chen, Chia-Wei Janet, Han-Sung Jung, Ting-Xin Jiang, and **Cheng-Ming Chuong.** 1997. "Asymmetric Expression of Notch/Delta/Serrate Is Associated with the Anterior-Posterior Axis of Feather Buds." *DB* **188** (1 Aug.): 181-187. (435)

Chen, J. J., B. J. Janssen, A. Williams, and **N. Sinha.** 1997. "A Gene Fusion at a Homeobox Locus: Alterations in Leaf Shape and Implications for Morphological Evolution." *The Plant Cell* **9** (Aug.): 1289-1304. (207)

Chen, J.-Y., J. Dzik, G. D. Edgecombe, L. R. Ramsköld, and **G.-Q. Zhou.** 1995. "A possible Early Cambrian chordate." *Nature* **377** (26 Oct.): 720-722. (93)

Chen, Jun-Yuan, and **Di-Ying Huang.** 2002. "A Possible Lower Cambrian Chaetognath (Arrow Worm)." *Science* **298** (4 Oct.): 187. (105)

Chen, Jun-Yuan, Di-Ying Huang, and **Chia-Wei Li.** 1999. "An early Cambrian craniate-like chordate." *Nature* **402** (2 Dec.): 518-522. (93)

Chen, Jun-Yuan, Di-Ying Huang, Qing-Qing Peng, Hui-Mei Chi, Xiu-Qiang Wang, and **Man Feng.** 2003. "The first tunicate from the Early Cambrian of South China." *PNAS* **100** (8 July): 8314-8318. (238)

Chen, Jun-Yuan, Paola Oliveri, Chia-Wei Li, Gui-Qing Zhou, Feng Gao, James W. Hagadorn, Kevin J. Peterson, and **Eric H. Davidson.** 2000. "Precambrian animal diversity: Putative phosphatized embryos from the Doushantuo Formation of China." *PNAS* **97** (25 April): 4457-4462. (173)

Chen, Jun-Yuan, **Lars Ramsköld**, and **Gui-qing Zhou.** 1994. "Evidence for Monophyly and Arthropod Affinity of Cambrian Giant Predators." *Science* **264** (27 May): 1304-1308. (193)

Chen, Pei-ji, Zhi-ming Dong, and **Shuo-nan Zhen.** 1998. "An exceptionally well-preserved theropod dinosaur from the Yixian Formation of China." *Nature* **391** (8 Jan.): 147-152. (340)

Chen, YiPing, Yanding Zhang, Ting-Xing Jiang, Amanda J. Barlow, Tara R. St. Amand, Yueping Hu, Shaun Heaney, Philippa Francis-West, Cheng-Ming Chuong, and **Richard Maas.** 2000. "Conservation of early odontogenic signaling pathways in *Aves*." *PNAS* **97** (29 Aug.): 10044-10049. (322)

Chiappe, Luis M. 1995a. "A Diversity of Early Birds." *NH* **104** (June): 52-55. (334)

———. 1995b. "The first 85 million years of avian evolution." *Nature* **378** (23 Nov.): 349-355. (334)

———. 1998. "Wings Over Spain." *NH* **107** (Sep.): 30-32. (333, 338)

Chiappe, Luis M., and **Lowell Dingus.** 2001. *Walking on Eggs: The Astonishing Discovery of Thousands of Dinosaur Eggs in the Badlands of Patagonia*. New York: Scribner. (283)

Chiappe, Luis M., and **Gareth J. Dyke.** 2002. "The Mesozoic Radiation of Birds." *Annual Reviews Ecology and Systematics* **33**: 91-124. (335)

Chinsamy, Anusuya, and **Andrzej Elzanowski.** 2001. "Evolution of growth pattern in birds." *Nature* **412** (26 July): 402-403. (336)

Chipman, Ariel D., Alexander Haas, Eitan Tchernov, and **Oded Khaner.** 2000. "Variation in Anuran Embryogenesis: Differences in Sequence and Timing of Early Developmental Events." *JEZ* **288** (15 Dec.): 352-365. (239)

Chittick, Donald E. 1984. *The Controversy: Roots of the Creation-Evolution Conflict*. Portland, OR: Multinomah Press. (26, 218, 441, 467, 480)

Cifelli, Richard L. 2001. "Early Mammalian Radiations." *Journal of Paleontology* **75** (Nov.): 1214-1226. (405, 461)

Cifelli, Richard L., and **Brian M. Davis.** 2003. "Marsupial Origins." *Science* **302** (12 Dec.): 1899-1900. (417)

Clack, Jennifer A. 1998. "A new Early Carboniferous tetrapod with a *mélange* of crown-group characters." *Nature* **394** (2 July): 66-69. (392)

Clack, J. A., P. E. Ahlberg, S. M. Finney, P. Dominguez Alonso, J. Robinson, and **R. A. Ketcham.** 2003. "A uniquely specialized ear in a very early tetrapod." *Nature* **425** (4 Sep.): 65-69. (420)

Clapham, M. E., and **G. M. Narbonne.** 2002. "Ediacaran epifaunal tiering." *Geology* **30** (July): 627-630. (196)

Clarke, Arthur C. 1998. "Presidents, Experts, and Asteroids." *Science* **280** (5 June): 1532-1533. (53)

———, ed. Ian T. Macauley. 1999. *Greetings, Carbon-Based Bipeds! Collected Essays, 1934-1998*. New York: St. Martin's Press. (53)

Clarke, Kenneth V. 1973. *The Biology of the Arthropoda*. New York: American Elsevier Publishing Company, Inc. (227, 230)

Clausen, Venus E. 1986. "Recent Debate Over *Archaeopteryx*." Geoscience Research Institute *Origins* **13** (1): 48-55. (289)

Clegg, Michael T., Michael P. Cummings, and **Mary L. Durbin.** 1997. "The evolution of plant nuclear genes." *PNAS* **94** (22 July): 7791-7798. (530)

Clegg, Michael T., Brandon S. Gaut, Gerald H. Learn Jr., and **Brian R. Morton.** 1994. "Rates and patterns of chloroplast DNA evolution." *PNAS* **91** (19 July): 6795-6801. (457)

Cleland, Carol E. 2001. "Historical science, experimental science, and the scientific method." *Geology* **29** (Nov.): 987-990. (47)

Clément, Gaël, Per E. Ahlberg, Alain Blieck, Henning Blom, Jennifer A. Clack, Edouard Poty, Jacques Thorez, and **Philippe Janvier.** 2004. "Devonian tetrapod from western Europe." *Nature* **427** (29 January): 412-413. (420)

Close, Frank. 1991. *Too Hot to Handle: The Race for Cold Fusion*. Princeton, NJ: Princeton University Press. (53)

Coates, M. I., and **J. A. Clack.** 1991. "Fish-like gills and breathing in the earliest known tetrapod." *Nature* **352** (18 July): 234-236. (398)

Coates, Michael, and **Marcello Ruta.** 2000. "Nice snake, shame about the legs." *TREE* **15** (Dec.): 503-507. (292)

Coen, Enrico. 1999. *The Art of the Gene: How Organisms Make Themselves.* Oxford: Oxford University Press. (206)

———. 2002. "The Making of a Blossom." *NH* **111** (May): 48-55. (102)

Cohen-Kiraly, William. 1997. "Creation Science Banned from Lakewood, Ohio, Classroom." *SI* **21** (Jan./Feb.): 6-8. (111)

Cohn, Martin J., and **Cheryll Tickle.** 1999. "Developmental basis of limblessness and axial patterning in snakes." *Nature* **399** (3 June): 474-479. (292)

Colbert, Edwin H., and **Michael Morales**. 1991. *Evolution of the Vertebrates: A History of the Backboned Animals Through Time*. 4th ed. New York: Wiley-Liss. (162-164, 283, 328, 398, 416-417, 422, 436, 461)

Colson, Charles, and **Nancy Pearcey.** 1999. *How Now Shall We Live?* Wheaton, IL: Tyndale House Publishers. (50, 111)

Condon, D. J., A. R. Prave, and **D. I. Benn.** 2002. "Neoproterozoic glacial-rainout intervals: Observations and implications." *Geology* **30** (Jan.): 35-38. (195)

Conrad, Ernest C. 1982a. "Are There Human Fossils in the 'Wrong Place' for Evolution?" *C/E* **3** (Spring): 14-22. (20)

———. 1982b. "True Vestigial Structures in Whales and Dolphins." *C/E* **3** (Fall): 8-13. (248)

Conway Morris, Simon. 1998a. *The Crucible of Creation: The Burgess Shale and the Rise of Complexity*. Oxford: Oxford University Press. (93, 108, 128, 161, 165-166, 171-172, 175, 179, 181, 187-188, 192-194, 211, 235, 242, 408 & Fig. 13)

———. 1998b. "Showdown on the Burgess Shale: The Challenge." *NH* **107** (Dec.): 48-51. (194)

———. 2000. "The Cambrian 'explosion': Slow-fuse or megatonnage?" *PNAS* **97** (25 April): 4426-4429. (235)

Cook, Daniel L., Anthony N. Gerber, and **Stephen J. Tapscott.** 1998. "Modeling stochastic gene expression: Implications for haploinsufficiency." *PNAS* **95** (22 Dec.): 15641-15646. (474)

Cooper, Henry S. F. Jr. 2001. "The Perfect Fossil." *NH* **110** (Nov.): 12-13. (229)

Cooper, Paulette. 1971. *The Scandal of Scientology*. New York: Tower Books. (490)

Corsetti, Frank A., Stanley M. Awramik, and **David Pierce.** 2003. "A complex microbiota from snowball Earth times: Microfossils from the Neoproterozoic Kingston Peak Formation, Death Valley, USA." *PNAS* **100** (15 April): 4399-4404. (195)

Corsetti, Frank A., and **James W. Hagadorn.** 2000. "Precambrian-Cambrian transition: Death Valley, United States." *Geology* **28** (April): 299-302. (198)

Courtillot, Vincent, trans. Joe McClinton. 1999. *Evolutionary Catastrophes: The Science of Mass Extinction*. Cambridge: Cambridge University Press. (199, 233)

Coyne, Jerry A. 1994. "Ernst Mayr and the Origin of Species." *Evolution* **48** (Feb.): 19-30. (142)

———. 1996. "God in the details." *Nature* **383** (19 Sep.): 227-228. (61)

Cracraft, Joel. 2001. "Gondwana Genesis." *NH* **110** (Dec.): 64-73. (335)

Crampton, James S., Alan G. Beu, Roger A. Cooper, Craig M. Jones, Bruce Marshall, and **Phillip A. Maxwell.** 2003. "Estimating the Rock Volume Bias in Paleobiodiversity Studies." *Science* **301** (18 July): 358-360. (192)

Cremo, Michael A., and **Richard L. Thompson.** 1993. *Forbidden Archaeology: The Hidden History of the Human Race*. San Diego, CA: Bhaktiveda Institute. (19, 492)

Crepet, William L. 1998. "The Abominable Mystery." *Science* **282** (27 Nov.): 1653-1654. (102)

———. 2000. "Progress in understanding angiosperm history, success, and relationships: Darwin's abominably 'perplexing phenomenon.'" *PNAS* **97** (21 Nov.): 12939-12941. (102)

Cromer, Alan. 1993. *Uncommon Sense: The Heretical Nature of Science*. New York: Oxford University Press. (53)

Crowe, Rebecca, and **Lee Niswander.** 1998. "Disruption of Scale Development by *Delta-1* Misexpression." *DB* **195** (1 March): 70-74. (281)

Cunha, Ana, Ricardo B. R. Azevedo, Scott W. Emmons, and **Armand M. Leroi.** 1999. "Variable cell number in nematodes." *Nature* **402** (18 Nov.): 253. (109)

Currie, Philip J., and **Kevin Padian**, eds. 1997. *Encyclopedia of Dinosaurs*. San Diego, CA: Academic Press. (13, 33, 36, 102, 163, 264, 291, 297, 302, 308, 310, 312, 314, 334, 336, 340, 345-346, 353, 370, 385, 422, 454)

Czerkas, Sylvia J., and **Stephen A. Czerkas.** 1991. *Dinosaurs: A Global View.* New York: Mallard Press. (164, 302, 313, 347, 356-357, 392, 427-428, 431-433 & Fig. 37)

Daeschler, Edward B., and **Neil Shubin.** 1998. "Fish with fingers?" *Nature* **391** (8 Jan.): 133. (399)

Dahn, Randall D., and **John F. Fallon.** 2000. "Interdigital Regulation of Digit Identity and Homeotic Transformation by Modulated BMP Signaling." *Science* **289** (21 July): 438-441. (320)

Dalrymple, G. Brent. 1991. *The Age of the Earth*. Stanford, CA: Stanford University Press. (160, 505)

Dalton, Rex. 1999. "Kansas kicks evolution out the classroom." *Nature* **400** (19 Aug.): 701. (39)

———. 2000a. "Feathers fly over Chinese fossil bird's legality and authenticity." *Nature* **403** (17 Feb.): 689-690. (385)

———. 2000b. "Fake bird fossil highlights the problem of illegal trading." *Nature* **404** (13 April): 696. (385)

———. 2000c. "Chasing the dragons." *Nature* **406** (31 Aug.): 930-932. (385)

———. 2000d. "Doubts grow over discovery of fossilized 'dinosaur heart.'" *Nature* **407** (21 Sep.): 275-276. (336)

Dalziel, Ian W. D. 1995. "Earth before Pangea." *SA* **272** (Jan.): 58-63. (160)

Damen, Wim G. M., Mathias Weller, and **Diethard Tautz.** 2000. "Expression patterns of *hairy*, *even-skipped*, and *runt* in the spider *Cupiennius salei* imply that these genes were segmentation genes in a basal arthropod." *PNAS* **97** (25 April): 4515-4519. (214)

Davies, Paul. 1999. *The Fifth Miracle: The Search for the Origin and Meaning of Life*. New York: Simon & Schuster. (61)

Davis, Percival, and **Dean H. Kenyon.** 1988. *Of Pandas and People: The Central Question of Biological Origin*. Dallas, TX: Haughton Publishing Co. (114)

———. 1993. *Of Pandas and People: The Central Question of Biological Origin*. 2nd ed. Dallas, TX: Haughton Publishing Co. (74, 79, 110, 112-113, 152, 218, 226, 265-266, 270, 285, 324, 326, 391, 395, 437, 523)

Dawkins, Richard. 1986. *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design*. 1996 pb ed. New York: W. W. Norton & Co. (131, 143, 147, 205, 236, 253, 392, 408)

———. 1994. "The eye in a twinkling." *Nature* **368** (21 April): 690-691. (253)

———. 1995. *River Out of Eden: A Darwinian View of Life*. New York: Basic Books. (253)

———. 1998. *Unweaving the Rainbow: Science, Delusion and the Appetite for Wonder*. Boston: Houghton Mifflin Company. (225)

Decker, Ronald, **Thierry Depaulis**, and **Michael Dummett.** 1996. *A Wicked Game of Cards: The Origin of the Occult Tarot*. New York: St. Martin's Press. (1)

De Duve, Christian. 1995. *Vital Dust: Life as a Cosmic Imperative*. New York: Basic Books. (225)

———. 1996. "The Birth of Complex Cells." *SA* **274** (April): 50-57. (225)

De Grazia, Alfred, **Ralph E. Juergens**, and **Livio Stecchini**, eds. 1966. *The Velikovsky Affair: Scientism vs. Science*. New Hyde Park, NY: University Press. (5)

DeHaan, Robert F., and **John L. Wiester.** 1999. "The Cambrian Explosion: The Fossil Record & Intelligent Design." *Touchstone* (July/Aug.): 65-69. (192, 247)

Dehal, Paramvir, Yutaka Satou, Robert K. Campbell, Jarrod Chapman, Bernard Degnan, Anthony De Tomaso, Brad Davidson, Anna Di Gregorio, Maarten Gelpke, David M. Goodstein, Naoe Harafuji, Kenneth E. M. Hastings, Isaac Ho, Kohji Hotta, Wayne Huang, Takeshi Kawashima, Patrick Lemaire, Diego Martinez, Ian A. Meinertzhagen, Simona Necula, Masaru Nonaka, Nik Putnam, Sam Rash, Hidetoshi Saiga, Masanobu Satake, Astrid Terry, Lixy Yamada, Hong-Gang Wang, Satoko Awazu, Kaoru Azumi, Jeffrey Boore, Margherita Branno, Stephen Chin-Bow, Rosaria DeSantis, Sharon Doyle, Pilar Francino, David N. Keys, Shinobu Haga, Hiroko Hayashi, Kyosuke Hino, Kaoru S. Imai, Kazuo Inaba, Shungo Kano, Kenji Kobayashi, Mari Kobayashi, Byung-In Lee, Kazuhiro W. Makabe, Chitra Manohar, Giorgio Matassi, Monica Medina, Yasuaki Mochizuki, Steve Mount, Tomomi Morishita, Sachiko Miura, Akie Nakayama, Satoko Nishizaka, Hisayo Nomoto, Fumiko Ohta, Kazuko Oishi, Isidore Rigoutsos, Masako Sano, Akane Saski, Yasunori Sasakura, Eiichi Shoguchi, Tadasu Shin-i, Antoinetta Spagnuolo, Didier Stainier, Miho M. Suzuki, Olivier Tassy, Naohito Takatori, Miki Tokuoka, Kasumi Yagi, Fumiko Yoshizaki, Shuichi Wada, Cindy Zhang, P. Douglas Hyatt, Frank Larimer, Chris Detter, Norman Doggett, Tijana Glavina, Trevor Hawkins, Paul Richardson, Susan Lucas, Yuji Kohara, Michael Levine, Nori Satoh, and **Daniel S. Rokhsar.** 2002. "The Draft Genome of *Ciona intestinalis*: Insights into Chordate and Vertebrate Origins." *Science* **298** (13 Dec.): 2157-2167. (238)

Delgado, Sidney, Didier Casane, Laure Bonnaud, Michel Laurin, Jean-Yves Sire, and **Marc Girondot.** 2001. "Molecular Evidence for Precambrian Origin of Amelogenin, the Major Protein of Vertebrate Enamel." *MBE* **18** (Dec.): 2146-2153. (178)

Deloria, Vine Jr. 1973. *God Is Red*. New York: Grosset & Dunlap. (5, 491)

———. 1974. "Myth and the Origin of Religion." *Pensée* (Fall): 45-50. (5, 491)

———. 1995. *Red Earth, White Lies: Native Americans and the Myth of Scientific Facts*. New York: Scribner. (5-6, 19, 29, 491, 503)

———, ed. Barbara Deloria, Kristen Foehner, and Sam Scinta. 1999. *Spirit & Reason: The Vine Deloria, Jr., Reader*. Golden, CO: Fulcrum Publishing. (5, 491)

———. 2002. *Evolution, Creationism, and Other Modern Myths.* Golden, CO: Fulcrum Publishing. (3, 5, 491, 503)

Delsuc, Frédéric, Matthew J. Phillips, and **David Penny.** 2003. "Comment on 'Hexapod Origins: Monophyletic or Paraphyletic?'" *Science* **301** (12 Sep.): 1482. (227)

Dembski, William A. 1998. *The Design Inference: Eliminating Chance Through Small Probabilities*. Cambridge: Cambridge University Press. (2, 61)

———. 1999. *Intelligent Design: The Bridge Between Science & Theology*. Downers Grove, IL: InterVarsity Press. (61, 211, 218, 226, 441)

———. 2002. *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence*. Lanham, MD: Rowman & Littlefield Publishers, Inc. (61, 211, 218, 226)

Dembski, William A., and **James M. Kushiner**, eds. 2001. *Signs of Intelligence: Understanding Intelligent Design*. Grand Rapids, MI: Brazos Press (Baker Book House). (110)

Demko, Timothy M., Judith Totman Parrish, and **Russell F. Dubiel.** 1998. "Plant taphonomy in incised valleys: Implications for interpreting paleoclimate from fossil plants." *Geology* **26** (Dec.): 1119-1122. (33)

Dennett, Daniel C. 1995. *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. 1996 pb ed. New York: Touchstone. (151, 209, 236)

———. 2003. *Freedom Evolves*. New York: Viking Press. (61)

Denton, Michael. 1985. *Evolution: A Theory in Crisis*. 1986 US ed. Bethesda, MD: Adler & Adler. (21, 79, 135, 163, 218, 227, 229, 241, 248, 260, 265-266, 272, 274, 364-365, 397, 417-418, 462, 467, 484, 494, 524-525, 527)

———. 1998. *Nature's Destiny: How the Laws of Biology Reveal Purpose in the Universe*. New York: The Free Press. (218, 484, 494)

Denton, Michael, and **Craig Marshall.** 2001. "Laws of form revisited." *Nature* **410** (22 March): 417. (484)

Denton, Michael J., Craig J. Marshall, and **Michael Legge.** 2002. "The Protein Folds as Platonic Forms: New Support for the Pre-Darwinian Conception of Evolution by Natural Law." *Journal of Theoretical Biology* **219** (7 Dec.): 325-342. (484)

Depew, Michael J., Thomas Lufkin, and **John L. R. Rubenstein.** 2002. "Specification of Jaw Subdivisions by *Dlx* Genes." *Science* **298** (11 Oct.): 381-385. (440)

De Robertis, E. M., and **Yoshiki Sasai.** 1996. "A common plan for dorsoventral patterning in Bilateria." *Nature* **380** (7 March): 37-40. (222)

De Rosa, Renaud. 2001. "Molecular Data Indicate the Protostome Affinity of Brachiopods." *SB* **50** (Nov.-Dec.): 848-859. (216)

De Tomaso, Anthony W., and **Irving L. Weissman.** 2004. "Evolution of a Protochordate Allorecognition Locus." *Science* **303** (13 Feb.): 977. (222)

DeYoung, Donald B. 1989. *Astronomy and the Bible: Questions and Answers*. Grand Rapids, MI: Baker Book House. (5, 26, 110, 13, 517)

Dial, Kenneth P. 2003. "Wing-Assisted Incline Running and the Evolution of Flight." *Science* **299** (17 Jan.): 402-404. (344)

Dickson, James H., Klaus Oeggl, and **Linda L. Handley.** 2003. "The Iceman Reconsidered." *SA* **288** (May): 70-79. (64)

Diekwisch, Thomas G. H. 2001. "Developmental Biology of Cementum." *International Journal of Developmental Biology* **45** (Sep.): 695-706. (525)

Dilcher, David. 2000. "Toward a new synthesis: Major evolutionary trends in the angiosperm fossil record." *PNAS* **97** (20 June): 7030-7036. (102)

Dingus, Lowell, and **Timothy Rowe**. 1998. *The Mistaken Extinction: Dinosaur Evolution and the Origin of Birds*. New York: W. H. Freeman & Co. (199, 261-262, 287-288, 291, 302, 312, 314, 322, 334-336, 342, 346, 353, 370, 372, 374-376, 378, 385, 503)

Disteche, Christine M. 1999. "Escapees on the X chromosome." *PNAS* **96** (7 Dec.): 14180-14182. (461)

Dobzhansky, Theodosius. 1975. "Darwinism or 'Oriented' Evolution?" *Evolution* **29** (June): 376-378. (403)

Dodson, Peter. 1996. *The Horned Dinosaurs: A Natural History*. Princeton, NJ: Princeton

---

University Press. (164, 431)

———. 2000. "Origin of birds: The final solution?" *AZ* **40** (Sep.): 504-512. (275, 291, 385, 408)

Doebley, John, and **Lewis Lukens.** 1998. "Transcriptional Regulators and the Evolution of Plant Form." *The Plant Cell* **10** (July): 1075-1082. (102)

Dominguez, Patrício, Antone G. Jacobson, and **Richard P. S. Jefferies.** 2002. "Paired gill slits in a fossil with a calcite skeleton." *Nature* **417** (20 June): 851-844. (217)

Donoghue, Philip C. J., and **Mark A. Purnell.** 1999. "Growth, function, and the conodont fossil record." *Geology* **27** (March): 251-254. (106)

Doolittle, W. Ford. 2000. "Uprooting the Tree of Life." *SA* **282** (Feb.): 90-95. (226)

Doolittle, W. Ford, and **James R. Brown.** 1994. "Tempo, mode, the progenote, and the universal root." *PNAS* **91** (19 July): 6721-6728. (457)

Dorit, Roger. 1997. "Molecular Evolution and Scientific Inquiry, Misconceived." *American Scientist* **85** (Sep.-Oct.): 474-475. (61)

Dornbos, Stephen Q., and **David J. Bottjer.** 2000. "Evolutionary paleoecology of the earliest echinoderms: Helicoplacoids and the Cambrian substrate revolution." *Geology* **28** (Sep.): 839-842. (86)

Downey, Roger. 2000. *Riddle of the Bones: Politics, Science, Race, and the Story of Kennewick Man*. New York: Copernicus. (64)

Doyle, Peter, with **Florence Lowry.** 1996. *Understanding Fossils: An Introduction to Invertebrate Paleontology*. Chichester, UK: John Wiley & Sons. (8, 86, 153-155, 166-167, 189, 191, 197, 233, 244, 251)

Drincovich, María F., Paula Casati, and **Carlos S. Andreo.** 2001. "NADP-malic enzyme from plants: a ubiquitous enzyme involved in different metabolic pathways." Federation of European Biochemical Societies *FEBS Letters* **490** (9 Feb.): 1-6. (530)

Drincovich, Maria F., Paula Casati, Carlos S. Andreo, Saul J. Chessin, Vincent R. Franceschi, Gerald E. Edwards, and **Maurice S. B. Ku.** 1998. "Evolution of C_4 Photosynthesis in *Flaveria* Species: Isoforms of NADP-Malic Enzyme." *Plant Physiology* **117** (July): 733-744. (530)

Droser, Mary L., Richard A. Fortey, and **Xing Li.** 1996. "The Ordovician Radiation." *American Scientist* **84** (March-April): 122-131. (86)

Droser, Mary L., James G. Gehling, and **Sören Jensen.** 1999. "When the worm turned: Concordance of Early Cambrian ichnofabric and trace-fossil record in siliciclastic rocks of South Australia." *Geology* **27** (July): 625-628. (183)

Droser, Mary L., Sören Jensen, and **James G. Gehling.** 2002. "Trace fossils and substrates of the terminal Proterozoic-Cambrian transition: Implications for the record of early bilaterians and sediment mixing." *PNAS* **99** (1 Oct.): 12572-12576. (183, 186)

Duboule, Denis. 1998. "*Hox* is in the hair: a break in colinearity?" *Genes & Development* **12** (1 Jan.): 1-4. (435)

———. 2000. "A Hox by any other name." *Nature* **403** (10 Feb.): 607, 609-610. (206)

Dummett, Michael, with **Sylvia Mann.** 1980. *The Game of Tarot from Ferrara to Salt Lake City*. London: Duckworth. (1)

Dunbar, Robin, and **Louise Barrett.** 2000. *Cousins: Our primate relatives*. London: Dorling Kindersley Publishing, Inc. (417)

Dusheck, Jennie. 2002. "The Interpretation of Genes." *NH* **111** (Oct.): 52-59. (54)

Dvorak, John J., **Carl Johnson**, and **Robert I. Tilling.** 1992. "Dynamics of Kilauea Volcano." *SA* **267** (Aug.): 46-53. (9)

Dzik, Jerzy. 1994. "Evolution of 'small shelly fossils' assemblages of the early Paleozoic." *APP* **39** (3): 247-313. (179)

———. 1995. "*Yunnanozoon* and the ancestry of the chordates." *APP* **40** (4): 341-360. (93)

———. 1999. "Organic membranous skeleton of the Precambrian metazoans from Namibia." *Geology* **27** (June): 519-522. (176)

———. 2002. "Possible ctenophoran affinities of the precambrian 'sea-pen' *Rangea*." *Journal of Morphology* **252** (June): 315-334. (223)

Ecker, Ronald L. 1990. *Dictionary of Science & Creationism*. Buffalo, NY: Prometheus Books. (26, 66, 127, 248, 469, 475, 480, 482, 487, 498, 518, 524)

Edey, Maitland A., and **Donald C. Johanson.** 1989. *Blueprints: Solving the Mystery of Evolution*. 1990 pb ed. New York: Penguin Books. (203, 260, 371)

Edwords, Frederick. 1981. "Why Creationism Should Not Be Taught as Science." *C/E* **2** (Winter): 6-36. (78)

———. 1982a. "Victory in Arkansas: The Trial, Decision, and Aftermath." *C/E* **3** (Winter): 33-45. (80, 480)

———. 1982b. "Creation-Evolution Debates: Who's Winning Them Now?" *C/E* **3** (Spring): 30-42. (259)

———. 1982c. "Those Amazing Animals: The Whales and the Dolphins." *C/E* **3** (Fall): 1-7. (248, 293)

Eger, Martin. 1988. "A Tale of Two Controversies: Dissonance In the Theory and Practice of Rationality." *Zygon* **23** (Sep.): 291-325. (400)

Ehrlich, Robert. 2001. *Nine Crazy Ideas: A Few Might Even Be True*. Princeton, NJ: Princeton University Press. (199)

Eldredge, Niles. 1980. "An Extravagance of Species." *Natural History* **89** (July): 46-51. (246)

———. 1981. "Do Gaps in the Fossil Record Disprove Descent with Modification?" *Creation/Evolution* **2** (Spring): 17-19.

———. 1982. *The Monkey Business: A Scientist Looks at Creationism*. New York: Washington Square Press. (66, 246, 441, 480, 487)

———, ed. 1987. *The* Natural History *Reader in Evolution*. New York: Columbia University Press. (102, 148)

———. 1991a. *Fossils: The Evolution and Extinction of Species*. New York: Harry N. Abrahms. (143, 149, 172, 460)

———. 1991b. *The Miner's Canary: Unraveling the Mysteries of Extinction*. New York: Prentice Hall Press. (199)

———. 1995. *Reinventing Darwin: The Great Debate at the High Table of Evolutionary Theory*. New York: John Wiley & Sons, Inc. (75, 146, 148, 150-151)

———. 2000. *The Triumph of Evolution: And the Failure of Creationism*. New York: W. H. Freeman & Co. (61, 66, 71, 197, 246, 252, 391, 408, 480)

Eldredge, Niles, and **Stephen Jay Gould.** 1988. "Punctuated equilibrium prevails." *Nature* **332** (17 March): 211-212. (246)

Eldredge, Niles, and **Ian Tattersall.** 1982. *The Myths of Human Evolution.* New York: Columbia University Press. (146)

Elena, Santiago F., Vaughn S. Cooper, and **Richard E. Lenski.** 1996. "Punctuated Evolution Caused by Selection of Rare Beneficial Mutations." *Science* **272** (21 June): 1802-1804. (153)

Ellegren, Hans, and **Ariane Carmichael.** 2001. "Multiple and Independent Cessation of Recombination Between Avian Sex Chromosomes." *Genetics* **158** (May): 325-331. (434)

Ellis, Richard. 2001. "The *Helicoprion* Mystery." *NH* **110** (March): 76-77, 80. (88, 92, 128, 137, 194, 246, 255, 292, 399, 417, 430, 460)

Ellwood, Brooks B., Stephen L. Benoist, Ahmed El Hassani, Christopher Wheeler, and **Rex E. Crick.** 2003. "Impact Ejecta Layer from the Mid-Devonian: Possible Connection to Global Mass Extinctions." *Science* **300** (13 June): 1734-1737. (199)

———. 2004. "Response to Comment on 'Impact Ejecta Layer from the Mid-Devonian: Possible Connection to Global Mass Extinctions'." *Science* **303** (23 Jan.): 471. (199)

Elowitz, Michael B., Arnold J. Levine, Eric D. Siggia, and **Peter S. Swain.** 2002. "Stochastic Gene Expression in a Single Cell." *Science* **297** (16 Aug.): 1183-1186. (474)

Elžanowski, Andrzej. 2001. "A new genus and species for the largest specimen of *Archaeopteryx*." *APP* **46** (4): 519-532. (304)

Emiliani, Cesare. 1992. *Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment*. Cambridge: Cambridge University Press. (85-86, 100, 105-107, 109, 158, 189, 197,

---

233, 503)

Engel, Michael S., and **David A. Grimaldi.** 2004. "New light shed on the oldest insect." *Nature* **427** (12 Feb.): 627-630. (230)

Enserink, Martin. 1999. "Fossil Opens Window On Early Animal History." *Science* **286** (3 Dec.): 1829. (128)

Erickson, Jon. 1991. *Dying Planet: The Extinction of Species*. Blue Ridge Summit, PA: TAB Books. (195, 199)

———. 1996. *Marine Geology: Undersea Landforms and Life Forms*. New York: Facts On File, Inc. (159-160)

———. 2000. *Making of the Earth: Geologic Forces That Shape Our Planet*. New York: Facts On File, Inc. (9, 160)

Erwin, Douglas H. 1996. "The Mother of Mass Extinctions." *SA* **275** (July): 73-78. (199)

———. 1998. "The end of the beginning: recoveries from mass extinctions." *TREE* **13** (Sep.): 344-349. (201)

———. 1999. "The Origins of Bodyplans." *AZ* **39** (June): 617-629. (138, 186, 200, 214, 380)

———. 2001. "Lessons from the past: Biotic recoveries from mass extinctions." *PNAS* **98** (8 May): 5399-5403. (201)

Erwin, Douglas H., and **Eric H. Davidson.** 2002. "The last common bilaterian ancestor." *Development* **129** (1 July): 3021-3032. (174, 185, 222, 460)

Erwin, Douglas, James Valentine, and **David Jablonski.** 1997. "The Origin of Animal Body Plans." *American Scientist* **85** (March-April): 126-137. (129, 214 & Fig. 6)

Evans, Christopher. 1974. *Cults of Unreason*. New York: Farrar, Straus & Giroux. (490)

Eve, Raymond A., and **Francis B. Harrold.** 1991. *The Creationist Movement in Modern America*. Boston: Twayne Publishers. (43, 471, 478-479, 483, 485, 488, 490)

Fairley, John, and **Simon Welfare.** 1998. *Arthur C. Clarke's Mysteries*. Amherst, NY: Prometheus Books. (53, 461)

Fastovsky, David E., and **David B. Weishampel.** 1996. *The Evolution and Extinction of the Dinosaurs*. Cambridge: Cambridge University Press. (11, 130, 194, 199, 238, 262, 271, 287-288, 291, 297, 302, 312, 314, 334, 336, 346, 384, 387, 408, 422, 431)

Feder, Jeffrey L., Stewart H. Berlocher, Joseph B. Roethele, Hattie Dambroski, James J. Smith, William L. Perry, Vesna Gavrilovic, Kenneth E. Filchak, Juan Rull, and **Martin Aluja.** 2003. "Allopatric genetic origins for sympatric host-plant shifts and race formation in *Rhagoletis*." *PNAS* **100** (2 Sep.): 10314-10319. (185)

Federer, William J. 1999. *America's God and Country: Encyclopedia of Quotations*. St. Louis, MO: Amerisearch, Inc. (25)

Fedonkin, Mikhail A., and **Benjamin M. Waggoner.** 1997. "The Late Precambrian fossil *Kimberella* is a mollusc-like bilaterian organism." *Nature* **388** (28 Aug.): 868-871. (460)

Fedoroff, Nina, and **Walter Fontana.** 2002. "Small Numbers of Big Molecules." *Science* **297** (16 Aug.): 1129-1131. (474)

Fedorov, Alexei, Scott Roy, Xiaohong Cao, and **Walter Gilbert.** 2003. "Phylogenetically Older Introns Strongly Correlate With Module Boundaries in Ancient Proteins." *GR* **13** (June 6a): 1155-1157. (463)

Feduccia, Alan. 1993. "Evidence from Claw Geometry Indicating Arboreal Habits of *Archaeopteryx*." *Science* **259** (5 Feb.): 790-793. (344)

———. 1995. "Explosive Evolution in Tertiary Birds and Mammals." *Science* **267** (3 Feb.): 637-638. (335)

———. 1999a. "1,2,3 = 2,3,4: Accommodating the cladogram." *PNAS* **96** (27 April): 4740-4742. (320)

———. 1999b. *The Origin and Evolution of Birds*. 2nd ed. New Haven, CT: Yale University Press. (263, 274-275, 279, 288, 291, 296-297, 304, 312, 315-316, 335-336, 340-342, 346-347, 370, 444)

———. 2002. "Birds are Dinosaurs: Simple Answer to a Complex Problem." *The Auk* **119** (Oct.): 1187-1201. (320, 327, 336, 341-342, 370, 382)

———. 2003a. "Bird origins: problem solved, but the debate continues…" *TREE* **18** (Jan.): 9-10. (320)

———. 2003b. "'Big bang' for tertiary birds?" *TREE* **18** (April): 172-176. (335)

Fenchel, Tom, and **Bland J. Finlay.** 1994. "The Evolution of Life without Oxygen." *American Scientist* **82** (Jan.-Feb.): 22-29. (197)

Fenton, M. Brock. 1992. *Bats*. New York: Facts On File, Inc. (265)

Ferguson, Andrew. 1998. "How Steven Pinker's Mind Works." *The Weekly Standard* **3** (12 Jan.): 16-24. (400)

———. 2001. "Evolutionary Psychology and Its True Believers." *The Weekly Standard* **6** (19 March): 31-39. (400)

Ferkowicz, Michael J., and **Rudolf A. Raff.** 2001. "Wnt gene expression in sea urchin development: Heterochronies associated with the evolution of developmental mode." *E&D* **3** (Jan.-Feb.): 24-33. (217)

Ferngren, Gary B., ed. 2002. *Science and Religion: A Historical Introduction*. Baltimore, MD: Johns Hopkins University Press. (57, 59, 66)

Finnerty, John R. 2001. "Cnidarians reveal intermediate stages in the evolution of Hox clusters and axial complexity." *AZ* **41** (June): 608-620. (238)

Finney, Stanley C., William B. N. Berry, John D. Cooper, Robert L. Ripperdan, Walter C. Sweet, Stephen R. Jacobson, Azzedine Soufiane, Aicha Achab, and **Paula J. Noble.** 1999. "Late Ordovician mass extinction: A new perspective from stratigraphic sections in central Nevada." *Geology* **27** (March): 215-218. (199)

Fischer, Daniel, and **Hilmar Duerbeck**, trans. Helmut Jenker. 1998. *Hubble Revisited: New Images from the Discovery Machine*. New York: Copernicus. (8)

Fisher, Daniel, and **Marcel Méchali.** 2003. "Vertebrate *HoxB* gene expression requires DNA replication." *The EMBO Journal* **22** (15 July): 3737-3748. (207)

Fisher, Harvey I. 1940. "The Occurrence of Vestigial Claws on the Wings of Birds." *The American Midland Naturalist* **23** (Jan.): 234-243. (263)

Fisher, Paul E., Dale E. Russell, Michael K. Stoskopf, Reese E. Barrick, Michael Hammer, and **Andrew A. Kuzmitz.** 2000. "Cardiovascular Evidence for an Intermediate or Higher Metabolic Rate in an Ornithischian Dinosaur." *Science* **288** (21 April): 503-505. (336)

Fitch, Walter M., and **Francisco J. Ayala.** 1994a. "Tempo and mode in evolution." *PNAS* **91** (19 July): 6717-6720. (457)

———. 1994b. "The superoxide dismutase molecular clock revisited." *PNAS* **91** (19 July): 6802-6807. (457)

Flindt, Max H., and **Otto O. Binder.** 1974. *Mankind—Child of the Stars*. Greenwich, CT: Fawcett Gold Medal Books. (5)

Foitzik, Kerstin, Ralf Paus, Tom Doetschman, and **G. Paolo Dotto.** 1999. "The TGF-β2 Isoform Is Both a Required and Sufficient Inducer of Murine Hair Follicle Morphogenesis." *DB* **212** (15 Aug.): 278-289. (435)

Force, Allan, Angel Amores, and **John H. Postlethwait.** 2002. "*Hox* Cluster Organization in the Jawless Vertebrate *Petromyzon marinus*." *JEZ* **294** (15 April): 30-46. (92)

Forey, Peter L. 1988. "Golden jubilee for the coelacanth *Latimeria chalumnae*." *Nature* **336** (29 Dec.): 727-732. (399)

Forey, Peter, and **Philippe Janvier.** 1993. "Agnathans and the origin of jawed vertebrates." *Nature* **361** (14 Jan.): 129-134. (87)

Forster, Catherine A., Scott D. Sampson, Luis M. Chiappe, and **David W. Krause.** 1998. "The Theropod Ancestry of Birds: New Evidence from the Late Cretaceous of Madagascar." *Science* **279** (20 March): 1915-1919. (333)

Forster, Lucy, Peter Forster, Sabine Lutz-Bonengel, Horst Willkomm, and **Bernd Brinkmann.** 2002. "Natural radioactivity and human mitochondrial DNA mutations." *PNAS* **99** (15 Oct.): 13950-13954. (203)

Forte, Maurizio, and **Alberto Siliotti**, eds. 1997. *Virtual Archaeology: Re-creating Ancient Worlds*. New York: Harry N. Abrams, Inc. (64)

Fortey, Richard. 2000a. "Crystal Eyes." *NH* **109** (Oct.): 68-73. (251)

———. 2000b. *Trilobite! Eyewitness to Evolution*. New York: Alfred A. Knopf. (85, 175, 194, 245-246, 251)

———. 2001. "The Cambrian Explosion Exploded?" *Science* **293** (20 July): 438-439. (189)

Frair, Wayne. 2000. "Baraminology—Classification of Created Organisms." *Creation Research Society Quarterly* **37** (Sep.): 82-91. (529)

Fraser, C. Nicholas. 1997. "Genesis of snakes in exodus from the sea." *Nature* **386** (17 April): 651-652. (292)

Freeland, Joanna R., and **Peter T. Boag.** 1999. "Phylogenetics of Darwin's Finches: Paraphyly in the Tree-Finches, and Two Divergent Lineages in the Warbler Finch." *The Auk* **116** (July): 577-588. (450)

Fricke, Henry C., and **Raymond R. Rogers.** 2000. "Multiple taxon- locality approach to providing oxygen isotope evidence for warm-blooded theropod dinosaurs." *Geology* **28** (Sep.): 799-802. (336)

Fridolfsson, Anna-Karin, Hans Cheng, Neal G. Copeland, Nancy A. Jenkins, Hsiao-Ching Liu, Terje Raudsepp, Trevor Woodage, Bhanu Chowdhary, Joy Halverson, and **Hans Ellegren.** 1998. "Evolution of the avian sex chromosomes from an ancestral pair of autosomes." *PNAS* **95** (7 July): 8147-8152. (434)

Fridolfsson, Anna-Karin, and **Hans Ellegren.** 2000. "Molecular Evolution of the Avian *CHD1* Genes on the Z and W Sex Chromosomes." *Genetics* **155** (August): 1903-1912. (434)

Friedman, William E., and **Sandra K. Floyd.** 2001. "The Origin of Flowering Plants and Their Reproductive Biology—A Tale of Two Phylogenies." *Evolution* **55** (Feb.): 217-231. (102)

Froede, Carl R. Jr. 1999. "Precambrian Plant Fossils and the Hakatai Shale Controversy." *Creation Research Society Quarterly* **36** (Dec.): 106-113. (100)

Futuyma, Douglas J. 1982. *Science on Trial: The Case for Evolution*. 1983 pb ed. New York: Pantheon Books. (20, 29, 66, 180, 203, 229, 240, 248, 283, 287, 293, 312, 322, 391, 395, 450)

———. 1986. *Evolutionary Biology*. 2nd ed. Sunderland, MA: Sinauer Associates, Inc. (229, 452)

———. 1994. "Ernst Mayr and Evolutionary Biology." *Evolution* **48** (Feb.): 36-43. (142)

———. 1998. *Evolutionary Biology*. 3rd ed. Sunderland, MA: Sinauer Associates, Inc. (432, 436)

Gabbott, S. E., R. J. Aldridge, and **J. N. Theron.** 1995. "A giant conodont with preserved muscle tissue from the Upper Ordovician of South Africa." *Nature* **374** (27 April): 800-803. (106)

Gaines, Robert R., and **Mary L. Droser.** 2003. "Paleoecology of the familiar trilobite *Elrathia kingii*: An early exaerobic zone inhabitant." *Geology* **31** (Nov.): 941-944. (33, 158)

Galis, Frietson. 2001. "Digit identity and digit number: indirect support for the descent of birds from theropod dinosaurs." *TREE* **16** (Jan.): 16. (320)

Galis, Frietson, Martin Kundrát, and **Barry Sinervo.** 2003. "An old controversy solved: bird embryos have five fingers." *TREE* **18** (Jan.): 7-9. (320)

Galis, Frietson, Jacques J. M. van Alphen, and **Johan A. J. Metz.** 2001. "Why five fingers? Evolutionary constraints on digit numbers." *TREE* **16** (Nov.): 637-646. (320)

Gamlin, Linda, and **Gail Vines**, eds. 1986. *The Evolution of Life*. 1991 pb ed. New York: Oxford University Press. (85, 101-102, 106-107, 109, 143, 172, 203, 207, 216, 220, 225, 230, 235, 238-239, 274, 392, 408, 422, 436, 460)

Gans, Carl, and **Ernest Glen Wever.** 1972. "The Ear and Hearing in Amphisbaenia (Reptilia)." *JEZ* **179** (Jan.): 17-34. (421)

García-Fernàndez, Jordi, and **Peter W. H. Holland.** 1994. "Archetypal organization of the amphioxus *Hox* gene cluster." *Nature* **370** (18 Aug.): 563-566. (235)

García-Moreno, Jaime, Michael D. Sorenson, and **David P. Mindell.** 2003. "Congruent Avian Phylogenies Inferred from Mitochondrial and Nuclear DNA Sequences." *JME* **57** (July): 27-37. (335)

Gardner, Martin. 1957. *Fads & Fallacies In the Name of Science*. Rev. ed. New York: Dover Publications. (473, 490)

———. 1997. “Intelligent Design and Phillip Johnson.” *SI* **21** (Nov./Dec.): 17-20. (42)

———. 2000. *Did Adam and Eve Have Navels? Discourses on Reflexology, Numerology, Urine Therapy, and Other Dubious Subjects*. New York: W. W. Norton & Co. (42)

Gardom, Tim, and **Angela Milner.** 1993. *The Natural History Museum Book of Dinosaurs*. 1998 pb ed. London: Carlton. (12)

Gascuel, Olivier. 2000. “On the Optimization Principle in Phylogenetic Analysis and the Minimum Evolution Criterion.” *MBE* **17** (March): 401-405. (241)

Gaunt, Stephen J. 1997. “Chick limbs, fly wings and homology at the fringe.” *Nature* **386** (27 March): 324-325. (211)

Gauquelin, Michel. 1967. *The Cosmic Clocks*. 1969 pb ed. New York: Avon Books. (494)

———, trans. James Hughes. 1970. *The Scientific Basis of Astrology: Myth or Reality*. New York: Stein & Day. (494)

———, trans. Sarah Matthews. 1983. *Birth-Times: A Scientific Investigation of the Secrets of Astrology*. New York: Hill & Wang. (494)

Gee, Henry. 1992. “Something completely different.” *Nature* **358** (6 Aug.): 456-457. (192)

———. 1994. “Return of the amphioxus.” *Nature* **370** (18 Aug.): 504-505. (235)

———. 1999. *In Search of Deep Time: Beyond the Fossil Record to a New History of Life*. New York: The Free Press. (62, 86, 92, 272, 291, 342, 399)

———. 2003. “Ending incongruence.” *Nature* **425** (23 Oct.): 782. (185)

Gee, Henry, and **Luis V. Rey.** 2003. *A Field Guide to Dinosaurs*. Hauppauge, NY: Barron’s. (337)

Geisler, Norman L., and **Paul K. Hoffman**, eds. 2001. *Why I Am a Christian: Leading Thinkers Explain Why They Believe*. Grand Rapids, MI: Baker Books. (22, 25, 110)

Geist, Nicholas R., and **Alan Feduccia.** 2000. “Gravity-defying behaviors: Identifying models for protoaves.” *AZ* **40** (Sep.): 664-675. (275, 291, 310, 333, 341, 344)

Gentry, Robert V. 1986. *Creation’s Tiny Mystery*. Knoxville, TN: Earth Science Associates. (480)

Gerhart, J. 2000. “Inversion of the chordate body axis: Are there alternatives?” *PNAS* **97** (25 April): 4445-4448. (222)

Gibbons, Ann. 1996. “Early Birds Rise From China Fossil Beds.” *Science* **274** (15 Nov.): 1083. (370)

———. 1997a. “Plucking the Feathered Dinosaur.” *Science* **278** (14 Nov.): 1229. (340)

———. 1997b. “Lung Fossils Suggest Dinos Breathed in Cold Blood.” *Science* **278** (14 Nov.): 1229-1230. (336)

Gibbs, W. Wayt. 2001. “On the Termination of Species.” *SA* **285** (Nov.): 40-49. (199)

Gibson-Brown, Jeremy J., Sergei I. Agulnik, Lee M. Silver, Lee Niswander, and **Virginia E. Papaloannou.** 1998. “Involvement of T-box genes *Tbx2-Tbx5* in vertebrate limb specification and development.” *Development* **125** (1 July): 2499-2509. (380)

Gilkey, Langdon. 1985. *Creationism on Trial: Evolution and God at Little Rock*. Minneapolis, MN: Winston Press, Inc. (480)

Gillooly, James F., James H. Brown, Geoffrey B. West, Van M. Savage, and **Eric L. Charnov.** 2001. “Effects of Size and Temperature an Metabolic Rate.” *Science* **293** (21 Sep.): 2248-2251. (429)

Gingerich, Philip D. 1994. “The Whales of Tethys.” *NH* **103** (April): 86-88. (248)

Gingerich, Philip D., **Munir ul Haq, Iyad S. Zalmout, Intizar Hussain Khan**, and **M. Sadiq Malkani.** 2001. “Origin of Whales from Early Artiodactyls: Hands and Feet of Eocene Protocetidae from Pakistan.” *Science* **293** (21 Sep.): 2239-2242. (248)

Gingerich, Philip D., **S. Mahmood Raza**, **Muhammad Arif**, **Mohammad Anwar**, and **Xiaoyuan Zhou.** 1994. “New whale from the Eocene of Pakistan and the origin of cetacean swimming.” *Nature* **368** (28 April): 844-847. (248)

Gingerich, Philip D., **B. Holly Smith**, and **Elwyn L. Simons.** 1990. “Hind Limbs of Eocene *Basilosaurus*: Evidence of Feet in Whales.” *Science* **249** (13 July): 154-157. (248)

Gingerich, Philip D., Neil A. Wells, **Donald E. Russell**, and **S. M. Ibrahim Shah.** 1983.

"Origin of Whales in Epicontinental Remnant Seas: New Evidence from the Early Eocene of Pakistan." *Science* **220** (22 April): 403-406. (248)

Gish, Duane T. 1978. *Evolution: The Fossils Say NO!* San Diego, CA: Creation-Life Publishers. (9, 102, 163, 218, 227, 232, 262-263, 286, 352, 399, 423, 526)

———. 1990. *The Amazing Story of Creation from science and the Bible*. El Cajon, CA: Institute for Creation Research. (34, 102, 218, 228, 250, 265-266, 293, 321, 344, 351, 411, 439)

———. 1992. *Dinosaurs by Design*. Green Forest, AR: Master Books. (34, 266, 274-275, 300, 329)

———. 1993. *Creation Scientists Answer Their Critics*. El Cajon, CA: Institute for Creation Research. (20, 25, 32, 67, 99, 102, 126, 135, 168, 218, 229, 237, 246, 250, 257, 259, 265-266, 296, 324, 357, 401, 467, 508, 511-512, 523-524, 526)

———. 1995. *Evolution: The Fossils STILL Say NO!* Rev. ed. of 1985, *Evolution: The Challenge of the Fossil Record* (in turn rev. of 1978, *Evolution: The Fossils Say NO!*). El Cajon, CA: Institute for Creation Research. (9, 19, 29, 67, 93, 96, 102, 131, 135, 163-164, 168, 180, 198, 218, 228-229, 232-234, 248, 250, 262-263, 265-266, 275, 284, 286-287, 292, 294, 300, 303, 321, 327, 359, 399, 401, 411-413, 423, 437, 450, 460-461, 526)

Glen, William, ed. 1994. *The Mass-Extinction Debates: How Science Works in a Crisis*. Stanford, CA: Stanford University Press. (199)

Glut, Donald F. 1982. *The Complete Dinosaur Dictionary*. 1992 pb ed. of rev. of 1972 *The New Dinosaur Dictionary*. Secaucus, NJ: Citadel Press. (164)

Godfrey, Laurie R., ed. 1983. *Scientists Confront Creationism*. 1984 pb ed. New York: W. W. Norton & Co. (4, 32, 66, 76, 102, 148, 265, 441, 471, 524)

Godwin, Alan R., and **Mario R. Capecchi.** 1998. "*Hoxc13* mutant mice lack external hair." *Genes & Development* **12** (1 Jan.): 11-20. (435)

Godwin, John. 1972. *Occult America*. New York: Doubleday. (490)

Gohau, Gabriel, rev. & trans. Albert V. Carozzi & Marguerite Carozzi. 1990. *A History of Geology*. New Brunswick, NJ: Rutgers University Press. (29)

Gold, Thomas. 1999. *The Deep Hot Biosphere*. New York: Copernicus. (515)

Golding, Brian G., and **Antony M. Dean.** 1998. "The Structural Basis of Molecular Adaptation." *MBE* **15** (April): 355-369. (336)

Goldstein, David B., and **Paul H. Harvey.** 1999. "Evolutionary inference from genomic data." *BioEssays* **21** (Feb.): 148-156. (241)

Gompel, Nicolas, and **Sean B. Carroll.** 2003. "Genetic mechanisms and constraints governing the evolution of correlated traits in drosophilid flies." *Nature* **424** (21 Aug.): 931-935. (393)

Goodfriend, Glenn A., and **Daniel Jean Stanley.** 1999. "Rapid strand-plain accretion in the northeastern Nile Delta in the 9th century A.D. and the demise of the port of Pelusium." *Geology* **27** (Feb.): 147-150. (10)

Goodwin, Brian. 1994. *How the Leopard Changed Its Spots: The Evolution of Complexity*. New York: Charles Scribner's Sons. (380)

Gore, Rick. 1989. "Extinctions." *NG* **175** (June): 662-699. (199)

———. 1993. "Explosion of Life: The Cambrian Period." *NG* **184** (Oct.): 120-136. (105, 129)

Gould, Stephen E., William B. Upholt, and **Robert A. Kosher.** 1995. "Characterization of Chicken Syndecan-3 as a Heparan Sulfate Proteoglycan and Its Expression during Embryogenesis." *DB* **168** (1 April): 438-451. (435)

Gould, Stephen Jay. 1977a. *Ever Since Darwin: Reflections in Natural History.* New York: W.W. Norton & Co. (239)

———. 1977b. *Ontogeny and Phylogeny*. Cambridge, MA: Belknap Press (Harvard University Press). (239)

———. 1980. *The Panda's Thumb: More Reflections in Natural History.* New York: W.W. Norton & Co. (48, 146, 324)

———. 1981. *The Mismeasure of Man.* New York: W.W. Norton & Co. (48, 240)

———. 1983. *Hen's Teeth and Horse's Toes.* New York: W.W. Norton & Co. (205, 240, 322, 391)

———. 1989. *Wonderful Life: The Burgess Shale and the Nature of History.* New York: W.W. Norton & Co. (97, 105, 132-133, 138, 158, 166, 171, 178, 184, 192, 242 & Figs. 3-5, 7-9, 13-14, 16-17, 23, 29)

———. 1990. "An Earful of Jaw." *NH* **99** (March): 12, 15-16, 18, 20, 22-23. (440)

———. 1991. *Bully for Brontosaurus: Reflections in Natural History.* New York: W.W. Norton & Co. (11, 230, 461, 468, 471, 498, 525)

———. 1992. "Impeaching a Self-Appointed Judge." *SA* **267** (July): 118-121. (68, 415, 444)

———, ed. 1993. *The Book of Life*. New York: W. W. Norton & Co. (86, 102, 162-163, 201, 398, 428, 430-431, 436, 441)

———. 1994a. "In the Mind of the Beholder." *NH* **103** (Feb.): 14-23. (199, 233)

———. 1994b. "Ernst Mayr and the Centrality of Species." *Evolution* **48** (Feb.): 31-35. (142)

———. 1994c. "Hooking Leviathan by It's Past." *NH* **103** (May): 8-15. (248, 461)

———. 1994d. "Tempo and mode in the macroevolutionary reconstruction of Darwinism." *PNAS* **91** (19 July): 6764-6771. (457)

———. 1994e. "Common Pathways of Illumination." *NH* **103** (Dec.): 10-20. (206, 209)

———. 1995. "Of it, not above it." *Nature* **377** (26 Oct.): 681-682. (93)

———. 1996. *Full House: The Spread of Excellence from Plato to Darwin.* New York: Harmony Books (Crown). (525)

———. 1998a. "On Embryos and Ancestors." *NH* **107** (July/Aug.): 20-22, 58-65. (107, 138, 173, 198)

———. 1998b. "Showdown on the Burgess Shale: The Reply." *NH* **107** (Dec.): 48, 52-55. (107, 194)

———. 1999a. *Rocks of Ages: Science and Religion in the Fullness of Life.* New York: The Library of Contemporary Thought (Ballantine). (471)

———. 1999b. "Dorothy, It's Really Oz." *Time* **154** (23 Aug.): 59. (39)

———. 2000. "Tales of a Feathered Tail." *NH* **109** (Nov.): 32, 34-42. (341)

———. 2002. *The Structure of Evolutionary Theory*. Cambridge, MA: Belknap Press (Harvard University Press). (77, 143, 153, 194, 206, 214, 222, 230, 239, 246, 260, 292, 408, 439, 525)

Grabiner, Judith D., and **Peter D. Miller.** 1974. "Effects of the Scopes Trial." *Science* **185** (6 Sep.): 832-837. (471)

Graham, David E., Ross Overbeek, Gary J. Olsen, and **Carl R. Woese.** 2000. "An archaeal genomic signature." *PNAS* **97** (28 March): 3304-3308. (101)

Grant, B. Rosemary, and **Peter R. Grant.** 1996. "Cultural Inheritance of Song and Its Role in the Evolution of Darwin's Finches." *Evolution* **50** (Dec.): 2471-2487. (450)

Grant, Michael. 1972. *Cleopatra*. New York: Dorset Press. (63)

Grant, Peter R. 1981. "Speciation and the Adaptive Radiation of Darwin's Finches." *American Scientist* **69** (Nov.-Dec.): 653-663. (450)

———. 1991. "Natural Selection and Darwin's Finches." *SA* **265** (Oct.): 82-87. (450)

Grant, Peter R., and **B. Rosemary Grant.** 1992. "Hybridization of Bird Species." *Science* **256** (10 April): 193-197. (450)

———. 1994. "Phenotype and Genetic Effects of Hybridization in Darwin's Finches." *Evolution* **48** (April): 297-316. (450)

———. 1997. "Genetics and the origin of bird species." *PNAS* **94** (22 July): 7768-7775. (450)

———. 2002a. "Adaptive Radiation of Darwin's Finches." *American Scientist* **90** (March-April): 130-139. (450)

———. 2002b. "Unpredictable Evolution in a 30-Year Study of Darwin's Finches." *Science* **296** (26 April): 707-711. (450)

Grassé, Pierre-P. 1977. *Evolution of Living Organisms: Evidence for a New Theory of Transformation*. English edition of 1973 French version. New York: Academic Press. (391)

Greene, Harry W., and **David Cundall.** 2000. "Limbless Tetrapods and Snakes with Legs." *Science* **287** (17 March): 1939-1941. (292)

Greenfield, Susan A. 1996. *The Human Mind Explained: An Owner's Guide to the Mysteries of the Human Mind.* New York: Henry Holt & Co. (238)

Greer, Joy M., John Puetz, Kirk R. Thomas, and **Mario R. Capecchi.** 2000. "Maintenance of functional equivalence during paralogous Hox gene evolution." *Nature* **403** (10 Feb.): 661-665. (206)

Gregg, K., S. D. Wilton, D. A. Parry, and **G. E. Rogers.** 1984. “A comparison of genomic coding sequences for feather and scale keratins: structural and evolutionary implications.” *The EMBO Journal* **3** (Jan.): 175-178. (278)

Grey, Kathleen, Malcolm R. Walter, and **Clive R. Calver.** 2003. “Neoproterozoic biotic diversification: Snowball Earth or aftermath of the Acraman impact?” *Geology* **31** (May): 459-462. (198)

Grieg, Duncan, Edward J. Louis, Rhona H. Borts, and **Michael Travisano.** 2002. “Hybrid Speciation in Experimental Populations of Yeast.” *Science* **298** (29 Nov.): 1773-1775. (146)

Griffiths, Paul E., and **Eva Neumann-Held.** 1999. “The many faces of the gene.” *BioScience* **49** (Aug.): 656-662. (54)

Grimaldi, David, and **Donat Agosti.** 2000. “A formicine in New Jersey Cretaceous amber (Hymenoptera: Formicidae) and early evolution of ants.” *PNAS* **97** (5 Dec.): 13678-13683. (229)

Grotzinger, John P., Samuel A. Bowring, Beverly Z. Saylor, and **Alan J. Kaufman.** 1995. “Biostratigraphic and Geochronologic Constraints on Early Animal Evolution.” *Science* **270** (27 Oct.): 598-604. (138, 196)

Guensburg, Thomas E., and **James Sprinkle.** 2001. “Earliest crinoids: New evidence for the origin of the dominant Paleozoic echinoderms.” *Geology* **29** (Feb.): 131-134. (86)

Gupta, Radhey S. 1998. “Protein Phylogenies and Signature Sequences: A Reappraisal of Evolutionary Relationships among Archaebacteria, Eubacteria, and Eukaryotes.” *Microbiology and Molecular Biology Reviews* **62** (Dec.): 1435-1491. (103, 225)

Hafen, Ernst, Konrad Basler, Jan-Erik Edstroem, and **Gerald M. Rubin.** 1987. “*Sevenless*, a Cell-Specific Homeotic Gene of Drosophila, Encodes a Putative Transmembrane Receptor with a Tyrosine Kinase Domain.” *Science* **236** (3 April): 55-63. (148)

Hagadorn, James W., Robert H. Dott Jr., and **Dan Damrow.** 2002. “Stranded on a Late Cambrian shoreline: Medusae from central Wisconsin.” *Geology* **30** (Feb.): 147-150. (189)

Hagen, Joel. 2003. “The Statistical Frame of Mind in Systematic Biology from *Quantitative Zoology* to *Biometry*.” *Journal of the History of Biology* **36** (Summer): 353-384. (408)

Hagmann, Michael. 2000. “Why Chicks Aren’t All Thumbs.” *Science* **289** (21 July): 372-373. (320)

Haines, Tim. 2001. *Walking with Prehistoric Beasts*. New York: DK Publishing. (248, 265)

Halanych, Kenneth M., and **Yale Passamaneck.** 2001. “A brief review of metazoan phylogeny and future prospects in Hox-research.” *AZ* **41** (June): 629-639. (216)

Halder, Georg, Patrick Callaerts, and **Walter J. Gehring.** 1995. “Induction of Ectopic Eyes by Targeted Expression of the *eyeless* Gene in *Drosophila*.” *Science* **267** (24 March): 1788-1792. (254)

Hall, Brian K. 1992. “Waddington’s legacy in development and evolution.” *AZ* **32** (Feb.): 113-122. (243)

———. 1999. “The paradoxical platypus.” *BioScience* **49** (March): 211-218. (461)

Ham, Ken. 1998. *The Great Dinosaur Mystery SOLVED!* Green Forest, AR: Master Books. (35-36, 316, 336, 340, 342)

Hamburger, Philip. 2002. *Separation of Church and State*. Cambridge, MA: Harvard University Press. (475)

Hancock, Graham. 1992. *The Sign of the Seal: The Quest for the Lost Ark of the Covenant*. New York: Crown Publishers. (2)

———. 2002. *Underworld: The Mysterious Origins of Civilization*. New York: Crown Publishers. (2)

Hancock, Graham, and **Robert Bauval.** 1996. *The Message of the Sphinx: A Quest for the Hidden Legacy of Mankind*. New York: Crown Publishers. (2)

Hanegraaff, Hank. 1998. *The Face that Demonstrates the Farce of Evolution*. Nashville, TN: Word Publishing. (19, 218, 251, 262, 266, 294, 321, 341, 361, 401, 439, 441, 526)

Hanson, Robert W., ed. 1986. *Science and Creation: Geological, Theological, and Educational*

Perspectives. New York: Macmillan. (66, 77, 441, 480)

Harlan, Stephen S., Larry Heaman, Anthony N. LeCheminant, and **Wayne R. Premo.** 2003. "Gunbarrel mafic magmatic event: A key 780 Ma time marker for Rodinia plate reconstruction." *Geology* **31** (Dec.): 1053-1056. (160)

Harold, Franklin M. 2001. *The Way of the Cell: Molecules, Organisms and the Order of Life.* Oxford: Oxford University Press. (61, 103)

Harris, Matthew P., John F. Fallon, and **Richard O. Prum.** 2002. "*Shh-Bmp2* Signaling Module and the Evolutionary Origin and Diversification of Feathers." *JEZ* **294** (15 Aug.): 160-176. (435)

Harrub, Brad, and **Bert Thompson.** 2001. "Archaeopteryx, Archaeoraptor, and the 'Dinosaurs-To-Birds' Theory (Part I)." *Reason & Revelation* **21** (April): 25-32. (290, 342, 361)

Hartl, Daniel L., Dmitry I. Nurminsky, Robert W. Jones, and **Elena R. Lozovskaya.** 1994. "Genome structure and evolution in *Drosophila*: Applications of the framework P1 map." *PNAS* **91** (19 July): 6824-6829. (457)

Hartman, Hyman, and **Alexei Fedorov.** 2002. "The origin of the eukaryotic cell: A genomic investigation." *PNAS* **99** (5 Feb.): 1420-1425. (225)

Hartmann, William K., and **Ron Miller.** 1991. *The History of Earth: An Illustrated Chronicle of an Evolving Planet*. New York: Workman Publishing. (517)

Hartz, Ebbe H., and **Trond H. Torsvik.** 2002. "Baltica upside down: A new plate tectonic model for Rodinia and the Iapetus Ocean." *Geology* **30** (March): 255-258. (160)

Hayes, Judith. 2000. *The Happy Heretic*. Amherst, NY: Prometheus Books. (38)

Hayward, Alan. 1985. *Creation and Evolution*. 1995 pb ed. Minneapolis, MN: Bethany House Publishers. (20, 218, 248, 250, 266, 352, 401, 441, 506, 509)

Heckman, Daniel S., David M. Geiser, Brooke R. Eidell, Rebecca L. Stauffer, Natalie L. Kardos, and **S. Blair Hedges.** 2001. "Molecular Evidence for the Early Colonization of Land by Fungi and Plants." *Science* **293** (10 Aug.): 1129-1133. (185)

Heinrich, Bernd. 1996. *The Thermal Warriors: Strategies of Insect Survival*. Cambridge, MA: Harvard University Press. (230)

Helariutta, Yrjö, Mika Kotilainen, Paula Elomaa, Nisse Kalkkinen, Kåre Bremer, Teemu H. Teeri, and **Victor A. Albert.** 1996. "Duplication and functional divergence in the chalcone synthase gene family of Asteraceae: Evolution with substrate change and catalytic simplification." *PNAS* **93** (20 Aug.): 9033-9038. (530)

Hellman, Hal. 1998. *Great Feuds in Science: Ten of the Liveliest Disputes Ever*. New York: John Wiley & Sons. (61, 194)

Helvarg, David. 1994. *The War Against the Greens: The "Wise-Use" Movement, the New Right, and Anti-Environmental Violence*. San Francisco: Sierra Club Books. (53)

Hendry, Andrew P., and **Michael T. Kinnison.** 1999. "Perspective: The Pace of Modern Life: Measuring Rates of Contemporary Microevolution." *Evolution* **53** (Dec.): 1637-1653. (147)

Hennig, Willi, trans. D. Dwight Davis & Rainer Zangerl. 1966. *Phylogenetic Systematics*. Urbana, IL: University of Illinois Press. (62, 408)

Henry, Jonathan J., and **Rudolf A. Raff.** 1990. "Evolutionary Change in the Process of Dorsoventral Axis Determination in the Direct Developing Sea Urchin *Heliocidaris erythrogramma*." *DB* **141** (1 Sep.): 55-69. (243)

Hickman, Carole S. 2001. "Evolution and development of gastropod larval shell morphology: experimental evidence for mechanical defense and repair." *E&D* **3** (Jan.-Feb.): 18-23. (177)

Hill, Jim, and **Rand Cheadle.** 1996. *The Bible Tells Me So: Uses and Abuses of Holy Scripture*. New York: Anchor Books. (464)

Hill, John E., and **James D. Smith.** 1984. *Bats: A Natural History*. Austin, TX: University of Texas Press. (265, 311)

Hillenius, Willem J. 1994. "Turbinates in Therapsids: Evidence for Late Permian Origins of Mammalian Endothermy." *Evolution* **48** (April): 207-229. (433)

Hinchcliffe, Richard. 1997. "The Forward March of the Bird-Dinosaur Halted?" *Science* **278** (24 Oct.): 596-597. (316)

Hinman, Veronica F., and **Bernard M. Degnan.** 2001. "Homeobox genes, retinoic acid and the development and evolution of dual body plans in the ascidian *Herdmania curvata*." *AZ* **41** (June): 664-675. (238)

Hinman, Veronica F., Albert T. Nguyen, R. Andrew Cameron, and **Eric H. Davidson.** 2003. "Developmental gene regulatory network architecture across 500 million years of echinoderm evolution." *PNAS* **100** (11 Nov.): 13356-13361. (217)

Hobmayer, Bert, Fabian Rentzsch, **Kerstin Kuhn**, **Christoph M. Happel**, **Christoph Cramer von Laue**, **Petra Snyder**, **Ute Rothbächer**, and **Thomas W. Holstein.** 2000. "WNT signaling molecules act in axis formation in the diploblastic metazoan *Hydra*." *Nature* **407** (14 Sep.): 186-189. (238)

Hochschild, Jennifer L., and **Nathan Scovronick.** 2003. *The American Dream and the Public Schools*. Oxford: Oxford University Press. (39)

Hoffman, Paul E., and **Daniel P. Schrag.** 2000. "Snowball Earth." *SA* **282** (Jan.): 68-75. (195)

Hoffmann, Hillel J. 2000. "When Life Nearly Came to an End: The Permian Extinction." *NG* **198** (Sep.): 100-113. (199)

Hofmann, Hans J., and **Eric W. Mountjoy.** 2001. "*Namacalathus-Cloudina* assemblage in Neoproterozoic Miette Group (Byng Formation), British Columbia: Canada's oldest shelly fossils." *Geology* **29** (Dec.): 1091-1094. (198)

Holden, Constance. 1999a. "Kennewick Man Gets His Day in the Lab." *Science* **283** (26 Feb.): 1239-1240. (64)

———. 1999b. "Ancient Bones Returned to Sod." *Science* **286** (12 Nov.): 1285. (64)

———. 2000a. "Dinos and Turkeys: Connected by DNA?" *Science* **288** (14 April): 238. (317)

———. 2000b. "Florida Meeting Shows Perils, Promise of Dealing for Dinos." *Science* **288** (14 April): 238-239. (385)

———. 2000c. "Bones Decision Rattles Researchers." *Science* **289** (29 Sep.): 2257. (64)

———. 2003. "Isotopic Data Pinpoint Iceman's Origins." *Science* **302** (31 Oct.): 759, 761. (64)

———. 2004. "Scientists Hope Ruling Will Lead Them to Bones." *Science* **303** (13 Feb.): 943. (64)

Holland, Nicholas D., and **Junyuan Chen.** 2001. "Origin and early evolution of the vertebrates: new insights from advances in molecular biology, anatomy, and palaeontology." *BioEssays* **23** (Feb.): 142-151. (93, 214)

Holland, Nicholas D., and **Linda Z. Holland.** 1999. "Amphioxus and the Utility of Molecular Genetic Data for Hypothesizing Body Part Homologies between Distantly Related Animals." *AZ* **39** (June): 630-640. (235, 380)

Holland, Steven M., and **Mark E. Patzkowsky.** 1999. "Models for simulating the fossil record." *Geology* **27** (June): 491-494. (175)

Hölldobler, Bert, and **Edward O. Wilson.** 1990. *The Ants*. Cambridge, MA: Belknap Press (Harvard University Press). (229)

Holmes, Bob. 2000. "Take me to your leader." *New Scientist* **166** (22 April): 40-43. (41)

Homberger, Dominique G., and **Kumudini N. de Silva.** 2000. "Functional microanatomy of the feather-bearing integument: Implications for the evolution of birds and avian flight." *AZ* **40** (Sep.): 553-574. (275, 344)

Hopson, James A. 1987. "The Mammal-like Reptiles: A study of transitional fossils." *ABT* **49** (Jan.): 16-26. (391, 406, 413-414, 436, 440)

Horgan, John. 1992. "The New Challenges." *SA* **267** (Dec.): 16-17, 20, 22. (142)

———. 1997. "Which Came First?" *SA* **276** (Feb.): 16, 18, 22. (339, 370)

Horton, Amy C., and **Jeremy J. Gibson-Brown.** 2002. "Evolution of Developmental Functions by the *Eomesodermin, T-brain-1*, *Tbx21* Subfamily of T-box genes: Insights from Amphioxus." *JEZ* **294** (15 Aug.): 112-121. (235)

Hotchkiss, Frederick H. C. 2000. "On the number of rays in starfish." *AZ* **40** (June): 340-354. (86)

Hou, Lianhai, Larry D. Martin, Zhonghe Zhou, and **Alan Feduccia.** 1996. "Early Adaptive Radiation of Birds: Evidence from Fossils from Northeastern China." *Science* **274** (15

Nov.): 1164-1167. (370)

Hou, Lianhai, Larry D. Martin, Zhonghe Zhou, Alan Feduccia, and **Fucheng Zhang.** 1999. "A diapsid skull in a new species of the primitive bird *Confuciusornis*." *Nature* **399** (17 June): 679-682. (370)

Hou, Lian-hai, Zhonghe Zhou, Larry D. Martin, and **Alan Feduccia.** 1995. "A beaked bird from the Jurassic of China." *Nature* **377** (19 Oct.): 616-618. (370)

Hoyle, Fred, and **Chandra Wickramasinghe.** 1993. *Our Place in the Cosmos: The Unfinished Revolution*. London: JM Dent. (418)

Hrincevich, Adam W., Axayácatl Rocha-Olivares, and **David W. Foltz.** 2000. "Phylogenetic analysis of molecular lineages in a species-rich subgenus of sea stars (*Leptasterias* subgenus *Hexasterias*)." *AZ* **40** (June): 365-374. (86)

Hu, Yaoming, Yuanqinq Wang, Zhexi Luo, and **Chuankui Li.** 1997. "A new symmetrodont mammal from China and its implications for mammalian evolution." *Nature* **390** (13 Nov.): 137-142. (416)

Hubbard, L. Ron. 1950. *Dianetics: The Modern Science of Mental Health*. 1968 pb ed. New York: Paperback Library. (490)

Hudson, Richard R. 1994. "How can the low levels of DNA sequence variation in regions of the *Drosophila* genome with low recombination rates by explained?" *PNAS* **91** (19 July): 6815-6818. (457)

Hudson, Richard R., and **Jerry A. Coyne.** 2002. "Mathematical Consequences of the Genealogical Species Concept." *Evolution* **56** (Aug.): 1557-1565. (408)

Huey, Raymond B., George W. Gilchrist, Margen L. Carlson, David Berrigan, and **Luís Serra.** 2000. "Rapid Evolution of a Geographic Cline in Size in an Introduced Fly." *Science* **287** (14 Jan.): 308-309. (392)

Hughes, Stuart W. 1983. "Textbook Publishers Face Scientists and Educators." *C/E* **4** (Spring): 33-34. (483)

Hughes, W. W. 1979. "Precambrian and Paleozoic Glaciation?" Geoscience Research Institute *Origins* **6** (1): 49-51. (195)

Hunter, Cornelius G. 2001. *Darwin's God: Evolution and the Problem of Evil*. Grand Rapids, MI: Brazos Press (Baker Book House). (3, 110, 136, 142, 218, 226, 229, 246, 248, 250, 256, 260, 266, 332-323, 389, 395, 463, 524, 526)

———. 2003. *Darwin's Proof: The Triumph of Religion over Science*. Grand Rapids, MI: Brazos Press (Baker Book House). (3, 110, 185, 218, 226, 229, 246, 250, 256, 260, 265-266, 332, 389, 395, 467, 524)

Hunter, John P., and **Jukka Jernvall.** 1995. "The hypocone as a key innovation in mammalian evolution." *PNAS* **92** (7 Nov.): 10718-10722. (416)

Huse, Scott M. 1997. *The Collapse of Evolution*. 3rd ed. Grand Rapids, MI: Baker Books. (9, 20-21, 110, 218, 250-251, 262, 266, 284, 292, 355, 442, 458, 493, 526)

Huxley, Thomas H. 1893. *Science and Hebrew Tradition*. New York: D. Appleton & Co. (327)

Huynen, Martijn A., and **Peer Bork.** 1998. "Measuring genome evolution." *PNAS* **95** (26 May): 5849-5856. (203)

Hyde, William T., Thomas J. Crowley, Steven K. Baum, and **W. Richard Peltier.** 2000. "Neoproterozoic 'snowball Earth' simulations with a coupled climate/ice-sheet model." *Nature* **405** (25 May): 425-429. (195)

Iannone, Carol. 1997. "The Truth About *Inherit the Wind*." *First Things* (Feb.): 28-33. (473)

Ingram, Jay. 1998. *The Barmaid's Brain and other strange tales from Science*. 2000 US ed. New York: W. H. Freeman & Co. (220)

Irvine, Steven Q., Janet L. Carr, Wendy J. Bailey, Kazuhiko Kawasaki, Nobuyoshi Sjimizu, Chris T. Amemiya, and **Frank H. Ruddle.** 2002. "Genomic Analysis of Hox Clusters in the Sea Lamprey *Petromyzon marinus*." *JEZ* **294** (15 April): 47-62. (92)

Irvine, Steven Q., and **Mark Q. Martindale.** 2001. "Comparative analysis of Hox gene expression in the polychaete *Chaetopterus*: Implications for the evolution of body plan

---

regionalization." *AZ* **41** (June): 640-651. (216)

Itoh, Takeshi, William Martin, and **Masatoshi Nei.** 2002. "Acceleration of genomic evolution caused by enhanced mutation rate in endocellular symbionts." *PNAS* **99** (1 Oct.): 12944-12948. (203, 225)

Jablonski, David. 1998. "Geographic Variation in the Molluscan Recovery from the End-Cretaceous Extinction." *Science* **279** (27 Feb.): 1327-1330. (201)

———. 1999. "The Future of the Fossil Record." *Science* **284** (25 June): 2114-2116. (192)

———. 2001. "Lessons from the past: Evolutionary impacts of mass extinctions." *PNAS* **98** (8 May): 5393-5398. (199)

Jablonski, David, Kaustuv Roy, James W. Valentine, Rebecca M. Price, and **Philip S. Anderson.** 2003. "The Impact of the Pull of the Recent on the History of Marine Diversity." *Science* **300** (16 May): 1133-1135. (192)

Jackson, Jeremy B. C., and **Alan H. Cheetham.** 1990. "Evolutionary Significance of Morphospecies: A Test with Cheilostome Bryozoa." *Science* **248** (4 May): 579-582. (153)

———. 1999. "Tempo and mode of speciation in the sea." *TREE* **14** (Feb.): 72-77. (153)

Janis, Christine. 1994. "The Sabertooth's Repeat Performances." *NH* **103** (April): 78-83. (392)

Janis, Christine M., John Damuth, and **Jessica M. Theodor.** 2000. "Miocene ungulates and terrestrial primary productivity: Where have all the browsers gone?" *PNAS* **97** (5 July): 7899-7904. (525)

Janvier, Philippe. 1995. "Conodonts join the club." *Nature* **374** (27 April): 761-762. (106)

———. 1999. "Catching the first fish." *Nature* **402** (4 Nov.): 21-22. (93)

Jeffery, Jonathan E., Olaf R. P. Bininda-Emonds, Michael I. Coates, and **Michael K. Richardson.** 2002. "Analyzing evolutionary patterns in amniote embryonic development." *E&D* **4** (July-Aug.): 292-302. (239, 417)

Jeffery, Jonathan E., Michael K. Richardson, Michael I. Coates, and **Olaf R. P. Bininda-Emonds.** 2002. "Analyzing Developmental Sequences Within a Phylogenetic Framework." *SB* **51** (May): 478-491. (239)

Jenkins, Farish A. Jr., and **Denis M. Walsh.** 1993. "An Early Jurassic caecilian with limbs." *Nature* **365** (16 Sep.): 246-250. (292)

Jensen, Sören, Beverly Z. Saylor, James G. Gehling, and **Gerard J. B. Germs.** 2000. "Complex trace fossils from the terminal Proterozoic of Namibia." *Geology* **28** (Feb.): 143-146. (183)

Jernvall, Jukka. 2000. "Linking development with generation of novelty in mammalian teeth." *PNAS* **97** (14 March): 2641-2645. (416)

Jernvall, Jukka, Soile V. E. Keränen, and **Irma Thesleff.** 2000. "Evolutionary modification of development in mammalian teeth: Quantifying gene expression patterns and topography." *PNAS* **97** (19 Dec.): 14444-14448. (416)

Ji, Qiang, Philip J. Currie, Mark A. Norell, and **Shu-An Ji.** 1998. "Two feathered dinosaurs from northeastern China." *Nature* **393** (25 June): 753-761. (341)

Ji, Qiang, Zhe-Xi Luo, Chong-Xi Yuan, John R. Wible, Jian-Ping Zhang, and **Justin A. Georgi.** 2002. "The earliest known eutherian mammal." *Nature* **416** (25 April): 816-822. (416)

Ji, Qiang, Mark A. Norell, Ke-Qin Gao, Shu-An Ji, and **Dong Ren.** 2001. "The distribution of integumentary structures in a feathered dinosaur." *Nature* **410** (26 April): 1084-1088. (341)

Ji, S.-A., Q. Ji, and **K. Padian.** 1999. "Biostratigraphy of new pterosaurs from China." *Nature* **398** (15 April): 573-574. (370, 385)

Jiang, Ting-Xin, Han-Sung Jung, Randall B. Widelitz, and **Cheng-Ming Chuong.** 1999. "Self-organization of periodic patterns by dissociated feather mesenchymal cells and the regulation of size, number and spacing of primordia." *Development* **126** (15 Nov.): 4997-5009. (435)

Jinks, Robert N., Tara L. Markley, Elizabeth E. Taylor, Gina Perovich, Ana I. Dittel, Charles E. Epifanio, and **Thomas W. Cronin.** 2002. "Adaptive visual metamorphosis in a

---

deep-sea hydrothermal vent crab." *Nature* **420** (7 Nov.): 68-70. (255)

Johanson, Donald C., and **Maitland A. Edey.** 1981. *Lucy: The Beginnings of Humankind*. New York: Simon & Schuster. (240)

John, Rosalind M., and **M. Azim Surani.** 2000. "Genomic Imprinting, Mammalian Evolution, and the Mystery of Egg-Laying Mammals." *Cell* **101** (9 June): 585-588. (461)

Johnson, Phillip E. 1991. *Darwin on Trial*. Washington, D.C.: Regnery Gateway. (44, 78-79, 102, 131-133, 140, 145, 202, 205, 218, 229, 248, 265-266, 331, 362-363, 389-391, 396, 401, 403, 441, 450, 455, 494, 524, 526)

———. 1993a. "The Religion of the Blind Watchmaker." *Perspectives on Science and Christian Faith* **45** (March): 46-48. (445)

———. 1993b. *Darwin on Trial*. 2nd ed. Downers Grove, IL: InterVarsity Press. (134, 209, 218, 409, 415, 445, 447, 451, 456)

———. 1993c. "God and Evolution: An Exchange (II)." *First Things* (June/July): 38-41. (409, 495)

———. 1995. *Reason in the Balance: The Case Against NATURALISM in Science, Law & Education*. Downers Grove, IL: InterVarsity Press. (59, 75, 79, 111, 134, 202, 218, 249, 256, 324, 382, 400, 450, 495)

———. 1997. *Defeating Darwinism by Opening Minds*. Downers Grove, IL: InterVarsity Press. (50, 55, 70, 75, 78-79, 111, 134, 151, 218, 371, 450, 473, 495, 498)

———. 1998a. *Objections Sustained: Subversive Essays on Evolution, Law & Culture*. Downers Grove, IL: InterVarsity Press. (50-51, 56, 151, 156, 202, 209, 218, 226, 495)

———. 1998b. "What Would Newton Do?" *First Things* (Nov.): 25-31. (449, 495)

———. 1999. "The Church of Darwin." *Wall Street Journal* (16 Aug.): A14. (40, 495)

———. 2000. *The Wedge of Truth: Splitting the Foundations of Naturalism*. Downers Grove, IL: InterVarsity Press. (212, 218, 226, 400, 450, 495, 498, 518, 523)

———. 2002. *The Right Questions: Truth, Meaning & Public Debate*. Downers Grove, IL: InterVarsity Press. (42, 58, 495)

Jolly, Alison. 1999. *Lucy's Legacy: Sex and Intelligence in Human Evolution*. Cambridge, MA: Harvard University Press. (238)

Jones, Terry D., James O. Farlow, John H. Ruben, Donald M. Henderson, and **Willem J. Hillenius.** 2000. "Cursoriality in bipedal archosaurs." *Nature* **406** (17 Aug.): 716-718. (341)

Jones, Terry D., John A. Ruben, **Larry D. Martin, Evgeny N. Kurochkin, Alan Feduccia, Paul F. A. Maderson, Willem J. Hillenius, Nicholas R. Geist**, and **Vladimir Alifanov.** 2000. "Nonavian Feathers in a Late Triassic Archosaur." *Science* **288** (23 June): 2202-2205. (279)

Jung, Han-Sung, Philippa H. Francis-West, Randall B. Widelitz, Ting-Xin Jiang, Sheree Ting-Berreth, Cheryll Tickle, Lewis Wolpert, and **Cheng-Ming Chuong.** 1998. "Local Inhibitory Action of BMPs and Their Relationships with Activators in Feather Formation: Implications for Periodic Patterning." *DB* **196** (1 April): 11-23. (435)

Kaiser, Jocelyn. 1994. "A New Theory of Insect Wing Origins Takes Off." *Science* **266** (21 Oct.): 363. (230)

Karlstrom, Karl E., Carol M. Dehler, Zachary D. Sharp, John W. Geissman, Maya B. Elrick, J. Michael Timmons, Laura J. Crossey, Samuel A. Bowing, Kathleen L. Davidek, Andrew H. Knoll, Susannah M. Porter, David J. Des Marais, and **Arlo B. Weil.** 2000. "Chuar Group of the Grand Canyon: Record of breakup of Rodinia, associated change in the global carbon cycle, and ecosystem expansion by 740 Ma." *Geology* **28** (July): 619-622. (160)

Kaufman, Alan J. 1997. "An ice age in the tropics." *Nature* **386** (20 March): 227-228. (195)

Kaufman, Alan J., Andrew H. Knoll, and **Guy M. Narbonne.** 1997. "Isotopes, ice ages, and terminal Proterozoic earth history." *PNAS* **94** (24 June): 6600-6605. (195)

Kelly-Borges, Michelle. 1995. "Sponges out of their depth." *Nature* **373** (26 Jan.): 284. (243)

Kemp, T. S. 1982. *Mammal-like Reptiles and the Origin of Mammals*. London: Academic

Press. (407, 413, 482)

Kempe, André, J. William Schopf, Wladyslaw Altermann, Anatoliy B. Kudryavtsev, and **Wolfgang M. Heckl.** 2002. "Atomic force microscopy of Precambrian microscopic fossils." *PNAS* **99** (9 July): 9117-9120. (175)

Kennedy, Martin J., Nicholas Christie-Blick, and **Anthony R. Prave.** 2001a. "Carbon isotopic composition of Neoproterozoic glacial carbonates as a test of paleoceanographic models for snowball Earth phenomena." *Geology* **29** (Dec.): 1135-1138. (195)

Kennedy, Martin J., Nicholas Christie-Blick, and **Linda E. Sohl.** 2001b. "Are Proterozoic cap carbonates and isotopic excursions a record of gas hydrate destabilization following Earth's coldest intervals?" *Geology* **29** (May): 443-446. (196)

Kennedy, Martin J., Bruce Runnegar, Anthony R. Prave, K.-H. Hoffmann, and **Michael A. Arthur.** 1998. "Two or four Neoproterozoic glaciations?" *Geology* **26** (Dec.): 1059-1063. (195)

Kenrick, Paul. 2003. "Fishing for the first plants." *Nature* **425** (18 Sep.): 248. (101)

Kenyon, Cynthia. 1994. "If Birds Can Fly, Why Can't We? Homeotic Genes and Evolution." *Cell* **78** (29 July): 175-180. (214, 440)

Kepler, Thomas B., and **Timothy C. Elston.** 2001. "Stochasticity in Transcriptional Regulation: Origins, Consequences, and Mathematical Representations." *Biophysical Journal* **81** (Dec.): 3116-3136. (474)

Kerr, Richard A. 1995. "Did Darwin Get It All Right?" *Science* **267** (10 March): 1421-1422. (153)

———. 1997. "Does Evolutionary History Take Million-Year Breaks?" *Science* **278** (24 Oct.): 576-577. (153)

———. 1998a. "Pushing Back the Origins of Animals." *Science* **279** (6 Feb.): 803-804. (173)

———. 1998b. "Tracks of Billion-Year-Old Animals?" *Science* **282** (2 Oct.): 19, 21. (184)

———. 1998c. "Fossils Challenge Age of Billion-Year-Old Animals." *Science* **282** (23 Oct.): 601-602. (184)

———. 2000. "Stretching the Reign Of Early Animals." *Science* **288** (5 May): 789. (138)

———. 2001. "Paring Down the Big Five Mass Extinctions." *Science* **294** (7 Dec.): 2072-2073. (199)

———. 2002a. "Did an Impact Trigger the Dinosaurs' Rise?" *Science* **296** (17 May): 1215-1216. (199)

———. 2002b. "Reversals Reveal Pitfalls in Spotting Ancient and E.T. Life." *Science* **296** (24 May): 1384-1385. (197)

———. 2002c. "Could Poor Nutrition Have Held Life Back?" *Science* **297** (16 Aug.): 1104-1105. (198)

———. 2003a. "Life's Diversity May Truly Have Leaped Since the Dinosaurs." *Science* **300** (16 May): 1067, 1069. (192)

———. 2003b. "Has An Impact Done It Again?" *Science* **302** (21 Nov.): 1314-1316. (199)

———. 2003c. "Extinction by a Whoosh, Not a Bang?" *Science* **302** (21 Nov.): 1315. (199)

Kim, Chang-Bae, Chris Amemiya, Wendy Bailey, Kazuhiko Kawasaki, Jason Mezey, Webb Miller, Shinsei Minoshima, Nobuyoshi Shimizu, Günter Wagner, and **Frank Ruddle.** 2000. "Hox cluster genomics in the horn shark, *Heterodontus francisci*." *PNAS* **97** (15 Feb.): 1655-1660. (235)

Kim, Hyi-Gyung, Sterling C. Keeley, Peter S. Vroom, and **Robert K. Jansen.** 1998. "Molecular evidence for an African origin of the Hawaiian endemic *Hesperomannia (Asteraceae)*." *PNAS* **95** (22 Dec.): 15440-15445. (530)

Kim, Ki-Joong, and **Robert K. Jansen.** 1995. "*ndhF* sequence evolution and the major clades in the sunflower family." *PNAS* **92** (24 Oct.): 10379-10383. (530)

King, Nicole, and **Sean B. Carroll.** 2001. "A receptor tyrosine kinase from choanoflagellates: Molecular insights into early animal evolution." *PNAS* **98** (18 Dec.): 15032-15037. (241)

Kingsolver, Joel G., and **M. A. R. Koehl.** 1985. "Aerodynamics, Thermoregulation, and the Evolution of Insect Wings: Differential Scaling and Evolutionary Change." *Evolution* **39** (May): 488-504. (230)

Kirschvink, Joseph L., **Robert L. Ripperdan**, and **David A. Evans.** 1997. "Evidence for a Large-Scale Reorganization of Early Cambrian Continental Masses by Inertial Interchange True Polar Wander." *Science* **277** (25 July): 541-545. (195)

Kishimoto, Jiro, Robert E. Burgeson, and **Bruce A. Morgan.** 2000. "Wnt signaling maintains the hair-inducing activity of the dermal papilla." *Genes & Development* **14** (15 May): 1181-1185. (435)

Kitcher, Philip. 1982. *Abusing Science: The Case Against Creationism*. 1998 pb ed. Cambridge, MA: MIT Press. (66, 203, 257, 400, 441, 524)

Klak, C., G. Reeves, and **T. Hedderson.** 2004. "Unmatched tempo of evolution in Southern African semi-desert ice plants." *Nature* **427** (1 Jan.): 63-65. (146)

Klesius, Michael. 2002. "The Big Bloom: How Flowering Plants Changed the World." *NG* **202** (July): 102-121. (102)

Knoll, Andrew H. 1994. "Proterozoic and Early Cambrian protists: Evidence for accelerating evolutionary tempo." *PNAS* **91** (19 July): 6743-6750. (457)

———. 2003. *Life on a Young Planet: The First Three Billion Years of Evolution on Earth*. Princeton, NJ: Princeton University Press. (86, 137, 173, 184-185, 188, 195, 214, 225)

Knoll, Andrew H., and **Sean B. Carroll.** 1999. "Early Animal Evolution: Emerging Views from Comparative Biology and Geology." *Science* **284** (25 June): 2129-2137. (190, 196-197, 214 & Figs. 24, 26)

Knott, K. Emily, and **Gregory A. Wray.** 2000. "Controversy and consensus in Asteroid systematics: New insights to ordinal and familial relationships." *AZ* **40** (June): 382-392. (86)

Koenig, Robert. 2001. "Creationism Takes Root Where Europe, Asia Meet." *Science* **292** (18 May): 1286-1287. (493)

Koentges, Georgy, and **Toshiyuki Matsuoka.** 2002. "Jaws of the Fates." *Science* **298** (11 Oct.): 371, 373. (440)

Kohn, Alexander. 1986. *False Prophets: Fraud and Error in Science and Medicine*. New York: Basil Blackwell. (48, 59)

Kollar, E. J., and **C. Fisher.** 1980. "Tooth Induction in Chick Epithelium: Expression of Quiescent Genes for Enamel Synthesis." *Science* **207** (29 Feb.): 993-995. (322)

Kollmar, Richard, Sashi Karia Nakamura, James A. Kappler, and **A. J. Hudspeth.** 2001. "Expression and phylogeny of claudins in vertebrate primordia." *PNAS* **98** (28 Aug.): 10196-10201. (214)

Koltunow, A. M., K. Gregg, and **G. E. Rogers.** 1986. "Intron sequences modulate feather keratin gene transcription in Xenopus oocytes." *Nucleic Acids Research* **14** (26 Aug.): 6375-6392. (278)

Kondo, Takashi, József Zákány, Jeffrey W. Innis, and **Denis Duboule.** 1997. "Of fingers, toes and penises." *Nature* **390** (6 Nov.): 29. (380)

Kossy, Donna. 2001. *Strange Creations: Aberrant Ideas of Human Origins from Ancient Astronauts to Aquatic Apes.* Los Angeles, CA: Feral House. (2)

Kouchinsky, Artem, Stefan Bengtson, and **Lisa-ann Gershwin.** 1999. "Cnidarian-like embryos associated with the first shelly fossils in Siberia." *Geology* **27** (July): 609-612. (178)

Kozlowski, J., M. Konarzewski, and **A. T. Gawelczyk.** 2003. "Cell size as a link between noncoding DNA and metabolic rate scaling." *PNAS* **100** (25 Nov.): 14080-14085. (429)

Krause, David W. 2000. "A Fossil Bonanza." *NG* **198** (Aug.): 52-57. (333)

Krings, Matthias, Helga Geisert, Ralf W. Schmitz, Heike Krainitzkit, and **Svante Pääbo.** 1999. "DNA sequence region II from the Neandertal type specimen." *PNAS* **96** (11 May): 5581-5585. (185)

Krings, Matthias, Anne Stone, Ralf W. Schmitz, Heike Krainitzkit, Mark Stoneking, and **Svante Pääbo.** 1997. "Neanderthal DNA Sequences and the Origin of Modern Humans." *Cell* **90** (11 July): 19-30. (185)

Krizek, Beth Allyn, and **Elliot M. Meyerowitz.** 1996. "Mapping the protein regions responsible for the functional specificities of the *Arabidopsis* MADS domain organ-identity proteins." *PNAS* **93** (30 April): 4063-4070. (102)

Krumlauf, Robb. 1994. "*Hox* Genes in Vertebrate Development." *Cell* **78** (29 July): 191-201. (206)

Ku, Maurice S. B., Yuriko Kano-Murakami, and **Makoto Matsuoka.** 1996. "Evolution and Expression of C_4 Photosynthesis Genes." *Plant Physiology* **111** (Aug.): 949-957. (530)

Kudoh, Tetsuhiro, and **Igor B. Dawid.** 2001. "Role of the *iroquois3* homeobox gene in organizer formation." *PNAS* **98** (3 July): 7852-7857. (207)

Kulessa, Holger, Gail Turk, and **Brigid L. M. Hogan.** 2000. "Inhibition of Bmp signaling affects growth and differentiation in the anagen hair follicle." *The EMBO Journal* **19** (15 Dec.): 6664-6674. (435)

Kumar, Sudhir, and **Sankar Subramanian.** 2002. "Mutation rates in mammalian genomes." *PNAS* **99** (22 Jan.): 803-808. (203)

Kundrát, Martin, Václav Seichert, Anthony P. Russell, and **Karel Smetana Jr.** 2002. "Pentadactyl Pattern of the Avian Wing Autopodium and Pyramid Reduction Hypothesis." *JEZ* **294** (15 Aug.): 152-159. (316)

Kurland, C. G., and **S. G. E. Andersson.** 2000. "Origin and Evolution of the Mitochondrial Proteome." *Microbiology and Molecular Biology Reviews* **64** (Dec.): 786-820. (225)

Kurtz, Paul, with **Barry Karr** and **Ranjit Sandhu**, eds. 2003. *Science and Religion: Are They Compatible?* Amherst, NY: Prometheus Books. (493)

LaHaye, Tim, and **David Noebel.** 2000. *Mind Siege: The Battle for Truth in the New Millennium*. Nashville, TN: Word Publishing. (3, 518)

Lahn, Bruce T., and **David C. Page.** 1999. "Four Evolutionary Strata on the Human X Chromosome." *Science* **286** (29 Oct.): 964-967. (461)

Lai, Lien B., Lin Wang, and **Timothy M. Nelson.** 2002. "Distinct But Conserved Functions for Two Chloroplastic NADP-Malic Enzyme Isoforms in C_3 and C_4 *Flaveria* Species." *Plant Physiology* **128** (Jan.): 125-139. (530)

Lambert, David, and **The Diagram Group.** 1983. *A Field Guide to Dinosaurs*. New York: Avon Books. (11-12, 272)

———. 1985. *The Field Guide to Prehistoric Life*. New York: Facts On File. (86-87, 163, 248, 324, 328, 398, 416-417, 422, 432, 458, 460)

———. 1987. *The Field Guide to Early Man*. New York: Facts On File. (240)

———. 1988. *The Field Guide to Geology*. New York: Facts On File. (160, 233)

———. 1990. *The Dinosaur Data Book*. New York: Avon Books. (11, 13, 162, 164, 300, 329, 417)

Lambier, Doug, and **Robert Stevenson.** 1997. *Genesis For Kids: Science Experiments That Show God's Power in Creation!* Nashville, TN: Tommy Nelson. (218)

Land, Michael F. 2002. "What is a naked retina good for?" *Nature* **420** (7 Nov.): 30-31. (255)

Langbein, Lutz, Michael A. Rogers, Hermelita Winter, Silke Praetzel, Ulrike Beckhaus, Hans-Richard Rackwitz, and **Jürgen Schweizer.** 1999. "The Catalog of Human Hair Keratins: I. EXPRESSION OF THE NINE TYPE I MEMBERS IN THE HAIR FOLLICLE." *Journal of Biological Chemistry* **274** (9 July): 19874-19884. (435)

Langbein, Lutz, Michael A. Rogers, Hermelita Winter, Silke Praetzel, and **Jürgen Schweizer.** 2001. "The Catalog of Human Hair Keratins: II. EXPRESSION OF THE SIX TYPE II MEMBERS IN THE HAIR FOLLICLE AND THE COMBINED CATALOG OF HUMAN TYPE I AND II KERATINS." *Journal of Biological Chemistry* **276** (14 Sep.): 35123-35132. (435)

Lapin, Daniel. 1999. *America's Real War*. Sisters, OR: Multnomah Books. (142)

Larson, Edward J. 1985. *Trial and Error: The American Controversy Over Creation and Evolution*. New York: Oxford University Press. (77, 468-469, 471, 475, 481-482)

———. 1997. *Summer for the Gods: The Scopes Trial and America's Continuing Debate Over Science and Religion*. New York: Basic Books. (468-471, 473, 475)

———. 2001. *Evolution's Workshop: God and Science on the Galápagos Islands*. New York: Basic Books. (450)

Larson, Peter, and **Kristin Donnan.** 2002. *Rex Appeal: The Amazing Story of Sue, the Dinosaur That Changed Science, the Law, and My Life.* Montpelier, VT: Invisible Cities Press. (36, 64, 336-337)

Larsson, Hans C. E., and **Günter P. Wagner.** 2002. "Pentadactyl Ground State of the Avian Wing." *JEZ* **294** (15 Aug.): 146-151. (316)

———. 2003. "Old morphologies misinterpreted." *TREE* **18** (Jan.): 10. (320)

Laufer, Ed, Randall Dahn, Olivia E. Orozco, Chang-Yeol Yeo, Jacqueline Pisenti, Domingos Henrique, Ursula K. Abbott, John F. Fallon, and **Cliff Tabin.** 1997. "Expression of *Radical fringe* in limb-bud ectoderm regulates apical ectodermal ridge formation." *Nature* **386** (27 March): 366-373. (211)

Laurin, Michel, Marc Girondot, and **Armand de Ricqlès.** 2000. "Early tetrapod evolution." *TREE* **15** (March): 118-123. (380)

Lawton-Rauh, Amy L., Elena R. Alvarez-Buylla, and **Michael D. Purugganan.** 2000. "Molecular evolution of flower development." *TREE* **15** (April): 144-149. (102)

Le, Thanh H., David Blair, Takeshi Agatsuma, Pierre-François Humair, Nick J. H. Campbell, Mori Iwagama, D. Timothy J. Littlewood, B. Peacock, David A. Johnston, J. Bartley, David Rollinson, E. A. Herniou, Dante S. Zarlenga, and **Donald P. McManus.** 2000. "Phylogenies Inferred from Mitochondrial Gene Orders—A Cautionary Tale from the Parasitic Flatworms." *MBE* **17** (July): 1123-1125. (241)

Leather, Jonathan, Philip A. Allen, Martin D. Brasier, and **Andrea Cozzi.** 2002. "Neoproterozoic snowball Earth under scrutiny: Evidence from the Fiq glaciation in Oman." *Geology* **30** (Nov.): 891-894. (195)

Lebedev, Oleg A. 1997. "Fins made for walking." *Nature* **390** (6 Nov.): 21-22. (399)

Ledent, Valérie, and **Michel Vervoort.** 2001. "The Basic Helix-Loop-Helix Protein Family: Comparative Genomics and Phylogenetic Analysis." *GR* **11** (May): 754-770. (222)

Lee, Michael S. Y. 1994. "The Turtles' Long-Lost Relatives." *NH* **103** (June): 63-65. (461)

———. 1998. "Phylogenetic Uncertainty, Molecular Sequences, and the Definition of Taxon Names." *SB* **47** (Dec.): 710-726. (408)

———. 2001. "Uninformative Characters and Apparent Conflict Between Molecules and Morphology." *MBE* **18** (April): 676-680. (241)

Lee, Michael S. Y., Gorden L. Bell, and **Michael W. Caldwell.** 1999. "The origin of snake feeding." *Nature* **400** (12 Aug.): 655-659. (292)

Lee, Michael S. Y., and **Richard Shine.** 1998. "Reptilian Viviparity and Dollo's Law." *Evolution* **52** (Oct.): 1441-1450. (292)

Lee, Patricia N., Patrick Callaerts, Heinz G. de Couet, and **Mark Q. Martindale.** 2003. "Cephalopod *Hox* genes and the origin of morphological novelties." *Nature* **424** (28 Aug.): 1061-1065. (460)

Lenormond, Thomas. 2002. "Gene flow and the limits to natural selection." *TREE* **17** (April): 183-189. (142)

Lenski, Richard E., and **Michael Travisano.** 1994. "Dynamics of adaptation and diversification: A 10,000-generation experiment with bacterial populations." *PNAS* **91** (19 July): 6808-6814. (153, 457)

Lerner, Eric. 1991. *The Big Bang Never Happened: A Startling Refutation of the Dominant Theory of the Origin of the Universe*. New York: Times Books. (26)

Lessem, Don. 1992. *Dinosaurs Rediscovered: New Findings Which Are Revolutionizing Dinosaur Science*. 1993 pb ed. (orig. pub. as *Kings of Creation*). New York: Touchstone Books. (283, 329, 347, 356)

Levinton, Jeffrey S. 1992. "The Big Bang of Animal Evolution." *SA* **267** (Nov.): 84-91. (135, 158, 171)

Levinton, Jeffrey S., and **Douglas J. Futuyma.** 1982. "Macroevolution: Pattern and Process Introduction and Background." *Evolution* **36** (May): 425-443. (143)

Lewin, Benjamin. 1994. *Genes V.* Oxford: Oxford University Press. (203, 206)

Lewin, Roger. 1980. "Evolutionary Theory Under Fire." *Science* **210** (21 Nov.): 883-887. (Fig. 10)

———. 1981. "Bones of Mammals' Ancestors Fleshed Out." *Science* **212** (26 June): 1492. (424)

———. 1997. *Patterns in Evolution: The New Molecular View.* New York: Scientific American Library. (103, 224, 227, 265, 335)

Lewontin, Richard. 1997. "Billions and Billions of Demons." *The New York Review of Books* (9 Jan.): 28-32. (48-49, 51-52, 54-55)

———. 2000a. *It Ain't Necessarily So: The Dream of the Human Genome and Other Illusions.* New York: New York Review Books. (54)

———. 2000b. "Computing the Organism." *NH* **109** (April): 94. (54)

Lézot, Frédéric, Jean-Luc Davideau, Bethan Thomas, Paul Sharpe, Nadine Forest, and **Ariane Berdal.** 2000. "Epithelial Dlx-2 Homeogene Expression and Cementogenesis." *Journal of Histochemistry & Cytochemistry* **48** (Feb.): 277-284. (525)

Li, Chia-Wei, Jun-Yuan Chen, and **Tzu-En Hua.** 1998. "Precambrian Sponges with Cellular Structures." *Science* **279** (6 Feb.): 879-882. (173)

Li, Wen-Hsiung. 1997. *Molecular Evolution*. Sunderland, MA: Sinauer Associates, Inc. (102, 203, 206)

Liem, Karel F. 1988. "Form and Function of Lungs: The Evolution of Air Breathing Mechanisms." *AZ* **28** (April): 739-759. (336)

Lin, Yu-Hsin, and **David Penny.** 2001. "Implications for Bat Evolution from Two New Complete Mitochondrial Genomes." *MBE* **18** (April): 684-688. (265)

Lippard, Jim. 1989. "A Further Examination of the Research of Walter Brown." *C/E* **9** (Winter): 17-33. (27, 288)

Litingtung, Ying, Randall D. Dahn, Yina L., John F. Fallon, and **Chin Chiang.** 2002. "*Shh* and *Gli3* are dispensable for limb skeleton formation but regulate digit number and identity." *Nature* **418** (29 Aug.): 979-983. (320)

Litynski, Zygmunt. 1961. "Should We Burn Darwin?" *Science Digest* **49** (Jan.): 61-63. (401)

Lockley, Martin. 1999. *The Eternal Trail: A Tracker Looks at Evolution*. Reading, MA: Perseus Books. (2)

Lombard, Eric R. 1979. "Evolutionary Principles of the Mammalian Middle Ear." *Evolution* **33** (Dec.): 1230. (355, 424)

Lowe, Christopher J., and **Gregory A. Wray.** 1997. "Radical alterations in the roles of homeobox genes during echinoderm evolution." *Nature* **389** (16 October): 718-721. (217)

Lubenow, Marvin L. 1992. *Bones of Contention: A Creationist Assessment of Human Fossils.* Grand Rapids, MI: Baker Books. (20, 110)

Lubick, Naomi. 2001. "Volcanic Accomplice." *SA* **284** (March): 19. (199)

———. 2002. "Snowball fights." *Nature* **417** (2 May): 12-13. (195)

Luke, Graham N., L. Filipe C. Castro, Kirsten McLay, Christine Bird, Alan Coulson, and **Peter W. H. Holland.** 2003. "Dispersal of NK homeobox gene clusters in amphioxus and humans." *PNAS* **100** (29 April): 5292-5295. (235)

Lumsden, Andrew, and **Robb Krumlauf.** 1996. "Patterning the Vertebrate Neuraxis." *Science* **274** (15 Nov.): 1109-1115. (206)

Luo, Zhe-Xi. 2000. "In search of the whales' sisters." *Nature* **404** (16 March): 235-237, 239. (248)

———. 2001. "The inner ear and its bony housing in tritylodontids and implications for evolution of the mammalian ear." *Bulletin Museum of Comparative Zoology* **156** (Oct.): 81-97. (440)

Luo, Zhe-Xi, Richard L. Cifelli, and **Zofia Kielan-Jaworowska.** 2001. "Dual origin of tribosphenic mammals." *Nature* **409** (4 Jan.): 53-57. (461)

Luo, Zhe-Xi, and **Alfred W. Crompton.** 1994. "Transformation of the Quadrate (Incus) Through the Transition from Non-Mammalian Cynodonts to Mammals." *Journal of Vertebrate Paleontology* **14** (Sep.): 341-374.

Luo, Zhe-Xi, Alfred W. Crompton, and **Spencer T. Lucas.** 1995. "Evolutionary Origins of the Mammalian Promontorium and Cochlea." *Journal of Vertebrate Paleontology* **15** (March): 113-121. (440)

Luo, Zhe-Xi, Alfred W. Crompton, and **Ai-Lin Sun.** 2001. "A New Mammaliaform from the Early Jurassic and Evolution of Mammalian Characteristics." *Science* **292** (25 May): 1535-

---

1540. (412)

Luo, Zhe-Xi, Qiang Ji, John R. Wible, and **Chong-Xi Yuan.** 2003. "An Early Cretaceous Tribosphenic Mammal and Metatherian Evolution." *Science* **302** (12 Dec.): 1934-1940. (417)

Luo, Zhe-Xi, Zofia Kielan-Jaworowska, and **Richard L. Cifelli.** 2002. "In quest for a phylogeny of Mesozoic mammals." *APP* **47** (1): 1-78. (405, 414-415, 461)

Lurquin, Paul F. 2003. *The Origins of Life and the Universe.* New York: Columbia University Press. (225)

Lynch, Michael, and **John S. Conery.** 2003. "The Origins of Genome Complexity." *Science* **302** (21 Nov.): 1401-1404. (221)

Mabee, Paula M., Karen L. Olmstead, and **Carol C. Cubbage.** 2000. "An Experimental Study of Intraspecific Variation, Developmental Timing, and Heterochrony in Fishes." *Evolution* **54** (Dec.): 2091-2106. (239)

MacDonald, Mary E., and **Brian K. Hall.** 2001. "Altered Timing of the Extracellular-Matrix-Mediated Epithelial-Mesenchymal Interaction that Initiates Mandibular Skeletogenesis in Three Inbred Strains of Mice: Development, Heterochrony, and Evolutionary Change in Morphology." *JEZ* **291** (15 Oct.): 258-273. (239, 439)

MacFadden, Bruce J., Nikos Solounias, and **Thure E. Cerling.** 1999. "Ancient Diets, Ecology, and Extinction of 5-Million-Year-Old Horses from Florida." *Science* **283** (5 Feb.): 824-827. (525)

Machalski, Marcin. 2000. "Borrowed plumes." *APP* **45** (4): 431-432. (279)

MacKenzie, Dana. 2003. *The Big Splat, or How Our Moon Came to Be*. Hoboken, NJ: John Wiley & Sons. (19, 517)

MacKenzie, Debora. 2000. "Unnatural selection." *New Scientist* **166** (22 April): 35-39. (493)

MacNaughton, Robert B., Jennifer M. Cole, Robert W. Dalrymple, Simon J. Braddy, Derek E. G. Briggs, and **Terrence D. Lukie.** 2002. "First steps on land: Arthropod trackways in Cambrian-Ordovician eolian sandstone, southeastern Ontario, Canada." *Geology* **30** (May): 391-394. (94)

Maderson, Paul F. A., and **Lorenzo Alibardi.** 2000. "The development of the sauropod integument: A contribution to the problem of the origin and evolution of feathers." *AZ* **40** (Sep.): 513-529. (275, 278-279)

Maderson, Paul F. A., and **Dominique G. Homberger.** 2000. "The evolutionary origin of feathers: A problem demanding interdisciplinary communication." *AZ* **40** (Sep.): 455-460. (275)

Maderson, Paul F. A., Dominique G. Homberger, Lorenzo Alibardi, Walter J. Bock, Alan H. Brush, Phil Currie, Paul G. Davis, Peter Dodson, James O. Farlow, Nicholas Geist, Matthew Harris, Larry D. Martin, Gopi K. Menon, Barry Pinshow, Warren P. Porter. John Ruben, Roger H. Sawyer, Peter Stettenheim, Stuart Sumida. Sam Tarsitano, and **Blair O. Wolf.** 2000. "Symposium on evolutionary origin of feathers: Panel discussion." *AZ* **40** (Sep.): 695-706. (275)

Mah, Christopher L. 2000. "Preliminary phylogeny of the Forcipulatacean Asteroidea." *AZ* **40** (June): 375-381. (86)

Maizels, Nancy, and **Alan M. Weiner.** 1994. "Phylogeny from function: Evidence from the molecular fossil record that tRNA originated in replication, not translation." *PNAS* **91** (19 July): 6729-6734. (457)

Mallatt, Jon, Junyuan Chen, and **Nicholas D. Holland.** 2003. "Comment on 'A New Species of Yunnanozoan with Implications for Deuterostome Evolution.'" *Science* **300** (30 May): 1372. (93)

Mallet, J. 2001. "The speciation revolution." *JEB* **14** (Nov.): 887-888. (144)

Mann, Charles. 1991. "Lynn Margulis: Science's Unruly Earth Mother." *Science* **252** (19 April): 378-381. (226)

Marden, James H. 1995. "Flying Lessons from a Flightless Insect." *NH* **104** (Feb.): 4, 6, 8. (230)

Marden, James H., and **Melissa G. Kramer.** 1994. "Surface-Skimming Stoneflies: A Possible Intermediate Stage in Insect Flight Evolution." *Science* **266** (21 Oct.): 427-430. (230)

Marée, Athanasius F. M., and **Paulien Hogeweg.** 2001. "How amoeboids self-organize into a fruiting body: Multicellular coordination in *Dictyostelium discoideum*." *PNAS* **98** (27 March): 3879-3883. (221)

Margulis, Lynn, Michael F. Dolan, and **Ricardo Guerrero.** 2000. "The chimeric eukaryote: Origin of the nucleus from the karyomastigont in amitochondriate protists." *PNAS* **97** (20 June): 6954-6959. (103, 225)

Margulis, Lynn, and **Karlene V. Schwartz.** 1988. *Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth*. 2nd ed. New York: W. H. Freeman & Co. (84-85, 100, 105, 107-109, 172, 194, 220, 227, 235, 460)

———. 1998. *Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth*. 3rd ed. New York: W. H. Freeman & Co. (92, 100, 103-105, 108-109, 227)

Marshall Graves, Jennifer A. 2002. "The rise and fall of *SRY*." *Trends in Genetics* **18** (May): 259-264. (461)

Marshall, J. S., J. D. Stubbs, and **W. C. Taylor.** 1996. "Two Genes Encode Highly Similar Chloroplastic NADP-Malic Enzymes in *Flaveria* (Implications for the Evolution of C_4 Photosynthesis)." *Plant Physiology* **111** (Nov.): 1251-1261. (530)

Martin, Derek, Derek E. G. Briggs, and **R. John Parkes.** 2003. "Experimental mineralization of invertebrate eggs and the preservation of Neoproterozoic embryos." *Geology* **31** (Jan.): 39-42. (173)

Martin, Larry D., and **Stephen A. Czerkas.** 2000. "The fossil record of feather evolution in the Mesozoic." *AZ* **40** (Sep.): 687-694. (275, 314, 341)

Martin, L. D., J. D. Stewart, and **K. N. Whetstone.** 1980. "The Origin of Birds: Structure of the Tarsus and Teeth." *The Auk* **97** (Jan.): 86-93. (294, 312, 327)

Martin, M. W., **D. V. Grazhdankin, S. A. Bowring**, **D. A. D. Evans**, **M. A. Fedonkin**, and **J. L. Kirschvink.** 2000. "Age of Neoproterozoic Bilatarian Body and Trace Fossils, White Sea, Russia: Implications for Metazoan Evolution." *Science* **288** (5 May): 841-845. (138)

Martin, William, and **Miklós Müller.** 1998. "The hydrogen hypothesis for the first eukaryote." *Nature* **392** (5 March): 37-41. (225)

Martin, William, Tamas Rujan, Erik Richly, Andrea Hansen, Sabine Cornelsen, Thomas Lins, Dario Leister, Bettina Stoebe, Masami Hasegawa, and **David Penny.** 2002. "Evolutionary analysis of *Arabidopsis*, cyanobacterial, and chloroplast genomes reveals plastid phylogeny and thousands of cyanobacterial genes in the nucleus." *PNAS* **99** (17 Sep.): 12246-12251. (225)

Martinez, Leonard. 2004. "Creation vs. Evolution." *El Paso Times* (23 January): 1D, 4D. (79)

Martinez, Pedro, Jonathan P. Rast, César Arenas-Mena, and **Eric H. Davidson.** 1999. "Organization of an echinoderm *Hox* gene cluster." *PNAS* **96** (16 Feb.): 1469-1474. (217)

Martini, Frederic H. 1998. "Secrets of the Slime Hag." *SA* **279** (Oct.): 70-75. (92)

Marzoli, Andrea, Paul R. Renne, Enzo M. Piccirillo, Marcia Ernesto, Giuliano Bellieni, and **Angelo De Min.** 1999. "Extensive 200-Million-Year-Old Continental Flood Basalts of the Central Atlantic Magmatic Province." *Science* **284** (23 April): 616-618. (199)

Maynard Smith, John. 1987. "Darwinism stays unpunctured." *Nature* **330** (10 Dec.): 516. (246)

———. 1998. *Shaping Life: Genes, Embryos and Evolution*. New Haven, CT: Yale University Press. (214)

Maynard Smith, John, and **Eörs Szathmáry.** 1999. *The Origins of Life: From the Birth of Life to the Origin of Language*. Oxford: Oxford University Press. (206, 225)

Mayr, Ernst. 1963. *Animal Species and Evolution*. 1966 ed. Cambridge, MA: Belknap Press (Harvard University Press). (142)

———. 1970. *Populations, Species, and Evolution: An Abridgement of* Animal Species and Evolution. Cambridge, MA: Belknap Press (Harvard University Press). (142)

———. 1988. *Toward a New Philosophy of Biology: Observations of an Evolutionist*. Cambridge, MA: Harvard University Press. (142)

———. 1991. *One Long Argument: Charles Darwin and the Genesis of Modern Evolutionary Thought*. Cambridge, MA: Harvard University Press. (142, 209, 260, 291, 450)

———. 1998. “Two empires or three?” *PNAS* **95** (18 Aug.): 9720-9723. (103)

———. 2001a. *What Evolution Is*. New York: Basic Books. (142, 206, 216, 225, 392)

———. 2001b. “Wu’s genetic view of speciation.” *JEB* **14** (Nov.): 866-867. (144)

Mazumdar, Aninda, and **D. M. Banerjee.** 1998. “Siliceous sponge spicules in the Early Cambrian chert-phosphorite member of the Lower Tal Formation, Krol belt, Lesser Himalaya.” *Geology* **26** (Oct.): 899-902. (173)

McAdams, Harley H., and **Adam Arkin.** 1997. “Stochastic mechanisms in gene expression.” *PNAS* **94** (4 Feb.): 814-819. (474)

McElwain, J. C., D. J. Beerling, and **F. I. Woodward.** 1999. “Fossil Plants and Global Warming at the Triassic-Jurassic Boundary.” *Science* **285** (27 Aug.): 1386-1390. (199)

McGinnis, William, and **Michael Kuziora.** 1994. “The Molecular Architects of Body Design.” *SA* **270** (Feb.): 58-61, 64-66. (206)

McGowan, Christopher. 1984. *In the Beginning ... A Scientist Shows Why the Creationists Are Wrong*. Buffalo, NY: Prometheus Books. (20, 66, 126, 163, 219-220, 227, 231, 233, 238, 263, 272-274, 295, 312, 399, 414, 424-425, 440-441, 461, 506, 511, 525)

———. 1991. *Dinosaurs, Spitfires, and Sea Dragons.* Rev. ed. of 1983 *The Successful Dragons: A Natural History of Extinct Reptiles*. Cambridge, MA: Harvard University Press. (163, 429)

McHenry, Henry M. 1994. “Tempo and mode in human evolution.” *PNAS* **91** (19 July): 6780-6786. (457)

McHugh, Damhnait. 1997. “Molecular evidence that echiurans and pogonophorans are derived annelids.” *PNAS* **94** (22 July): 8006-8009. (85)

———. 2000. “Molecular phylogeny of the Annelida.” *Canadian Journal of Zoology* **78** (Nov.): 1873-1884. (85)

McIver, Thomas. 1987. “A Creationist Walk Through the Grand Canyon.” *C/E* **7** (Spring): 1-13. (480)

———. 1988a. “Creationist Misquotation of Darrow.” *C/E* **8** (Spring): 1-13. (480)

———. 1988b. *Anti-Evolution: A Reader’s Guide to Writings before and after Darwin*. Baltimore, MD: Johns Hopkins University Press. (66, 91, 288, 480)

McKown, Delos B. 1982. “Creationism and the First Amendment.” *C/E* **3** (Winter): 24-32. (480)

———. 1993. *The Mythmaker’s Magic: Behind the Illusion of “Creation Science.”* Buffalo, NY: Prometheus Books. (66, 498)

McMenamin, Mark A. S. 1998. *The Garden of Ediacara: Discovering the First Complex Life.* New York: Columbia University Press. (104, 137, 160, 173, 177, 179, 182, 188, 191, 196-197, 215, 255, 460 & Fig. 20)

Medina, Mónica, Allen G. Collins, Jeffrey D. Silberman, and **Mitchell L. Sogin.** 2001. “Evaluating hypotheses of basal animal phylogeny using complete sequences of large and small subunit rRNA.” *PNAS* **98** (14 Aug.): 9707-9712. (185, 241)

Meffert, Lisa Marie. 1999. “How Speciation Experiments Relate to Conservation Biology: The assumption of captive breeding strategies—that founder events reduce genetic variation—may not always be correct.” *BioScience* **49** (Sep.): 701-711. (146)

Melchor, Ricardo N., Silvina de Valais, and **Jorge F. Genise.** 2002. “Bird-like fossil footprints from the Late Triassic.” *Nature* **417** (27 June): 936-938. (346)

Menon, Gopinathan K., and **Jaishri Menon.** 2000. “Avian epidermal lipids: Functional considerations and relationship to feathering.” *AZ* **40** (Sep.): 540-552. (275, 282, 433)

Meyer, Axel. 1998. “HOX gene variation and evolution.” *Nature* **391** (15 Jan.): 225, 227-228. (206)

Meyerowitz, Elliot M. 2002. “Plants Compared to Animals: The Broadest Comparative Study of Development.” *Science* **295** (22 Feb.): 1482-1485. (103)

Miller, Arnold I., and **Michael Foote.** 2003. “Increased Longevities of Post-Paleozoic Marine Genera After Mass Extinctions.” *Science* **302** (7 Nov.): 1030-1032. (201)

Miller, David J., David C. Hayward, John S. Reece-Hoyes, Ingo Scholten, Julian Catmull,

Walter J. Gehring, Patrick Callaerts, Jill E. Larsen, and **Eldon E. Ball.** 2000. "*Pax* gene diversity in the basal cnidarian *Acropora millepora* (Cnidaria, Anthozoa): Implications for the evolution of the *Pax* gene family." *PNAS* **97** (25 April): 4475-4480. (238)

Miller, Kenneth R. 1982. "Answers to the Standard Creationist Arguments." *C/E* **3** (Winter): 1-13. (102)

———. 1994. "Life's Grand Design." *Technology Review* **97** (Feb./March): 24-32. (256, 324)

———. 1999. *Finding Darwin's God: A Scientist's Search for Common Ground Between God and Evolution*. New York: Cliff Street Books. (30, 61, 66, 71-72, 110, 143, 202, 398, 471, 509)

Mills, Gordon C. 1998. "Similarities and Differences in Mitochondrial Genomes: Theistic Interpretations." *Perspectives on Science and Christian Faith* **50** (Dec.): 286-291. (226)

Milton, Richard. 1994. *Forbidden Science: Exposing the Secrets of Suppressed Research*. London: Fourth Estate. (1, 53, 388)

———. 1997. *Shattering the Myths of Darwinism*. Rev. ed. of orig. 1992 (Britain) *Facts of Life*. Rochester, VT: Park Street Press. (1, 2, 4, 6-9, 12-17, 24, 28-29, 218, 248, 263, 266, 285, 349, 395, 441, 450, 494, 526)

Mindell, David P., Michael D. Sorenson, and **Derek E. Dimcheff.** 1998. "Multiple independent origins of mitochondrial gene order in birds." *PNAS* **95** (1 Sep.): 10693-10697. (393)

Mindell, David P., Michael D. Sorenson, **Derek E. Dimcheff, Masami Hasegawa, Jennifer C. Ast**, and **Tamaki Yuri.** 1999. "Interordinal Relationships of Birds and Other Reptiles Based on Whole Mitochondrial Genomes." *SB* **48** (March): 138-152. (335)

Mineta, Katsuhiko, Masumi Nakazawa, Francesc Cebrià, Kazuho Ikeo, Kiyokazu Agata, and **Takashi Gojobori.** 2003. "Origin and evolutionary process of the CNS elucidated by comparative genomics analysis of planarian ESTs." *PNAS* **100** (24 June): 7666-7671. (238)

Minguillón, Senda Jiménez-Delgado, Georgia Panopoulou, and **Jordi Garcia-Fernàndez.** 2003. "The amphioxus Hairy family" differential fate after duplication." *Development* **130** (15 Oct.): 5903-5914. (235)

Mitsiadis, Thimios A., Yvonnick Chéraud, Paul Sharpe, and **Josiane Fontaine-Pérus.** 2003. "Development of teeth in chick embryos after mouse neural crest transplantations." *PNAS* **100** (27 May): 6541-6545. (322)

Mlot, Christine. 1996. "Microbes Hint at a Mechanism Behind Punctuated Evolution." *Science* **272** (21 June): 1741. (153)

Molloy, P. L., B. C. Powell, K. Gregg, E. D. Barone, and **G. E. Rogers.** 1982. "Organisation of feather keratin genes in the chick genome." *Nucleic Acids Research* **10** (11 Oct.): 6007-6021. (278)

Monastersky, Richard. 1991. "The Lonely Bird: Claims of the Earliest Avian Fossil Launch a Paleontological Flap." *Science News* **141** (17 Aug.): 104-105. (356, 359)

———. 1993. "A clawed wonder unearthed in Mongolia." *Science News* **143** (17 April): 245. (342)

———. 1998. "Life Grows Up." *NG* **193** (April): 100-115. (182, 191)

———. 2001. "Pterosaurs: Lords of the Ancient Skies." *NG* **199** (May): 86-105. (163, 310, 444)

Montague, Ashley, ed. 1984. *Science and Creationism*. New York: Oxford University Press. (66, 480, 506)

Mooi, Rich, and **Bruno David.** 2000. "What a new model of skeletal homologies tells us about asteroid evolution." *AZ* **40** (June): 326-339. (86)

Moore, David S. 2001. *The Dependent Gene: The Fallacy of "Nature vs. Nurture."* New York: Times Books (W. H. Freeman/Henry Holt & Co.). (54, 239)

Moore, Randy. 1998a. "Creationism in the United States: I. Banning Evolution from the Classroom." *ABT* **60** (Sep.): 486-498, 500-502, 504-507. (469)

———. 1998b. "Creationism in the United States: II. The Aftermath of the Scopes Trial." *ABT* **60** (Oct.): 568-577. (469)

———. 1998c. "Thanking Susan Epperson." *ABT* **60** (Nov.-Dec.): 642-644, 646. (475)

———. 1998d. "Creationism in the United States: III. The Ban on the Teaching of Evolution Reaches the U.S. Supreme Court." *ABT* **60** (Nov.-Dec.): 650-661. (475)

———. 1999a. "Creationism in the United States: IV. The Aftermath of *Epperson v. Arkansas*." *ABT* **61** (Jan.): 10-22. (475)

———. 1999b. "Creationism in the United States: V. The *McLean* Decision Destroys the Credibility of 'Creation Science.'" *ABT* **61** (Feb.): 92-101. (480)

———. 1999c. "The Courage of Don Aguillard." *ABT* **61** (March): 166-167, 170-174. (473, 482)

———. 1999d. "Creationism in the United States: VI. Demanding 'Balanced Treatment.'" *ABT* **61** (March): 175-180. (482, 498)

———. 2001a. "The Lingering Impact of the Scopes Trial on High School Biology Textbooks." *BioScience* **51** (Sep.): 790-796. (471)

———. 2001b. "Educational Malpractice: Why Do So Many Biology Teachers Endorse Creationism?" *SI* **25** (Nov./Dec.): 38-43. (471)

———. 2002. "Teaching Evolution: Do State Standards Matter?" *BioScience* **52** (April): 378-381. (471)

Moreland, J. P., ed. 1994. *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer*. Downers Grove, IL: InterVarsity Press. (25, 80, 218, 441, 457-458, 467)

Moreland, J. P., and **John Mark Reynolds**, eds. 1999. *Three Views on Creation and Evolution.* Grand Rapids, MI: Zondervan Publishing House. (50, 110-111, 210, 218, 250, 441, 458, 461, 467)

Morell, Virginia. 1993. "*Archaeopteryx*: Early Bird Catches a Can of Worms." *Science* **259** (5 Feb.): 764-765. (344)

———. 1996. "A Cold, Hard Look at Dinosaurs." *Discover* **17** (Dec.): 98-108. (336)

———. 1998a. "Kennewick Man's Trials Continue." *Science* **280** (10 April): 190, 192. (64)

———. 1998b. "Kennewick Man's Contemporaries." *Science* **280** (10 April): 191. (64)

———. 1999. "Dietary Data Straight From the Horse's Mouth." *Science* **283** (5 Feb.): 773. (525)

Morgan, Bruce A., Roslyn W. Orkin, Selina Noramly, and **Alejandro Perez.** 1998. "Stage-Specific Effects of *Sonic Hedgehog* Expression in the Epidermis." *DB* **201** (1 Sep.): 1-12. (435)

Morris, Henry M. 1963. *The Twilight of Evolution*. 1995 pb ed. Grand Rapids, MI: Baker Book House. (5. 31, 65, 110, 218, 401)

———. 1972. *The Remarkable Birth of Planet Earth*. 1978 pb ed. San Diego, CA: Creation-Life Publishers. (5, 501)

———. 1975. *The Troubled Waters of Evolution*. San Diego, CA: Creation-Life Publishers. (218)

———, ed. 1985. *Scientific Creationism.* 1996 pb ed. (rev. from 1974). Green Forest, AR: Master Books. (13, 20, 29, 98-99, 102, 163, 204, 218, 250, 262, 265-266, 284, 292, 321, 424, 499, 503, 507, 509, 516)

Morris, Henry M., and **John D. Morris.** 1996a. *The Modern Creation Trilogy Volume I: Scripture and Creation.* Green Forest, AR: Master Books. (29, 65, 71, 461)

———. 1996b. *The Modern Creation Trilogy Volume II: Science and Creation.* Green Forest, AR: Master Books. (20, 29, 32, 65, 91, 126, 135, 169, 208, 218, 228-229, 237, 248, 290, 342, 401, 420, 424, 450, 460, 481, 503, 507, 517, 524, 526)

———. 1996c. *The Modern Creation Trilogy Volume III: Society and Creation.* Green Forest, AR: Master Books. (80)

Morris, Henry M., and **Gary E. Parker.** 1987. *What Is Creation Science?* 1997 pb ed. (rev. from 1982). Green Forest, AR: Master Books. (19, 20, 25, 29, 80-82, 85, 101-102, 204, 218, 250, 262, 266, 241, 401, 424, 439, 509, 516, 523, 526)

Morris, John D. 1999. "Creation and the Kansas Schools." Institute for Creation Research *Acts & Facts* (Oct.): 1-3. (40)

Morris, Richard. 2001. *The Evolutionists: The Struggle for Darwin's Soul*. New York: W. H. Freeman & Co. (143)

Morton, Glenn R. 2001. "Transitional Forms and the Evolution of Phyla." *Perspectives on Science and Christian Faith* **53** (March): 42-51. (243)

Motani, Ryosuke. 2000. "Rulers of the Jurassic Seas." *SA* **283** (Dec.): 52-59. (163)

Motani, R., H. You, and **C. McGowan.** 1996. "Eel-like swimming in the earliest ichthyosaurs." *Nature* **382** (25 July): 347-348. (163)

Mueller, Marge, and **Ted Mueller**. 1997. *Fire, Faults & Floods: A Road & Trail Guide*

Exploring the Origins of the Columbia River Basin. Moscow, ID: University of Idaho Press. (9)

Müller, Werner A. 1996. *DB.* 1997 English trans. New York: Springer. (206, 216, 238, 318, 438, 440)

Müller, Wolfgang, Henry Fricke, Alex N. Halliday, Malcolm T. McCulloch, and **Jo-Anne Wartho.** 2003. "Origin and Migration of the Alpine Iceman." *Science* **302** (31 Oct.): 862-866. (64)

Muncaster, Ralph O. 1997. *Creation versus Evolution: New Scientific Discoveries*. Mission Viejo, CA: Strong Basis To Believe. (218, 439, 467)

Murakami, Yasunori, Michio Ogasawara, Fumiaki Sugahara, Shigeki Hirano, Nori Satoh, and **Shigeru Kuratani.** 2001. "Identification and expression of the lamprey *Pax6* gene: evolutionary origin of the segmented brain of vertebrates." *Development* **128** (15 Sep.): 3521-3531. (207)

Murphy, Adam E., Bradley B. Sageman, and **David J. Hollander.** 2000. "Eutrophication by decoupling of the marine biogeochemical cycles of C, N, and P: A mechanism for the Late Devonian mass extinction." *Geology* **28** (May): 427-430. (199)

Murphy, J. B., R. A. Strachan, K. D. Parker, M. B. Fowler, and **R. D. Nance.** 2000. "Proto-Avalonia: A 1.2-1.0 Ga tectonothermal event and constraints for the evolution of Rodinia." *Geology* **28** (Dec.): 1071-1074. (160)

Musser, George. 2001. "Earth-Shattering Theory." *SA* **285** (Nov.): 18. (517)

Nagel, Laura, and **Dolph Schluter.** 1998. "Body Size, Natural Selection, and Speciation in Sticklebacks." *Evolution* **52** (Feb.): 209-218. (146)

Narayanan, Karthikeyan, Rampalli Srinivas, Amsaveni Ramachandran, Jianjun Hao, Bruce Quinn, and **Anne George.** 2001. "Differentiation of embryonic mesenchymal cells to odontoblast-like cells by overexpression of dentin matrix protein 1." *PNAS* **98** (10 April): 4516-4521. (322)

Narbonne, Guy M., and **James G. Gehling.** 2003. "Life after snowball: The oldest complex Ediacaran fossils." *Geology* **31** (Jan.): 27-30. (196)

Nardi, Francesco, Giacomo Spinsanti, Jeffrey L. Boore, Antonio Carapelli, Romano Dallai, and **Francesco Frati.** 2003a. "Hexapod Origins: Monophyletic or Paraphyletic?" *Science* **299** (21 March): 1887-1889. (227)

———. 2003b. "Response to Comment on 'Hexapod Origins: Monophyletic or Paraphyletic?'" *Science* **301** (12 Sep.): 1482. (227)

Nedin, Christopher. 1999. "*Anomalocaris* predation on nonmineralized and mineralized trilobites." *Geology* **27** (Nov.): 987-990. (177)

Neidert, Adam H., Vikrant Virupannavar, Gillian W. Hooker, and **James A. Langeland.** 2001. "Lamprey *Dlx* genes and early vertebrate evolution." *PNAS* **98** (13 Feb.): 1665-1670. (92)

Nesse, Randolph, and **George C. Williams.** 1998. "Evolution and the Origins of Disease." *SA* **279** (Nov.): 86-93. (467)

Neumann, Carl J., and **Christiane Nuesslein-Volhard.** 2000. "Patterning of the Zebrafish Retina by a Wave of Sonic Hedgehog Activity." *Science* **289** (22 Sep.): 2137-2139. (254)

Newell, Coke. 2000. *Latter Days: A Guided Tour Through Six Billion Years of Mormonism*. New York: St. Martin's Press. (489)

Newman, Mark. 2001. "A new picture of life's history on Earth." *PNAS* **98** (22 May): 5955-5956. (192)

Newman, Stuart A., and **Gerd B. Müller.** 2000. "Epigenentic Mechanisms of Character Origination." *JEZ* **288** (15 Dec.): 304-317. (214)

Niklas, Karl J. 1994. "Morphological evolution through complex domains of fitness." *PNAS* **91** (19 July): 6772-6779. (457)

Nilsson, Dan-E., and **Susanne Pelger.** 1994. "A pessimistic estimate of the time required for an eye to evolve." *Proceedings of the Royal Society of London* **B** (Biological Sciences) **256**

(22 April): 53-58. (253)

Nishimura, José M. Grajales, Esteban Cedillo-Parod, Carmen Rosales-Domínguez, Patricia Padilla-Avila, Antonieta Sánchez-Ríos, Dante J. Morán-Zenteno, Walter Alvarez, Philippe Claeys, José Ruíz-Morales, and **Jesús García-Hernández.** 2000. "Chicxulub impact: The origin of reservoir and seal facies in the southeastern Mexico oil fields." *Geology* **28** (April): 307-310. (199)

Nishiyama, Tomoaki, Tomomichi Fujita, Tadasu Shin-I, Motoaki Seki, Hiroyo Nishide, Ikuo Uchiyama, Asako Kamiya, Piero Carninci, Yoshihide Hayashizaki, Kazuo Shinozaki, Yuji Kohara, and **Mitsuyasu Hasebe.** 2003. "Comparative genomics of *Physcomitrella patens* gametophytic transcriptome and *Arabidopsis thaliana*: Implication for land plant evolution." *PNAS* **100** (24 June): 8007-8012. (102)

Nobles, David R., Dwight K. Romanovicz, and **R. Malcolm Brown Jr.** 2001. "Cellulose in Cyanobacteria. Origin of Vascular Plant Cellulose Synthase?" *Plant Physiology* **127** (Oct.): 529-542. (225)

Noramly, Selina, Allison Freeman, and **Bruce A. Morgan.** 1999. "β-catenin signaling can initiate feather bud development." *Development* **126** (15 Aug.): 3509-3521. (435)

Norell, Mark. 1998. "First Came Feathers." *NH* **107** (Sep.): 33. (344)

———. 2001. "The Proof Is in the Plumage." *NH* **110** (July/Aug.): 58-63. (341)

Norell, Mark, **Luis Chiappe**, and **James Clark.** 1993. "New Limb on the Avian Family Tree." *NH* **102** (Sep.): 38-43. (342)

Norell, Mark A., and **Julia A. Clarke.** 2001. "Fossil that fills a critical gap in avian evolution." *Nature* **409** (11 Jan.): 181-184. (335)

Norell, Mark A., **Eugene S. Gaffney**, and **Lowell Dingus.** 1995. *Discovering Dinosaurs in the American Museum of Natural History*. New York: Alfred A. Knopf. (13, 342)

Norell, Mark A., Qiang Ji, Keqin Gao, Chongxi Yuan, Yibin Zhao, and **Lixia Wang.** 2002. "'Modern' feathers on a non-avian dinosaur." *Nature* **416** (7 March): 36-37. (341)

Norell, Mark A., Peter Makovicky, and **James Clarke.** 1997. "A *Velociraptor* wishbone." *Nature* **389** (2 Oct.): 447. (308)

Norman, David. 1985. *The Illustrated Encyclopedia of Dinosaurs: An Original and Compelling Insight Into Life in the Dinosaur Kingdom*. New York: Crescent Books. (14-15, 164, 272, 301-302, 305, 307, 337, 344 & Fig. 31)

———. 1991. *Dinosaur!* New York: Macmillan. (329, 347)

———. 1994. *Prehistoric Life: The Rise of the Vertebrates.* New York: Macmillan. (178, 182, 184, 191, 194, 238, 417, 420, 422, 436, 459)

Normile, Dennis. 2000. "New Feathered Dino Firms Up Bird Links." *Science* **288** (9 June): 1721. (341)

Novacek, Michael J., Mark Norell, Malcolm C. McKenna, and **James Clark.** 1994. "Fossils of the Flaming Cliffs." *SA* **271** (Dec.): 60-63, 66-69. (342)

Noveen, Alexander, Ting-Xin Jiang, and **Cheng-Ming Chuong.** 1995. "Protein Kinase A and Protein Kinase C Modulators Have Reciprocal Effects on Mesenchymal Condensation during Skin Appendage Morphogenesis." *DB* **171** (1 Oct.): 677-693. (435)

Nowak, Ronald M. 1994. *Walker's Bats of the World*. Baltimore, MD: John Hopkins University Press. (265)

Numbers, Ronald L. 1992. *The Creationists: The Evolution of Scientific Creationism*. 1993 pb ed. Berkeley, CA: University of California Press. (42, 80, 110, 248, 441, 478, 487, 489, 493, 528)

Oakley, Todd H. 2003. "The eye as a replicating and diverging, modular developmental unit." *TREE* **18** (Sep.): 623-627. (251)

Oakley, Todd H., and **Clifford W. Cunningham.** 2002. "Molecular phylogenetic evidence for the independent evolutionary origin of an arthropod compound eye." *PNAS* **99** (5 Feb.): 1426-1430. (254)

Oberg, James. 2003. "Lessons of the 'Fake Moon Flight' Myth." *SI* **27** (March/April): 23, 30. (19)

Olsen, Paul E. 1999. "Giant Lava Flows, Mass Extinctions, and Mantle Plumes." *Science* **284** (23 April): 604-605. (199)

Olsen, P. E., D. V. Kent, H.-D. Sues, C. Koeberl, H. Huber, A. Montanari, E. C. Rainforth, S. J. Fowell, M. J. Szajna, and **B. W. Hartline.** 2002. "Ascent of Dinosaurs Linked to an Iridium Anomaly at the Triassic-Jurassic Boundary." *Science* **296** (17 May): 1305-1307. (199)

———. 2003. "Response to Comment on 'Ascent of Dinosaurs Linked to an Iridium Anomaly at the Triassic-Jurassic Boundary'." *Science* **301** (11 July): 169. (199)

Onuma, Yasuko, Shuji Takahashi, Makoto Asashima, Soichiro Kurata, and **Walter J. Gehring.** 2002. "Conservation of *Pax 6* function and upstream activation by *Notch* signaling in eye development of frogs and flies." *PNAS* **99** (19 Feb.): 2020-2025. (254)

Oreskes, Naomi, with **Homer Le Grand**, eds. 2001. *Plate Tectonics: An Insider's History of the Modern Theory of the Earth*. Boulder, CO: Westview Press (Perseus Books). (503)

Orr, H. Allen. 2001. "Some doubts about (yet another) view of species." *JEB* **14** (Nov.): 870-871. (144)

Oster, G., and **P. Alberch.** 1982. "Evolution and Bifurcation of Developmental Programs." *Evolution* **36** (May): 444-459. (434)

Ostrom, John H. 1979. "Bird Flight: How Did It Begin?" *American Scientist* **67** (Jan.-Feb.): 46-56. (244)

Padian, Kevin. 1996. "Early bird in slow motion." *Nature* **382** (1 Aug.): 400-401. (333)

———. 1998. "When is a bird not a bird?" *Nature* **393** (25 June): 729-730. (341)

———. 1999. "Charles Darwin's Views of Classification in Theory and Practice." *SB* **48** (June): 352-364. (408)

———. 2001. "Cross-testing adaptive hypotheses: Phylogenetic analysis and the origin of bird flight." *AZ* **41** (June): 598-607. (337)

———. 2003. "Four-Winged Dinosaurs, Bird Precursors, or Neither?" *BioScience* **53** (May): 450-452. (344)

Padian, Kevin, and **Luis M. Chiappe.** 1998. "The Origin of Birds and Their Flight." *SA* **278** (Feb.): 38-47. (314, 334, 339)

Padian, Kevin, and **John R. Horner.** 2002. "Typology versus transformation in the origin of birds." *TREE* **17** (March): 120-124. (292)

Palenik, Brian. 2002. "The genomics of endosymbiosis: Hosts keep the baby and the bath water." *PNAS* **99** (17 Sep.): 11996-11997. (225)

Palmer, Douglas. 1999. *Atlas of the Prehistoric World*. New York: Discovery Books. (102, 129, 178, 189, 199, 235, 337, 399, 428)

Pályi, Gyula, Claudia Zucchi, and **Luciano Caglioti**, eds. 2002. *Fundamentals of Life*. Paris: Éditions scientifiques et médicales Elsevier SAS. (227)

Panero, Jose, Javier Francisco-Ortega, Robert K. Jansen, and **Arnoldo Santos-Guerra.** 1999. "Molecular evidence for multiple origins of woodiness and a New World biogeographic connection of the Macaronesian Island endemic *Pericallis* (Asteraceae: Senecioneae)." *PNAS* **96** (23 Nov.): 13886-13891. (530)

Panganiban, Grace, Steven M. Irvine, Chris Lowe, Henry Roehl, Laura S. Corley, Beverley Sherbon, Jennifer K. Grenier, John F. Fallon, Judith Kimble, Muriel Walker, Gregory A. Wray, Billie J. Swalla, Mark Q. Martindale, and **Sean B. Carroll.** 1997. "The origin and evolution of animal appendages." *PNAS* **94** (13 May): 5162-5166. (214)

Panganiban Grace, and **John L. R. Rubenstein.** 2002. "Developmental functions of the *Distal-less*/Dlx homeobox genes." *Development* **129** (1 Oct.): 4371-4386. (206)

Papadopoulos, Dimitri, Dominique Schneider, Jessica Meier-Eiss, Werner Arber, Richard E. Lenski, and **Michel Blot.** 1999. "Genomic evolution during a 10,000-generation experiment with bacteria." *PNAS* **96** (30 March): 3807-3812. (153)

Park, Robert L. 2000. *Voodoo Science: The Road from Foolishness to Fraud.* Oxford: Oxford University Press. (53)

Parker, Andrew. 2003. *In the Blink of an Eye*. Cambridge, MA: Perseus Books. (92, 175, 177, 179, 191, 193, 197, 199, 251, 265, 336 & Fig. 11)

Pasquinelli, Amy E., Brenda J. Reinhart, Frank Slack, Mark Q. Martindale, Mitzi I. Kuroda, Betsy Maller, David C. Hayward, Eldon E. Ball, Bernard Degnan, Peter Müller, Jürg Spring, Ashok Srinivasan, Mark Fishman, John Finnerty, Joseph Corbo, Michael Levine, Patrick Leahy, Eric Davidson, and **Gary Ruvkun.** 2000. "Conservation of the sequence and temporal expression of *let-7* heterochronic regulatory RNA." *Nature* **408** (2 Nov.): 86-89. (239)

Paul, Gregory S. 1988. *Predatory Dinosaurs of the World*. 1989 pb ed. New York: Touchstone Books. (269, 271-272, 296-297, 301, 312, 328-329, 331, 337, 341, 344-345, 350, 377 & Fig. 32)

———. 2002. *Dinosaurs of the Air: The Evolution and Loss of Flight in Dinosaurs and Birds*. Baltimore, MD: Johns Hopkins University Press. (305, 337, 341, 377)

Paulsson, Johan, Otto G. Berg, and **Måns Ehrenberg.** 2000. "Stochastic focusing: Fluctuation-enhanced sensitivity of intercellular regulation." *PNAS* **97** (20 June): 7148-7153. (474)

Pawlowski, Jan, Maria Holzmann, Cédric Berney, José Fahrni, Andrew J. Gooday, Tomas Cedhagen, Andrea Habura, and **Samuel S. Bowser.** 2003. "The evolution of early Foraminifera." *PNAS* **100** (30 Sep.): 11494-11498. (185)

Pelli, Denis G., and **Steven C. Chamberlain.** 1989. "The visibility of 350° C black-body radiation by the shrimp *Rimicaris exoculata* and man." *Nature* **337** (2 Feb.): 460-461. (255)

Pennisi, Elizabeth. 1996. "Tracing Backbone Evolution Through a Tunicate's Lost Tail." *Science* **274** (15 Nov.): 1082-1083. (238)

———. 1999. "From Embryos and Fossils, New Clues to Vertebrate Evolution." *Science* **284** (23 April): 575, 577. (440)

———. 2001. "A Molecular Approach to Mushroom Hunting." *Science* **293** (10 Aug.): 1027-1028. (185)

———. 2002a. "Evo-Devo Devotees Eye Ocular Origins and More." *Science* **296** (10 May): 1010-1011. (254)

———. 2002b. "Tunicate Genome Shows a Little Backbone." *Science* **298** (13 Dec.): 2111-2112. (238)

———. 2003. "Uphill Dash May Have Led to Flight." *Science* **299** (17 Jan.): 329. (344)

Pennock, Robert T. 1999. *Tower of Babel: The Evidence against the New Creationism*. Cambridge, MA: MIT Press. (2, 60-61, 66-67, 71, 371, 450, 494, 506)

Perfetta, Patrick J., Kevin L. Shelton, and **James H. Stitt.** 1999. "Carbon isotope evidence for deep-water invasion at the Marjumiid-Pterpcephaliid biomere boundary, Black Hills, USA: A common origin for biotic crises on Late Cambrian shelves." *Geology* **27** (May): 403-406. (198)

Peterson, Gregory R. 2002. "The Intelligent-Design Movement: Science or Ideology?" *Zygon* **37** (March): 7-23. (524)

Peterson, Kevin J., and **Eric H. Davidson.** 2000. "Regulatory evolution and the origin of the bilaterians." *PNAS* **97** (25 April): 4430-4433. (214)

Pettersson, Hans. 1960. "Cosmic Spherules and Meteoric Dust." *SA* **202** (Feb.): 123-132. (504)

Pfeiffer, Thomas, and **Sebastian Bonhoeffer.** 2003. "An evolutionary scenario for the transition to undifferentiated multicellularity." *PNAS* **100** (4 Feb.): 1095-1098. (220)

Pigliucci, Massimo. 2001. "Design Yes, Intelligence No: A Critique of Intelligent Design Theory and Neocreationism." *SI* **25** (Sep./Oct.): 34-39. (61)

———. 2002. *Denying Evolution: Creationism, Scientism, and the Nature of Science*. Sunderland, MA: Sinauer Associates, Inc. (66, 470, 495)

Pineda, D., J. Gonzalez, P. Callaerts, K. Ikeo, W. J. Gehring, and **E. Salo.** 2000. "Searching for the prototypic eye genetic network: *Sine oculis* is essential for eye regeneration in planarians." *PNAS* **97** (25 April): 4525-4529. (254)

Pinker, Steven. 1997a. *How the Mind Works*. New York: W. W. Norton & Co. (400)

———. 1997b. "Why They Kill Their Newborns." *New York Times Magazine* (2 Nov.): 52-54. (400)

———. 2002. *The Blank Slate: The Modern Denial of Human Nature*. New York: Viking Press. (400)

Plait, Philip C. 2002. *Bad Astronomy: Misconceptions and Misuses Revealed, from Astrology to the Moon Landing "Hoax"*. New York: John Wiley & Sons. (5, 19)

Pollitt, Katha. 1999. "Weird Science." *The Nation* **269** (20 Sep.): 10. (39)

Polly, P. David. 2000. "Development and evolution of occlude: Evolution of development in mammalian teeth." *PNAS* **97** (19 Dec.): 14019-14021. (416)

Popadic, Aleksandar, and **Wyatt W. Anderson.** 1994. "The history of a genetic system." *PNAS* **91** (19 July): 6819-6823. (457)

Posada, David, and **Keith A. Crandall.** 2001. "Simple (Wrong) Models for Complex Trees: A Case from Retroviridae." *MBE* **18** (Feb.): 271-275. (241)

Poulsen, Christopher J. 2003. "Absence of a runaway ice-albedo feedback in the Neoproterozoic." *Geology* **31** (June): 473-476. (195)

Powell, C. McA., and **S. A. Pisarevsky.** 2002. "Late Neoproterozoic assembly of East Gondwana." *Geology* **30** (Jan.): 3-6. (160)

Prave, A. R. 2002. "Life on land in the Proterozoic: Evidence from the Torridonian rocks of northwest Scotland." *Geology* **30** (Sep.): 811-814. (94)

Presland, R. B., K. Gregg, P. L. Molloy, C. P. Morris, L. A. Crocker, and **G. E. Rogers.** 1989. "Avian keratin genes. I. A molecular analysis of the structure and expression of a group of feather keratin genes." *Journal of Molecular Biology* **209** (20 Oct.): 549-559. (278)

Price, Robert M. 1980. "The Return of the Navel, the 'Omphalos' Argument in Contemporary Creationism." *C/E* **1** (Fall): 26-33. (65)

Prokoph, Andreas, Anthony D. Fowler, and **R. Timothy Patterson.** 2000. "Evidence for periodicity and nonlinearity in a high-resolution fossil record of long-term evolution." *Geology* **28** (Oct.): 867-870. (201)

Prum, Richard O. 1999. "Development and Evolutionary Origin of Feathers." *JEZ* **285** (15 Dec.): 291-306. (274)

———. 2002. "Why Ornithologists Should Care About the Theropod Origin of Birds." *The Auk* **119** (Jan.): 1-17. (291)

———. 2003a. "Dinosaurs take to the air." *Nature* **421** (23 Jan.): 323-324. (344)

———. 2003b. "Are Current Critiques of the Theropod Origin of Birds Science?" *The Auk* **120** (April): 550-561. (320, 341, 382)

Prum, Richard O., and **Alan H. Brush.** 2002. "The Evolutionary Origin and Diversification of Feathers." *The Quarterly Review of Biology* **77** (Sep.): 261-295. (274-275, 278-280, 319, 335, 341, 386, 434)

———. 2003. "Which Came First, the Feather or the Bird?" *SA* **288** (March): 84-93. (280, 341)

Prum, Richard O., and **Scott Williamson.** 2001. "Theory of the Growth and Evolution of Feather Shape." *JEZ* **291** (15/30 April): 30-57. (274-275)

Purnell, Mark A. 1995. "Microwear on conodont elements and macrophagy in the first vertebrates." *Nature* **374** (27 April): 798-800. (106)

Quigg, Antonietta, Zoe V. Finkel, Andrew J. Irwin, Yair Rosenthal, Tung-Yuan Ho, John R. Reinfelder, Oscar Schofield, Francois M. M. Morel, and **Paul G. Falkowski.** 2003. "The evolutionary inheritance of elemental stoichiometry in marine phytoplankton." *Nature* **425** (18 Sep.): 291-294. (199)

Racki, Grzegorz, and **Christian Koeberl.** 2004. "Comment on 'Impact Ejecta Layer from the Mid-Devonian: Possible Connection to Global Mass Extinctions'." *Science* **303** (23 Jan.): 471. (199)

Radinsky, Leonard B. 1969. "The Early Evolution of the Perissodactyla." *Evolution* **23** (June): 308-328. (531)

———. 1987. *The Evolution of Vertebrate Design*. Chicago: University of Chicago Press. (88, 92, 398, 406, 436)

Raff, Rudolf A. 1996. *The Shape of Life: Genes, Development, and the Evolution of Animal Form.* Chicago: University of Chicago Press. (216, 239, 439)

Randi, James. 1980. *Flim-Flam! The Truth About Unicorns, Parapsychology, and Other Delusions*. New York: Lippincott & Crowell. (490)

Ransom, C. J. 1976. *The Age of Velikovsky*. New York: Delta Books. (5)

Rasmussen, Birger, Stefan Bengtson, Ian R. Fletcher, and **Neal J. McNaughton.** 2002. "Discoidal Impressions and Trace-Like Fossils More Than 1200 Million Years Old." *Science* **296** (10 May): 1112-1115. (184)

Rasmussen, Birger, Pradip K. Bose, Subir Sarkar, Santanu Banerjee, Ian R. Fletcher, and **Neal J. McNaughton.** 2002. "1.6 Ga U-Pb zircon age for the Chorhat Sandstone, lower Vindhyan, India: Possible implications for early evolution of animals." *Geology* **30** (Feb.): 103-106. (184)

Ratzsch, Del. 1996. *The Battle of Beginnings: Why Neither Side Is Winning the Creation-Evolution Debate*. Downers Grove, IL: InterVarsity Press. (66, 218, 298, 526)

Rauhut, Oliver W. M., Thomas Martin, Edgardo Ortiz-Jaureguizar, and **Pablo Puerta.** 2002. "A Jurassic mammal from South America." *Nature* **416** (14 March): 165-168. (405)

Raup, David M. 1991. *Extinction: Bad Genes or Bad Luck?* New York: W. W. Norton & Co. (199, 202, 250)

———. 1994. "The role of extinction in evolution." *PNAS* **91** (19 July): 6758-6763. (199, 457)

Ravitch, Diane. 2003. *The Language Police: How Pressure Groups Restrict What Students Learn*. New York: Alfred A. Knopf. (77)

Ravitch, Diane, and **Chester E. Finn Jr.** 1987. *What Do Our 17-Year-Olds Know? A Report on the First National Assessment of History and Literature*. New York: Harper & Row. (473)

Ravizza, G., and **B. Peucker-Ehrenbrink.** 2003. "Chemostratigraphic Evidence of Deccan Volcanism from the Marine Osmium Isotope Record." *Science* **302** (21 Nov.): 1392-1395. (199)

Ray, Jyotiranjan S., Mark W. Martin, Ján Veizer, and **Samuel A. Bowring.** 2002. "U-Pb zircon dating and Sr isotope systematics of the Vindhyan Supergroup, India." *Geology* **30** (Feb.): 131-134. (184)

Reinhart, Brenda J., and **Gary Ruvkin.** 2001. "Isoform-Specific Mutations in the *Caenorhabditis elegans* Heterochronic Gene *lin-14* Affect Stage-Specific Patterning." *Genetics* **157** (Jan.): 199-209. (239)

Reisz, Robert R., and **Hans-Dieter Sues.** 2000. "The 'feathers' of *Longisquama*." *Nature* **408** (23 Nov.): 428. (279)

Remington, David L., and **Michael D. Purugganan.** 2002. "*GAI* Homologues in the Hawaiian Silversword Alliance (Asteraceae-Madiinae): Molecular Evolution of Growth Regulators in a Rapidly Diversifying Plant Lineage." *MBE* **19** (Sep.): 1563-1574. (530)

Renesto, Silvio. 1994. "*Megalancosaurus*, a Possibly Arboreal Archosauromorph (Reptilia) from the Upper Triassic of Northern Italy." *Journal of Vertebrate Paleontology* **14** (March): 38-52. (291)

Rennie, John. 1994. "Darwin's Current Bulldog." *SA* **271** (Aug.): 24-25. (142)

———. 2002. "15 Answers to Creationist Nonsense." *SA* **287** (July): 78-85. (361, 526)

Repetski, John E. 1978. "A Fish from the Upper Cambrian of North America." *Science* **200** (5 May): 529-531. (89)

Rice, William R., and **Ellen E. Hostert.** 1993. "Laboratory Experiments on Speciation: What Have We Learned in 40 Years?" *Evolution* **47** (Dec.): 1637-1653. (146)

Rich, Patricia Vickers, **Thomas Hewitt Rich**, **Mildred Adams Fenton**, and **Carroll Lane Fenton.** 1996. *The Fossil Book: A Record of Prehistoric Life*. Rev. pb ed. Mineola, NY: Dover Publications, Inc. (88, 94, 101-102, 105-107, 172, 229-230, 246, 398, 416, 427, 432, 458, 460)

Richards, Robert J. 1992. *The Meaning of Evolution: The Morphological Construction and Ideological Reconstruction of Darwin's Theory.* Chicago: University of Chicago Press. (241)

Richardson, Michael K. 1995. "Heterochrony and the Phylotypic Period." *DB* **172** (1 Dec.):

412-421. (239, 241)

Richardson, Michael K., Steven P. Allen, Glenda M. Wright, Albert Raynaud, and **James Hanken.** 1998. "Somite number and vertebrate evolution." *Development* **125** (15 Jan.): 151-160. (334)

Richardson, Michael K., and **Paul M. Brakefield.** 2003. "Hotspots for evolution." *Nature* **424** (21 Aug.): 894-895. (393)

Richardson, Michael K., and **Ariel D. Chipman.** 2003. "Developmental Constraints in a Comparative Framework: A Test Case Using Variations in Phalanx Number During Amniote Evolution." *JEZ* **296B** (15 April): 8-22. (217, 245)

Richardson, Michael K., and **Gerhard Keuck.** 2002. "Haeckel's ABC of evolution and development." *Biological Reviews* **77** (4): 495-528. (241)

Richardson, Michael K., and **Helmut H. A. Oelschläger.** 2002. "Time, pattern, and heterochrony: a study of hyperphalangy in the dolphin embryo flipper." *E&D* **4** (Nov.-Dec.): 435-444. (245)

Richardson, Michael K., and **Glenda M. Wright.** 2003. "Developmental Transformations in a Normal Series of Embryos of the Sea Lamprey *Petromyzon marinus* (Linnaeus)." *Journal of Morphology* **257** (Sep.): 348-363. (92)

Riddle, Robert D., and **Clifford J. Tabin.** 1999. "How Limbs Develop." *SA* **280** (Feb.): 74-79. (318)

Ridgwell, Andy J., Martin J. Kennedy, and **Ken Caldeira.** 2003. "Carbonate Deposition, Climate Stability, and Neoproterozoic Ice Ages." *Science* **302** (31 Oct.): 859-862. (195)

Ridley, Mark, ed. 1997. *Evolution.* Oxford: Oxford University Press. (146, 153, 214, 253, 471)

Ridley, Matt. 1993. *The Red Queen: Sex and the Evolution of Human Nature*. New York: Macmillan. (240)

———. 2003. *Nature via Nurture: Genes, Experience, and What Makes Us Human*. New York: HarperCollins Publishers. (48, 292)

Rieseberg, L. H., and **J. M. Burke.** 2001. "A genic view of species integration." *JEB* **14** (Nov.): 883-886. (144)

Rieseberg, Loren H., Olivier Raymond, David M. Rosenthal, Zhao Lai, Kevin Livingstone, Takuya Nakazato, Jennifer L. Durphy, Andrea E. Schwarzbach, Lisa A. Donovan, and **Christian Lexer.** 2003. "Major Ecological Transitions in Wild Sunflowers Facilitated by Hybridization." *Science* **301** (29 Aug.): 1211-1216. (520)

Ritvo, Harriet. 1997. *The Platypus and the Mermaid and Other Figments of the Classifying Imagination*. Cambridge, MA: Harvard University Press. (260-261)

Roberts, David. 1993. "The Iceman: Lone Voyager From the Copper Age." *NG* **183** (June): 36-67. (64)

Robinson, Leif J. 2000. "Not in Kansas Anymore." *Sky & Telescope* **99** (April): 8. (39)

Rodríguez-Esteban, Concepción, John W. R. Schwabe, Jennifer De La Peña, Bryon Foys, Brian Eshelman, and **Juan Carlos Izpisúa Belmonte.** 1997. "*Radical fringe* positions the apical ectodermal ridge at the dorsoventral boundary of the vertebrate limb." *Nature* **386** (27 March): 360-366. (211)

Rodríguez-Trelles, Francisco, Rosa Tarrío, and **Francisco J. Ayala.** 2002. "A methodological bias toward overestimation of molecular evolutionary time scales." *PNAS* **99** (11 June): 8112-8115. (185)

Rodríguez-Trelles, Francisco, James R. Weinberg, and **Francisco J. Ayala.** 1996. "Presumptive Rapid Speciation after a Founder Event in a Laboratory Population of *Nereis*: Allozyme Electrophoretic Evidence Does Not Support the Hypothesis." *Evolution* **50** (Feb.): 457-461. (146)

Rogers, Raymond R., David W. Krause, and **Kristina Curry Rogers.** 2003. "Cannibalism in the Madagascan dinosaur *Majungatholus atopus*." *Nature* **422** (3 April): 515-518. (36)

Rokas, Antonis, Barry L. Williams, Nicole King, and **Sean B. Carroll.** 2003. "Genome-scale approaches to resolving incongruence in molecular phylogenies." *Nature* **425** (23 Oct.): 798-804. (185)

Romer, Alfred Sherwood. 1966. *Vertebrate Paleontology*. 3rd ed. Chicago: University of Chicago Press. (232, 389)

———. 1970. *The Vertebrate Body*. 4th ed. Philadelphia: W. B. Saunders Company. (417)

Romer, Alfred Sherwood, and **Thomas S. Parsons.** 1986. *The Vertebrate Body*. 6th ed. Philadelphia: Saunders College Publishing. (436)

Ross, Hugh. 1994. *Creation and Time: A Biblical and Scientific Perspective on the Creation-Date Controversy*. Colorado Springs, CO: Navpress. (22, 26, 71, 218, 441, 506)

———. 1995. *The Creator and the Cosmos: How the Greatest Scientific Discoveries of the Century Reveal God*. Rev. ed. Colorado Springs, CO: Navpress. (26, 218)

———. 1996. *Beyond the Cosmos: The Extra-Dimensionality of God: What Recent Discoveries in Astronomy and Physics Reveal about the Nature of God*. Colorado Springs, CO: Navpress. (22, 26, 218)

———. 1998. *The Genesis Question: Scientific Advances and the Accuracy of Genesis*. Colorado Springs, CO: Navpress. (22, 26, 218, 248, 441, 518)

Roush, Wade. 1997. “A ‘Master Control’ Gene for Fly Eyes Shares Its Power.” *Science* **275** (31 Jan.): 618-619. (254)

Rowe, Timothy. 1996. “Coevolution of the Mammalian Middle Ear and Neocortex.” *Science* **273** (2 Aug.): 651-654. (412, 440)

Rowley, Peter. 1971. *New Gods in America: An Informal Investigation into the New Religions of American Youth Today*. New York: David McKay. (19, 490)

Ruben, John A., **Cristiano Dal Sasso**, **Nicholas R. Geist**, **William J. Hillenius**, **Terry D. Jones**, and **Marco Signore.** 1999. “Pulmonary Function and Metabolic Physiology of Theropod Dinosaurs.” *Science* **283** (22 Jan.): 514-516. (432)

Ruben, John A., and **Terry D. Jones.** 2000. “Selective factors associated with the origin of fur and feathers.” *AZ* **40** (Sep.): 585-596. (275, 337, 340, 433)

Ruben, John A., **Terry D. Jones**, **Nicholas R. Geist**, and **W. Jaap Hillenius.** 1997. “Lung Structure and Ventilation in Theropod Dinosaurs and Early Birds.” *Science* **278** (14 Nov.): 1267-1270. (336)

Rubidge, Bruce S., and **Christian A. Sidor.** 2001. “Evolutionary Patterns Among Permo-Triassic Therapsids.” *Annual Reviews Ecology and Systematics* **32**: 449-480. (395, 405, 407, 414)

Ruiz-Trillo, I., J. Paps, M. Loukota, C. Ribera, U. Jondelius, J. Baguñà, and **M. Riutort.** 2002. “A phylogenetic analysis of myosin heavy chain type II sequences corroborates that Acoela and Nemertodermatida are basal bilaterians.” *PNAS* **99** (20 Aug.): 11246-11251. (109)

Rundle, H. D., F. Bredon, C. Griswold, A. Ø. Mooers, R. A. Voss, and **J. Whitton.** 2001. “Hybridization without guilt: gene flow and the biological species concept.” *JEB* **14** (Nov.): 868-869. (144)

Rundle, Howard D., **Arne Ø. Mooers**, and **Michael C. Whitlock.** 1998. “Single Founder-flush Events and the Evolution of Reproductive Isolation.” *Evolution* **52** (Dec.): 1850-1855. (146)

Runnegar, Bruce. 2000. “Loophole for snowball earth.” *Nature* **405** (25 May): 403-404. (195)

Ruse, Michael, ed. 1988. *But Is It Science? The Philosophical Question in the Creation/Evolution Controversy*. Buffalo, NY: Prometheus Books. (66, 493)

———. 2000. *The Evolution Wars: A Guide to the Debates*. Santa Barbara, CA: ABC-CLIO. (66)

———. 2001. *Can a Darwinian Be a Christian? The Relationship between Science and Religion*. Cambridge: Cambridge University Press. (71)

Rutherford, Suzanne L. 2000. “From genotype to phenotype: buffering mechanisms and the storage of genetic information.” *BioEssays* **22** (Dec.): 1095-1105. (203)

Ruvinsky, Ilya, and **Jeremy J. Gibson-Brown.** 2000. “Genetic and developmental bases of serial homology in vertebrate limb evolution.” *Development* **127** (15 Dec.): 5233-5244. (380)

Ruvinsky, Ilya, Lee M. Silver, and **Jeremy J. Gibson-Brown.** 2000. “Phylogenetic Analysis of

---

T-Box Genes Demonstrates the Importance of Amphioxus for Understanding Evolution of the Vertebrate Genome." *Genetics* **156** (Nov.): 1249-1257. (235)

Ryan, Frank. 2002. *Darwin's Blind Spot: Evolution Beyond Natural Selection*. Boston: Houghton Mifflin Company. (225, 458)

Salaneck, Erik, Robert Fredriksson, Earl T. Larson, J. Michael Conlon, and **Dan Larhammar.** 2001. "A neuropeptide Y receptor Y1-subfamily gene from an agnathan, the European river lamprey." *European Journal of Biochemistry* **268** (Dec., No. 23): 6146-6154. (92)

Salazar-Ciudad, Isaac, and **Jukka Jernvall.** 2002. "A gene network model accounting for development and evolution of mammalian teeth." *PNAS* **99** (11 June): 8116-8120. (416)

Saló, Emili, Jordi Tauler, Eva Jimenez, José Ramón Bayascas, Javier Gonzalez-Linares, Jordi Garcia-Fernàndez, and **Jaume Baguñà.** 2001. "Hox and ParaHox genes in flatworms: Characterization and expression." *AZ* **41** (June): 652-663. (238)

Sampson, Scott D., **David W. Krause**, and **Catherine A. Forster.** 1997. "Madagascar's Buried Treasure." *NH* **106** (March): 24-27. (333)

Sanderson, Michael J. 2003. "Molecular data from 37 proteins do not support a Precambrian origin of land plants." *American Journal of Botany* **90** (June): 954-956. (185)

Sanz, José L., Luis M. Chiappe, Bernardino P. Pérez-Moreno, Angela D. Buscalioni, José L. Moratalla, Francisco Ortega, and **Francisco J. Poyato-Ariza.** 1996. "An Early Cretaceous bird from Spain and its implications for the evolution of avian flight." *Nature* **382** (1 Aug.): 442-445. (333)

Sarfati, Jonathan. 1999. "The non-evolution of the horse." Answers in Genesis *Creation ex Nihilo* **21** (June-Aug.): 28-31. (525)

Sasai, Masaki, and **Peter G. Wolynes.** 2003. "Stochastic gene expression as a many-body problem." *PNAS* **100** (4 March): 2374-2379. (474)

Sato, Akie, Colm O'hUigin, Felipe Figueroa, Peter R. Grant, B. Rosemary Grant, Herbert Tichy, and **Jan Klein.** 1999. "Phylogeny of Darwin's finches as revealed by mtDNA sequences." *PNAS* **96** (27 April): 5101-5106. (450)

Sato, Akie, , Herbert Tichy Colm O'hUigin, Peter R. Grant, B. Rosemary Grant, and **Jan Klein.** 2001. "On the Origin of Darwin's Finches." *MBE* **18** (March): 299-311. (450)

Satoh, Gouki, Jun K. Takeuchi, Kinya Yasui, Kunifumi Tagawa, Hidetoshi Saiga, Peijun Zhang, and **Nori Satoh.** 2002. "*Amphi-Eomes/Tbr1*: An Amphioxus Cognate of Vertebrate *Eomesodermin* and *T-Brain1* Genes Whose Expression Reveals Evolutionarily Distinct Domain in Amphioxus Development." *JEZ* **294** (15 Aug.): 136-145. (235)

Sawyer, Roger H., Travis Glenn, Jeffrey O. French, Brooks Mays, Rose B. Shames, George L. Barnes, Jr., Walter Rhodes, and **Yoshinori Ishikawa.** 2000. "The expression of Beta (β) keratins in the epidermal appendages of reptiles and birds." *AZ* **40** (Sep.): 530-539. (275)

Schäfer, Günter, Martin Engelhard, and **Volker Müller.** 1999. "Bioenergetics of the Archaea." *Microbiology and Molecular Biology Reviews* **63** (Sep.): 570-620. (103)

Schafersman, Steven. 1982. "Censorship of Evolution in Texas." *C/E* **3** (Fall): 30-34. (77)

Schick, Theodore Jr., and **Lewis Vaughn.** 1999. *How to Think about Weird Things: Critical Thinking for a New Age*. 2nd ed. Mountain View, CA: Mayfield Publishing Company. (61)

Schierwater, Bernd, and **Rob Desalle.** 2001. "Current Problems with the Zootype and the Early Evolution of Hox Genes." *JEZ* **291** (15 Aug.): 169-174. (214)

Schilthuizen, Menno. 2001. *Frogs, flies, and dandelions: Speciation—The Evolution of New Species.* Oxford: Oxford University Press. (142, 146, 523)

———. 2002. "Caution: Species Crossing." *NH* **111** (Sep.): 62-71. (523)

Schopf, J. William. 1994a. "Disparate Rates, Differing Fates: Tempo and Mode of Evolution Changed from the Precambrian to the Phanerozoic." *PNAS* **91** (19 July): 6735-6742. (457)

———. 1994b. "The early evolution of life: solution to Darwin's dilemma." *TREE* **9** (Oct.): 375-377. (171-172)

———. 1999. *Cradle of Life: The Discovery of Earth's Earliest Fossils*. Princeton, NJ: Princeton University Press. (197)

———. 2000. "Solution to Darwin's dilemma: Discovery of the missing Precambrian record of life." *PNAS* **97** (20 June): 6947-6953. (175)

Schroeder, Gerald. 1997. *The Science of God: The Convergence of Scientific and Biblical Wisdom*. New York: The Free Press. (22, 141-142, 163, 218, 441)

———. 2001. *The Hidden Face of God: How Science Reveals the Ultimate Truth*. New York: The Free Press. (170, 218)

Schultz, Ted R. 2000. "In search of ant ancestors." *PNAS* **97** (19 Dec.): 14028-14029. (229)

Schwartz, Herman, ed. 2002. *The Rehnquist Court: Judicial Activism on the Right*. New York: Hill and Wang. (498)

Schwartz, Jeffrey H. 1999. *Sudden Origins: Fossils, Genes, and the Emergence of Species*. New York: John Wiley & Sons. (20, 143, 206, 214, 240, 380, 424)

Schwartz, Robert M., and **Margaret O. Dayhoff.** 1978. "Origins of Prokaryotes, Eukaryotes, Mitochondria, and Chloroplasts." *Science* **199** (27 Jan.): 395-403. (226)

Schweitzer, M. H., J. A. Watt, R. Avci, L. Knapp, L. Chiappe, M. Norell, and **M. Marshall.** 1999. "Beta-Keratin Specific Immunological Reactivity in Feather-Like Structures of the Cretaceous Alvarezsaurid, *Shuvuuia deserti*." *JEZ* **285** (15 Aug.): 146-157. (342)

Schweitzer, Mary Higby, and **Cynthia Lee Marshall.** 2001. "A Molecular Model for the Evolution of Endothermy in the Theropod-Bird Lineage." *JEZ* **291** (15 Dec.): 317-338. (335-336, 417)

Scott, Eugenie C. 2000. "Not (Just) in Kansas Anymore." *Science* **288** (5 May): 813, 815. (41)

Segel, Lee A. 2001. "Computing an organism." *PNAS* **98** (27 March): 3639-3640. (221)

Segerstråle, Ullica. 2000. *Defenders of the truth: The battle for science in the sociobiology debate and beyond.* Oxford: Oxford University Press. (48, 51, 69, 229)

Seilacher, Adolf, Edward W. Bolton, Martin Meschede, and **Hans Luginsland.** 2000. "Precambrian 'fossil' *Vermiforna* is a tectograph." *Geology* **28** (March): 235-238. (183)

Seilacher, Adolf, Pradip K. Bose, and **Friedrich Pflüger.** 1998. "Triploblastic Animals More Than 1 Billion Years Ago: Trace Fossil Evidence From India." *Science* **282** (2 Oct.): 80-83. (184)

Sereno, Paul C. 1999. "Definitions in Phylogenetic Taxonomy: Critique and Rationale." *SB* **48** (June): 329-351. (408)

Shankland, Marty, and **Elaine C. Seaver.** 2000. "Evolution of the bilaterian body plan: What have we learned from annelids?" *PNAS* **97** (25 April): 4434-4437. (216)

Shanks, Niall, and **Karl H. Joplin.** 1999. "Redundant Complexity: A Critical Analysis of Intelligent Design in Biochemistry." *Philosophy of Science* **66** (June): 268-282. (61)

Shaw, K. L. 2001. "The genealogical view of speciation." *JEB* **14** (Nov.): 880-882. (144)

Sheldon, Peter R. 1987. "Parallel gradualistic evolution of Ordovician trilobites." *Nature* **330** (10 Dec.): 561-563. (246)

Sheldrake, Rupert. 1998. "Could Experimenter Effects Occur in the Physical and Biological Sciences?" *SI* **22** (May/June): 57-58. (494)

———. 1999. *Dogs That Know When Their Owners Are Coming Home: And Other Unexplained Powers of Animals*. New York: Crown Publishers. (494)

———. 2001. "Research on the Feeling of Being Stared At." *SI* **25** (March/April): 58-61. (494)

———. 2002. "Are Melting Points Constant?" *SI* **26** (Sep./Oct.): 40-41. (494)

Shen, Weiping, and **Graeme Mardon.** 1997. "Ectopic eye development in *Drosophila* induced by directed *dachshund* expression." *Development* **124** (1 Jan.): 45-52. (254)

Shermer, Michael. 1997. *Why People Believe Weird Things: Pseudoscience, Superstitions, and Other Confusions of Our Times*. New York: W. H. Freeman & Co. (1, 259, 475)

———. 2001. *The Borderlands of Science: Where Sense Meets Nonsense*. Oxford: Oxford University Press. (143)

Shigetani, Yasuyo, Fumiaki Sugahara, Yayoi Kawakami, Yasunori Murakami, Shigeki Hirano, and **Sigeru Kuratani.** 2002. "Heterotopic Shift of Epithelial-Mesenchymal

---

Interactions in Vertebrate Jaw Evolution." *Science* **296** (17 May): 1316-1319. (440)

Shimeld, Sebastian M., and **Peter W. H. Holland.** 2000. "Vertebrate innovations." *PNAS* **97** (25 April): 4449-4452. (214)

Shipman, Pat. 1989. "Sixth Find Is a Feathered Friend." *Discover* **10** (Jan.): 63. (287-288)

———. 1997. "Birds do it … did dinosaurs?" *New Scientist* **153** (1 Feb.): 27-31. (370, 385)

———. 1998. *Taking Wing:* Archaeopteryx *and the Evolution of Bird Flight*. New York: Simon & Schuster. (230, 261-263, 271-272, 275, 287-288, 291, 304, 311, 313, 328, 339, 244, 346, 375)

Shore, Steven N. 1983. "Footprints in the Dust: The Lunar Surface and Creationism." *C/E* **4** (Fall): 32-35. (506)

Shu, D.-G., L. Chen, J. Han, and **X.-L. Zhang.** 2001. "An Early Cambrian tunicate from China." *Nature* **411** (24 May): 472-473. (238)

Shu, Degan, and **Simon Conway Morris.** 2003. "Response to Comment on 'A New Species of Yunnanozoan with Implications for Deuterostome Evolution.'" *Science* **300** (30 May): 1372. (93)

Shu, D.-G., S. Conway Morris, J. Han, Z.-F. Zhang, K. Yasui, P. Janvier, L. Chen, X.-L. Zhang, J.-N. Liu, Y. Li, and **H.-Q. Liu.** 2003a. "Head and backbone of the Early Cambrian vertebrate *Haikouichthys*." *Nature* **421** (30 Jan.): 526-529. (93)

Shu, Degan, Simon Conway Morris, Z. F. Zhang, J. N. Liu. Jian Han, Ling Chen, X. L. Zhang, K. Yasui, and **Yong Li.** 2003b. "A New Species of Yunnanozoan with Implications for Deuterostome Evolution." *Science* **299** (28 Feb.): 1380-1384. (93)

Shu, D.-G., H.-L. Luo, S. Conway Morris, X.-L. Zhang, S.-X. Hu, L. Chen, J. Han, M. Zhu, Y. Li, and **L.-Z. Chen.** 1999. "Lower Cambrian vertebrates from south China." *Nature* **402** (4 Nov.): 42-46. (93)

Shu, D., X. Zhang, and **L. Chen.** 1996. "Reinterpretation of *Yunnanozoon* as the earliest known hemichordate." *Nature* **380** (4 April): 428-430. (93)

Shubin, Neil. 1998. "Evolutionary cut and paste." *Nature* **394** (2 July): 12-13. (392)

———. 2002. "Origin of evolutionary novelty: Examples from limbs." *Journal of Morphology* **252** (April): 15-18. (222)

Shubin, Neil, Cliff Tabin, and **Sean Carroll.** 1997. "Fossils, genes and the evolution of animal limbs." *Nature* **388** (14 Aug.): 639-647. (380)

Shubin, Neil, David B. Wake, and **Andrew J. Crawford.** 1995. "Morphological Variation in the Limbs of *Taricha granulosa* (Caudata: Salamandridae): Evolutionary and Phylogenetic Implications." *Evolution* **49** (Oct.): 874-884. (380)

Sidor, Christian A. 2001. "Simplification as a Trend in Synapsid Cranial Evolution." *Evolution* **55** (July): 1419-1442. (420)

Sidor, Christian A., and **James A. Hopson.** 1998. "Ghost lineages and 'mammalness': assessing the temporal pattern of character acquisition in the Synapsida." *Paleobiology* **24** (Spring): 254-273. (Fig. 34)

Sieh, Kerry, and **Simon LeVay**. 1998. *The Earth in Turmoil: Earthquakes, Volcanoes, and Their Impact on Humankind*. New York: W. H. Freeman & Co. (9)

Simon, Alexander L., Eric A. Stone, and **Arend Sidow.** 2002. "Inference of functional regions in proteins by quantification of evolutionary constraints." *PNAS* **99** (5 March): 2912-2917. (241)

Simons, Lewis M. 2000. "Archaeoraptor Fossil Trail." *NG* **198** (Oct.): 128-132. (385)

Simpson, George Gaylord. 1944. *Tempo and Mode in Evolution.* New York: Columbia University Press. (99)

———. 1949. *The Meaning of Evolution: A Study of the History of Life and Its Significance for Man.* New Haven, CT: Yale University Press. (168)

———. 1953. *The Major Features of Evolution.* New York: Columbia University Press. (99)

———. 1961a. *Horses: The Story of the Horse Family in the Modern World and through Sixty Million Years of History*. New York: The Natural History Library (Anchor Books). (525)

———. 1961b. *Principles of Animal Taxonomy*. New York: Columbia University Press. (395, 523)

———. 1983. *Fossils and the History of Life*. New York: Scientific American Library. (32, 83, 86, 101, 143, 153, 172, 198, 265, 272, 299, 392, 408 & Fig. 10)

Simpson, Sarah. 2001. "Triggering a Snowball." *SA* **285** (Sep.): 20, 22. (195)

Sinha, Satrajit, and **Elaine Fuchs.** 2001. "Identification and dissection of an enhancer controlling epithelial gene expression in skin." *PNAS* **98** (27 Feb.): 2445-2460. (435)

Sites, Jack W. Jr., and **Jonathan C. Marshall.** 2003. "Delineating species: a Renaissance issue in systematic biology." *TREE* **18** (Sep.): 462-470. (144)

Siveter, David J., Mark Williams, and **Dieter Waloszek.** 2001. "A Phosphatocopid Crustacean with Appendages from the Lower Cambrian." *Science* **293** (20 July): 479-481. (189)

Sjøvold, Torstein. 1993. "Frost and Found." *NH* **102** (April): 60-63. (64)

Slack, J. W. W., P. W. H. Holland, and **C. F. Graham.** 1993. "The zootype and the phylotypic stage." *Nature* **361** (11 Feb.): 490-492. (214)

Sloan, Christopher P. 1999. "Feathers for *T. rex*?" *NG* **196** (Nov.): 98-107. (356, 385)

Smid, J. R., J. E. Rowland, W. G. Young, T. J. Daley, K. T. Coschigano, J. J. Kopchick, and **M. J. Waters.** 2004. "Mouse Cellular Cementum is Highly Dependent on Growth Hormone Status." *Journal of Dental Research* **88** (Jan.): 35-39. (525)

Smith, Andrew B. 2003. "Making the Best of a Patchy Fossil Record." *Science* **301** (18 July): 321-322. (192)

Smith, George H. 2000. *Why Atheism?* Amherst, NY: Prometheus Books. (19)

Smith, Kathleen K. 2002. "Sequence Heterochrony and the Evolution of Development." *Journal of Morphology* **252** (April): 82-97. (239)

Smolen, Paul, Douglas A. Baxter, and **John H. Byrne.** 1999. "Effects of macromolecular transport and stochastic fluctuations on dynamics of genetic regulatory systems." *American Journal of Physiology – Cell Physiology* **277** (Oct.): C777-C790. (474)

Smoot, George, and **Keay Davidson.** 1993. *Wrinkles in Time*. New York: William Morrow & Co. (26)

Snelling, Andrew A., and **David E. Rush.** 1993. "Moon Dust and the Age of the Solar System." Answers in Genesis ("*Creation ex Nihilo*") *CEN Technical Journal* **7** (1): 2-42. (510)

Sokal, Alan, and **Jean Bricmont**. 1998. *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science*. New York: Picador USA. (59)

Sonder, Ben. 1999. *Evolutionism and Creationism*. New York: Franklin Watts (Grolier Publishing). (66)

Sonleitner, Frank J. 1986. "What Did Karl Popper Really Say About Evolution?" *C/E* **6** (Summer): 9-14. (59)

———. 1987. "The Origin of Species by Punctuated Equilibrium." *C/E* **7** (Spring): 25-30. (143)

———. 1991. *What's Wrong With Pandas? A Closeup Look at Creationist Scholarship*. Berkeley, CA: National Center for Science Education**.** (114)

———. 1994. *The New Pandas: Has Creationist Scholarship Improved?* Berkeley, CA: National Center for Science Education**.** (114)

Sordino, Paulo, Frank van der Hoeven, and **Denis Duboule.** 1995. "*Hox* gene expression in teleost fins and the origin of vertebrate digits." *Nature* **375** (22 June): 678-681. (380)

Speakman, J. R. 1993. "Flight capabilities in *Archaeopteryx*." *Evolution* **47** (Feb.): 336-340. (272)

Speakman, J. R., and **S. C. Thomson.** 1994. "Flight capabilities of *Archaeopteryx*." *Nature* **370** (18 Aug.): 514. (272)

Spoor, F., S. Bajpah, S. T. Hussain, K. Kumar, and **J. G. M. Thewissen.** 2002. "Vestibular evidence for the evolution of aquatic behaviour in early cetaceans." *Nature* **417** (9 May): 163-166. (248)

Springer, Mark S., Emma C. Teeling, Ole Madsen, Michael J. Stanhope, and **Wilfred de Jong.** 2001. "Integrated fossil and molecular data reconstruct bat echolocation." *PNAS* **98** (22 May): 6241-6246. (265)

Stahl, Barbara J. 1985. *Vertebrate History: Problems in Evolution*. Rev. pb ed. New York: Dover Publications, Inc. (87-88, 90, 92, 163, 235, 263, 265, 274-275, 305, 314, 328, 331, 394, 412, 414,

---

416, 419, 455, 461)

Stanley, Steven M. 1996. *Children of the Ice Age: How a Global Catastrophe Allowed Humans to Evolve*. New York: Harmony Books. (240)

Stansfield, William D., **Jaime S. Colomé**, and **Raúl J. Cano**. 1996. *Schaum's Outline of Theory and Problems of Molecular and Cell Biology*. New York: McGraw-Hill. (225)

Stark, Rodney. 2003. *For the Glory of God: How Monotheism Led to Reformations, Science, Witch-Hunts, and the End of Slavery*. Princeton, NJ: Princeton University Press. (25, 56, 382, 424, 523)

Stauber, Michael, Alexander Prell, and **Urs Schmidt-Ott.** 2002. "A single *Hox3* gene with composite *bicoid* and *zerknüllt* expression characteristics in non-Cyclorrhaphan flies." *PNAS* **99** (8 Jan.): 274-279. (207)

Stauber, Michael, Heike Taubert, and **Urs Schmidt-Ott.** 2000. "Function of *bicoid* and *hunchback* homologs in the basal cyclorrhaphan fly *Megaselia* (Phoridae)." *PNAS* **97** (26 Sep.): 10844-10849. (207)

Steghaus-Kovac, Sabine. 2002. "Tug-of-War Over Mystery Fossil." *Science* **295** (15 Feb.): 1212-1213. (337)

Steiner, Michael, and **Joachim Reitner.** 2001. "Evidence of organic structures in Ediacara-type fossils and associated microbial mats." *Geology* **29** (Dec.): 1119-1122. (196)

Stettenheim, Peter R. 2000. "The integumentary morphology of modern birds—an overview." *AZ* **40** (Sep.): 461-477. (275, 278-279, 433)

Stock, Christina. 1995. "Flying in the Face of Tradition: Avian Evolution May Have Been Anything But Gradual." *SA* **272** (June): 22. (335)

Stock, David W., Debra L. Ellies, Zhiyoung Zhao, Marc Ekker, Frank H. Ruddle, and **Kenneth M. Weiss.** 1996. "The evolution of the vertebrate Dlx gene family." *PNAS* **93** (1 Oct.): 10858-10863. (525)

Stokstad, Erik. 2000a. "Feathers, or Flight of Fancy?" *Science* **288** (23 June): 2124-2125. (279)

———. 2000b. "Tiny, Feathered Dino Is Most Birdlike Yet." *Science* **290** (8 Dec.): 1871-1872. (344)

———. 2001a. "New Fossil Fills Gap in Bird Evolution." *Science* **291** (12 Jan.): 225. (335)

———. 2001b. "Doubts Raised About Dinosaur Heart." *Science* **291** (2 Feb.): 811. (336)

———. 2002a. "'Fantastic' Fossil Helps Narrow Data Gap." *Science* **296** (26 April): 637, 639. (416)

———. 2002b. "Fossil Plant Hints How First Flowers Bloomed." *Science* **296** (3 May): 821. (102)

———. 2002c. "Fossil Bird From China Turns Rail, Spills Guts." *Science* **297** (26 July): 495. (338, 385)

———. 2003. "Four-Winged Dinos Create a Flutter." *Science* **299** (24 Jan.): 491. (344)

Stollewerk, Angelika, Michael Schoppmeier, and **Wim G. M. Damen.** 2003. "Involvement of *Notch* and *Delta* genes in spider segmentation." *Nature* **423** (19 June): 863-865. (207)

Stoner, Douglas S., Baruch Rinkevich, and **Irving L. Weissman.** 1999. "Heritable germ and somatic cell lineage competitions in chimeric colonial protochordates." *PNAS* **96** (3 Aug.): 9148-9153. (238)

Storch, Gerhard. 1992. "The Mammals of Island Europe." *SA* **266** (Feb.): 64-69. (265, 309)

Strahler, Arthur N. 1987. *Science and Earth History—The Evolution/Creation Controversy*. Buffalo, NY: Prometheus Books. (2, 4, 14, 34, 66, 146, 163, 180, 231-232, 235, 248, 399, 413, 420, 441, 461, 493, 498, 503, 506, 524)

Strauss, Evelyn. 1999. "Can Mitochondrial Clocks Keep Time?" *Science* **283** (5 March): 1435, 1437-1438. (185)

Strobel, Lee. 1998. *The Case for Christ: A Journalist's Personal Investigation of the Evidence for Jesus*. Grand Rapids, MI: Zondervan Publishing House. (25)

———. 2000. *The Case for Faith: A Journalist Investigates the Toughest Objections to Christianity*. Grand Rapids, MI: Zondervan Publishing House. (25, 34)

Sucena, Elio, Isabelle Delon, Isaac Jones, François Payre, and **David L. Stern.** 2003. "Regulatory evolution of *shavenbaby/ovo* underlies multiple cases of morphological parallelism." *Nature* **424** (21 Aug.): 935-938. (393)

Sues, Hans-Dieter. 2001. "Ruffling feathers." *Nature* **410** (26 April): 1036-1037. (341)

Sumida, Stuart S., and **Christopher A. Brochu.** 2000. "Phylogenetic context for the origin of feathers." *AZ* **40** (Sep.): 486-503. (275, 279, 291, 312, 319, 337)

Sun, Hongmin, Douglas P. Dickinson, John Costello, and **Wen-Hsiung Li.** 2001. "Isolation of *Cladonema Pax-B* Genes and Studies of the DNA-Binding Properties of Cnidarian Pax Paired Domains." *MBE* **18** (Oct.): 1905-1918. (238)

Sun, Hongmin, Srinivas Merugu, Xun Gu, Yuan Yuan Kang, Douglas P. Dickinson, Patrick Callaerts, and **Wen-Hsiung Li.** 2002. "Identification of Essential Amino Acid Changes in Paired Domain Evolution Using a Novel Combination of Evolutionary Analysis and In Vitro and In Vivo Studies." *MBE* **19** (Sep.): 1490-1500. (238)

Sun, Hongmin, Andrei Rodin, Yihong Zhou, Douglas P. Dickinson, Donald E. Harper, David Hewett-Emmett, and **Wen-Hsiung Li.** 1997. "Evolution of paired domains: Isolation and sequencing of jellyfish and hydra *Pax* genes related to *Pax-5* and *Pax-6*." *PNAS* **94** (13 May): 5156-5161. (238)

Sun, Ge, **David L. Dilcher**, **Shaolin Zheng**, and **Zkekun Zhou.** 1998. "In Search of the First Flower: A Jurassic Angiosperm, *Archaefructus*, from Northeast China." *Science* **282** (27 Nov.): 1692-1695. (102)

Sun, Ge, Qiang Ji, **David L. Dilcher**, **Shaolin Zheng, Kevin C. Nixon**, and **Xinfu Wang.** 2002. "Archaefructaceae, a New Basal Angiosperm Family." *Science* **296** (3 May): 899-904. (102)

Sunderland, Luther D. 1988. *Darwin's Enigma: Fossils and Other Problems*. 1998 pb ed. subtitled as *Ebbing the Tide of Naturalism* (*nota bene*: though the text is unchanged, pagination differs from the original printing). Green Forest, AR: Master Books. (3, 5, 19, 91, 266, 321, 344, 354-355, 414, 424, 441)

Sutcliffe, Owen E., Derek E. G. Briggs, and **Christopher Bartels.** 1999. "Ichnological evidence for the environmental setting of the Fossil-Lagerstätten in the Devonian Hunsrück Slate, Germany." *Geology* **27** (March): 275-278. (166)

Svitil, Kathy. 1994a. "Bird or Mole?" *Discover* **15** (Jan.): 51-52. (342)

———. 1994b. "Seven Perching Dinosaurs." *Discover* **15** (Jan.): 52, 54. (302)

Swain, Peter S., Michael B. Elowitz, and **Eric D. Siggia.** 2002. "Intrinsic and extrinsic contributions to stochasticity in gene expression." *PNAS* **99** (1 Oct.): 12795-12800. (474)

Swalla, Billie J., and **William P. Jeffery.** 1996. "Requirement of the *Manx* Gene for Expression of Chordate Features in a Tailless Ascidian Larva." *Science* **274** (15 Nov.): 1205-1208. (238)

Swisher, Carl C. III, Yuan-qing Wang, Xiao-lin Wang, Xing Xu, and **Yuan Wang.** 1999. "Cretaceous age for the feathered dinosaurs of Liaoning, China." *Nature* **400** (1 July): 58-61. (102, 370)

Szathmáry, Eörs. 1999. "When the means do not justify the end." *Nature* **399** (24 June): 745. (424)

Tabin, Clifford J., Sean B. Carroll, and **Grace Panganiban.** 1999. "Out on a Limb: Parallels in Vertebrate and Invertebrate Limb Patterning and the Origin of Appendages." *AZ* **39** (June): 650-663. (380)

Taquet, Philippe, trans. Kevin Padian. 1994. *Dinosaur Impressions: Postcards from a Paleontologist*. 1998 English ed. Cambridge: Cambridge University Press. (14, 281, 329, 342)

Tarzia, Wade. 1990. "Linguistic Tendencies in Creationist Texts: Hypotheses." *C/E* **10** (Summer): 11-19. (259)

Tarsitano, Samuel F., Francis Horne, Christopher Plummer, Karen Millerchip, and **Anthony P. Russell.** 2000. "On the evolution of feathers from an aerodynamic and constructional view point." *AZ* **40** (Sep.): 676-686. (275, 291, 344)

Taubes, Gary. 1993. *Bad Science: The Short Life and Weird Times of Cold Fusion.* New York: Random House. (53)

Tausta, S. Lorraine, Heather Miller Coyle, Beverly Rothermel, Virginia Stiefel, and **Timothy**

Nelson. 2002. “Maize C4 and non-C4 NADP-dependent malic enzymes are encoded by distinct genes derived from a plastid-localized ancestor.” *Plant Molecular Biology* **50** (Nov.): 635-652. (530)

Tax, Sol, ed. 1960. *Evolution After Darwin: The University of Chicago Centennial. Volume 1. The Evolution of Life: Its Origin, History and Future*. Chicago: University of Chicago Press. (99, 531)

Taylor, G. Jeffrey. 1994. “The Scientific Legacy of Apollo.” *SA* **271** (July): 40-47. (517)

Taylor, Paul S. 1987. *The Great Dinosaur Mystery and the Bible*. San Diego, CA: Master Book Publishers. (11, 34)

———. 1995. *The Illustrated Origins Answer Book: Concise, Easy-to-Understand Facts about the Origin of Life, Man, and the Cosmos*. 5th ed. Gilbert, AZ: Eden Communications. (42-43, 102, 208, 218, 248, 276, 349, 382, 441, 510, 526, 528)

Tchernov, Eitan, **Olivier Rieppel**, **Hussam Zaher**, **Michael J. Polcyn**, and **Louis L. Jacobs.** 2000. “A Fossil Snake with Limbs.” *Science* **287** (17 March): 2010-2012. (292)

Teeling, Emma C., Ole Madsen, Ronald A. Van Den Bussche, Wilfried W. de Jong, Michael J. Stanhope, and **Mark S. Springer.** 2002. “Microbat paraphyly and the convergent evolution of a key innovation in Old World rhinolophoid microbats.” *PNAS* **99** (5 Feb.): 1431-1436. (265)

Teeling, Emma C., Mark Scally, Diana J. Kao, Michael L. Romagnoli, Mark S. Springer, and **Michael J. Stanhope.** 2000. “Molecular evidence regarding the origin of echolocation and flight in bats.” *Nature* **403** (13 Jan.): 188-192. (265)

Templeton, Alan R. 1996. “Experimental Evidence for the Genetic-Transilience Model of Speciation.” *Evolution* **50** (April): 909-915. (146)

Terling, C., R. Heymann, B. Rozell, B. Obrink, and **J. Wroblewski.** 1998. “Dynamic expression of E-cadherin in ameloblasts and cementoblasts in mice.” *European Journal of Oral Sciences* **106** (Jan., Supplement): 137-142. (525)

Testaz, Sandrine, Artem Jarov, Kevin P. Williams, Leona E. Ling, Victor E. Koteliansky, Claire Fournier-Thibault, and **Jean-Loup Duband.** 2001. “Sonic hedgehog restricts adhesion and migration of neural crest cells independently of the Patched-Smoothened-Gli signaling pathway.” *PNAS* **98** (23 Oct.): 12521-12526. (438)

Theißen, Günter. 2002. “Orthology: Secret life of genes.” *Nature* **415** (14 Feb.): 741. (203)

Thewissen, J. G. M., and **Sunil Bajpal.** 2001. “Whale Origins as a Poster Child for Macroevolution.” *BioScience* **51** (Dec.): 1037-1049. (248)

Thewissen, J. G. M., and **S. T. Hussain.** 1993. “Origin of underwater hearing in whales.” *Nature* **361** (4 Feb.): 444-445. (248)

Thewissen, J. G. M., **S. T. Hussain**, and **M. Arif.** 1994. “Fossil Evidence for the Origin of Aquatic Locomotion in Archaeocete Whales.” *Science* **263** (14 Jan.): 210-212. (248)

Thewissen, J. G. M.,, and **S. I. Madar.** 1999. “Ankle Morphology of the Earliest Cetaceans and Its implications for the Phylogenetic Relations among Ungulates.” *SB* **48** (March): 21-30. (248)

Thewissen, J. G. M., S. I. Madar, and **S. T. Hussain.** 1998. “Whale ankles and evolutionary relationships.” *Nature* **395** (1 Oct.): 452. (248)

Thewissen, J. G. M., **L. J. Roe**, **J. R. O’Neil**, **S. T. Hussain**, **A. Sahni**, and **S. Bajpal.** 1996. “Evolution of cetacean osmoregulation.” *Nature* **381** (30 May): 379-380. (248)

Thewissen, J. G. M., **E. M. Williams, L. J. Roe**, and **S. T. Hussain.** 2001. “Skeletons of terrestrial cetaceans and the relationship of whales to artiodactyls.” *Nature* **413** (20 Sep.): 277-281. (248)

Thomas, David Hurst. 1999. *Skull Wars: Kennewick Man, Archaeology, and the Battle for Native American Identity*. New York: Peter N. Nevraumont (Basic Books). (64)

Thomas, Michael A., Kathleen A. Walsh, Melisande R. Wolf, Bruce A. McPheron, and **James H. Marden.** 2000. “Molecular phylogenetic analysis of evolutionary trends in stonefly wing structure and locomotor behavior.” *PNAS* **97** (21 Nov.): 13178-13183. (230)

Thomas, R. D. K., Rebecca M. Shearman, and **Graham W. Stewart.** 2000. “Evolutionary

Exploitation of Design Options by the First Animals with Hard Skeletons." *Science* **288** (19 May): 1239-1242. (215)

Thomas, Richard H. 2003. "Wingless Insects and Plucked Chickens." *Science* **299** (21 March): 1854-1855. (227)

Thomas, Robert L., and **F. David Farnell**, eds. 1998. *The Jesus Crisis: The Inroads of Historical Criticism into Evangelical Scholarship*. Grand Rapids, MI: Kregel Publications. (468)

Thompson, Bert. 1995. *Creation Compromises*. Montgomery, AL: Apologetics Press. (25, 401, 441)

Thornhill, Richard H., and **David W. Ussery.** 2000. "A Classification of Possible Routes of Darwinian Evolution." *Journal of Theoretical Biology* **203** (21 March): 111-116. (61)

Thornton, Joseph W. 2001. "Evolution of vertebrate steroid receptors from an ancestral estrogen receptor by ligand exploitation and serial genome expansions." *PNAS* **98** (8 May): 5671-5676. (222)

Thornton, Joseph W., Eleanor Need, and **David Crews.** 2003. "Resurrecting the Ancestral Steroid Receptor: Ancient Origin of Estrogen Signaling." *Science* **301** (19 Sep.): 1714-1717. (222)

Thulborn, T. 2003. "Comment on 'Ascent of Dinosaurs Linked to an Iridium Anomaly at the Triassic-Jurassic Boundary'." *Science* **301** (11 July): 169.

Tiffin, Lee. 1994. *Creationism's Upside-Down Pyramid: How Science Refutes Fundamentalism*. Amherst, NY: Prometheus Books. (66)

Ting-Berreth, Sheree A., and **Cheng-Ming Chuong.** 1996. "Local Delivery of TGF β2 Can Substitute for Placode Epithelium to Induce Mesenchymal Condensation during Skin Appendage Morphogenesis." *DB* **179** (1 Nov.): 347-359. (435)

Torsvik, Trond H. 2003. "The Rodinia Jigsaw Puzzle." *Science* **300** (30 May): 1379-1381. (160)

Tortora, Gerard J., **Berdell R. Funke**, and **Christine L. Case.** 1995. *Microbiology: An Introduction*. Redwood City, CA: Benjamin/Cummings. (225)

Toumey, Christopher P. 1994. *God's Own Scientists: Creationists in a Secular World*. New Brunswick, NJ: Rutgers University Press. (18, 42, 472, 474, 476-477, 486-487, 523)

Tsiantis, Miltos. 2001. "Control of Shoot Cell Fate: Beyond Homeoboxes." *The Plant Cell* **13** (April): 733-738. (207)

Tsukui, Tohru, Javier Capdevila, Koji Tamura, Pilar Ruiz-Lozano, Concepción Rodriguez-Esteban, Sayuri Yonei-Tamura, Jorge Magallón, Roshantha A. S. Chandraratna, Kenneth Chien, Bruce Blumberg, Ronald M. Evans, and **Juan Carlos Izpisúa Belmonte.** 1999. "Multiple left-right asymmetry defects in *Shh*$^{-/-}$ mutant mice unveil a convergence of the Shh and retinoic acid pathways in the control of *Lefty-1*." *PNAS* **96** (28 Sep.): 11376-11381. (435)

Tucker, Abigail S., Karen L. Matthews, and **Paul T. Sharpe.** 1998. "Transformation of Tooth Type Induced by Inhibition of BMP Signaling." *Science* **282** (6 Nov.): 1136-1138. (525)

Tudge, Colin. 1996. *The Time Before History: 5 Million Years of Human Impact*. New York: Scribner. (157, 236)

———. 2000. *The Variety of Life: A Survey and a Celebration of all the Creatures that Have Ever Lived.* Oxford: Oxford University Press. (230, 275, 335, 380, 408)

Unwin, David M. 1998. "Feathers, filaments and theropod dinosaurs." *Nature* **391** (8 Jan.): 119-120. (340)

———. 1999. "Pterosaurs: back to the traditional model?" *TREE* **14** (July): 263-268. (310)

———. 2003. "Smart-winged pterosaurs." *Nature* **425** (30 Oct.): 910. (311)

Unwin, David M., and **Donald M. Henderson.** 2002. "On the trail of the totally integrated pterosaur." *TREE* **17** (Feb.): 58-59. (310)

Vacelet, J., and **N. Boury-Esnault.** 1995. "Carnivorous sponges." *Nature* **373** (26 Jan.): 333-335. (243)

Valentine, James W. 1994. "Late Precambrian bilaterians: Grades and clades." *PNAS* **91** (19 July): 6751-6757. (214, 457)

———. 1997. "Cleavage patterns and the topology of the metazoan tree of life." *PNAS* **94** (22 July): 8001-8005. (216)

Valentine, James W., David Jablonski, and **Douglas H. Erwin.** 1999. "Fossils, molecules and embryos: new perspectives on the Cambrian explosion." *Development* **126** (1 March): 851-859. (128, 185, 188, 214)

Van Alphen, J. J. M., and **O. Seehausen.** 2001. "Sexual selection, reproductive isolation and the genic view of speciation." *JEB* **14** (Nov.): 872-873. (144)

Van Dover, Cindy Lee, Ete Z. Szuts, Steven C. Chamberlain, and **J. R. Cann.** 1989. "A novel eye in 'eyeless' shrimp from hydrothermal vents of the Mid-Atlantic Ridge." *Nature* **337** (2 Feb.): 458-460. (255)

Van Genderen, Marcel, Bart Koene, and **Jan Willem Nienhuys.** 2002a. "Sheldrake's Crystals." *SI* **26** (Sep./Oct.): 35-40. (494)

———. 2002b. "A Last Reply to Sheldrake." *SI* **26** (Sep./Oct.): 41. (494)

Van Till, Howard J. 1993. "God and Evolution: An Exchange (I)." *First Things* (June/July): 32-38. (409)

Velicer, Gregory J., Lee Kroos, and **Richard E. Lenski.** 1998. "Loss of social behaviors by *Myxococcus xanthus* during evolution in an unstructured habitat." *PNAS* **95** (13 Oct.): 12376-12380. (220)

Velikovsky, Immanuel. 1950. *Worlds in Collision*. 1970 pb ed. New York: Dell. (4, 9)

———. 1952. *Ages in Chaos*. Garden City, NY: Doubleday. (4)

———. 1955. *Earth in Upheaval*. 1968 pb ed. New York: Dell. (4)

———. 1960. *Oedipus and Akhnaton*. Garden City, NY: Doubleday. (4)

———. 1977. *Peoples of the Sea*. Garden City, NY: Doubleday. (4)

———. 1978. *Ramses II and His Time*. Garden City, NY: Doubleday. (4)

Vickery, Minako S., and **James B. McClintock.** 2000. "Comparative morphology of tube feet among the Asteroidea: Phylogenetic implications." *AZ* **40** (June): 355-364. (86)

Vogel, Gretchen. 1999. "The Why Behind the Y Chromosome." *Science* **286** (29 Oct.): 877, 879. (461)

Vogler, A. P. 2001. "The genic view: a useful model of the process of speciation?" *JEB* **14** (Nov.): 876-877. (144)

Von Mering, Christian, Evgeny M. Zdobnov, Sophia Tsoka, Francesca D. Ciccarelli, Jose B. Pereira-Leal, Christos A. Ouzounis, and **Peer Bork.** 2003. "Genome evolution reveals biochemical networks and functional modules." *PNAS* **100** (23 Dec.): 15428-15433. (254)

Voss, S. Randal, and **H. Bradley Shaffer.** 1997. "Adaptive evolution via a major gene effect: Paedomorphosis in the Mexican axolotl." *PNAS* **94** (9 Dec.): 14185-14189. (239)

Voss, S. Randal, Jeramiah J. Smith, David M. Gardiner, and **David M. Parichy.** 2001. "Conserved Vertebrate Chromosome Segments in the Large Salamander Genome." *Genetics* **158** (June): 735-746. (239)

Wada, Hiroshi, Hidetoshi Saiga, Noriyuki Satoh, and **Peter W. H. Holland.** 1998. "Tripartite organization of the ancestral chordate brain and the antiquity of placodes: insights from ascidian *Pax-2/5/8*, *Hox* and *Otx* genes." *Development* **125** (15 March): 1113-1122. (207)

Wade, Nicholas. 1998. *The Science Times Book of Fossils and Evolution.* New York: The Lyons Press. (92, 199, 248, 254, 292, 399)

Wagner, Andreas. 2000. "Inferring Lifestyle from Gene Expression Patterns." *MBE* **17** (Dec.): 1985-1987. (32)

Wagner, Günter P., Chris Amemiya, and **Frank Ruddle.** 2003. "Hox cluster duplications and opportunity for evolutionary novelties." *PNAS* **100** (9 Dec.): 14603-14606. (206)

Wagner, Günter P., and **Chi-Hua Chiu.** 2001. "The Tetrapod Limb: A Hypothesis on Its Origin." *JEZ* **291** (15 Oct.): 226-240. (380)

Wagner, Günter P., and **Jacques A. Gauthier.** 1999. "1,2,3 = 2,3,4: A solution to the problem of the homology of the digits in the avian hand." *PNAS* **96** (27 April): 5111-5116. (319)

Walkden, Gordon, Julian Parker, and **Simon Kelley.** 2002. "A Late Triassic Impact Ejecta Layer in Southwestern Britain." *Science* **298** (13 Dec.): 2185-2188. (199)

Walker, Gabrielle. 2003a. *Snowball Earth: The Story of the Great Global Catastrophe That Spawned Life As We Know It*. New York: Crown Publishers. (182, 195, 460)

———. 2003b. "The Longest Winter." *NH* **112** (April): 44-51. (195)

Walker, Tas. 2000. "Slow Fish in China." Answers in Genesis *Creation ex Nihilo* **22** (June-Aug.): 38-39. (93)

Waller, Geoffrey, ed. 1996. *SeaLife: A Complete Guide to the Marine Environment*. Washington, D.C.: Smithsonian Institution Press. (248)

Walters, Jerome. 2001. *One Aryan Nation Under God: How Religious Extremists Use the Bible to Justify Their Actions*. Nashville, IL: Sourcebooks, Inc. (464)

Wang, Yuanqing, Yaoming Hu, Jin Meng, and **Chuankui Li.** 2001. "An Ossified Meckel's Cartilage in Two Cretaceous Mammals and Origin of the Mammalian Inner Ear." *Science* **294** (12 Oct.): 357-361. (440)

Ward, Keith. 1996. *God, Chance & Necessity*. 1997 US reprint. Oxford: Oneworld. (253)

Ward, Peter D. 1994. *The End of Evolution: On Mass Extinctions and the Preservation of Biodiversity*. New York: Bantam Books. (192, 199)

———. 2000. *Rivers in Time: The Search for Clues to Earth's Mass Extinctions*. New York: Columbia University Press. (199, 202, 427)

Ward, Peter D., and **Donald Brownlee.** 2000. *Rare Earth: Why Complex Life is Uncommon in the Universe*. New York: Copernicus. (195, 199)

———. 2002. *The Life and Death of Planet Earth: How the New Science of Astrobiology Charts the Ultimate Fate of Our World.* New York: Times Books (Henry Holt & Co.). (192)

Warren, R., L. Nagy, J. Selegue, J. Gates, and **S. Carroll.** 1994. "Evolution of homeotic gene regulation and function in flies and butterflies." *Nature* **372** (1 Dec.): 458-461. (207, 230)

Watson, James D., with **Andrew Berry.** 2003. *DNA: The Secret of Life*. New York: Alfred A. Knopf. (203, 205, 254)

Watson, Lyall. 1973. *Supernature: A Natural History of the Supernatural.* 1974 pb ed. New York: Bantam Books. (494)

Webber, Robert E. 2002. *The Younger Evangelicals: Facing the Challenges of the New World*. Grand Rapids, MI: Baker Books. (110)

Weber, Christopher Gregory. 1980. "Common Creationist Attacks on Geology." *C/E* **1** (Fall): 10-25. (13)

———. 1981. "Paluxy Man—The Creationist Piltdown." *C/E* **2** (Fall): 16-23. (20)

Webster, Andrea J., Robert J. H. Payne, and **Mark Pagel.** 2003. "Molecular Phylogenies Link Rates of Evolution and Speciation." *Science* **301** (25 July): 478. (147)

———. 2004. "Response to Comments on 'Molecular Phylogenies Link Rates of Evolution and Speciation'." *Science* **303** (9 Jan.): 173. (147)

Webster, Donovan. 2000. "Debut Sue." *NG* **197** (June): 24-37. (308)

Weil, Anne. 2002. "Upwards and onwards." *Nature* **416** (25 April): 798-799. (416)

Weinberg, James R., Victoria R. Starczak, and **Daniele Jörg.** 1992. "Evidence for Rapid Speciation Following a Founder Event in the Laboratory." *Evolution* **46** (Aug.): 1214-1220. (146)

Weinberg, Samantha. 2000. *A Fish Caught in Time: The Search for the Coelacanth*. New York: HarperCollins Publishers. (398)

Weinberg, Steven. 1992. *Dreams of a Final Theory*. New York: Pantheon Books. (59)

Weiner, Jonathan. 1994a. *The Beak of the Finch: A Story of Evolution in Our Time*. 1995 pb ed. New York: Vintage Books. (450)

———. 1994b. "The Handy-Dandy Evolution Prover." *New York Times Magazine* (8 May): 40-41. (450)

Weishampel, David B., **Peter Dodson**, and **Halszka Osmólska**, eds. 1990. *The Dinosauria*. 1992 pb ed. Berkeley, CA: University of California Press. (162, 164)

Weiss, K., D. Stock, Z. Zhao, A. Buchanon, F. Ruddle, and **C. Shashikant.** 1998. "Perspectives on genetic aspects of dental patterning." *European Journal of Oral Sciences* **106** (January, Supplement): 55-63. (525)

Wellman, Charles H., Peter L. Osterloff, and **Uzma Mohiuddin.** 2003. "Fragments of the earliest land plants." *Nature* **425** (18 Sep.): 282-285. (101)

Wellnhofer, Peter. 1988. "A New Specimen of *Archaeopteryx*." *Science* **240** (24 June): 1790-1792. (287)

———. 1990. "*Archaeopteryx*." *SA* **262** (May): 70-77. (287, 331)

———, trans. Michael Robinson. 1991. *Pterosaurs: The Illustrated Encyclopedia of Prehistoric Flying Reptiles*. 1996 reprint. New York: Barnes & Noble. (163, 279, 310-311, 444)

Wells, Jonathan. 2000a. *Icons of Evolution: Science or Myth? Why Much of What We Teach About Evolution Is Wrong*. 2002 pb ed. Washington, D.C.: Regnery Publishing, Inc. (93, 115-118, 136, 138-139, 170-171, 181, 185, 211, 214, 217-218, 226, 235, 241, 254, 267, 284, 289, 317, 324, 332, 334, 367-368, 371-372, 375, 382, 385, 387, 408, 441, 450, 452, 524, 526)

———. 2000b. "Survival of the Fakest." *AS* **10** (Dec.): 18-24, 26-27. (452)

West, John Anthony. 1993. *Serpent in the Sky: The High Wisdom of Ancient Egypt*. Wheaton, IL: Quest Books. (2)

West, John Anthony, and **Jan Gerhard Toonder.** 1970. *The Case for Astrology*. 1973 pb ed. Baltimore, MD: Penguin Books. (2)

Westenberg, Kerri. 1999. "From Fins to Feet." *NG* **195** (May): 114-126. (399)

Whitbread, L. A., K. Gregg, and **G. E. Rogers.** 1991. "The structure and expression of a gene encoding chick claw keratin." *Gene* **101** (30 May): 223-229. (278)

Whitcomb, John C., and **Henry M. Morris.** 1961. *The Genesis Flood: The Biblical Record and It's Scientific Implications*. 1966 ed. Philadelphia: The Presbyterian and Reformed Publishing Co. (34, 80)

White, Michael. 2001. *Acid Tongues and Tranquil Dreamers: Tales of Bitter Rivalry That Fueled the Advancement of Science and Technology*. New York: William Morrow. (260)

Whitfield, Philip. 1993. *From So Simple A Beginning: The Book of Evolution*. New York: Macmillan. (143, 199, 203, 206, 226, 235, 238, 292, 392, 408, 460)

Whiting, Michael F., Sven Bradler, and **Taylor Maxwell.** 2003. "Loss and recovery of wings in stick insects." *Nature* **421** (16 Jan.): 264-267. (230)

Widelitz, Randall B., Ting-Xin Jiang, Jianfen Lu, and **Cheng-Ming Chuong.** 2000. "*β-catenin* in Epithelial Morphogenesis: Conversion of Part of Avian Foot Scales into Feather Buds with a Mutated β-Catenin." *DB* **219** (1 March): 98-114. (281)

Wieland, Carl. 1988. "Putting Feathers on Reptiles." Answers in Genesis *Creation ex Nihilo* **11** (Dec.): 31-32. (277)

———. 1994. "Bird Evolution flies out the window." Answers in Genesis *Creation ex Nihilo* **16** (June-Aug.): 16-19. (277)

———. 1998. "Agnostic critique of evolution." Answers in Genesis ("*Creation ex Nihilo*") *CEN Technical Journal* **12** (2): 158-160. (1, 20)

Wiens, John J. 2001. "Shape Shifters." *NH* **110** (Oct.): 70-75. (292)

Wiens, John J., and **Jamie L. Slingluff.** 2001. "How Lizards Turn into Snakes: a Phylogenetic Analysis of Body-Form Evolution in Anguid Lizards." *Evolution* **55** (Nov.): 2303-2318. (292)

Williams, Hill. 2002. *The Restless Northwest: A Geological Story*. Pullman, WA: Washington State University Press. (9)

Wills, Matthew A., and **Richard A. Fortey.** 2000. "The shape of life: how much is written in stone?" *BioEssays* **22** (Dec.): 1142-1152. (192, 214)

Wilson, Clifford A. 1972. *Crash Go the Chariots: An Alternative to Chariots of the Gods?* New York: Lancer Books. (2)

———. 1974. *UFOs and Their Mission Impossible*. New York: Signet Books. (2)

———. 1976. *The Chariots Still Crash*. New York: Signet Books. (2)

Wilson, Clifford, and **John Weldon.** 1978. *Close Encounters: A* Better *Explanation*. San

---

Diego, CA: Master Book Publishers. (2)

Wilson, David B., ed. 1983. *Did the Devil Make Darwin Do It? Modern Perspectives on the Creation-Evolution Controversy*. Ames, IA: Iowa State University Press. (66, 441, 480)

Wilson, Edward O. 1975. *Sociobiology: The New Synthesis*. 2000 pb ed. Cambridge, MA: Belknap Press (Harvard University Press). (229)

Witham, Larry A. 2002. *Where Darwin Meets the Bible: Creationists and Evolutionists in America*. Oxford: Oxford University Press. (25, 40, 55, 71, 102, 110-111, 261, 472, 489)

———. 2003. *By Design: Science and the Search for God*. San Francisco: Encounter Books. (40, 60, 71, 111, 194, 226, 257, 402, 526)

Witmer, Lawrence M., Sankar Chatterjee, Jonathan Franzosa, and **Timothy Rowe.** 2003. "Neuroanatomy of flying reptiles and implications for flight, posture and behaviour." *Nature* **425** (30 Oct.): 950-953. (311)

Witt, Christopher C., and **Robb T. Bromfield.** 2004. "Comment on 'Molecular Phylogenies Link Rates of Evolution and Speciation' (I)." *Science* **303** (9 Jan.): 173. (147)

Woese, Carl R. 1998. "Default taxonomy: Ernst Mayr's view of the microbial world." *PNAS* **95** (15 Sep.): 11043-11046. (103)

Wolf, Blair O., and **Glenn E. Walsberg.** 2000. "The role of the plumage in heat transfer processes of birds." *AZ* **40** (Sep.): 575-584. (275, 337)

Wolfram, Stephen. 2002. *A New Kind of Science*. Champaign, IL: Wolfram Media. (59)

Wolpert, David H., and **William G. Macready.** 1997. "No Free Lunch Theorems for Optimization." *IEEE Transactions on Evolutionary Computation* **1** (April): 67-82. (61)

Wolpoff, Milford, and **Rachel Caspari.** 1997. *Race and Human Evolution*. New York: Simon & Schuster. (48)

Wong, Kate. 2002. "Taking Wing." *SA* **286** (Jan.): 16, 18. (344)

Wood, Rachel A., John P. Grotzinger, and **J. A. D. Dickson.** 2002. "Proterozoic Modular Biomineralized Metazoan from the Nama Group, Namibia." *Science* **296** (28 June): 2383-2386. (178)

Wood, Todd Charles. 2002. "The AGEing Process: Rapid Post-Flood Intrabaraminic Diversification Caused by Altruistic Genetic Elements (AGES)." Geoscience Research Institute *Origins* **54** (1): 5-34. (530)

Wood, Todd Charles, and **David P. Cavanaugh.** 2001. "A Baraminological Analysis of Subtribe Flaveriinae (Asteraceae: Helenieae) and the Origin of Biological Complexity." Geoscience Research Institute *Origins* **52** (1): 7-27. (530)

———. 2003. "An Evaluation of Lineages and Trajectories as Baraminological Membership Criteria." *Occasional Papers of the Baraminology Study Group* (online journal at www.bryancore.org/bsg/) No. 2: 1-6. (531)

Wood, Todd Charles, Kurt P. Wise, Roger Sanders, and **Neal Doran.** 2003. "A Refined Baramin Concept." *Occasional Papers of the Baraminology Study Group* (online journal at www.bryancore.org/bsg/) No. 3: 1-14. (529)

Woodmorappe, John. 2001a. "Mammal-like reptiles: major trait reversals and discontinuities." Answers in Genesis ("*Creation ex Nihilo*") *CEN Technical Journal* **15** (1): 44-52. (463)

———. 2001b. "Eviscerating Eldredge." Answers in Genesis ("*Creation ex Nihilo*") *CEN Technical Journal* **15** (2): 13-16. (246)

Woodward, Thomas. 1991. "A Professor Takes Darwin to Court." *Christianity Today* **35** (19 Aug.): 33-35. (443)

Wraith, Amanda, Anna Törnsten, Patrick Chardon, Ingrid Harbitz, Bhanu P. Chowdhary, Leif Andersson, Lars-Gustav Lundin, and **Dan Larhammar.** 2000. "Evolution of the Neuropeptide Y Receptor Family: Gene and Chromosome Duplications Deduced from the Cloning and Mapping of the Five Receptor Subtype Genes in Pig." *GR* **10** (March): 302-310. (92)

Wray, Gregory A. 2001. "Resolving the *Hox* Paradox." *Science* **292** (22 June): 2256-2257. (206)

Wray, Gregory A., Jeffrey S. Levinton, and **Leo H. Shapiro.** 1996. "Molecular Evidence for

---

Deep Precambrian Divergences Among Metazoan Phyla." *Science* **274** (25 Oct.): 568-573. (185, 214)

Wray, Gregory A., and **Rudolf A. Raff.** 1990. "Novel Origins of Lineage Founder Cells in the Direct-Developing Sea Urchin *Heliocidaris erythrogramma*." *DB* **141** (1 Sep.): 41-54. (243)

———. 1991. "Rapid Evolution of Gastrulation Mechanisms in a Sea Urchin with Lecithotrophic Larvae." *Evolution* **45** (Dec.): 1741-1750. (243)

———. 1998. "Body Builders of the Sea." *NH* **107** (Dec.): 38-46. (217)

Wright, Paul, Lesley Cherns, and **Peter Hodges.** 2003. "Missing molluscs: Field testing taphonomic loss in the Mesozoic through early large-scale aragonite dissolution." *Geology* **31** (March): 211-214. (175)

Wu, Chung-I. 2001a. "The genic view of the process of speciation." *JEB* **14** (Nov.): 851-865. (144)

———. 2001b. "Genes and speciation." *JEB* **14** (Nov.): 889-891. (144)

Wuethrich, Bernice. 1999. "Stunning Fossil Shows Breath of a Dinosaur." *Science* **283** (22 Jan.): 468. (432)

Wyss, André. 2001. "Digging Up Fresh Clues About the Origin of Mammals." *Science* **292** (25 May): 1496-1497. (412)

Xiao, Shuhai, Xunlai Yuan, and **Andrew H. Knoll.** 2000. "Eumetazoan fossils in terminal Proterozoic phosphorites?" *PNAS* **97** (5 Dec.): 13684-13689. (173)

Xiao, Shuhai, **Yun Zhang**, and **Andrew H. Knoll.** 1998. "Three-dimensional preservation of algae and animal embryos in a Neoproterozoic phosphorite." *Nature* **391** (5 Feb.): 553-558. (173)

Xu, Shizhong. 2000. "Phylogenetic Analysis Under Reticulate Evolution." *MBE* **17** (June): 897-907. (523)

Xu, Xing, Mark A. Norell, Xiao-lin Wang, Peter J. Makovicky, and **Xiao-chun Wu.** 2002. "A basal troodontid from the Early Cretaceous of China." *Nature* **415** (14 Feb.): 780-783. (386)

Xu, Xing, Zhi-lu Tang, and **Xiao-lin Wang.** 1999a. "A therizinosaurid dinosaur with integumentary structures from China." *Nature* **399** (27 May): 350-354. (341, 386)

Xu, Xing, Xiao-lin Wang, and **Xiao-chun Wu.** 1999b. "A dromaeosaurid dinosaur with a filamentous integument from the Yixian Formation of China." *Nature* **401** (16 Sep.): 262-266. (341)

Xu, Xing, Zhong-he Zhou, and **Richard O. Prum.** 2001. "Branched integumental structures in *Sinornithosaurus* and the origin of feathers." *Nature* **410** (8 March): 200-204. (341)

Xu, Xing, Zhong-he Zhou, and **Xiao-lin Wang.** 2000. "The smallest known non-avian theropod dinosaur." *Nature* **408** (7 Dec.): 705-708. (344)

Xu, Xing, Zhong-he Zhou, Xiao-lin Wang, Xuewen Kuang, Fucheng Zhang, and **Xiangke Du.** 2003. "Four-winged dinosaurs from China." *Nature* **421** (23 Jan.): 335-340. (344)

Yanai, Itai, Adnan Derti, and **Charles DeLisi.** 2001. "Genes linked by fusion events are generally of the same functional category: A systematic analysis of 30 microbial genomes." *PNAS* **98** (3 July): 7940-7945. (203)

Yang, Ji, Hongya Gu, and **Ziheng Yang.** 2004. "Likelihood Analysis of the Chalcone Synthase Genes Suggests the Role of Positive Selection in Morning Glories (*Ipomoea*)." *JME* **58** (Jan.): 54-63. (530)

Yang, Ji, Jinxia Huang, Hongya Gu, Yang Zhong, and **Ziheng Yang.** 2002. "Duplication and Adaptive Evolution of the Chalcone Synthase Genes of Dendranthema (Asteraceae)." *MBE* **19** (Oct.): 1752-1759. (530)

Yang, Ziheng, and **Rasmus Nielsen.** 2000. "Estimating Synonymous and Nonsynonymous Substitution Rates Under Realistic Evolutionary Models." *MBE* **17** (Jan.): 32-43. (203)

Youngblood, Ronald, ed. 1986. *The Genesis Debate: Persistent Questions About Creation and the Flood.* 1990 pb ed. Grand Rapids, MI: Baker Book House. (110)

Yuan, Xunlai, Shuhai Xiao, Ronald L. Parsley, Chuanming Zhou, Zhe Chen, and **Jie Hu.** 2002. "Towering sponges in an Early Cambrian Lagerstätte: Disparity between nonbilaterian and bilaterian epifaunal tierers at the Neoproterozoic-Cambrian transition." *Geology* **30** (April): 363-366. (196)

Zanis, Michael J., Douglas E. Soltis, Pamela S. Soltis, Sarah Mathews, and **Michael J. Donoghue.** 2002. "The root of the angiosperms revisited." *PNAS* **99** (14 May): 6848-6853. (102)

Zetterberg, Peter, ed. 1983. *Evolution versus Creationism: The Public Education Controversy*. Phoenix, AZ: Oryx Press. (4, 66, 74-75, 102, 407, 425, 430, 441, 487, 523)

Zhang, Fucheng, and **Zhonghe Zhou.** 2000. "A Primitive Enantiornithine Bird and the Origin of Feathers." *Science* **290** (8 Dec.): 1955-1959. (333, 335)

Zhao, Yuanxiang, and **Steven S. Potter.** 2001. "Functional specificity of the *Hoxa13* homeobox." *Development* **128** (15 Aug.): 3197-3207. (435)

Zhou, Xijin, and **Xing Xu.** 1998. "The oldest Coelurosaurian." *Nature* **394** (16 July): 234-235. (386)

Zhou, Zhiyan, and **Shaolin Zheng.** 2003. "The missing link in *Ginkgo* evolution." *Nature* **423** (19 June): 821-822. (102)

Zhou, Zhonghe, Julia A. Clarke, and **Fucheng Zhang.** 2002. "*Archaeoraptor*'s better half." *Nature* **420** (21 Nov.): 285. (385)

Zhou, Zhonghe, and **Fucheng Zhang.** 2002. "A long-tailed, seed-eating bird from the Early Cretaceous of China." *Nature* **418** (25 July): 405-409. (338)

Zimmer, Carl. 1992. "Ruffled Feathers." *Discover* **13** (May): 44-54. (359)

———. 1998. *At the Water's Edge: Macroevolution and the Transformation of Life*. New York: The Free Press. (239, 248, 260, 322)

———. 2000a. "In Search of Vertebrate Origins: Beyond Brain and Bone." *Science* **287** (3 March): 1576-1579. (92)

———. 2000b. "The Hidden Unity of Hearts." *NH* **109** (April): 56-61. (417)

———. 2001a. "Prepared for the Past." *NH* **110** (April): 28-29. (417)

———. 2001b. "How Old Is It?" *NG* **200** (Sep.): 78-101. (173)

———. 2001c. *Evolution: The Triumph of an Idea*. New York: HarperCollins Publishers. (39, 199, 214, 225, 248, 260)

———. 2002a. "All for One and One for All." *NH* **111** (Feb.): 34-36. (220)

———. 2002b. "Darwin's Avian Muses Continue to Evolve." *Science* **296** (26 April): 633, 635. (523)

———. 2002c. "The Once and Future Male." *NH* **111** (Sep.): 22, 24-27. (461)

Zou, Hongyan, and **Lee Niswander.** 1996. "Requirement for BMP Signaling in Interdigital Apoptosis and Scale Formation." *Science* **272** (3 May): 738-741. (281)

Internet Website Addresses

	Åbo Akademi, Finland (120)	abo.fi
	Academic Press (344)	apnet.com
ARN	Access Research Network (40, 71, 111, 202, 268, 389 451-452)	arn.org
ASA	American Scientific Affiliation (445)	asa3.org
AiG	Answers in Genesis (1, 2, 19-20, 44, 93, 226, 248, 265, 277, 280, 344, 510, 519)	answersingenesis.org, aig.gospelcom.net & aig.smartbusiness.org
	Apologetics Press (361, 526)	apologeticspress.org
	Apologetics.Org (110)	apologetics.org
	Association for Biblical Astronomy, Bouw (43)	www2.baldwinw.edu/~gbouw/
	Austin Community College, Ziser (125)	www2.austincc.edu

	Baraminology Study Group (529-531)	bryancore.org/bsg
	Bible-Science Assoc. (54)	creationsafaris.com
	Boston Review (496)	bostonreview.mit.edu
	Brad DeLong's Website (27)	econ161.berkeley.edu
BBC	British Broadcasting Corp. (344, 385)	bbc.co.uk

	Calvin College (464)	calvin.edu
	Cato Institute (22)	cato.org
	Chick Publications (20)	chick.com
	Christ@Work, Bates (518)	fcci.org
CBN	Christian Broadcasting Network (316)	CBN.com
	Christian Life Training (32)	clt.org
	Christian Research Institute, Hanegraaff (25, 523)	equip.org
	Columbia University (Figs. 30, 32-33, 36)	columbia.edu
	Cornell Cold Fusion Archive, Lewenstein (53)	wpi.edu/Academics/Depts/Chemistry/Courses/CH215X/coldfusion.html
	Creation Moments, Bible Science Assoc. (42)	creationmoments.com
	Creation Page, Bowden (43)	ourworld.compuserve.com/homepages/bowdenmalcolm/homepage.htm
CRS	Creation Research Society (100, 389, 529)	creationresearch.org
	Creation Science Assoc. of Mid-America (41)	csama.org
	Creation Science Fellowship of Pittsburgh (110)	csfpittsburgh.org

	Dan Bolser Website (Fig. 1)	bio.cc/Scientists/Dan_bolser/
	Darwiniana and Evolution (343)	origins.tv/darwin/dinobirds.htm
	Darwinism Refuted (278)	darwinismrefuted.com
	Developmental Biology Online (408)	devbio.com
	DinoData (344)	dinodata.net
	Dinosauria On-Line (263, 276, 300, 316)	dinosauria.com
	Dinosauricon (377, 381 & Figs. 29, 34)	dinosauricon.com
DI	Discovery Institute (40, 54, 73, 258, 466)	discovery.org
	Dr. Dino, Hovind (519)	drdino.com

	Eagle Forum, Schlafly (40, 518-519)	eagleforum.org
	East Tennessee Creation Science Assoc. (1)	etcsa.org
	Eden Communications (7)	christiananswers.net
	Education Week's Teacher Magazine (78)	edweek.org
	El Paso Times (79)	elpasotimes.com

	Family Life Center (71)	familylifecenter.net
	Florida Museum of Natural History (525)	flmnh.ufl.edu

	Genesis Mission, Creager (164)	genesismission.4t.com
	Geoscience Research Institute (527)	grisda.org
	Graptolite Net (123)	graptolite.net
	Hare Krishna News Network (19)	krishna.org
	Harun Yahya, Oktar (341, 493)	harunyahya.org
	Holy Smoke (102)	holysmoke.org
	Independent Record (Helena, MT) (526)	helenair.com
	Indiana Institute of Science (184)	iisc.ernet.in
ICR	Institute for Creation Research (2, 20, 40-41, 80, 110, 226 275, 289, 294, 351, 360, 385, 401, 450, 519, 530)	icr.org
Idnet	Intelligent Design Network (46)	intelligentdesignnetwork.org
	Interactive Bible (473)	bible.ca
	International Association for Dental Research (525)	iadr.confex.com/
	Issues 2000 (518)	issues2000.org
	Johns Hopkins University Press (347)	press.jhu.edu
	Kansas Citizens for Science (37)	kcfs.org
	Kansas Standards Markups, Krebs (37, 45, 520)	sunflower.com/~jkrebs
	Kansas State Board of Education (46)	ksde.org
	Koinonia House, Missler (344)	khouse.org
	Lambert Dolphin Website (32)	ldolphin.org
	Laura Lee Show Website (306)	lauralee.com
	Leadership U (248, 445, 524)	leaderu.com
	Max Planck Institute for Molecular Genetics (235)	molgen.mpg.de/~amphioxus
	Mel Gablers Educational Research Analysts (79)	members.aol.com/TxtbkRevws/
	Miller & Levine Website (324)	millerandlevine.com
	Minnesota Department of Education (510)	education.state.mn.us
	More Than Words (3)	morethanwords.net
	NASA Space Geodesy Program	lupus.gsfc.nasa.gov/vlbi.html
	National Academies Press (229)	nap.edu
NCSE	National Center for Science Education (20, 73, 102, 500)	ncseweb.org
	National Coalition Against Censorship (39)	ncac.org
	Netwurking News (3)	goodschools.com
	New Scientist Magazine (344)	newscientist.com
	No Answers in Genesis (519)	home.austarnet.com.au/stear/default.htm
	OBJECTIVE: Christian Ministries (529)	objective.jesussave.us
	Omniology, Henry Johnson (19, 347)	omniology.com
	Origins (527 & Fig. 13)	origins.org
	Origins of Man and the Cosmos (42)	users2.ev1.net/~origins/
	Palaeontologia Electronica (385)	palaeo-electronica.org
	Palaeos (93, 106, 178 & Figs. 2, 37)	palaeos.com
	Palomar College (Fig. 35)	palomar.edu
	Path Lights (47)	pathlights.com
	People for the American Way (39)	pfaw.org
	Peripatus (182 & Figs. 18-21)	peripatus.gen.nz/
	PRWeb Free Wire Service (494)	prweb.com
PBS	Public Broadcasting System (21, 151, 248, 382)	pbs.org

Reasononline (60)	reason.com
Relativity on the WWW, Hillman (27)	math.ucr.edu.home/baez/relativity.html
Revolution Against Evolution (464)	rae.org
Rocky Mountain Creation Fellowship (110)	youngearth.org
Ron Morris Website (341)	angkor.com/cityrain/
Ruth Dewel Homepage (223 & Fig. 25)	appstate.edu/dept/biology/dewelra.htm

Salon (27, 39)	salon.com
Sam Gon's Trilobite Website (245)	aloha.net/~smgon/ordersoftrilobites.htm
Science Magazine (336)	sciencemag.org
Smithsonian National Museum of Natural History (Figs. 3-9, 11-17, 19, 22-23, 27-28, 31)	nmnh.si.edu
South Bay Creation Science Association (354)	creationinthecrossfire.com

Talk Origins (2, 19-20, 25, 61, 146, 151, 259, 382, 402, 409, 493, 496, 508 & Fig. 35)	talkorgins.org
Talk Reason (61, 75, 253, 465, 495)	talkreason.org
Tennessee Eagle Forum (519)	tneagleforum.org
Texans for Better Science Education (40)	strengthsandweaknesses.org
Texas A&M University (Fig. 31)	tamuk.edu
Trinity College, *Religion in the News* (38)	trincoll.edu
True Origin (46, 58, 382, 389)	trueorgin.org
True Parents (Unification Church) (404)	tparents.org
Tufts University, Dennett (61)	tufts.edu
Twin Cities Creation Science Assoc. (42, 385)	tccsa.freeservers.com

University of Bristol (93)	bris.ac.uk
University of California, Berkeley Museum of Paleontology (121-124 & Fig. 1)	ucmp.berkeley.edu
University of California, Santa Barbara (403)	ucsb.edu
University of Oregon (235)	uoregon.edu
University of Texas, Arlington (Fig. 38)	uta.edu
University of Texas, Knoxville (259)	utk.edu

Washington Post (38)	washingtonpost.com
Wikipedia Online Encyclopedia (119)	wikipedia.org
Wolf-Ekkehard Lönnig Website (278)	mpiz-koeln.mpg.de/~loennig/internetlibrary.html