Chapter 2. ‘Dem Bones

In science and scholarship *expertise* may be thought of as the knack of when to ask relevant questions, and then being able to tell whether you’ve got a good answer. When logic is involved, this relates to how you validate the assumptions of a deductive chain, or the conclusions of inductive reasoning, along with gauging how cogent all the logical links are. Socrates was someone who apparently had a lot of fun with that (though it eventually got him in trouble when he started asking too many theologically “wrong” questions). But viewed more as a methodological exercise, all questions and answers become diagnostic, for they reveal the mindset of the person asking or answering them. Pose enough of the right questions and no array of screens can long obscure the truth.

In 1994 PBS aired a documentary by Randall Balmer called “In the Beginning: The Creationist Controversy.” It investigated the social and political context of the creation/evolution debate, and so devoted very little time to the actual scientific merits of either side, although Balmer clearly favored the evolutionary interpretation. Concerning the hot-button topic of whether evolution should be overtly 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. Partly through their dedicated effort, Texas had steadfastly resisted any science textbook that contained evolutionary references. Since no publisher was willing to field a volume that would not sell in the giant Texas market, the Gablers’ opposition enacted a *de facto* veto for the entire nation.[1]

Through the years the Gablers have taken on the role of textbook fact checker, 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. As someone with a dusty history baccalaureate tucked away in his own past, I entirely sympathize with their fury at incompetent authorship. But the Gablers are not just apolitical scholarly nitpickers—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. Their success in derailing this foray into cultural relativism 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.[2]

Now the Gablers do not favor banning the teaching of evolution. 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 rosy 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.”[3]

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, the Gablers’ laudable goal of expunging falsehood and distortion from school texts had just slammed into a very large brick wall. For the plain truth was both of Mel Gabler's examples were incontrovertibly *false*, and therefore 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 were entirely unaware of this condition tells volumes about the nature of their scholarship, and suggests how potentially dangerous the political manifestation of creationism can be when wielded by scientific illiterates.

Gabler's first example was an allusion to the "Cambrian Explosion," where a bevy of early multicellular life made a very splashy appearance about 540 million years ago. As we'll see, it is a common creationist conviction that this circumstance bodes ill for "evolution." How they arrive at this conclusion will trace a path of paleontological misrepresentation that is replayed age after period after epoch all through their review of the fossil record. To discover how Mel Gabler could come to believe fish and algae and trees appeared at "almost the same time" is to observe again the fruits of relying on limited reading material—the pernicious scholarly affectation that propels all ideological and pseudoscientific investigation.

But Gabler hadn't stopped with fossil conundrums. By offering the lunar dust argument as a premier example of antievolutionary evidence Gabler slips us firmly onto the thin ice of Creation Science. Because Intelligent Design isn't trying to lasso the history of the solar system to a Bishop Ussher chronology, this little gem doesn't come up in their literature. But that does nothing to lessen the disquieting significance of the *Gabler* version of antievolutionism seriously endeavoring to insert this young earth subject matter directly into high school science courses.

The assorted claims for a young earth and universe are the subject of the next chapter, but at this juncture it is worthwhile following Gabler's lunar dust tale to its apotheosis. It is a characteristic creationist example of what happens when you rely on people who only tell half the story. Unlike the NASA Joshua computer myth, this time we know exactly where to trace the source: 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 x 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 x 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).
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> 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 x 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.[4]

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. 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."[5]

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.[6] 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, leaving 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 recognized off in his creationist corner, a great deal of any meteoric nickel filtering down from space would end up washed into the sea, but again 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 any accumulated sediments back deep into the earth for recycling, only some of which ends up emerging 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.[7]

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.[8]

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.[9]

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 already picked up on this issue and called attention to the fact that NASA had far lower measurements in hand than Pettersson's 1960 work.[10] 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.[11]

An internet check with NASA's publication catalog and e-mail 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), where exactly in the Hawkins edition he extracted this little gem is anybody's guess. But again, let us suppose this time Morris hasn't transposed his digits and really got it right.[12] Why then didn't he 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.[13]

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.[14] 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" (which will float by again in the chapter on the Flood) 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*.[15] 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. But he did not, much as he'd sidestepped the Biblical Flat Earth. So was this a case of not wanting to criticize a fellow creationist? Doesn't it then matter to Gish whether the sage Morris might have included in a potential *school text* a "fact" that was empirically preposterous? In the creationist methodological shell game, Gish matches Phillip Johnson tête-à-tête for skill in masquerading as *Venus mercenaria*, an otherwise inoffensive invertebrate of the mollusk "type."[16]

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.[17]

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 small?[18] 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?"[19]

Instead of simply admitting, heaven forfend, 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.[20] 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 coalesced from an identical accretion disk as the 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 and splattered off a mass of the lighter surface material. It was from this distinctive debris that our moon was composed.[21]

The Cambrian Explosion

Having now sifted through several megatons of lunar dust malarkey, that the Gablers failed to tumble onto any of this doesn't inspire much confidence that they'd be able to successfully evaluate the far more esoteric details of Cambrian fossil invertebrates. Primed by a sincere religious conviction and bottomless technical naiveté, such unsophisticated creationists are ready to follow the call of more articulate ideologues like Gary Parker, beckoning them to wade into the warm Cambrian sea:

> 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").[22]

One must marvel at this skillful display of stage management.

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.[23]

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. But right from the start we have misdirection, 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 properly speaking aren't "plants" anyway, a taxonomical nicety that will have some interesting repercussions later for Michael Denton's typological visions). All we have here from Parker is the *word*, casually planted as it were on the rhetorical table like a tasty morsel—but one with its own far from modest creationist string attached.

The jellyfish and segmented worms were around long before the Cambrian, as Parker himself acknowledged a few pages later. This meant they were holdovers rather than newcomers. Two other animal phyla originating before the Cambrian were the "sea cucumbers" and "beardworms," though those latter were only isolated in Precambrian deposits since Parker wrote his book. All this is most relevant to the question of how many truly novel forms popped up fresh in the Cambrian Explosion, rather than being likely offshoots from things already knocking about (in this respect, keep those segmented annelid worms in mind). That aside, Parker's tubular sponges, the bug-like trilobites, and the "lampshell" brachiopods that look superficially like clams, were all pretty much as advertised.[24]

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 a major marine predator, when they did indeed look like the large one suggested by 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 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.[25]

Could it be Parker has slipped a cog here, and mistaken an illustration of fauna typical of that period as applying to the earlier Cambrian? This seems increasingly likely once we spot the *twelfth* animal in Parker's tableau, one he didn't mention in the text, nor in the caption. But swimming discretely at the upper left corner of Figure 23 was, plain as day, a "heterostracan fish." Now no matter how Parker may wriggle in the net, there is no getting around the fact that the early jawless agnathan fishes do not join the fossil parade until the middle of the Ordovician period, and then only fragmentarily. The *heterostracan* fishes, in fact, were a specialized variety that properly belonged to the even later Silurian and Devonian periods, around 70 million years after the end of the Cambrian. Since he gave no sources for any of this (not even for the Darwin quote), there's no way of pinning down at what stage of his "research" Parker went astray.[26]

Of course, were Parker an *evolutionist* he could place an *ancestral* one in the Cambrian without raising much of a sweat, since dermal plates are known which probably belonged to a primitive agnathan. Much conjecture would have remained, though, about what such a specimen might have *looked like*, as paleontologists are not shy about pointing out (though recently some early Cambrian craniate "fish" have turned up, resembling lamprey larvae).[27] Yet Parker knew exactly what *he* wanted. His Cambrian "heterostracan fish" was a creature resembling a plump trout or bass, except with all the fins missing. Unless the savvy reader picked up on that finless 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 reference works reveal a creature nothing like any catch Parker would reel in from the waters off California: sheathed in massive overlapping plates, *Anglaspis* looked rather like a swimming asparagus tip.[28]

You'll notice here that Parker *never* said there were any fish in the Cambrian. He 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. Then he drew the animal to resemble the original in much the same way Marcel Duchamp handled nudes descending staircases. But his primary sins were ones of omission. He made no mention whatsoever of all the contemporary marine forms *not* found in those Cambrian waters: sharks or advanced fish or turtles or seals or dolphins. Nor did he think it relevant to note what any Cambrian diver would observe 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 or frogs or lizards or birds frolicking around them—let alone lions and tigers and bears.[29]

Need we scratch our heads then in wonderment 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*, and what that diet regularly consists of is a carefully selected mishmash of half-truths and outright falsehood. Take a look at how the grand oracle himself, Henry Morris, outlined the taxonomical "facts" in his ever-trusty textbook, *Scientific Creationism*:

> 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:
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> 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.[30]

If the creationist novice didn't stop for breath in this incredible passage, they might easily jump from the first three items that all ring the "Cambrian" bell and not dwell too much on those funny little chimes like the "Triassic" or "Precambrian." But slow down long enough to read him and what he's just said here is 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 Gish's *Apatosaurus* (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 any of it. If he had, his balloon would have begun to deflate in a hurry.

Starting at the top of the taxonomical hierarchy, the five *kingdoms* of life are the bacterial Monera, the more complex Protoctista (which embrace a spectrum of unicellular organisms, from protozoa and diatoms, to their multicellular offshoots, like seaweed), the Fungi, the Animalia and the Plantae. As Morris' own list acknowledged, the first two kingdoms are known to have arrived long before the Cambrian, and we saw from Parker's seascape that also included the Animalia. 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, so lumped fungi together with the equally disparate bacteria and algae. The problem is conventional plant fossils don't make their bow until comparatively late in the geological parade, during the Devonian period, well over 100 million years after the Cambrian ended (as his "plant" list would have made clearer had he restricted them to *plants*).[31]

Now of course, were Morris accepting an *evolutionary* framework, he might have legitimately argued that plants probably owed their origin to some pre-plant form dating back into the Cambrian or beyond. But as that is definitely *not* his position, saying as he did that all kingdoms were present "from the Cambrian onward" was technically wrong.

The second claim, about there being no new animal phyla, is a lulu for the same reason, for the only people who can say that with a straight face are *evolutionists*. To execute the same trick if you're a creationist like Morris requires you either to ignore most of the animals in question, or accept the evolutionary assumptions under which the are related to others within the phylum. Remember that the classification level "phylum" (tucked below *kingdom* and above *class*) reflects the general "body plan" of an organism. The extinct trilobites are grouped together with spiders, crabs, and insects in the Arthropoda phylum, for example—a broad umbrella that might make the unwary forget just how distinctive each are in their own right, differing even to the number and character of their appendages. Depending on who's counting, there are around thirty-three currently living animal phyla.[32] We've already seen four originated before the Cambrian, and Parker alluded to another six Cambrian ones, although several of those depended on *evolutionary* assumptions again for their interpretation. 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 Mid-Cambrian Burgess Shale, called *Amiskwia*, 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. 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 related to hagfish. Even with the Carboniferous example living 150 million years later, the Cambrian conodonts would still have gone extinct 200 Ma, thus allowing the exclusion of their potential 34th phylum from our living list.[33]

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. 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.[34]

So that gives maybe five more phyla to add to the Cambrian brood, for a running total of fifteen. Unfortunately, the fossil record on the remaining eighteen is starting to scrape the bottom of the barrel. 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 worm. There are some burrows and tracings in Silurian rocks suspected to have been made by a "spoon worm" (Echiura). The fossil pixies have been kinder recently for comb jellies (Ctenophora) and the diminutive "water bears" (Tardigrada), with ones turning up in the Burgess Shale and other 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. This also meant comb jellies managed to do their thing for 300 million years (from the Devonian right down to the present) and the water bears for a comparable amount of time (from the Cambrian to the Cretaceous) without leaving *any* intervening fossil trace. Unless their phyla took a vacation on Mars, or were subject to multiple creation events, it would appear that small, unshelled invertebrates stand a bad chance of getting fossilized. Duh.[35]

Tossing those four 1980s phyla in the Dumpster leaves fourteen more miniscule and icky ones to deal 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 would suspect, or was it possible these animals were *literally* created the day before their initial observance? We have here the Alphonse/Gaston problem, back with a vengeance. By what "theistic realism" could *any* of these flimsy beings be attributed *without fossil evidence* to an environment over half a billion years ago? For foolish consistency's sake—ever the hobgoblin of tiny minds, as Emerson once said—these fourteen phyla will just have to go.[36]

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*. To illustrate that "nearly all" animal phyla originated in the Cambrian, they showed a "generalized schematic of the fossil record." This displayed 41 bars representing current and extinct phyla; solid segments indicated fossil representation and dotted lines the absence of same. 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.[37]

Not that this helped their case much, 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 unfossilized dotted lines were included). Ironically, this was *lower* than the roughly 50% value established by a phylum by phylum evolutionary walkthrough. Given all that, just how indisputable a fact of *creationist* logic was it for Henry Morris to roundly declare *all* animal phyla present from the Cambrian onward? Point two down.[38]

Now so far we might be accused of nitpicking poor Henry Morris' take on the taxonomical record. But with his contention No. 3 were are in a wholly different category. Saying that all animal classes are represented in the Cambrian is so egregiously, *stupidly* in error that only a paleontological ignoramus could have made it. Never mind the logical absurdity of making that blanket statement along with at least one extremely prominent exception to it (the Devonian insects)—what about class *Amphibia*, class *Reptilia*, class *Aves*, class *Mammalia*? The whole range of terrestrial vertebrate life is missing! Nowhere has Morris (or any other creationist, for that matter) ever offered even a scrap of fossil evidence that amphibians or reptiles or birds or mammals are known from Cambrian deposits. And for a darned good reason, too—there aren't any. Morris' statement here was so flat out *wrong*, there was no leeway at all.[39]

Had Morris written a history book 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 like a summer's breeze.

By the penultimate claim you can readily understand how folk like the Gablers could get seriously confused over "algae" and "trees," since Morris relied on a woefully antiquated definition of "plant" that actually incorporated three of the other *kingdoms*. This may have been fine for social chatter in 1940, but by 1985 botanical taxonomy had moved a long way. Stepping back from Morris' fantasy garden, there are ten plant divisions (the botanical equivalent of the zoological phyla). Two of them refer to the mosses (Bryophyta) and the remainder to the vascular plants (Tracheophyta). As already noted, the earliest plants appeared in the Devonian period, about 400 million years ago, and again not all at once. The last division to arrive was one Morris rather conspicuously left off his outline: the flowering plants (Angiospermophyta, a.k.a. Anthophyta), which showed up only in the Cretaceous period, about the time the iguanodontid dinosaurs were stomping about. So much for Morris' fourth point.[40]

But what of Morris' topper, the 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. It depends for its success 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, for instance, how much earlier would you expect to find their ancestors, and what should these have looked like? Unless you had that sort of standard to go by, the passengers on the creationist airline would never realize how high over the data their sky pilot intended to fly, or whether at that altitude they might be liable to intellectual asphyxiation.[41]

Before checking out the Intelligent Design brochure on the Cambrian Explosion, we would do well then to introduce a few of the actual combatants, so that later you can keep an eye peeled for them to see how well they fit into the creationist picture. All of them were described in Stephen Jay Gould's *Wonderful Life*, a book which modern creationists freely draw on for their Cambrian adventure. But the prime lesson of Gould's book was that it marked the first prominent shot in a major reevaluation of the Cambrian fauna, a revolution which was in full tilt by the time Marvin Mattelson and Christopher A. Klein contributed paintings for a 1993 article on them in *National Geographic*.[42]

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 Fastovsky and Weishampel described the bestiary as "like a parts store for segmented organisms."[43] In fact, the terror of the Cambrian sea turned out to have been a previously unknown creature that consisted of pieces formerly mistaken for separate animals. Putting them back together resulted in the giant *Anomalocaris*, which could get up to a meter long and looked like a segmented squid with shrimp tails parked by its circular mouth as grasping tentacles. It might have been an arthropod, or belong to an entirely new phylum—but trying to decide which when there are *no* living counterparts to compare it to is no easy task. In fact, quite a number of the Cambrian oddities fall under the "arthropods of uncertain affinity" umbrella, like *Marrella* (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*, with its five doorknob-shaped eyes over a clawed mouth dangling from a long hose.

Not all the Cambrian animals were unrelated to existing phyla, however, and thereby hangs an evolutionary tale. *Eldonia*, a flattened jellied beanbag small enough to fit in your palm, was first thought to have been some form of jellyfish, but more recent detailed study suggests it was an ancestral echinoderm. Among the arthropods, the slightly smaller *Canadaspis* is an early crustacean, while *Sanctacaris* belongs to the chelicerates (the bunch that include the terrestrial spiders and scorpions)—though in neither case were these representatives typical of *modern* crustaceans or chelicerates. Nor may we forget *Pikaia*, 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 15 million years earlier).[44] Very shortly these unprepossessing chordates will wriggle their way right through the very heart of creationist illogic about the Cambrian.

There remain two other relevant blocks of fauna 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 about the strange Cambrian play is that *ancestral forms* of modern phyla were present among a much larger ensemble of extinct body plans. But why were there so many divergent arthropods to begin with, and what was responsible for the *parts store*? Since every one of these must have derived from some genetic sequence, a question to keep tucked in the back of the mind concerns what manner of *homeobox* genes they might have had, and what role those could have played in running off so many developmental permutations.

But that's the sort of reasoning you employ when you are open to letting the fossil players speak their own lines. Only having an assembled cast all rehearsed for *The Tempest* can be downright vexing for a director ideologically committed to a performance of *Much Ado About Nothing*, in which case the only recourse is to lock the stage door and narrate the tale to suit. To see just how much can be emoted about the Cambrian Explosion without hitting *any* of the essential marks, Phillip Johnson's *Darwin on Trial* is again hard to surpass. Where 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 Morris' second and fifth taxonomical points for a direct bid at philosophical supremacy:

> 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.[45]

[*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.[46]

[*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.[47]

With so many loose ends exposed in Johnson's argument one good tug will unravel the whole thing. Borrowing a cue from *The Sound of Music*, "a very good place to start" would be at the beginning—how "shortly before" the Cambrian *did* these Ediacara fauna appear? The Ediacarans showed up on stage about *70 million years* earlier.[48] That happens to be more time than 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. By failing to give the reader a sense of the gigantic timeframe involved, Johnson stumbled over what he had written only a few pages before, in another of his lucid "explanatory" footnotes:

> 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.[49]

However often Johnson gets hung up on the issue of pacing, it's not evolutionists who are either ambiguous or confused.[50] When they argue over how fast some Gaston split off from an

Alphonse, the "rapid" evolution of Niles Eldredge works off the same process of *speciation* as Richard Dawkins' "slow" evolution. The conceptual tussle is one of seeing the connecting links from one evolutionary landing to the next taking place in separate bursts as though climbing a *staircase* versus gliding along an extended continuous *ramp*. There's actually no reason to believe both punctuated steps and gradual ramps can't play an interactive role in evolutionary change (a third view, "punctuated anagenesis," has even emerged recently to reconcile the two polarities). But the reason *why* the rate of significant evolutionary change remains a hot topic in paleontology brings up the realities of geological deposition, which creationists like Johnson are not keen to call attention to.[51]

Although slow as molasses by human standards, whether it occurs by step or ramp, the speed with which speciation is seen to unfold in the living world is still far too fast to be caught very often by the indiscriminate sieve of fossilization. This means the animals most likely to hog any single prehistoric group shot are the *local* stabilized majorities who have already undergone their speciation trips and dominate the random sampling (either by the temporary success of sheer numbers or the prolonged persistence of their particular species). Since speciation is something 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 since 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 20 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 missed the picture of Burgess "diversity" would have been very different.[52]

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).[53] Since there was no land life during the Cambrian or before, to shed light on the "explosion" what you need are plenty of sediments from the coastal margins of the Rodinia supercontinent that existed during the Precambrian, and was just rifting into smaller landmasses as the Cambrian dawned. 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, which means—whether creationists like it or not—the fossil record of that time is far from being anywhere near complete.[54]

Johnson was being particularly ingenuous (if not galling) when he singled out the Burgess Shale to "demolish" the notion that soft-bodied creatures wouldn't fossilize, for the issue was not whether it was *possible* for that to happen, but under what *circumstances* that takes place. The Burgess was formed when a massive submarine landslide swept everything down slope to the anoxic bottom where decay was prevented. Such events are so exceedingly rare in geological history paleontologists have a special name for them—another datum Johnson didn't bother to note, although Gould's *Wonderful Life* certainly did:

> 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.[55]

The Bermuda Triangle Defense

Knowing all this, two observations may be made about how Johnson approached the Cambrian. The first is methodological: at every opportunity he managed to leave out any hint of the *when*, *where*, or *what* that might have put Precambrian conditions in context. In this he was only following standard creationist procedure, for the most celebrated fossil "gaps" happen to exist precisely because the relevant strata are not well represented, or involve small animals unlikely to be fossilized to begin with. To the extent that creationists like Johnson conceal that background they reason exactly like believers in the Bermuda Triangle, who similarly muse on the "mysterious" loss of vessels without dragging in distracting miscellany—like the hurricane that tore through the area on the night in question.[56]

The second point is a scholarly one. There are a *lot* of "100,000 years" to fill between the Ediacara fauna and the Cambrian Explosion, along with a whole supercontinent around which to deploy them. Allowing ten or twenty million years of Precambrian metazoans as a detour puts something of a stretch on Johnson's glib characterization that Gould's view of Cambrian evolution involved "a direct leap from unicellular organisms." Yet Johnson thought he could invoke Gould here to dispose of those recalcitrant Ediacarans for him as summarily as King Lear did his thankless daughter.[57] That was particularly strange because Johnson showed no comparable inclination to defer to Gould's authority on other fossil matters, especially the weightier reptile-mammal transition we'll be getting to in due course. Such selectivity is again a hallmark of pseudoscientific analysis, where general quotations are allowed to substitute for a thorough exposition of the evidence.[58]

But there is peril in relying on authority quotes without fully comprehending the context in which they were made. Much as Dr. Watson had when Holmes remarked about the dog *not* barking in the night, Johnson trotted right past a vital clue. Those peculiar Ediacarans were *diploblastic* organisms—a technical way of saying they had two body layers, apparently sandwiched together something like fluid-filled air mattresses, with no evident body openings or internal organs. 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 or comb jellies), the Ediacaran layout is sufficiently distinct to warrant putting them on their own taxonomical siding. But if Johnson was going to snatch one end of Seilacher and Gould's logic, it seemed remiss of him 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*.[59]

Here's where another problem kicks in for Johnson's version of the Cambrian, as 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.[60]

What Johnson had mistaken for a blanket statement only covered those Ediacaran air mattresses—Gould was ruling those specialized organisms out as plausible triploblastic ancestors, not claiming that everything alive in the Precambrian was unrelated to later forms. As has already been pointed out, five of the Cambrian metazoan phyla have laid fair claim to Precambrian fossil ancestry, and these are rather revealing ones. All happen to be organisms thought to have evolved early on, like the diploblastic jellyfish and triploblastic worms (annelids and their buddies), along with rudimentary forms of the arthropods that would so hog the subsequent Cambrian zoo.[61]

The scientific debate about Precambrian animals concerns more than just their physical anatomy. Growth patterns are particularly revealing of phyletic affinity (as we'll see shortly with the echinoderms and early chordates). But just because the Ediacaran *Spriggina* closely resembles an eyeless soft-bodied trilobite doesn't prove it as far as a trained paleontologist is concerned. To be "certain" of that would depend on knowing a lot more. For instance, 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 requires having plenty of individuals to compare, especially of the same species, and hopefully including a range from juvenile to adult. But at this juncture reasonable inferences snag on the aforementioned fossil reality, which simply lacks the fine distribution to resolve such questions. In this respect another possible annelid ancestor, *Dickinsonia*, tells the tale: an oval creature that looked like a small corrugated floor mat, each of the four currently described species are known from only a sparse sampling of individuals. It is presently the *best represented* of the Australian Ediacarans.[62]

So long as creationists wall the Cambrian off from the Precambrian environment there is little incentive for them to poke around too closely looking for evidence of ancestry. Evolutionists naturally labor under no such philosophical constraint. After it was realized that phosphatization (a fossilization process replacing soft tissues with calcium phosphate) could under certain conditions preserve tiny organisms up to 2 millimeters long, the distinctive *embryos* of Precambrian triploblastic metazoans have been coaxed from that past world. Again this was a wielding of the double-edged fossil sword, for whatever *adult* forms these cell clusters were capable of developing into escaped fossilization completely (just like those three hundred million years of invisible post-Devonian comb jellies). While too large for phosphatization, these miniscule triploblasts were still too perishable to withstand more conventional preservation.[63]

So what do we have? From all these new observations a previously hidden world is being revealed, of tiny "advanced" triploblasts living inconspicuously for many millions of years among the ruling 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 a good fifty million years. 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. As this "hyperglaciation" 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 photosynthetic bacteria in what was for them a congenial environmental window. That is, until a rise in oxygen levels removed a final barrier to the overwhelming expansion of those triploblasts whose diverging biochemistry and evolving visual acuity were capable of exploiting that new fuel to the utmost.[64]

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 creationists have been wringing every ounce of antievolutionary 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 "Garden of Ediacara" ecosystem around 540 million years ago. This would relate the Cambrian Explosion to that pattern seen later in the history of life, especially among the vertebrates, where a mass extinction can so clear the deck of major lifeforms that whatever happens to be left over finds the place all to themselves, often prompting a riot of adaptive evolution. When it comes to environmental niches, nature seems to abhor ecological vacuums as much as spatial ones.[65]

But the question of what sparked such 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 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 so many developmental switches were starting in neutral, thus allowing practically every combination to get a chance on the stage? Although creationists seemed in no hurry to think about it, I expected evolutionists to hit on the implications of homeobox genes at once. So it was reassuring to find the latest works by Simon Conway Morris on the Cambrian and Mark McMenamin on the Ediacarans doing precisely that, pointedly wondering about how homeobox and other developmental genes related to the early history of life.[66]

With each new discovery the picture of Precambrian life grows a bit clearer, and progress continues to be made in sorting out the Cambrian fauna. For example, for some years the curious early Cambrian halkieriids were a mystery, known as they were only by the sclerites (calcareous plates) which presumably covered their bodies. When in 1990 a full specimen was found in the Sirius Passet *Lagerstätte* of Greenland, *Halkieria* was revealed to be a worm-like animal looking something like a scale-studded shoe sole, though with small shells attached for some reason near either end. The characteristic arrangement of the halkieriids' sclerites have linked them to the polychaete worms (represented in the Burgess by the similarly scaled *Wiwaxia*), while the placement and form of *Halkieria's* peculiar end shells have led Conway Morris to suggest a potential relationship with the brachiopods.[67]

That's how real science advances, step by careful step. But nothing of that character is associated with the shrunken homunculus creationism endeavors to put in its place, because too many of the facts have to be ignored to keep evolution at bay. Showing no less aplomb than Henry Morris had with the lunar dust, Phillip Johnson left out the critical *beginning* of Gould's Cambrian life story, and so missed yet another tantalizing insight into what brought about that extraordinary phyletic revolution. *Wonderful Life* explained:

> Puzzles mount upon puzzles the more we consider details of the astounding 100-million-year period between the Ediacara fauna and the consolidation of modern body plans in the Burgess Shale. The beginning of the Cambrian is not marked by the appearance of trilobites and the full range of modern anatomy identified as the Cambrian explosion. The first fauna of hard parts, called the Tommotian after a locality in Russia (but also world-wide in extent), contains some creatures with identifiably modern design, but most of its members are tiny blades, caps, and cups of uncertain affinity—the "small shelly fauna," we paleontologists call it, with honorable frankness and definite embarrassment. Perhaps efficient calcification had not yet evolved, and the Tommotian creatures are ancestors that had not yet developed full skeletons, but only laid down bits of mineralized matter in small and separate places all over their bodies. But perhaps the Tommotian fauna is yet another failed experiment, later supplanted by trilobites and their cohort in the final pulse of the Cambrian explosion.
>
> Thus, instead of Darwin's gradual rise to mounting complexity, the 100 million years from Ediacara to Burgess may have witnessed three radically different faunas—the large pancake-flat soft-bodied Ediacara creatures, the tiny cups and caps of the Tommotian, and finally the modern fauna, culminating in the maximal anatomical range of the Burgess. Nearly 2.5 billion years of prokaryotic cells and nothing else—two-thirds of life's history in stasis at the lowest level of recorded complexity. Another 700 million years of the larger and much more intricate eukaryotic cells, but no aggregation to multicellular animal life. Then, in the 100-million-year wink of a geological eye, three outstandingly different faunas—from Ediacara, to Tommotian, to Burgess. Since then, more than 500 million years of wonderful stories, triumphs and tragedies, but not a single new phylum, or basic anatomical design, added to the Burgess complement.[68]

Two conclusions fairly jump from those "small shelly fauna," both stemming from the fact that the Tommotian gulf fell *in between* the Ediacaran and Burgess worlds, each representing happenstance glimpses of the transforming Rodinian ecosystem. The first deduction reinforced that relentless geological lesson paleontologists already labor under with a resigned shrug: an entire assemblage of life went about its business for millions of years without leaving much of a trace of whatever soft bodies were hunkering inside or beneath those diminutive shells. Why then should we expect any evolving soft-bodied Precambrian "prototrilobites" or their possible "protoarthropod" cousins to have fared much better?[69]

The significance of this cannot be overstated. The early Cambrian could have been positively *crawling* with relatives of the Burgess Shale's *Pikaia* or Chengjiang's *Cathaymyrus*—or any of the other Alphonses and Gastons known only from those deposits—and we would have no way of knowing it because there aren't any suitable *Lagerstätten* to have preserved them. And this would be equally true whether we were thinking of evolutionary ancestors for those forms … or merely more of the same created "type" as envisaged (sort of) in the characteristically vague antievolutionary literature. Trying to make more of the absence of precursor critters in the early Cambrian, as creationists are wont to do, is all too directly an invocation of the Bermuda Triangle Defense.

Now the second conclusion to be gleaned from the Tommotian fauna is akin to Edgar Allan Poe's story about the purloined letter, where something was missed just because it was so obvious. Spotting this one required asking a really basic question—why *shells*? Going to all that effort to secrete the dead weight of a protective container would only make sense if there were a profound downside to *not* doing so. Those mute shells drummed a very loud song, if only one was disposed to listen: the Cambrian Explosion meant the advent of *predators*. Not having internal organs restricted the Ediacarans to filter feeding off the byproducts of microscopic organisms or symbiotic bacteria. But the triploblasts, living so peripherally to begin with, literally had the *guts* (and eventually the attendant nervous system) to do more. The working evolutionary assumption here would be that this afforded the triploblastic lineage the option of breaking out of their ecological niche by adapting to the capture and digestion of increasingly larger prey. The outcome can be objectively seen in the vibrant Burgess Shale arms race of shells and carapaces versus grabbing arms and slicing teeth.[70]

But Johnson's eyes were so firmly glued on the golden prize of "no new phyla" he roared right past all the *wonder* of that "wonderful life," and never spotted how the tracks ahead were running out. The warning flag was raised when he brought up Charles Walcott, whose expeditions first discovered the Burgess Shale in 1909. Gould had gone into considerable detail in *Wonderful Life* exploring what "motivated" Walcott to employ his "shoehorn." It was a penetrating study that delved into Walcott's biography, including his personal correspondence and diaries, and showed there was far more to the man and the matter than Johnson's abridged version.[71]

Quite like Phillip Johnson, Charles Doolittle Walcott was a politically conservative devout Presbyterian. Other than being a teetotaler, though, Walcott's political and social conservatism, along with his scientific predilections, landed him at the opposite pole from the frequently radical reformism favored by most turn-of-the-century creationists. Where Walcott and Johnson would seem to part company was that Walcott was both a theistic evolutionist and competent in paleontology. But by the time of the Burgess expeditions Walcott had taken on so many administrative duties, at the Smithsonian Institution and elsewhere (at which he excelled), he hadn't actually studied the Burgess specimens very closely before pronouncing so categorically on their affinities. In this analytical respect Walcott sidled closer to Johnson after all.

Johnson also used his own nifty shoehorn, endeavoring to fit the "artifact theory" and its relation to the "cone of increasing diversity" into contemporary reflections of those ideas, without properly explaining what they meant for *Walcott*. According to Gould's recounting, the God of Walcott's theistic evolution advanced life along a "ladder of progress" in which change worked *very slowly* on a small number of existing body plans. As an organism's ordained evolutionary development brought it to a higher rung it duly supplanted earlier dominant ones, with the top of the ladder currently and rightly occupied by that pinnacle of creation, mankind (ideally Christian, if not American). The particular "cone of increasing diversity" Walcott was defending consisted of the belief that as you worked your way back down the ladder, the *only* thing you should find would be progressively simpler versions of those triumphant known phyla. With no room for failure or experimentation deep in the past, this was what "motivated" Walcott's misreading of the Burgess Shale. By letting his *religious* conceptions dictate what the facts were to mean, in this respect Walcott functioned eerily like Johnson himself. As Gould described it, for Walcott "The Burgess shoehorn was more than a buttress to a comfortable and convenient view of life; it was also a moral weapon, and virtually a decree of God."[72]

Because Walcott was an evolutionist, for whom a phylum represented a gathering of physically related lineages, he at least had some good reason for poking around the phyletic classification of the Burgess animals. But a creationist has no such excuse, and this is where Johnson's logic train finally derailed: for since when was God supposed to have created *phyla*? As creationists from Morris to Johnson have repeatedly reminded us, God only made fixed "kinds" or "types," within which alone variation (*maybe* involving speciation) is allowed to take place. The practical fact is that no creationist is willing to countenance the flaming heresy that any major phylum constitutes itself a *created type*. The creationist relegates any similarities observed at that rarified taxonomical level to purely coincidental dynamic or stylistic qualities of the divine design. To take our own chordate phylum as example, no creationist alive considers them a "type"—including as they do the small transparent baglike marine tunicates (sea squirts) and somewhat more substantial cephalochordate lancelets, along with complex higher vertebrates like sharks, snapping turtles, and Phillip Johnson.

Harrumphing that only "evolution of a sort" has taken place "within the confines of basic categories which themselves show no previous evolutionary history" is the sort of blather that takes place when you step so far back from what you're talking about everything becomes a meaningless blur. The fact is that the sort of "chordate" that shows up in the Cambrian was about the most primitive example of that phylum imaginable, and this poses the same questions of pattern and sequence raised in last chapter's thought experiments. Had the Intelligent Designer selected a well-developed vertebrate member of the chordates for this debut instead—say, a sperm whale—and its presence in the Cambrian would have given evolutionists severe migraines. But again we observe the creative force gratuitously following the evolutionary call sheet by dropping the rudimentary *Pikaia* and *Cathaymyrus* onto the scene. Likewise, paleontologists have since turned up versions of the Cambrian predator *Anomalocaris* that suggest affinities with the arthropods and even to the peculiar *Opabinia*. In what respect does all this fail to qualify as relevant to evolutionary history?[73]

But for Johnson the details do not matter at all, which allows him the Byzantine luxury of some truly indolent prose. Whatever did he 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? This is as ridiculous as Duane Gish's circumlocutions around the nested "kinds" we saw last chapter. Were Johnson to step down a taxonomical rung and consider *classes*, of course, he would confront a markedly different picture. None of the prominent living animal classes can be traced so far back as the Cambrian, and their sequential appearance since then speaks of nothing but evolutionary change—especially so for the most recent diversification among the chordates, where branches of the reptile class spawned the mammal and bird classes. But that is precisely the sort of "change" Johnson will *not* accept. So which is it? Is modification within a phylum trivial or is it not?

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." This idea is hardly a statement of fundamental evolutionary principle, especially when it comes to our own phylum Chordata. How 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."

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 *Marrella* was a one-off "kind" or "type." But deciding that brings in those odious comparison questions, and who knows where that would lead? *Marrella* may be a relatively isolated specimen, but not all its neighbors were so lonely. The Burgess Shale exhibited a bevy of arthropods appearing sufficiently like *Alalcomenaeus* to raise questions about their affinity: *Actaeus*, *Emeraldella*, *Leanchoilia*, *Molaria, Sidneyia,* and *Waptia*. Where in their case do "created types" leave off, and by what definable criteria can creationists draw that magic line? These would seem eminently pertinent inquiries—yet this degree of typological investigation is precisely what no creationist is ever caught doing.[74]

It's not that creationists *never* mention specific fossil examples, but apart from such standards as *Archaeopteryx* these appear with an irregularity atypical of serious scientific literature. They also tend to exhibit a degree of superficiality that suggests the authors didn't necessarily try to understand what they were writing about first, but instead grabbed somebody else's talisman, to be waved at evolution rather in the way crucifixes are supposed to deflect vampires. In his 1995 book, *Reason in the Balance*, Phillip Johnson tossed off how 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." Besides the dashing ease with which Johnson crumpled tens of millions of years worth of Ediacaran diploblasts and triploblasts into "a few exceptions," there remained the matter of *what* made those trilobite eyes so "famous" and why their complexity posed some 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?[75]

Discussions of this hobbyhorse are actually not all that common even in the creationist canon, but one recent foray comes from Scott Huse. His 1997 version was abstracted and embellished from the account Duane Gish gave in his children's book, *The Amazing Story of Creation from science and the Bible*, which we have already sampled regarding the sauropod bookings on Noah's Ark. Among creationists 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.[76]

Were the creationist motto not "Shoot first, don't research later," Huse might have shown somewhat more 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.[77]

Now consider the alternatives here. The evolutionary interpretation: 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—and please pay no attention to the man behind the curtain. This is the flip side of the "greedy irreductionism" that creationists use to shoulder aside all evolutionary inferences from nature, but with the trilobites their willingness to see evidence of design lays a trail straight to a mountain of "misplaced concreteness."

What does it say about the quality or ingenuity of an engineer who began by introducing an inferior system, then took many millions of years trying out partial fixes before finally hitting on the "famous" remedy? With the non-phacopids fated to toddle about with substandard vision for their remaining 200 million years on earth, would this not again suggest a designer thoroughly dedicated 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? Were these among the last trilobites to pick a number off the Intelligent Design ophthalmologist counter—or had their Creation Science health insurance been cancelled following that incident of Eve with the apple? Perhaps that would explain the one family of trilobites (the Ordovician trinucleids) that dispensed with eyes altogether: they went blind from the wait.[78]

Lurking behind my stiletto sarcasm is a quite serious point. Once living systems are attributed to intentional design rather than purely natural processes, why shouldn't the result be open for critical evaluation? Creationists readily dismiss such arguments as trying to "second guess" God's intent, as Stephen Meyer put it to me, but why would such an approach be philosophically illegitimate? The feisty 17th century mathematician Leibniz went further than that. As noted by Philip Kitcher in his critique of creationism, "For Leibniz, to invoke 'design' without saying what counts as good design is not only vacuous but blasphemous."[79]

Unlike the brute "forces of nature," efforts of design inevitably carry with them the weighty baggage of *responsibility*, as liability litigation often expensively demonstrates. This distinction seems clear enough when it comes to the disastrous interaction of iceberg and *Titanic*. Modern glaciology suggests the snow that composed the berg may have fallen as long ago as 50,000 years, though the fateful chunk probably calved from the Greenland ice sheet sometime around 1909, just about the time the doomed liner's keel was being laid. As a purely natural phenomenon, however, no charges of malicious conspiracy or negligence could be leveled against the ice (such as why it was floating where it was, or why its perilous edges were concealed beneath the waves). The iceberg was just being an iceberg.[80]

But such naturalistic absolution does not extend to an object of deliberate design like the *Titanic*. Now it is perfectly appropriate to inquire why there were inadequate lifeboats, or whether it was sound practice not to extend the watertight compartments past E Deck. To say the White Star Line didn't want to infringe on First Class passenger convenience by requiring them to clamber through bulkhead doorways, or unduly restrict their leisured promenade along the uncluttered Boat Deck of a vessel deemed "practically unsinkable," would be technically correct but supremely hollow rejoinders. Unlike the amoral qualities of natural systems, the attendant consequences cannot be separated from any exercise in design. 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.[81]

In asking where trilobite eyes "come from" Johnson 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. But establishing the scientific facts here would be no easy task (and with no guarantee anyway it would persuade ideological creationists). 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 among fossil trilobites are also remote. So without access to the Wayback Machine the only way in theory to *explicitly* account for such sophisticated adaptations would be to somehow retrocalculate the ancestral trilobite 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.[82]

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. In this respect geneticists have been poking around the chromosomes of living forms like the redoubtable fruit fly and have isolated a few of the pertinent developmental genes (such as the insect *eyeless* and its assorted homologues). 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 unspecified 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.[83]

But just because much remains to be learned shouldn't obscure what has been discovered so far, and how all that relates to the larger tapestry of life on earth. One clear lesson here is that no matter where you start on the chain it doesn't usually take long for evolutionary thinkers to focus on substantive comparisons of the structure of living forms, which should come as no surprise, since that is part of the phenomena to be explained.[84] Yet step over to the creationist side of the debate and these exciting fields of inquiry disappear into the same impenetrable fog that cloaks the unmentionables of biogeography and the finer details of the fossil record. To appreciate the scale of this further omission, consider how evolutionists perceive the "big picture," as summarized 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.[85]

Berra's digest version seems clear enough. The living descendants of the animal life that appeared so long ago (embracing the surviving lineages of those Cambrian phyla the creationist worldview elects to wall off as static isolates) have defining developmental features that reveal their underlying physical relationship. Now supposing these macroevolutionary inferences are as hopelessly faulty as creationist doctrine insists, there would seem no good reason for either Creation Science or Intelligent Design not to make the most of it. After all, when one has the weighty evidential hammer in hand, why not use it? But turn to the prominent antievolutionary literature and the reader discovers *none* of these topics surface there—not even in what Percival Davis and Dean Kenyon intend as an instructional creationist school text, *Of Pandas and People*.[86] 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."[87]

But McGowan had plenty to say about living animals, devoting a whole chapter to it in his 1984 critique of creationism, *In the Beginning…* This account takes on added relevance when compared to the creationist silence on these matters (especially so for Duane Gish, who cannot claim to have been unaware of the points raised in McGowan's book). Starting with the plants that Henry Morris had so much trouble with earlier, McGowan pointed out that when you study the variety of living forms, discriminating between "plant" and "animal," or even telling where single cells leave off and multicellularity commences, can be quite a chore:

> My first surprise as a purist zoology student was that there was no satisfactory way of separating the plants from the animals. The theoretical distinction between the two is the way of feeding; plants manufacture their own food from the air and water using light energy (the process called photosynthesis), while animals obtain their food by eating plants or other animals. Among the countless single-celled organisms that can be seen in a droplet of water—*Amoeba*, *Ceratium*, *Paramecium,* and *Euglena* to mention but a few—there are some that manufacture their own food and others that consume ready-made food. There is no convenient way of drawing the line. There are even some types, such as *Euglena*, of which some of the species are plants, others are animals, and others still can be plant or animal depending on their environment. This is a most perplexing situation for people interested in classification, and some of them have spent considerable amounts of time trying to decide how to deal with the problem. The modern solution is to classify all single-celled organisms (organisms that have a well-defined nucleus) into one kingdom, the Protista, recognizing that there is a continuous spectrum between plants and animals. 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?
>
> As if having no clear-cut distinction between plants and animals were not bad enough, this same group contains organisms that transcend the line between single-celled and many-celled (or multicellular) organisms. If you scraped off some of the green film that collects at the top of a cold-water fish tank and looked at it under a microscope, one of the organisms you would probably see is a protistan called *Gonium*. *Gonium* comprises four round green cells enclosed in a thin capsule. The four cells are probably best thought of as forming a colony rather than a multicellular organism because each one looks like its neighbor and each performs the same function. Each, for example, has a pair of flagella (whip-like processes) that project through the capsule and are used for swimming, and each cell manufactures food through the process of photosynthesis. There is, therefore, no division of labor or specialization of any of the cells for separate functions that characterize the multicellular organisms. But our sample from the fish tank might also contain a specimen of *Volvox*, a rather beautiful sphere filled with hundreds of emerald-green cells embedded in a jelly which they secrete. There may be some connective strands running between the cells and there is a degree of specialization among them because some are modified for

> reproduction. Should this complex be described as a colony of single-celled organisms or as a multicellular organism? Perhaps it should be viewed as an intermediate stage.
>
> There are many more organisms which straddle the line between the unicellular and the multicellular levels or organization. Some, like *Volvox*, manufacture their own food by photosynthesis and are therefore plants, but there are others that feed on ready-made foods and are therefore described as animals. A particularly problematic group of protistans to classify are the slime molds. For most of the time they look like amoebae—shapeless blobs of protoplasm that move with a slow, flowing motion, engulfing bacteria and other particles of food as they go. Because the individual cells stay joined together when they multiply, the organism is essentially multicellular, but it cannot be described as a truly multicellular organism because there are no boundaries between the cells. Under certain conditions the organism develops one or more stalked balls, very much like the fruiting bodies of fungi, and each ball comprises a number of individual cells which are specialized for dispersal. The organism can therefore be said to be multicellular at this stage of its life cycle. When these individual cells, or spores, are released, they grow flagella which they use for swimming. They eventually fuse together in pairs, the flagella are lost, and a new amoeba-like organism is formed. The cycle starts all over again. In this organism, then, we see a number of transitions: from flagellated cell to amoeboid cell, from unicellular to multicellular organism.[88]

Had there been no intermediate organisms like these between plant and animal, unicellular and multicellular, then creationists could simply have declared as much and wandered off. But McGowan here was pointedly asserting the contrary, so if creationism wanted to buttress its standing as a discipline capable of thinking its own argument through, this would have been a dandy place to start. If living forms show such variety when it comes to what creationists aver are thoroughly fixed categories, why should it be inconceivable for fossil life to have been comparably disparate? And what ever might their ancient genetic programs have been capable of developing into? Given their track record, I wouldn’t expect creationists to blithely roll over on this one, but if they thought like scientists they ought at least to have expressed an opinion on it. Instead, the subject simply doesn’t come up—out of sight, out of mind. The creationist failure to even *mention* this information, let alone present a cogent reason why it doesn’t signify what evolutionists contend it does, is the continuation of the magic show they try to pass off as “science.”

While the unanswered questions piled up, McGowan went on to dig the creationist hole still deeper. His next move was to call onstage a character we’ve already met, one of those seemingly inconsequential players from the Cambrian phyletic drama, the “velvet worms”:

> Are arthropods related to worms? Actually we have good evidence that they evolved from them, the gap being bridged by a small group of animals that live their lives unobtrusively beneath the bark of dead trees in the warmer parts of the world. These animals have no common name and are called onychophorans. They are fairly small, about 10 cm long, and have an elongated and internally segmented body reminiscent of a worm. Unlike worms, however, they have many pairs of legs, and a pair of antennae on the head. I imagine that most people would have difficulty deciding whether they were looking at a worm or at some sort of arthropod if they saw an onychophoran in their back garden. Like worms, they have a thin cuticle, and are therefore soft to the touch, but they breathe through a tracheal system just like insects. 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. What is more, there are beautiful fossil onychophorans which date back to the Cambrian and which look just like their living descendants. 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."[89]

And 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 McGowan's onychophorans were nowhere in evidence when he set about establishing why "The Fossil Record of Insects Offers Remarkable Support for Creation." Nor did Gish mention something else he could have known about: the rather celebrated head-on prediction made by entomologists William Brown, Edward Wilson, and Frank Carpenter, who described the sort of late Mesozoic ancestor they were expecting for wasps and ants. Their expectations were exactly confirmed just a few years later by the discovery of the Cretaceous "wasp-ant" *Sphecomyrma* in 1966. Apparently when evolutionists successfully define in advance both the characteristics and time frame for one of those supposedly nonexistent transitional insect fossils, this was something too inconsequential to bother his readers with.[90]

Not that Gish went out of his way to clarify the areas he did touch on, such as when he insisted insects were "present in such amazing numbers and varieties in rocks of the Pennsylvanian that the so-called Pennsylvanian Period has been called 'The Age of Insects.'" While fossils of *parts* of insects are indeed strewn throughout the strata since their appearance some 400 million years ago, those sufficiently detailed to allow the fine tracing of evolutionary development are far from numerous. The reason why: as viewers of *Jurassic Park* may recall, the recipe for exceptionally good insect fossils (including *Sphecomyrma*) is to find them trapped in amber. Except the resins responsible for amber didn't evolve in conifers until early in the Cretaceous, and only over the last 60 million years have sufficient amber deposits become available from a scatter of ancient forests.[91]

Nor did Gish burden his readers with any details about those prehistoric insects, such as why they differed so from modern forms that they were classified as distinct orders to begin with. The earliest "dragonflies" used a more primitive system of veins in their wings, for example. And the very fact that the "giant dragonflies" of order Megasecoptera could get as large as a parrot suggested their metabolism was not quite like current insects, where body size is severely constrained by having to breathe through their skin via a network of tracheal tubes.[92] As far as Gish was concerned, though, the earliest "dragonflies" were "just that—dragonflies." Since creationists never get around to specifying what an "intermediate" form is supposed to look like in a particular case, one can therefore only wonder why finding so many "almost-dragonflies" back before the earliest recognized ones show up wouldn't qualify as evidence for some sort of "evolution."[93]

And of course the apparent evolutionary adaptations of *living* insects escaped his attention altogether, like the business end of stinging insects pointed out by Douglas Futuyma: "Wasps and bees did not develop a sting *de novo* in order to protect themselves. They use a modified egg-laying tool that is adapted in their more primitive relatives to insert eggs into plants. The result is that only female wasps and bees can sting, and the males are defenseless."[94]

Which brings us to some juicy irony. For by the early 1990s Gish had a lot more available data on living insects to overlook as he slid backwards down the creationist learning curve. In particular, at exactly the same 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?[95]

Returning to McGowan's transitional examples and Gish's pirouetting around them, so far the Creation Scientist has relied on the basic magician's trick of misdirection, keeping the reader's attention diverted as much as practical from the succession of evidentiary rabbits hopping from McGowan's hat. Since the typical creationist reader seldom studies widely enough to encounter such information independently, this has proven an empirically tractable approach. But with the concluding step in McGowan's logical chain Gish attempted a far more challenging illusion: stepping forward and actually discussing them, in a dazzling bid to seize the transitional rabbits in midair and somehow make them appear to leap from his own creationist prop instead.

What Gish had to say in 1995 about "The Great Gulf Between Invertebrate and Vertebrate" revealed so much about his general scholarly technique that it is worth quoting in its entirety. All you need to know up front are two background details Gish did not provide: geologist Arthur Strahler was drawing on the final leg of Chris McGowan's analysis, 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.[96] 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.[97]

How Gish documented the fossil history of fish will be explored next chapter, but when it came to vertebrate origins his hyperbole did not quite cover some unsightly holes in his reasoning.[98] Gish's account had turned the 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 demanding trick Gish interposed the *ad hoc* condition that there had to be "billions times billions" of transitional forms (in this he sounded a bit too much like Johnny Carson's pastiche of Carl Sagan). 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. Given how *Amphioxus* is virtually soft-bodied that should come as no surprise—even to Gish, who was presumably aware that *Pikaia* was found in one of those *Lagerstätten* (this was also true for the more recent Chinese *Cathaymyrus* that doubled the Cambrian chordate collection). But, like Phillip Johnson, Gish managed to cordon off the implications of this intelligence both for himself and his readers.

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.[99] 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? Well, we'll see how creationists handle that trick shortly with 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, I'll settle for Conway Morris' take on the subject. 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.[100]

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—the development of horses took about the same time as the entire reptile-mammal transition, for instance, about 50 million years. As far as evolutionary theory is concerned it is only necessary for some forms to occasionally be able to generate larger taxonomical shifts—not that every living thing inevitably roars along a perpetual evolutionary conveyor belt. 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. Gish's simplistic idea is further belied by a study of living examples, where the environment and competition shows modification is by no means a given. Colin Tudge pointed that out about the tug of war between leopards and impalas, which have stayed comparatively unchanged for the last three million years. The leopard has not grown ever stronger, nor the impala more agile, and the reason for such mutual stasis was firmly grounded in their ecological context:

> 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.[101]

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.[102] 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.[103]

After reading a work of genuine scholarship you ought to know more about the subject than when you started. If dealing with a controversial topic, at least the author would have honestly dealt with the opposition's case—the first (and most essential) "Rule of the Game" remember!

What the McGowan episode clearly illustrated is how absent that basic principle is from the everyday methodology of creationism. If all a person knew about evolutionary theory were what propagandists like Gish elected to tell about it, they'd have no inkling of the depth and wonder of the evidential world McGowan represented. This is because the dedicated creationist does not have the object of informing the reader on all points—their goal is an apologetic one, of persuading the reader of the error of something they regard as an ideologically pernicious doctrine. Starting with the certainty that evolution *must* be false, once they have constructed a line of reasoning that appears to justify that conviction their brain disengages and cant takes over.

That a lot of critical evidence has to be bent or ignored is of peripheral concern for someone engaged in a profound social conflict with the presumed powers of darkness. For them, losing is not an allowed outcome, which means creationism and evolution aren't really playing the same game. While McGowan and the gang were winding up to pitch an even more blistering series of fossil fast balls, back in Mudville the creationist boosters were being regaled with the most glowing tales of their own team's success. But such morale-boosting revisionism becomes quite a sorry spectacle once you know the full score. Much like watching a Stalinist airbrushing out Trotsky from state photos, Gish's *Creation Scientists Answer Their Critics* insisted Mighty Casey had not struck out:

> 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.[104]

Now is where the real fun comes in, for with those "disreputable claims" we are moving from the scanty traces of early life to the much firmer stack of terrestrial vertebrates that lived from the Permian period onward. This improvement in the paleontological record is due to the nature of the fossilization process and the character of the body parts being preserved. 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 variable) skeletons. This difference in structural anatomy means that the normal operation of river systems are often enough to preserve scientifically revealing pieces: from the occasional river flood drowning migrating herds to the gentle silting over of stray carcasses.

In a later chapter we'll see Phillip Johnson strenuously trying to invert this relationship, and insist that the record of vertebrate evolution is to be ignored in favor of what he contends is a picture of static invertebrate creation. That, too, will be amusing to watch.

Because the concept of human evolution is fraught with so many emotionally charged implications, that particular hot potato will be covered at suitable length under its own chapter.

What remains is still provocative enough for our present purpose. Given that both *Archaeopteryx* and mammals are distinctly warm-blooded animals, any concession of ancestry among the cold-blooded reptilian amniotes exceeds the load limit of creationism's microevolutionary box. Consequently something has to be done up front to preclude that macroevolutionary connection, and here *Archaeopteryx* provides a type study.[105] To follow their evaluation of that Jurassic flyer is to expose all the variegated splendor of the antievolutionary mindset. Once people are able to convince themselves that a "reptilian bird" isn't *really* a "reptilian bird," the creationist intellect appears permanently inoculated against the intrusion of virtually any intermediate form. Tossing aside 50 million years' worth of transitional "mammal-like reptiles" becomes then merely a matter of enthusiasm, not philosophy.

Archaeopteryx and bird evolution

Since most everybody on either side of the creation/evolution debate makes a point of saying something about *Archaeopteryx*, there is ample verbiage to draw on. 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, he also obligingly lunged into deep scholarly quicksand. As was noted last chapter apropos the sixth paragraph below, when Parker wasn't actively pureeing the facts (avian muscle attachments), he was prone to excessive confidence when it came to what he extracted from his cited sources (Michael Denton). 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.[106]

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.[107] 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 say 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*. It's not a completely unfamiliar tale, but as far as creationism is concerned, evidently 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.[108] Now whether creationists think there were just seven *Archaeopteryxes* alive in all history is something they have yet to make plain, but evolutionists think that rather 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 them to look even *more* unlike later birds, and more like a 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, if only because small flyers are among the worst candidates for successful preservation—as the sketchy fossil record for birds and bats confirms.[109]

But let's suppose the fossil genie had smiled on paleontology long ago, and some of the revealing 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. Add to that 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. That creationists try to discuss *Archaeopteryx* as though this information were irrelevant is yet another installment of the Bermuda Triangle Defense, and says a lot about why they end up holding such idiosyncratic opinions about ancient life. For the scholarly purpose of assessing what creationists ought to have known about the matter, Chris McGowan again had something pertinent to offer when Henry Morris and Duane Gish 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.[110]

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 while trying to put his own inimitable spin on the data. "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."[111]

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.[112]

What Denton had found so "amazingly complex" were the *barbules* that help a ruffled flight feather regain its asymmetrical aerodynamic shape. These are actually yet another differentiating keratin layer, splitting from the main *barbs* that form the obviously fluffy part of a feather—just as the barbs themselves are the offshoots of the scale-like central rachis rib. The business end of the barbules consists of how their frays 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 Chris McGowan showed by examining the range of contour and surface feathers of the flightless penguin. On the smallest feathers the scale-like core of the inner rachis remains pronounced, grading out to those on the wing's leading edge (adapted for swimming rather than flight) where the more familiar long central rachis shaft is seen.[113]

If feathers had originally developed for some other reason than flight (say, as insulation to keep the chicks of small active theropod dinosaurs from radiating away their body heat in the nest), clearly no creationist with their eyes glued on barbules is liable to tumble on it. Not when they can't even get a proper grip on *Archaeopteryx*'s undeniably reptilian characteristics, which become glaringly obvious once the fragments of the holiday bird are stitched back together again. Fortunately, some years before Parker's recipe for carved *Archaeopteryx*, Douglas Futuyma had already accomplished that delicate operation:

> *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.[114]

Only from the confident high ground of creationist typology, Parker thought they could. Up at that altitude it didn't matter what features the archaeopterygid "type" possessed. 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" are easier to defend without the distraction of intermediates flapping around, the prudent creationist knows not to allow *Archaeopteryx* to fly freely from the typological birdcage.[115]

Duane Gish followed through on that argument by darting out from behind a turn-of-the-century ornithologist to lob what he apparently thought was a particularly damaging evidential grenade. Except this time he drastically misjudged the length of the fuse, and ended up blowing off his own logical foot:

> 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*.[116]

Since we have 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 saying. 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—while the partial "Haarlem" (a.k.a. Teyler) unearthed in 1855, and so before the feathered archaeopterygids were even recognized, was pegged then as some sort of pterosaur.[117] 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."[118]

Now while "reptile" is a rather broad term, *Compsognathus* is anything but, and that distinction brings us to a third (and rather chunky) piece missing from Parker's 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 topic here began in 1969 when John Ostrom discovered the most bird-like of the maniraptoran theropods, *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 barricade 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 and earliest crocodiles.[119]

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 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.[120]

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.[121] 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.[122]

So 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, otherwise the jig was up. Through it all, Gish also 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, lest the reader know too much about what the issues were and start deliberately weighing the evidence on their own. Since those features literally ran from head to toe, this was no peripheral omission.[123]

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.[124] 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.[125]

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 the Alphonse/Gaston problem. No paleontologist contends *Compsognathus* was itself the "parent" of *Archaeopteryx*, only that their lineages shared a comparatively close common ancestry—an idea that would seem reasonably supported by something that really was a fact, namely the aforementioned circumstance that several 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.[126]

Following that corkscrew logic, Gish reached so far out for his second "fact" he fell off the hayride. 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.[127] 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.[128]

The nasty 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 had backward-pointing pubic bones virtually identical to *Archaeopteryx*. So why didn’t Gish know it?[129] 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.”[130]

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 a 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*.[131] 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.[132]

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 its 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.[133]

Although creationists pay lip service to how marvelous be the works of creation, they devote precious little effort to actively studying them. In the creationist catalog of wonders, birds simply *are*, with 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).[134] 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.[135]

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.[136] 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 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.[137]

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.[138]

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.[139] 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.[140]

Round Two is shaping up as a technical knockout for the other side. Bird hands appear to develop five cellular "anlagen"—for of which 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.[141]

Tough times for the dinosaur theory? That depends, of course, on what anlagen were present in the embryonic hands of *Archaeopteryx*, or the maniraptoran dinosaurs and their kin, but as yet these are unavailable for comparison.

Moving on to Round Three, 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? Without skipping a beat, creationists displayed here all the blasé insouciance of a garden party host in an existentialist farce, casually motioning for the servants to tidy up after hyenas devour one of the guests. 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.[142]

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 the genes for their 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.[143]

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 certainly 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, Richard Milton, Jonathan Wells, 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.[144]

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 the sort of contingent adaptation to be expected from natural evolution rather than intentional design. Johnson's Research Notes documented the matter thus:

> 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.[145]

As we'll see again with the reptile-mammal transition, Johnson's solicitude about not unduly distracting his readers appears to coincide with topics not easily bent into shape for the curlicued Intelligent Design cloisonné.

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—precisely 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.[146]

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.[147] 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."[148]

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*."[149] In other words, the similarity was likely due to the 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.[150] Of course (as we'll see next chapter) there are still a few creationist dogmatists who can't even manage to get that bit straight.

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." Certainly Johnson never drew any definite conclusions, probably because he hasn't brought them up since. An insufficient supply of capable associates, perhaps.[151]

Like Tippi Hedron waiting unsuspectingly by the tricky bars in Alfred Hitchcock's *The Birds*, creationists hoping these Mesozoic flyers would pose a problem for evolution were 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.[152] 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.[153]

What we're seeing here 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. 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.[154]

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? Why are evolutionists so 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.[155] 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 Early Cretaceous finds coming from China.[156]

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.[157] 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.[158] 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."[159]

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.[160] Applying either Baconian induction or the Alphonse/Gaston rule, knowing at least a few nonavian dinosaurs had genes for making feathers jacked up the likelihood their ancestors had them too, and paleontologists will continue hunting for even earlier *Lagerstätten* to clarify the picture. 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.[161]

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 the feathered dinosaurs. 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. Phillip Johnson even caught the bug 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."[162]

However, if the idea is to show proper caution when approaching new information, especially material of a problematic or controversial character, that is decidedly *not* how Parker and his fellow creationists have played this "final piece in the *Archaeopteryx* puzzle."

The questions are simple enough. Was *Protoavis* a "modern" bird? In fact, was it a "bird" at all? And how would you go about telling this? If *Protoavis* were 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. All the controversy that swirled around *Protoavis* turned on the poor quality of the fossils and how those finds were to be interpreted.[163]

First, the up side. Mudstone would not likely have preserved feathers or feather impressions in the first place, 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, but *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.[164]

All of which makes Gary Parker's treatment of this subject particularly strange. For much of this intelligence appeared in the very first report on the find in the British journal *Nature* in 1986. And guess what happened to be the only source Parker offered for his *Protoavis* argument? Showing no equivocation or caution, Parker conjured up that "quarry full of bird bones" in complete defiance of the *Nature* text. Not only did he have to step right over the illustration of the very fragmentary state of the fossils involved, Parker also had to ignore all the questions being raised even then about the problematic character of Chatterjee's discovery.[165]

But 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 the far more extensive trail of breadcrumbs laid down since then by his fellow creationist Duane Gish. 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 appearing in Gregory Paul's *Predatory Dinosaurs of the World*.[166]

As a disarticulated ensemble, there was no guarantee Chatterjee's fossils were even from the same animal—which would capsize any anatomical generalizations made under the assumption that they were.

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.[167]

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.[168] 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.[169] 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.[170] 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."[171]

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 in *Science* and *Science News* covered it. While the ever-feisty Robert Bakker 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.[172]

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*![173]

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 *Science* and *Science News* 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 Alan Feduccia made: "Calling this the original bird is irresponsible."[174]

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.[175]

Apart from a flurry of conditional "ifs" and a paltry concession to the "intense controversy" at the end, 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 other original specimen, which showed a modest feature barely more "substantial" than the latest *Archaeopteryx* find (something else Gish presumably knew about). The evolution of Gish's *Protoavis* triptych showed how Creation Science's most articulate defender was embarked on an almost hallucinatory disconnect from the grubby facts. And all this while paleontologists were discovering those genuinely impressive articulated Cretaceous birds.[176]

Since we're about done mucking out the bottom of the creationist birdcage we may as well touch on the oddest claim put forward regarding *Archaeopteryx*. A 1968 *Science Digest* piece had referred to a Mexican archeologist who described a Mayan sculpture he had discovered as bearing "a vague resemblance" to a reptilian bird. Seizing this miniscule thread, Henry Morris thereupon wove into *Scientific Creationism* (a provisional classroom textbook) some whole cloth of pure von Däniken stripe: "The evidence seems clear that archaeopteryx, or some equivalent ancient bird, was contemporaneous with man and only became extinct a few thousand years ago."[177] Although Douglas Futuyma and Chris McGowan both called attention to this ridiculous conclusion jump, Duane Gish didn't think it worth mentioning when he affirmed the scientific sagacity of Henry Morris *et al*. in *Creation Scientists Answer Their Critics*.[178]

Yet wasn't Morris only applying the essence of creationist logic? Their whole approach to evolution and the fossil record has been one long procession of "Mayan sculptures." That's because creationists face the same difficulty Cynthia Giles had when she tried to fold the Renaissance tarot into the occult mythology mold: the facts are never going to fit the model if the model's wrong. That means the only way to sustain the illusion is through apologetic subterfuge and suppression of evidence. The repeated technical gaffs and scholarly excesses of creationists like Morris and Gish are therefore not rare exceptions—they're the persistent outcome of an ideological way of looking at the world, one that has decided in advance what the "true facts of nature" are supposed to be.

But what if you could both concede the facts and render them harmless? Compared to Creation Scientists bogging down on the anatomy of *Archaeopteryx*, Phillip Johnson's approach 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.[179]

Here a crib from the doleful Poe seems apt. Quoth the *Protoavis*, "Nevermore!"

For with *Darwin on Trial* we are embarked on something of a Magical Mystery Tour, widening a defensive trench network 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."[180] But we've already encountered that line of reasoning—it's the von Däniken defense. By invoking it here as a universal solvent to erode the evolutionary implications of the fossil data, Intelligent Design may have skipped out a different exit from Scientific Creationism, but they still end up together outside the Natural Science Hall complaining in the parking lot.

Denton could freely acknowledge the specifics of fossil sequences like the reptile-mammal transition because he promptly upped up the ante by requiring the preservation of internal organs before conclusive inferences could be drawn.[181] 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.[182]

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 "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 … until you stop to remember this is one game creationists do not themselves play. Through 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 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 they've just 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.

But when Johnson insisted *Archaeopteryx* was only a "lonely exception to a consistent pattern of fossil disconfirmation" he stepped off the logical bus. 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 Alphonse/Gaston problem comes to haunt Intelligent Design as much as Creation Science. We already know there are darned 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 grubby specifics, all his allusion to "fossil disconfirmation" represented was an artful synonym for the Bermuda Triangle Defense.

Much like Denton, Johnson seemed blissfully 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 sort of spin on the history of paleontological discovery (which, as far as we can tell, he's never substantively studied). But if we step back one taxonomical notch, the vertebrate class to appear prior to Aves was our own Mammalia. While Darwinists believed mammals had evolved from some early reptilian form, it wasn't until well into the 19th century that even 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?

The Reptile-Mammal Transition

Henry David Thoreau once remarked that some circumstantial evidence was conclusive—like finding a trout in the milk. Taken together with the nine thousand species of birds, the four thousand-plus extant mammal ones embrace about half of all living vertebrates. To acknowledge as well their descent from reptiles (or more properly, the basal amniotes from which the present Reptilia also developed along a separate track) would seem no modest concession. So 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 in about the same amount of space he luxuriated on 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.[183]

As with his discussion of the Cambrian Explosion, just about everything in this passage about evolution's "crown jewel" was either misleading or outmoded, and so could be taken as another Olympian "hide the ball" game. 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."[184]

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 shortly, then proceeded to wrap the gem in four layers of padding. 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. That mummification job complete, 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.[185]

It was again considerate of Johnson to spare the reader that unnecessary distraction of "more specific technical terms." But 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. But 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 effects the shape of teeth. 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.[186]

The problem for the convergence argument as Johnson framed it comes the moment you 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).[187] 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.[188]

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. Like B. F. Skinner happily directing readers back to his previous book, Johnson only *thought* he had.[189]

The sources in his Research Notes were all marshaled in defense of 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 Gish's "no cousins" rule? No animal can have ancestors if there were cousins that resembled it?

Johnson sounded even more like Duane Gish in his reliance on the Grassé book, which in characterizing modern (non-French) Neo-Darwinism as the "myth of evolution" has been mined for authority quotes almost as frequently as the *oeuvres* of Stephen Jay Gould.[190] But in this exercise Johnson was showing the drawback of trying to invade a technical discipline like paleontology armed only with general quotations instead of an informed familiarity with the evidence. By their very nature, fossils are not uncovered all at once—nor are the first ones dug up likely to be either complete or representative of their taxa. Because 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 should more examples turn up. 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. Although 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. By siphoning off Grassé without explaining on what basis those changes had taken place, Johnson stepped into the same scholarly boat as Gish: either he was aware of this information and didn't care to explain it, or he didn't know anything about it and was writing from ignorance. There wasn't enough distracting detail in *Darwin on Trial* to decide which.[191]

The crux of Johnson's argument turned out to rest on the Hopson article, but at this stage his tenuous grip on the Map of Time caught up with him. His one technical assertion—that *Morganucodon* "is substantially older than the therapsid that precedes it"—was simply wrong (as Hopson's figures 3, 6 & 10 made plain). 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 Alphonse/Gaston rule is 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*, this is a perfectly satisfactory link to the earliest recognized mammal family in the primitive subclass of Eotheria, the Morganucodontidae of the Late Triassic.[192]

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. 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.[193]

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."[194]

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 we've already seen that Creation Science is not one of Johnson's favored subjects. 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?[195]

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*) … which he temporarily relabeled "mammal-like reptiles" for the duration of the trick. Creation Science taxonomy in action is a marvel to behold.[196]

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.[197]

Without gulping for air or embarrassment, 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."[198]

All this made for some juicy 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.[199]

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.[200]

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 disconnect." 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. The other two were directly contradicted by his own primary source of Stahl, let alone the rest of the available literature … and, of course, we have those ghostly "other examples" hovering over the convergence claim. Looked at as an argument 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 metabolic distinctions between modern reptiles and mammals is obvious. 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.[201]

While the Gould excerpt 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 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*, possibly represented today by the plucky turtles. Interestingly enough, one of the amphibian characteristics reptiles lack is a notch at the back of the skull, the otic arch, where amphibians have their external ears. This suggests the earliest amniotes may 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."[202]

Now the idea of descendants developing their hearing by the reconfiguration of the amphibian stapes bone (itself a modification of the hyomandibular bone in fish) only 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.[203]

But that was hardly all that was happening with the early amniotes. The really diagnostic development concerned openings in the skull to allow more complex jaw muscle attachments that added strength to the bite. In this fundamental area there was an early split along two divergent paths. 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.[204]

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.[205] 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.[206]

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 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.[207]

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." 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.[208] Even as 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.[209]

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.[210]

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.[211]

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.[212]

Yes, the last of the therapsids were evidently *fur-balls*, as a glance at any recent illustration of one would have indicated. 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.[213] 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* (an even butt-uglier cousin of our old pal *Moschops*). 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.[214]

Which poses a question of judgment. 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, because unlike the dinosaurs (where most of them weren't developing into anything bird-like) the synapsids were plowing a wide swath towards Mammalia. To remove the "relevant suspects" here 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 summer dandelions.

When it comes to the circumstantial evidence for macroevolutionary change, at what point are there enough trout in the milk? Look again at that jaw-ear conversion—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 look 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.[215]

In spite of all the daunting odds, paleontologists had obtained the fossil evidence for this most amazing transformation. And something else, too, from the other end of the spectrum—for it turns out that living mammals rehearse this ancient minuet in their own embryology. You may recall my tip-off about it from last chapter. The full story is that 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. One may view this either as still more frosting on the evolutionary cake, or as just another of those mysterious coincidences that so litter the creationist garden.[216]

At this point our basic "Rules of the Game" jump back in concerning scholarly scruples.

Since Johnson cited Hopson's article, we know he had the jaw embryology information 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 all these points up front? Was he thinking that, if he didn't mention them, his readers wouldn't notice? (Given the state of creationist scholarship, that would actually be a pretty safe bet.) 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 gears of the creationist *deus ex machina* grind along quite nicely on autopilot.

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.[217]

That Johnson's discourse on the reptile-mammal transition is as incompetent as it is underscores a rather glaring circumstance: that is the *only* account 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.[218]

Phillip Johnson's personal contribution to the logic of creationism may turn out to be his special honing of the *meaningless concession*. Confronted by facts you can neither refute nor account for, you "concede" or "accept" them while actually doing neither. Creationists have long adopted that stance tactically 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 remember Johnson's forte is that of "analyzing the logic of arguments and identifying the assumptions that lie behind those arguments." Consequently he can't resist giving us more than he bargained for.

How far Johnson was willing to go in provisionally conceding things may be traced through 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 garner attention in the conservative *National Review* … as well as a flock of notice in *Christianity Today*. Things came to a popular head after William F. Buckley got into the act, suggesting this was information too hot for nervous evolutionists to handle.[219] It was then that 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.[220]

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. In the grand tradition of genius unjustly denied (from Immanuel Velikovsky to Erich von Däniken), Johnson enthusiastically excoriated his critic:

> The review was 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."[221]

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.[222] 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. More of the gory details of Gould's review and Johnson's forensic response will be explored in due course—but what concerns us here is what Johnson had to say on the "narrow" therapsid point. This is where Johnson hit logical bottom:

> 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.[223]

There are several methodologically peculiar things about this passage.

First, Johnson had quite obviously 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 jumping 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.[224]

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.[225]

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 this characteristic fielding of the Bermuda Triangle Defense, 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.[226]

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. And indeed, as we'll see next chapter, much the same thing applies to the origin of dinosaurs. Both of those macroevolutionary spurts took place over a very long time, and clearly followed exactly the pattern that Meyer & Wells insist *isn't* seen: the distinctly Darwinian sequence of new forms starting out with "slight differences appearing first, then greater differences emerging later."

That Meyer & Wells haven't paid any attention to either the mammal or dinosaur cases is one reason for being somewhat skeptical of their fecundity whilst lecturing on the panorama of fossil history, but Phillip Johnson doesn't have the convenient out of extenuating ignorance.[227]

And Johnson's hole only gets deeper when we look at the second peculiar thing about his rejoinder to Stephen Jay Gould. In *Darwin on Trial* Johnson had written that *Archaeopteryx* was 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 were 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 how he had just run out of "rare exceptions" to concede.[228]

Ah, how easy the mantra, for in what way did any of this "acceptance" ever manifest itself? When I inquired some years ago via e-mail 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, which he likened to Marxists seizing on the exploitation of a few factory workers as confirmation of their general ideology. Some acceptance![229]

At the 1998 Whitworth "Creation Week" gathering I listened while he pilloried Gould once more for criticizing his book only on niggling details, during which he did not volunteer the therapsid matter. In the question period that followed I explained how Gould had brought up that "narrow point." Then I tried to get Johnson to explain in what respect the reptile-mammal transition failed to qualify both as a relevant criticism of *Darwin on Trial* and as a genuine macroevolutionary phenomenon, and I grew quite flustered as he stuck to his philosophical defense.

Finally, he cautioned the audience that my evident annoyance was due to his treading on my supposed evolutionary religion, and moved on to the next raised hand.

While no one in the audience seemed aware that Gould's review had not been as gauzy as Johnson intimated, it was interesting that Stephen Meyer made no move to correct Johnson about leaving out the therapsid issue. Had I not raised it in my own question, the assembly would have been left with Johnson's version uncontradicted. Afterward I asked Meyer whether it was *philosophically* legitimate for Johnson to proceed as though he had successfully disposed of the therapsids without actually mentioning any of them, either there or in his books.

I never did get an answer.

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 e-mail exchange, and also brought the point up at Whitworth, 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 was venturing far beyond merely rejecting my conceit as being wrong. He was denying the very reality and integrity of my own thought processes in reaching it. Putting words in people's mouths is unsanitary enough without "theistic realism" coming along, trying to inject them directly into the brain.

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.[230]

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.[231]

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. Those issues will be explored in the final chapter. But the obvious hot topic right now concerns the fossil brigade. 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.[232]

So many questions are posed by the existence of the 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. Since Wise is the chap with the doctorate in paleontology, he may be presumed reasonably apprised of the latest findings and opinions in the evolutionary theater. While obviously not "intermediate" in any temporal sense, was it true then 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.[233]

What does it say about Wise's scientific methodology that he thought he could dangle the duckbill like Groucho Marx's old stage prop, "mosaic" stuck in its beak as the secret word, 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.

As for those invertebrate intermediates supposedly lying beyond the evolutionary event horizon, their inscrutability was not quite so deep as Wise made out. 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."[234]

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 (yawn): 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.[235]

Yes, there is a deadening failure of imagination involved here, 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. And evidently not invertebrate biologists when they again applied their feeble Darwinism to nature and successfully imagined the "unimaginable" and deduced the hitherto unknown internal anatomy of the monoplacophorans. For advocates of a discipline supposedly on the ropes over the dire challenge of animal mosaics, evolutionists persist in their curiously long-running streak of lucky paleontological guesses.

Meanwhile, Zeno's weary Tortoise falls ever farther behind, 'til only a miracle can save him.

NOTES to Chapter 2

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[1] Schafersman (1982), Larson (1985, 123-4, 129, 139-140), Stanley L. Weinberg, "Creationism in Iowa: Two Defense Strategies," in Hanson (1986, 63-64), Ruth Brown (2002, 125-126, 257-258) and Ravitch (2003, 92-95, 105-107)—Ravitch noting the ironic similarity of the Gablers' method to that of radical feminists! Cf. Gould (2002a, 989).

[2] 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.

[3] Johnson (1991, 6). Cf. Edwords (1981, 23-29) on how committed Creation Science has actually been to this Bible-free "equal time" credo.

[4] Henry Morris (1985, 151-153).

[5] Henry Morris (1972, 92). 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). Although Falwell believes evolution false and pernicious, he doesn't devote the airtime to it that D. James Kennedy does. When I followed Falwell's half-hour syndicated "Perspectives" radio program in 1993 the subject didn't come up at all (whether his "Old-Time Gospel Hour" addressed it on television during that same period I can't say). Falwell's evident concern that year was the threat of homosexual rights, as manifested in the National Endowment for the Arts (NEA) and the new Clinton administration. A "Sodom & Gomorrah" tape was offered for $35 via toll-free number, and through several consecutive weeks this was even promoted as the "final week for the final time." Since only about 5 minutes of new material occurred in a week's worth of otherwise tracked broadcasts, our local American Christian Network affiliate tired of the repetition and ended up dropping the series. Not that they didn't wholeheartedly agree with its message—only that they felt it wasn't worth the money required to hear what little there was of it.

[6] Since 182 feet is about 55 meters, Morris' 54 "feet" may have come from conflating English and metric. In the next chapter we shall encounter a similar numerical faux pas when catastrophist Richard Milton took on the subject of brontosaur dimensions.

[7] 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. The details of plate tectonics can be found in almost any contemporary geology source, such as Emiliani (1992, 234-253); 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, indicates about half of the seafloor has been lost since then via subduction. Without bothering with even a single 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, 272) have persuaded themselves that the pendulum has indeed swung, confidently declaring that "the whole concept of plate tectonics now is under a cloud."

[8] Pettersson (1960).

[9] 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.

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[10] 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).

[11] 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).

[12] 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."

[13] 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.

[14] Wendell Bird (1989, Vol. 2, 334) and Paul Taylor (1995, 17-18, 70-72) variously 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). The co-author Andrew Snelling has occupied an equivocal position on the creationist landscape, as recounted in note 388 of chapter five.

[15] McGowan (1984) was in Gish's bibliography, but he cited it only once, Gish (1993, 163), for a quote concerning the argument that evolution violates the 2nd Law of Thermodynamics (one of the more peculiar creationist claims, addressed in chapter seven).

[16] 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."

[17] DeYoung (1989, 33-34).

[18] 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.

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[19] 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).

[20] 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."

[21] Hartmann & Miller (1991, 44-57) or G. Taylor (1994) describe the detective process of discovering the actual origin of the moon, and Musser (2001c) comments on recent developments. It is important to remember that the Apollo samplings showed the lunar surface is not of one age (the highlands range from 3.8 to 4.5 billion years old, while the younger maria run 3 to 3.9 billion). By that later time the meteoric influx rate had dropped off markedly, as was inferred already from the structure of lunar cratering, with younger less worn ones being rarer and smaller than the increasingly eroded older and larger ones. Although there is no weather on the moon, over billions of years the sun and meteoric impacts do take their toll, which is why the lunar surface doesn't look quite so craggy as in Chesley Bonestell's evocative space travel paintings of half a century ago. 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 sublime indifference to the scientific literature linking lunar composition to the early earth's outer crust—none of which they discussed before venturing their 1996 judgment.

[22] Morris & Parker (1987, 126).

[23] Morris & Parker (1987, 127). A virtually identical picture is shown in Austin (1994, 140), as a "Reconstruction of pre-Flood ocean floor suggested by Paleozoic fossils," where the "assortment of different body plans is similar to modern oceans."

[24] Morris & Parker (1987, 129) re Precambrian jellyfish and annelids. Sea cucumbers (phylum Echiurida) are listed as Precambrian fauna in Emiliani (1992, 669). Beardworms (Pogonophora) 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 Boore & Brown (2000) suggesting beardworms may not be a phylum, but rather a family within the annelids. Fortey (2000b) offers the big picture on trilobites.

[25] 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. For "the works," a recent *American Zoologist* symposium explores all the crannies: 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). A measure of the degree of change involved: the Cambrian "starfish" *Edrioaster bigsby* (class Edrioasteroidea) resembled a flattened baseball, with the five "arms" wrapped around it like seams, while the "crinoid" *Gogia* (class Eocrinoidea) shown in J. John Sepkoski Jr., "Foundations: Life in the Oceans," in Gould (1993, 58)

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had long tendril arms set on a low body whose pored plate sutures differed from the later true crinoids.

[26] 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. The Austin (1994, 140) "pre-Flood ocean floor" scene did not identify the array as Cambrian, and its "fish" was more accurately depicted.

[27] See Stahl (1985, 34-35, 45) on mid-1980s Cambrian fossil fish and the evolutionary expectation that early chordates would resemble larval lamprey or hagfish. Cf. Radinsky (1987, 36-38) reconstructing an ancestral chordate based on evolutionary assumptions with more recent work, such as Neidert *et al.* (2001), Force *et al.* (2002) and Irvine *et al.* (2002) on lamprey genetics relating to the evolution of early vertebrates, with Salaneck *et al.* (2001) on a possible early neuropeptide receptor preserved in the lamprey genome, relating to Wraith *et al.* (2000).

Concerning the fossil evidence, Holland & Chen (2001, 145-148), Degan Shu *et al.* (2003), 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. Another Early Cambrian agnathan (*Haikouichthys*) further clarifies the primitive stem-group craniates, Shu *et al.* (2003a), and may actually be the same species as *Myllokunmingia* (see palaeo.gly.bris.ac.uk/Palaeofiles/Lagerstatten/chngjang/animalia.html).

[28] Stahl (1985, 32) or Rich *et al.* (1996, 346) illustrated *Anglaspis*. Cf. Ellis (2001b, 84-85). Incidentally, the summary of heterostracan diversity by Radinsky (1987, 36-38) cautions how little is known of their internal anatomy. A problem for some creationists comes if they don't properly comprehend how agnathan fish differed from modern ones. Since their dogma mandates fossils appear "fully formed" (hence as recognized categories) their idea of "fish" may be far from the scientific understanding. This was illustrated when creationist Luther Sunderland (an engineer at GE) latched onto the original source for the Late Cambrian dermal plates, Repetski (1978), and conjured them into a "fully developed" heterostracan. 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) and Morris & Morris (1996b, 299) also relied on Repetski, without clarifying what sort of fish were involved.

[29] Gish (1995, 54) offered a similarly selective list: "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." While the anachronistic sea urchins remain, the nautiloids have gone, to be replaced by "swimming crustaceans" and "other complex invertebrates." These probably reflected the newer information available by then from Gould (1989) about the Burgess Shale specimens. The problem was those "crustaceans" were *evolutionary ancestors*, not modern crabs or lobsters as his use of the familiar term might have led someone to think. See also note 44 below.

[30] Henry Morris (1985, 79).

[31] Similarly ambiguous terminology figures in Carl R. Froede Jr.'s 1999 contribution on "Precambrian Plant Fossils and the Hakatai Shale Controversy" for the *CRS Quarterly* (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). 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. 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

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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 primitive 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 (1998b) 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.

[32] 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 effect our cataloguing exercise.

[33] 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, and Margulis & Schwartz (1988, 220-221) for the priapulids. 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 clear enough to settle that issue (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 getting fossilized. They concluded "The cyclical alteration of phases of growth and function provides compelling evidence that elements were retained through the life of the animal." See also 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 (2001b, 78-80, 86-87) and Parker (2003, 202-203). Known endearingly as the "slime hag," for their characteristic excretions, fossil hagfish were unknown until one turned up from 330 mya, Martini (1998).

[34] 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 history.

[35] 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 (surprise!) 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.

[36] 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

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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). 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).

[37] Davis & Kenyon (1993, 95). At a 1998 "Creation Week" symposium at Whitworth College in Spokane, Washington, a distributed flier criticized the California Academy of Sciences for a supposedly misleading evolutionary wall display positioning 440-million-year-old fossil corals below 550-million-year-old echinoderms; Wells (2000a, 54-55) also alludes to it. Phillip Johnson used the CAS example in a 1994 debate with science historian William Provine (text obtained from the ARN website), where Provine not only agreed that the display was "terrible"—he went on to add criticism of his own. The CAS display (reproduced at the ARN website) looks suspiciously like it was based on a *cladogram*, a taxonomical technique classifying forms along branching nodes independent of chronology (more on cladistics in due course). But creationists extolling *Of Pandas and People* (prominently displayed on a hall table at the Spokane gathering) might have paused over a similar illustrative vagueness in Davis & Kenyon. 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. The latest Discovery Institute slide show (presented by Stephen Meyer in October 2001) has made some progress by acknowledging that half of the phyla aren't preserved in the Cambrian, while inferring the rest as parasites of known ones. This still left out the naturalistic logic whereby phyletic candidates were identified in terms of their evolutionary ancestors.

[38] By contrast, evolutionists are not wedded to playing the "hunt the living phyla" game. Emiliani (1992, 444) characterized the Cambrian by the appearance of 10 major phyletic players: the extinct archaeocyathans (early coral-like animals whose secreted casings looked like nested ice cream cones) and conodonts; the hyolithans (early beardworms), mollusks, brachiopods, arthropods, echinoderms, and hemichordates; as well as the protoctist foramanifera and radiolaria (both microscopic marine plankton). Simpson (1983, 73-78) would be typical of how evolutionists interpreted the Cambrian phyla when Morris and Parker were writing.

[39] The most obvious case of evasion concerns Duane Gish: although McGowan (1984, 102) alluded briefly to Morris' taxonomical excesses, Gish (1993) did not discuss the matter. Morris & Morris (1996b, 299) have hedged their bets here: "It is significant that every one of the great phyla and most of the classes of the animal kingdom appear in the Cambrian rocks, supposed by evolutionists to be the oldest of the fossil-producing geological ages." They then repeated their traditional mantra: "If practically *all* the animal classes and phyla are found in *all* the geologic 'ages,' or more accurately, the rock systems of the geologic column, there is very little left of even a superficial appearance of evolution." Michael Behe's similar sliding use of "most" versus "all" will be examined regarding his "irreducible complexity" argument.

[40] 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. Incidentally, Gary Parker put his oar in this stream himself: "First, there's the matter of 'misplaced fossils.' Evolutionists believe, for example, that the land plants didn't appear until over 100 million years after the Cambrian trilobites died out. Yet over sixty genera of woody plants spores, pollen, and wood itself have been recovered from lowest 'trilobite rock' (Cambrian) throughout the world. The evidence is so well known that it's even in

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standard college biology textbooks. A botany textbook by Weier, Stocking, and Barbour puts it this way: 'despite tempting fragments of evidence, such as cutinized [waxy] spores and bits of xylem [wood] dating back to the Cambrian period….' most evolutionists still believe that land plants didn't evolve until much later. But notice, the evolutionist argues 'in spite of the evidence,'" Morris & Parker (1987, 165). The inclusions and ellipses were Parker's, and no page number was given for the botany literature cited on page 320 (the 1974 textbook itself was unavailable to check Parker's characterization). It was interesting, though, to watch Parker suddenly castigating evolutionists for *not* making too much of fragmentary data! C. Brown (2002, 104-105, 112n) recounted how Clifford Burdick (Christian) and Cremo & Thompson (Hare Krishna) have fielded similar antievolutionary arguments, based on a problematic 1966 fossil pollen report by R. M. Stainforth in *Nature* (210:292-294). The tactical open-mindedness of Parker, Burdick or Cremo & Thompson may be contrasted with paleontologists Rich *et al*. (1996, 373-374): "Thick-walled spores with shapes similar to those of some modern terrestrial plants have been found in Early Cambrian rocks of India and Russia. *Aldanophyton* consists of a series of carbonized imprints from Siberia with shoots up to 5 inches (13 cm.) wide. It resembles a small lycopod (club moss) with spirally arranged leaves, each about 3 inches (8 mm.) [*sic*] wide. But whether, indeed, it was a vascular plant, and whether or not the fossil spores recovered from rocks of this same time period were contaminant, is not really known. So until more and better material from Cambrian and Ordovician rocks is found, paleobotanists will remain wary of accepting any of these early fossils as true land-plant material." A chart illustrated several fossil spore shapes, which being so geometrical could easily be confused, especially when only poorly preserved.

[41] Ecker (1990, 15-18) summarized what Scientific Creationism has made of "abrupt appearance" references from mainstream evolutionists.

[42] Gore (1993, 122-123, 128-129). One may compare Palmer (1999, 62-65) on Cambrian illustration.

[43] Fastovsky & Weishampel (1996, 71).

[44] Conway Morris (1998a, 103-104, 130-131, 173). Though Valentine *et al.* (1999, 854) characterize *Eldonia* as an organism "of uncertain affinity." Additional Chinese specimens of possible early chordates have continued to be discovered, Enserink (1999) and Ellis (2001b, 80-83). A rare Lower Cambrian English *Lagerstätten* (cf. note 55 below on this term) 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.

[45] Johnson (1991, 54). The "research notes" for the chapter did not specifically reference the Dawkins (1986, 229) quote; another creationist who found it useful was Gish (1995, 56-57).

[46] Johnson (1991, 54-55). His Research Notes cited Gould (1989, 58-60, 311-314) for background information, Johnson (1991, 167). First discovered in Australia in 1947, the Ediacara fauna have since been found worldwide (and are also referred to as the Vendian fauna, for the "Vendian Era" applied by some geologists to the late Precambrian), as ably described by Mark McMenamin (1998) in *The Garden of Ediacara*. Cf. Ellis (2001b, 25-31). Of course, for a paleontologist, finding one Alphonse in Australia and a second in Canada automatically qualifies it as a "fauna of global extent," even though what all the inferred intervening Alphonses were up to in the meantime would be a matter of informed scientific conjecture.

[47] Johnson (1991, 55-56). The *Wonderful Life* quotes were drawn from Gould (1989, 271-273).

[48] 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).

Strahler (1987, 401-403) noted the dated Creation Science references a quarter century after mainstream textbooks had incorporated the new Precambrian data. For example, the 1974 edition of Gish's *Evolution: The Fossils Say NO!* flatly denied the existence of any Precambrian metazoans, cited by Futuyma (1988, 188). Subsequently Gish (1995, 55-59) revamped the text: (1) removing the obsolete statement, (2) siphoning a misreading of Gould and others to declare the Precambrian fauna unrelated to later forms, then (3) delicately cleaning up after himself by the refined revisionism of suggesting only *evolutionists* had been mistaken here. Thus did Gish sidestep creationism's own feeble prescience when it came to anticipating Precambrian paleontological discovery.

[49] Johnson (1991, 52).

[50] Davis & Kenyon (1993, 86) are hot contenders for exaggeration here: "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." No references were offered, but sources compound their confusion. Gould (1980, 184): "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." Or Eldredge & Tattersall (1982, 59): "Speciation can occur very quickly. In perhaps a few hundred years, new reproductively isolated species can form." Davis & Kenyon had conflated speciation with "major change"—even though sibling species can be virtually identical, as when breeding at different times of the year (see note 15, chapter four). Substantive adaptive change on the scale of bats or whales is far from brisk—Eldredge & Gould ballparked that at "five to fifty thousand years" (see note 240, chapter four). Incidentally, the standardized quantification of speciation rates in terms of "darwins" and "haldanes" has recently come into practice, per Hendry & Kinnison (1999). For comparison, one may throw in the "shop talk" in the *Journal of Evolutionary Biology* concerning Wu (2001a,b) by Bridle & Ritchie (2001), Britton-Davidian (2001), Mallet (2001), Mayr (2001b), Orr (2001b), Rieseberg & Burke (2001), Rundle *et al.* (2001), Shaw (2001), van Alphen & Seehausen (2001) and Vogler (2001). Representing quite a spectrum of current thinking about how to pin down the genetic, adaptive, and ecological factors affecting speciation, none of the pros and cons of Wu's "genic view" of speciation involved any apparent anxiety or uncertainty over the rate of speciation in geologic history.

[51] For a short presentation of the contending views as they relate to interpreting the preserved fossil data, Doyle & Lowry (1996, 82-85) is most informative. Recent studies of fossil speciation rates suggest no single model is the "correct" one, but rather that various tempos come into play over the life of a lineage, including "coordinated stasis" where extinction and speciation ebb and flow together. See Kerr (1997) and Douglas H. Erwin & Robert L. Anstey, "Speciation in the Fossil Record," in Mark Ridley (1997, 244-254).

[52] Levinton (1992) explored how preservation and rate affected understanding of the Cambrian Explosion; see Gould (1989, 224) for distribution of the Cambrian examples. Tudge (1996, 102-106) explained how population size figured 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.

[53] 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.

[54] See Dalziel (1995), Jon Erickson (1996, 9-13; 2000, 13-14), McMenamin (1998, 176-185) and Torsvik (2003) on Rodinia and Precambrian continental drift. While Precambrian strata underlie most of Africa, Australia, the Americas, a good chunk of Antarctica and northeast Europe, plus bits of Asia, not much helps the Cambrian Explosion quest. Land deposits or any predating the Ediacara window wouldn't help—nor even finding marine rocks of the right age if it meant tunneling through a mountain or a city to reach them. Lambert & The Diagram Group (1988, 184-191), Dalrymple (1991, 127) and Jon Erickson (2000, 7, 195) map an assortment of Precambrian deposits. The Cambrian continent of Laurentia was roughly North America turned 90° and

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positioned along the equator, with Greenland to the east and the Burgess Shale on the north coast, Parker (2003, 80). For all that real estate, though, there are just *thirteen* really useful sites, mostly along the same cordillera that snagged the Burgess beachfront property, Conway Morris (1998a, 118).

[55] Gould (1989, 61), which was one page after the Ediacara fauna spread cited by Johnson in *Darwin on Trial*. The concept of *Lagerstätten* failed to make it into the brief Cambrian jab in Schroeder (2001, 120-121). Likewise Gish's *Creation Scientists Answer Their Critics*, or the latest edition of *Evolution: the Fossils STILL Say NO!* Even though he offered no geological details for either the Ediacaran or Cambrian fossil ensembles, Gish nonetheless rejected as "incredible" the notion that Precambrian ancestors for the Cambrian fauna would have been soft-bodied, and that such creatures would have rarely fossilized, Gish (1993, 118-119; 1995, 67). This, even though Gish (1993, 117-118; 1995, 55, 66) had quoted from the very page of Simpson (1949, 18) where Simpson had written 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."

Briggs (1991) and Doyle & Lowry (1996, 36-41) discuss prominent *Lagerstätten* and the circumstances of their formation. A "Mother Lode" of another sort was exhibited by the scholarly befuddlement of Morris & Morris (1996b, 60-61) when they stressed "the abundance of fossils whose soft parts have been preserved in the Cambrian rocks." Their evidence consisted of this quote from 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, that "60" value referred to all the prime sites covering the half billion years *from the Cambrian on*, as a chart on p. 132 made plain. Briggs highlighted only *six* major deposits for the Cambrian proper (four of those were in North America, with the other two 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." Only the Yunnan China and Burgess *Lagerstätten* have preserved faunal assemblages broad enough to get a passable glimpse of Cambrian paleoecology in action.

[56] The benchmark exposés of the Bermuda Triangle myth by Lawrence Kusche (1975; 1980) methodically uncovered a mountain of relevant information ignored by the paranormalists, from Winer (1974; 1975) up near the top of the food chain, down to the dregs of Berlitz & Valentine (1974; 1977). Apropos Berlitz, Randi (1980, 42): "It is careless of a man to fail to sufficiently research a subject on which he claims to be an authority. It is irresponsible for him to resist telling the facts when he discovers them. And it is irresponsible and callous for him to continue to misrepresent matters about which he has been informed to the contrary. *J'accuse* Charles Berlitz of these failings." There's even a *Biblical* take on things: although aware of Kusche's work suggesting nothing strange was going on to begin with, George Johnson & Tanner (1976) maintained the Bermuda Triangle operated as a satanic cold storage for errant souls awaiting Judgement Day. Meanwhile, there is some suggestive evidence that rare submarine gas explosions (notably from methane hydrates) might be responsible for some disappearances, as noted by Jon Erickson (1996, 212-214). Much larger hydrate leaks may also have contributed to an abrupt global warming during the Eocene, Wing (2001, 52-53).

[57] Gish (1993, 116) also 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." Likewise, Schroeder (1997, 89): "In a leap, life moved from single-celled protozoa and the amorphous Ediacaran clumps to multicellular complexity."

Genetic studies have tended to date the main phyletic splits before their fossil appearance, though given the limits of the fossil record that is less surprising than if the dates had fallen *after* their physical appearance. Surveys of the data 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), Benton & Ayala (2003) and Peterson *et al.* (2004). Jonathan 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

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back as a billion years, Pennisi (2001) re Heckman *et al.* (2001). This is some 250 Ma before their fossil appearance among land plants. But it is debatable whether this translates into 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."

[58] Since the 1993 update of *Darwin on Trial* did not revise the Cambrian text, nor did he elaborate on it in any later book, one may presume Johnson considered his presentation adequate. Using the Skinner tactic, 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." Denton (1985, 187) had earlier breezed through the Cambrian without introducing any of the characters, except to remark 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." Morris & Morris (1996b, 59-60) took a similar position on the Ediacaran biota.

[59] Monastersky (1998b, 112-113) noted Seilacher's controversial take on the Ediacaran biota has modified through the years. Norman (1994, 32-38) discusses various interpretations, and why it is not easy to decide what was going on among organisms so unlike contemporary forms. McMenamin (1998) bucks the current by thinking most of the odder Ediacarans were unrelated to contemporary forms—cf. Walker (2003a, 257-258n).

[60] Gould (1989, 312-313). Norman (1994, 38) was skeptical of Precambrian burrowing creatures. See Ellis (2001b, 43-44) and Kerr (1998c) on the possible triploblastic trace fossils described by Seilacher *et al.* (1998), and Rasmussen *et al.* (2002) for more recent finds (see also note 235 below). Noting that the current conservative estimate for the appearance of bilaterian animals is about 550 mya (roughly 15 million years 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."

[61] Morris & Morris (1996b, 282) jumped the same faulty conclusion on Seilacher's work as Johnson. The fossil reality was considerably more varied than the truncated creationist version. Emiliani (1992, 432) indicated 68% of the Ediacara biota were apparently cnidarians (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. 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 ~580 mya have since turned up from China, Kerr (1998a) on Li *et al.* (1998).

[62] See McMenamin (1998, 32-37, 146-147) on the pros and cons of *Dickinsonia* and *Spriggina* in relation to annelids and arthropods. "*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). Valentine *et al.* (1999, 854) classify *Dickinsonia* among the quilted Ediacaran biota. 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 (1998b, 105) may represent an eyeless grazing ancestor to the hard-shelled Cambrian trilobites, Parker (2003, 257-259).

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[63] Bengtson & Zhao (1997), Bengtson (1998), Xiao *et al.* (1998; 2000), Gould (1998a), Juan-yuan Chen *et al.* (2000) and Zimmer (2001d, 96-97). 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. The "fully biomineralized" remains of a meter-sized Proterozoic cnidarian (or poriferan) reef-hugger from around 549 mya 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." Cf. Fortey (2000b, 136-140), Schopf (2000) and Parker (2003, 173) on the limitations of fossil preservation and how it affects paleontological interpretation (such as sand grain size re Ediacaran specimens). Kempe *et al.* (2002) describe new microscopy techniques being applied to microfossil analysis.

[64] 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 (2002c) re Anbar & Knoll (2002). Cf. note 70 (chapter three) on chert deposition as depicted in YEC literature. Conway Morris (1998a, 28-29) and McMenamin (1998, 207) contend some Ediacarans lingered on (such as the frond-like *Charniodiscus* evolving into the primitive Cambrian sea pen, *Thaumaptilon*). 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. Kaufman *et al.* (1997) and Hoffman & Schrag (2000) focus on the Rodinian hyperglaciation, which may have involved several cycles—Jon Erickson (1991, 124) illustrates glacial distribution on the continents as presently located. The Paleozoic climate shift 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). See Ward & Brownlee (2000, 102-155), Sarah Simpson (2001a), Lubick (2002) and Gabrielle Walker (2003a,b) on the developing "snowball earth" scenario. 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.

[65] The change to a mass extinction view of the Precambrian was underway by Simpson (1983, 139), with Gould (1998a, 65) or Kerr (2002d) 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.

[66] Conway Morris (1998a, 148-151; 2000b). McMenamin (1998, 226-235) offered a preliminary Ediacaran taxonomy based on a simple set of cell division rules, suggesting future lines of genetic research to resolve their relationship to contemporary fauna; cf. Thomas *et al.* (2000) on the dynamics of "Skeleton Space." Mark Ridley (1997, 262-268, 319-326) included Slack *et al.* (1993) from *Nature* and Wray *et al.* (1996) in *Science* in the Oxford Reader series. Avise (1998, 230n) noted apropos the Cambrian Explosion: "Developmental alterations mediated by changes in regulatory genes almost certainly were involved in these evolutionary transformations." Some additional examples of how the subject arises in the regular scientific literature: Kenyon (1994), Valentine (1994), Carroll (1995), Erwin *et al.* (1997, 135-136), Panganiban *et al.* (1997), Maynard Smith (1998), 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 (2001g, 117-128), Gould (2002a, 1155-1173), Newman & Müller (2002) and Schierwater & Desalle (2002). Meanwhile, *none* of the contributors to Moreland & Reynolds (1999) gave homeobox and development genes a passing glance, let alone think to relate these features to what was going on back in the Cambrian.

[67] 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). How distinctive the Cambrian biota were is an ongoing debate, as Briggs *et*

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al. (1992) and Gee (1992) contend imprecise taxonomy overstated their phyletic disparity. Conway Morris (1998b) got into a deliciously feisty debate with Gould (1998c) in *Natural History*, wrestling over the halkieriid-brachiopod connection en route. Cf. Ellis (2001b. 31-44). 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). Or the more recent jousts over who gets dibs to African anthropology, Roger Lewin (1987), Hellman (1998, 159-176) and Van Couvering (2001). But Gould's death terminated his end of the seesaw, leaving the quite temperate Gould (2002a, 1159) as his final word on his disagreement with Conway Morris (see also note 328 of chapter five for some addenda).

[68] Gould (1989, 59-60). Incidentally, while the phyletic point in *Wonderful Life* was not tempered by his usual proviso that the Bryozoan phylum appeared later, Gould (1998a, 60; 1998c, 52) has stuck to his guns on the Ordovician dating.

[69] Nor did the Cambrian start with the Tommotian. The Cambrian period began about 544 million years ago with an even earlier phase called the Manakayan, which lasted some 14 million years but contained only the most fragmentary of fossil examples, Gould (1994a, 17). Norman (1994, 38-40) described how some of the Tommotian "small shelly fauna" have been attributed to ancestral mollusks and cephalopods, as well as how earlier interpretations of others have been abandoned when more complete specimens have turned up. Palmer (1999, 58-61) illustrates the current take on such early Cambrian life. 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 sample was of the Tommotian fauna, Chien did not call attention either to their pertinence regarding the preservation of early Cambrian life, nor did he 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.

[70] See McMenamin (1998, 258-261) or Parker (2003, 250-254) on the predatory interpretation of the Cambrian Explosion. Of further relevance: the calcareous tubes of the sessile colonial coral-like Chinese 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. Cf. Hickman (2001) discussing defensive shell development in gastropods. Incidentally, the apparent disappearance of *Cloudina* reef communities figures in the calibration of the Precambrian mass extinction (re note 65 above).

[71] Gould (1989, 240-277).

[72] Gould (1989, 263). Johnson missed the gist of the "cone of increasing diversity." Gould (1989, 46-49) stressed that while the *disparity* of life has dropped, its *diversity* has increased: ever more variation on the few surviving body plans. Cf. Peter Ward (1994, 21), Conway Morris (1998, 207), Jablonski (1999, 2116) and Ward & Brownlee (2002, 18, 40-42) on post-Cambrian diversification. Though Wills & Fortey (2000, 1148-1150), and Newman (2001) re the extensive new catalog of Alroy *et al.* (2001), represent qualified demurs, Kerr (2003b) notes the general pattern still holds per Jablonski *et al.* (2003). Cf. 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).

[73] 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.

[74] 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! The taxonomical vacuity of ID and Creation Science (as with the Morrises re note 39 above) may be contrasted with what functioning paleontologists do, from Gould (1989, 210-211, 220-221) and

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Conway Morris (1998a, 181-183) to Budd (2002) variously making sense of Cambrian taxonomy. See also the survey by Glenn Morton (2001). To some extent creationists may be getting into trouble due to their penchant for dated scholarship, mining evolutionary arguments long after they had grown passé in the active science. For example, Hall (1992, 131) called attention to an older view that "the kinds of developmental differences that distinguish phyla and classes should differ qualitatively from the differences that distinguish species and genera." This is just the sort of thinking antievolutionists are disposed to today. Unfortunately, Hall also noted how such conceptions were belied by "empirical evidence to the contrary," citing such work as Henry & Raff (1990) and Wray & Raff (1990; 1991) on 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." Glenn Morton's article called attention to much the same point made by Vacelet & Boury-Esnault (1995, 335) concerning the phyletic placement among the sponges of the curious carnivorous Cladorhizidae; cf. the commentary by Kelly-Borges (1995). Note 85 below picks up on the further genetic trail spurred by such evolutionary clues.

[75] Johnson (1995, 87). His Research Notes offered no trilobite resources—which may be calibrated against Sam Gon's trilobite website (aloha.net/~smgon/ordersoftrilobites.htm).

[76] 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 did declare (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). Raup (1991, 34-35) would be an instance of an evolutionist bringing up the subject.

[77] See Doyle & Lowry (1996, 223-230), Fortey (2000a; 2000b, 84-119), Parker (2003, 216-224) or Sam Gon's website 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."

[78] The section on trilobites in Austin (1994, 144-145) provided by Walter R. Barnhart, Marcia L. Folsom, and Kurt P. Wise is an instance where all the salient information was presented to no effect. Although aware that insect lenses produced blurred vision and that only some trilobites had the schizochroal lens system, their conclusion remained that this was evidence of "an exceedingly brilliant designer!"

[79] Kitcher (1982, 138). Kitcher went on to note the example of *coprophagy* in rabbits, where the animals have adopted eating 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.

[80] Johnson (1995, 90) and Behe (1996, 223-224) danced around this issue, never quite addressing 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. This is not quite an academic issue, given Pat Robertson's June 1998 opinion that Orlando's "gay friendly" policies might bring down on Florida the wrath of God, via hurricanes, tornadoes, or even directed meteor impact. As Johnson castigated Stephen Jay Gould for having "a spectacularly shallow theology" (no examples were given, but Gould was a philosophical agnostic who veers towards a functional atheism), one wonders what depth gauge Johnson would apply to Robertson's foray into "theistic meteorology."

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[81] William Dembski acknowledged the philosophy of this point in a 2001 piece, "Teaching Intelligent Design: What Happened When? A Response to Eugenie Scott" (available at discovery.org), 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." Of course an omnipotence (or something not so omnipotent) could design anything in any way whatsoever, and for any purpose (even a disreputable or stupid one). But how actively Intelligent Design will follow the available physical evidence remains to be seen. For example, John Jefferson Davis, "Response to Howard J. Van Till," in Moreland & Reynolds (1999, 229) thought the idea of God starting up the theistic evolution clockwork long ago and then letting everything run on autopilot an "impoverishment" of divine activity … yet immediately cited as the "prominent examples" of *discontinuity* the origin of life and the Cambrian Explosion—events dating quite obviously a very long time ago. Hadn't anything been done *lately*? Or had the creator closed up shop deep in the Precambrian, skipping off to the next galactic county like Harold Hill in *The Music Man* before anyone could ponder the design implications of whimsies like sickle-cell anemia? More on that issue in chapter four.

[82] 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. David Berlinski's special hairsplitting foray into this subject will be explored in chapter seven.

[83] Little data were available to Gamlin & Vines (1986, 218-219) or even the more recent textbook, Müller (1996, 208-209). 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). When the *eyeless* gene family was first found it was briefly thought that the "master control" gene for eyes had been found, but it soon became apparent (pardon the pun) that multiple genes contribute to the process, such as Roush (1997) re Shen & Mardon (1997) on the *dachshund* gene. *Pax 6* is still one of the most strikingly conserved and powerful of the components, though, as indicated by the ectopic eyes that 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, Barinaga (1995) re Halder *et al.* (1995), Onuma *et al.* (2002). 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." See also 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.

[84] McMenamin (1998, 133) and Ellis (2001b, 10) note the shrimp *Rimicaris* living around geothermal vents: like many deepwater critters, 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

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membrane. See also Van Dover *et al.* (1989) and Pelli & Chamberlain (1989). Now while a creationist may chalk these developments off as yet more providential design, an evolutionist spots the same sort of differential adaptation that characterized the trilobites so long ago (where some had the double lenses, while others did not). The assorted *Rimicaris* species thus function as analogous miniature genetic laboratories, and future study of how such independent sensory systems relate genetically should expose one more facet of the processes governing the appearance of eyes. Cf. Land (2002) re Jinks *et al.* (2002) on a deep-sea crab's degenerate "naked retina" adapted for hydrothermal proximity sensing.

[85] 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 (cf. note 63 above). 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).

Surveying the current array of developmental genes now known to play a role among extant organisms, Erwin & Davidson (2002) argue for a quite simple common ancestor for the Bilateria (possessing mesodermal layers along an anterior/posterior axis, with a two-ended gut and a central nervous system). Tabin *et al.* (1999, 650) noted "there is abundant evidence for continuity in the genetic information for building body wall outgrowths, and/or appendages in several phyla which must date at least to the common, potential appendage-bearing pre-Cambrian ancestor of most protostomes and deuterostomes." Incidentally, this observation did not surface in Wells (2000a, 284) citing the Tabin paper generally under the topic "genetic networks."

More specifically, Ledent & Vervoort (2001, 767) indicate 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. (For further connections on the natural evolution of the bHLH genes, see note 85 of chapter four.) 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. Panganiban & Rubenstein (2002) on the evolutionary implications of *Distal*-less/Dlx homeobox genes in invertebrates and vertebrates, 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 revived now that the actual genetics is becoming known, Gould (2002a, 1116-1122) re De Robertis & Sasai (1996), Bang *et al.* (2000) and Gerhart (2000).

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). Cf. also Dominguez *et al.* (2002) on a curious gilled Carboniferous fossil. 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, Wray & Raff (1998), Martinez *et al.* (1999), Arenas-Mena *et al.* (2000), Cameron *et al.* (2000), and Ferkowicz & Raff (2001). In the "missing the forest for the trees" department, the

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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.

[86] 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). Over in Intelligent Design: Denton (1985; 1998), Johnson (1991; 1993; 1995; 1997; 1998a; 2000), Moreland (1994a), Behe (1996) and Dembski (1999a); Wells (2000a, 51) skated past the issue in a near miss. 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.

[87] McGowan (1984, 76).

[88] McGowan (1984, 69-70). 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). Apropos Chlorophyta: "Most botanists agree that somewhere in this extremely diverse group lie the ancestors of the plants." Subdividing the slime molds into four phyla, the "cellular slime molds" (Acrasiomycota, covering two classes) net McGowan's example; Gamlin & Vines (1986, 43) characterized the cooperative aspect of slime molds as "one of the most remarkable phenomena of the natural world." Ingram (1998, 67-76) describes *Volvox* (with its comparatively recent evolution, during the last 30 million years); Zimmer (2002a) relates it to the larger issue of the origin of multicellularity. Per the theoretical side of the evolution of multicellularity, cf. Pfeiffer & Bonhoeffer (2003) re such work as Velicer *et al.* (1998). A chart in Roger Lewin (1997, 67) shows how the various living eukaryotes may be related based on recent analysis of their ribosomal RNA; cf. Barrier *et al.* (2001).

[89] McGowan (1984. 73-74), citing 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." Meanwhile … 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. 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.* (2003) further indicate the primitive wingless springtails (Collembola) thought basal to insects may have diverged from the arthropod line prior to crustaceans. See also Abzhanov & Kaufman (1999a,b; 2000), Akam (2000) and Budd (2002) on insect developmental biology.

[90] 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). 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; Futuyma (1986, 341) illustrated *Sphecomyrma*. 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. Incidentally, Hölldobler & Wilson's *The Ants* garnered a Pulitzer Prize for general nonfiction (noteworthy for a weighty 600-page technical read). 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. 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.

[91] Gish (1995, 69). Case (1982, 148-168) is illustrative: the oldest was a "quite rare" unknown species of ancestral arachnid from the Silurian, with a later true spider from the Middle Pennsylvanian shown on another plate. An indeterminate species of true dragonfly (order Odonata) from the Late Pennsylvanian was represented by a wing fragment. Shear (1993) recounts newer fossil insect finds, particularly relating to the earliest appearance of spiders. It is of relevance to note that the very first fossil of the primitive mesothele spiders only recently turned up, Selden (1996)—thus expanding that record from zero to 295 million years!

[92] Gamlin & Vines (1986, 81-84, 175, 177) summarize insect evolution and biology, including how the tracheal system limits insect size. Gish's discussion of fossil insects ended with a chart for such early forms as the Palaeodictyoptera and Megasecoptera, along with Odonata, but the text explained nothing about them nor was a source given. Incidentally, Henry Morris (1985, 86) had his own problems with Carboniferous giantism, when he included imaginary "giant ants" among their fauna. No ants of any size are known prior to the Mesozoic, and the largest ones barely top an inch, Haines (2001, 42-45). Morris cited only a dated 1951 *Scientific American* quote declaring insects hadn't changed greatly since the "Oligocene." As the passage appeared to peg that at 70 mya (the term currently applies to a period beginning only about 35 mya), Morris evidently hadn't honed his geochronology before reprinting the statement.

[93] Kritsky (1987) and Ecker (1990, 113-115) survey insect evolution against creationist claims. The giant *Meganeura* was noted by Lambert & The Diagram Group (1985, 60-61) and Dixon & Matthews (1992, 27); Heinrich (1996, 12-13, 18) commented on its metabolic implications in his work on the evolutionary development of insect thermoregulation. The Carboniferous appears to have had especially high atmospheric oxygen content, Berner (1999) and Sarah Simpson (2001b). This may have eased the limitation on early insect metabolism—cf. Wills & Fortey (2000, 1149). Being such an ancient lineage, dragonflies have many features unlikely to be clarified by fossils alone, such as their distinctive mating practices that employ sexual organs located differently in the body segments than in other insects, R. Chapman (1969, 307-318). Denton (1985, 219-220) duly found this arrangement utterly inexplicable.

[94] Futuyma (1982, 66). See R. Chapman (1969, 332-333) on bee stinger anatomy. Insects also adapted existing body parts (evolved in response to the proliferation of seed-bearing gymnosperms) to the later flowering angiosperms, as explained by John Noble Milford, "Long Before Flowering Plants, Insects Evolved Ways to Use Them," in Wade (1998a, 117-122) and Pellmyr & Krenn (2002). For a more icky example of making the most of hardware, courtesy of Heinrich (1996, 73-74), honeybees cool themselves by evaporation after regurgitating nectar onto their head and mouthparts. "The honeybees' mechanism for keeping cool may seem almost bizarre, but it could have evolved as only a slight elaboration of their method for making honey, or *vice versa*." Yellowjackets, while they do not make honey, similarly thermoregulate themselves and their comb by fluid regurgitation.

[95] 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 (2002a, 1165-1169), noting also Warren *et al.* (1994). 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 precursors"—Rich *et al*. (1996, 231-232) illustrates an example, *Stenodictya lobata*. Exactly how early winged

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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. The problem of working out the evolutionary history of insect flight had not been made any easier by the ancillary adaptations catalogued by Heinrich (1996, 3): "sexual signaling by color markings (some dragonflies, grasshoppers, butterflies), sexual signaling by sound patterns (katydids, crickets, some grasshoppers), armor (beetles), mimicry and camouflage (innumerable groups), sailing in the air (very small insects), sailing on water (some stoneflies), flight control by gyroscope-like modifications of the hind 'wings' (flies), shielding against solar radiation (principally beetles, butterflies), and convection baffles (some dragonflies and butterflies)." 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).

[96] Strahler (1987, 404-405), citing McGowan (1984, 76).

[97] 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*.

[98] Gish's reference to "the entire Cambrian can be compressed into a mere five million years" involved a bungled reading of Gould (1994a, 16-17) and others concerning recent radiometric dating. Gould wrote only about the busy "explosion" part occurring over a few million years or so—not that the entire Cambrian covered that time. Gish (1995, 46, 59-60) repeated the mistake, and did so once more in his 1998 debate with Pigliucci (re note 106, chapter one). 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 million years (starting 490 mya), but by the 1980s the Cambrian was pushed clear back to 600 mya. 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 mya (with the Tommotian phase coming at 530 mya) involved a 5% change from the previously accepted figure of 570 mya (when the Cambrian was thought to cover 65 million years). But the start of the subsequent Ordovician has also shifted to 500 mya—meaning the span from the small shelly fauna to Parker's "heterostracan fish" still covers about 40 million years.

[99] Gish (1995, 71, 130).

[100] 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)

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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 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).

[101] Tudge (1996, 96). Dawkins (1986, 242-246) and Dennett (1995, 290-291) affirm that Darwinian evolution is not governed by "constant speedism" impelling relentless change.

[102] 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.

[103] McGowan (1984, 76-78). See Gamlin & Vines (1986, 68, 72-73, 93) on 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). The June 2001 issue of *American Zoologist* has several articles on how *Hox* is involved in their respective development: Hinman & Degnan (2001) on tunicates, Finnerty (2001) on cnidarians, Saló *et al.* (2001) on flatworms, and Burke & Nowicki (2001) on vertebrates. Whitfield (1993, 88), Norman (1994, 50-54), Müller (1996, 66-68) and Fastovsky & Weishampel (1996, 73-75) note the tunicate-vertebrate connection, and Buss (1999) re Stoner *et al.* (1999) cover the rough-and-tumble character of protochordate colonial reproduction. Identifying Cambrian tunicates have been tricky, though a firm one finally turned up, Jun-Yuan Chen *et al.* (2003) contra Shu *et al.* (2001). Pennisi (1996) re Swalla & Jeffery (1996) cover tunicate tail development genes, and simplified forms of vertebrate genes in its genome relate to cell signaling and development, Pennisi (2002e) on Dehal *et al.* (2002). *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. See also Mineta *et al.* (2003) on genes recruited for the central nervous system in planaria.

[104] 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. the concrete examples cited per note 106 (chapter one).

[105] This has been the case from the start. Dingus & Rowe (1998, 134-138) recount how arch-rivals Richard Owen and Thomas Huxley each handled the implications of the first *Archaeopteryx* that came to their attention in the early 1860s. The antievolutionary Owen diligently highlighted every avian feature he could spot, but never compared it to any fossil reptile. 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 Shipman (1998, 29) put it, but doing so by using as exemplar the very Dinosauria Owen had originally named. Creationists have been skating around in like manner ever since.

[106] 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

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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).

[107] 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).

[108] See Hartmut Haubold, "Solnhofen Formation," in Currie & Padian (1997, 676-677) for its geology, fauna and paleoenvironment, and Benton (1996, 88-89) for a tidy summary of the Jurassic landscape with map. Paul (1988, 63, 66) explains why the general absence of bird bits in the Jurassic (unlike the following Cretaceous period, when they are known) makes it unlikely there were abundant birds or protoavians much earlier than *Archaeopteryx*. Chatterjee (1997, 132-135) surveys fossilized feathers and feather impressions.

[109] 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 among the critical reviewers of Davis & Kenyon's *Of Pandas and People* (which included Michael Behe, Stephen Meyer, J. P. Moreland, Norman Geisler and Kurt Wise). 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

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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.

[110] McGowan (1984, 119). Bock (2000, 480, 484) notes a similar dearth of available fossil data.

[111] 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). Paul Taylor (1995, 104) also carefully appropriated Stahl. Taylor, Denton and Gish are among the sources David Buckna riffs off in his antievolution campaign—the secondary nature of which showing in his joust with Jeff Poling (dinosauria.com/jdp/evol/five.htm) when he offered Denton's version of Stahl as the original text. Buckna scores points for 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?" This may be an allusion to Carl Wieland (1988; 1994) from *Creation Ex Nihilo* (available at answersingenesis.org/docs/1201.asp & 1352.asp) drawing on 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 are 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. Wieland also sought to invoke Brush (1996, 140) for an authority quote: "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." A German-language ID site also fielded the Brush quote (posted at 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). But all this apologetics depends on what exactly Brush meant by "scales." The more recent Brush (2000, 633) is relevant, explaining his position that feathers developed from filament-forming "tubercule-like" features (similar to those seen in dinosaurs and living reptiles) rather than directly from "a flat Archosaurian scale." Prum & Brush (2002, 267-269, 284-285) explain the developmental differences between tubular feathers and flat scales, while affirming the homology of scales and feathers at the deeper developmental level of the placode ("an epidermal thickening above a condensation of dermal cells"). The upshot is that the origin of feathers still lies naturally in antecedents, building on one portion of the dinosaurian scaly covering to generate the distinctive tubular arrangement of feathers. 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." Concerning the clear relationship of feathers and reptile "scales" in the broader sense, French paleontologist Taquet (1994, 197) commented: "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." Besides their relevance for feather evolution, Menon & Menon (2000, 551) noted that "retinoids are increasingly being implicated in morphogenesis, homeobox gene transcription, etc." See also notes 159 & 214

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below. Zhou & Niswander (1996), Crowe & Niswander (1998) and Widelitz *et al.* (2000) examine the signaling paths that transform scutellae into feather filaments and buds.

[112] 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." It clearly didn't occur to the Creation Scientist that feather evolution might have added a host of new stages to the substrate that leads to scales in some contexts and feathers in others, as indicated by the more recent detailed evidential surveys by Prum (1999) and Prum & Brush (2002; 2003). See also Prum & Williamson (2001) for a review of 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). See also Shipman (1998, 148-159), Feduccia (1999b, 127-130) and Tudge (2000, 516-518) for airings of the issues.

[113] McGowan (1984, 119-120), though Feduccia (1999b, 130) demurs; cf. Prum (1999, 302) and Prum & Brush (2002, 266). The barbules of a flying contour feather are clearly illustrated in Stahl (1985, 351) or Gamlin & Vines (1986, 112)—which may be contrasted with the stylized barbule depiction in Gish (1992, 67), arrayed with all the regularity of a chain link fence. That Gish might have been aware of a more accurate representation comes courtesy of one of Lucas & Stettenheim's 1972 illustrations, reprinted in Prum (1999, 293), Prum & Williamson (2001, 33) and Prum & Brush (2002, 263), which showed how easily the frayed forward-facing distal barbules snag on the differently shaped ones slanting backwards on the proximal face of the ramus. Very little research has been done so far, though, on the developmental genetics of barbule generation, as noted by Prum & Brush (2002, 291).

[114] 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).

[115] The birds of a feather start with Henry Morris (1985, 85): "*Archaeopteryx* is a bird, not a reptile-bird transition. It is an extinct bird that had teeth." Huse (1997, 150) relied on veterinarian Randy L. Wysong's 1981 book, *The Creation-Evolution Controversy* to declare: "although it has been argued that Archaeopteryx combined certain reptilian and avian characteristics, it is today classified by most paleontologists as a true bird, not a reptile-bird intermediary. This is because each of the features of Archaeopteryx is either found to exist in true birds or is absent in many reptiles." A former Jehovah's Witness, Wysong is a rare example of that domination prominent in the Creation Science movement, as noted by Numbers (1992, 430n). Gish (1995, 129-141) provided the source material for Ankerberg & Weldon (1998, 221): "despite all the claims that

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Archaeopteryx is a transitional form between reptile and bird, that is simply not the case." A few antievolutionists swim against the typological current by trying to sequester *Archaeopteryx* on the reptile side. Milton (1997, 106-108) took that approach, as did Davis & Kenyon (1993, 105-106), 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), they concluded: "Clearly, the characteristics of *Archaeopteryx* are not predicted by Darwinism for a transition between reptiles and birds." If a bird with reptilian features would not be expected by Darwinists claiming birds evolved from them, Davis and Kenyon spared the reader the instructive pleasure of a description of what would. Jonathan Wells' version will be explored in the last chapter.

[116] 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.

[117] 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 Briggs (1991, 136) for fleshed out illustrations of *Archaeopteryx* and *Compsognathus*.

[118] Here one may submit Parker's oblique allusion to Fred Hoyle's hoax theory, in which poor *Archaeopteryx*'s robust furcula was yanked in the opposite direction. Following Lee Spetner in the early 1980s, Hoyle & Wickramasinghe claimed the London and Berlin *Archaeopteryx* specimens were actually 19th century forgeries concocted to bolster the new evolution theory. The irony for Gish concerns how they maintained the feathers had been carved onto otherwise perfectly genuine *Compsognathus* skeletons. Subsequent study quickly blew the hoax idea to smithereens, as recounted by McIver (1988b, 121, 277-278), Shipman (1989), Berra (1990, 41), Fastovsky & Weishampel (1996, 301), Dingus & Rowe (1998, 121-123), Feduccia (1999b, 38-39), or more extensively by Shipman (1998, 141-148). While Answers in Genesis currently lists the *Archaeopteryx* hoax theory among the "Arguments we think creationists shouldn't use," a few creationists have dangled its desiccated remains every so often, perhaps hoping to cast sufficient shadow to cover their moves while *Archaeopteryx* is properly "dereptilized." 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. Morris & Morris (1996b, 67-68) and Harrub & Thompson (2001) try to keep the hoax theory aloft, as did Intelligent Design proponent Stephen Meyer in an opening seminar of the 1998 Whitworth College "Creation Week." Casually tossing off how doubt had been cast on their authenticity, when I stopped Meyer 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?

[119] Lambert & The Diagram Group (1983, 138-141), Simpson (1983, 180-183), and Norman (1985a, 191-193) reflected the skeptical consensus while the dinosaur theory gained steam, compared to promoters like Bakker (1986, 298-322), Dawkins (1986, 101), Futuyma (1986, 335-

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337) or Paul (1988, 352-357). But not long after, Norman (1991, 199) wrote, "At the present time the majority of dinosaur paleontologists (myself included) favor a shared ancestry for theropod dinosaurs and birds probably in the Early Jurassic Period, and therefore support Ostrom's conclusions." Michael Benton, "Dinosaur Summer," in Gould (1993, 146), likewise decided "*Archaeopteryx* is, of course, more dinosaur-like than any living bird, having just evolved from the dinosaurs." 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 this shift has taken 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.

[120] Below that wanted poster, Huse (1997, 89) cited only Henry 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 (2001b, 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 (2002a, 1171-1173). With ironic 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 (1998a, 134-136), Greene & Cundall (2000) on Tchernov *et al.* (2000), and Coates & Ruta (2000). Cf. also Jenkins & Walsh (1993) on legged caecilian fossils. Incidentally, Gish (1995, 112) set his 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 revisions raise the standard.

[121] 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." Edwords (1982d, 3-4) also took Gish to task for the bovine cetacean chimera. While *Creation Scientists Answer Their Critics* did not comment on any of this, Gish (1993, 137) did briefly touch on whales, berating Gould and Eldredge's punctuated equilibrium for being unable to demonstrate their "impossible" transformation from a land animal. As we'll see in chapter four, the joke has a final delayed punch line: just about the time Gish was not responding to Futuyma's criticism, those very whale intermediates were being dug up by a fossil expedition in Pakistan.

[122] 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

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"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 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.

[123] Again, McGowan (1984, 116-117) 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. Paleontologists have since confirmed many theropods had furcula, and the very recent discovery of feathered dinosaurs will be discussed shortly. Lambert & The Diagram Group (1990, 121) listed the archaeopterygid family generally among the theropods; the latest cladistic analyses by Fastovsky & Weishampel (1996, 300-309), Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 71-79), or Dingus & Rowe (1998, 180-194), specifically group them as avian maniraptorans.

[124] 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.

[125] 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).

[126] Ratzsch (1996, 43) included the idea that related species can't coexist on his list of "popular creationist misunderstandings" of evolutionary theory. Because the bird-like dromaeosaurid (a.k.a. maniraptorans) and troodontid dinosaur families come from the Cretaceous period, after the Jurassic archaeopterygids, a reasonable prediction can be made regarding how future editions of Gish *et al*. will adapt the "descendants living before ancestors" argument. As we'll see in the last chapter, Intelligent Design theorist Jonathan Wells does exactly that in his critique of evolutionary biology textbooks. For a reality check: Philip J. Currie, "Theropoda," in Currie & Padian (1997, 734) noted small theropods are scarce in Jurassic rocks to begin with, but that both families "are represented from well-preserved skeletons from Lower Cretaceous rocks, and Late Jurassic dromaeosaurid and troodontid teeth have also been reported." Cf. Dodson (2000, 506, 509). A basal troodontid has turned up from the Early Cretaceous, Xu *et al.* (2002)—and a fragmentary therizinosaurid coelurosaur is known from the Early Jurassic, Zhao & Xu (1998). Since at least one Cretaceous therizinosaur possessed proto-feather integuments, Xu *et al.* (1999a), that taxon apparently lies fairly close to the stem group for birds; cf. Prum & Brush (2002, 278-279). Incidentally, Paul (1988, 357-360) suggested that the Cretaceous maniraptorans might have evolved from the earlier flying archaeopterygids, rather than the other way around—a theory pursued at greater length in Paul (2002). That would have made the maniraptorans' retention of deadly grasping arms an interesting exception to the trend among later flightless birds, where the limbs grew functionally useless. The recent discovery of the tiny *Microraptor* by Xu *et al.* (2000)

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has stirred up this pot however, 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). See also note 161 below.

[127] The three bones of the vertebrate pelvis (which end up fused together and keep you from dropping through your legs) are configured a lot like the Greek letter pi, *Π*, where the top is the *ilium* bone, and the branches are the *pubis* in front and the *ischium* behind. 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.

[128] 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).

[129] The reverted pubis is clearly visible in the skeleton of *Deinonychus antirrhopus* illustrated in Norman (1985a, 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.

[130] 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 (1985a, 37) showed how the related muscle attachments facilitated dinosaur locomotion. While the saurischian 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.

[131] Gish (1995, 132), citing a 1994 *Discover* article on the new *Archaeopteryx*.

[132] Shipman (1998, 45). See also Feduccia (1999b, 77) and Elžanowski (2001).

[133] 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 (1985a, 192) indicates. From the dates of his sources, Gish was barely catching up with the literature available when he'd written his 1985 version. Samuel Tarsitano's 1980 criticism of

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the dinosaur theory was a case in point. 1990s paleontologists weaned on cladistics, like Fastovsky & Weishampel (1996, 309), were unimpressed by his argument because it did not actually contest the anatomical similarities, but only held them to be examples of evolutionary convergence (forms of different lineages appearing alike due to shared environment or lifestyle). For cladists, disregarding so many specific and varied relationships violates their principle of "parsimony"—a concept also prominent in genetic analysis, Roger Lewin (1997, 49-51). Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 72) criticized the various thecodonts (a paraphyletic grab bag which has far fewer shared characteristics) proposed by Tarsitano on these parsimonious grounds. Cf. Dodson (2000, 508-509) on "parsimony" and Sumida & Brochu (2000, 488-490) on thecodonts for contrast. Feduccia (1999, 86-87, 89, 133-135), Geist & Feduccia (2000, 669-673) and Tarsitano *et al.* (2000, 682) offer the Late Triassic thecodont *Megalancosaurus* as an illustration of the sort of arboreal form they believe birds developed from. Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 72) represent a minority interpretation of it as actually an *aquatic* form. The disputes range broader still re Feduccia (1999, 86-88, 93-96, 133-135) and Jones *et al.* (2000) on the vaned spines of the curious Triassic reptile *Longisquama*. 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 (2000b) and Sumida & Brochu (2000, 490-492). Cf. Prum & Brush (2002, 267, 282-283). One may view *Longisquama* illustrated as a glider in Wellnhofer (1991, 177). Until that dust settles, the witty conclusion of Fastovsky & Weishampel (1996, 321) is likely to prevail: "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!"

[134] 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).

[135] See Wellnhofer (1991, 155-158), Kevin Padian, "Pterosauria," in Currie & Padian (1997, 615), Unwin (1999), Geist & Feduccia (2000, 669-670) and Monastersky (2001a, 94) on the debate over pterosaur quadrupedality.

[136] One can approach this from several angles, since scientists interested variously in bats, birds, or pterosaurs, readily compare their specialty with the anatomy of the other two. Examples would be Hill & Smith (1984, 50-51), Shipman (1998, 41-44), and Wellnhofer (1991, 178-183).

[137] See Fastovsky & Weishampel (1996, 295-296, 300-301, 305-306), Kevin Padian, "Bipedality," in Currie & Padian (1997, 68-70), Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 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 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?"

[138] 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).

[139] 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,

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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).

[140] 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!

[141] 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. See also Müller (1996, 190-193) or Riddle & Tabin (1999) on what is known of avian wing development at the genetic end, which involves several interacting genes, including one wryly named *sonic hedgehog*—who says scientists don't have a sense of humor? (Cf. note 212 below, as well as 135, chapter three, re alanine coding.) The issue may yet be resolved from the genetic end, though, Sumida & Brochu (2000, 492-493) and Prum (2002, 7-9). Wagner & Gauthier (1999) suggest a DNA reading "frame shift" may have resulted in a digital reassignment at some stage in the game, though not without some contrarious commentary by Feduccia (1999a). Cf. Feduccia's similar exchange 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).

[142] Henry Morris (1985, 85). Similar sentiments surface in Sunderland (1988, 78, 87), Wendell Bird (1989, Vol. 1, 283n), Gish (1990, 60; 1995, 138) and Hanegraaff (1998, 173-174n).

[143] 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, 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). Cf. also Holden (2000a) on tentative dinosaur DNA.

[144] The role call: Henry Morris (1985), Morris & Parker (1987), Wendell Bird (1989), Sunderland (1988) and Gish (1990; 1992; 1993; 1995) on the YEC side; Denton (1985), Hayward (1985), Davis & Kenyon (1993), Milton (1997) and Wells (2000a) orbiting ID; Huse (1997). Ankerberg & Weldon (1998) and Hanegraaff (1998) pulling up the rear. All discussed *Archaeopteryx* and bird evolution without noting this experimental induction of teeth.

[145] Johnson (1995, 228), re: Gould (1980, 19-26). Gould's first name was correctly spelled in the body of the text, Johnson (1995, 90). 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.

[146] 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.

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[147] Davis & Kenyon (1993, 105) veered the closest, acknowledging that *Archaeopteryx* had teeth "like some later fossil birds such as *Hesperornis* of the Cretaceous Period."
[148] Gish (1995, 138), again citing Martin *et al.* (1980). Cf. Thomas Huxley's 1876 view of *Hesperornis* and *Ichthyornis* in Huxley (1893, 93-100).
[149] 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*.
[150] 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, Gish (1992, 81) invoked *Baryonyx* as the dragon slain by St. George.
[151] 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 a 1990 *Scientific American* article by Peter Wellnhofer, 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. The seemingly contemporary Milton (1997), Huse (1997), Ankerberg & Weldon (1998), and Hanegraaff (1998) manifested their zeal by not discussing the newly discovered Cretaceous flock at all. The Wells (2000a) version will flutter by in the last chapter.
[152] 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) possessed sickle-shaped maniraptoran-style foot claws, Sampson *et al*. (1997, 24-26) and Krause (2000, 54)—though with demurs by Geist & Feduccia (2000, 666-667) on Forster *et al.* (1998).
[153] 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.
[154] 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 indicate underlying metabolism). Cf. Chinsamy & Elzanowski (2001) on avian & theropod bone histology. Interestingly, pterosaurs (neither dinosaurs nor birds) appear to have developed some

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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).

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). See Chiappe & Dyke (2002) for a current survey of the 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. 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.

[155] 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*). *Troodon* is shown feathered in Palmer (1999, 118), and Larson & Donnan (2002, 315-319) explain the rationale for a feathered *T. rex* chick. 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.

[156] See Chiappe (1998) for the Spanish finds, and Stokstad (2002c) on a recent Chinese example described by Zhou & Zhang (2002). Regarding Chinese stratigraphy, uncertainty about the Jurassic-Cretaceous boundary has carried over into a dispute about dating the early toothless Chinese bird, *Confuciusornis*, described by Hou *et al.* (1995; 1999). Opponents of the dinosaur theory, such as Alan Feduccia, prefer to stick with the original Late Jurassic identification (145 mya), while subsequent work with the deposit has supported an Early Cretaceous dating (125 mya), Swisher *et al.* (1999) and Barrett (2000). For particulars on the controversy, see 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).

[157] 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).

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[158] 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 (1997b) to dispose of all the Chinese feathered theropods, evidently unaware this particular dispute only concerned the strange *Sinosauropteryx* filaments.

[159] Morris & Parker (1987, 139), or Hanegraaff (1998, 38-39) secondarily—cf. *Caudipteryx* and *Sinosauropteryx* in Ackerman (1998, 74-75, 82-83). 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) and Martin & Czerkas (2000, 690-691). Gould (2000c) assesses the early flightless bird theory. 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 mya): 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. Particularly noteworthy is the chemical analysis of the feathery filaments preserved on a Cretaceous alvarezsaurid, showing the decay products distinctive of β-keratins, Schweitzer *et al.* (1999). Interestingly, a putative quilled psittacosaur tail has been found, Steghaus-Kovac (2002)—though smuggled from the same problematic region as the faked *Archaeoraptor liaoningensis* covered note 53 (chapter five). If confirmed, this would put some integumentary structures on the ornithischian side of the dinosaur fence. See Gee & Rey (2003, 102) for how these might have related to the living animal.

[160] Particularly puzzling is *Mononykus*, an early flightless bird (or was it an extremely birdlike dinosaur?) with weirdly shrunken forelimbs resembling those of a mole, and so possibly used for digging. Due to the rules of priority the spelling of the name 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. 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).

[161] Norman (1985a, 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, 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 (2002a). There was evidence that the small feathered *Microraptor* may have been an arboreal dromeosaurid, and recently some amazing fossils have turned up indicating it was feathered on both front and hind limbs, as well as its tail, opening the possibility that *Microraptor* could have been a glider, like a dinosaurian flying squirrel. See the December 6, 2000 reports by the BBC (bbc.co.uk/1/hi/sci/tech/1058475.stm), *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 (2003a) & 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 (January 28, 2003). 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 (2003a) 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.

[162] Johnson (1991, 78). As the text was in one of his explanatory footnotes, it may have been a late inclusion in the text. There were neither references nor subsequent elaboration there, or in his later books, concerning either the find or the dispute over its significance.

[163] 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).

[164] 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.

[165] Parker's reference was to Beardsley (1986).

[166] 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

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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."

[167] 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.

[168] 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*.

[169] The context of Jensen's find and the fossil bed itself are covered by Kevin Padian & Luis M. Chiappe, "Bird Origins," in Currie & Padian (1997, 78) and Brooks B. Britt & Brian D. Curtice, "Dry Mesa Quarry," in Currie & Padian (1997, 196). Dingus & Row (1998, 213) regard the femurs as suggesting the presence of nonflying maniraptorans.

[170] 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 million years. 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.

[171] 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 bibliography duplicated Sunderland (1988, 184-188). Among them were obscure items Sunderland used to support his own arguments, but which Huse never cited at all. Two were to a 1978 book and its review by Lombard (1979) in *Evolution*. Huse's citation exactly matched the listings in Sunderland, right down to the jumbled name and inaccurate date of "1980" for the Lombard piece (see note 206 below). Huse is thus a splendid example of scholarly parasitism, albeit an indiscriminate and untidy one.

[172] Alun Anderson (1991), 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, as noted by 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).

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[173] 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.
[174] Alun Anderson (1991).
[175] Gish (1995, 137). There were three footnotes. The first paragraph cited Beardsley's *Nature* piece, Monastersky (1991) and "Alan" Anderson (1991)—the condensed secondary Hanegraaff (1998, 35, 174n) copied Gish's version right down to the misspelling. The "Alan" Anderson citation has floated around independently of Gish, as with Harrub & Thompson (2001, 30-31) and their rejoinder to Rennie (2002b) at apologeticspress.org/docsdis/2002/dc-02-sa13.htm—which leaves open the scholarly possibility that Gish had drawn on the "Alan" article secondarily himself. 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 the critical *Discover* one, where they would have been more relevant.
[176] 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. A studied disinclination to investigate the mounting flock of Cretaceous fossil birds has afflicted those who have played the *Protoavis* card more recently, such as Paul Taylor (1995, 42, 104). Though YEC believer Jon Covey did manage to spell Alun Anderson's name correctly in his mid-1990s version (cited in note 168 above). The final unqualified chirp in this avian tale comes from the always-amusing Milton (1997, 108), citing only Chatterjee's Royal Society report as confirmation that "true birds, essentially the same as modern birds, were flying happily in the skies of Texas" back in the Triassic. Until Chatterjee describes the rest of his sadly mashed fossils in peer-reviewed literature, paleontologists are wary of taking *Protoavis* seriously. See Fastovsky & Weishampel (1996, 298), Luis M. Chiappe, "Aves," in Currie & Padian (1997, 32), Dingus & Rowe (1998, 192), or Shipman (1998, 112-113), as well as Feduccia (1999b, 38, 398-399).
[177] The text remains in the 20th printing from 1996, Henry Morris (1985, 122). The *Science Digest* piece was a short anonymous comment (November 1968, p. 1) on a picture of a long-necked birdlike figure that resembled a heron more than *Archaeopteryx*. One of the few creationists to follow Morris in Mayan art appreciation was Randy Wysong, whom Huse (1997, 63) cited as justification 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." "The Scholar's Lighthouse" (hislight.com/support/creation-evolution/mandino.html) added to the misinformation daisy chain by swallowing Huse's version of Wysong's acceptance of Morris' overplaying of *Science Digest*.
[178] Futuyma (1982, 179) and McGowan (1984, 107). Gish (1993, 73-74) nonetheless fumed over evolutionists like Futuyma and Niles Eldredge who regarded Creation Science as a gathering of incompetents and liars.
[179] Johnson (1991, 79).
[180] Denton (1985, 195).
[181] Denton (1985, 180-182). Wendell Bird (1989, Vol. 1, 220-221) followed Denton's reasoning.
[182] I brought this comparative anatomy example up with Phillip Johnson in a 1998 e-mail exchange, but he didn't remark on it.
[183] 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

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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, 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. For example, Camp followed the "fully formed" appearance theme by quoting Carroll (1988, 193), "The earliest known amniotes are immediately recognizable because of similarities of their skeleton to those of primitive living lizards." Camp did not quote the preceding sentence: "In sharp contrast with the fossil record of amphibians, modern amniotes are linked to their Paleozoic ancestors by a relatively complete sequence of intermediate forms." Thus those identifications could be made precisely because of their distinctive resemblances.

Other of Camp's selective quotations was the first sentence of Carroll (1988, 397): "The transition between pelycosaurs and therapsids has not been documented. It may have involved an environmental shift as well as changes in morphology and physiology. The therapsids are already quite diverse when they first appear in the Upper Permian of Russia." As Camp did not discuss the available deposits and their relation to the continental distribution of these forms, this was yet another reliance on the Bermuda Triangle Defense.

Source parallels between Camp and Hunter 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, William Dembski and Stephen Meyer populate the back cover of *Darwin's God* with praise.

[184] Johnson (1991, 13).

[185] 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

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antidotes to the tired old creationist claim that the fossil record reveals no transitions between 'major kinds.'"

[186] 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). 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.

[187] Stahl (1985, 293-295). Though their core anatomy obviously betrays their separate lineages, the musculature and adaptations of tuna and some sharks have converged to a remarkable degree, Summers (2004) re Donley *et al.* (2004).

[188] 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. Benton (1990, 250-251) relates 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 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.

[189] There were several spots in Johnson's book where the issue of anatomical convergence might have come up, but didn't. Homology was mentioned on page 65, but no specific examples were given. There was a quote (page 70) 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 the *Coelacanth* or the amphibian *Seymouria* (pages 74-75) did not actually put the argument in convergent terms. Finally, "convergent evolution" was not among Johnson's index topics. (For a tantalizing clue to how Johnson may have come to his convergent conclusions, see note 222 to chapter four.)

[190] 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 remark (and a statement on the mysterious origin of insects) turned

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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 Bert Thompson (1995, 26) sufficed with a fast jab. 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. The background for Creation Science confusion here partly lies in the peculiar history of French science, as outlined 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.

[191] 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 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.

[192] 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.

Simpson (1953, 348) remarked how "numerous lineages of therapsid reptiles were all changing adaptively in a mammal-like direction. Paleontologists use the arbitrary criterion that a reptile became a mammal when a dentary-squamosal joint developed and the functional jaw movement ceased to be on the articular-quadrate joint. This line was probably crossed separately by at least five different lineages (leading to monotremes, multituberculates, triconodonts, symmetrodonts, and panthotheres, although it is just possible that two or three of these early differentiated from a single crossing of the lines; there may have been some other late Triassic-early Jurassic crossings with early extinction)."

A lot more data had accumulated in the third of a century after Simpson's observation to clarify the branches. Thus Hopson (1987, 24): "given the known imperfections of the fossil record, the correlation between degree of advancement toward mammals and time of appearance is surprisingly high." Likewise Radinsky (1987, 7-8) on the congruence of a cladistic assessment with the fossil sequence. Cf. also 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. This will be seen in later chapters concerning the predatory

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"carnosaurs" among theropod dinosaurs, whether the dog-like mesonychids are closely related to whales, as well as sorting out the finer points of elephant ancestry.

[193] 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).

Gould (2002a, 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."

Dodson (2000, 506-508) offers similarly wary comments about cladism. See Gamlin & Vines (1986, 32-33), Whitfield (1993, 176-177), Fastovsky & Weishampel (1996, 51-54. 61-63, 70, 90) or Tudge (2000, 33-62) for the origin of the technique and illustrations of how cladistics is applied to an evolutionary context (a useful set of online links are available at devbio.com/chap22/link2205.shtml). Lee (1998), Sereno (1999a) 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). Such issues also play a role in the debate over whether Archaebacteria constitute a separate domain of life (re note 31 above). Hagen (2003) surveys the often bumpy process of applying mathematical analysis to systematics.

To see what potential typologists are up against, consider that the "Character description and systematic distribution" of 275 features Luo *et al.* (2002, 48-78) used to evaluate early mammal relationships required *thirty-one pages* of double-column fine print. This may be compared to the fluffier Cornelius Hunter (2001, 40-41) claiming that independent cladistic 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. The steel, plastics and paints used by given car 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 relationships 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. Cf. also notes 230-233, chapter four, on the brief creationist hope that cladistics marked a return to nonevolutionary systematics.

[194] 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

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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.)

[195] 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.

[196] 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.

[197] 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.

[198] 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, and Czerkas & Czerkas (1991, 119) for an evocative painting of what the living (and quite furry) *Diarthrognathus* probably looked like.

[199] 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 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 136, chapter five).

[200] 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

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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.

[201] Similarly to Johnson, Hoyle & Wickramasinghe (1993, 158-159) dismissed the synapsid ancestry of mammals solely on the grounds that "the genetic material of a mammal is grossly different from that of a reptile." Here 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.

Johnson and Hoyle & Wickramasinghe's views were glossing over the actual range of mammalian variation, such as the urogenital system that differs significantly among the egg-laying monotremes, the marsupials and placentals, Lambert & The Diagram Group (1985, 156) or Colbert & Morales (1991, 241). Cf. also Dunbar & Barrett (2000, 74) on primate specialties. Although creationists don't dwell on this sexually explicit subject, we'll see shortly that evolutionists focus on these clues to the ancestral mammalian system. But even extant reptile metabolism is far from uniform, as noted by Lambert & The Diagram Group (1990, 178). Crocodile hearts are intermediate between basal reptiles and birds, and their sprinting and aquatic Mesozoic forms suggest modern crocodiles are the less-adventurous remnant of a once more physiologically diverse lineage; cf. Ellis (2001b, 159-166), Schweitzer & Marshall (2001, 322, 326) and Zimmer (2001b). See Burggren (2000) on the diversity of vertebrate hearts, and Zimmer (2000b) for the latest thinking on their underlying evolutionary development. Finally, 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.

[202] 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. See note 126, chapter three, for more on the "anapsids" and turtles. 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).

[203] 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.

[204] 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).

[205] Gish (1995, 151). This was not a notable improvement over Gish (1978, 81).

[206] 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

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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. Much like Daniel Lapin on Ernst Mayr (see note 136, chapter five), Stark waded into a broad issue without grasping the details (cf. note 183, chapter four). "Perhaps the most amazing aspect of the current situation is that while Darwin is treated as a secular saint in the popular media, and the 'theory' of evolution is regarded as the invincible challenge to all religious claims, it is taken for granted among the leading biological scientists that the origin of species has yet to be explained." He then quoted the reviewer (whose name he slightly misspelled as "Szathmaŕy") that Schwartz had not "in general" provided a solution to the species problem. What Stark had missed were the details of Szathmáry's review. 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 (such as Sheldon's trilobites, re note 212, chapter four) that would not have required Schwartz's model.

Without comparing the views of any creationists (such as Duane Gish or Kent Hovind), Stark (2003, 124, 394n) generally raged at "strident evolutionists being as unscientific as *any* fundamentalists" and classifying evolutionary theory as "arrogant occultism." Stark (2003, 123) grumped: "From Thomas Hobbes through Carl Sagan and Richard Dawkins, false claims about religion and science have been used as weapons and science to 'free' the human mind from the 'fetters of faith.'" Stark did not discuss what these "false claims" might have been. There were there no source notes for the paragraph, and none of Stark's bibliographic listings for Dawkins (such as *The Selfish Gene*, *The Blind Watchmaker* and *Climbing Mount Improbable*) or the lone Sagan (1975) citation pertained to this issue. Stark (2003, 455) did list a "Ross, Thomas W. 1985. 'The Implicit Theology of Carl Sagan.' *Pacific Theological Review* 18:24-32," but didn't allude to it in either text or notes.

[207] 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.

[208] 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,

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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.

[209] 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.

[210] 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.

[211] 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 (2001b, 176-182) describes sirenian diversity.

[212] 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).

[213] 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). 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.

[214] 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

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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. A clue to the diverging role of keratin concerns how skin buckles: reptiles turn outward (evagination), producing scales and feathers, while mammals fold inward (invagination), generating glands and hair, Oster & Alberch (1982). Cf. Prum & Brush (2002, 289) on how such contingent differences participate in (and constrain) the generation of evolutionary novelties like feathers. On the DNA end, a variety of genes participate in the developmental biology of both hair and feathers: BMP receptor expression, *sonic hedgehog* and TGF-β2, 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). Harris *et al.* (2002, 160), affirm "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).

[215] 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).

In contrast, those rare creationist works that touch on the subject are more eccentrically illustrated. Gish (1995, 164-166) showed on separate pages full skeletons of *Dimetrodon* and *Sphenacodon* and the skull of a therocephalian, *Theriognathus*, examples well back on the therapsid line of descent—but none of the later forms relevant to the jaw-ear shift. (Had he cared to misidentify them, at least we knew Gish had a couple spare "mammal" labels.)

As for Davis & Kenyon (1993, 120), their coverage of the jaw/ear shift was a thorough muddle. Declaring "there is no fossil record of such an amazing process," they 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.

[216] As McGowan (1984, 139) and Hopson (1987, 18) mentioned this item, 1990s creationists 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 (1999a, 577), Shigetani *et al.* (2002), and Koentges & Matsuoka (2002) re Depew *et al.* (2002) track the progress of

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research into the genetics of vertebrate jaw evolution. 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.

[217] Huse (1997, 89). No citations were offered to support Huse's statement.

[218] 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 at all—nor (apart from the Wise ricochet noted below) did any of the antievolutionists in Moreland (1994a) 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 (1999a) 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*.

[219] Doug Bandow (1991). Bandow is the author of *The Politics of Plunder: Misgovernment in Washington*. "Johnson lacks a technical background," observed Bandow, "but he makes up for that deficiency with his ability to deconstruct poor reasoning." 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).

[220] 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 (2001a, 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.

[221] 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).

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[222] 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 flap over 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 a larger audience with this information.

[223] Johnson (1993b, 208-209).

[224] 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. Adding to the mess, Johnson relied on this very distinction when defending Cambrian uniqueness in his June 18, 2001 "Weekly Wedge Update" at the Access Research Network website. Johnson 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. The context concerned criticism he was leveling at Ohio State University evolutionary biologist Steve Rissing, accusing Rissing of misreading the contents of a scientific paper. (More on the Rissing matter in chapter six.) William Dembski has also tried to play both sides of the Cambrian paradigm fence. Among the platoon of straw men targeted by his 2002 piece lampooning "Evolutionary Logic" (available at arn.org/docs/dembski/wd_evolutionary_logic.htm) were evolutionists who reference "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." He offered no examples … nor noticed the applicability of the charge to his own ID compatriots.

[225] 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. (More on Wells' textbook critique in the concluding chapter.) 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. Yet I couldn't help comparing this with 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.

[226] 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. Because there is no indication that antievolutionists have ever conceptualized what a "type" or "kind" involves, or what a Darwinian "branching tree of life" would look like at the evidential level, there is no actual framework in their own thinking by which the competing models might be compared. Toss in some vigorous Zeno-slicing, and the creationist has all the apologetic thrust necessary to render any evolutionary patterns undetectable.

[227] 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.

[228] 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.

[229] Since I wanted to observe how he responded to the problems themselves without ideological context my original e-mail messages were carefully composed so as not to intimate whether I was in agreement with creationism or evolution. Johnson assumed by my polite curiosity that I was a fellow traveler, for he promptly invited me to undertake the typological study of the dinosaurs I had mentioned—thus inadvertently illustrating my point that such creationist analysis did not exist, otherwise he could have simply directed me to them. The Creation Scientist Kent Hovind likewise took the lack of rudeness in a similar questioning letter as sign of agreement with his views, a misapprehension I did subsequently disabuse him of too.

[230] 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."

[231] Phillip E. Johnson, "Foreward," in Moreland (1994a, 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 (1994) and Valentine (1994).

[232] Kurt Wise, "The Origin of Life's Major Groups," in Moreland (1994a, 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 asinine 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 254 (chapter six) 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.

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[233] 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 (2002e) on work reflected by Marshall Graves (2002). Cf. John & Surani (2000) on monotreme genetics, and Disteche (1999) re Carrel *et al.* (1999), and Vogel (1999c) re Lahn & Page (1999) on the dynamics of the X and Y chromosome (issues that will resurface in chapter five concerning the debate over the tracing of 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 mya 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. A slippery "Science" citation courtesy of Phillip Johnson and Michael Behe will be explored in chapter four.

[234] Norman (1994, 59).

[235] Margulis & Schwartz (1988, 216-218). Cf. Lambert & The Diagram Group (1985, 54), Eldredge (1991a, 101-102), Rich *et al.* (1996, 239) or Ellis (2001b, 54-55). 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 the cursory discussion of mollusk evolution in Gish (1995, 63, 68) either, which 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 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,

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3023-3024). Walker (2003a, 213-215) notes newer evidence relating trace fossils to *Kimberella*, which would suggest a more complex metazoan locomotion for it.