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Original Biomaterials in Fossils

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Abstract

Characterizing and understanding original tissue fossils holds great interest because of what these fossils imply about the incongruous timelines that help define biblical creation versus evolution. General expectations suggest, and repeatable lab experiments demonstrate, that biomaterials original to fossilized organisms have a finite shelf life. Tissues in fossils confront evolutionary time. This article reviews generations of research that have exposed and explored original biomaterial fossils, establishing beyond reasonable doubt the reality of endogenous fossil tissues as a genuine feature of Earth layers. It also surveys original biomaterial fossils in geological context and updates both the secular and creation-based research status of this science. We conclude that original biomaterials found throughout the fossil record confirm the biblical timeline of Creation-Flood geology.

Introduction

The broadest definition of a fossil as the remains of a once-living organism ranges from a partly rotten carcass to a solid, mineralized body part. However, even the typical professional scientist seems to understand fossils almost strictly in terms of hard body parts or rare impression fossils such as prints or casts found as solid rock. Supposedly, shells and teeth preserve most readily, and bones preserve if replaced by minerals in a process called secondary mineralization. This common and widespread understanding leaves little room to expect fossils to still retain original bone mineral bioapatite, let alone other, softer body tissues to have persisted without having been mineralized. And yet such soft parts, or at least their partially decayed remnants, have been described in technical literature for decades.

First, however, clarifying certain terms clears verbal clutter that might otherwise cloud this discussion. The phrase "soft tissue" carries ambiguity, since it is found in secular literature descriptions of mere impressions, like casts or molds in solid rock matrix—even though these may have no organics endogenous to the organism that left its imprint. For example, a dinosaur footprint preserved the "soft tissue" outline of a dinosaur's foot, but none of its original biochemistry. These "soft tissue" impressions are of less interest to the question of evolutionary time, since the minerals of which rocks are composed are much more resistant to chemical decomposition than bodily organics.

For this reason, we propose using the phrase "original biomaterials" to refer to the many instances of virtually unaltered organic residue found in fossils. By "original" is meant that the organic material described from within the fossil came from the organism that occurs as a fossil, and did not somehow originate from an outside, perhaps more modern source that then carried the organics into the fossil. In other

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words, "original" opposes "contaminant." "Biomaterial" seems broad enough to convey all the range of fossil organics described in paleontological literature, from the tiny vitaminlike chlorophyll molecules that pervade shale and were original to algae, to whole or nearly whole mastodon carcasses found too deeply buried in permafrost for even wild, starving dogs to access its ancient flesh. There is somewhere in the literature an example of probably every point in the fossil biomaterial continuum that ranges from an entire large animal to the last partly intact biochemical from long-buried animals or plant. Of greatest interest to origins discussions are those original biomaterial fossils with the highest integrity and which are found in the lowest rock layers. Indeed, rock types from all geologic "eras" contain original tissue fossils.

Why does this investigation matter? In brief, the outcomes can help adjudicate between two timelines and the two paradigms that they represent. Evolutionary time posits that billions of years, while biblical creation maintains that only thousands of years, have elapsed since the formation of fossiliferous Earth materials. If original biomaterials can be shown to last for hundreds of millions of years, then their discovery in the field does not discern between these two paradigms. In that case, either perspective could accommodate the data. But if original biomaterials can be shown to last no more than hundreds of thousands of years, then their many discoveries and descriptions exclude evolutionary time while confirming the Bible's timeline. For this reason, the first section of this paper identifies studies on the decay rates of two biomaterials that have been reported in several fossils. If repeatable science establishes that biomaterials could not last through deep time and that original biomaterials occur in fossils, then it opposes the now iconic evolutionary timeline, even as many other sciences already do.

Protein and DNA Decay Rates

Merely an intuitive sense of how short a time vertebrate body tissues should last, even ensconced in sedimentary rock, prompts puzzling questions from those of both creationary and evolutionary perspectives. Few anticipate that biochemicals and even whole tissues could last any longer than perhaps 1,000 years. On this basis, the evolutionist must answer the question of how original biomaterials could last for tens of millions of years. But again on this basis the biblical creationist must answer the question of how original biomaterials could have lasted since Noah's Flood, over four to five millennia. It would seem on the surface that this fossil evidence entangles both paradigms. However, research on biomolecular decay rates supplies objective data that erase this creationist question but sharpen the evolutionary dilemma.

Collagen Decay

Collagen occurs in all multicellular animals, and is the most abundant protein of vertebrates. Repeated experiments accelerate bone collagen decay under high temperature, obtaining a rate that can then be converted to a decay rate under reasonable earth surface temperatures, ultimately supplying a maximum expected lifetime for that molecule. At 90°C, collagen in bone decays almost completely after a month. Several bioanalytical techniques have been used to assess the integrity of collagen at points throughout the experiment. Each begins by dissolving bioapatite in weak acid buffer. The overwhelming prevalence of collagen in bone is intensified during fossilization because of its insolubility in water. Thus, demineralization of fossil bone can yield a high purity of collagen. In one technique, the collagen thus separated is first weighed, then thoroughly desiccated before reweighing. Subtracting the two mass values reveals the protein's tendency to lose water weight, a correlative to its integrity. As the collagen molecule disintegrates over time, the numbers of water molecules it can absorb decreases until no collagen structure remains and hence no water is retained.

Alternatively or in addition, bone collagen fractions collected from different decay times can be run on an SDS-PAGE gel that separates molecules by molecular weight. Except for a spike in the first few days of the typically one-month experiment, the longer collagen is held under 90°C, the more it degrades, and thus shortens. Shorter proteins have lower molecular weights and travel further through the SDS-PAGE gel pulled by the same voltage. After a month at 90°C, these gels reveal collagen extracts that have degraded to tiny peptides and individual amino acids, as confirmed by comparison with proteins of known molecular weights.

Resulting decay rates are then converted using a version of the Arrhenius equation into rates that are based on much lower temperatures (Thomas, 2013). The principle at work behind this conversion describes a degradative reaction based primarily on chemical kinetics, such that an increase in temperature also increases the occurrence of molecular collisions and thus the chemical reactions that break down biomaterials like collagen. However, at certain temperatures cross-linking occurs, producing a new and resistant material (see discussion below regarding kerogen). Accordingly, bone collagen held at a steady annual temperature of 10°C will completely disintegrate under the best possible preservation conditions after 300,000 to 900,000 years (Buckley et al., 2011). Expressed another way, Collins and colleagues have determined a half-life for bone collagen at 7.5°C of 130,000 years (Buckley et al., 2008). We can solve the standard logarithmic decay half-life equation for time (t) until collagen decays to 1%, at which point it is no longer detectable and in practice no longer recognizable as collagen.

$N = N_o e^{-\lambda t}$, Where N is the number of intact (or still-detectable) collagen molecules after time (t), N_o is the number of original collagen molecules, e is the base of natural logarithms, and λ is ln 2/ half-life. Setting N to $0.01N_o$, t = 8.64 X 10^5 years—fewer than one million years at 7.5C, the average temperature in Montana where the most famous dinosaur proteins were recovered (see below).

This experiment-based decay rate of collagen was determined by archaeologists who investigate materials they believe date from tens of thousands of years ago, and not paleontologists who work with material they have age-dated by biostratigraphy at tens or hundreds of millions of years. So when these archaeologists heard about original dinosaur protein, they of course rejected its veracity on the grounds that collagen could not have lasted since the Mesozoic. Thus, this illustrated how known science accounts for the persistence of bone collagen for thousands of years since the Flood, while challenging deep time.

DNA Decay

Michael Collins and colleagues used the experiment-based collagen decay rates described above to rebut Mary Schweitzer's 2007 *Science* paper describing *Tyrannosaurus rex* tissues, as discussed below (Buckley et al., 2008). Later, Collins worked with Allentoft to experimentally investigate DNA decay rates. This team conducted a rigorous investigation of 158 fossil birds to determine a half-life of 521 years for moa mitochondrial DNA in bone at 13.1°C, the average temperature of New Zealand where the samples were collected (Allentoft et al., 2012). Their results showed that DNA decays more slowly than prior experiments with DNA decay kinetics, and attributed the difference to pH. Preceding researchers experimented with DNA at pH 5, but the moa bone microenvironments were near pH 7. Whereas an increasingly acidic environment undoubtedly accelerates DNA decay, I suspect that their slower-than-expected fossil-DNA-based rate is instead, or in addition to pH considerations, a function of their method of time-calibration. Allentoft et al. (2012) used uniformitarian carbon dates for the bones from which they extracted the DNA, then tied their DNA decay curve to carbon years, assuming that carbon years equal calendar years. However, carbon years often fail to correlate to actual time, and in general, older carbon dates separate further from an artifact's actual age (Snelling, 2008).

Several indicators suggest that 521 years represents an unrealistically long half-life for DNA. For example, Theodore Siek cited forensics studies showing that DNA degradation in natural environments including domestic settings, in water, and in ice, imposes relatively narrow time restrictions on expected DNA recovery for forensics analyses (Siek, 2010). Nevertheless, for the sake of argument one can overlook the radiocarbon bias incorporated into the Allentoft DNA decay rate, since even this unrealistically large 521-year half-life refutes many claimed ages for DNA found in fossils.

DNA in Fossils

For example, the still-unsullied integrity of DNA from amber-encased insects dramatically confronts the evolutionary age assignments. A series of reports from the 1990's led by Raul Cano, then of California Polytechnic State University, confirmed DNA in amber insects. One study, published in *Nature*, asserted an age of between 120 and 135 million years for a weevil's DNA from Lebanese amber (Cano et al., 1993). This and similar results were disputed even before Allentoft's DNA half-life was published. Workers at The Natural History Museum in London tried to repeat the DNA extraction protocols from Dominican amber, but obtained negative results. This casts doubt on the original reports, but is complicated by the general expectation that "DNA is extremely fragile, degrades in water and tends to fall apart and lose its 'signature' very easily" (Austin, n.d.). So, a responsible secular investigator who wishes to report DNA from ancient fossils faces the challenge of offering some kind of solution to a seemingly impossible question: How could DNA have lasted millions of years? A much easier path would avoid this dilemma entirely by leaning toward the interpretation that no endogenous fossil DNA persists in samples that are too old to contain it. For example, some secular researchers claim that DNA from ancient ambers originated from recent bacterial contamination. However, they have not yet produced a comparison of bacterial, modern insect, and fossil insect DNA sequences to support this contention, leaving for its basis the sheer need to rescue millions-of-years ages. More work needs to be done to verify the many solid clues pointing to genuine ancient DNA—and it needs to happen soon, before that DNA completely decays.

Dinosaur DNA reports exist, but have not yet brought forth enough clarity to make an airtight case against millions-of-years age assignments. In 1994, Woodward and colleagues described DNA they captured from dinosaur bone (Woodward et al., 1994). Their report was quickly and roundly rebuffed by experts who claimed that the detection techniques used could not yet rule out contamination. Since then, ancient DNA (aDNA) recovery techniques have dramatically improved, and yet, to my knowledge, very few reports of fossil DNA surface in the literature. Also, one of the secular tests of aDNA authenticity compared the target sequence to chicken DNA, based on the belief that since dinosaurs evolved into birds, they should share a similar sequence (Morell, 1993). Woodward et al. (1994) did not match the DNA to chicken, so his discovery was supposed to have been labeled "anomalous" instead of dinosaurian. But with

such an overtly evolution biased protocol, and assuming the source dinosaur was fossilized only thousands of years ago during Noah's Flood, Woodward's team may have sequenced genuine dinosaur DNA. We may never know for sure, but one vote against Woodward's DNA being dinosaurian came in a report by Hedges and Schweitzer (1995) showing that its 133 bp-long sequence of mitochondrial cytochrome b gene clustered more closely with mammals than nonmammals.

Woodward suffered open ostracism from the science community, so it is tempting to attribute the dearth of dinosaur or other Mesozoic fossil DNA reports over the last few decades to avoidance of attempts to search for it. Does the fear of ostracism or the actual absence of dinosaur DNA from fossils play the largest role in its scarcity in scientific literature? Why search for something that will only threaten one's livelihood? Perhaps it was for this kind of professional pressure, documented by Bergman (2008), that the next report of dinosaur DNA fell short of specifically calling it of dinosaur origin. Instead, the coauthors merely noted that a chemical signature matching that of DNA was found inside Cretaceous *Tyrannosaurus rex* osteocytes. We mention other biochemicals from this report in the next section (Schweitzer et al., 2013a). This *T. rex* "DNA" could have been sequenced to discern its authenticity, but was not. Perhaps the painfully contentious nature of Mesozoic DNA continues to dampen researchers' enthusiasm for definitely identifying dinosaur or similar DNAs. On the other hand, creation research has nothing to fear from such discoveries, and much to gain, since DNA should never be expected to last a million years under any reasonable earth surface environment.

DNA's half-life is short enough to clearly confront Mesozoic-dated DNAs as well as to challenge reported dates of Cenozoic aDNAs. As examples, a string of reports from Europe's supposedly oldest human remains from the Sima de los Huesos cave system in Spain cite ages that hover around 700,000 years, whereas the Allentoft data place an outer limit on DNA longevity at that cave's temperature of 10.6C of approximately 350,000 years (Thomas and Tomkins, 2014). Secular reports of aDNA from Holocene deposits actually often fit within the expected shelf life for DNA predicted by Allentoft et al. (2012). Thus, each report needs sifting to determine whether or not it presents genuinely endogenous DNA, and if it does, whether or not DNA's half-life refutes that aDNA's secular age assignment.

Mary Schweitzer's Findings

The few scientists or laypersons who have heard whispers of fossil tissues seem only to be aware of one find—a claim by Mary Schweitzer of North Carolina State University that soft, pliable tissue was found in a *Tyrannosaurus rex* femur (Schweitzer et al., 2005; see Figure 1). Unaware, for whatever reasons, of other similar discoveries, many secularists find it easier to dismiss this claim as a singular anomaly by merely arguing that a sample size of one is too small to support a far-reaching conclusion such as that these tissues are genuine. They have argued, for example, that this supposed anomaly might be explained as bacterial contamination, for example mucilaginous bacterial biofilm (Kaye et al., 2008; Anderson, 2015). In a private conversation, one Smithsonian paleontologist even suggested that the investigators probably mistook contamination from a field worker's lunch for soft, pliable connective tissue including blood vessels and erythrocyte-like elements.

Figure 1. Unarticulated hadrosaur vertebra found in northern South Dakota in 2012 from the Hell Creek Formation, the same formation that harbors Mary Schweitzer's original dinosaur tissue fossil finds. Photo by Paul Koepp.

Sheer time delay caused by the ensuing debate over whether researchers found original soft tissue or some kind of mistake probably blunted the impact that even the splashy *T. rex* report could have had if secular scientists had readily accepted its conclusions upon publication. This debate has also offered a seemingly easy exit for those less willing to admit to the reality of Mesozoic original tissue fossils—namely, that by declaring without explanation that the results are inconclusive—we must wait on further investigations to settle the matter.

One is reminded at this point of origin of life research, wherein evolutionary biologists admit that abiogenesis has its difficulties, but show faith that biochemists are working on the problem and one day will solve it. In reality, however, those biochemists have merely encountered a myriad of chemical hurdles to abiogenesis. Left alone, complicated biochemicals essential to life, like proteins and nucleic acids, spontaneously degrade into smaller, simpler components, but abiogenesis requires nature to do just the opposite. In other words, science has proven beyond a reasonable doubt that originating life without a Creator is impossible. But rather than admit this truth and accept its theological consequences, run-of-the-mill secularists sometimes skirt the whole discussion and at worst purpose-

fully maintain ignorance of it so they can deceive themselves into thinking that origin of life research still has hope. The same laws of chemical degradation that ensure biomolecules fall apart instead of self-assemble and thus refute abiogenesis also explain why original tissue fossils look like recent deposits. After a million years they should all have disintegrated completely. So, for the same reasons that all researchers should embrace the science that disproves abiogenesis, they should likewise embrace the science that disapproves millions of years for fossils, including original tissues.

Calling on more research is no longer a valid excuse. The necessary investigations have now run their courses, proving beyond all reasonable doubt that the *Tyrannosaurus* tissues were genuine and not contaminations. First, Schweitzer and colleagues sequenced collagen protein from the dinosaur fossil, found in Montana's Hell Creek Formation, and designated Cretaceous (Organ et al., 2008). Collagen protein is an essential and integral component of bone, epithelial, and other vertebrate tissues, but microbes are not known to manufacture it (see Anderson, 2015).

Second, Schweitzer et al. (2013a) published a more detailed analysis of her *Tyrannosaurus*' biochemicals, using immunofluorescence as a primary detection tool. Accordingly, antibodies of those specific biochemicals are applied to a small slice of acid-demineralized bone tissue. If the target biochemical is present, the antibody adheres to it. Unbound antibodies wash off. Fluorescent markers are then applied to the samples, designed to attach to the other end of the antibody molecules. The resulting image shows fluorescent patches only where the target biochemical occurs in the fossil. Schweitzer and colleagues imaged proteins specific to vertebrates, including PHEX and histone H4 (Schweitzer et al., 2013a). She also coauthored a paper describing many of the same vertebrate-specific proteins in a Hell Creek Formation hadrosaur femur, being careful to collaborate with an outside laboratory that sequenced some of the hadrosaur collagen, including elastin and laminin (Schweitzer et al., 2009).

Third, although her very thorough work should put the nail in the coffin of bacterial contamination objections, other authors have added new research that bolsters the conclusion of genuine original dinosaur tissue fossils in general. Anderson and Armitage published their remarkable discovery of a large, soft and pliable whitish sheet of fibrillar tissue integral to a bony *Triceratops* horn core, also collected from the Hell Creek Formation (Armitage and Anderson, 2013; Armitage, 2015). Whether or not most evolutionists choose to assent to the fossil tissue data championed by Schweitzer, the data unambiguously demonstrate the parsimony of her conclusion that the fossil biomaterials are endogenous, as further illustrated in the next section.

Fossil Tissue in Mesozoic Strata

Perhaps the best-preserved fossils with probably the highest number of original tissue reports describe Cenozoic fossils. For example, just one Siberian mammoth bone yielded 126 unique, partly intact protein types, detected by tandem mass spectroscopy (Capellini et al., 2012). However, we restrict the current discussion to original tissue fossils from much lower geologic strata because they intensify the strain between secular age assignments and age expectations that follow from biblical creation. Mesozoic strata supposedly straddle an evolutionary time range of 252 to 66 million years. Many and perhaps the most intriguing original tissue fossil discoveries hail from the Mesozoic Erathem.

Many who begin investigating this issue are surprised to find that the scientific literature has for decades been sprinkled with original tissue fossil discoveries. Long before Schweitzer's spectacularly bloody *T. rex*, investigators had been describing dinosaur proteins and proteinaceous bone structures. One early detection tool was electron microscopy. Top British journal *Nature* published electron micrographs of dinosaur tissue in 1966 (Pawlicki et al., 1966). A group of paleontologists applied the technique in 2008 to exceptionally well-preserved *Psittacosaurus* remains from China, publishing images of dinosaur collagen fiber bundles (Lingham-Soliar, 2008). South African researcher Theagarten Lingham-Soliar published stunning skin color images from a separate *Psittacosaurus*, also from China, finding evidence of original, unaltered pigments including carotenoids and melanins (Lingham-Soliar and Plodowski, 2010).

Lindgren et al. (2010) described scale skin and hemoglobin decay products—still colored red as were some of Schweitzer's *T. rex* and hadrosaurine samples—in a Kansas mosasaur. Researchers working in southern China reported endogenous protein from a *Lufengosaurus* bone taken from the tiny Jurassic sauropod's embryo (Reisz et al., 2013).

Polish researcher Roman Pawlicki's scientific output detailing original dinosaur tissues spanned more than three decades, and included exquisite electron micrographs of bone tissue from a Gobi Desert *Tarbosaurus bataar* in 1998, for example. The report noted, "the descriptions presented confirm that the morphology of the vascular canals in dinosaur bones and the bones of modern reptiles is the same" (Pawlicki and Wowogrodzka-Zagorska, 1998, p. 76). It appears this is the same Tarbosaurus that he had imaged in 1978 (Pawlicki, 1978). A string of papers from Pawlicki and various coauthors, dating back to at least 1966, also imaged original cells, chemically verified original collagen (Pawlicki et al., 1966) and even reported an immunoassay detecting DNA in dinosaur osteocytes (Pawlicki, 1995). Armitage verified fresh-looking tissues by

generating high quality SEM images of dinosaur bone in 2001 (Armitage, 2001). This important research verified for and brought under the umbrella of the creation science community what secular researchers had been publishing. Two years later a separate team sequenced some non-collagen protein fragments from an *Iguanodon* bone housed at the Natural History Museum of London (Embery et al., 2003). This list does not exhaust research on the topic, but serves to illustrate the repeatability of finding endogenous, minimally altered biomaterials.

Thus, long before Schweitzer's work, researchers had described amino acids from dinosaur bone, including a New Mexico *Seismosaurus* (Gurley et al., 1991) and even in fossil shells (Akiyama and Wyckoff, 1970). Note the significant contrast between the statement from *Biogeochemistry of Amino Acids* (published in 1980 and partly sponsored by the Carnegie Institution of Washington) that declares "work with dinosaur remains demonstrated that enough protein for analysis could often be recovered from bones and teeth as old as the Jurassic" (Wyckoff, 1980, p. 19), and the statement which currently appears on a sign at the entrance to the paleontology exhibit at the Carnegie museum in Pittsburgh that comments "fossils that are traces of prehistoric life have no original organic parts preserved." These two statements could not stand in more abject opposition (see Figure 2).

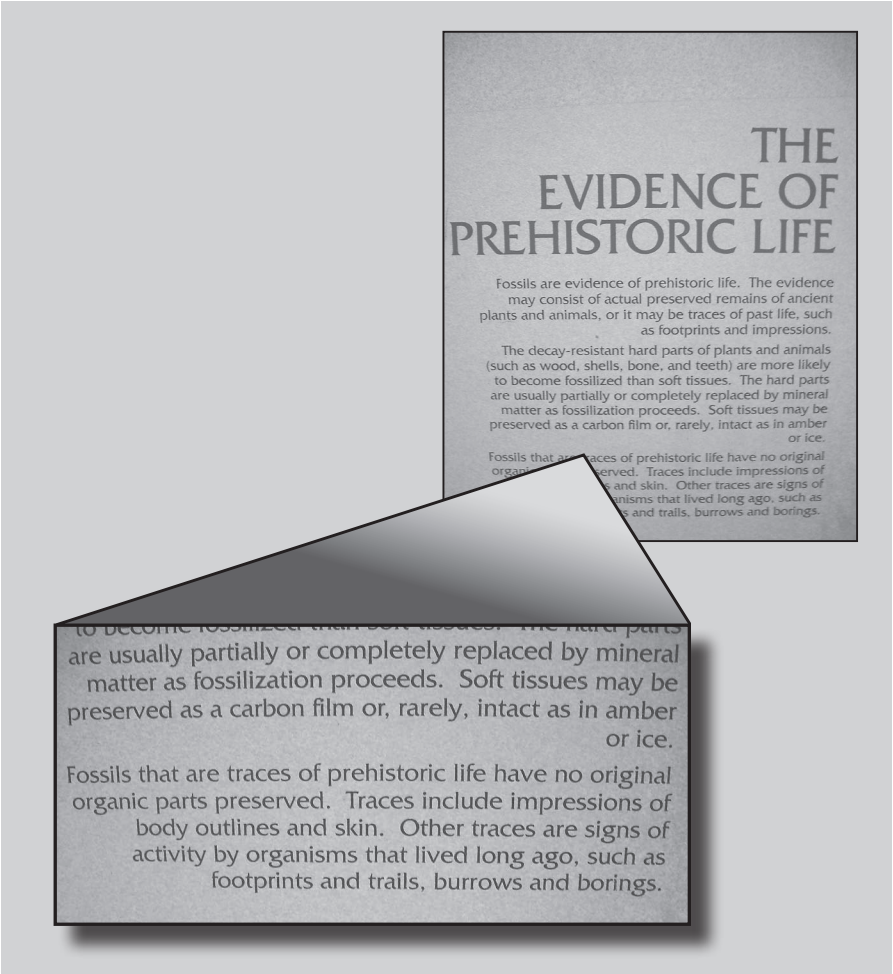

Figure 2 (a and b). Incorrect information on a sign in the Carnegie Museum of Natural History in Pittsburgh. Photo by Brian Thomas.

Fossil Tissue in Paleozoic Strata

Paleozoic original tissues seem to be less well represented in the literature than Mesozoic or Cenozoic finds, but there are some examples. Their lower numbers in lower strata could be an artifact of investigator bias. After all, secularists have a difficult enough time imagining that original tissues somehow lasted tens of millions of years, so they generally would not imagine that original tissues could preserve for hundreds of millions of years.

What expectations would a Flood geology perspective bring to this issue? Flood geologists maintain that almost all Mesozoic and Paleozoic strata derive from Noah's Flood. By considering this factor in isolation, one might expect fossils from any Flood stratum to have been deposited at virtually the same time only 4500 or so years ago, and therefore should contain virtually equal numbers of original tissue fossils. Indeed, Baumgardner et al. (2003) found striking concordance between carbon ages for Mesozoic and Paleozoic coals. However, many Paleozoic strata in particular appear to have experienced greater temperatures. Even a brief high temperature episode could greatly accelerate biochemical decay, and if temperatures reach a certain height, facilitate biomolecular reorganization or alteration. As an example, Burgess Shales include exceptional preservation of Cambrian marine paleofauna, but their organic content has largely been transformed into thin, carbonaceous residues. Many organics from this loca-

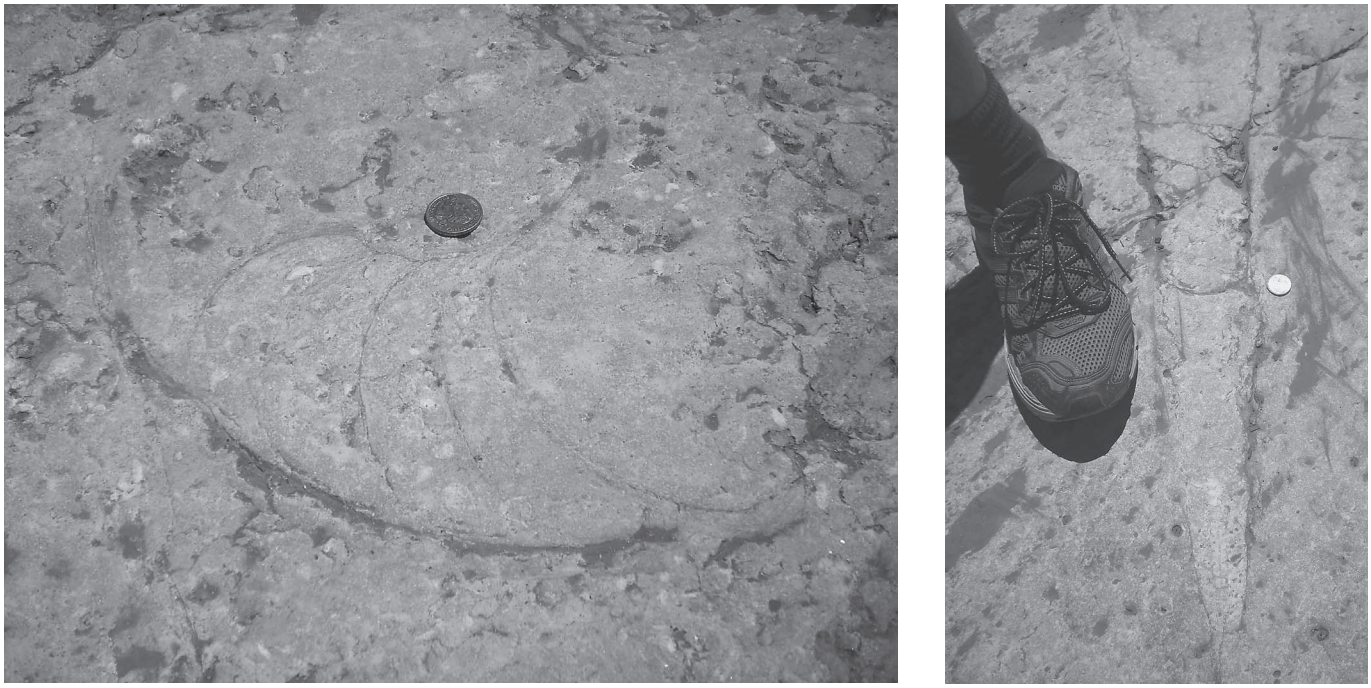

Figure 3 (a and b). Ancient hydrothermal fluids completely dissolved, transformed, and/or replaced all original tissues from nautiloids found in the Redwall limestone, here exposed at Grand Canyon. Photos by Brian Thomas.

tion and others have been kerogenized, a taphonomic process whereby excess heat cross-links biochemicals into a decay-resistant material, kerogen.

One spectacular exception came from a German and Russian team's recent investigation of a *Vauxia gracilenta* sea sponge fossil from British Columbia's famous Burgess Shale deposits (Ehrlich, et al., 2013). They searched for, but failed to find, endogenous DNA. Uniformitarians expect its absence on the basis of their age assignment, and catastrophists expect its absence on the basis of the elevated temperatures that its rocks indicate once occurred there. But the team identified intact chitin using a half dozen different techniques including fluorescence microscopy, fourier transform infrared microscopy, high-performance capillary electrophoresis, high-pressure liquid chromatography, mass spectroscopy, and others. Chitin is a biochemical found in squid beaks and pens, arthropod exoskeletons, and certain fungi. In sea sponge support structures, chitin incorporates tiny glass-like spicules. Experimentally determining a chitin decay rate could add a new and very valuable biochemical clock against which to judge conventional age assignments of chitinous fossils like this. The study authors noted the mixed results from attempts to estimate chitin's longevity before plainly admitting that the mechanism for Cambrian chitin preservation is simply unknown.

Geologic observations of heated Paleozoic strata, for example radiohalos caused by thermal fluid transport of uranium decay daughter products (Snelling, 2005) and metamorphosed rock on the margins of hydrothermal pipes that penetrate sedimentary layers, clearly indicate ancient heating. Paleozoic nautiloid fossils from the base of the Redwall Limestone described by Austin preserve no original tissues (Austin, 1994, p. 27; see Figure 3). The nautiloids' soft body parts do not occur *in situ*, and even their shell material has been replaced by hydrothermal fluid-derived mineralization.

Flood geologists generally relate these phenomena, as well as voluminous paleovolcanism like the Siberian and Deccan traps, to Genesis 7:11. Because many of the earliest Flood deposits, which generally correspond to the Paleozoic Erathem, were exposed to more heat for a longer time than later Flood deposits, Flood geologists would generally not expect them to yield as many unaltered original tissue fossils as from upper layers that may not have been exposed to as much heat for as many days or months during the Flood. However, not all places on Earth were affected in the same ways. Differential heating leaves open the possibility that rare Pa-

leozoic zones remained cool enough to permit original tissue fossil preservation through the torturous Flood year until today, and indeed several remarkable cases have been reported, including the Burgess *Vauxia* sponge already mentioned. Of course, other factors also must exist for any of these biomaterials to persist longer than hundreds of years or so, most notably the absence or diminishment of biodegrading microbes.

Ordovician graptolite periderm exhibited collagen-like structures, imaged by wide-angle X-ray diffraction in 1972 (Towe and Urbankek, 1972). The researchers found a few amino acids, but not 4-hydroxyproline or 5-hydroxylysine, which characterize collagen. X-ray diffraction did reveal helical fibers consistent with collagen's triple helix structure. Their results were thus not definitive for original collagen, since perhaps minerals could somehow have replaced the collagen and preserved only its molecular shape, but were consistent enough with the hypothesis of original collagen to warrant further investigation. Spectacularly preserved Paleozoic scorpion and false scorpion fossils retained their original exoskeletons, as chemical analyses revealed chitin and chitin-associated protein (Cody et al., 2011).

The possibility of endogenous biochemistry in early Cambrian fossils from China's Chengjiang biota, perhaps the world's best-preserved Cambrian Lagerstatten, has not been settled in the literature. Nevertheless, several features of some of these supposedly 520 million-year-old fossils strongly suggest they retain original tissues. One nontrilobite arthropod *Cindarella eucalla* showed obvious dark coloration, which in more recently deposited fossils (whose biochemistry *has* been tested consistently) indicates endogenous pigmentation such as melanins. It preserved 1,000 ommatidia on the half of its eye that was exposed. Compound eyes are composed of cone-shaped units called ommatidia, each equipped with a cornea, light-sensitive cells, and an optic nerve. "A thin film overlying the eye indicates the presence of an eye exocuticle, the film shows wrinkles and tears indicating the soft tissue shrank during initial burial" (Zhao et al., 2013, p. 2751).

Research into the mode of taphonomy preserving the Chengjiang biota has not yet adequately resolved the modes of preservation in my estimation, and controversy persists in the literature. Some authors seem to slap a glib and hasty explanation into their reports, for example claiming preservation by silicification, phosphatization, carbonization, pyritization, phyllosilicate metamorphism, or apatite permineralization—all processes known to contribute to fossilization in some specimens—but do not report positive tests to support such claims. As an aside, some of these modes of preservation counterintuitively involve bacterial degradative action across a soft tissue organ or other surface. The resulting carbon dioxide waste acidifies the microenvironmnent to which a preserving layer of mineral adheres. Other reports do not even attempt to answer taphonomic preservation questions, instead burrowing into a certain fossil's anatomical details, or possible phylogenies.

Burgess Shale expert Derek Briggs coauthored a review of Chengjian biota, saying,

> Elemental mapping of fossils from the Maotianshan Shale revealed that two modes of preservation are important in that deposit. In most cases the major morphological features of Chengjiang fossils are preserved as carbonaceous compressions; however, features of many of these fossils are preserved in pyrite. (Gaines et al., 2008, p. 755)

Pyrite is not original tissue, but "carbonaceous compressions" might be. They could signify some kind of kerogenization via heating, as discussed above. Alternatively, it might signify decayed remnants of original biochemistry like that verified in many other Mesozoic and Cenozoic settings. Future research may reveal whether or not these Paleozoic features consist entirely or partly of postmortem mineralization or of original biochemistry, but the high quality of preservation is consistent with the hypothesis that Chengjiang biota may preserve some original biomaterial.

Fossil Tissue in Ediacaran Source

The record for oldest evolutionary age assignment for original tissue fossils, to this author's knowledge, so far belongs to still-flexible, proteinaceous marine tube worm tubes taken from Siberian drill core samples of Ediacaran strata (Moczydlowska et al., 2014). The study authors were explicit in describing the worm casings as not mineralized, and original to the worms, as comparisons revealed virtual identity with the chitin-structural protein composite of worm casing seen in its "living fossil" counterpart, sea floor worms in the family Siboglinidae. Any objective viewer should meet the age assignment of 520 million supposed years for these still-soft worm casings with skepticism, if not incredulity.

Reactions to Discoveries

Why do so few scientists seem acquainted with this rich vintage of scientific reports of original tissue fossils? When Schweitzer's *T. rex* tissue publications began circulating, why did most secular scientists seem to act as if this was the first of its kind? The answers to these questions may be perpetually relegated to speculation, but a few possibilities present themselves.

First, Schwietzer's *Science* report pioneered visceral color images. Prior reports showed black-and-white electron micrographs, black-and-white hand-drawn sketches, charts of amino acid content, two-tone immunoassay images,

Figure 4. CBS News Anchor Leslie Stahl points to Mary Schweitzer's computer screen, showing video of rebounding elastic tissue taken from a *Tyrannosaurus rex* fossil. "B-Rex" episode on *60 Minutes*, aired November 15, 2009, posted on cbsnews.com/videos/b-rex/

plus many words. Such means of communication simply cannot convey what color photographs can, and although the image-rich Schweitzer et al. (2005) *Science* paper did not include video, the *T. rex* tissues were video recorded and this kind of footage adds a whole new dimension of communication. This is clearly exemplified by watching CBS's *60 Minutes* program titled "B-Rex" (see Figure 4).

Scientists are people too, so great images can make great impressions on them just as on others. The first blood-red *T. rex* pictures to be published undoubtedly made their way to a wider viewing audience than previous reports of original tissue fossils. The image said it all. No words were necessary. Even nonscientists became intrigued, and experts from outside the discipline of paleontology finally intersected with the story of original biomaterial fossils.

Paleontologists are not necessarily trained in biochemistry deeply enough to intuitively realize that proteins and DNA cannot last a million years. So as they were discovering and describing these biomolecules in fossils in earlier decades, mostly for the benefit of other paleontologists, the chances that biochemists came across and evaluated the results may have been much smaller. Some who happened to run across such reports reasoned, without hiccup, that since these biochemicals were found in fossils, and since the fossils were millions of years old, biochemicals can obviously last millions of years. Perhaps protein decay rates were not obvious to those who used this logic. It wasn't until Schweitzer's *T. rex* images that biochemists seem to have become aware of what paleontologists had been uncovering, and at that point they began expressing dissent. Fierce debate ensued.

In particular, *Science* magazine published a letter by Buckley et al. (2008) that included Michael Collins as a coauthor offering a rebuttal to Asara et al.'s 2007 *T. rex Science* paper. These researchers argued that whatever Schweitzer's lab found in that *T. rex* femur, it was most likely not original bone collagen, since their lab results clearly limit collagen's maximum longevity to fewer than one million years assuming reasonable earth surface temperatures. Michael Collins runs one of the world's few archaeobiology labs, specializing in biochemical decay rates. As discussed above, Collins and colleague's repeated tests have supplied maximum shelf lives for bone collagen and bone DNA that are incongruent with the naive conclusion that biomaterials must somehow simply persist across deep time. Currently, the evolutionist community (including theistic) enjoys no consensus on answering the questions surrounding endogenous fossil biochemistry. A gamut of explanations and excuses continues to troll the intellectual seascape. They include stories that cannot accommodate the data, such as sheer belief that (1) biochemical molecules last longer than studies show, (2) that there is no such thing as soft-tissue-containing fossils, or (3) that all specimens are merely bacterial contaminants.

In sum, it seems plausible that color photographs showing obvious fresh-looking original tissue fossils drew enough attention that for the first time biochemistry-minded researchers became aware of these finds, and this may account for their broader impact. If a broader spectrum of investigators had been scouring paleontological reports, these biochemists could probably have expressed their dissent decades ago. Despite newfound attention, both casual and serious researchers have not all answered some of the fundamental questions that these original biomaterials generate.

Proposed Mechanisms of Preservation

At least three reports have described attempts to explain biochemical longevity within the framework of deep time, and none of them withstand close scrutiny.

Smectite Adhesion

In the first report under consideration, researchers used six different techniques to verify original keratin protein in a lizard skin fossil from the Green River Formation (Edwards et al., 2011). Knowing that keratin could not last for over 50 million years without some very significant (essentially miraculous) external help, the team speculated that smectite minerals in the clay-rich matrix adhered to and stabilized proteins to preserve the whole skin structure. Whereas smectites do have amazing properties including the ability to act like molecular tubes that entrap smaller molecules, this explanation suffers from several shortcomings.

First, the authors did not discuss how smectites could be transported onto the skin, but this must have occurred via water flow. The presence of water accelerates biochemical decay directly by oxidation and indirectly by facilitating other degradative chemistry and by enabling microbial growth. The authors ignore these considerations. Second, they mapped keratin's sulfurous composition on lizard scales, so their model requires an exceedingly unlikely scenario of the fossil remaining dry for 40 million years after it was wet enough to bring in smectites. Sulfur is water soluble and should have been removed long ago by ground water percolation under a scenario of evolutionary time. Essentially, their model is very unlikely because it invokes a set of implausible conditions.

Apatite Sequestration

In the literature, Mary Schweitzer has not followed the original fossil tissue evidence to the logical conclusion that dinosaur and other fossils were deposited thousands, not millions of years ago. One of her workarounds, coauthored by Mike Buckley who had rejected her initial conclusions in *Science* along with Collins, argued that bone collagen could last millions of years on the basis of bone collagen ultrastructure and its interaction with bioapatite (San Antonio et al., 2011). Accordingly, because collagen must expand in order to degrade, and because bioapatite is so tightly packed around each collagen molecule that it prevents collagen from expanding, the collagen can supposedly last as long as the apatite persists.

However, in making their case, these authors fell prey to a common circular argument. They first asserted that their observations of collagen ultrastructure support their belief that collagen could last millions of years. Then, they argued that because the dinosaur fossils from which they obtained collagen were deposited millions of years ago, the experimentally determined decay rates—which they conveniently downgraded to decay "models"—must be in error. In the end, they simply dismissed the collagen decay experiments and backfilled their "knowledge" that collagen must have persisted over deep time with a convenient story. In reality, the decay experiments already took into account collagen ultrastructure and its interaction with bioapatite, and thus already represent a best-case preservation scenario. If apatite sequestration really could preserve collagen for 180 million years—the oldest secular age assignment for it of which I am aware—then apatite would have preserved collagen in the decay experiments virtually indefinitely, but it did not.

Iron Adhesion

Apparently satisfied that she had answered the question of how collagen could have lasted for millions of years, Schweitzer next tackled the question of preserving whole tissues such as blood vessels. Her coauthored paper reported that when placed in homogenized and concentrated blood, bird blood vessels in bone did not appreciably decay even after being held at room temperature for two years (Schweitzer et al., 2013b). On this basis, the authors speculated that blood-derived iron adhered to the inner and outer surfaces of dinosaur blood vessels to preserve them for millions of years. While certainly informative, the bird tissue results fall short of explaining the original tissue fossil data for three reasons.

First, without an actual decay rate of vascular tissue in blood concentrate, we cannot reliably extrapolate an age expectation. Two years is too short a time, even at room temperature, from which to draw these authors' conclusion. Second, not only did the dinosaur soft tissue in bone include collagen protein and blood vessels, but also whole osteocytes with several vertebrate-specific proteins still intact inside them. Osteocytes do not behave like collagen, so apatite sequestration should not be invoked to explain their preservation. But the tiny points of access to osteocytes in bone like canaliculi have too small a diameter to permit the imaginary blood concentrate access. They are much smaller than capillary tubes. So, even if blood-derived iron can preserve, it does no good if it cannot reach the cells in question. Last, many original biomaterial fossils occur in virtually bloodless settings. For example, no evidence for ancient blood baths presents itself in most of the fossils described above, such as dinosaur skin or Sabellidae worm casings. By far the most straightforward explanation of original tissue fossil preservation involves reassigning their ages from millions down to thousands of years (Demassa and Boudreaux, 2015).

Future Research Directions

As above discussions hint, opportunities for researching original biomaterial fossils abound. For example, a huge quan-

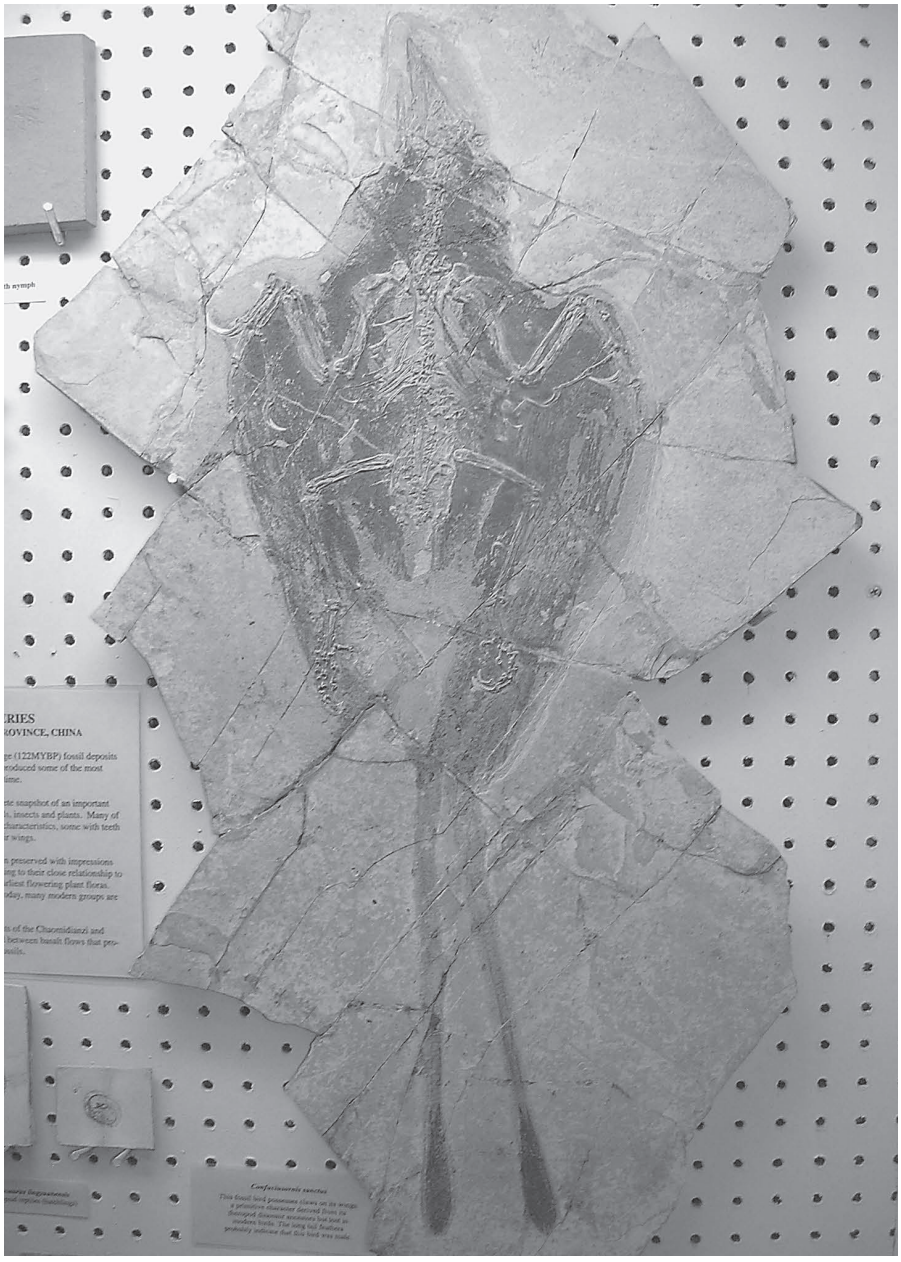

Figure 5. A darkened halo, perhaps often consisting of original pigmentation, surrounds many fossils, like the plumage surrounding this *Confuciusornis sanctus* extinct bird fossil displayed at the Museum at Black Hills Institute, Hill City, South Dakota. Photo by Brian Thomas.

tity of fossils seem to preserve original pigmentation, including famous ones like "Ida" from Messel shale, several mosasaurs, and a supposedly feathered dinosaur *Sinosauropteryx*, as well as more mundane finds like Cenozoic penguin feathers and Mesozoic bird feathers from Brazil. Many fossils retain a dark-colored halo of pigmentation that paleontologists increasingly recognize—in part thanks to the increased attention that Schweitzer has brought to biogeochemistry—originates from original biological pigmentation (see Figure 5).

Pigments like melanins are very resistant biological materials, and might be expected to outlast DNA and proteins, but could they really last for millions of years? Taphonomic scenarios need to be proposed and tested, and decay rates for melanins should be experimentally established if we are to gain a firm understanding of these relatively common fossil biochemicals.

Similarly, chitin is another long-lasting biopolymer, but just how long is not yet known with experimental certainty. An empirically derived decay rate for chitin could open expansive new areas of research into the potential longevity of fossilized chitin, which has been reported—especially that of fungal chitin—as occurring throughout the fossil record.

Additional work needs to occur to more precisely understand DNA in fossils. For example, by applying a corrective algorithm to carbon dates, one could adjust downward to a more realistic rate the published half-life of the control region of ancient mitochondrial DNA (Thomas and Tomkins, 2014). Other aDNAs, most notably mammalian chromosomal DNA in light of the numerous ancient genomes for genera like *Homo*, *Ursa*, and *Equus* as examples, should also be subjected to decay analyses. Also, as noted above, creation researchers should increase attempts to detect aDNA, especially from amber, bone, and tooth fossils, since its discovery would be consistent with the creation model prediction that some aDNAs might still be detectable after only several thousand years have elapsed.

Finally, future research into original biomaterial fossils would benefit from more precise terminology, and investigators cannot successfully engage in this research without carefully sifting through literature. The *Nature* paper describing "exceptional preservation" in a Cambrian nontrilobite arthropod (Reisz et al.,

2013) exemplifies this need for careful sifting. A colleague forwarded the paper to me under the impression that it presented original tissue fossil data, but the report did not verify any biomaterial. It cited "non-biomineralized compound eyes," not "non-mineralized," merely indicating that the creature's compound eye ommatidia were simply somehow preserved (Zhao et al., 2013). One last example also illustrates the potential for confusion and thus the need to vet literature that uses phrases like "remarkable preservation" and even "soft tissue" to mean both original or mineralized fossils typifies scores of similar reports. Its title, "Soft-tissue preservation in the Lower Cambrian linguloid brachiopod from South China" might give the impression to those who only read headlines of endogenous biomaterials, but the report permits "early phosphatic mineralization and subsequent replacement by the clay minerals may also have played a taphonomic role in a way analogous to the Burgess Shale" as a means of preservation (Zhang et al., 2004, p. 261).

Conclusions

In his brief review of original tissue fossils, creation researcher Mike Oard wrote,

> It truly is astonishing that bacteria, DNA, red blood cells, bone proteins, etc. could really survive the vicissitudes of tectonics, heating events, water seeping through the rocks, and other geological processes for millions of years and remain 'alive.' Before this barrage of discoveries, scientists considered that such survival was impossible past several thousand or tens of thousands of years. The evidence sits much more comfortably within the young-Earth Creation/Flood model. (Oard, 2001)

And this evidence continues to accumulate into the body of technical literature. Plenty of original biomaterial finds have firmly established proteins endogenous to Cenozoic and Mesozoic fossils, plus a few finds in lower layers, and each carries with it a strong implication of a recent creation and Flood.

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