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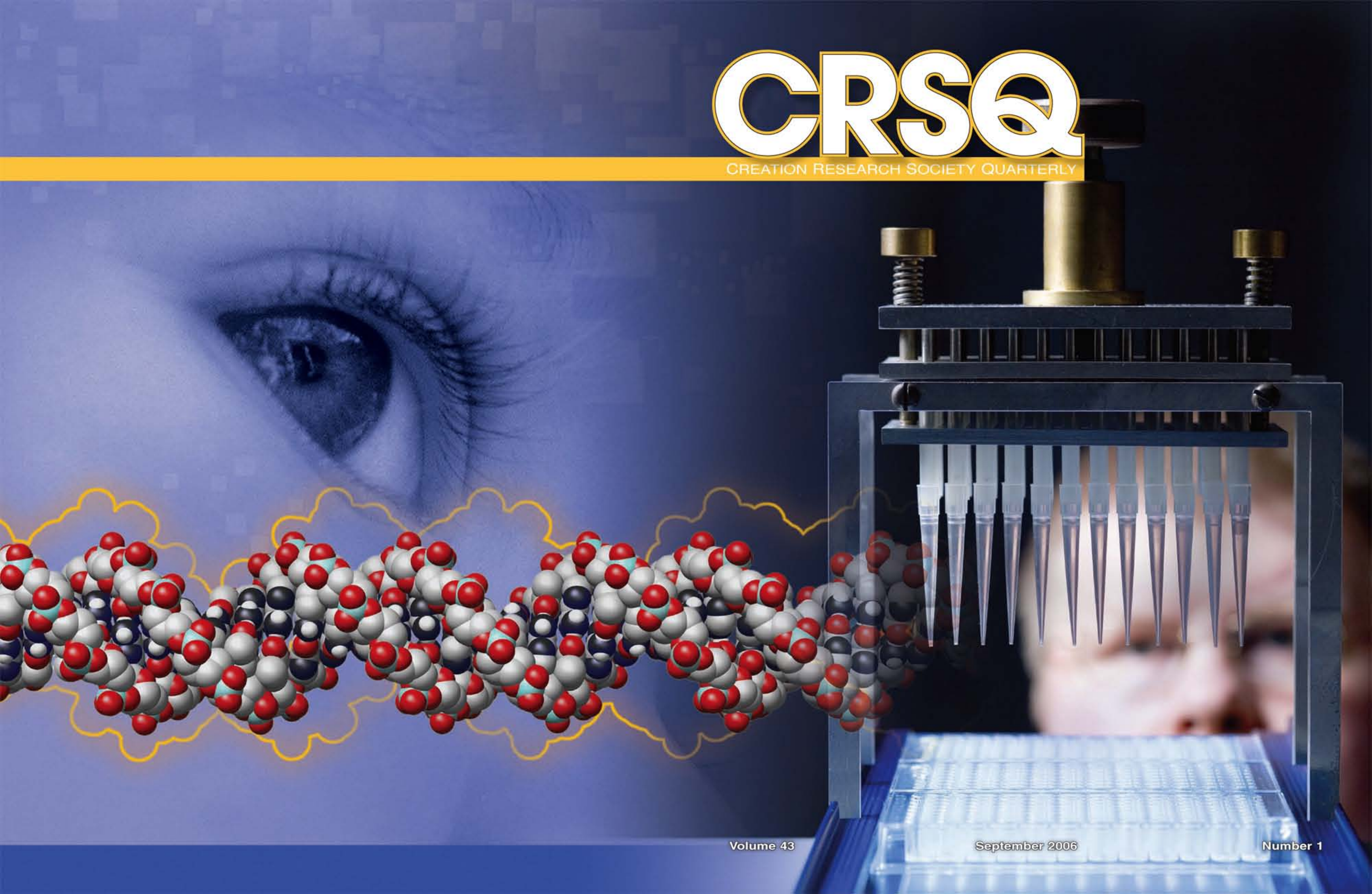

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Articles

Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

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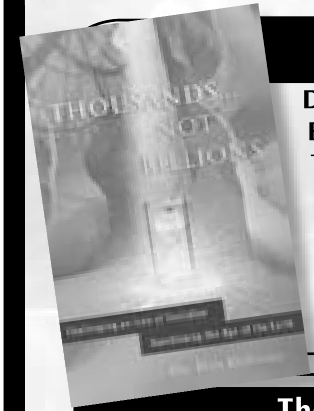


Thousands...Not Billions

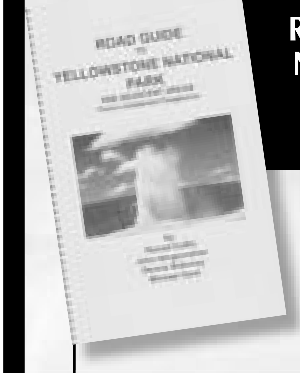
Don DeYoung. 2005. Master Books, 190 pages. $14.00.

This non-technical book is the laymen's guide to the Radioisotopes and the Age of the Earth (RATE) project. It has been written to equip the layperson to defend scientific six-day creation and refute modern dating techniques.

Thousands... Not Billions DVD

RATE Group. 2005. Institute for Creation Research, 48 minutes. DVD. $20.00.

See and hear the radioisotopic evidence for a young earth! Loaded with detailed animations, illustrations, and photos, this documentary summarizes the findings and amazing discoveries of the *Radioisotopes and the Age of the Earth* (RATE) Project. For advanced high school ages and up.

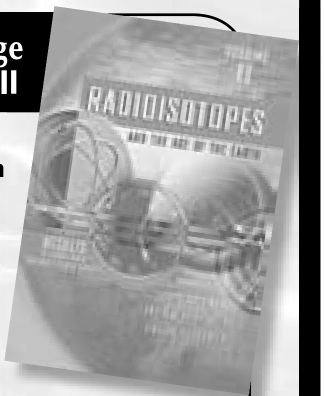


Road Guide to Yellowstone National Park and Adjacent Areas From a Creationist Perspective

Harold Coffin, John Hergenrather, Dennis Bokovoy, and Michael Oard. 2005. Creation Research Society, 101 pages. $12.00.

This is the second in a series of geological road guides for National Parks, National Monuments, and other significant geological regions frequented by a large number of tourists. The guide is a mile-by-mile log of significant geological sites, along with biological and historical tidbits, all from a creationist perspective. In addition to the major roads in the Park, the road guide includes the Beartooth Highway between Red Lodge and Cooke City, Montana, northeast of Yellowstone Park—one of the most spectacular drives in the United States. The guide contains numerous color pictures and diagrams of Yellowstone Park in beautiful half-page size, with a spiral binding.

Radioisotopes and the Age of the Earth, Volume II



Larry Vardiman, Andrew Snelling, and Eugene Chaffin (editors). 2005. Institute for Creation Research and Creation Research Society, approximately 876 pages. $80.00 (hard cover).

The age of the earth is an important issue in Christianity today. If the six-day Genesis account is fallacious, then how can the rest of Scripture be relied upon? *Radioisotopes and the Age of the Earth: Results of a Young-Earth Creationist Research Initiative* addresses the issues raised by the first RATE technical book in 2000. The RATE team dared to ask tough questions and has discovered that radioactive dating methods and their results are not thorough, consistent, or reliable. One of the "pillars" of old-earth evolution really supports the Scriptural account of "in the beginning."

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Editorial

Intelligent Design
Answers Its Critics…Mostly

In May of 2006, Biola University (La Mirada, CA) hosted an "Intelligent Design Answers Its Critics" seminar. A panel of five proponents of Intelligent Design (ID) squared off against a panel of critics (some more critical than others). Dr. Stephen Meyer began the evening with a brief overview of ID, explaining what he considered ID to mean, and the scientific basis for the idea. He emphasized that ID was not based upon Genesis or any biblical perspective. He also offered several examples of ID "research," which were subsequently woven into some of the arguments throughout the remainder of the evening.

With a few exceptions, the critics seemed to be far less interested in dealing with the scientific evidence, instead wanting to focus more on their claim that ID is merely a religious viewpoint. In fact, there were several occasions when the evolutionists appeared to sense the ID panel was gaining the scientific "upper hand," and they quickly worked to move the subject away from arguments of scientific evidence. I have often noticed this tactic among evolutionists and have suggested that it illustrates their unwillingness (inability?) to address the topic strictly in terms of the scientific merit. Rather than confront the scientific data for or against ID, or creation, or evolution (i.e., common descent), they seem to be content in stonewalling the discussion with claims of how ID/creation is not science. This becomes their refuge from the "storm" of trying to defend against scientifically based challenges (and what a storm that can be for evolutionists).

In that vein, a common criticism repeatedly offered by the critics' panel was that ID is not science because articles supportive of ID are not published in respected scientific journals. The same argument, of course, is constantly leveled at creation science. Dr. Meyer offered his own experience of publishing a pro-ID article in a science journal (Meyer, 2004) as a counter example of this claim. But, he also used it as evidence for the difficulty of publishing such articles in journals. Even though his article went through the journal's normal peer-review process, the mere fact such a pro-ID paper was even published was met with loud outrage among the evolutionary community. This outrage ultimately caused the journal's editorial board to offer an "official apology." This was an unprecedented decision since such apologies are almost exclusively reserved for articles involving fraud or other ethical violations.

Not surprisingly, the panel of critics at the Biola event generally took a dismissive attitude toward Meyer's account. Such a "hand-waving" tactic is common among evolutionists when dealing with arguments and evidence that they are unwilling or unable to counter. In fact, at a recent debate I was involved in, my opponent attempted to dismiss the relevance of Meyer's experience, claiming that it only represented one example. Ironically, if the evolutionists had their way, there would not even have been this one example.

What is more, ID is already found in the scientific literature, because an increasing number of papers and textbooks are negatively addressing it (especially Behe's concept of "irreducible complexity;" see Behe, 1996). Proponents of ID are simply not being provided opportunity to respond. Even though this is a common tactic in evolutionist circles, is it scientifically appropriate to discuss only the negative aspects of ID/creation, and not allow discussion of its positive aspects? If it is scientific to discuss the negative, how is it not scientific to discuss the positive?

Creation scientists are fully aware of this level of prejudice in publishing articles. For example, in the July/August 2002 issue of *Research News* the editor declared that he would never publish a paper supporting "scientific creationism" and even considered it completely appropriate to allow negative comments about "creationism" without giving creationists any opportunity for response. He justified this on what he called the editor's "higher calling." Apparently this "higher calling" is the calling to protect evolution from its critics and the journal's readers from exposure to alternative positions.

Dr. Jonathan Wells, sitting on the ID panel, interjected that many aspects of Darwin's arguments in *Origin of Species* (and even some arguments still made today) involved comparisons to intelligent design. Wells suggested that part of Darwin's reasoning was his conviction that certain biological systems were poorly designed, therefore "God would not have done it that way." Hence, Darwin concluded that life had developed by a less intelligent and more random process than by design. Aside from his great ignorance of the sophisticated and complex biological world he was observing, Darwin clearly used an approach of contrasting different views of origins as a means of explaining and developing his own ideas, a practice that scientists apparently are no longer allowed. Wells then asked whether parts of Darwin's *Origin of Species* must be considered too religious for science classes today (some of the critics agreed they might).

The critics also tried to suggest that as the minority position among scientists, ID cannot be accepted as legitimate science. Again, such arguments frequently have been used against creationists as well, along with an attempt to convey the idea that scientific truth is based on popular consensus among scientists. (I have been a practicing scientist for over 20 years and do not seem to recall ever "voting" on a scientific truth.) The primary purpose of this strategy again seems to be to insulate evolution from criticism and challenge. Interestingly, many major contemporary scientific concepts and breakthroughs were not initially very popular, some languishing in various levels of obscurity for decades. The day that scientific "truth" becomes merely a function of popular acceptance is the day that science no longer functions.

What is more, I would challenge that evolution (i.e., common descent) has achieved its level of popular acceptance more through intimidation by its ardent supporters than by its scientific veracity. Using processes of professional bullying and intimidation (ex. threats of tenure denial, etc., see Bergman, 1984 for specific examples), proponents of evolution have achieved a dramatic chilling effect on questions and challenges to the orthodoxy of evolution. It has been my experience that the vast majority of scientists are evolutionists simply because that is what they were taught. Often they have not even considered an alternative view, or they have a very ill informed misconception of alternative views. Most, in fact, are grossly unaware of the flaws and shortcomings of evolution, since such are almost never taught and rarely appear in the scientific literature. Yet, virtually any concept or teaching in science is "fair game" for critical analysis, except evolution. Why is evolution exempt? Comparative criticism between two ideas almost always serves to enhance and sharpen current scientific thought, helping to sort out the "deadwood." And, evolution contains an enormous amount of "deadwood." (As a result of creationists' and IDers' criticisms, evolutionists have removed a little of the deadwood—more or less—although most evolutionists would not publicly acknowledge this.)

Meyer asked whether science was ever advanced if the minority position always remained quiet. In fact, he challenged that one of the best ways for science to protect itself from "bad" ideas is not censorship but full disclosure and argumentation. Yet, science is sometimes viewed as a noble effort that is somehow above human pettiness and shortcomings. As such, this provides science an amazing ability for "self-correction." However, science is merely an investigative process to understand the world around us. Those engaged in this process are scientists, and sometimes they can be just as petty and flawed as anyone else. Thus, this "self-correction" in science does not result from the nobility of science or scientists but rather from the dogged determination of those who disagree with a current paradigm. "Self-correction" is dependent on the ability of scientists to express opinions and offer challenges without fear of reprisal. If this freedom is dampened, so is this "self-correction." Bad ideas then become insulated, and linger as accepted paradigms long after their scientific value and usefulness is exhausted (spontaneous generation is an excellent historical example).

On the other hand, an interesting aspect of ID is its attempt to be a "big tent" for all those who recognize all the evidence of design in the cosmos. This also means that the ID movement is represented by a wide variety of differing views. Some of these views were represented on the ID panel at Biola; from Dr. Michael Behe's acceptance of evolutionary common descent, to Dr. Meyer's form of "old-earth" progressive creation, to Dr. Paul Nelson's young-earth creation position. Not surprisingly, the panel of critics occasionally worked to exploit these differences among the ID panelists and probably were the most successful when they posed the question, "Does ID need to make scientific predictions?" This caused an almost equal division among the ID panelists between the negative and affirmative positions.

Certainly, Behe's "irreducible complexity" does make scientific predictions (Behe, 1996), and evolutionists have engaged in a contradictory attack upon it: deny that it makes any scientific predictions and at the same time attempt to refute the predictions it does make. There are now numerous journal articles dealing with so-called refutations of "irreducible complexity." If it makes no scientific predictions, how can they refute it?

But I think ID has struggled to offer more than a few scientific predictions. The ID panel's division over the need for such predictions reflects this conflict. I would suspect such predictions are difficult to develop within such a "big tent" as ID. Any predictions it makes cannot contradict "common descent," or address the age of the earth or the age of the human genome, or deal very specifically with the standard geologic column. Such specific predictions would reduce this "big tent," sending at least one group in the ID camp packing. Such lack of specific predictions will certainly continue to be a source of evolutionists' criticism.

In this area, a young-earth creation (YEC) model is far superior. Even though evolutionists usually refuse to acknowledge it, YEC makes numerous specific predictions. All these predictions can be (and are being) subjected to scientific analysis and experimentation. For example, some YEC predictions are that the earth is young, the human genome is young and degrading, mutations are almost always (always?) degenerative (even so-called "beneficial" ones), and there are systematic gaps in the fossil record between all major phyla.

We do not claim to have answers to every question. But ongoing research efforts by the Creation Research Society (and other sister organizations) continue to address questions in the creation model, strengthen our understanding of creation, and offer ever greater challenges to evolution (i.e., common descent). In fact, the genetics arguments for creation are becoming so strong they may soon become, dare I say, "overwhelming."

Behe, M. 1996. *Darwin's Black Box*. The Free Press (Simon & Shuster), New York, NY.

Bergman, J. 1984. *The Criterion: Religious Discrimination in America*. Onesimus Publishing, Richfield, MN.

Meyer, S. 2004. The origin of biological information and the higher taxonomic categories. *Proceedings of the Biological Society of Washington* 117(2):213–239.

Kevin Anderson, Ph.D.
Editor
Creation Research Society Quarterly

Book Review

The Genesis Trilogy

by Kacy Barnett-Gramckow

Moody Press, Chicago, 2004, Book I, 384 pp; Book II, 400 pp; Book III, 424 pp, $13 each.

The author of the Genesis Trilogy, Kacy Barnett-Gramckow, fills a need in Christian literature by painting a picture of three biblical events in a historical novel form. Her approach is unique in that she writes the novels from the point of view of the women that participated in the events. When we interviewed Kacy on the Revolution Against Evolution television show, she indicated that the inspiration for these novels came from sources such as the Creation Research Society, Institute for Creation Research and Answers in Genesis, as well as my own web site. John Woodmorappe's book, *Noah's Ark: a Feasibility Study*, was a resource she consulted as she constructed the plot for her stories.

I asked Kacy if she had considered crafting these stories with the possibility that there may have been an advanced technology before the Flood. She had considered it, but the publisher thought the idea a bit too avant-garde for most readers. So the settings for the stories were in an agrarian society governed by tribes. The plots of each book paint a tapestry of complicated sets of interpersonal relationships within a wicked society. Kacy related to me that the most difficult problem in writing the first book was that she knew that all of the characters except Noah and his family would die in the Flood.

Kacy employs an interesting effect in changing the King James spelling of the names of the biblical characters to reflect the correct pronunciation in Hebrew. Noah became *Noakh*, Ham was *Khawm*, and Japheth became *Yepheth*. Kacy's intent was to remain true to the biblical story and introduce very little in the way of speculation. She succeeded in her mission. Some of the plots include events from Jewish tradition such as the death of Nimrod. Others involve creationist speculations such as the dispersion of people groups to North and South America. None of these are outside of what we might know from the Bible.

The novels are not only a marvelous read, they provide a new perspective for creation thinkers who typically read research papers from a male point of view. Here is a set of novels that start with a biblical foundation, mixed in with imagination that is consistent with that foundation. They are woven together with a set of interpersonal relationships that is generally perceived from a feminine viewpoint. This produces a unique perspective of the conditions at the Flood, before and afterward, and why God was justified in sending his judgment on the earth.

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The Elimination of Mutations by the Cell's Elaborate Protein Quality Control Factory: A Major Problem for Neo-Darwinism

Jerry Bergman[*]

Abstract

Proper protein folding requires specific "chaperones" and other molecular machinery called "folding factors." Both the genomic code and the folding machinery are required in order to produce a functional protein. The cell also has an elaborate quality control system to ensure that the cellular parts are manufactured to the required specifications. Recent research has added new levels of complexity to our current level of understanding of cell biology quality control. One important role of this newly discovered system is the removal and recycling of improperly folded proteins caused by any number of factors including mutations. Mutations are assumed by neo-Darwinists to be the ultimate source of all new genetic information. In order to produce a new protein by mutations, however, both appropriate folding and quality control systems also must adapt. Without them, a mutant is useless, even if it produces a selective advantage. Quality control results in many, if not most, mutated proteins being repaired or cut up and recycled, even if they are beneficial to the organism. This detail manifests irreducible complexity that favors intelligent design.

Introduction

Natural selection cannot produce new genetic information, but can only select from what already exists in the genome. Mutation now is believed to be the only significant mechanism capable of producing new genetic information. For this reason, mutations are believed to be the ultimate source of all genetic variety (Mayr, 1967, 2001). According to neo-Darwinism this genetic variety enabled natural selection to evolve all life over vast time periods. But many changes in the DNA base sequence never result in amino acid changes within the protein because several different DNA codons translate the same amino acid. This built-in stability factor has been discussed by Colin Brown (1999, 2000) under the designation of "symmetric variation." Assuming that mutation and natural selection could produce new proteins, a method must evolve simultaneously to process the new proteins properly.

Protein processing is a complex procedure that is just now beginning to be understood (Lee and Yu, 2005; Houry, et al., 1999). It involves folding a newly synthesized amino acid polymer chain into its proper physical shape, called its "conformation." It also requires a complex cellular quality control system present in the cell. The existing system

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would eliminate many, if not most, new proteins, even if they were beneficial in the organism and even if they conferred a selective advantage. The system exists because many aberrant proteins are extremely harmful to cells and, for this reason, are cut up and recycled (Lee and Yu, 2005; Sitia and Braakman, 2003). Potentially beneficial proteins caused by mutations are also cut up and recycled by the ubiquitin-proteasome degradation system designed to ensure a high fidelity of protein expression (Lee and Yu, 2005). The process of "cutting up" proteins involves enzymes that break the peptide bonds between the amino acids that make up the protein chain. The result is "amino-acid monomers" that are then reused to make other proteins.

Many mutational changes in proteins that might be beneficial are not seen in living organisms because they do not make it through the cell's quality control system, part of which is described below. Many mutations that could be beneficial to an adult block an embryo from progressing past the first cell divisions because the mutant interferes with normal cellular function (Lee and Tsai, 2005). If they pass this hurdle, the systems described below are activated.

Proper Processing Required

Proper protein production required for cell survival and growth requires an elaborate quality control system (Collet and Bardwell, 2002). This system entails the involvement of a host of regulators that function as monitors, ushers, transporters, inspectors, security guards, and "emergency technicians" (Xu, et al., 1997). It is described as "wonderfully complex and highly dynamic ... the details of which are only beginning to emerge" (Lorimer, 1997, p. 720). Research in the decade since Lorimer made this observation has confirmed his prediction. For example, "the number of proteins that can be classified as molecular chaperones" has steadily increased (Lee and Tsai, 2005, p. 259).

Promoting protein assembly requires constantly controlling the flurry of cellular activity necessary to maintain the cellular state of dynamic equilibrium called *homeostasis* (Ellis, 1996; Morimoto, 1996). This control system, together with the cell's elaborate repair system, blocks the expression of nearly all mutations that produced significant conformational changes (Lee and Yu, 2005). This process works against evolution by mutations. A family of illnesses, called conformation diseases, results when certain misfolded proteins escape the degradation process (Lee and Yu, 2005). Examples include amyloidosis, Creutzfeldt-Jakob's disease, scurvy, cystic fibrosis, sickle-cell anemia, Alzheimer's syndrome, and certain other degenerative diseases (Selkoe, 2003).

The Folding Requirement

In the words of Pennisi (1996), a cell is like a "crowded marketplace, with proteins hustling from one job to the next, jostling and potentially interfering with one another along the way" (p. 1613). Proteins consist of hundreds of amino acids that first are sequentially assembled by ribosomes according to a sequence based on the mRNA code template. The long amino acid chains are then folded into specific, intricate, three-dimensional shapes that contain all the twists, turns, folds, pockets, and loops essential for performing the numerous functions required by the cell.

Each protein can fold myriads of different ways, and for this reason require guidance to fold correctly. This guidance is often provided by large complex machine-like molecules called *chaperones*. The chaperones are equipped to properly fold specific proteins or specific types of proteins (Lee and Tsai, 2005; Ellis, et al., 2000). The chaperones are themselves produced by ribosomes according to a code sequence contained in the genes. Other structures also may aid in folding so that there is a whole protein folding system ensuring that newly sequenced proteins are folded into their correct shapes. This is critical because, as noted above, improper folding of a particular protein can produce death or disease.

Johnson (1994) asserted that this entire complex folding system is required because the supposed "age of the Universe is short compared with the time it would take even a small protein to sample the many billion possible folds en route to the right one" (p. 29). As the unfolded protein chain of amino acid residues move toward its final folded form, numerous factors could render it useless because

> amino acids attract all manner of other molecules intent on illicit chemical liaisons. Anyone who has had to deal with unfolded proteins in a test tube knows the hazards only too well: rather than ending up with fully functioning protein molecules, you are more likely to get a glutinous tangled mess, the chemical equivalent of a plateful of overcooked spaghetti. But in cells, proteins do fold correctly, or we wouldn't be here to wonder about them (Johnson, 1994, p. 29).

The folding is double-checked several times by numerous other quality control systems, many of which involve enzymes produced by ribosomes, requiring the proper gene sequence. Mutational changes sufficient to produce a new protein would also likely require a new set of custom chaperones and enzymes to fold the new protein properly. Many mutations may be expected to interfere with this process of quality control and would produce a non-functional protein until the quality control system also evolved to fold and process the new protein properly. In the meantime, the misfolded protein would be recycled or could potentially cause disease or even death.

Some proteins in mammalian cells begin folding with the assistance of specialized chaperones while still being translated, a condition called co-translational folding. This folding occurs in networked tunnels in the endoplasmic reticulum (ER) found throughout the cell near the nucleus. Sequential interactions with a set of specific chaperones often are required for each folding step. Folding is then completed after the protein is produced (called post-translational folding), and individual protein subunits are usually folded before the assembly of multiple different chains, a process known as oligomerization (Sitia and Braakman, 2003).

Final folding is completed inside the ER next to where the protein assembly ribosomes are located. The finished protein is then transported elsewhere by special membrane-bound containers for further processing. The finished protein may perform its role in the body either in the cell or outside, as is the case with secreted proteins. A multitude of other processes involving both software-like and hardware-like systems must all work together to ensure successful protein manufacture. This system would need to be adjusted and/or greatly modified to properly process a new protein produced by mutations (Ibba and Söll, 1999). Some of the sequential interactions and the specifically designed chaperones required for each one of these steps will now be discussed.

Recognition of Correct Folding

Although a strand of amino acid residues can fold in a large number of ways, the chaperones are able to distinguish the one correct way, called the "native folding arrangement" from the many incorrect patterns (Sitia and Braakman, 2003). Chaperones are especially critical in discriminating between native and nonnative protein foldings. Multimolecular complexes, called *folding factors*, provide matrices that couple retention in the ER to proper folding and assembly.

A mechanism exists to help ensure that proteins are not ejected from the ER before they are completely folded. Both when folding occurs, and during assembly, special chemical compounds expose the amino acid's hydrophobic surfaces, unpaired cysteines, or immature glycans, allowing ER-resident chaperones or oxidoreductases to interact with them to help ensure proper folding. As a consequence of this interaction, altered or damaged proteins are retained in the ER or are retrieved from an organelle called the Golgi complex and chauffeured back to the ER to be repaired. The Golgi complex is part of the protein processing and modification system. Incompletely folded proteins can also form aggregates that prevent them from entering the vesicles used to transport properly processed proteins away from the ER. This system works against neo-Darwinian evolution by mutations because "mutations or even unbalanced subunit synthesis make folding or assembly—and hence exit from the ER—impossible" (Sitia and Braakman, 2003, p. 892).

Workforce Regulation

The cell keeps track of how many of *each specific kind* of chaperone is available for use. It uses this information to regulate the number of each chaperone type by sending signals to the nucleus to increase, or decrease, the number of specific chaperones to be produced. To maintain the effectiveness of its quality-control mechanisms in a variety of physiological environments, cells have "regulatory circuits that monitor the levels of available chaperones" in both the cytosol (the cell part that lacks membranes or particulate sub cellular components) and the ER (Sitia and Braakman, 2003, p. 893). Optimal levels of the desired folding factors are also regulated in each area of the cell.

Feedback Regulation

Part of the ER quality control involves sending messages back to the nucleus to help regulate the level of chaperone production. This is a basic, but very important, feedback mechanism.

MicroRNA Regulation Control

MicroRNAs (miRNAs) are small, short strings of RNA existing in large numbers in every cell type. They bind to mRNA molecules in order to regulate their function, either by inhibiting them from making proteins, or by targeting them for destruction (Enright, et al., 2003). Many fundamental development processes are microRNA regulated. For a new protein to exist, it must evolve a compatible microRNA regulation system, or it must be properly regulated by an existing system. Without this system, too much or too little protein will result, causing injury or death to cell or organism.

Location Specificity

Although most folding factors are "ubiquitously expressed throughout the body, some are tissue-type specific or cell-type specific, and probably fulfill a particular synthetic task" (Sitia and Braakman, 2003, p. 891). Collagen is a fibrous protein used for a glue function in connective tissue, bone, skin and cartilage. Efficient collagen production requires the expression of a chaperone called heat shock protein 47 (hsp47). On a wider level, "a tissue-specific protein-disulphide-isomerase-like protein, PDIp, is produced in the pancreas and probably permits the massive secretion of digestive enzymes" (Sitia and Braakman, 2003, p. 891). Heat shock proteins (hsp) are a superfamily of proteins that help to refold proteins in specific locations where heat, acid-base imbalances, or other factors cause distortions (called *denaturations*) of the protein's conformation.

Fail-safe Inspection

After folding, a protein must then successfully pass through multiple layers of monitoring before it can be sent to the location in the cell, or the body as a whole, where it is to be used. Sitia and

Braakman (2003) call this a “fail-safe” inspection system.

Time Limits

The cell is able to determine when a protein has had enough time to fold properly. It must then discriminate between those that have the needed time from those that have not yet folded properly but will do so with more time.

Bridge Builders

Disulfide bridges are one of the four types of chemical bonds used to produce the final stable protein structure. Sulfur bonds are commonly used to stabilize protein folds and must be maintained by a host of oxidoreductase enzymes. The large number of oxidoreductases in the ER indicates that regulation of disulfide-bond formation is critical for proper folding. A disulfide bond is a weak bond, only slightly stronger than that of a single hydrogen bond, yet these bonds are crucial to produce native conformations for many proteins because the disulfide bond helps create the needed loops and folds in the protein molecules. Native and nonnative disulfide cross-links are transiently formed; both correct and incorrect disulfide links can easily form and break. Stability is usually achieved only when the total system is folded. Correct folding also requires guidance, for which continuous oxidoreductase activity helps to ensure that these covalent disulfide links remain flexible until the complete correct folding has been completed.

Redox Regulation

A sensitive chemical balance must be maintained between reducing and oxidizing (redox) conditions along the protein's pathway throughout the entire folding process. The redox gradient between the ER and the cytosol is important for many reasons including intercompartmental signaling. Redox regulation is particularly important in the cell's

> integrated response to oxidative stress, in which adaptive responses emanating from different compartments are coordinated. And redox reactions with opposite electron fluxes must take place in the ER to mediate formation, isomerization and reduction of disulphides. The wealth of redox assistants allows these fluxes to be separate, and channels electron transport through specific protein–protein interactions (Sitia and Braakman, 2003, p. 892).

Emergency Response

At least two examples exist of the cell's complex rapid-response traffic control teams: “[1.] The accumulation of aberrant proteins in the cytosol triggers the heat-shock response, resulting in *de novo* synthesis of hsp70 and other cytosolic chaperones. [2.] But if aberrant proteins accumulate in the ER, cells activate a different response, the Unfolded Protein Response (UPR)” that results in the coordinated synthesis of both specific ER-resident chaperones and enzymes (Sitia and Braakman, 2003, p. 893, brackets added).

A variety of signals can lead to the UPR pathway (Obeng and Boise, 2005). How the diverse unfolded (or misfolded) proteins that accumulate in the ER provoke the UPR pathway is complex. Sitia and Braakman explain that the UPR is a multifaceted system that regulates both the proteins involved in quality control and many other aspects of the entire secretory pathway system (Sitia and Braakman, 2003).

Consequences of Failure

When the system becomes swamped by having too few of the needed structural components, or when it is sent defective parts, ER stress can result, a condition in which the folding ER machinery cannot cope with its protein load (Wickner, et al., 1999). Stress can also be caused by synthesis of mutated or orphan proteins, or the absence of the required cofactors. An example of the latter is scurvy, in which collagen cannot fold properly because of a lack of vitamin C. In an attempt to produce a needed protein, higher levels of the relevant signal are sent because mutated proteins that do not function are unable to provide the feedback needed to stop the signals. As a result, a drastic increase in defective or nonfunctional proteins takes place.

Meltdown Regulation

When damage is so great that further operation of the cell could be lethal to the organism, three independent controls insure that an orderly slowdown occur to try to prevent cell death. These controls are the ER sensors, Ire1, and PERK plus ATF6, which together

> guarantee a tripartite response with synergic strategies. By phosphorylating eIF2alpha, PERK transiently attenuates translation [stops protein synthesis], limiting protein load. ATF6 drives the transcriptional upregulation of many ER-resident proteins and folding assistants [these proteins help to direct the orderly cell shutdown]. Ire1 activates XBP-1, which in turn induces transcription of factors that facilitate ER-associated degradation (ERAD) [this causes the destruction of the ER system itself]. The two-step activation of XBP-1 (transcriptionally induced by ATF6 and post-transcriptionally regulated by Ire1) guarantees the proper timing of the UPR [unfolded protein response]; attempts to fold proteins precede the decision to degrade them [the cell tries to fold them, and if this fails, only then do they break them down for destruction]. If the response fails to clear the ER, apoptosis [cell death] is induced through several pathways (Sitia and Braakman, 2003, p. 893, brackets added).

Mutations and Folding

When a protein is not folded properly, even after repeated attempts, specialized proteins exist to ensure its proper dismantling and recycling (Goldberg, 2003). A mutant or unbalanced subunit that adversely affects proper folding or assembly, triggers this process. These proteins, and all terminally misfolded molecules, are "retrotranslocated" or "dislocated" across the ER membrane "to be degraded by cytosolic proteosomes" (Sitia and Braakman, 2003, p. 892). The proteosomes are complex barrel-shaped macromolecules designed to break down improperly folded proteins and recycle their usable parts (Chin, 2000). Not only are most abnormal, incompletely synthesized, or incompletely assembled proteins degraded, but even incorrectly distributed proteins also are degraded by adenosine triphosphate dependent proteases (Wickner, et al., 1999). How misfolded proteins are recognized and selectively degraded is just beginning to be understood. We do know that it is a very intricate process (Goldberg, 2003).

These quality control mechanisms all must be tightly regulated and serious consequences result from loss of this regulation.

> Quality control must be a balance between retaining and degrading potentially harmful products and not preventing export of biologically active proteins. CFTR mutants in cystic fibrosis illustrate an overzealous quality control, where biologically active mutants cannot leave the ER. In this case, relaxing the quality control could cure the patient. But disease can also originate from defective degradation. If the rate of synthesis of a protein exceeds the combined rates of folding and degradation, a fraction of it will accumulate intracellularly (Sitia and Braakman, 2003, p. 893).

Misfolded proteins must move across the ER membrane rapidly enough and be degraded fast enough by the proteosome to prevent aggregations (called aggresomes) from building up inside (or outside) of the ER. The importance of this process is illustrated by what results if the system does not work properly; "ER storage diseases" are examples. Much has now been "learned about how

Table 1. The Cell's Quality Control System. Most of the Quality Control Systems Reduce the Number of Mutations.

	Step	Requirements
1.	**Proper Protein Processing:**	monitors, transporters, and feedback systems
	Quality Control Features:	inspectors, security guards, and emergency technicians
2.	**Protein Folding:**	chaperones and other protein folding machinery
	Quality Control Features:	checking systems, correct folding recognition system
3.	**Workforce Regulation:**	chaperone number control system
	Quality Control Features:	feedback systems to control up-down regulation system,
4.	**Location Specificity:**	systems to regulate levels of specific protein in specific locations
	Quality Control Features:	feedback systems, up-down regulation systems, such as the fail-safe inspection system.
5.	**Recycling:**	time limit systems to regulate protein-folding progress
	Quality Control Features:	quality and damage monitoring and repair systems.
6.	**Emergency Response:**	heat-shock systems, refolding protein response pathway
	Quality Control Features:	pathway regulation systems
7.	**Meltdown Regulation:**	three independent systems designed to produce an orderly slowdown of protein production
	Quality Control Features:	tightly regulated quality control and systems to regulate the three slowdown protein regulation systems

proteins are handled by the ER folding and quality-control machineries, and some of this knowledge has begun to be translated to industry and to the clinic. Yet, many questions remain" (Sitia and Braakman, 2003, p. 894).

Further elucidation of these detailed, coordinated systems will allow drug designers to produce compounds that respond to deal with faulty elements that cause degenerative diseases, or even to induce apoptosis in tumors, causing them to self-destruct. Although much is known about the mechanisms already described, much remains to be learned about this cell quality control system (Houry et al., 1999).

Summary

Most mutations that cause conformational changes in proteins would have a difficult time making it past the cellular quality control system and, even when they do, the consequences could be catastrophic (Strauss, 1997). Conversely, some mutations may be silent (not expressed) as a result of the actions of some of the quality control mechanisms discussed above (for a discussion of silent mutations, see Brown, 1999). A major concern for neo-Darwinism is how a potentially beneficial mutation could get past the control system without triggering the cell-death alarm. This topic has been largely ignored by Darwinists. Sitia and Braakman (2003) mention evolution only twice, and then only in passing. In both cases, they merely assume the validity of evolution, rather than trying to support or even explain it. They are actually arguing against evolution when they admit that the complex cellular control system described in their paper strongly works against mutational change, and they note that "a certain degree of freedom from quality control is essential for the evolution of proteins" (Sitia and Braakman, 2003, p. 892). If it works too well, macroevolution stops.

The authors admit that this freedom from control comes at a price for multicellular organisms and they give the example of proteins that can take on more than one conformation, but this causes systemic amyloidosis (runaway misfolding, which causes clumping), and can undergo uncontrolled aggregation outside of the cells (Sitia and Braakman, 2003). The evidence we have now indicates that very little freedom exists, severely limiting evolution by mutation. For a summary of the quality control systems discussed in this paper see Table 1.

All living cells are incomprehensibly complex. All the activities discussed above are now going on in every single living cell in your body, and in this review I have only briefly outlined the wonder and complexity of one quality control system. I ignored many other regulation systems such as those regulating development, an important new research area involving genes such as the *hox* genes (see Brown, 2000). No human enterprise comes close to the choreography and efficiency of so many intricately coordinated parts. This surely is a clear example of irreducible complexity (Behe, 1996). If past experience holds true, the cell's quality control factory will prove to be even far more detailed than revealed here (Bergman and You, 1998). This evidence supports the origin of life by direct and miraculous creation and works against neo-Darwinian speculations.

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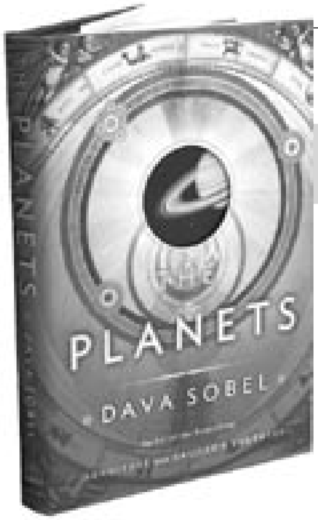

Book Review

The Planets

by Dava Sobel

Viking Penguin Group, New York, 2005, 270 pages, $25.00.

Author Sobel is a former *New York Times* science reporter. She has a gift for expressing science concepts in clear, refreshing style. Her other best sellers include *Longitude* (1995) and *Galileo's Daughter* (2005). Sobel shows a familiarity with scripture. She refers to the Bible in a positive, non-disparaging way, even though she mixes in secular science ideas such as the big bang. I was surprised to see the following quotes in this popular book. The earth will eventually become a "charred cinder where God once walked among men. This dim future, however, lies far ahead as to allow the descendents of Adam and Noah ample time to find another home" (p. 19). Solar eclipses are suggested to be "part of a divine design" (p. 27). Also, page 20 quotes Genesis 1:21–24 regarding the creation of whales and beasts of the earth. It should be added that Sobel also adds detailed astrology ideas to the book without negative comment.

The book surveys historical and modern discoveries within the solar system, and there is poetry in Sobel's writing style. As one example she describes the moon as waxing, waning, and whining for our attention (p. 104). The 15 mile (24 km) height of the Olympus Mons volcano on Mars is pictured as the Alps positioned atop the Rockies, in turn sitting atop the Himalayas (p. 125). The writing is current and includes the 2003 discovery of the planetoid Sedna, slightly larger than Pluto and the most distant known solar system object.

The author includes many minor facts which add to the book's interest. Hence the element uranium, found in 1789, is named in honor of planet Uranus, discovered eight years earlier by William Herschel (p. 184). William had the habit of rubbing onion on his skin to ward off disease while he observed the heavens in the damp night air (p. 204). The book has many further ideas to offer, both trivial and fundamental. A comprehensive glossary and index are included.

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A Subaqueous Tectonic and Hydrothermal Origin for Colossal Cave, Arizona

Carl R. Froede, Jr.*

Abstract

Colossal Cave is a feature of both archeological and geological interest. Only recently has the cave system been systematically explored, and much work still remains to thoroughly document this extensive feature. The formation and development of the cave has not been adequately addressed in uniformitarian geological literature. Apparently, the naturalist interpretation cannot easily explain the problems that "uniformitarian time" creates in understanding the geologic history of the area and the formation of Colossal Cave. In contrast, Colossal Cave is easily addressed by the Creation-Flood framework. The uplift of the adjacent Rincon Mountains during the late stages of the Flood caused the recently deposited and semi-lithified sedimentary overburden to slide off and pile up around the base of the uplifted metamorphic core complex. During this event, the strata were subjected to the expulsion of both interstitial and hydrothermal fluids, which created preferential pathways through the carbonate strata and resulted in the formation of numerous cave systems. Following Floodwater withdrawal, speleothem development occurred in the open passageways where overlying carbonate source rocks were present. The eventual drying of the climate has resulted in dust accumulation rather than further carbonate mineral deposition.

Introduction

Colossal Cave is the only commercially developed cave system located in the 2,400 acres of Colossal Cave Mountain Park. While several other caves are known to exist within the property, they are not open to the public (see appendix). The park is located in a beautiful setting adjacent to the Rincon Mountains, approximately twenty-two miles southeast of Tucson, Arizona (Figure 1). The Rincon Mountains are part of the rather unique set of metamorphic core complex (MCC) mountains adjacent to the city of Tucson (see Froede et al., 2003). The geological history of the Colossal Cave area has presented an unwitting puzzle to uniformitarian scientists because the tectonism that uplifted the Rincon Mountains occurred much later than the original deposition of the carbonates that contain Colossal Cave. The contorted strata and development of the cave system challenge several uniformitarian assumptions regarding time and are best understood in the Creation-Flood framework.

Area Stratigraphy

The geology around Colossal Cave has been used by the local university as a teaching tool in the training of graduate students in earth science (Figure 2). Mapping of the sedimentary strata has provided hands-on experience in understanding the complex structural geology in the area around the caverns (Davis,

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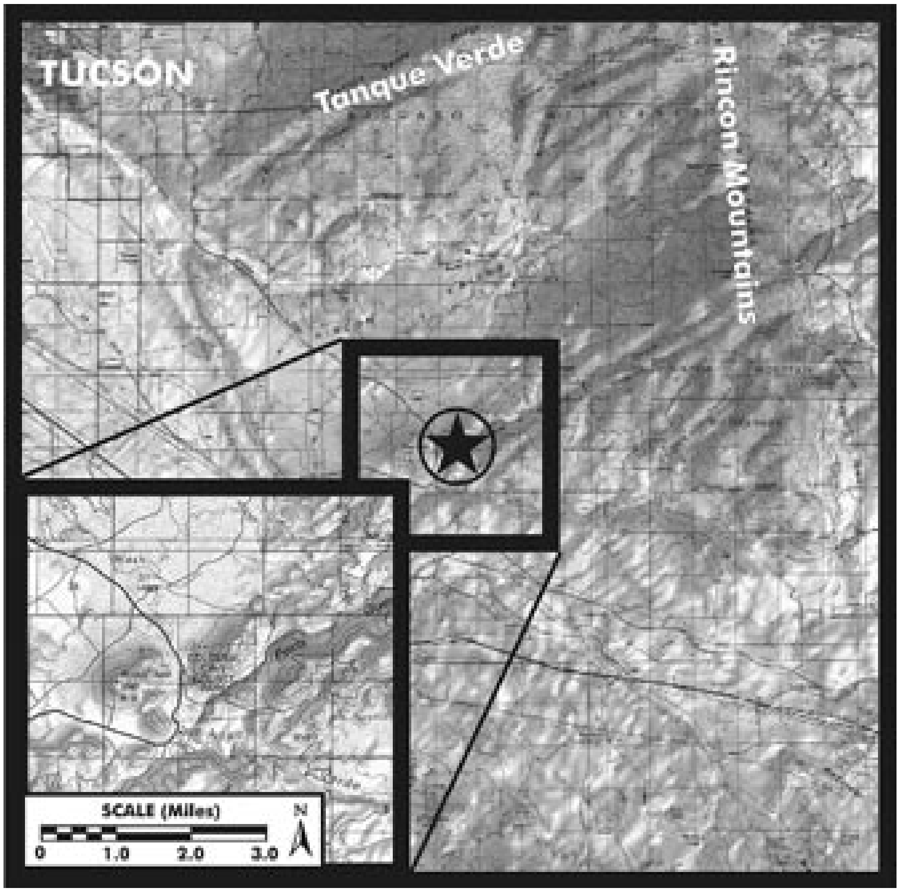

Figure 1. Topographic map showing location of Colossal Cavern in relation to the city of Tucson, Arizona, and the adjacent metamorphic core complex mountains. Detailed inset shows elevation contours at 164-foot intervals around the Colossal Cave area. The Paleozoic strata in which the cave system is developed were derived from the adjacent Rincon Mountains by gravity sliding. Modified United States Geological Survey Quadrangle (Tucson, Arizona [1994]—1:100,000 scale) using Maptech ©2001 software at 1X elevation.

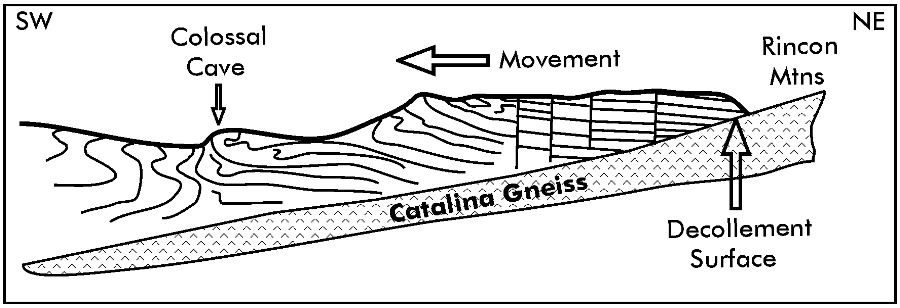

Figure 2. General diagram showing the Santa Catalina Fault surface over which the Paleozoic sedimentary strata have moved, creating gravity-induced folding. The location of Colossal Cave is approximated based on topography and stratigraphy. Modified from Davis et al., 1974.

et al., 1974). Regarding the sedimentary pile around Colossal Cave, Davis (1975) has written:

> Sedimentary rocks studied within the Colossal Cave domain are Paleozoic in age and form a sheet approximately 150 m thick that rests on the southeast limb of the Rincon Peak antiform. The rocks consist of limestone with interbedded shale and include formations of Cambrian through Permian age. In general, the strata strike east and dip 20°N. However, Arnold (1971) noted that the strike of the rocks in the northern part of the Colossal Cave domain defines a convex-southwestward arc. (p. 981.)

Regarding the presence of folds in the Paleozoic strata, Davis (1975) stated:

> Spectacular macroscopic recumbent and overturned folds pervade the sedimentary rocks in the Colossal Cave domain. The folds are best exposed in Posta Quemada Canyon in the northern part of the area ... the folds in the Colossal Cave domain have unbroken hinge zones. Profile analysis of the folds in the Colossal Cave domain was difficult because of the large size of the structures. Orientation relations of folds in the Colossal Cave domain indicate that the folds are overturned to recumbent with gently plunging axes and gently inclined axial surfaces. The exposed portions of the limbs of the asymmetric macroscopic folds are parts of Z-shaped asymmetric folds. (p. 982.)

A summary of the fold attributes for Colossal Cave as described by Davis (1975) is presented in Table I.

Later Davis (1977) added to the understanding of the area around Colossal Cave when he stated:

> The low-angle juxtaposition of relatively unmetamorphosed...upper Paleozoic strata directly on cataclastically deformed augen gneiss represents one of the puz-

Table I. A summary of fold attributes noted by Davis (1975; Table 1) for the sedimentary pile around the Colossal Cave area.

Attribute	Colossal Cave
Dominant rock type	Limestone
Sheet thickness	150 meters (164 yards)
Structural position	South limb of Rincon Peak antiform
Surface profile	Tight with sub-angular-to-chevron hinge zones
Layer form	Class 1C – (see Ramsey, 1967)
Attitude of underlying gneiss	N. 70° W., 30° SW.
Orientation of folds	Recumbent to overturned. Axes: 15° E. Axial surfaces: N. 15° W., 20° NE.
Asymmetry	Overturned basinward

> zling characteristics of metamorphic core complexes. During the arching, some of the lower Paleozoic strata were rendered ductile through metamorphism and flowed down the structural gradient. The effect of this deformation is inferred to have been a thinning of the strata by flow and a diminishing of the stratigraphic interval separating the upper surface of the crystalline rocks and the relatively unmetamorphosed upper Paleozoic and Cretaceous units. No special preparation was necessary to prepare the units for gravity-induced folding. *Layering, not faults, joints, or cleavage, is the obvious control for the fold deformations* ... the folds, are flexural slip and flexural flow, types in which layer control is dominant (Donath and Parker, 1964). If dynamic metamorphism had preceded the gravity-induced folding, one would expect that such an event would be disclosed by some form of early cleavage or fold set. These are not seen. The thermal event in the Rincon Mountains area weakened the units and caused them to yield by folding, not along pre-existing secondary structural weaknesses, but along primary layering. (p. 1214, italics added)

In summarizing the history of the sediment pile in which Colossal Cave developed, Davis (1977) stated:

> I see no reason to depart from my chief conclusions regarding timing that (1) "most of the gravity-induced folding accompanied the 28 to 24 m.y. uplift" and (2) "it is probable that some low-angle displacement or gravity-induced folding accompanied emplacement and (or) incipient uplift of the gneiss. (p. 1215.)

Escabrosa Limestone

Colossal Cave is formed in the Paleozoic Escabrosa Limestone. Several smaller limestone layers overlie this unit, separated by siliciclastic sediments (i.e., sands, silts, and clays). The limestone has been described by Bryant (1968):

> The Escabrosa ranges in thickness from about 600 to 750 feet. The unit is typically coarse-grained, light gray to white limestone, commonly containing a very high percentage of crinoidal debris. Bedding is thick to massive, and clastic content is very low. Fossils in the Escabrosa are not very abundant except for the prevalent crinoidal debris, but in general the unit is less fossiliferous than most of the younger formations. Throughout most of southeastern Arizona it is overlain disconformably by the Horquilla Limestone (Pennsylvanian). (p. 36.)

According to Beus (1989), the limestone varies in composition with the addition of chert in some locations and in others as a crinoidal grainstone. Regarding the paleontology of the formation, he added:

> The Escabrosa contains a variable invertebrate fauna including abundant brachiopods and corals and less common mollusks and trilobites. Conodonts and foraminifera indicate an age of late Kinderhookian through late Meramecian for this unit. (p. 304.)

A uniformitarian framework define the Escabrosa Limestone as lower/middle Mississippian and corresponds to an age ranging between 363 to 333 Ma (Harland et al., 1990).

Formation of the Rincon Mountains

The Rincon Mountains lie to the north of the unmetamorphosed but highly deformed Paleozoic strata from which Colossal Cave is formed. The mountains are part of the Santa Catalina-Rincon-Tortolita crystalline complex (Keith et al., 1980) and are interpreted as having

Figure 3. Conduits exposed in the side of the limestone block present clear evidence of water development. These features would have formed initially under subaqueous conditions and further developed once groundwater dropped below the level of the cave.

Figure 4. A vertical complex of individual conduits (perpendicular to the cave floor) that originated underwater and converged to form the larger passage through the limestone. Features like this one require subaqueous formation and development—a situation that uniformitarian scientists have not yet addressed in their historical model at Colossal Cave.

initiated during the Laramide orogeny (late Cretaceous—70 Ma) with uplift continuing at discrete intervals into the late Oligocene (22 Ma; Coney, 1980). The formation of the Rincon Mountains predates late Tertiary basin-range faulting.

The Rincon Mountains formed by the injection of Tertiary granitic melts into preexisting Precambrian granite. This created uplift and resulted in large-scale block faulting and rotation. The upper few thousand feet of the crystalline rocks became sheared as they moved laterally under gravitational force. This created a broad mylonitic zone of deformed metamorphic rocks. Above this area of tectonic stress, a décollement surface formed whereby overlying Paleozoic sedimentary strata moved laterally across the uplifting mountain toward the basin floor. Water is viewed as an important component for all of this tectonic activity in both uniformitarian position (Coney, 1980) and young-earth creation (Froede et al., 2003).

Colossal Cave Formation and Development

According to Cockrum and Maierhauser (1996), following the creation of the Rincon Mountains, "hot, mineral-bearing solutions caused part of the silica and hematite from some layers (especially the Bolsa quartzite) to be dissolved and redeposited in the cracks and crevices of some of the fractured layers" (p. 5).

However, they do not credit this hydrothermally-charged water with forming the cave system, rather they stated that:

> Colossal Cave was formed by the slow action of water seeping into the rocks and dissolving away part of the limestone. Although the general pattern of passages in the limestone appears to be in a northwest to southeast direction, no one level of water flow occurred throughout the cave. In fact, the various chambers and tunnels have been described as an irregular maze. (Cockrum and Maierhauser, 1996, p. 6–7.)

In describing the present state of knowledge regarding Colossal Cave, they further stated (p. 7):

> the Cave (sic) was formed sometime during the Pliocene Epoch of the late Tertiary, about one to two million years ago. In any case, as it exists today, Colossal Cave is thought to be about 600 feet in length and 380 feet at the widest part. Earlier, the Cave was probably longer, for both the northwest and the southeast ends of the caverns and chambers appear to be filled with plugging material from the eroding hillsides. The total length of all the known passages is about two miles. (Cockrum and Maierhauser, 1996, p. 7.)

During my cave tour, I observed several locations within the cave where water played a dominant role in its creation (Figures 3 and 4). An examination of just the commercial portion of the cave by scientists knowledgeable of cave formation and development would redefine the origin of this cave from subaerial to subaqueous.

Perhaps the best information in support of a subaqueous hydrothermal origin for Colossal Cave comes from the analysis of dogtooth spar calcite crystals collected from within the cavern. Peachey (1999) stated that:

> The initiation of speleogenesis appears to have occurred in the interval following mid-Tertiary (late Eocene-early Miocene) movements due to the local MCC but before late Tertiary (mid-Miocene-early Pliocene) interruption by the Basin and Range orogeny block-faulting—locally between 20–18 mya and 15–12 mya. *It is hypothesized that hot brines carrying H_2S encountered the buried limestones. Oxidation of the H_2S then created H_2SO_4 which dissolved the carbonate in a manner largely seen at Carlsbad Caverns.* (p. 23, italics added)

He further speculated that:

> If ongoing work demonstrates the validity of this explanation, Colossal Cave as well as several other southern Arizona caves will become known as the first representatives of a previously undescribed subcategory of hypogenic (deep) cave development. (Peachey, 1999, p. 23.) [Editor's Note: This is not the first time that this dissolution process has been proposed. In 1988, Mârza and Silvestru first mentioned hydrothermal karst phenomenon associated with Neogene metasomatic sulphide ore deposits from Rodna Veche (Mârza, Ioan and Silvestru, Emil. 1988. Studia Universitatis "Babes-Bolyai," *Geologica-Geographica,Cluj-Napoca*, XXXIII, pp. 77–81). In 1990, Silvestru introduced the category "hypogenic karst" based on his cave and karst studies and he noted that many Americans were ignorant of French and Romanian karstology references! (See Silvestru, E. 1990. Propositions pour une classification litho-génétique des formes karstiques et apparentées. *Karstologia*, La Rivoire, France. Nr.15, pp. 55–57).]

It should be noted that the dominant uniformitarian model for cave development remains the carbonic acid dissolution of carbonate rock typically above the groundwater table (e.g., Jennings, 1985; James and Choquette, 1988; White, 1988; Ford and Williams, 1989; Palmer, 1991; Gillieson, 1996).

The concept of cave formation and development by sulfuric acid speleogenesis was first proposed by Egemeier (1981). In 1990, Hill proposed that Carlsbad Caverns (and other caves within the Guadalupe Mountains) were formed by sulfuric-acid dissolution. She linked the migration and upward leakage of underlying oil and gas deposits to the formation of sulfuric acid in groundwater that moved along joints and sedimentary structures forming the caverns (Hill, 1990). An excellent summary of the sulfuric acid theory of speleogenesis is found in Jagnow et al. (2000). More recently, Naturalists have added microbial catalysis as a possible source of sulfuric acid for cave formation (Engel et al., 2004).

Problems with Lithification and Tectonism

Uniformitarian stratigraphy defines the Escabrosa Limestone as having formed during the Mississippian Period (363 to 333 Ma). The timing of the uplift of the Rincon metamorphic core complex mountains initiated during the Laramide orogeny (70 Ma) and continued in several pulses into the late Oligocene (22 Ma). The amount of time separating the end of carbonate deposition from the beginning of tectonic uplift ranges from 263 to 311 million years (Ma). The concept of "time" within the philosophy of uniformitarian earth history is not typically given much thought. However, I believe that Colossal Cave presents a rather striking example of too much time in the constraints of the uniformitarian paradigm.

The Escabrosa Limestone is one of several stratigraphic layers that repose deformed at the base of the Rincon Mountains (Figures 5a and 5b). The contorted limestone strata reflect semi-lithified folding, not brittle faulting. We should expect that tectonism occurring hundreds of millions of years following the deposition of the Escabrosa Limestone would break rather than bend and deform the strata. We would not expect the strata to remain semi-lithified over the course of hundreds of millions of years and then behave plastically as a result of tectonism. The concept of applying deep-seated metamorphism to create movement, thinning, and plastic deformation to overlying well-lithified sedimentary strata has not been demonstrated scientifically. The folded and contorted limestones provide no evidence of the effects of metamorphism. The excessive time between deposition and uplift creates serious problems and questionable concepts for the uniformitarian philosophy.

The theory of plate tectonics (PT) asserts that mountain building on the continents occurs primarily as a function of plate collision or subduction. Tectonism is understood to take many millions of years with the typical rate of uplift measured in inches per year or even inches per century. However, this concept of mountain building does not appear to apply to the MCC mountains adjacent to Colossal Cave. These mountains are viewed as having formed due to the injection of a Tertiary-age granitic melt over the course of at least three (possibly more) episodes of tectonism, spanning up to 50 Ma. This period of MCC tectonism is bracketed by the Laramide orogeny and basin and

Figure 5. (A, *left*) Looking northeast up Posta Quemada Canyon, which is just to the southeast of Colossal Cave. The canyon sidewalls exhibit strata in both near-horizontal and contorted orientation. (B, *below*) A close-up of the far end of the canyon. The physical form of the layered sediments clearly supports Davis's contention that these strata moved under gravitational force. Young-earth creationists contend that all of this (i.e., sediments and tectonics) can be attributed to the global flood of Genesis.

range extensional tectonics and yet directly unrelated to either. This is another example where existing PT theory provides no credible support to the understanding of the orogenic history of the area (see Reed, 2000).

Uniformitarian scientists assert that much of the sedimentary overburden above the uplifted MCC mountains simply slipped off the side of the mountains during uplift (e.g., Davis et al, 1974; Davis, 1975; 1977; 1980; 1987). This would imply a steady, rapid rate of uplift in order to maintain the integrity of the strata and prevent its erosion over the subsequent hundreds of millions of years (see Froede et al., 2003).

Creation-Flood Framework

As previously noted, the physical condition of the deformed and contorted strata that form Colossal Cave suggests that sediments moved off the rising Rincon Mountains as semi-lithified strata. Uniformitarian scientists have stated that the formation of the metamorphic core complex mountains strongly supports a setting with abundant water and it is reasonable to expect that the Flood-deposited semi-lithified strata would have moved from off the top and/or side of the rising MCC mountains during subaqueous tectonism. The subsequent formation and development of the cave system would coincide with conduit development due to the expulsion of both connate and hydrothermal waters associated with subaqueous orogenesis in a manner consistent with the karstification and cave formation processes discussed by young-earth creationists (Silvestru, 2001; 2003; Woodmorappe, 2001).

Eventual Floodwater withdrawal coupled with a wet weather post-Flood climate (Oard, 1990) would be conducive for speleothem development at a rapid rate. The further lithification of the limestones coupled with a drying climate would see a decrease in calcium carbonate deposition within the cave. The weather experienced by this portion of Arizona today has terminated any further development of calcite deposits in Colossal Cave, and dust deposition and accumulation now predominate (Figure 6).

Conclusion

It is incumbent for creationists to define the rock record within the context of

Figure 6. The flowstone presents clear evidence that it was created in subaerial conditions in a manner typical to speleothem development. The drying of the climate since the end of the Ice Age has transformed the cave from active calcite deposition during wet periods to experiencing only present-day dust accumulation.

biblical history. The purported passage of millions of years between the watery deposition of the Paleozoic strata and onset of considerable tectonic uplift is not supported by the empirical evidence found in this area of study. That uniformitarian scientists readily acknowledge the abundance of water in the formation of metamorphic core complex mountains and invoke hydrothermal fluids to erode and redeposit silica within the adjacent contorted and deformed strata should be applauded. The more important question for the uniformitarian interpretation begs for an answer defining the source of all this water.

The Creation/Flood framework provides an interpretation consistent with the physical evidence. Simply stated, the semi-lithified Flood-deposited sediments slipped from the top or side of the Rincon Mountains while being uplifted subaqueously during the Flood. The strata slumped adjacent to the uplifted mountain and were further altered as interstitial and hydrothermal fluids moved through them. Speleothem development occurred following Floodwater withdrawal but has terminated in today's dry weather setting. Dust covers much of the flowstone today.

Appendix

An interesting story was recently posted on the *Tucson Citizen* web page regarding the discovery of a new cave on park property. The cave has been named La Tetera—Spanish for tea kettle. Many of the explored rooms are reported as being barren of speleothems and containing sand on the cave floor. However, several newly discovered rooms contain dripstone, flowstone, and rare cave crystals described as "Disneyesque" by the cave's explorers. The following is a summary of the information provided on the web page (Kimble, 2004):

> In January 1996, a Colossal Cave employee observed a geyser of steam shooting at least six feet into the air. The steam was reported to be coming from a 3.5 inch-diameter opening in the ground. Over the course of several years the opening widened and six years following its discovery the first cave explorers entered and lowered themselves to the sandy floor of the cave. The interior is reported to be hot with humidity near 100 percent; however, there was no flowstone or dripstone in the immediate area. A number of prehistoric animal bones (e.g., horse, camel, tortoise, frogs, snakes, and rodents) were found around the floor area and how this material got there remains a mystery. Over the course of many months, five initial rooms were mapped. Additional rooms were subsequently identified following the discovery of moving air coming from a small cave wall opening. The heat and humidity provide for continued cave dripstone and flowstone formation where it has developed. Crystals cover a large room in a newly discovered area and progress in cave mapping has stopped until a means can be determined to further explore the cave system without destroying the delicate cave crystals. While exploration of the cave has only proceeded down to around 100 feet below the ground surface, spelunkers believe that it continues much deeper. They hope to continue exploration once they determine how to proceed and not destroy the delicate cave formations. It is estimated that La Tetera is approximately 10 million years in age.

The presence of a deep-seated heat source supports the idea that hydrothermal processes probably created this cave system. It is interesting that sufficient heat still exists today allowing for continued dripstone and flowstone development despite its alleged old age. The reference to high humidity without extensive speleothem development in various cave passages is curious in that the system yet remains in its present state even after "10 million years."

Again, the concept of deep time does not appear to match the physical evidence described in this newly discovered cave.

Acknowledgments

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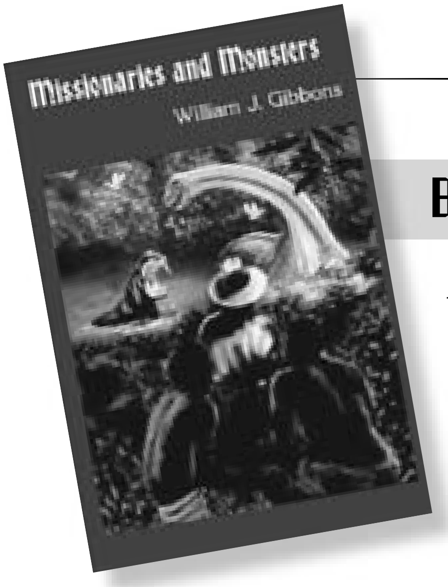

Book Review

Missionaries and Monsters (second edition)

by William J. Gibbons

Coachwhip Publications, Landisville, PA, 2006, 103 pages, $9.95.

"There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy." Such were the words of Hamlet in Shakespeare's play. All too often people are trapped by the limits of their experience. William Gibbons' exploration of cryptozoology, *Missionaries and Monsters*, invites readers to go outside the limits of what they think and believe, and take a look at the reports of others which are almost beyond belief.

Gibbons takes the reader on a journey through descriptions of several different types of reported monsters including the Loch Ness monster and similar creatures, sea serpents, dragons, large snakes, strange apes, and other interesting creatures. Gibbons does not try to convince the reader that all of these creatures exist. Instead, he makes the reader aware of the reports of these creatures to understand that the search for them is more than a fool's errand. Some reports may turn out to be fictional, and others may be real, but the search is an informed one. Whether you consider these stories plausible or not, the book is filled with story after story of page-turning excitement for any age or background.

Gibbons writes from a young earth perspective, and even includes Behemoth from the book of Job in his list of accounts. For creationists, this book provides a good but incomplete guide to the variety of reports of animals, both amazing and presumed extinct, and can provide those who wish to be "living fossil hunters" with an idea of where and what to look for. For others, the book serves as a reminder that there is more to God's creation than what lives in the backyard and in the local zoo.

The book's main shortcoming is minor but pronounced. While a short bibliography is included, there are few citations throughout the entire text. This makes verification and further research very difficult. This book appears to be a primary source for many accounts, but it is difficult to tell because of the lack of footnoting.

What is obvious, however, is that much lurks in the earth's remote places, and whoever is willing to seek out the inhabitants of such areas is likely to be rewarded. The author is part of a team that is exploring the Cameroon in search of Mokele-Mbembe, a sauropod dinosaur, recent eyewitness reports of which are recorded in the book.

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Pioneering ^{14}C Dating of Wyoming Amber and Its Implications for a Young Earth and Global Catastrophism

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Abstract

The geologic column not only has a problem with coal containing anomalously large amounts of ^{14}C, but also with ^{14}C in dinosaur bones, carbonized wood and amber as well. The purpose of this paper is to 1) review radiocarbon dating of carbonized wood and dinosaur bones, 2) introduce radiocarbon and infrared studies of amber, and 3) correlate radiocarbon dates of ambers and other natural resins with real time. This is the first known instance of "true amber" being directly dated. ^{14}C dates for amber were at the upper limit of the AMS dating method. The Hanson Ranch amber buried with a triceratops is slightly younger than Baltic amber used as controls, but all true ambers are about the same radiocarbon age as the coals used as blanks. Dinosaur bones and carbonized wood were all within the range of both the conventional and AMS methods. The primary chemical in the Hanson Ranch amber is succinic acid and its salts, succinates and succinites the same as Baltic amber, based on infrared studies. The dinosaurs and amber on the Hanson ranch appear to have been deposited catastrophically.

Introduction

Radiocarbon (RC) dates have been measured for many kinds of specimens that were previously thought to be too ancient to contain detectable levels of Carbon-14 (^{14}C). Coal specimens are typically 40,000 RC years before the present (BP) (Rotta, 2004), as is carbonized wood (Fields et al., 1990). Dinosaur bone apatite for five different dinosaurs from the western United States were in the range of 9,890 to >36,500 RC years (Fields et al. 1990; Dahmer et al., 1990). Diamond is at <58,000 RC years (Baumgardner et al., 2003). Fossilized wood in ancient sandstone (allegedly 225-230 M years) gave an RC date of 33,720 (± 430) RC years BP (Snelling, 1999).

These anomalous ^{14}C readings obviously contradict currently accepted geologic thinking concerning the age of the specimens tested. These measurements, coupled with additional contradictory observations, create a serious challenge for the standard geologic model.

Contemporary geological thought faces a period of crisis not unlike that in physics around the turn of the twentieth century. At that time, anomalies in the measurements of the advance of the perihelion of the planet Mercury caused astronomers to predict the existence of an undiscovered planet somewhere between Mercury and Venus, tugging on Mercury. The predicted planet was named Vulcan. In addition, a very famous set of experiments by Michaelson and Morley using light beams failed to measure the Earth's speed through a

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hypothetical ether that was thought to fill empty space. And the final anomalous set of observations from this time also concerned the nature of light, definitely contradicting the accepted wave theory of light. All three of these insurmountable problems were solved by a single brilliant scientist—Albert Einstein. Einstein demonstrated that the old theories of light, gravity, space, and time were inadequate and had to be replaced by new theories that could naturally explain the anomalous observations. These new theories are quantum mechanics, and the special and general theories of relativity.

A similar crisis exists in the standard geologic model today, where anomalous dates and other geologic observations cry out for a new model to accurately explain them. True science seeks an understanding of all the facts gleaned from observation, and not just those most compatible with a specific theory. It also accepts proven anomalies as a sign that the current theory is inadequate. The discovery of anomalies is an integral part of the nature of knowledge, and therefore the replacement of older theories by newer and more encompassing theories is what makes science function, and denying the existence of valid anomalous measurements and observations is simply impeding science.

The authors were privileged to have worked with the July 5–14, 1996, dinosaur excavation team in Wyoming during and after the excavations. We evaluated and photographed many of the amber specimens, and assisted scientists associated with the Polish Academy of Sciences with our reports, photo-macrographs of amber, references and selected Hanson Ranch samples of amber for RC dating.

Why Radiocarbon Date Amber?

An unexpected RC date of 12,800 years before the present (BP) was obtained for "a burnt branch" imbedded in the Cretaceous rock strata at the bottom of the Paluxy River, Texas (Beierle, 1979). This suggested that the specimen appeared to be 10,000 times younger than its date in the accepted geologic column of 108 million years BP. Therefore, we determined to test the validity of the controversial theory of the coexistence of humans and dinosaurs by RC dating. Measuring a relatively young date for amber would support the possibility of correspondingly younger dates for dinosaurs and accepted geologic ages in general. If these younger ages were indeed accurate, then confirming human and dinosaur footprints together in the fossil record would be a monumental scientific breakthrough (Morris, 1980), offering still more evidence of our young-earth hypothesis. This controversy was thus at the forefront of the origins debate in the late 1970s and 1980s.

Confirming that fossils containing carbon, including amber, also contain measurable ^{14}C would be consistent with the claim that dinosaurs and man did indeed coexist (even without finding their footprints together in the same strata). It would also show that the Glen Rose Cretaceous strata (also called the "Austin Chalk") were deposited only thousands of years ago. The implications would present a serious challenge to the viewpoint of long ages for Earth's history. It would mean that the alleged 65 million years of evolution since the time of the dinosaur never existed, and the long-age geologic column would indeed collapse. Thus, a straightforward way to settle the controversy was to accelerate all the relevant research. This would include the fields of paleoarchaeology and radiometric dating.

Regarding paleoarchaeology, beginning in 1982, some of us participated in excavations on the ledges of the famous Paluxy River in Glen Rose Texas. These excavations were initiated by Carl Baugh of the Creation Evidences Museum (CEM) after permission was granted by the McFall Ranch family to excavate on their Paluxy River ledges (Baugh and Wilson, 1991) rather than continuing research on the river bottom (Morris, 1980).

The first task we undertook was to evaluate a human handprint impression imbedded in the cretaceous limestone excavated in 1982 (Baugh and Wilson, 1991). Its features were identical to the modern human hand, and were associated with a trail of four, 16-inch-long human-like footprints. The project director of this independent study, a Ph.D. in geophysics, wrote a paper that was presented at the First International Conference on Creationism (ICC) (DeVilbiss, 1986). A group of eight independent researchers (Fields et al., 1990) presented a follow-up paper at the Second ICC. Since the publication of these two Proceedings papers, two more human-like footprint trails have been discovered. One trail has an impressive nine-inch-long human-like footprint in the bottom of an eroded 17-inch-long dinosaur print. The human-like print was the missing fourth print in a trail of five that was part of an original shallow series excavated in 1982. The clay at the bottom of the dinosaur print had not been completely removed in 1982, as discovered in 1997 by a CEM team member. Finally, the footprint combination was extracted from the rock with the landowner's permission and can be seen at CEM.

Prior to the above research, the famous Taylor trail of human-like and dinosaur-like prints together in the Paluxy River bottom had been observed (Morris, 1980). The different interpretations by various parties were the primary cause of the controversy, not the existence of pristine ones found in subsequent years on the McFall ledge (~90 human-like and 300 dinosaur prints). The latter were excavated under tons of Cretaceous limestone and several inches of clay, five strata above the river bottom

(Baugh and Wilson, 1991; Helfinstine and Roth, 1994).

In addition, another major discovery in the Paluxy River was a trail of 136 dinosaur footprints thought to be that of the *Acrocanthosaurus* (Patton, 2000). This should be of great interest to all ichnologists (scientists who study track or footprint remains of extinct plants or animals), and those hungry for dinosaur lore. These prints were rediscovered during a draught in 2000 by a geologist directing the research at that time. This trail was named the Turnage Patton Trail. Patton (2000) describes the trail on his web site, and the *CRSQ* reader is encouraged to examine the footprint trail photos of both species.

> The prints are deep and incredibly detailed. The work of uncovering and cleaning the trails began September 9th and continued through October 14. It was conducted under the auspices of the Metroplex Institute Of Origin Science and the Creation Evidence Museum. The leading dinosaur track authorities have acknowledged that they know of no other single consecutive dinosaur trails in North America that are this long. Both the length and the beautifully preserved detail certainly make this one of the finest displays of dinosaur tracks in the world. The primary trail is finally obscured at the upper end by erosion for a distance of about thirty feet and then the trail appears again for another twenty-one consecutive tracks, making a total of 157 (Patton, 2000).

Ripple marks in sedimentary rock can be found in the river bottom with the dinosaur and human footprints also (Patton, 2000). All the above information is documented and is presented here to demonstrate the necessity to radiocarbon date as many different fossils as possible, including amber, to determine a more accurate time period when the above species left their "ichnites."

Radiocarbon Dating of Fossils

Since 1978 there have been successful efforts by several teams to RC date fossil materials such as a burnt tree limb imbedded in the cretaceous sedimentary strata of the Paluxy River bottom (Beierle, 1979). Dating of carbonized fossil wood from Paluxy River between the top two strata gave RC ages of 38,000; 39,000 (Morris, 1980); 37,480 (+2950/-2140); and 37,420 (+6120/-3430) for carbonized wood in clay layers, and 45,000 (+5550/-3250) for coalified wood and reeds (Fields et al. 1990) using the conventional method. AMS was used on carbonized wood embedded in the rock itself and only exposed to the atmosphere for one-half hour during break-up of rock. The burning condition of the wood (from lightning, manmade fire, volcanic eruptions or asteroid impaction) found imbedded in the river (Beierle, 1979) could have "fixed" the ^{14}C in the wood while it was still hot and smoldering in limestone and/or clay watery mixture, thus preventing old humic acids and carbonates from the limestone watery mix and Bentonite/Illite clays from "diluting" the ^{14}C content by absorbing into the cellulose structure of the wood. The date for this wood was only 12,800. AMS was also used on carbonized wood embedded in the rock itself and only exposed to the atmosphere for one-half hour while the rock was disrupted, and an age of >49,900 RC years BP was obtained in 2005 from a licensed analytical lab in the United States of America. According to a private communication with Dr. John DeVilbiss (Spring of 1986), examination of the clay between the rock strata indicated an estimated age of >5,000 to < 50,000 years BP.

Carl Baugh dated his *Acrocanthosaurus* bone discovery and he obtained an age of >36,600 RC years. At that time no one had any idea the significance of that data. Thus, to determine the time line when these footprints were impressed in the original limy mud and to perhaps further confirm the coexistence of humans with dinosaurs, dinosaur bone fragments from Texas to Alaska have also been radiocarbon dated with RC ages ranging from 9,980 to >36,500 RC years BP (Fields et al. 1990). If these dates are valid the conclusions become obvious: Man and dinosaurs did indeed live together and the evolutionary geologic column must be a factor of 1000 to 10,000 times younger than currently geological thinking assumes. Indeed, the principles of sedimentology supporting the geologic column have already been strongly challenged by lab and flume studies as Berthault (1994) suggests and which this research seems to confirm. Notably, when AMS was employed to date other *Acrocanthosaurus* bones, much younger RC dates of 23, 760 (±270) and 25,750 (± 280) years were obtained (Dahmer et al. 1990).

Fortunately, our consulting geophysicist in the 1980s (DeVilbiss, 1986) could not find volcanic material to K/Ar date in the clay between rock strata. The existence of such material might have caused some confusion in dating, based on what is now known about problems with long age radiometric dating systems (Miller, 2005). However, according to Dr. John DeVilbiss (private communication, Spring of 1986) an examination of the clay between rock strata by a soil lab gave an estimated age of >5,000 to < 50,000 years BP, as noted earlier. Nonetheless, are these RC dates any more reliable than the long age radiometric dating systems? The diversity of anomalous RC dates found for the fossil wood and dinosaur bones suggests a lack of accuracy in RC dating, and further points to the possibility that no radiometric dating can provide absolute ages (Brown, 1992; Van Oosterwych-Gastuche, 1999).

Because of the challenges put forth by old-earth scientists of differing philosophies on origins, the thought remained that maybe the bone and carbonized wood samples could have been contaminated with modern carbon 14 from the environment. It is logical that contamination could give rise to a variety of RC dates if the weight of carbon absorbed onto bone surfaces or into bone matrices were 1% or greater (Stafford, 1992). Therefore, our goal was to demonstrate that RC dating of amber from the Cretaceous period might help in grappling with the contamination question. Amber contains about 80% carbon (Rice, 1980).

In our estimation there appeared to be several potential outcomes to this study: 1) Because of amber's high carbon content (80%) there would be far more of a chance of contamination than with dinosaur bones containing 2–5% carbon (Andre Ivanov, 1995, personal communication). If amber specimens were contaminated it would give very young RC dates. 2) On the other hand, there could be less risk of absorption of atmospheric ^{14}C in the amber due to the composition and nature of amber itself. 3) It could also be that contamination is just a "straw man" argument and not a significant problem; evolutionists may simply offer contamination as a simplistic answer to why fossils allegedly 70 million or more years old contain detectable levels of ^{14}C. 4) The anomalous dating problem could actually be that RC dating is based on false assumptions and does not give absolute ages (Brown, 1992; Whitelaw, 1993; Van Oosterwyck-Gaustuche, 1999; Humphreys, 2004).

Thus, amber was thought to be the fossil material best suited to test the contamination theory. The fortuitous finding of amber in Wyoming in 1996 (Ceranowicz et al. 2001) expedited the research, avoiding several of the complications associated with finding, expense, and collecting of useful samples of amber.

Physical and Chemical Characterization of Amber; Locations Worldwide and Geology of the Wyoming and Baltic Sites

Amber is known to have a much higher percentage of carbon than wood. According to the AMS lab, the carbon content was 82–88% based on the observed CO2 pressure (Ceranowicz et al., 2001). Details of amber chemistry can be found in Rice (1980) such as that the material burns with a readily-bright yellow flame; contains 79% carbon, 10.5% hydrogen, and 10.5% oxygen, sometimes traces of sulphur; it decomposes at 250° C, and gives off white fumes and pine odor. (Additional background on amber chemistry and history can be found on various Internet web sites.) On the other hand, ten dinosaur bone fragments from the Carnegie Museum of Natural History in Pittsburgh contained only 2 to 7% carbon based on scrapings of their brown to black surfaces as determined by analysis in a Leco furnace analyzer (Fields et al. 1990; Dahmer et al., 1990). Similar percentages are found in the cross sections of dinosaur bones that were seemingly partially or completely petrified (Andre Ivanov, 1996, personal communication).

Rice's book entitled, *Amber, The Golden Gem of the Ages* (1980) is an excellent source of information regarding the history and/or physical properties of amber. Baltic amber comes from deposits in the coastal regions of the Baltic Sea around Denmark, Sweden, northern Germany, Poland and the Soviet Union. Elsewhere, small quantities of amber or fossil resins have been found in Sicily, Romania, China, Burma, Thailand, Japan, the Soviet Union, Canada, and the United States. Currently, large quantities are being mined in the Dominican Republic (Rice, 1980).

A simple description of amber in its raw state, as we found it in Wyoming, follows:

> It sometimes has a dusty, friable reddish-brown, light brown or grey crust, due to alteration. It is found in variously shaped nodules—. When present in alluvial sand or gravel, amber no longer has the opaque coating and is often rounded into pebbles or grain. (Lyman, 1986, p. 308.)

Amber also floats in salty seawater, which is why for centuries amber has been found along the Baltic Sea shores as undersea currents or other disturbances release them from their underwater burial sites. Other major sources of amber include: Colombia, Dominican Republic, Mexico, South Carolina, New Jersey, and even above the Arctic Circle such as Axel Heiberg Island as well as other lesser sites in the United States and worldwide (Rice, 1980).

Ceranowicz et al (2001) gives more locations. Also, as was found out later in Poland, the triceratops site amber contained succinites based on infrared absorption spectra (Figure 1), which confirmed it was true amber. These are cross-linked carbon bonds and are salts of succinic acid called succinites or succinates.

The smoke of amber is said to be a potent therapeutic agent used through the ages. The basic formula for succinic acid is that of dicarboxylic acid (four carbon atoms). Amber contains 3–8% succinic acid (Rice, 1980).

Amber in a Global and Local Perspective

The Hanson Ranch, Roxson Wyoming is located in eastern Wyoming some 80 miles west of Mount Rushmore, South Dakota, and 15 miles west of Route 85 on Cheyenne River Road. We eventually collected a number of samples under the direction of Joe Taylor of the Mt. Blanco Fossil Museum, Crosbyton Texas, who knew where to find the actual 30-cm-thick "gumbo clay layer" in which "Vinny" the triceratops was uncovered. Joe also helped us gain permission of the Hanson family to pursue this quest, as well as showing us the exact strata in which "Vinny" had been excavated (Derstler, 1994). A photo essay of the Hanson Ranch excavations can also be found in this *CRSQ* issue. In addition, a paper by Holroyd et al. (1996) provides a more complete description of the Hanson Ranch and potential research

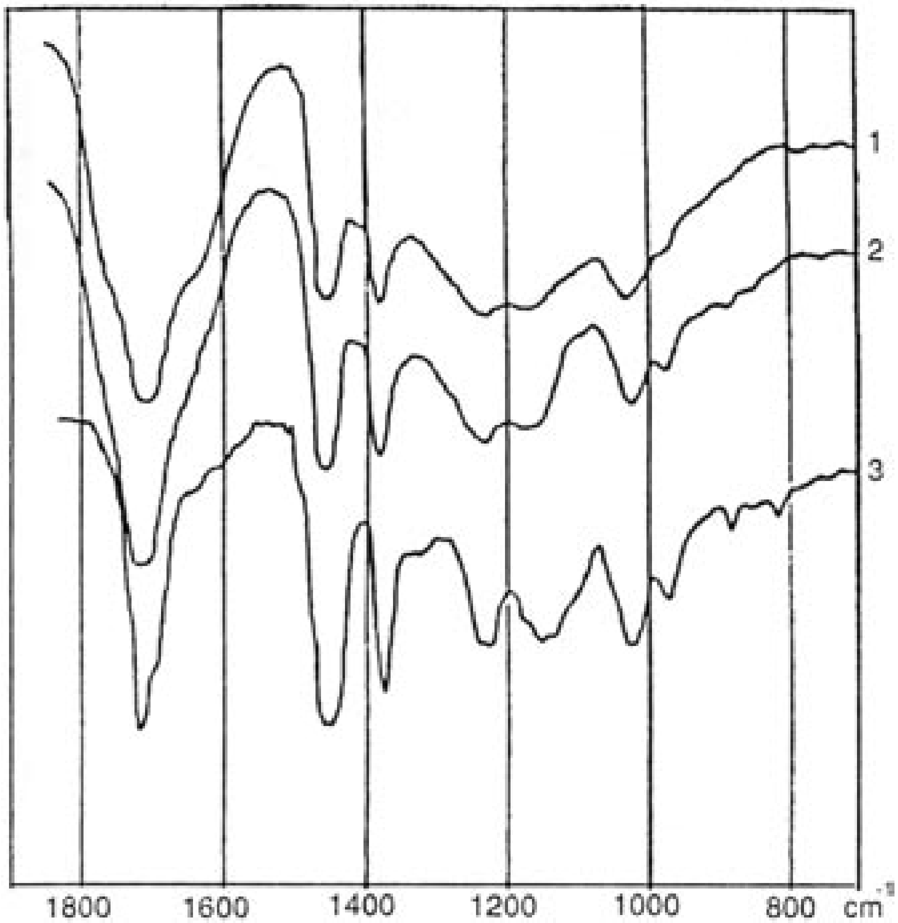

Figure 1. Infrared absorption spectra (IRS) for cedarite samples. 1 – IRS 369, cedarite, Cedar Lake, Cretaceous (MZ, inv. No. 2148, from coll. Of University of Toronto; 2 – IRS 474, cedarite, Grassy Lake, coal mine near the village of Bassano, S. Alberta, Cretaceous (MZ, coll. A. Zobel); 3 – IRS 508, cedarite, collected on July 11th 1996 by Hugh Miller and his team (Paul McDorman, Bryce Gaudian, Matt Miller, Andy Greybeal, and others) at Hanson Ranch, 2360 South Cheyenne River Rd., New Castle, Wyoming, from Upper Cretaceous (upper Maastrichtian) clay (Lance formation). MZ – Museum of the Earth, Polish Academy of Sciences, Warsaw.

ideas. Southwestern Adventist University is now involved in collecting dinosaur specimens from the Hanson Ranch.

Both the hadrosaur and triceratops (three miles away) fossils were buried not in stone but in the dark grey clay (gumbo) of the Lance formation. The clay is called "loam" (Ceranowicz et al., 2001). The paleontologist who originally uncovered "Vinny" in the 1990s, Kraig A. Derstler, is quoted by Ceranowicz (2001) as saying:

> The loam contains muscovite flakes and coalified plant detritus, especially small wood fragments. The minute laminations visible in the loams are underlined by the flatly deposited fragments of coalified remains. This positioning suggests peaceful sedimentation." (p. 77)

However, minute laminations and flatly deposited wood detritus do not necessarily suggest a "peaceful sedimentation." Based on paleohydraulics (Berthault, 1988, 2002a, 2002b, 2004; Clark and Voss, 1994; Fineberg, 1997; Flood, 1981; Julien et al., 1993; Lalomov, 2001; Makse et al., 1997; McKee et al., 1967; Snelling, 1997; Walthur, 1894) minute laminations could suggest deposition in a fast moving current. Mt. St. Helens (WA) is a prime example of rapid deposition of fine laminations. Flat woody material could have been deposited along with the clay and dinosaur bones in a prone position due to the mechanics of rapid deposition. A flume experiment might help settle this minor dispute by adding differently shaped wood chips to a rapid moving clay/water mixture at different hydraulic speeds and studying the alignment of the flat wood chips.

The largest amber museum and amber research center in the world is located in Warsaw, Poland at the "Museum of the Earth." Therefore, we sought the help of Polish scientists who initially used a ^{14}C conventional lab in Poland. However, because of the small size of the Wyoming amber the conventional lab analysis could not date it. Instead, they took samples from the museum in Warsaw and RC dated them with Wyoming amber at an Accelerated Mass Spectrometer (AMS) lab, and wrote an excellent article, which is available from Hugh Miller. This proved to be a difficult analysis as they stated in the monograph, "true amber, succinate, has never been RC dated because it is considered too old for that" (Ceranowicz et al., 2001, p. 77).

They also pointed out in the introduction of the amber paper:

> In order to contrast any possible dating made on the material from Wyoming it was considered necessary to date simultaneously some true amber (succinate) samples from excavations in known geologic deposits, which could perhaps constitute a better blank than the traditional coal samples used in ^{14}C analysis. For this purpose the resins already dated (Table I for "young amber, copal

> and colophony) were considered too young for comparison and also not referable to any deposit since found on the beach (along the Baltic Sea coast). Thus two excavated samples were obtained from the Museum of the Earth in Warsaw for comparison. The actual results of amber did not help much with the dating of the formation in Wyoming, but since it is the first time amber was tested for RC content it is considered useful to publish the results obtained. (Ceranowicz et al., 2001, p. 77.)

AMS generally requires samples that contain a minimum of 3 mg of carbon. However, it is interesting that when we dated mammoth tusk (to be reported in a future paper), an AMS lab found only 0.2 mg of collagen, yet came up with an RC date of ~ 4,980 RC years BP. This knowledge should be helpful in dating ancient fossil bones.

Table I. Tabulated Radiocarbon Dates for the Three Amber Samples and Previously Dated "Young Ambers," Colophony and Copal,*

Specimen Year dated	Location, Collector	RC Years BP, Equipment	Evolution age, years	Creation age, years
#2961 2001	Saxony, Germany(b), Ceranowicz	>49,210 AMS	~40,000,000	~5,350 (± 100) pre-flood
#2962 2001	Sambian Pen. Russia(c) Ceranowicz	>51,900 AMS	~ same	ditto
#2963 2001	Wyoming(d) USA, Miller Team	>46,450 AMS	~100,000,000	ditto
Previously ^{14}C dated amber type resins from Introduction to the paper*, 1996				
7 Kg"Young amber or Collophony" from Bay of Gdansk, Poland		620 (± 30)	Modern	Post-flood modern
Three "young ambers"		> 60,000	?	~5,350 (± 100) Pre-flood
Copal from Angola		37,700	?	~5,350 (± 100) Pre-flood
Four colophony samples		620–7120	Recent	620–4725 (± 100) Post flood
Scots pine colophony		525	Recent	Post-flood modern
* Ref. Ceranowicz, B.K., Maciej Giertych, and Hugh Miller 2001. Cedarite from Wyoming: infrared and radiocarbon data, *Prace Muxeum Ziemi* 46: 77–80, PL ISSN 0032-6275" (a)				
(a) Barbara Kosmowska-Ceranowicz, Museum of the Earth, Polish Academy of Sciences, Amber Division, Al. Na Skarpie 20/26, 00-488 62-035, Warsaw, Poland Maciej Giertych, Institute of Dendrology, Polish Academy of Sciences, 62-035 Kornik, Poland. Giertych coauthored the paper with other primary author Ceranowicz and with Hugh Miller, The Paleo Group, Box 2613, Columbus, OH 43216, USA supplying the sample from Wyoming and the major USA references; both English and Polish.				
(b) Succinate amber from the Museum of the Earth from upper Oligocene/lower Miocene sediments in Goitsche (near Bitterfeld) Germany; collected in 1986.				
(c) Succinate amber from Museum of the Earth, Warsaw, Poland in Primorskoe Mine, Kalingrad region of Russia in Upper Eocene blue earth sediment (Prussian formation); collected in 1996.				
(d) A brittle amber-like deposit of fossilized resin embedded in clay from the Hanson Ranch, 2360 South Cheyenne River Rd., New Castle, Wyoming, USA, from Upper Cretaceous (upper Maasstrichtian) clay (Lance formation) July 11th, 1996.				

Peaceful vs. Rapid Deposition of Amber in the Wyoming Dinosaur Graveyards

The last two statements of the paleontologist who originally excavated the Vinny site in 1994 (see previous section) were best challenged by Gary Gordon, formerly of ICR, when he was examining the many small carbonized wood fragments **(see Photo Essay, p. 104, Figure 15)**. During an interview with our videographer, Andy Graybeal, Gary Gordon remarked, "the finely divided chopped-up slivers of coalified wood in the GUMBO matrix speaks of a 1000-mi/hr swirling tidal wave moving across the earth as might have happened during the flood of Noah as the moon's gravity sent these tidal waves moving around the earth for 150 days, twice a day." Fine laminations can form during rapid hydraulic depositions, such as at Mt. St. Helens "miniature Grand Canyon." These laminations deposited rapidly in hours rather than during some assumed "peaceful sedimentation." Most geologic estimates suggest deposition rates throughout the geologic column at a "rate of one centimeter/1000 years is typical" (Officer, 1996) or as at Sideling Hill Mountain MD Museum Display the estimated rate for the 380 foot road cut is ~ one centimeter/1600 years. (See Internet sites for details of this "Syncline": http://www.dnr.state.md.us/publiclands/western/sidelinghill.html, and http://www.mgs.md.gov/esic/brochures/sideling.html.) Lab and flume studies (Julien et al. 1993; Snelling, 1997) support the proposed catastrophic hydraulic deposition activities that laid down the dinosaur graveyards of Wyoming.

The chopped-up woody material and tiny broken pieces of amber (rarely more than pea-size) are further evidence of rapid hydraulic deposition. Most of the amber particles were much less than ½ cm in diameter and almost always jagged, giving the appearance of having been broken off much larger pieces. Baltic amber did not contain jagged portions and were much larger than Wyoming amber. If Baltic amber did participate in a hydraulic situation, it could be speculated that the event was much less violent than that occurring in Wyoming.

Radiocarbon Dating of Mammoths vs. Dinosaurs

One of Paleo's major projects for 2005 was to collect and study a large number of important RC dates. One such article dealt with the RC ages of Mammoths (Vasil'chuk et al., 1997). Three hundred and sixty RC dates are tabulated based upon ^{14}C dating of bones [~130], tusks & molars [~190], and soft tissue [~40]. On the Eurasian continent the dates ranged from 9,670 (± 60) to >53,170 RC years BP. Except for 21 dates, all were less than 40,000 RC years. Of the dates older than 40,000 RC years, most were in the range of the 43,380 (± 380) years for Prudhoe Bay unfossilized wood buried in permanent permafrost at a 120-foot depth (RC age obtained from a licensed USA ^{14}C lab in 2004). Vasil'chuk et al. (1997) conducted extensive studies of these bones (Permafrost region) but collagen content was not discussed. They also dated plant material found with the bones. They concluded; 1) there was no statistical RC difference between the bones and that of the organic material and 2) dating of mammoth bones is reliable. In addition, Wrangel Island in the Arctic Ocean above Siberia gave eight mammoth bones, tusks, and teeth whose purified collagen was used to obtain RC ages of less than 5,000 years (Vartanyan 1995).

Possible Contamination with Modern RC

The Paleo Group (~1990) RC dated five different collagen-poor dinosaur bone fragments in a similar range of ages (9,890 (± - 50) to 25,750 (± 250) RC years) as RC ages of various mammoths. One licensed AMS lab RC dated the humic and alkaline fractions for a sixth dinosaur bone that was found 20 miles from the Arctic Ocean in Alaska, and obtained 36,140 (±560) and 31,050 (± 230) RC dates respectively (contract with licensed overseas lab in 1998). Even though amber has a large surface area containing high concentrations of carbon (80% carbon), the ^{14}C ages for amber were in the same range as other fossils, including coal. Thus, if carbon compounds had a tendency to pick up modern CO_2 from the air or from organic chemical absorption, the high carbon content of amber would likely make it the best candidate for such absorption. But, there was no indication of such contamination based on the results of ^{14}C dating of amber. Challenges by Stafford (1992) for relatively young dinosaur bone ^{14}C ages therefore seem to be inappropriate arguments for anomalous RC ages for Cretaceous/Jurassic dinosaurs.

These dinosaur bones did not contain collagen, only bone apatite (Dahmer et al.,1990). Bone fragments containing little or no collagen were therefore RC dated. Paleo observed and concluded that:

- Even without bone collagen, dinosaur bones contained residual 2–5% carbon throughout the bone structure (Andre Ivanov, 1996, personal communication) similar to that obtained by surface scrapings (Dahmer et al., 1990). That is sufficient reason to suggest that dinosaur bone apatite is as reliable as dating mammoth bones with or without dating extracted collagen.
- It is well known that carbon can absorb organics, but there is only a limited amount by weight of organic contaminants (gas or liquid) that can be absorbed on the surface of carbon. The time period for this absorption is days, months, or at most a few years depending on the amount of organic contaminants to be removed. However, the time period is not 70 megayears; otherwise there would be little need for activated carbon producing manufacturers. For example, nickel electroplating solutions must be kept pure of organic contamination by continual filtering through filter pumps containing activated carbon. The carbon pack must be changed weekly during high production (Safranek, et al. 1960). It would appear that the bones were not completely petrified and some, like the famous *Acrocanthosaurus* along the Paluxy River, contained kerogenous material in the Haversian canals as observed when sectioned and mounted (Hugh Miller, 1990. Unpublished photomicrograph of cross section of an *Acrocanthosaurus* bone fragment from Creation Evidence Museum,

Glen Rose, Texas). Because of the antibacterial nature of the succinates (succinites) in amber, it is unlikely that ^{14}C atoms would displace carbon atoms from the tightly linked bonds of the succinic acid type molecules anymore than that for diamond (Baumgardner et al., 2003). Since the RC dates were at the upper limit of AMS dating system it is obvious there was no contamination.

- Evolutionists have occasionally suggested that certain microbes may have contaminated the amber (and dinosaur bones) with modern ^{14}C atoms, thereby giving an inappropriately young RC age. However, there is no evidence to suggest that solidified amber can absorb modern ^{14}C in any form, so microbial activity is likely irrelevant to the RC dates obtained. Furthermore, the analytical procedures for testing ^{14}C content in amber involve acid and base treatments that would remove any cellular tissue and microbial waste products observed by the lab (Snelling, 1999). It may also be safe to assume that RC dating of dinosaur bones would not be affected by microbial activity, but some questions still remain. RC dating of collagen from dinosaur bones may be necessary to help address these questions.
- Hydrothermal activity, such as associated with volcanism, is known to cause older RC dates based on absorbing of old carbon containing gases (Van Oosterwych-Gastuche, 1999). Water under high temperature and pressure could cause contamination of plant and animal materials with old carbon in the formative period of burial and fossilization, which then could hypothetically become "fixed." Thus, the true ages of many fossils could be much younger than RC dating suggests. Research is planned to evaluate possible contamination of modern organic materials with old carbon containing materials.
- In the case of textiles, a hydrothermal condition has caused old textiles to appear much younger (Van Oosterwych-Gastuche, 1999).
- We attribute the lack of collagen and soft tissue in dinosaur bones to the hot environment of the western United States. The more northerly the latitude, the more collagen would be expected to be found in bones due to preservation by colder weather or permafrost, as may have been discovered with some mammoths. This concept of organic material preservation in colder climates is consistent with a creation paradigm of flood and ice age and meltdown over only thousands of years (Oard, 2004a,b). The recent discovery of soft tissue in a T-Rex bone is a major age problem for evolutionary biologists and paleontologists (Schweitzer et al., 2005), and ^{14}C dating of this and other fossils may further contradict accepted geologic dates.

Radiocarbon Date for Wyoming Amber within Range of the AMS Detection System?

The article from Poland (Ceranowicz et al., 2001) concluded:

> Sample 3, from Wyoming, is almost significantly different from zero and therefore its upper limit appears to be not very far from the minimal age given. The probability that it is different from zero is of the order of 94% (P = 0.0608) suggesting that the dating of the Lance Formation should be almost within the range of ^{14}C dating. However, the infrared spectrum similarity with other Cretaceous sediments agrees with the placement of Lance Formation in that stratigraphic position. Also since the succinite samples gave a positive FMC reading, had either of them been used as the blank rather than coal (which had 0.0031 FMC) the Wyoming sample would be even less suspect of young age. (p. 80.)

Observations and Conclusions

- Amber specimens from the Wyoming triceratops site are tiny, bubbly, and of differing colors of yellow to red, as if they had experienced very high heat and pressure. Some amber particles are macro-cracked with numerous fractures like brittle chromium deposits on nickel-plated steel or zinc die castings (Safranek, et al. 1960). This indicates that the inherent brittleness of amber was responding to a significant outside force such as temperature and pressure, and fragmented as did the carbonized woody material.
- Much of the amber was red with some ranging from yellow to orange to red across only a few mm on some specimens. This indicates a high rate of oxidation due to a high temperature over a short time period. Description of some amber specimens is consistent with Lyman's (1986) description, "amber sometimes has a dusty, friable reddish-brown, light brown or grey crust, due to alteration" (p. 308).
- Very small sheets of clear or white mica (muscovite) next

to amber, and in the matrix clay of the "Vinny" horizon indicate that mica sheets could have been forcibly separated from their original matrix by tumbling effect with pebbles and rocks in high speed currents of water over long periods of time.

- The original wood, now brittle, cracked, and carbonized could have been subjected to high temperatures and pressures after burial. The small specimens (less than 1 square inch) along with parts of cones were carbonized similar to what can be seen in the clay and rock of the Paluxy River, Texas and in Colorado with dinosaur age fossils. For amber particles to be buried with the triceratops in a saltwater solution they would have to have been buried quickly otherwise, they would have been easily carried away. This strongly suggests a powerful saltwater hydraulic event.
- Even though many RC ages are near the upper detection limit of the AMS system, the fact that there is some ^{14}C in all carbon-containing fossils, but less than that contained in diamond (Baumgardner, 2003), supports the paradigm of a recent worldwide cataclysmic event depositing these fossils.
- Correlation of amber RC dates with real time seems to fit well for real time calculations for other fossils using Brown's (1992) correlation equation and support the contention that radiocarbon dating assumptions are erroneous.
- RC dating is truly "our friend" (Humphreys, 2004) as new data (Snelling, 1999; Wieland, 2003; Baumgardner, 2003) is consistent with RC dates of the 1980's (Fields et al., 1990; Dahmer et al, 1990) as supporting a young earth and catastrophism.
- This study, along with hundreds of other individual studies by different researchers (many of which have appeared in the *CRSQ*), continue to support a needed revision of the standard evolutionary geologic column based on Paleohydraulics, as Berthault (2004b) and others have done with the Tonto Group of the Grand Canyon, Lalomov (2001) in the Crimea, and Morris (1980), Fields et al. (1990), and Baugh and Wilson (1991) along the Paluxy River, Texas.

Proposed Future Research on Amber

We plan to continue RC and infrared studies of resins from various strata worldwide in cooperation with other scientific organizations when funds are available. We hope to organize results based on location in the geologic column. We also plan to perform flume studies using different sizes and shapes of wood chips in a clay media to see how they line up in the subsequent sediments; the results of such studies could guide field workers in the study of paleohydraulics. It is very important to design proper experiments that will determine if old carbon will indeed age modern biotic matter in hydrothermal conditions. An intensive ^{14}C study of deep core samples of organic materials from Prudhoe Bay etc. also needs to be initiated. Hopefully such studies will help science understand the reason for similarities in ^{14}C ages for dinosaurs and mammoths, as well as other fossils like amber and unfossilized wood and when they were deposited. Such intensive research programs will be done in due course only when funds become available.

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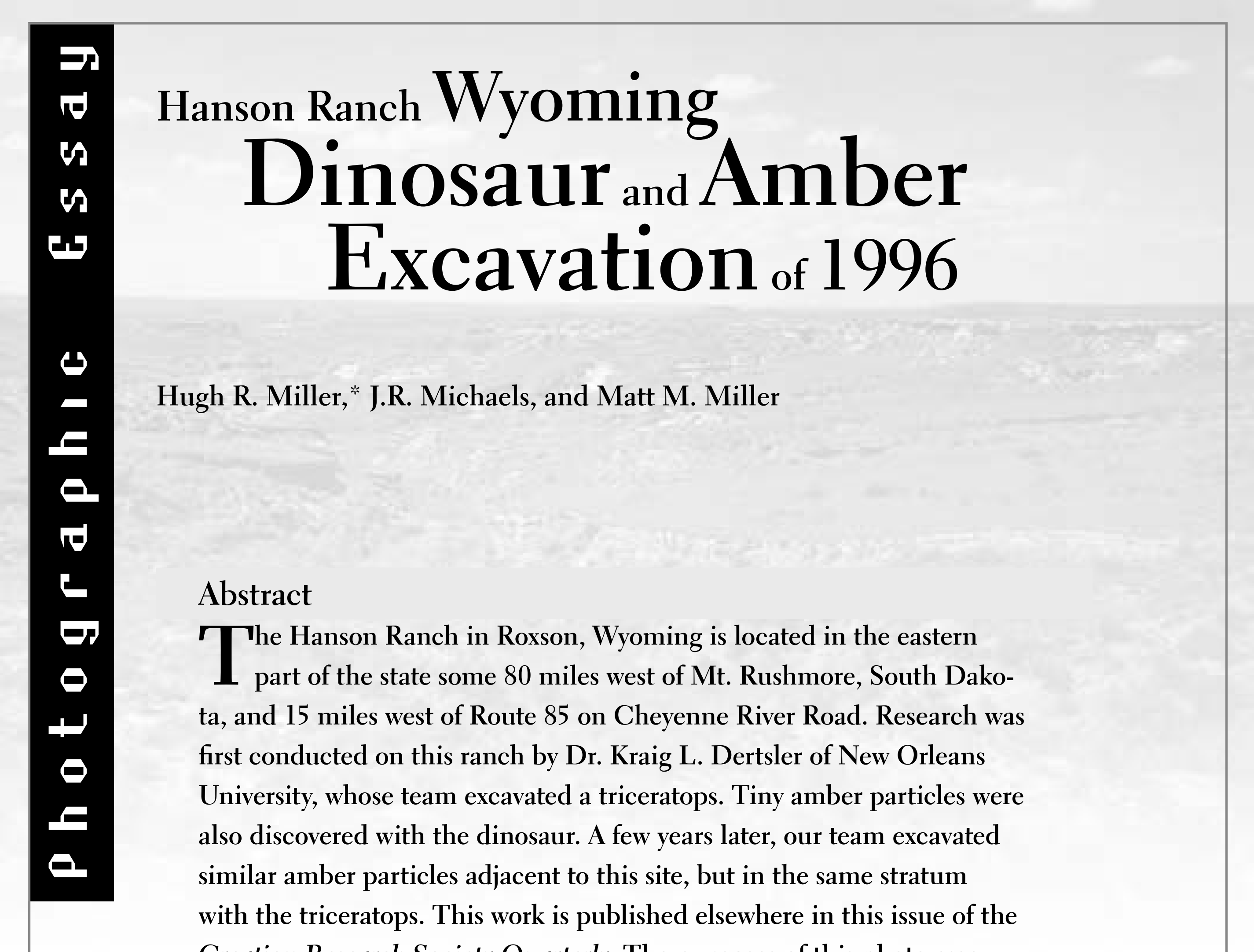

Photographic Essay

Hanson Ranch Wyoming Dinosaur and Amber Excavation of 1996

Hugh R. Miller,* J.R. Michaels, and Matt M. Miller

Abstract

The Hanson Ranch in Roxson, Wyoming is located in the eastern part of the state some 80 miles west of Mt. Rushmore, South Dakota, and 15 miles west of Route 85 on Cheyenne River Road. Research was first conducted on this ranch by Dr. Kraig L. Dertsler of New Orleans University, whose team excavated a triceratops. Tiny amber particles were also discovered with the dinosaur. A few years later, our team excavated similar amber particles adjacent to this site, but in the same stratum with the triceratops. This work is published elsewhere in this issue of the *Creation Research Society Quarterly*. The purposes of this photo essay are to show some of the interesting formations, including hoodos, that exist on this ranch; some of the fossil material, like amber, that was C-14 dated; and a few of the many dinosaur bone fragments and carbonized wood that await C-14 dating if funding sources can be identified. C. W. Holroyd and co-workers discussed other research potentials at this site in a previous issue of *CRSQ* (33:136).

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This essay is dedicated to the many individuals too numerous to mention for their pioneering vision and perseverance that made these excavations possible in the 1995–1996 dig seasons. It's a shame that (through no fault of their own) their project was discontinued on this ranch. Fortunately Joe Taylor and Otis Kline (and others) were able to continue with their cooperative joint field research projects with active field museums like Mount Blanco Fossil Museum, Crosbyton, Texas, and F.A.C.T. Museum and Research Station in Glendive, Montana, respectively.

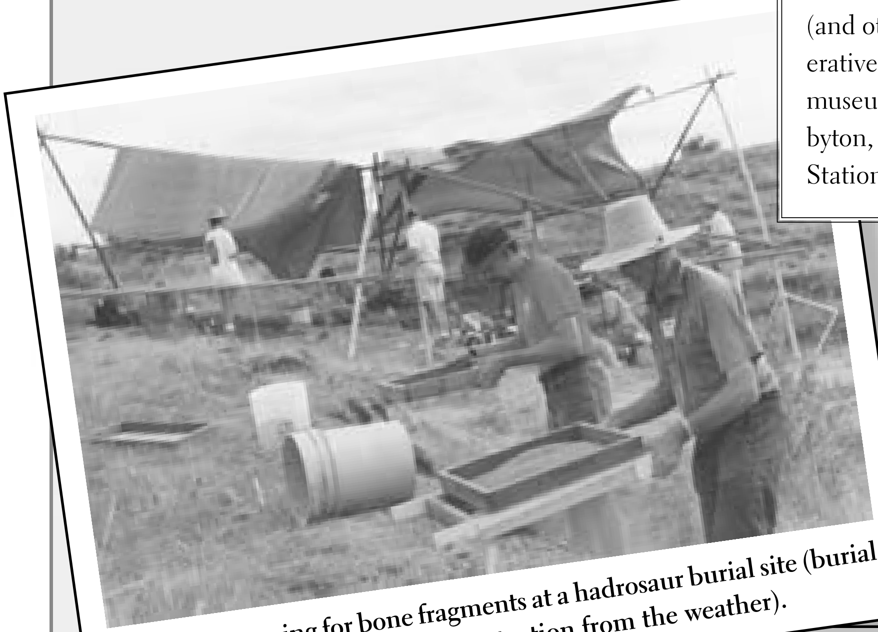

Figure 1. Screening for bone fragments at a hadrosaur burial site (burial site in background with canvas protection from the weather).

Figure 2. Thirty team members, including eight from Columbus Ohio's Creation Research Science Education Foundation. Joe Taylor of Mt. Blanco Fossil Museum (Crosbyton, TX) and Buddy Davis of Answers in Genesis participated the week of July 7–17, 1996.

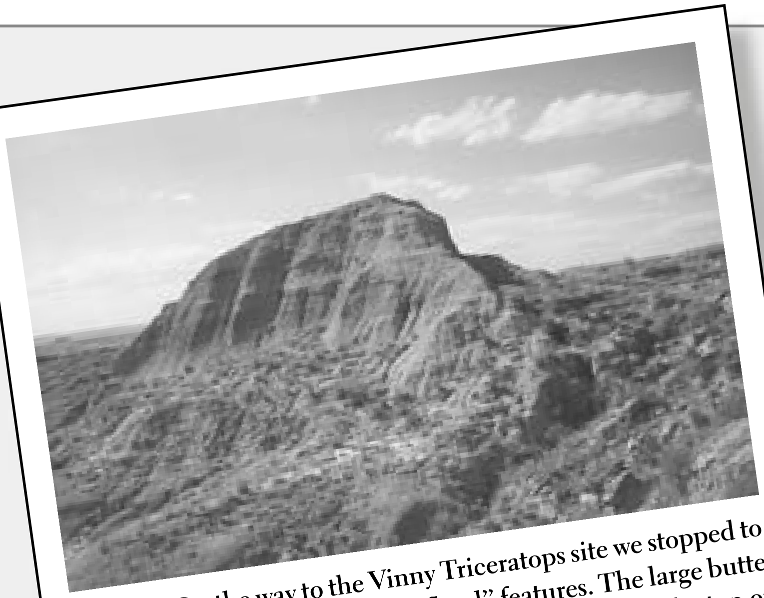

Figure 3. On the way to the Vinny Triceratops site we stopped to take photos of some geological "flood" features. The large butte formation in the foreground was photographed from the top of the unique hoodo-type structures shown in Figure 4.

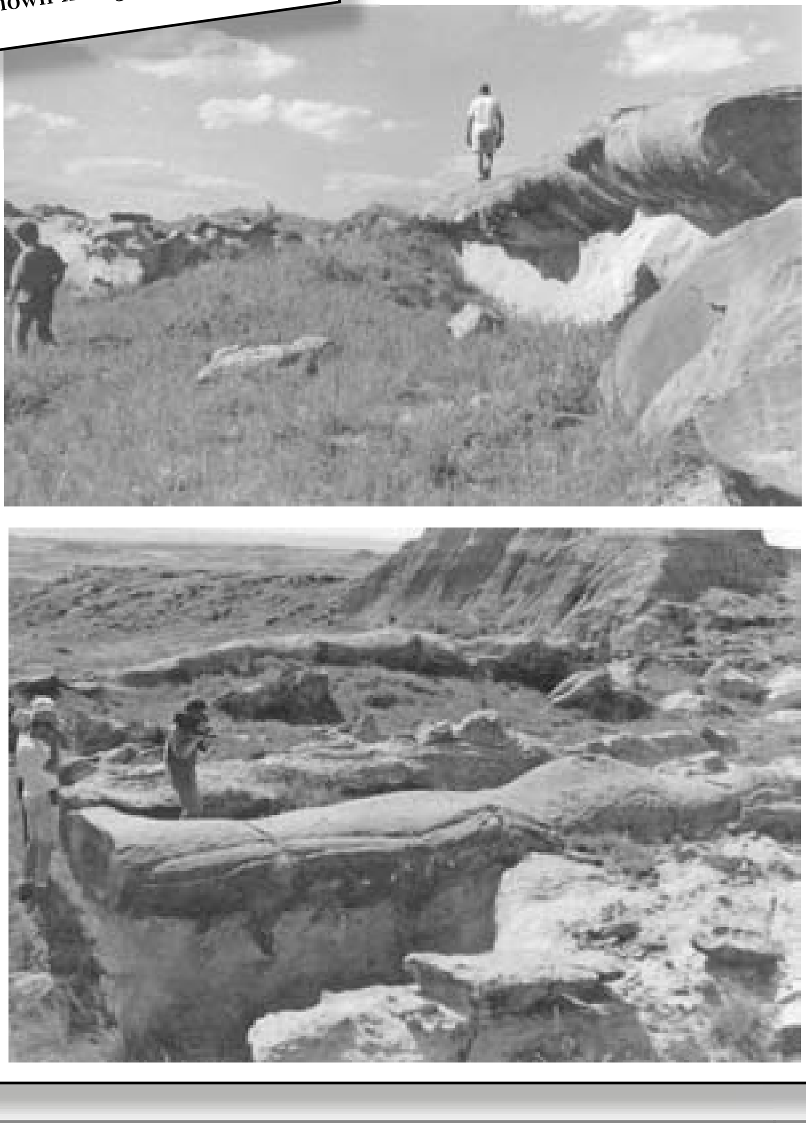

Figure 4. A top and bottom view of these unique formations. Their rounded surfaces suggest they lithified quickly after water transport, perhaps during a quiet time between transgression and regression. The stratum upon which the sandstone rests appears to have eroded preferentially to the top portion. Co-author Matt Miller is in the foreground (bottom picture), and Andy Greabel is videotaping the scene.

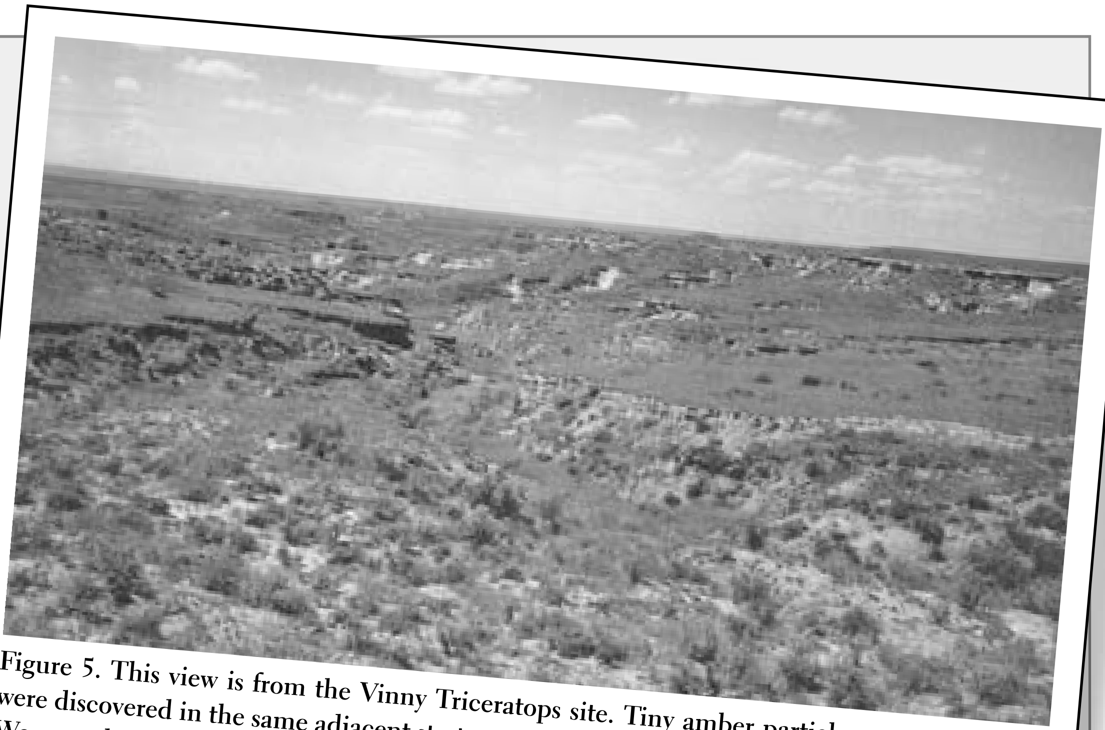

Figure 5. This view is from the Vinny Triceratops site. Tiny amber particles, pea-size or less, were discovered in the same adjacent stratum with the dinosaur, but not in the stratum above. We spent half a day looking in the wrong top stratum until Joe Taylor arrived and provided assistance (www.mtblanco.org and www.omniology.com). Small amounts of amber are also found in other areas of Wyoming and at the F.A.C.T. Research Station in the Montana Badlands near Glendive, MT (www.creationtruth.org).

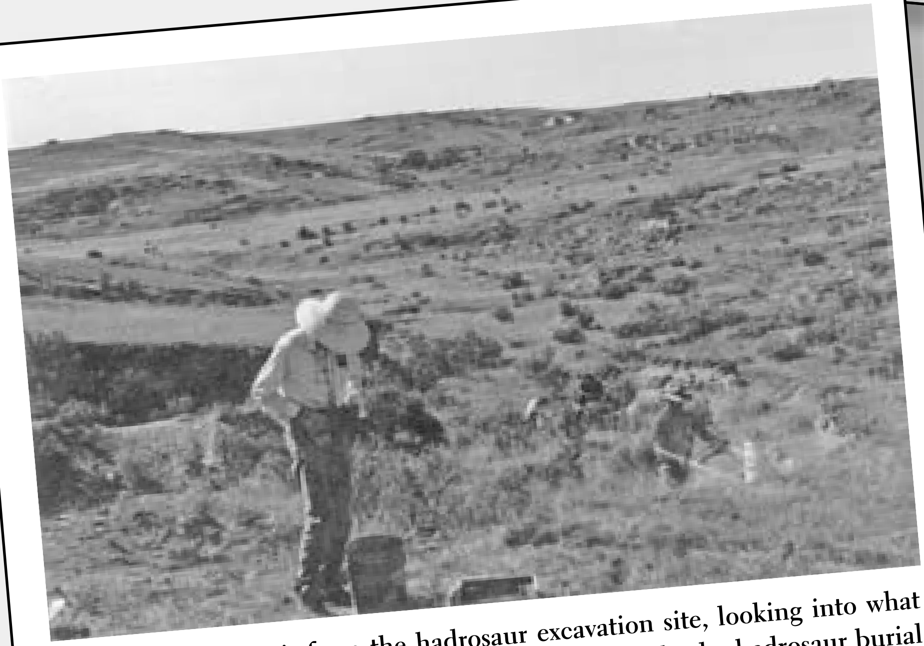

Figure 6. This view is from the hadrosaur excavation site, looking into what has been called the "Dragon's Graveyard." This is indeed a hadrosaur burial ground, but other dinosaurs, including a triceratops and T-Rex (first one ever) are just a few miles away. The late John A. Watson, geology consultant and friend to all, is in the foreground. More about him can be found at www.creationevidence.org.

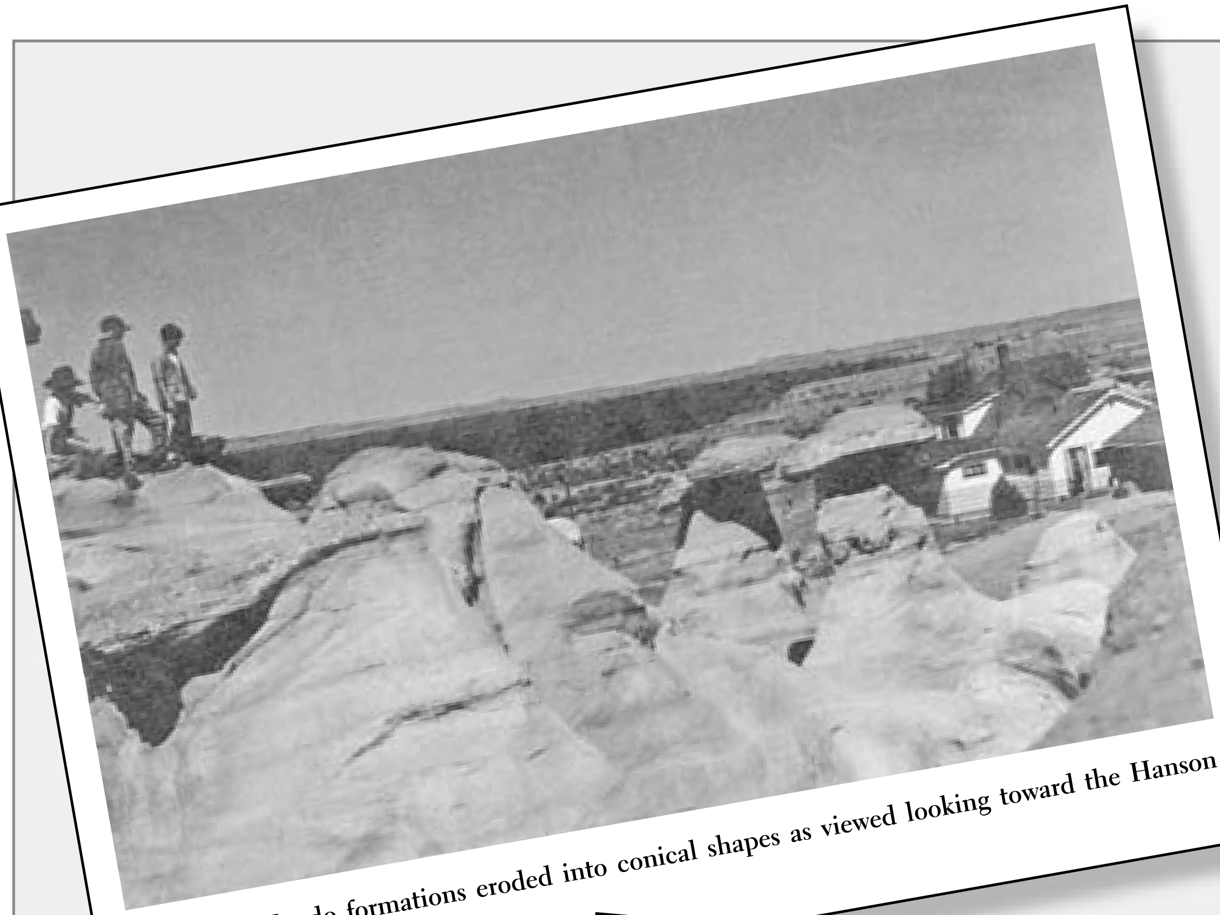

Figure 7A. Hoodo formations eroded into conical shapes as viewed looking toward the Hanson family home.

Figure 7B. The same hoodo formations near the Hanson Home.

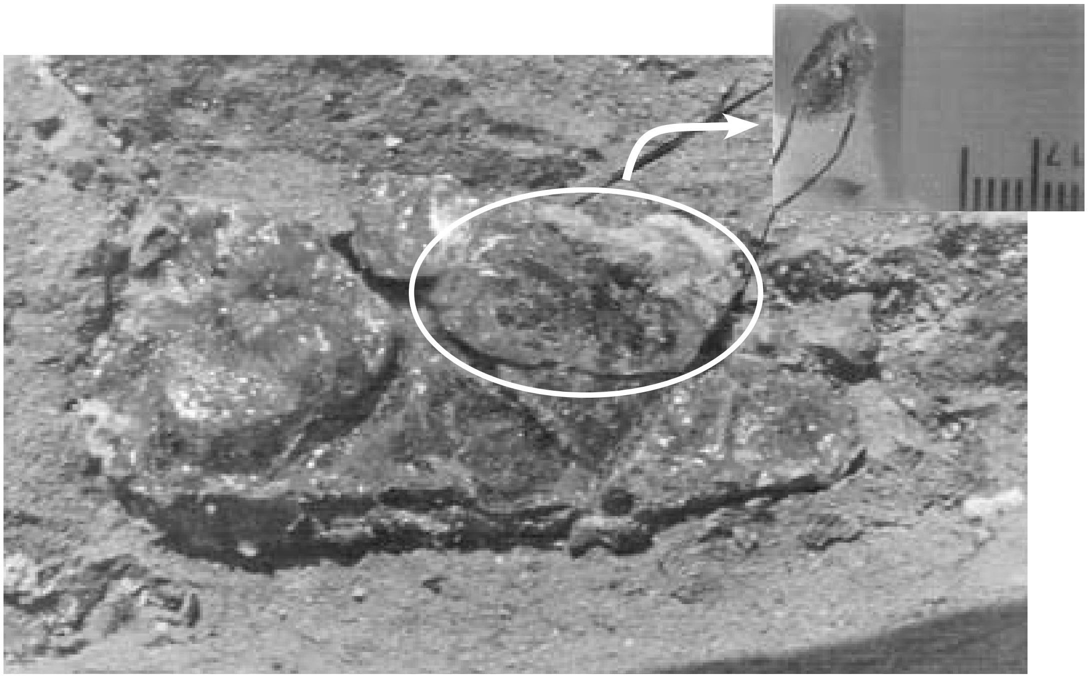

Figure 8A. Photo-macrograph of the largest amber piece with dimensions of 1x2 cm. Note the macro-cracks. One section (circled) eventually exfoliated from the main structure as shown above in the insert.

Figure 8B. In the center of the photo-macrograph is a pea-size amber specimen with white flakes of mica (sodium chloride crystals?). A nearby sliver of carbonized vegetable matter is imbedded in the same clay matrix. Initially, the joke among our discoverers was that the white flakes must certainly be dinosaur dandruff.

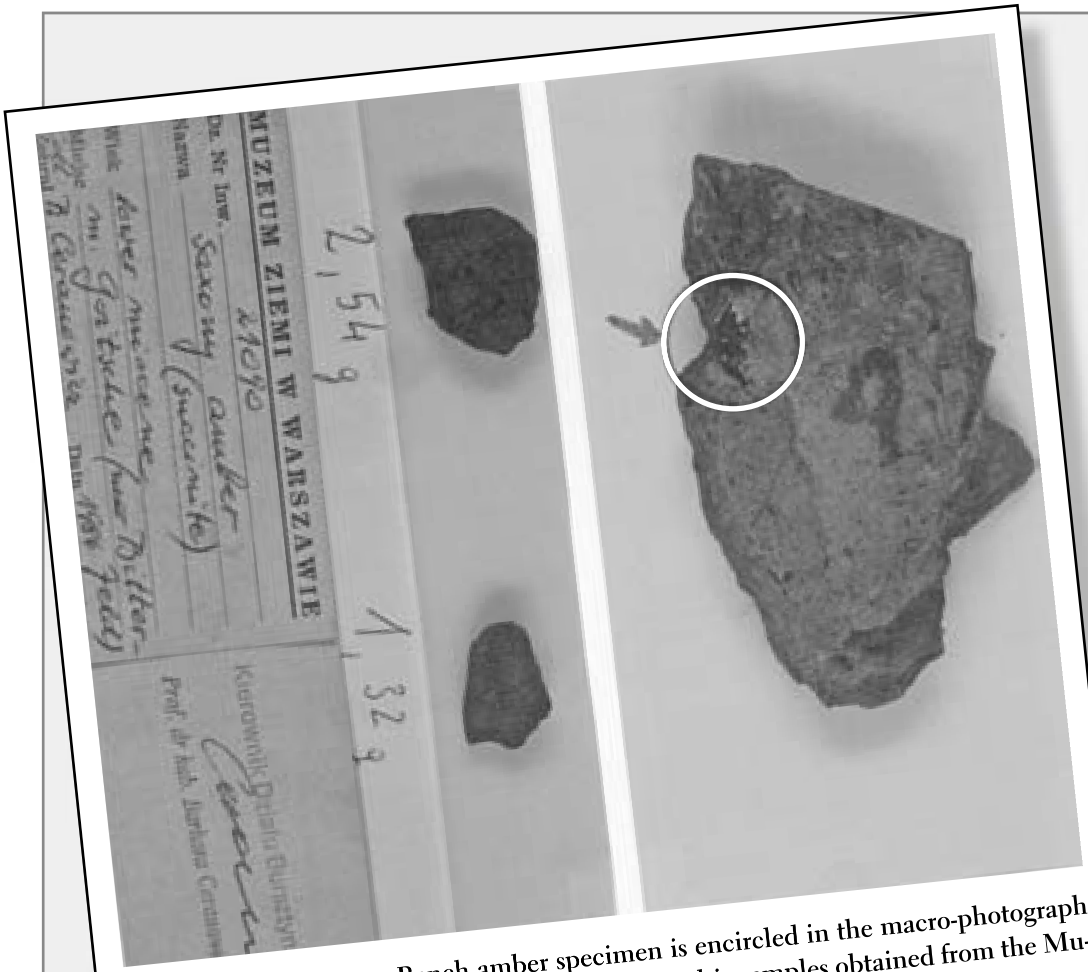

Figure 9A. The Hanson Ranch amber specimen is encircled in the macro-photograph on the right. In the photo on the left are the two Baltic samples obtained from the Museum of the Earth, Warsaw, Poland along with the forms containing the author's name, signature, and the weights of the specimens (Ceranowicz, 2001).

Figure 9B. Photos taken in Poland of the three specimens that were C-14 dated (Ceranowicz, 2001). The specimen on the right is the sample of pea-sized amber still imbedded in the clay matrix from the Hanson Ranch triceratops horizon before it was extracted for AMS-C-14 dating.

Figure 10. This is the first amber-containing cone discovered by our team looking for amber. Both amber and coalified or carbonized wood were found in the specimen. We learned from Joe Taylor that Dr. Kraig Derstler (1994) had also found amber actually buried with the triceratops, so there may still be a sufficient amount available for study.

Figure 11. Jeremy Auldaney (1996, private communication) sent a copy of photos in Figures 10 and 11 to a professor of geological and biological sciences at the University of California, who responded as follows: "The two specimens conform quite closely to cone scales of ovulate (seed-bearing) cone of a conifer described by E. Dorf (1942) as Araucarites longifolia (Lesquereux) Dorf, although neither appears to exhibit the elongate apex of the scales illustrated by E. Dorf (1942)." Paul McDorman of Cincinnati found this specimen as we excavated the adjacent strata but in the same horizon as the triceratops.

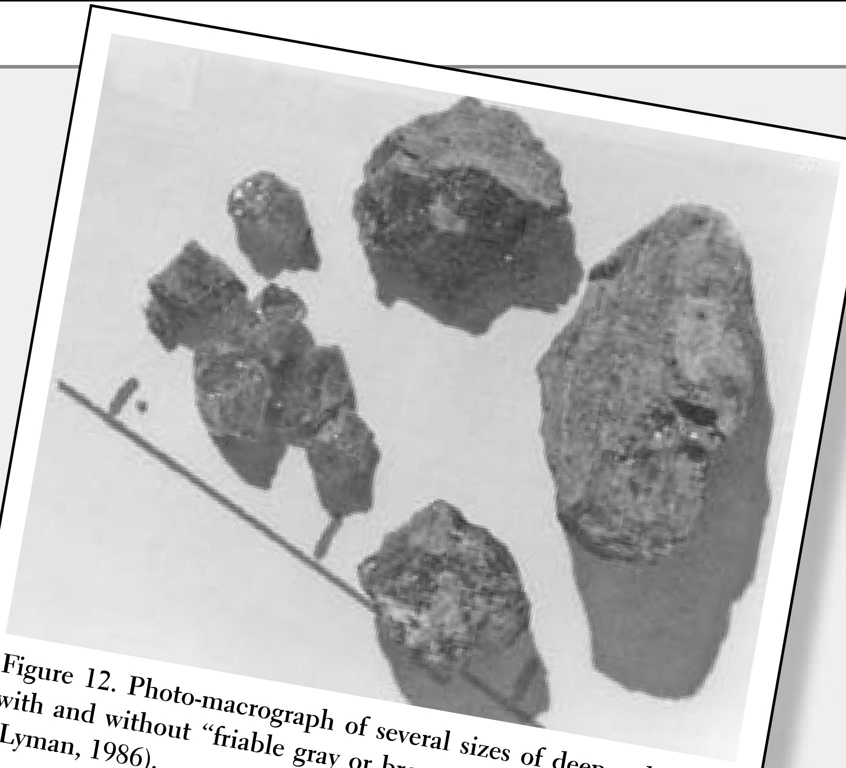

Figure 12. Photo-macrograph of several sizes of deep red amber with and without "friable gray or brown crust due to alteration" (Lyman, 1986).

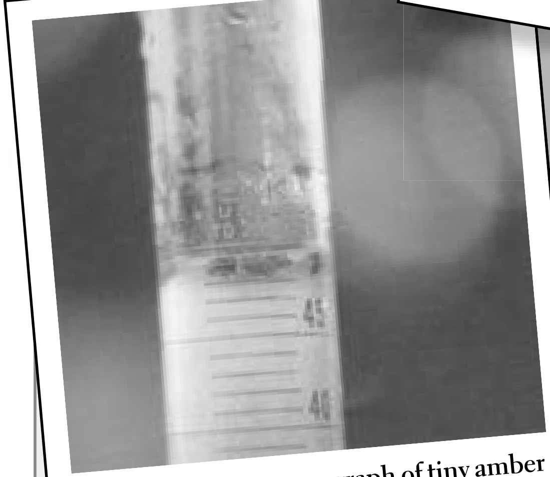

Figure 13. Photo-macrograph of tiny amber particles floating in concentrated table salt having a specific gravity of 1.18, like seawater. To be buried with the ponderous triceratops bones the burial must have been rapid, otherwise the amber would have floated away regardless of the specific gravity of the water.

Figure 14. Photo-macrograph of carbonized dinosaur "cartilage" from the hadrosaur site with broken and unbroken sections. Because of the carbonized inter-surfaces of these specimens, they could be carbon dated (as were bone surface scrapings of the Acrocanthosaurus from the Paluxy River, TX). These small cartilages were often observed on surfaces of cow trails as one walked the Hanson Ranch.

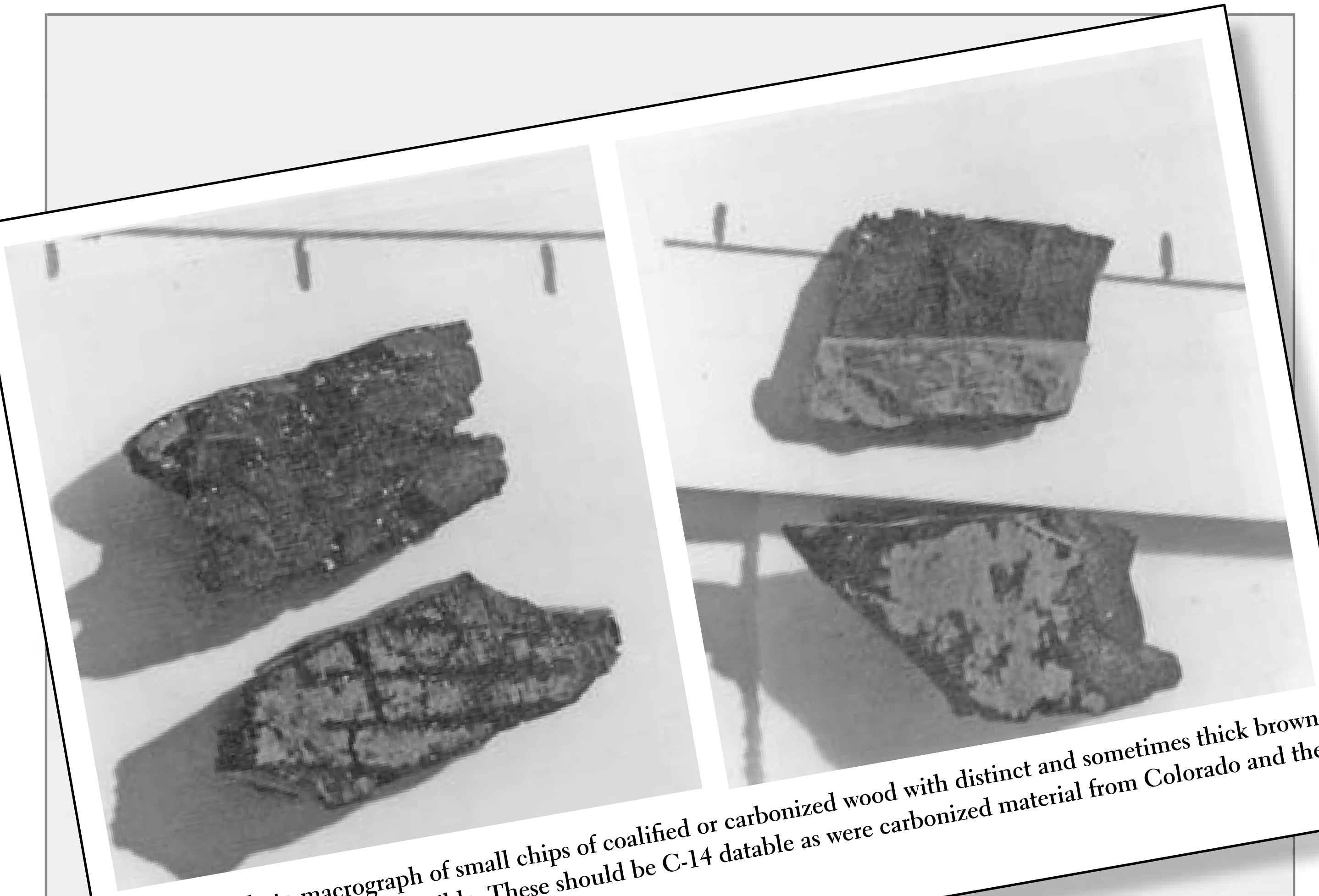

Figure 15. Photo-macrograph of small chips of coalified or carbonized wood with distinct and sometimes thick brown woody-colored surfaces still visible. These should be C-14 datable as were carbonized material from Colorado and the Paluxy River, TX.

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Isotopic Analysis of Fruitland Formation Coal Bed Carbon Dioxide and Methane

John R. Doughty*

Abstract

Radiocarbon is found throughout the geological record, and the confirmation of this hypothesis in the cases investigated in this paper strengthens the young earth creationist paradigm. This research builds upon the work done with coal and carbon dioxide and extends it to the analysis of coal bed methane gas wells. The resulting data indicate that the carbon dioxide and methane gases trapped in the Fruitland Formation are thousands, not millions of years old.

Introduction

This paper provides another piece of evidence in support of the young earth. Those taking an evolutionary position of Earth's history often assume that natural gas, which is presumed to be an old, fossil gas, is carbon-14 "dead." One purpose of this paper is to show that such an assumption is quite false. This work experimentally verifies that significant, detectable carbon-14 (^{14}C) is found in both the CO_2 and CH_4 found in Cretaceous formation coal bed methane (CBM), that is, methane from gas wells drilled into coal beds. A subsequent work will investigate the presence of ^{14}C in deep Ordovician strata natural gas wells in the Permian Basin of Texas. Once again, the presence of the radiocarbon is reasonably explained by the flood deposition of organic material and its subsequent degradation over thousands (not millions) of years.

Background

A review of radiocarbon literature revealed that some accelerator mass spectrometer (AMS) labs use CO_2 gas as ^{14}C free baseline (also called a procedural blank) because it is presumed to be ^{14}C "dead," being derived from fossil gas. However, in all the cases reported, there was ^{14}C present in significant amounts (0.049 to 0.25 percent modern carbon; pMC). Such amounts were presumed to be due to system contamination and were subtracted from samples containing ^{14}C to obtain a "corrected" value. In the search for ^{14}C free procedural blank, Taylor and Southon (2005) used diamonds as targets in the University of California-Irvine AMS device. They obtained mean values over the range of 0.012 to 0.016 pMC, which they then attributed to "ion source crosstalk" rather than being intrinsic to the samples. Earlier, Baumgardner (2005) reported a mean uncorrected value of 0.12 ($\pm$0.01) pMC for six diamonds that were combusted in pure oxygen and converted to CO_2 for preparation for the standard analytical technique used by Isotrace AMS Lab at the University of Toronto. Still earlier, Baumgardner et al. (2003) showed ^{14}C to be present in coal. They reported a mean corrected value of 0.247 pMC for coal derived from ten different mines in the USA. The Isotrace Lab subtracted 0.077 pMC from the uncorrected values. The data set included coals from the Eocene, Cretaceous, and Pennsylvanian eras, and the close grouping of these ^{14}C concentrations indicates a single depositional event, the Flood. Therefore, I expected to find significant ^{14}C in both carbon dioxide and methane extracted from the Fruitland Formation coal bed in northwest New Mexico.

This work presents the ^{14}C and other isotopic data obtained from samples taken from three wells in the central portion of the formation area known as the Fruitland Fairway, a region known for high initial well pressures. The wells had an average production depth of 2700 feet.

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The formation is from the Cretaceous period, and is conventionally dated as 73 to 78 million years (Ma) (Fassett, 2000). The trapping mechanism, confinement caused by hydrostatic pressure, is totally different from conventional natural gas wells. The methane is maintained in an adsorbed state in micropores (<0.5 nm diameter) within the coal matrix. The reservoir permeability is provided by fracture-like networks known as *cleats*. The cleat porosity is on the order of 0.5% to 2%. The low porosity restricts subsurface water transport (Snyder et al., 2003). When the coal bed is penetrated and water is pumped out, the hydrostatic pressure is reduced and the methane desorbs and flows out with the water.

Schoell et al. (2001) made a case based on an analysis of the stable isotope, carbon-13 ($\delta^{13}C$), for the subsurface conversion of CO_2 to methane simultaneously with a bacterial oxidative removal of C2+ hydrocarbons (alkanes). Seewald et al. (1998) have shown experimentally that CO_2 is produced when hydrocarbons are in the presence of water and mineral catalysts. Some analysts have expressed concern about the validity of ^{14}C based analyses due to possible contamination of the source material by recent meteoric groundwater containing dissolved CO_2. However, Snyder et al. (2003) and Riese et al. (2005) performed analyses of Fruitland formation coal bed brines using both the stable water-derived isotopes, oxygen ($\delta^{18}O$) and deuterium (δD), and the accompanying radioactive isotopes of iodine and chlorine (^{129}I and ^{36}Cl). They concluded that the waters are predominantly connate, that is, water trapped at the time of formation, and have not undergone extensive migration since deposition because the formation is heterogeneous.

This conclusion was based in part by the analysis of formation waters that indicated recent water flows only at the edges of the formation. Other models for the Fruitland basin assumed a significant subsurface flow through a presumed homogeneous formation. If there was indeed recent penetration of meteoric water, then it should be evidenced by both stable oxygen isotope and the radiocarbon data. The stable isotope data of Riese et al. (2005) followed the global meteoric water line (GMWL) rather well, but that data doesn't of itself provide an age estimate. They presented minimum ages derived from ^{129}I and ^{36}Cl that commonly differed by an order of magnitude with an average radioiodine age of 32 Ma and average radiochlorine age of 1.5 Ma. I expected to see ^{14}C values for both CO_2 and CH_4 obtained from Fruitland formation coal bed methane gas wells close to the uncorrected mean value of 0.286 pMC (0.21 pMC corrected) based on 12 data points obtained by Baumgardner et al. (2003) for somewhat similar Cretaceous coals. Note that a pMC value of 0.21 translates to a maximum age of 50 thousand years.

Methods and Materials

Gas Sample Preparation

The sampling apparatus is identical to that described in my previous article (Doughty, 2005) with the exception that the 10cc. closed-end sample cylinders have been replaced by double-ended 10cc. cylinders. This allowed the sample gas to flow through the system and vent it to the atmosphere. The exit valves attached to the sample cylinders are closed while the system vent valve is still open, thus providing a higher assurance for an uncontaminated sample. When the source pressure was greater than 10 psi, all valves were closed and then the system vent valve was carefully opened to reduce the internal pressure to 10 psi or below, since the AMS lab prefers samples to be less than 10 psi.

The same preparation procedure was used as in the previous work (Doughty, 2005) where 18 fill and purge cycles using high purity helium were used to eliminate any residual atmospheric CO_2 gas from the system, including all the sample cylinders. The system is then filled with 30 psi of high purity helium before it is taken to the field. However, in this work, more than one well was sampled during the field visit. Consequently, after the first sample set was taken, the first set of two sample cylinders were removed from the system. After verifying that all valves were closed, the two 10cc cylinders were removed from the system, the valve ends capped and placed in a box for transport to the University of Arizona AMS lab. The next set of sample cylinders were then attached to the system. Since a portion of the system had been opened to the atmosphere (and thus to possible contamination due to atmospheric CO_2), it had to be purged. However, only 17cc of the sampling system was exposed to the air. It was an easy matter to run a minimum of 15 purge-and-fill cycles at the low gas well pressures found in the Fruitland Formation wells. Additionally, the vent valve is opened for approximately one minute prior to opening the sample cylinder valves and is left open while the gas is also flowing through the sample cylinder. Thus, a more than ample volume exchange is provided to assure a pure sample. An example of one of the well sites where samples were taken is shown in Figure 1.

Figure 1. Sampling Fruitland Formation CBM Gas Well Vanderslice 101, August 5, 2005.

Table I. Fruitland Formation Well Gas Characteristics

Well sampled	Pressure psi	Temp. °F	CO_2, %	CH_4 %	N_2 %
Scott Com 291	9	50	7.4	92.2	0.065
Page 101R	4	50	25.2	73.3	0.271
Vanderslice 101	30	50	14.3	85.1	0.062

AMS Analysis of Gas

At the University of Arizona AMS lab, all gas samples were attached to an analysis system line, and pumped down the line before opening the sample cylinder valve. A small portion of the sample was taken for stable isotope analyses using a conventional mass spectrometer. Approximately one milligram of CO_2 was extracted and run through a cold trap to remove any traces of water. Then, downstream of the water trap, the CO_2 was trapped by a mild cryogenic cold finger. The remaining methane was collected and later passed over CuO in a furnace to convert it to CO_2 for subsequent processing into graphite targets for the AMS device. It took approximately three months to process three well sample sets (six sample cylinders). One sample set, the Page 101R well gas, was rerun because of an anomaly (a lab procedural error) yielding an abnormal result (much too high) for the methane ^{14}C value. Fortunately, there was ample gas available for the rerun and the "AM" result compared closely with the second companion "BM" sample, as it should.

Results

The physical characteristics of the well gases sampled at the wellhead of the three Fruitland Fairway wells are shown in Table I. All wells had a water separator located upstream of the sampling port. Any residual traces of water were

Table II. Fruitland Formation CBM Gas Well Sample Isotope Values

Well & Sample # *Suffix*: C=CO_2, M=CH_4	Date analyzed	Mass mg	δ^{13}C, CO_2	δ^{13}C, CH_4	α, $CO_2 \leftrightarrow CH_4$	δ^{18}O, CO_2	^{14}C/C, pMC uncorrected	^{14}C/C,pMC corrected
Scott Com 291, #1AC	11/02/05	0.1	14.94			***7.99***	***10.51±0.2***	***7.56±0.92***
Scott Com 291, #1AM	11/02/05	1.16		-44.52	1.06223		1.18±0.03	0.90±0.1
Scott Com 291, #1BC	11/02/05	0.11	15.52			17.04	5.86±0.08	3.18±0.86
Scott Com 291, #1BM	11/02/05	1.15		-44.52	1.06284		1.05±0.03	0.77±0.14
Page 101R, #2AC	12/08/05	0.21	18.64			12.75	1.21±0.05	0.96
Page 101R, #2AM	01/24/06	0.58		-43.33	1.06478		0.62±0.03	0.46
Page 101R, #2BC	01/12/06	0.37	17.79			12.225	1.33±0.05	1.09
Page 101R, #2BM	01/24/06	0.99		-43.84	1.06446		0.79±0.03	0.59
Vanderslice 101, #3AC	11/03/05	0.2	17.13			16.72	2.69±0.16	1.18±0.51
Vanderslice 101, #3AM	11/03/05	1.15		-43.73	1.06364		0.37±0.02	0.27
Vanderslice 101, #3BC	11/03/05	0.2	17.15			16.685	2.23±0.1	0.99
Vanderslice 101, #3BM	11/08/05	1.21		-43.83	1.06378		0.28±0.03	0.21

Notes:

1. Scott Com 291 #1AC values (in ***bold italics***) were not included in mean value calculations. Sample contaminated in lab processing.
2. Stable isotope mean values: δ^{13} C(CO_2) = 16.86‰ pdb, δ^{13} C(CH_4) = -43.96‰ pdb, δ^{18}O = 15.1‰ smow, Fractionation factor: $\alpha(CO_2 \leftrightarrow CH_4) = 1.06362$.
3. ^{14}C/C corrected mean values: ^{14}C/C(CO_2) = 1.48 pMC, ^{14}C/C(CH_4) = 0.53 pMC. Δ^{14}C/C = 0.95 pMC.
4. All wells were sampled on 8/05/05.

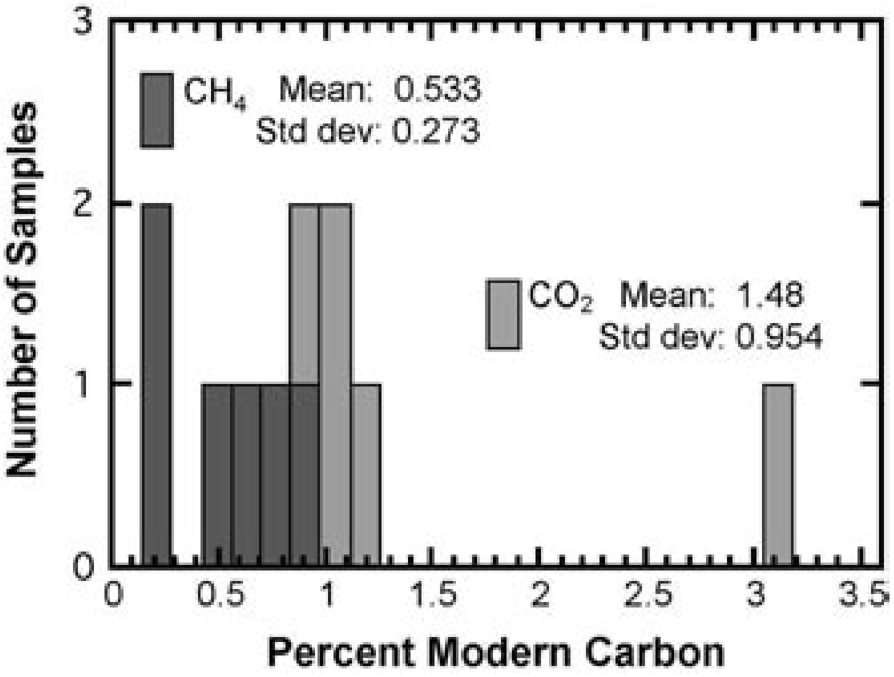

Figure 2. Distribution of ^{14}C values for the three CBM gas wells

removed at the University of Arizona AMS lab as noted above. All samples were taken from producing (flowing) wells. Two identical samples were taken at each well site. The samples were analyzed for their isotopic content of $\delta^{13}C$, $\delta^{18}O$, and ^{14}C. The results are shown in Table II. The stable isotope mean values are $\delta^{13}C(CO_2)$ = 16.86‰ pdb, $\delta^{13}C(CH_4)$ = -43.96‰ pdb, $\delta^{18}O(CO_2)$ = 15.1‰ smow where "pdb" and "smow" are the reference standards to which the data are compared. The "pdb" standard , PeeDee Formation Belemnite, for carbon-13 is defined as 0‰, and the "smow" reference for oxygen-18 is standard mean ocean water, where $\delta^{18}O$ = 0‰. The mean values for the radiocarbon results for the CO_2 are $^{14}C/C$(uncorrected) = 2.76 pMC and $^{14}C/C$(corrected) = 1.48 pMC and for the CH_4 $^{14}C/C$(uncorrected) = 0.77 pMC and $^{14}C/C$(corrected) = 0.53 pMC. The corrected values for $^{14}C/C$ (CO_2) and $^{14}C/C$ (CH_4) are shown in histogram format in Figure 2.

Discussion

First, I note that my initial hypothesis was not substantiated. The $^{14}C/C$ ratios for the carbon dioxide are a factor of three to four greater than those for the methane. They are also substantially greater than the $^{14}C/C$ mean value, 0.361 pMC, obtained from carbon dioxide gas wells (Doughty, 2005). It is assumed that the CO_2 and CH_4 were produced at essentially the same time via reactions between the coal, water, minerals, and microbes under pressure and slightly elevated temperature. The results suggest that there was some contamination of the original carbon dioxide by dissolved CO_2 brought into the coal by meteoric groundwater sometime after the deposition of the Fruitland Formation.

The isotopic mean values for $\delta^{13}C$ (CO_2) and $\delta^{13}C$ (CH_4) agree closely as expected with those of Schoell et al. (2001) who found $\delta^{13}C$ (CO_2) = 16.0‰ and $\delta^{13}C$ (CH_4) = -43.8‰. Their mean value of the fractionation factor, α ($CO_2 \leftrightarrow CH_4$), for the $\delta^{13}C$ is 1.0625, which is essentially the same as that of this work, 1.0632. Using the equation of Bottinga given in Faure and Mensing (2005, p. 775), this value of 1.0625 results in a calculated temperature of 332°K (59°C) for the formation at a time when fractionation took place. Such a temperature is conducive to microbial action. Therefore, the view of Schoell et al. (2001) that the CH_4 was produced by methanogenesis and the CO_2 was produced by bacterial oxidation of hydrocarbons is reasonable.

The $\delta^{18}O$ and ^{14}C data for the Fruitland Fairway coal bed methane gas samples did produce some unexpected results. First, the Scott Com well sample #1AC is deemed spurious because both $\delta^{18}O$ and $^{14}C/C$ values (shown in bold print in Table II) were abnormally high when compared to the other data, especially considering the fact that the Scott Com #1BC values were obtained from the same sample gas. In other words, the Scott Com #1AC $\delta^{18}O$ value should have been 17 (±1.0) and the pMC value 3.2 (±1.0). Consequently, the $\delta^{18}O$ and $^{14}C/C$ values for the Scott Com sample #1AC are not included in the mean value calculations for $\delta^{18}O$ and $^{14}C/C$. Note that the remaining $^{14}C/C$ values for CO_2 are higher than the corresponding $^{14}C/C$ values for CH_4 from the same well as shown in Table II. Note that the mean value for $\delta^{18}O$ (CO_2) is 15.1‰ SMOW, which places it well within the usual data range for sedimentary rocks, yet the data thus far suggests an additional source of ^{14}C in the carbon dioxide.

A good cross-check on the data is to calculate the $\delta^{18}O(H_2O)$ values based on the $\delta^{18}O(CO_2)$ results. The issue in doing such a calculation is the availability of a fractionation factor, α, for CO_2 gas to liquid $H_2$0. Faure & Mensing (2005) give one for atmospheric CO_2 at 19°C as 1.04247. However, as noted above, the fractionation temperature for CO_2 and CH_4 gas is calculated to be 59°C. Consequently, I have taken the $\delta^{18}O$ values for three wells where the resident

Table III. Calculated $\delta^{18}O(H_2O)$ values compared with $^{14}C/C(CO_2)$

Sample #	$\delta^{18}O(CO_2)$ ‰ SMOW	$\delta^{18}O(H_2O)$‰ SMOW	$^{14}C/C\ (CO_2)$ pMC corrected
FF#1B	17.04	-8.94	3.18 (+0.86)
FF#2A	12.75	-13.13	0.96
FF#2B	12.225	-13.64	1.09
FF#3A	16.72	-9.26	1.18 (+0.51)
FF#3B	16.685	-9.29	0.99

Note: $\delta^{18}O(H_2O)$ mean value = -10.85‰ SMOW.
$^{14}C/C\ (CO_2)$ mean value = 1.48 pMC.

CO_2 was in contact with water as given in my previous paper (Doughty, 2005). The mean value for the $\delta^{18}O(CO_2)$ is 26.222‰ SMOW. The CO_2 gas to liquid H_20 fractionation factor, $\alpha(CO_{2g}\leftrightarrow H_2O_l)$, for CO_2 in contact with water is given by the following equation:

$$\alpha\ (CO_{2g}\leftrightarrow H_2O_l) = \frac{\delta^{18}O\ (CO_2)\ g + 1000}{\delta^{18}O(H_2O)_l + 1000}$$

By definition $\delta^{18}O(H_2O)_l$ equals zero for the SMOW standard. Therefore, $\alpha(CO_{2g}\leftrightarrow H_2O_l) = 1.02622$. The $\delta^{18}O(H_2O)$ can then be computed from the $\delta^{18}O(CO_2)$ results given in Table II. The working equation is as follows:

$$\delta^{18}O(H_2O) = \frac{\delta^{18}O(CO_2) - 26.22}{1.02622}$$

The results are shown in Table III where, as noted above, the $\delta^{18}O(H_2O)$ value for the Scott Com well sample #1AC is not included in calculating $\delta^{18}O(H_2O)$ SMOW mean value. The resulting mean value is -10.85‰ SMOW, which agrees closely with the mean value of -10.1‰ SMOW for 112 production wells in the Fruitland field (Riese et al., 2005). The usual data range of $\delta^{18}O(H_2O)$ SMOW for meteoric water is 0‰ to -25‰.

Conclusions

It is noteworthy that $^{14}C/C$ values for the Vanderslice 101 #3AM and #3BM methane results (0.21 and 0.27 pMC) are in very close agreement with the corrected mean value of 0.21 pMC for Cretaceous coals. Thus, the maximum conventional age for the area of the Fruitland Formation where the sampled wells are located is 49,770 years.

I conclude that the FF#1A sample was contaminated in the processing at the AMS lab. That is shown by both the high $\delta^{18}O(H_2O)$ value and the high $^{14}C/C$ value, which are twice that of the FF#1B sample, which itself is quite high. Again, it is the same gas. Another reasonable conclusion is that the emplaced derivative CO_2 was subsequently slightly contaminated by somewhat younger dissolved CO_2 that was present in meteoric water that penetrated the coal bed formation shortly after its deposition, probably at the time of the Laramide uplift. Otherwise, the $^{14}C/C$ values for CO_2 and CH_4 should be identical, which they are not. On the other hand, if the coal bed had been penetrated by significant amounts of meteoric water in very recent geologic times as presumed in earlier hydrodynamic models of the San Juan Basin, then the $^{14}C/C$ values for CO_2 would have been substantially higher than those realized in this work.

Another primary finding is that there is indeed significant, detectable ^{14}C in both the CO_2 and CH_4; i.e., the fossil gas is not carbon-14 "dead." One could argue that the CH_4 was manufactured via methanogenesis from waterborne "contaminated" CO_2. However, the CO_2 is thought to be produced by the bacterial oxidative removal of C2+ hydrocarbons (alkanes), whose origin is contemporaneous with the coal. The fact that the $^{14}C/C$ values for CO_2 are consistently greater than those for CH_4 by only 0.95 pMC as shown in Figure 2 suggests that any such "contamination" is restricted to the CO_2 and is indeed slight.

The isotopic analysis presented in this paper, using $\delta^{18}O(H_2O)$ and $^{14}C/C(CO_2)$ values contained in the CBM gas, can be applied to other CBM fields to verify whether or not they do have a continuous flow of recent meteoric subsurface water throughout the formation. Such information is important to petroleum geologists in the prediction and modeling of the production potential of CBM fields.

Finally, the evidence presented in this paper strongly suggests that both gases had a common source (coal) thousands—not millions—of years ago, that was laid down in the aftermath (Cretaceous period) of the Genesis Flood.

Acknowledgements

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agement and accompaniment throughout this work.

"Call to me and I will answer you and tell you great and unsearchable things you do not know." (Jeremiah 33:3)

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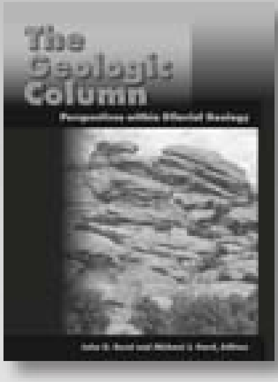

More Precise Calculations of the Cost of Substitution

Walter ReMine*

Abstract

This paper extends the applicability and accuracy of the cost of substitution beyond its traditional range, and demonstrates a useful calculation method. Using my previous clarification of the fundamental cost concept, this paper derives a method for computing the cost of substitution under wide genetic circumstances, including haploids; and diploids with varying degrees of dominance, inbreeding, and with a sex-linked locus. Unlike the traditional approaches, this method is accurate even under fluctuations in parameter values (such as population size, selection coefficient, dominance, and inbreeding coefficient). To display general-purpose results, the parameters are then held constant, and the total cost of substitution is graphed. This includes cases where the selection coefficient is not small and where the traditional equations become highly inaccurate. It is shown that neither environmental change nor soft selection reduces cost problems, at least in single substitutions.

Note added in publication: This paper offers previously unpublished clarifications, derivations and graphs, and refutes widely accepted solutions to a central problem in evolutionary genetics known as Haldane's Dilemma. It was submitted to the journal *Theoretical Population Biology*, where all the peer-reviewers found no errors. Nonetheless, they rejected it from publication on the grounds that it is not a "sufficient advance," and "there is little interest in this subject today among population biologists; it is one of those subjects which has sunk almost beyond trace." This has all been very unfortunate, as there continues to be widespread misunderstanding within the scientific community regarding these important matters, even among those who have studied the cost literature for years. It is hoped that the clarifications presented in this paper will eventually reach the greater scientific community. *Walter J. ReMine*

Introduction

J.B.S. Haldane (1957) introduced the cost of substitution concept, though its usage became hampered by various confusions, and it eventually fell into common disuse. It was criticized for requiring constant population size, and constant selective values, and for its reliance on "genetic death" and "genetic load," whose physical interpretation is dubious. Such issues severely limited its deployment. Those difficulties were addressed and eliminated in ReMine (2005), which clarified cost theory and generalized the cost of substitution to have a concrete physical interpretation, without reliance on genetic death or genetic load, and while allowing fluctuations in any parameters. This paper applies that conceptual clarification to obtain more precise mathematical results.

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For any given evolutionary scenario, cost theory calculates the required reproduction rate (referred to as the "cost of evolution") and compares it with the species actual reproduction rate (referred to as the "payment"). If the species cannot "pay the cost," then the scenario is not plausible. That concept is general, and can apply to any model of any evolutionary scenario, because they all require some level of reproduction rate. For ease of comprehension, calculation, and discussion, cost theory partitions the cost of evolution into a sum of various costs, with each cost named according to its specific role. Thus, the cost of substitution is one of many costs that each add extra reproduction rate to the amount required by the scenario (ReMine, 2005).

Evolutionary theory requires that some traits originate as rare beneficial mutations and then, through reproductive means, these increase in number of copies. This increase requires extra reproduction rate. Under the clarified definition, the cost of substitution (C_S) is the extra reproduction rate required to increase a trait (or traits) at the rate given by an evolutionary scenario. This paper uses that clarified cost concept to study single substitutions (non-overlapping in time), under genetic circumstances of broad interest (the same cases studied by Haldane, 1957), and derives equations that are more general, more precise, and well-grounded in concrete physical principles.

Let Q be a specific genotype. At the start of generation i, let P be the "effective starting count"—the effective number of individuals who produce genotype-Q progeny. As the cycle of that generation comes to a close, let P′ be the "ending count" of genotype-Q individuals due solely to the reproduction of the former group. (Throughout this paper, a primed quantity, such as P′, denotes a quantity as the generation comes to a close.) The increase is $\Delta P = P' - P$. Then the cost of substitution for genotype-Q, in generation i, is:

$$\text{Cost}_i = \frac{\Delta P}{P} = \frac{P'}{P} - 1, \text{ if} > 0; \quad \text{otherwise, Cost}_i = 0 \qquad (1)$$

Next this equation is restated in terms more traditional to population genetics. For generation i, define the following variables. Let N_e be the effective breeding population size. Let the **population growth factor** be $G = N_e'/N_e$, (which is 1.0 when the population size remains constant). For calculating the cost of a given genotype, let g be its **effective starting frequency** at the start of generation i, and let g′ be its **ending frequency** at the end of generation i. These are given by: $g = P/N_e$, and $g' = P'/N_e'$. Restating equation 1:

$$\text{Cost}_i = G\frac{g'}{g} - 1\,, \quad \text{if} > 0; \quad \text{otherwise, Cost}_i = 0 \qquad (2)$$

The **total cost of substitution** (the "total cost") merely sums Cost_i over all the generations of the substitution.

$$\text{Total cost of substitution} = \sum \text{Cost}_i \qquad (3)$$

The total cost of substitution is later divided by the average number of generations per substitution, to obtain the average cost per generation (C_S)—which is a focus of concern in cost arguments.

Next the equations for the cost of substitution are derived under various genetic circumstances, together with a method for iteratively calculating the total cost of substitution. In each case, the method is accurate even when the selection coefficient is large and when the parameters are arbitrarily changed each generation (unlike the traditional concept, which is too narrowly defined).

In all the following cases, A is the substituting allele, and *a* is the old-type allele, with frequencies p and q, respectively. The substitution's **starting frequency** is p_0; this is the frequency at the beginning of the entire substitution. (Note: p_0 is different from the "effective starting frequency" of a given generation i.) Genotype growth is specified by selection coefficients, where $0 < s \leq 1$. All cases assume random mating (except for the inbreeding fraction f). These are the same genetic circumstances studied in Haldane (1957).

To calculate the cost of a given genotype in a given generation, I am using its effective starting frequency and ending frequency. Throughout this paper these quantities are enclosed in boxes for easy identification.

Haploids, clonal, or self-fertilizing organisms, or for maternally inherited cytoplasmic characters

$$\begin{array}{lcccl}
\text{Genotype:} & A & & a & \\
\text{Selective value:} & 1 & & 1\text{-}s & \\
\text{Frequency:} & \boxed{p} & + & q & = 1 \\
\text{Apply Selection:} & p & + & (1\text{-}s)q & = 1 - sq \\
\text{Normalize:} & \boxed{\dfrac{p}{1\text{-}sq}} & + & \dfrac{(1\text{-}s)q}{1\text{-}sq} & = 1
\end{array} \qquad (4)$$

That gives the new allele frequencies:

$$p' = \frac{p}{1-sq} \quad ; \quad q' = 1 - p' \tag{5}$$

By equation 2:

$$\text{Cost}_i = \frac{G}{(1-sq)} - 1\text{, if} > 0; \quad \text{otherwise, Cost}_i = 0 \tag{6}$$

Equations 3, 5, and 6 allow iterative calculation of the total cost of substitution, while allowing changes in any parameters at the start of each generation. With parameters held constant, results are shown in Graph 1.

Diploids

In diploids, Mendelian segregation (in combination with some mating scheme, such as random mating or inbreeding) can affect the genotype frequencies, while tending to leave allele frequencies unaffected. Such change is due solely to the passive remixing of alleles at the gene level, and does not require extra reproduction rate from whole-bodies; therefore we do not tally it into the reproduction rate that whole-bodies are required to produce. So, we disallow it from our cost computation, that is, we calculate the cost after the effects of the mating scheme and Mendelian segregation have been allotted.

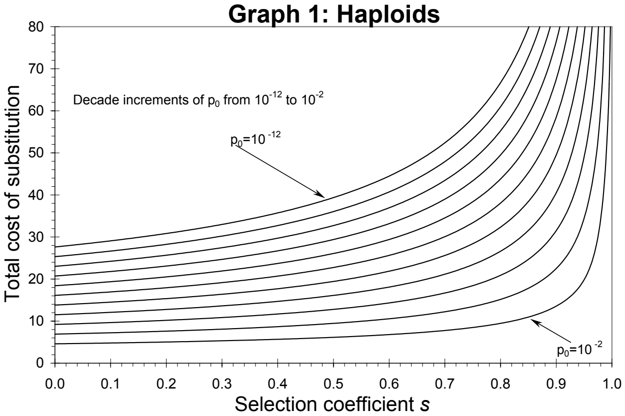
The adult population has a reproductive capacity, which is redistributed toward progeny of each given genotype at a predictable rate. That distribution is given by the "effective starting frequencies" of the genotypes, as follows:

$$g_{AA} + g_{Aa} + g_{aa} = 1 \tag{7}$$

That is, a fraction (g_{AA}) of the population's reproductive capacity goes toward producing the AA genotype. Another fraction (g_{Aa}) goes towards producing the A*a* genotype. And so forth.

As the cycle of one generation completes, let the genotypes' actual "ending frequencies" be labeled as follows:

$$g_{AA}' + g_{Aa}' + g_{aa}' = 1 \tag{8}$$


Graph 1: Haploids

Each genotype has its own cost, given by equation 2 as:

$$\text{Cost\_}AA_i = G\frac{g_{AA}'}{g_{AA}} - 1, \quad \text{if} > 0;$$

$$\text{otherwise Cost\_}AA_i = 0 \tag{9}$$

$$\text{Cost\_}Aa_i = G\frac{g_{Aa}'}{g_{Aa}} - 1, \quad \text{if} > 0;$$

$$\text{otherwise Cost\_}Aa_i = 0 \tag{10}$$

$$\text{Cost\_}aa_i = G\frac{g_{aa}'}{g_{aa}} - 1, \quad \text{if} > 0;$$

$$\text{otherwise Cost\_}aa_i = 0 \tag{11}$$

I am merely applying equation 2 to each genotype after discounting the passive redistribution effects of mating and Mendelian segregation. In this way, I calculate only the requirements on the reproduction rate of individuals (whole-bodies)—the cost. The producers of a given genotype are required to pay the cost of that genotype. It is usually sufficient to focus solely on the greatest cost, as this almost always forms the most stringent test of the scenario, thus:

$$\text{Cost}_i = \text{Maximum}(\text{Cost\_}AA_i, \text{Cost\_}Aa_i, \text{Cost\_}aa_i) \tag{12}$$

For a well-behaved substitution, the Cost_*AA* $_i$ always dominates. Therefore,

$$\text{Total cost of substitution} = \sum_{i=1}^{N} \text{Cost\_}AA_i \tag{13}$$

The following case studies demonstrate this method.

An Autosomal Locus in a Diploid

The diploid cases allow dominant and recessive substitutions, specified by recessivity h, where $0 \le h \le 1$. When h=0 this represents a fully dominant substitution.

$$\begin{array}{llllllll}
\text{Genotype:} & AA & & Aa & & aa & & \\
\text{Selective value:} & 1 & & 1\text{-}hs & & 1\text{-}s & & \\
\text{Frequency:} & \boxed{p^2} & + & 2pq & + & q^2 & = & 1 \\
\text{Selection:} & p^2 & + & (1\text{-}hs)2pq & + & (1\text{-}s)q^2 & = & 1\text{-}2hspq\text{-}sq^2
\end{array} \tag{14}$$

Normalize:

$$\boxed{\frac{p^2}{1\text{-}2hspq\text{-}sq^2}} + \frac{(1\text{-}hs)2pq}{1\text{-}2hspq\text{-}sq^2} + \frac{(1\text{-}s)q^2}{1\text{-}2hspq\text{-}sq^2} = 1$$

That gives the new genotype frequencies. The new allele frequencies are:

$$p' = \frac{p^2 + (1\text{-}hs)pq}{1 - 2hspq - sq^2}\ , \quad q' = 1 - p' \tag{15}$$

By equation 9 and the above boxed quantities:

$$\text{Cost\_}AA_i = \frac{G}{1\text{-}2hspq\text{-}sq^2} - 1\ , \quad \text{if} > 0;$$

$$\text{otherwise, Cost\_}AA_i = 0 \tag{16}$$

The total cost of substitution can be iteratively calculated by equations 13, 15, 16, while allowing changes in any parameters at the start of each generation. With parameters held constant, results are shown in Graphs 2 through 5.

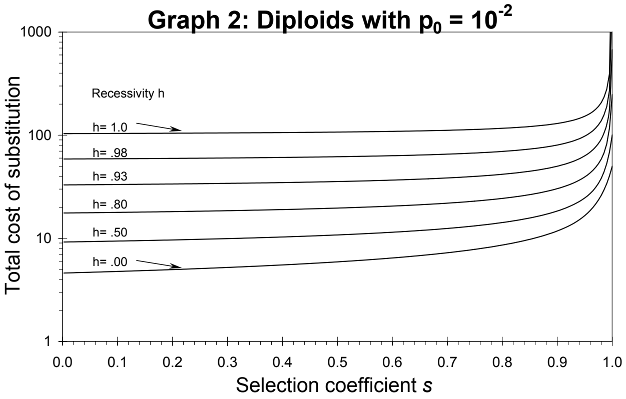
An Autosomal Locus in a Diploid with Inbreeding

Assume an inbreeding coefficient f, $(0 \le f \le 1)$, where a fraction, f, of the population mates only with its own genotype, and the remainder of the population mates randomly.

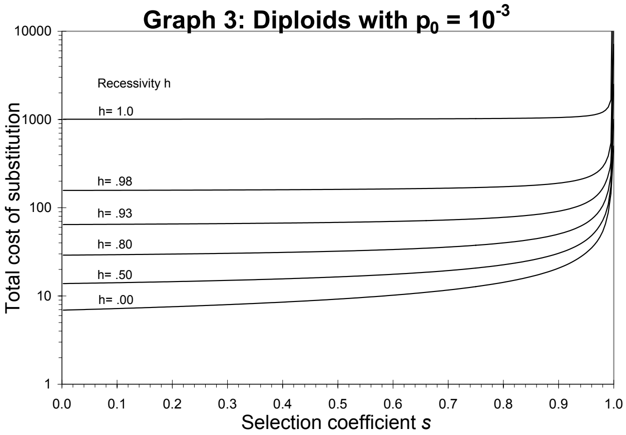
$$\begin{array}{llllllll}
\text{Genotype:} & AA & & Aa & & aa & & \\
\text{Selective value:} & 1 & & 1\text{-}hs & & 1\text{-}s & & \\
\text{Random mate:} & p^2 & + & 2pq & + & q^2 & = & 1 \\
\text{Inbreeding:} & 1+\dfrac{fq}{p} & & 1\text{-}f & & 1+\dfrac{fp}{q} & &
\end{array}$$

Combining the effects of random mating and inbreeding, the effective frequency of reproducers for each genotype is obtained:

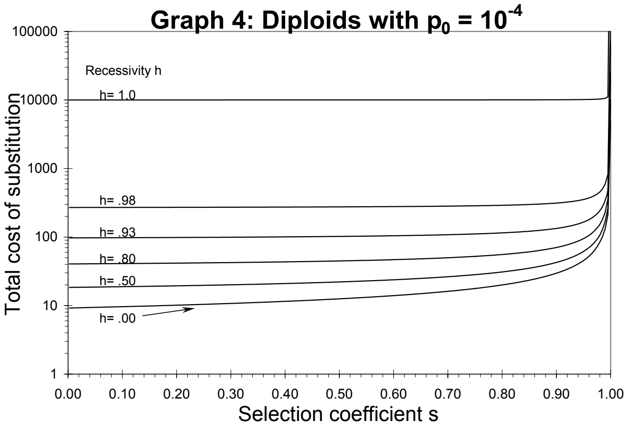
$$\begin{array}{llllllll}
\text{Frequency:} & \boxed{p^2+fpq} & + & 2pq(1\text{-}f) & + & q^2+fpq & = & 1 \\
\text{Selection:} & p^2+fpq & + & (1\text{-}hs)2pq(1\text{-}f) & + & (1\text{-}s)(q^2+fpq) & = & \text{RHS}
\end{array}$$



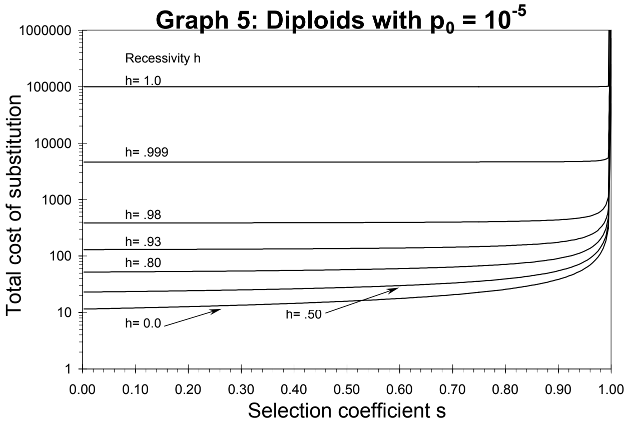
Graph 2: Diploids with $p_0 = 10^{-2}$



Graph 3: Diploids with $p_0 = 10^{-3}$



Graph 4: Diploids with $p_0 = 10^{-4}$



Graph 5: Diploids with $p_0 = 10^{-5}$

where the right-hand side is:

$$RHS \equiv 1 - spq(2h - 2fh + f) - sq^2 \qquad (17)$$

Normalize to obtain new genotype frequencies:

$$\boxed{\frac{p^2+fpq}{RHS}} + \frac{(1-hs)2pq(1-f)}{RHS} + \frac{(1-s)(q^2+fpq)}{RHS} = 1$$

$$p' = \frac{p^2 + pq(1 - hs + fhs)}{RHS} \quad ; \quad q' = 1 - p' \qquad (18)$$

Apply equation 9.

$$Cost\_AA_i = \frac{G}{RHS} - 1, \text{ if} > 0;$$

$$\text{otherwise, } Cost\_AA_i = 0 \qquad (19)$$

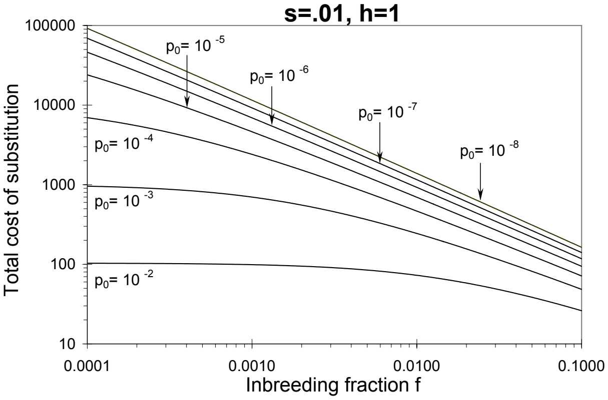
Equations 13, 17, 18, 19 allow iterative calculation of the total cost of substitution, while allowing changes in any parameters at the start of each generation. With parameters held constant, results are shown in Graphs 6 through 9.

For additional insight, examine a fully dominant substitution, while allowing any inbreeding fraction f, ($0 \le f \le 1$). Define P_A as the number of copies of allele A at the start of generation i. So, $P_A = p \cdot 2N_e$, and at the end of the generation $P_A' = p' \cdot 2N_e \cdot G$, for an increase of $\Delta P_A = p' \cdot 2N_e \cdot G - p \cdot 2N_e$. (By equation 12, $Cost_i = Cost\_AA_i$. Using h=0 with equations 17, 18, and 19, and the identity $p^2+pq=p$, it is easily shown that $Cost_i/\Delta P_A = 1/P_A$.) Therefore:

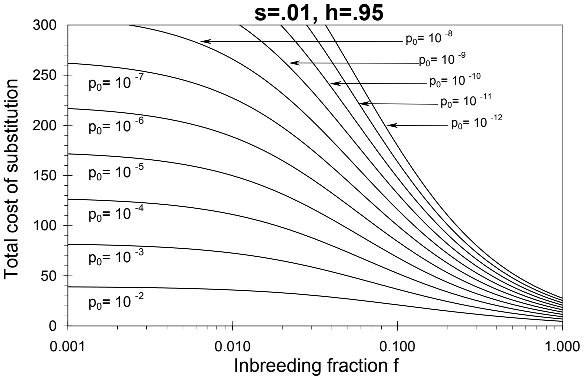
$$Cost_i = \frac{\Delta P_A}{P_A}, \text{ if} > 0; \quad \text{otherwise, } Cost_i = 0 \qquad (20)$$

Thus, in any given generation, the cost of substitution ($Cost_i$) is given by the percent increase in the number of copies of the substituting allele (regardless of the number of copies of the old allele). This happens to be the same equation as in haploids, and because of that equality, a proof previously established for haploids (ReMine, 2005, appendix) applies to this case in diploids, and the following result is proven. For a fully dominant substitution (with or without any amount of inbreeding fraction f, and allowing a non-constant population size), for a substitution of any given duration, the minimum total cost of substitution is achieved only when the cost each generation ($Cost_i$) is constant throughout the substitution. In cases of haploids, or diploids with full dominance, cost constancy provides the minimum total cost for a substitution of any given duration. This proof opposes the notion that the

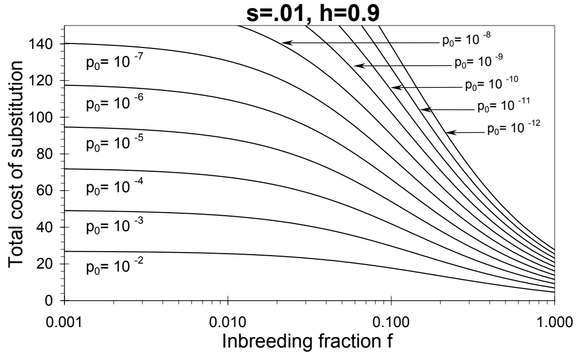
Graph 6: Diploids with inbreeding, s=.01, h=1



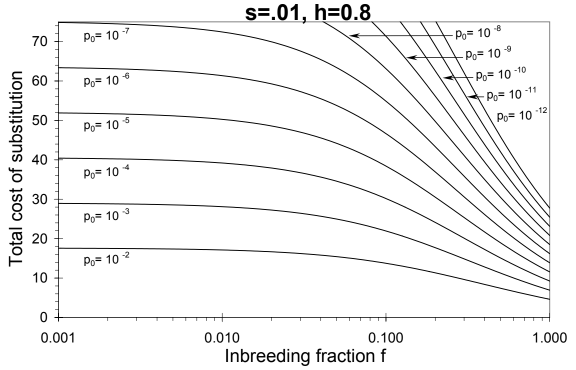
Graph 7: Diploids with inbreeding, s=.01, h=.95



Graph 8: Diploids with inbreeding, s=.01, h=0.9



Graph 9: Diploids with inbreeding, s=.01, h=0.8



total cost can be lowered by arbitrary fluctuations in selection coefficients (as in some versions of soft selection), or fluctuations in population size.

A Sex-Linked Locus in a Diploid

For a sex-linked locus, males and females have different selection coefficients (s_m and s_f) and different costs. Assume the males to be the heterogametic sex, but the results are the same (only swapped) if females are so. Define the male and female allele frequencies: ($p_m+q_m=1$) and ($p_f+q_f=1$). We here assume the *A* allele is neutral or beneficial in both sexes, and disallow less fortunate circumstances (such as beneficial in one gender and harmful in the other). Let the female population size have a growth factor of G_f, and for the male population it is G_m. Assume male and female progeny are produced at the same rate (a sex ratio of 1:1), as is ordinarily the case.

For the case of female progeny, random mating produces the generating function, $(p_m+q_m)(p_f+q_f)=1$, which determines the genotype frequencies given in equation 21.

$$\begin{array}{lccccccc}
\text{Genotype:} & AA & & Aa & & aa & \\
\text{Selective value:} & 1 & & 1\text{-}hs_f & & 1\text{-}s_f & \\
\text{Frequency} & \boxed{p_m\, p_f} & + & (p_m\, q_f + q_m\, p_f) & + & q_m\, q_f & = 1
\end{array} \tag{21}$$

$$\begin{aligned}
\text{Selection: } & p_m\, p_f + (1\text{-}hs_f)(p_m\, q_f + q_m\, p_f) + (1\text{-}s_f)q_m\, q_f \\
& = RHS2 \\
\text{where: } \quad & RHS2 \equiv 1 - hs_f\,(p_m\, q_f + q_m\, p_f) - s_f\, q_m\, q_f
\end{aligned} \tag{22}$$

This is normalized to obtain the new genotype frequencies for females:

$$\boxed{\frac{p_m\, p_f}{RHS2}} + \frac{(1\text{-}hs_f)(p_m\, q_f + q_m p_f)}{RHS2} + \frac{(1\text{-}s_f)q_m\, q_f}{RHS2} = 1 \tag{23}$$

The new allele frequencies for females are:

$$\begin{aligned}
p_f' &= \frac{p_m\, p_f + 0.5\,(1\text{-}hs_f)(p_m\, q_f + q_m p_f)}{RHS2} \quad ; \\
q_f' &= 1 - p_f'
\end{aligned} \tag{24}$$

Applying equation 9 gives the cost for genotype *AA* females. This is the extra reproduction rate necessary to produce enough genotype *AA* females to satisfy the scenario (including males too, at a progeny sex ratio of 1:1).

$$\begin{aligned}
&\text{Cost\_}\mathit{AA\_females}_i = \frac{G_f}{RHS2} - 1, \quad \text{if} > 0; \\
&\text{otherwise, Cost\_}\mathit{AA\_females}_i = 0
\end{aligned} \tag{25}$$

In the case of male progeny, for alleles A and *a*, the males are effectively haploid. Male progeny inherit this chromosome from their mother; therefore p_f is the effective frequency of mating that produces the A genotype in male progeny.

$$\begin{array}{lccccc}
\text{Genotype:} & A & & a & \\
\text{Selective value:} & 1 & & 1\text{-}s_m & \\
\text{Frequency:} & \boxed{p_f} & + & q_f & = 1
\end{array} \tag{26}$$

$$\text{Apply Selection: } \; p_f + (1\text{-}\,s_m)\, q_f = 1 - s_m\, q_f \tag{27}$$

This is normalized to obtain the new genotype frequencies for males:

$$\boxed{\frac{p_f}{1 - s_m\, q_f}} + \frac{(1 - s_m)\, q_f}{1 - s_m\, q_f} = 1 \tag{28}$$

The new allele frequencies for males are:

$$p_m' = \frac{p_f}{1 - s_m\, q_f} \quad ; \quad q_m' = 1 - p_m' \tag{29}$$

Applying equation 2 gives the cost for genotype A males. Physically this is the extra reproduction rate necessary to produce enough genotype A males to satisfy the scenario requirements (including females too, at a progeny sex ratio of 1:1).

$$\begin{aligned}
&\text{Cost\_}\mathit{A\_males}_i = \frac{G_m}{1 - s_m\, q_f} - 1, \quad \text{if} > 0; \\
&\text{otherwise, Cost\_}\mathit{A\_males}_i = 0
\end{aligned} \tag{30}$$

The scenario requires the larger of the two costs, therefore:

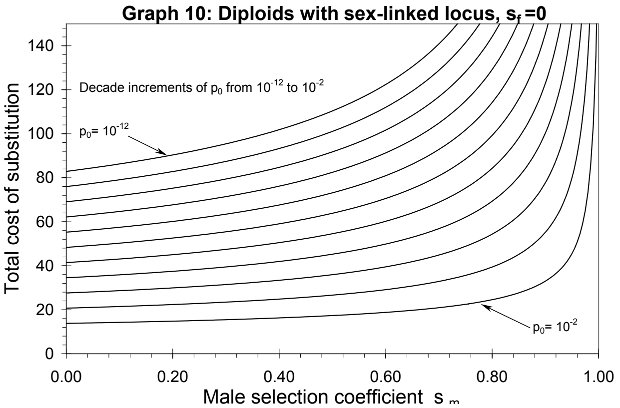
$$\text{Cost}_i = \text{Maximum}(\,\text{Cost\_}A\text{\_}males_i\,,\ \text{Cost\_}AA\text{\_}females_i\,) \qquad (31)$$

The total cost of substitution can be iteratively calculated (from equations 3, 22, 24, 25, 29, 30, and 31), while allowing changes in any parameters at the start of each generation. With parameters held constant, results are shown in Graphs 10 through 13.

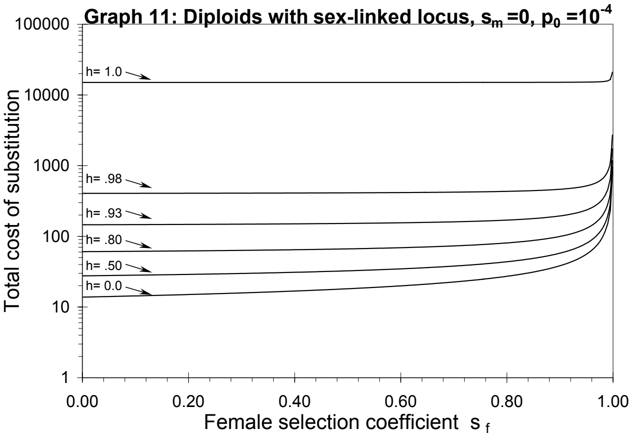
Haldane (1957) assumed tiny s-values (s_m & $s_f \rightarrow 0^+$), where the substitution is very slow, with ample time for allele frequencies to equalize between the sexes, so he assumed p_m=p_f. Unlike Haldane (1957), my iterative calculation allows the sexes to have unequal allele frequencies, and their *appropriate* values are recalculated each generation.

The sex with the higher selection coefficient tends to dominate the substitution process. When the heterogametic sex (male in this study) has the higher selective value (s_m) (as in Graph 10), then the total cost tends to be haploid-like and depends little on the recessivity in females. On the other hand, when the female selective value (s_f) is the higher (as in Graph 11), then the cost takes on the behavior of diploids—for example, the cost increases rapidly with recessivity h. (Note: If the substituting allele is beneficial in one sex, and detrimental or heterosis in the other, then the total cost of substitution will be higher and its behavior will be more complex. However, the cost interactions between the two sexes are too numerous for discussion here.)

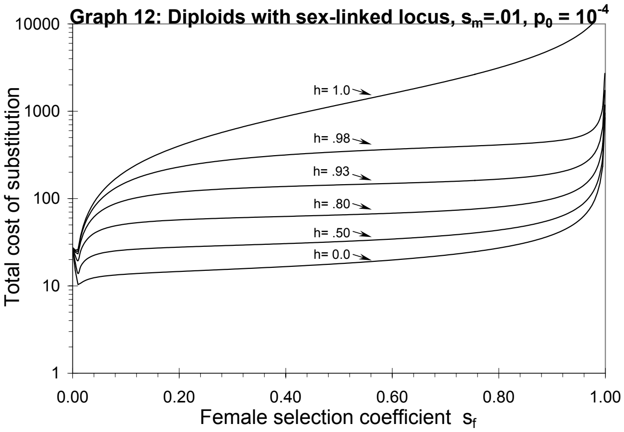
For scenarios with constant male and female population sizes (i.e., G_f =G_m =1), the sex with the lower cost will have some reproduction rate leftover. The leftover must be accounted through elimination of individuals of that gender; otherwise it would cause that gender's population size to increase (making G_f >1 or G_m >1). (Also the elimination must be accounted without altering allele frequencies for that gender, which is reserved for the selection coefficients.) In short, the leftover individuals of that gender must be eliminated, even though some of them possess the substituting allele—their production is wasted. On the other hand, when the costs for the two sexes are equal (such that Cost_A_*males* $_i$ = Cost_AA_*females* $_i$), then there is no leftover to waste, so the situation is more efficient at converting the reproduction rate into higher growth for the substituting allele—and this reduces the total cost of substitution. This higher efficiency is seen by the slight dip in total cost at the left end of Graph 12, which occurs when the costs for the two genders tend to be equal throughout the substitution. When selection coefficients for the two sexes are always equal, as in Graph



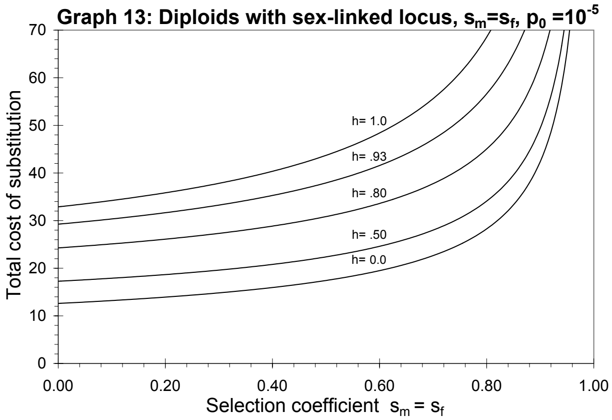
Graph 10: Diploids with sex-linked locus, s_f =0



Graph 11: Diploids with sex-linked locus, s_m =0, p_0 =10^{-4}



Graph 12: Diploids with sex-linked locus, s_m=.01, p_0 = 10^{-4}



Graph 13: Diploids with sex-linked locus, s_m=s_f, p_0 =10^{-5}

13, then the total cost is lower than when one selection coefficient is always zero, as in Graphs 11 or 12, but still higher than cases without the sex-linked locus.

Comparison with Haldane's Cost Concept

Haldane (1957) defined the cost of substitution in terms of "genetic death" (originally called "selective death"), which has been a source of much confusion. He did not give an explicit physical definition of genetic death; instead he gave a mathematical equation for it, a different equation for each specific case. In each case, his genetic death concept is identified as the amount subtracted from 1 on the far right-hand side of my equations 4, 14, 17, 22, and 27. In effect, that is how Haldane obtained his equations for genetic death. For example, for an autosomal locus in a diploid, his equation is $2hspq+sq^2$ (see it on the right side of my equation 14), which he interpreted as the genetic deaths of the heterozygote ($2hspq$), plus the genetic deaths of the disfavored homozygote (sq^2).

As pointed out in ReMine (2005), Haldane's genetic death concept exists only *between the mathematical steps* of (1) selection and (2) normalization. But in nature those happen physically in one event, not in separate steps. Therefore, Haldane's genetic death concept is a mathematical phantom that does not exist in physical reality. For this and many additional reasons, genetic death has been a continual source of confusion.

My cost concept uses quantities (enclosed in boxes here) that appear immediately before selection is applied and immediately after normalization is applied. Thus, these values straddle the line used by Haldane. Unlike Haldane, I use quantities (the genotype frequencies enclosed in boxes) whose physical meaning is concrete, and whose use is already ubiquitous in population genetics. I suggest his concept of genetic death is physically unclear and should be abandoned.

Haldane's concept worked correctly only under his two assumptions: (1) constant population size, and (2) small selection coefficients ($s \rightarrow 0^+$). His 1957 paper studied the same cases examined here. For each case, and for each generation, after applying Haldane's two assumptions, my cost of substitution is identical to his. (That is, under his two assumptions, my cost equations 6, 16, 19, 25, and 30 reduce to his cost equations 1, 5, 10, and the second equation on his page 518.) Under his two assumptions, my cost *each generation* is identical to his, therefore the *total* cost of substitution is also identical. However, my cost equations for any given generation are accurate for all selection coefficients (even large selection coefficients), and for fluctuations in any parameters (such as population size)—whereas Haldane's equations are not.

In the case of a sex-linked locus, Haldane's focus on genetic death led to error. In each generation, he calculated the genetic deaths of disfavored males, and totaled that over the entire substitution. He did likewise for females. Apparently to calculate the average rate of genetic death, he then averaged those two totals together (instead of taking the larger of the two, as in my equation 31), to obtain his total cost of substitution. The genetic death concept focuses on death (not reproduction rate), so it failed to inform Haldane that the costs for males and females are linked together, because male and female progeny are produced at the same rate. This is yet another example of how Haldane's concept of genetic death caused confusion and error.

Discussion

Under the above variety of genetic circumstances, the parameters were held constant, and the graphs display the total cost of substitution. Each curve plots 201 data points, (200 intervals), equally spaced visually across the horizontal range. In Graphs 1 through 5, there is a high cost impulse at $s=1$, which goes off-scale vertically.

The graphs show that the total cost increases with selection coefficient s. (That holds for all cases, except for some complicated interactions involving a sex-linked locus in diploids, as discussed above.) The traditional total cost formulas assumed infinitesimally small selection coefficients ($s \rightarrow 0^+$), and therefore underestimate the total cost in realistic situations. However, the underestimate is less than ten percent error as long as $s<0.17$, which covers the most typical evolutionary substitutions.

The total costs for "haploids" and "fully dominant substitutions in diploids" are nearly identical (so only the former is graphed here). They diverge from each other only slightly as the selection coefficient increases, with diploids having the slightly lower total cost. Using the haploid case as a reference, the diploid case has lower total cost by no more than 1.4 percent (9.2 percent) for all selection coefficients less than 0.2 (0.8).

Traditionally the total cost of semi-dominant substitutions ($h=0.5$) is given as double that of dominants ($h=0$). That is accurate to within ten percent for selection coefficients $s<0.35$, according to these results.

It is known that almost all beneficial mutations fail to substitute; instead they are eliminated by genetic drift without ever reaching fixation. In such instances, they only partially substitute within a population, and they incur a portion of the total cost of substitution. Even though such substitutions are unsuccessful, they are nonetheless part of the scenario, and they incur a cost that the species must pay if the scenario is to be plausible. Haldane did not account this *cost of unsuccessful substitution* (C_U). When a single beneficial mutation is lost, this cost may be small, but it becomes significant when multiplied by its overwhelming prevalence in nature. Kimura and Maruyama (1969) estimated that this adds 2 to the cost of each successful substitution. Their calculation should be revisited, especially in light of: (a) recent clarifications of the cost concept, and (b) modern measurements concerning the mutation rate and the frequency of nondominant mutations (which have a high cost of unsuccessful substitution).

Of special concern is the high cost of recessive substitution. Their total cost is quite high, (easily in the thousands), and substantially constant over any selective value s. Graphs 6 through 9 show the effects of inbreeding, which may dramatically lower the cost of recessive substitutions. For example, at a starting frequency of $p_0=10^{-5}$ and no inbreeding (f=0), the total cost is 100,000, but is reduced to 7,000 by an inbreeding fraction, f=0.001. However, for a high starting frequency of $p_0=10^{-2}$, that same inbreeding fraction has virtually no effect. In other words, a given level of inbreeding may produce dramatic cost reductions when starting frequencies are low, but at high starting frequencies there is scarcely any reduction. This is shown in Graph 6.

For the same reason, however, inbreeding simultaneously increases costs. Inbreeding causes an increased production of homozygotes that express the beneficial recessive mutation and aid its substitution. Thus, some beneficial recessive mutations (that would be lost at lower cost under no inbreeding) will successfully substitute under inbreeding—thus incurring a high cost of substitution. Also, some beneficial recessive mutations (that would substitute only slightly under no inbreeding) will substitute further under inbreeding—thus increasing the cost of unsuccessful substitution. In other words, it is not immediately obvious whether inbreeding will increase or decrease the costs associated with substitution, or by how much. The role of inbreeding is a double-edged sword that cuts in both directions, and needs further research.

The costs derived in this paper are mechanical and unavoidable. In realistic situations the actual cost of substitution can be higher, but cannot be lower. The equations give a lower bound, regardless of the type of selection (such as "soft selection" versus "hard selection"), and regardless of environmental change. This lower bound in *any single generation* (as shown in equations 6, 16, 19, 25, 30, and 31) is independent of those factors, and therefore so is the total, summed over all generations. This means that, contrary to common assumption, environmental change (such as employed in Felsenstein, 1971 and 1972), and soft selection (such as employed in Grant and Flake, 1974, and Wallace, 1991) cannot even slightly reduce cost problems for single substitutions. Those errors were caused by confusion factors identified in ReMine (2005), such as genetic death, genetic load, extinction, and the environment. Those factors are largely irrelevant to the central issue, which is the *growth* (in number of copies) of the substituting allele, and the extra reproduction rate necessary to achieve it.

Haldane (1957) estimated that the average value for the total cost of substitution is 30. To rationalize that low figure, he employed an environmental-change scenario to bypass the earliest stages of substitution, where most of the total cost would ordinarily be incurred. The scenario (given in Haldane, 1957 and 1961) assumes that neutral mutations and slightly deleterious mutations occasionally drift upward to maintain a pool of these at elevated frequencies—call these "pool mutations"—and when the environment changes, some of these are converted to beneficial, which then begin their substitution at an elevated starting frequency, thereby dramatically lowering their total cost of substitution. This scenario is awkward to justify for most substitutions (much less for all substitutions, as assumed by Haldane), and especially during multiple-concurrent substitutions, because the same environmental change alleged to start one substitution would likely disrupt or reverse the ongoing substitutions.

As discussed in ReMine (1993), the environmental-change scenario tries to obtain a "free lunch" from nature. Environmental-change, like mutation, is random concerning the organism, and therefore is far more harmful than beneficial. For every "neutral or slightly deleterious" mutation that converts to "beneficial," there will be vastly more converted to become more harmful, with these also tending to have a larger effect—for a net effect that is overwhelmingly harmful. If one pool mutation converts from neutral to beneficial, this would be overwhelmed by thousands that become detrimental and must be eliminated—and precisely because these eliminations start at elevated frequencies, this increases the cost of mutation (which is the extra reproduction rate required for coping with the elimination of harmful mutations). That makes cost problems worse. In a similar way, for every pool mutation that converts to beneficial, there would be many beneficial alleles at fixation that convert to harmful, and must be substituted just to break even. To avoid a theoretical Ponzi scheme, almost all of these must be substituted by a directly new mutation (not a pool mutation), thereby incurring a full (non-discounted) cost of substitution, and usually resulting in a net fitness loss. When fully accounted, the environmental-change scenario makes cost problems worse. There is no free lunch.

In other words, Haldane gave poor justification for his figure of 30, and we must seek a more realistic figure, which will surely be higher. Even after removing the environmental-change scenario, the value of 30 implicitly assumes: (1) a nearly nonexistent role for recessive substitutions, (2) no cost for unsuccessful substitutions, and (3) a high reliance on small population sizes (which receive beneficial mutations at a much lower rate and slows down beneficial evolution). It is doubtful those assumptions are realistic or consistent with other considerations from evolutionary theory.

Conclusions

Compared to the traditional cost derivations, the equations described in this paper are general-purpose, simpler, and easier to understand. The total cost of substitution is then calculated iteratively, generation by generation, for improved accuracy. This method allows arbitrary changes to any parameters at the start of each generation, which can be conveniently handled by computers. In addition, this method is transparently clear, whereas Haldane's derivations are opaque.

Though the environmental-change scenario was traditionally used, it was never given a proper cost analysis. When fully tallied it actually makes the cost problems worse. The same applies to the concept of soft selection (at least for single substitutions).

The following areas are suggested for further research in cost theory: the frequency and role of nondominant or recessive mutation, the overall effect of inbreeding, the cost of unsuccessful substitutions, and the effect of unequal sex ratios at conception or in the breeding population.

Most importantly, this paper calls for the average total cost of substitution (such as Haldane's figure of 30) to be given an explicit justification within some widely accepted evolutionary model. The graphs and methods presented in this paper can help estimate it across a blend of circumstances anticipated in nature.

Appendix: Notes on Haldane's Derivations

Haldane's equations for the cost *each generation* are typographically correct (Haldane, 1957). However, I detect the following typographical errors in his derivations for the *total* cost of substitution. Most of these are clearly typographical errors, because they disappear in his subsequent equations. Some of them, however, are in his final equations for the total cost of substitution, so researchers should be wary of that. (A) In the calculation prior to his equation 7, there should be a factor (1–2h) multiplying the second p_0. (B) In his equation 9, the first K in the denominator should be k. (C) In the calculation following his equation 9, there should be an opening bracket immediately between the μ and the second natural logarithm, mated with a closing bracket immediately after the last parenthesis of that equation. (D) In his equation 11, it may be that the K should be $2K$, because the missing "2" shows up again in his next equation. (E) In the equation before his equation 12, the sign before the ½ should be negative. (F) In his equation 12, the sign before his second natural logarithm should be negative. (G) In his equation 13 (in his equation for female, and in his separate equation for male), the first p_0 should be a factor in the denominator, not the numerator. For the reader's convenience, my paper uses modern notation rather than Haldane's.

Haldane's subsequent paper (Haldane, 1961) attempts to derive "more precise" cost equations when selection coefficients are not small. I regard that paper as a decrease in clarity and accuracy from his previous attempt (1957), and largely irrelevant to understanding cost theory today. Absent is his previous emphasis on "reproductive capacity," which should be the central issue. Instead the 1961 paper focuses exclusively on genetic death, which should now be abandoned as unnecessary confusion. In effect, his 1961 paper takes each of his previous equations for genetic death (only this time allowing a large selection coefficient) and pursues the task of deriving a closed-form equation for its sum over all generations of the substitution (to obtain the total cost of substitution). The paper's lengthy mathematical contrivances are opaque and conceptually ill founded. For example in haploids, in a given generation, his cost of substitution, sq, is accurate only for a *small* selection coefficient. When his 1961 paper imposes a *large* selection coefficient into that same equation, the result is useless or erroneous for its intended purpose (that of establishing a limit on the substitution rate). His 1961 paper thereby arrives at erroneous cost equations, and mistaken conclusions, such as the notion of "negative cost."

Acknowledgements

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Author and Title Index for Volume 42, 2005–2006

Lazella M. Lawson*

This title/author index covers articles, panorama notes and other features. For items with two or more pages, the reference is to the first page only. After the page number, a letter indicates which type of entry is involved: article (A), panorama note (P), letter to the editor (L), book or video review (R), cover photo (CP), or other departments (such as laboratory director's comments, president's remarks, photo essays, etc.) (D).

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Book Review

Saints and Scholars: A Unique Introduction to the History of Cambridge (DVD)

£10 from http://www.christianheritageuk.org.uk

In the Round Church in Cambridge is a fascinating exhibit which depicts the influence of Christianity on the development of the English culture, and how events that occurred at Cambridge shaped much of the history of the world. The bookshop offers books by Michael Behe and openly promotes intelligent design materials. The DVD reviewed here is being shown continuously to visitors at the Round Church. I believe it is a valuable account of how Christian thought and the influence of scholars at Cambridge changed the world and launched the development of science. It explains that Cambridge is not only one of the oldest and most beautiful university cities in the world but also is one of the most important. Yet its history can only be understood through an appreciation of the defining influence of Christianity.

The DVD begins by describing many of the prominent scholars at Cambridge who impacted the culture of the world. Isaac Newton attended Trinity College at Cambridge, and it was there he developed his *Principia Mathematica* where he defined the principles of calculus. His achievements have caused many to give him the title of Man of the Millennium. The colleges at Cambridge have produced over 30 Nobel Prize winners, not only in science, but also in literature and the arts. Among these are Spencer, Milton, Wordsworth, Tennyson, Keynes, and Darwin. Much of what shaped Western thought, good and bad, originated here.

The Romans built a road to Cambridge around 400 AD. The name comes from a bridge over the river Cam. The Round Church was built in 1130 before the founding of the university and its design shows the influence of the Normans. In 1209, teachers and students left Oxford and founded the university at Cambridge, which became a monastery. Ely Cathedral was founded in 1284 and its foundations can be seen at St. John's college. The first college at Cambridge was St. Peter's Outside Trumpington Gate. At Peterhouse, the students wore clerical robes, and these were the predecessor of the traditional gowns worn at graduation. King Henry VI founded King's College and Lady Margaret Burford founded Christ College and St. John's. A statue of Lady Burford depicts her as stamping out ignorance as part of her faith.

The High Renaissance marked a time where the church was under attack because of abuses. Consequently many at Cambridge began to examine the classical Greek and Roman literature and sought to emphasize the importance of the here and now. These were the first to be called humanists, and Erasmus in 1511 published the first Greek and Latin edition of the New Testament. Several students, including Hugh Latimer, Nicholas Ridley, and Thomas Bilney found that Latin obscured the meaning of many essential Christian doctrines. Martin Luther in Germany also was influenced by this work and ended up challenging the Catholic practices of selling of indulgences, showing that the scriptures clearly mark salvation as a free gift of God. Erasmus's work gave birth to William Tyndale's translation into English and a translation into German. Because of this, it is often said that Erasmus "laid the egg that Luther hatched."

The first Protestant teachings were preached from St. Edward's Church in Cambridge. In 1521, Luther's works were denounced and burned in front of St. Peter's Church. From that point on, Latimer, Ridley, Bilney and their group met in secret at a pub called the Whitehorse Inn.

At the same time, the political arena was creating a stir. King Henry VIII had a daughter Mary by his wife Catherine, but lacked a son for an heir. He sought reason to divorce her and appointed Thomas Cramer as Archbishop of Canterbury, who provided him with a theological justification. The pope refused to grant the king a divorce, so he split from the Catholic church and founded his own church, still Catholic, but under his direction. Under Henry VIII, the monasteries were dissolved and the colleges of Sydney Sussex, Emmanuel, and Trinity were founded. Thomas Cramer went on to write the Book of Common Prayer.

Henry VIII was succeeded by Mary, who ordered the Protestants killed, including Latimer, Ridley, and Bilney. Elizabeth, who was Protestant, succeeded Mary, but didn't like the Puritans and persecuted them. Puritans were Protestants who were concerned with keeping their doctrine pure. Cambridge's Sydney Sussex and Emmanuel colleges were centers for Puritan training. John Harvard was a Puritan trained in Cambridge, and because of persecution from Elizabeth, ended up establishing Harvard University in America.

At Cambridge, Protestant Christianity had a profound effect upon the development of science. Francis Bacon of Trinity College assembled the methodology of hypothesis and observation. He was quoted as saying, "No man can search too far or be too well studied in the word of God and the works of God's hand, nature." William Harvey of St. John's college pioneered the study of the circulatory system. Isaac Newton believed that his scientific understanding was a gift of God, and believed there was no conflict between Christianity and science. According to Newton, "The universe was made by God and is reasonable and understandable. God is the God of order and not of confusion."

For the most part, scientists of this time did not have any problems reconciling science to faith. Over the door of the Cavendish laboratory, Psalm 111:2 is inscribed in Latin: "Great are the works of the Lord, studied by those who delight in Him." Scientific scholars and men of faith there included James Clerk Maxwell, J. J. Thompson, John Fleming, and William Henry Bragg, all pioneers in their respective disciplines. Like Newton before him, William Paley opposed those who would explain the universe in pure mechanistic terms.

Eventually the mechanistic view of the universe won out. Charles Darwin, a theological student at Christ College, developed the theory of evolution after his voyage on the *Beagle* and many found this view disturbing because it robbed people of their dignity and meaning. Consequently, there was a divide between that which was considered scientific, and those who sought to preserve human experience that cannot be measured in the laboratory. Romantic poets such as Wordsworth, Byron, Coleridge, and Tennyson, emphasized human feelings. The divide between scientific fact and meaning continued to widen, and later Ludwig Lichtenstein proclaimed that "meaning and significance is completely irrational."

Others disagreed, and continued to maintain their Christian faith. Charles Simeon of King's College was appointed vicar of Holy Trinity Church, and for 54 years expounded the Christian faith. One of his students was Henry Martyn who became a missionary to India. Simeon's teaching is still influential today, and the Cambridge Christian Union and many of the large Cambridge churches have thriving congregations.

Christianity at Cambridge was also a strong voice for social reform. William Wilberforce, after his conversion, teamed with William Clarkson as a voice to abolish the slave trade. Just before his death in 1833, the slaves were emancipated, bringing his dream into realization.

Christian Heritage at the Round Church proclaims that Christianity still has the power to change lives. It is a dynamic force that shapes spiritual, moral, intellectual, and cultural life. It is intellectually viable, bringing significance to the individual. Their motto is "Remember your former leaders and imitate their faith."

This DVD helps us realize how much science was advanced by our Christian heritage. But it is apparent that those who dwell on the benefits of science fail to realize the foundation that Christianity laid for their thought. The belief that the universe is orderly and can be studied gave rise to scientific investigation, but ironically the scientific investigation in its own right caused some to doubt that the universe is orderly, with its origin in chaos.

Doug Sharp

Notes from the Panorama of Science

The Rationality of Hypothesized Immaterial Mental Processes

The article "The Origin of Consciousness" (Thompson and Harrub, 2004) discusses the notion of what may be immaterial processes or aspects of the "mind." The notion that these processes have immaterial components is, of course, a hypothesis. While reading this article and the book by Eccles and Robinson (1994), it occurred to me that establishing the scientific consistency and rationality of some of the hypothesized immaterial mind concepts might aid in their acceptance as *bona fide* entities worthy of further scientific investigations. Under these conditions, all the evidence for these traits would be scientific in character. In this note, research is presented that verifies such consistency and rationality. Many scientists are predisposed to accept hypothesized entities that are not directly observable, if such entities are presented rationally and their assumed existence explains physical behavior. What constitutes the material world and, hence, the "immaterial" varies historically. An 1850s list of terms that signify material entities or describable processes would be vastly different from the same type of list published today. If a notion or process does not appear in such a list, then it might be considered as "immaterial." Thus, for the purposes of this note, consider the immaterial notions listed under Karl Popper's "World 2—States of Conscious" (Eccles and Robinson, 1984, p. 30).

As a mathematician, I spend vast amounts of time "talking to myself" (mentally). I also mentally visualize mathematical symbols or geometric imagery, when necessary. Usually, this mental "voice" tells me in words what I need to do to establish a particular mathematical result. To the materialist, this audio-styled end product must result from physical brain activity. I concede that this is probably the case. I asked myself, "How can I take such an assumed material outcome and construct a model that implies the need for an additional immaterial object or an immaterial 'process'?" After at most one second, my mental voice said what to many would be mostly nonsense words: "At the first level they appear, consider a finite ternary relation where informally the first and third coordinates are words taken from a standard language that you can speak or write down, and that correspond to empirical observations. You could also use images. The second coordinates are represented by λ, δ, ϕ, . . . , which denote a finite list of nonstandard 'words' that are not members of the standard language or a standard image but rather are members of the hyperlanguage extension. This should do the job."

Assuming I know what my mental voice is talking about, I asked, "What does this model?" "It models what you have just done. It models a pure creative process," are the very words I heard. But is this truly a creative leap? The absolute facts are that I have never before constructed such an object for any purpose. I have never read or heard of anyone else constructing such an object for any purpose. I know what the terms mean, but I never before considered combining them in this rather simple fashion. Indeed, this is a basic construction and how I arrived at this mental voice conclusion is not based upon any form of logical deduction I can perform. Some materialists have argued that this suggested construction is obtained by random chance and mere choice on my part. Although a rather absurd materialistic statement, this might have some infinitesimal validity if this process had occurred to me just once. But, since this same process has occurred to me hundreds and hundreds of times throughout my life, then statistically a mere choice made in but one second from a vast array of random possibilities becomes highly unlikely.

Albeit my mental voice claimed otherwise, I was not sure that this construction does "do the job." However, after some effort (Herrmann, 2004), it has been formally shown that this ternary "logic-system" mathematically generates an "ultralogic" (Herrmann 1984, 1987, 1993). Physically, ultralogics are often interpreted as influencing material behavior where their influence originates from a region exterior to our standard material universe. This exterior region is called the pure nonstandard physical world (NSP-world). Ultralogics can be interpreted as being intelligently designed with an intelligent agent signature. Further, they have various theological interpretations (Herrmann, 2002).

The depicted mental voice process is an example of an entity in the Karl Popper list. It comes under the heading of "creative imagination." This ultralogic models this form of creative thought, where the nonstandard words, represented by the finite list λ, δ, ϕ, . . ., are the immaterial part of the process. Owing to the presence of this immaterial part, the entire modeled process is classified as immaterial. Further, it might appear that the original instructions I followed lead to a self-reference trap where they develop a useless infinite regression. This is definitely not the case, due to the phrase "At the first level they appear." The nonstandard objects represented by λ, δ, ϕ, . . . have formal definitions that I won't present.

Under established behavior of a logic-system, this ultralogic takes the question I asked, combines it with one of the immaterial components λ, δ, ϕ, . . . and "logically" yields the answer I mentally heard. This first ultralogic gives no further indication as to how I receive such information. There are other NSP-world mechanisms that might aid in the actual production of the end products, the conclusions (Herrmann, 1999a, 1999b). However, the new results presented in this note are only intended to show that the behavior being described is scientifically consistent and rational. This will establish my basic premise that, in their most basic form, certain assumed immaterial processes that cross the mind-brain frontier are also scientifically consistent and rational.

Other than the empirical results and instructions that produce this partially empirically obtained logic-system, I cannot give any other information as to how I am able to perform such creative acts. I cannot write a computer program that instructs a machine to follow a certain procedure that will, in general, duplicate such specific creative events. I have described one event as it actually occurred within me, not what occurs within others. How does this yield a direct form of evidence? Referring to their notion of the immaterial mind, Eccles and Robinson (1984) state, "The only unarguable claim regarding the existence of a thought or feeling is the one made by the person having the thought or feeling. He has *direct* evidence. But as an observer of others he can only make inferences and identifications" (p. 53). Using various forms of "language" or "imaginary," it seems reasonable that many others would describe their truly creative acts in a similar fashion. Some might conclude that there does appear to be an immaterial "something" that has influenced their creative conclusions. As this occurs, the evidence would continue to mount, evidence that would strongly suggest that one can rationally suppose the existence of such an immaterial influence.

Although "thoughts" are listed as an immaterial World 2 item, is it a fact that some "thoughts" can truly be classified as immaterial? My experience indicates that if the notion of "thoughts" means some mental concept that cannot be truly expressed in terms of any material language or imaginary, then the answer is *yes*. When the modeling processes that generate the General Grand Unification model were introduced in 1978 (Herrmann, 1982, 1993, 2002), I became keenly aware of one basic fact: I could not describe, in a non-mathematical manner, the ideas—the "thoughts"—the symbolism was attempting to convey. There were no words yet devised that would even yield an approximate description for the information being communicated to me through the mathematical expressions. Even though, after 27 years, modern illustrations and new terminology have been discovered that tend to describe the basic behavior of the NSP-world, I still cannot convey its more subtle aspects to others. This includes subtle aspects of the ultralogics discussed in this research note. Then there is the great frustration I felt as a child when I was not able to express my thoughts in any manner, using the limited language I possessed.

I am not the only individual who recognizes such communication inabilities as fact. "We can all recognize that when we are attempting to express subtle thoughts, particularly those that are novel and as yet unclear, we may tentatively try now this, now that, verbal expression. . . . In attempting to convey some experience it is difficult to give satisfactory verbal expression to one's thoughts. One searches for the right words and syntactic arrangement so that one can have hope that one's thoughts may achieve a clear expression to listeners or readers" (Eccles and Robinson, 1984, p. 117).

The idea that such thoughts are essentially immaterial has many complementary models. Constructing scientific or mathematical theories via deductive logic is a major occupation for many individuals, and especially for me. Indeed, almost all of humankind performs similar deductions thousands of times a day. Many ultralogics model the immaterial aspects of this form of thought (Herrmann, 1993, 2002). You can apply such ultralogics to a fully expressible set of behavioral hypotheses. Some of their conclusions can be fully expressed as a set of sentences from a standard language. However, you cannot express, in any comprehensible way, other "deductive" conclusions. Under the general immaterial requirements, this ultralogic process is an immaterial process. Further, similar to the previous discussion, you have direct knowledge that subtle deductive conclusions rationally exist, and also know certain general properties for how they are generated. Such ultralogics form an immaterial fundamental aspect for the mental search for expressible conclusions that supply additional behavioral characteristics. These ultralogics supply additional rational knowledge that, in many cases, a set of expressible conclusions is not completely satisfactory in that there remain characteristics that cannot be communicated. However, they allow for a continual immaterial search that discriminates between expressible characteristics that do yield a more satisfactory behavioral description and inexpressible ones. Such an immaterial search process can be partially described by employing informational NSP-world mechanisms (Herrmann, 1999a, 1999b). A discussion of this process is beyond the scope of this note.

Eccles and Robinson (1984) discuss experiments that seem to imply that "mental intentions," considered as immaterial and World 2 in character, influence only the physical SMA (supplementary motor area of the brain) in a very discriminating fashion prior to a voluntary movement. A modification of the original answer conveyed to me models this behavior. The logic-system is a finite binary relation having the representations λ, δ, ϕ . . . for pure nonstandard objects as first coordinates, where each is interpreted as an appropriate mental intention, and the corresponding second coordinate is a description or image for the SMA-induced voluntary movement. Again this is not a standard object and can be considered as immaterial in character.

The scientific consistency and rationality for immaterial aspects of creative imagination, certain thought processes and mental intentions has been demonstrated via the science of mathematical modeling. This does not give direct evidence for their existence. If there are no reasonable materialistic explanations for these notions, then these new research conclusions will aid individuals in accepting the indirect evidence for the immaterial hypothesis. Although these models verify my original premise, they are rather weak empirically-styled models. Consequently, further research based upon combinations of standard and nonstandard items may yield mathematical models that correctly predict measurable mind-brain behavior.

If an immaterial influence is accepted, then it needs to be interpreted. It is rather a matter of choice. Many members of the parapsychology movement might accept that an immaterial influence is an entity that is physical-like in character. However, distinct from the usual parapsychology assumptions, an ultralogic-produced influence is usually interpreted as emanating from (or is transmitted through) an omnipresent external universe in which our comprehensible material universe is embedded. Intelligent design or intelligent agent terminology can also be used to describe all of these models. For me, however, I choose to accept these investigated influences as having immaterial aspects and that they are manifestations of an event that, remarkably, was described thousands of years ago. That is, "God formed man of the dust of the ground, and breathed into his nostrils the breath of life; and man became a living soul."

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Letters to the Editor

Another Perspective on the Fiery Flying Serpent

I was delighted with David Woetzel's article, *The Fiery Flying Serpent* (*CRSQ* March, 2006, p. 241). The analysis of biblical and other ancient records were, in themselves, worthy, and a perfect introduction to present-day expeditions, but the recent living-pterosaur sightings were thereby given less attention (probably of necessity). As another investigator of the living-pterosaur phenomenon, I'd like to summarize some of the details that were missed and give another perspective.

Woetzel's expedition (with Garth Guessman and Jacob Kepas) was, for the year 2004, the third of three light expeditions to Umboi Island. It seems the first was a brief one-man effort: An Australian spent two nights on a southern beach as he unsuccessfully searched the night sky for ropens (apparently without interviewing any eyewitness). Later, in September, I arrived and spent two weeks on Umboi (south-central villages), returning to the U.S. just days before Guessman and Woetzel started for the Southwest Pacific.

In earlier light expeditions, from 1994 through 2002, three pioneer ropen investigators stand out: missionary Jim Blume; Carl Baugh; and Baugh's coworker, Paul Nation. The three more-recent American explorers (Woetzel, Guessman, and me) owe much to the three earlier pioneers who, in countless ways, helped us prepare for our own expeditions.

My initial first priority on Umboi Island was videotaping and photographing a ropen. After one week, realizing the creature was too elusive, I started videotaping eyewitnesses instead. Two of these were later again interviewed by Mr. Guessman and Mr. Woetzel (William Gima and Jonah Jim), but most of our exploring and interviewing was non-overlapping (my colleagues were mostly in the north, where no investigator had yet been; I was only in the south, where earlier explorers had already established friendships with villagers).

The Woetzel-Guessman-Kepas investigation did more than simply add to the volume of credible eyewitness testimony evidence from previous expeditions. Mr. Woetzel's own sighting is more significant, I suspect, than even he realizes. One skeptic (a standard-model evolutionist) has emphasized that Woetzel saw only a brief light at a distance (no pterosaur-form), but the circumstantial evidence is significant. The mountain behind which the moving light disappeared (Mt. Tolo or Tolou) houses three crater lakes, including Lake Pung. A few weeks before Woetzel's sighting, I interviewed three young men who, as boys ten years earlier, had been terrified at the sight of a giant ropen as it flew over Lake Pung in the middle of the day. In addition, Jonah Jim (interviewed by me and later by Guessman) saw a giant ropen flying toward Mt. Tolo [Tolou] a few years later. His sighting, by contrast, was at night. Jonah Jim saw not only the long tail and wings of the creature, but also the glow. Since both of these sightings by local villagers were of a giant flying creature with a long tail, and one sighting confirmed that this Rhamphorhynchoid-like creature glows at night, Woetzel's sighting was probably that same kind of creature. His sighting was literally un-meteoric as well, for the large glowing object was moving almost horizontally at a low altitude, with no meteor tail.

Jacob Kepas himself saw a similar creature when he was a boy. Mr. Guessman interviewed Kepas (before the three flew to Umboi Island) and I later reviewed the videotaped record of the session. One night, the boy heard a noise and ran outside in time to see the wings and glow of the creature they call Seklo-bali. This was on the mainland. (Perhaps this childhood encounter influenced him to help in the late-2004 investigation.)

I suspect that Mr. Woetzel either does not fully appreciate some of the eyewitness testimonies from his own expedition, or, more likely, had insufficient space for them in an article that included a number of related subjects. The original apparent discrepancies in the testimony evidence of Jonah Jim and Gideon Koro (Koro was one of the three Lake Pung boys) have now been reasonably explained by communication problems (details are soon to be published). The length of the ropen's tail is striking. Apparently, two separate ropens have been described (1994 and 2001, at and near Lake Pung) with tails of about three meters and seven meters in length. The ratio between wingspan and total length is, apparently, similar to Sordes Pilosus fossils. These eyewitnesses I found to be highly credible, with no hint of dishonesty and with no reasonable motive for deceit.

Woetzel and Guessman had prepared a detailed questionnaire before their expedition. The questionnaire itself and the data obtained with it are worthy of note. (My own interviews were open-ended, but there are positive and negative aspects to both interview approaches.) Afterwards, Mr. Guessman gave me copies of the filled-in forms of eight in-depth interviews that he had conducted. Of the four who chose from among the many silhouettes of birds, bats, and pterosaurs, only two were reliable. (The other two did not get a good view of the wings.) Of the two reliable eyewitnesses, however, both chose the silhouette of the Sordes Pilosus, a Rhamphorhynchoid pterosaur. This is significant.

I suspect that Mr. Woetzel and Mr. Guessman may have used separate interview sheets and that Guessman never received copies of Woetzel's filled-in forms, for by the time I received copies, there were eight, with no reliable silhouette choice of a Dimorphodon. Be that as it may, I agree with Mr. Woetzel regarding resemblances to pterosaur fossils: Why should we expect the ropen to greatly resemble one type of pterosaur fossil much more than any other? The creation model allows for much superficial variation, even if the ancestors of the ropen are represented by fossils.

To those of us who have been deeply involved in these investigations, the relevance to creationism is obvious. I believe that the universal-pterosaur-extinction axiom was constructed to support standard-model evolution philosophy. Some day, when these cryptozoological investigations evolve into detailed, direct research and the ropen graduates from cryptozoology to zoology (with residence in a zoo, we hope), the artificial credibility that universal extinction seemed to bestow on the general theory of evolution should evaporate. And how many "living fossils" can be discovered before the theory that requires massive extinctions (or major transformations) itself becomes extinct?

Although I am delighted in the article as a whole, I question the accuracy of the "composite drawing" (figure 10). Of all the eyewitnesses interviewed by me, Mr. Guessman, and Mr. Woetzel, I believe the one who had the best daylight sighting was Duane Hodgkinson, the World War II veteran. Over a period of eighteen months, I had many short interview sessions with him (by email, telephone, and survey forms sent by mail; Mr. Guessman had a long videotaped interview with him in person, and I reviewed this video as well). Hodgkinson made comments and corrections to the sketches Mr. Guessman and I gave to him. In the final sketch, the head was far smaller than Mr. Woetzel's sketch. In addition, the beak/mouth was sharper and the head appendage narrower and close to parallel to a longer neck. Also, the feet of the "pterodactyl" that Hodgkinson saw were tucked up to the body, not large and extended as shown in Figure 10 of the article. I suspect that Mr. Woetzel had no eyewitness feedback that could have improved his sketch.

But all sketches and interviews point to one thing: The old standard-model explanation for living "pterodactyls" in Papua New Guinea—the Flying Fox fruit bat—has been shot down. It is the ropen that glows at night, has a long tail, eats fish and/or clams, robs graves, and, seen up close, resembles a Rhamphorhynchoid pterosaur—not a fruit bat.

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Response to 'Another Perspective'

Let me express my appreciation for Jonathan Whitcomb's kind comments about the historical and biblical analysis in my article. I certainly did not mean to minimize the interviews and eyewitness portions. However, I am optimistic that a major breakthrough will soon make the interviews less significant. A good photograph or captured creature will hopefully be available to compare with the historical records.

Whitcomb writes, "I question the accuracy of the 'composite drawing' (figure 10)." The decision to pattern the composite after Dimorphodon was made for three reasons:

1. There were many brief interviews that we conducted along the trail, oftentimes without the time to do a detailed questionnaire with our prepared sheets or the video camera rolling. Villagers who looked at our picture book of various pterosaurs consistently picked out the Dimorphodon, but were quick to add that Ropen had a head crest and bumps down its back. In my article I wrote, "Indeed the natives to whom we showed color pterosaur pictures identified Dimorphodon as the closest fit to the Ropen."
2. Stories told to us emphasized the human-like face and bipedal locomotion of the Ropen. Those interviewed in the earlier trips by Carl Baugh also made a strong case for the human-like face of the cryptid. In fact, many of the older islanders proudly claim the Ropen as their forbearer. A squat face fits this characterization better than a slender head with a prominent beak.
3. Lastly, the carved Ropen statue played a role. Its shallow face and short, curved beak leaned me towards the Dimorphodon features.

The silhouette sheets our expedition used in interviewing were primarily a means of checking the native's credibility and distinguishing general morphology, like wing configuration. Guessman reminded me that actually there was more than one national that chose the Dimorphodon head from the color booklet over the various head shapes on the silhouette page because it was rounder and less elongated than most other pterosaurs.

Nonetheless, there is nothing like getting a good close-up photo of the Ropen to trump all these speculations! My prayer is that we can soon accomplish that so that this wondrous creature can be used to lift up the name of our great Creator.

Dave Woetzel
Bow, NH

* * *

Quartz Gravels in the Carolinas

In the article concerning sand-to-pebble sillciclastic sediments on the Florida peninsula (*CRSQ* March, 2006, p. 229), rounded gravels are described that are very similar to quartz gravels that I have found in piedmont soils in North and South Carolina. The gravels are sometimes somewhat evenly distributed throughout the soil, or they may be limited to the topsoil horizons. In some locations they occur in distinct beds, ranging from a few inches to a few feet in thickness, at the base of the soil, lying unconformably above weathered igneous or metamorphic bedrock. Unlike the Florida gravels, those in North Carolina piedmont soils usually include angular fragments, which tend to be apparently vein quartz. The rounded quartzite gravels tend to be less rounded the further west they are found.

However, I would suggest that there may be a different source for these gravels (and possibly the Florida gravels as well) than quartz veins in basement rocks of the Appalachian Mountains. In north central North Carolina, east of the Appalachian escarpment (north of Winston-Salem), there is a 200-foot-thick layer of quartzite that sits exposed on top of two monadnocks about 1,400 feet above the surrounding land surface. One is Pilot Mountain, and the other is Hanging Rock.

Since there are erosional remnants capped by a rock layer of unknown horizontal extent, the quartzite may have originally covered much of the southeastern US and provided gravels found in many areas. It may be that, as the Flood waters receded from the continent, the force of the cascade, which would have dwarfed Niagara Falls, would have broken up the quartzite as the escarpment moved to the west, ultimately pounding the rock into gravel-to-sand-sized fragments that would have been more rounded the further east (or southeast) they were transported before deposition.

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Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York.

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Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* has been gradually enlarged and improved and now is recognized as the outstanding publication in the field. In 1996 the *CRSQ* was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

Activities—The Society is a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the Biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. All members of the Society subscribe to the following statement of belief:

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.
3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.