

HOW DO WE KNOW WHAT IS

TRUE

The search for truth goes all the way back to Adam and Eve, who sought to understand the world that God had prepared for them. They may not have used the word *epistemology*, but they learned some painful lessons about potential pitfalls in the search for truth. For scholars and teachers, the issue of epistemology, of how human beings acquire and evaluate knowledge, and how to determine what is true, is a vital topic. Intuitively, it seems straightforward—we carefully find the facts, and then we know what is true. Unfortunately, in many scholarly pursuits, it isn't that simple. How can human beings determine what is trustworthy knowledge? The following is an approach that I as a scientist find reliable and productive.

BY LEONARD R. BRAND

Evaluating Purported Knowledge

There are several important steps or processes to use in determining what ideas one can trust as truth. I will illustrate these steps using simple examples from my area of study, paleontology and biology, but the principles will apply to any discipline. I will discuss how data, interpretations, hypotheses, and worldview are involved in the development of ideas, and how to evaluate them.

When I read a discussion about how different types of animals came to exist, and see statements claiming that (1) fish evolved from relatives of starfish; after which (2) some fish evolved into amphibians; then (3) amphibians evolved into reptiles; and (4) from them came birds and mammals, what am I to think? How reliable are these conclusions (theories)? The first task in evaluating this claim is to determine what is fact and what is interpretation or explanation (I will use the terms *fact* and *data* as synonymous).

Conclusions in science always combine *data* (specific observations, measurements) and *interpretation* of the data—that is, possible explanations of the facts. Let's analyze this story about origins. Fact: Among invertebrate groups, there are two basic types of symmetry in how their early stages (larvae) develop. Larvae of starfish and their relatives (echinoderms) have the same type of symmetry (bilateral) as fish and other vertebrates. These are observations, or *data*. Now, what do these data tell us? This takes us into the arena of *interpretation*. The data collected tell us that the symmetry in vertebrates is the same type as in starfish larvae, but different from the symmetry of other invertebrates. Most scientists have concluded that these data tell us vertebrates evolved from relatives of starfish. If a common ancestor had that type of symmetry, that would explain why it appears in both fish and starfish larvae—they inherited it from their common ancestor. That may seem to be the end of the investigation, but it isn't, because we need to ask another question—are there other ways to explain how they could acquire the same symmetry? Did the symmetry evolve from a common ancestor, or did God create

them that way? Since there is more than one possible way to interpret the data, any one explanation of how they came to have that type of symmetry is an interpretation, a hypothesis, not a scientific fact.

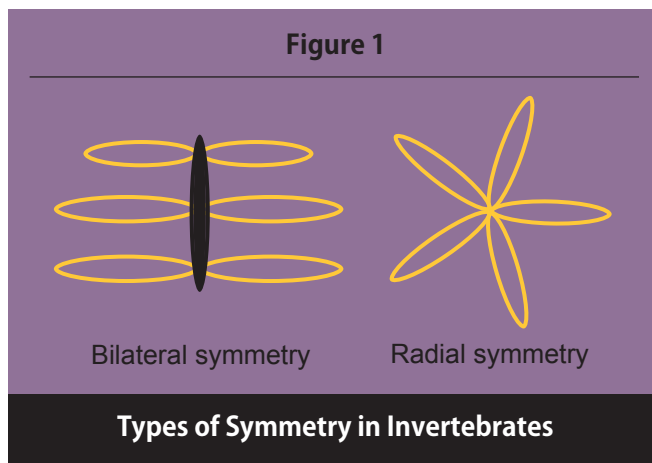
We could continue with many more questions and hypotheses, but the point is simply to emphasize the difference between facts (or data) and interpretations. Conclusions in science and other disciplines generally begin with data, but they always include interpretations as well. Data almost never suggest directly how to interpret them. Scientists have to think of ways the facts could be explained, and devise hypotheses to explain them.

Hypotheses are interesting to explore and discuss, but what people really would like to know is this: Which hypothesis is

true? How can we decide that? This is done by gathering more data, by doing experiments, or by making observations to test the hypotheses. In some cases, scientific experiments can accomplish this with considerable certainty. For example, if I want to know what will happen to a book when I drop it, I can do simple experiments—drop the book many times and record whether it falls up or down. It doesn't take long to discover that it always falls downward. This process in-

volves basic laws of physics that are reliable and can be tested repeatedly.

Can we follow the same procedure, and determine with the same confidence, why vertebrates and starfish larvae have the same type of symmetry? We could conduct many observations and experiments on fish and starfish, and learn all about their larvae, embryos, and behavior. However, we can't make the one observation that we really need because we were not there to observe the first starfish or the first fish, to see where starfish and fish came from. Consequently, our hypotheses about the origin of fish and starfish will remain interpretations, not facts. Similarly, many other ideas in geology, paleontology, and evolutionary biology will always be only hypotheses because we cannot go back in time to see what actually happened. More observations may reduce the number of viable hypotheses, but we still were not there, so critical data remain beyond our reach.



In science, the level of certainty achieved in the study of history of the Earth and of life can never approach that of the study of gravity or physiological processes occurring today that can be experimentally and repeatedly analyzed.

Since that is true, why do so many scientists speak with such assurance about the origin of rock layers, fossils, and evolution? Has research in recent decades produced new evidence that clinches the case for evolution of all life over eons of geological time? Our purpose here is not to answer questions about evolution,¹ but to understand the epistemology or process used to evaluate data. How do scientists who write about evolution achieve such a high level of certainty?

Worldviews

This question can only be answered if we consider worldviews and how they influence the search for truth.² A worldview is a set of assumptions that influences how people interpret the world and how they answer the important questions of life, such as where did we come from, how should we live, and where are we going? Everyone has a worldview, and how people interpret evidence and data is influenced by that worldview. A person's worldview influences whether he or she is optimistic or pessimistic. A friend of mine used to say the difference between an optimist and a pessimist is that the pessimist has better information!

More importantly, at least some of the assumptions behind any worldview must be taken on faith, and they can influence just about everything. One worldview is based on the assumption that God is real, He has communicated with us in the Bible, and His communication can be trusted to give us truth. Another worldview assumes there have never been any supernatural, miraculous events in the history of the universe, and everything must be explained by known or discernable natural laws.

This oversimplifies somewhat the role of assumptions and faith. There is evidence for the Christian worldview; it is not based on blind faith. And yet we cannot prove it. There is always a definite element of faith. Scientists and others who embrace the naturalistic worldview marshal a lot of evidence to support their view. But how do they know there has never been any supernatural intervention? That is an assumption, based on faith, and faith alone. Each worldview uses evidence, or *data*, but the *interpretations* of that data (the explanations) always depend on one or more significant *assumptions*.

How Are Worldviews Used to Create Interpretations?

Why are so many scientists convinced that the evolution of all life is a fact? What sort of intellectual processes produce such unanimity of thought on this issue? Scientists present massive amounts of evidence to prove evolution. But to understand that

evidence, we must return to our discussion of data and interpretation, and how they relate to worldviews.

The interpretation of animal symmetry illustrates the influence of a worldview. If I am at least willing to consider that there could be a Creator, I can ask: "Does the similarity in symmetry between starfish larvae and fish mean they evolved from a common ancestor, or did God create each group that way?" If I embrace a naturalistic worldview, I cannot even consider asking that question because my worldview by definition absolutely rejects the possibility of a Creator. It doesn't rule out this idea because of data. The assumptions of the naturalistic worldview preclude consideration of any type of intelligent creator. To actively ponder whether starfish and fish were created would require a change of worldview.

Scientists do not choose evolution as the only scientifically correct explanation because of overwhelming evidence. Rather,

Two Examples of Worldviews

Christianity; the Great Controversy Between Christ and Satan

Assumption: God is real and is the Creator of the universe and life.

Resulting worldview: God created a perfect, sinless world. Humanity fell, and redemption came through Jesus' death on the cross.

Future—restoration to sinless perfection at Christ's second coming.

Naturalism

Assumption: The universe and life arose through natural law; there has never been any intelligent, supernatural intervention in the universe.

Resulting worldview: All plants and animals evolved from a common ancestor. Pain, suffering, death, and natural evil are normal, inevitable processes.

Future—annihilation, extinction.

the choice is heavily influenced by worldview—in a naturalistic worldview, the origin of all biological features must always be explained by evolution, no matter what the evidence. Don't misunderstand that statement. A huge and growing amount of data is being marshaled to support the evolution of all life forms from a common ancestor. This can indeed look overwhelming. However, the evidence and associated conclusions are almost never discussed in a way that openly examines the relationship between data and interpretation, or how assumptions and worldviews affect the conclusions. It takes careful examination of the logic involved to recognize how certain ideas depend on a naturalistic worldview.

Evaluating Truth Claims

So how do we evaluate truth claims? I recommend using the steps discussed in this article. Study the assertions to separate *data* from *interpretation*. Then seek to understand the *assumptions* on which the interpretations depend. These steps are often difficult but are essential in order to evaluate the reliability of the conclusions. When reading a book or article, it is often necessary to know the worldview of the author in order to fully

understand what the material is saying.

For example, a recent book states that “all of us—you, me, the elephant, and the potted cactus—share some fundamental traits. Among these are the biochemical pathways that we use to produce energy, our standard four-letter DNA code, and how that code is read and translated into proteins. This tells us that every species goes back to a single common ancestor.” What is the author saying? The title of the book is *Why Evolution Is True*,³ written by a person who is committed to the naturalistic worldview. His view of science is not postmodern; by “true,” he means it is a fact, just like the fact that gravity will pull a dropped book downward, not upward. The author’s *data* are: All organisms have the same basic biochemistry in their cells, including the same DNA code. His *interpretation* is: All creatures acquired that biochemistry by evolution from a common ancestor. The data don’t naturally lead to that conclusion; the conclusion requires the *assumption* that the origin of all creatures come through evolution, not by creation. Later in the book, he writes: “The most commonly suggested alternative takes us into the realm of the supernatural.” He rejects this alternative because *his worldview does not allow it*. If we understand how all of these elements—*data, interpretation, assumption, and worldview*—are involved in his thinking process, we can understand what he is really saying and why. Then we can evaluate the strength of his argument, and whether we wish to follow him to the same conclusion. In a theistic worldview, it is perfectly logical (and not contradictory to valid scientific evidence) to conclude that an intelligent Designer invented biochemistry and used it to make you, me, the elephant, and the potted plant. The difference between these conclusions of the theist and the evolutionist is not in the *data*; the difference is in the *worldview*.

In some cases, it can be complicated to assess the argument because a person needs advanced knowledge of the topic to make such an analysis. However, the process of understanding the relationship between data and worldview is the same. Some arguments can sound very convincing until one expends considerable mental effort, combined with in-depth knowledge of the topic, to analyze them carefully.⁴ As a result, the author’s conclusion may fall apart if his or her worldview and assumptions are not true.

In the previously mentioned book, the author argues that some complex parts of organisms, like the flagellum, a complicated structure for locomotion of bacteria, evolved by combining (“co-opting”) proteins from other, simpler structures. This purports to explain why it wouldn’t be too difficult to evolve a complex flagellum.⁵ Co-opting is a common evolutionary argument for various biological structures or systems. Theists ask, How do we know that proteins were co-opted to help make a flagellum? What are the data to demonstrate this process? This is how scientists who rule out the supernatural reach this conclusion: There are similar proteins in flagella and in some other structures (*data*). Their evolutionary worldview requires that flagella evolved, rather than being created (*assumption, worldview*). So a naturalistic explanation for the evolution of flagella is needed. Part of the explanation includes the idea that proteins were co-opted (*interpretation*).

This is just a hypothesis, a story suggesting one way for the

process to occur. There is no hard evidence that such a complicated co-option process actually occurred, but the theory requires something like this; and consequently, the idea has become widely accepted. It is simply an untested hypothesis, but is often described as if it were a fact. The logic was—*commitment to a worldview generates a problem; since data are lacking, an unsupported hypothesis suggests a solution to the problem*.

Creationists also look for hypotheses to explain some puzzles that they lack adequate evidence to solve. The point is that it is important to recognize the relationship between worldviews, assumptions, and interpretations, and to investigate the process used to analyze the relationships between the elements.

There are actually many serious lines of evidence with which secular, evolutionary science has great trouble.⁶ You will not normally read about those areas in publications written by scientists who reject biblical creation. That isn’t because they are consciously trying to hide something. However, if a well-entrenched scientific theory claims something cannot exist, it will be difficult for many to see it, even if it does, or could, exist.

Every area of study, be it science or theology, involves evidence and assumptions, and all produce questions that are difficult to answer. We will be in a much better position to understand how to seek truth if we are aware of how data, interpretations, and worldviews influence us and others.

Worldviews and the Search for Confidence

A reader may challenge the previous statement by saying that I am making too strong a statement about interpretations being dependent on worldview. However, a scientist who accepts naturalism would likely respond, “No, you are the one who doesn’t understand. Science cannot accept miracles. An evolutionary explanation is the only valid intellectual one if you want to be a scientist.” I have heard and read this strong sentiment many times from scientists in my discipline.⁷ The primary origin of the confidence that evolution can explain everything in biological origins arises from this commitment to a secular, naturalistic worldview. It will only allow an evolutionary explanation. But if one cannot, by definition, consider any other possible explanations for the evidence, can this still be an objective search for truth?

To look at both sides of this argument, we can ask if a Christian worldview can also close minds, preventing an open, objective examination of alternative ideas. Yes, it can. I know Christians who don’t believe dinosaurs ever existed, and they think their view is based on the Bible. But what are the data to support that interpretation? Either of these worldviews can limit the possible explanations that will be considered.

Then how can we resolve this dilemma? In reality, I don’t find it to be a dilemma at all. I am an unembarrassed believer in a trustworthy Bible, with its description of a literal, recent creation week, global flood catastrophe, and Jesus as our Redeemer. I am also active as a publishing research paleontologist. I will not give up my biblical worldview, but to be effective in science, I must know and understand what my naturalist colleagues believe and publish. In other words, while a worldview can limit one’s ability to evaluate all the options, we don’t have to let it do that. Since I hold a minority worldview, I am con-

tinuously pondering the options for interpreting the data, and for resolving the seeming contradictions that creationists face in explaining some geological data in a short Earth history. At times, I ask myself how the few of us could be right and the majority could be wrong in their conclusions.

However, one observation in particular helps me know how to relate to this. Most anti-creationist lectures and books reveal that the authors and speakers are totally unaware of how scientifically educated creationists think. They seem to have no interest in seeking to understand the thinking of persons who hold a creationist worldview, or to comprehend the basic questions that divide the two groups. Unfortunately, some creationists are like that, also. However, I know a number of creationists whose confidence in Scripture makes them unafraid to study the contrasting opinions and worldviews, and seek out the most challenging questions to answer. My faith does not de-

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pend on resolving in this lifetime the difficult questions raised by science, but it is fascinating to look for answers, and my confidence in God's Word leads me to predict that we will eventually find the answers. We don't need to be afraid of following the evidence wherever it may lead.

Most advocates of the naturalistic worldview, on the other hand, have little incentive to seek a deep understanding of the Christian worldview, to know why creationists think differently from scientists who reject the supernatural. Although the evidence also raises many questions that are unanswered in a naturalistic worldview, those who accept that philosophy are generally unaware that those questions exist.

The real issue is not whether a particular worldview can narrow a person's perspective. All worldviews can do that. The issue is whether people cling to their worldviews due to habit, or because they understand what they believe and why. How strong is their understanding of the important questions and issues that separate creationist and evolutionary worldviews? Do students (and teachers) know the God behind the Christian perspective? Or do they hold that view because their parents transmitted it to them?

I teach a class on philosophy of science and origins to graduate-level biology and geology students at Loma Linda University in Loma Linda, California. In this class, I assign the best anti-creation books I can find—that is, the ones that raise the

most difficult questions and challenges. I also have my students read the book that I think best presents a biblically faithful creationist perspective. We discuss the issues presented in these books, seeking to understand the strengths and difficulties of each viewpoint, from both a scientific and a theological perspective. My students know what I believe, and I hope they will develop the same confidence in Scripture that I have. But I don't want them to believe something just because I say it. My goal is for them to know why they believe what they do, to become "thinkers, and not mere reflectors of other men's thoughts,"⁸ who are well prepared to deal constructively with the issues they will face in the future, when they may not have a mentor available to encourage them.

Current Trends Among Christians

In this article, I have described two worldviews, one based on the belief that the Bible gives trustworthy facts, even about Earth history, and one that rejects any supernatural intervention in history.

An increasingly popular trend in Christendom is the mixing of Christianity with the theory that all life has evolved. In order to blend these philosophies, some things in each worldview have to be given up. The result is theistic evolution or evolutionary creation.⁹ According to this worldview, God created life forms through the process of evolution over millions of years.

In its attempt to meld scientific research and biblical statements about the creation of the world, theistic evolution actually establishes a dichotomy between science and religion by relegating each to a separate sphere. While theistic evolutionists believe that religion can provide spiritual guidance, they hold that only through science can human beings produce reliable explanations of the natural world. That is, religion gives subjective, prejudiced views, while a secular approach provides theories and explanations that are unbiased and neutral, unaffected by religious assumptions. In other words, secular science has *facts* while religion has *assumptions*. This has led to a two-level understanding of "truth":

Religion—personal, subjective values, emotions (heart)
Science—public, objective, reliable facts (mind)

But there is no such thing as a neutral search for truth. Both secular science and religious views are based on a worldview, a set of assumptions that influences everything. A Christian worldview regards the Bible as a trustworthy basis for an integrated view of the world, a "biblically informed perspective on all reality"¹⁰ that does not divorce religion from the rest of experience and knowledge. In contrast, a naturalistic worldview requires that separation.

Secularism introduces its own biases into the search for understanding, and is no more neutral than religion. A worldview

based on either philosophy can provide a foundation for the search for truth, but they will lead in very different directions. The traditional Christian worldview starts with a belief in the truth of the central events of biblical history: Creation, Fall, Redemption, and Restoration (the Great Controversy between Christ and Satan). Commitment to this set of truths forms the foundation for an integration of all knowledge, not just religious knowledge.

In reality, theistic evolution has essentially abandoned any attempt to make this integration. It interjects a few “religious” concepts into a secular view of the universe. This worldview accepts as fact the interpretation that all life resulted from evolution. But does the evidence warrant this? Have the advocates of theistic evolution carefully considered which Christian concepts must be rejected in order to accept their worldview? Do they recognize that the evolutionary theory they accept as fact is based on the *assumption* that, throughout history, no supernatural intervention could ever have occurred? Is it good epistemology to try to blend two worldviews based on directly contradictory assumptions and incompatible epistemological principles?

Advocates of theistic evolution or evolutionary creation who candidly address the topic recognize that their worldview leads to a god who created by the process of mutation, death, and survival of the fittest through ages of pain and suffering. This “creation” process requires death and natural evil (hurricanes, volcanoes, floods, earthquakes). Their deity must not interfere with all these destructive processes, so that the creation will not be unduly forced, but will be “free.”¹¹ Is such a god worthy of our worship? Is this evil-ridden world really free, or merely dysfunctional?

Wisdom

I recommend one more step in the search for truth, as described by King Solomon: “The fear of the Lord is the beginning of wisdom, and knowledge of the Holy One is understanding” (Proverbs 9:10, NIV).¹² Knowledge is important, especially when it is combined with wisdom. God and His Word are the ultimate source of wisdom, no matter what area we teach. In many fields of scholarly study, the Bible doesn’t provide a lot of specific information. It does give the most important basic concepts, and it is a reliable source of wisdom.

Solomon does not write only about the wisdom of salvation. He develops the theme of wisdom throughout the first nine chapters of Proverbs, applying it to morals and ethics in real-life situations. As a paleontologist, I especially noted that it even brings in the subject of origins: “By wisdom the Lord laid the earth’s foundations, by understanding he set the heavens in

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place; by his knowledge the deeps were divided, and the clouds let drip the dew” (Proverbs 3:19, 20). Although Solomon is using poetic language, he clearly regards God as the Earth’s designer and creator.

How should we decide which epistemology to use, which worldview to adopt? There is much evidence to consider, but above all is the need for wisdom. When God responded to Job, He didn’t provide answers to the difficult questions. Instead, He challenged Job—and us—to remember how little human beings know in comparison to the God who created all and is Master and Redeemer of all. Were we here when the Earth was created? Where were we when the rocks and fossils were formed?

In the end, we should choose a worldview to evaluate purported knowledge on the basis of wis-

dom. “Wisdom is supreme; therefore get wisdom. Though it cost you all you have, get understanding. Esteem her, and she will exult you; embrace her, and she will honor you” (Proverbs 4:7, 8).

Solomon revealed elsewhere in Proverbs where wisdom comes from—“the fear of the Lord.” Do we know the divine mind and supreme being behind the Bible? Does our relationship with Jesus give us assurance that we can have confidence in His communication to us? These may seem like rather subjective questions, not relevant to a scholarly discussion of epistemology. However, I believe they are the most important questions. What is the primary difference between the worldviews we have discussed? The difference is in the nature of God and how He interfaces with us and with nature. How could we, with our human limitations, know what God is like unless He tells us? Does God obey the humanly invented rule that He cannot involve Himself in the physical processes in the universe? Only a deep personal knowledge of God can give us the wisdom to make a truly informed choice of what standard we will use to recognize true and trustworthy knowledge—the Word of God or contemporary scientific interpretations. If the Bible is what it claims to be, it is not just a book, but the revelation and reflection of the divine Being behind the Bible. This will give us confidence in choosing a worldview.

Biblically Motivated Scientific Discovery

This article has discussed some factors that must be considered in seeking and evaluating knowledge. Is there a way that a biblically based worldview can directly make scholarly contributions? Many critics of the Bible claim this is not possible. By contrast, I predict that if the Bible presents a true history of the Earth and of biological origins, scientists who are informed by Bible history gain an advantage in generating successful scien-

tific hypotheses. That will sound preposterous to many, but some of us have been doing just that for many years, and publishing the results in highly esteemed, peer-reviewed scientific journals.¹³ Other scholars use their worldview to suggest research ideas, so a theist can do likewise!

I do not go to a scientific conference and state that I think a certain scientific theory is true because the Bible says so. However, the Bible presents the basic elements of a worldview that includes a literal creation, global flood, and short time for life on Earth. That framework has implications for processes in both geology and paleontology. Based on these implications, we can propose hypotheses that can be tested with the same research protocols that any earth scientist uses.

Several factors are needed to implement such a research process. First of all, it requires independent thought, recognizing that some accepted scientific concepts must be wrong, if my biblical worldview is right. Second, it requires solid knowledge of the scientific literature on the topic and high-quality research. Third, it is essential to remember that the Bible doesn't give many details, and we may have to reject several hypotheses before finding one that not only fits the Bible but also explains the evidence. There is a danger, illustrated in the work of some believers, of thinking that because they believe the Bible, any scientific idea they come up with must be correct.

Among the significant research done by creationist scientists is the study of the Coconino Sandstone trackways conducted by the author of this article, who says that his worldview suggested a viable hypothesis relating to Noah's flood to explain a phenomenon that other scientists had thought showed a desert origin for the tracks. At the right, a normal trackway, going upward in the photo, and a trackway of an animal moving sideways with all toes pointing upward, at right angles to the direction of the animal's movement.



In researching possible explanations for the Coconino trackways, a salamander was placed underwater at the laboratory. As it attempted to walk upward, it drifted sideways due to the water current. This seems to be the only way to explain why in the fossil trackways, the animals' feet are pointing at right angles to their direction of movement.

A number of research projects have been done by creationists, based on a biblical worldview, and published in peer-reviewed scientific research journals. I will briefly describe just one example. The Coconino Sandstone in northern Arizona is generally believed to be an accumulation of desert sand dunes, cemented into sandstone. The only fossils are trackways of animals on the dune surfaces. These trackways are commonly cited as evidence of a desert origin of the sand deposit. I wondered if the Coconino Sandstone could be windblown sand, if it formed during the global flood. Of course, the Flood was complex, and we can't be sure there weren't some episodes of high winds during that event. However, it is worth suggesting the hypothesis (resulting from my *worldview*) that the trackways were made under water. Research over a number of years (*data* and *interpretations*) has resulted in papers presented at national geology meetings and publications in quality earth science journals.¹⁴ There are features, not recognized by other researchers, that seem impossible to explain unless the trackways were made completely under water.

My worldview opened my eyes to see things not noticed by others. The evidence was there all the time, but worldview influences what questions are asked, and what researchers notice. A naturalistic worldview does not rule out the possibility of underwater tracks, but it also did not suggest such a hypothesis. My biblical viewpoint provided an advantage in research. This has happened in many cases, for me and for other researchers. There is a vast potential for this type of Bible-inspired advance in a variety of disciplines.

Conclusion

To understand how human beings acquire and evaluate knowledge, and how to determine what is true involves consideration of the relationships between data, interpretations, assumptions, and worldviews. All of these contribute to the scholarly search for truth, and none can be safely ignored. A very important element of wisdom is to begin with the "fear of the Lord." There will always be challenges in our search for truth, but if we put a biblical worldview to practical use in suggesting concepts for study and research, this may even help to advance the scholarly understanding of our disciplines. ☞

This article has been peer reviewed.



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12. All Bible texts in this article are quoted from the New International Version. Scripture texts credited to NIV are from the *Holy Bible, New International Version*, copyright © 1973, 1978, International Bible Society. Used by permission of Zondervan Bible Publishers.
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14. L. R. Brand, "Variations in Salamander Trackways Resulting From Substrate Differences," *Journal of Paleontology* 70 (1996):1004-1010; _____, Reply to Comments on "Fossil Vertebrate Footprints in the Coconino Sandstone (Permian) of Northern Arizona: Evidence for Underwater Origin," *Geology* 20 (1992):668-670; _____ and T. Tang, "Fossil Vertebrate Footprints in the Coconino Sandstone [Permian] of Northern Arizona: Evidence for Underwater Origin," *Geology* 19 (1991):1201-1204; _____, "Field and Laboratory Studies on the Coconino Sandstone (Permian) Fossil Vertebrate Footprints and Their Paleocological Implications," reprinted in *Terrestrial Trace Fossils*, W. A. S. Sarjeant, ed., *Benchmark Papers in Geology* 76 (1983):126-139; _____, "Field and Laboratory Studies on the Coconino Sandstone (Permian) Fossil Vertebrate Footprints and Their Paleocological Implications," *Palaeogeography, Palaeoclimatology, Palaeoecology* 28 (1979):25-38.