

An NSTA Q&A on the Teaching of Evolution

Editor's Note—NSTA thanks Dr. Gerald Skoog for his help in developing the following question-and-answer (Q&A) document. Skoog is a retired Paul Whitfield Horn Professor and dean of the College of Education at Texas Tech University and a former NSTA President. His research and published work on the teaching of evolution has made him a well-known authority on this topic.

The teaching of evolution in the science classroom is dominating the conversation in states and school districts around the country. Though the theory of evolution is supported by a robust body of science knowledge and has universal support from the scientific community, the public is receiving conflicting messages about what is and isn't science. Even more disturbing is that evolution is being wrongly positioned as in direct conflict with religious beliefs.

The scientific and education communities have increased efforts to help the public better understand the nature of science, evolution's role as a unifying concept of biology, and the comprehensive and varied scientific evidence for the theory of evolution. They also want to communicate that learning about the natural world does not and should not conflict with religious beliefs. Above all, science teaching seeks to educate students about "the most powerful mechanism we have for obtaining confirmable information about the natural world" (John Moore, quoted in Bybee 2004).

By staying within these boundaries, science does not and will not enter the realm of religion and will never force students to make unnecessary choices about their beliefs. "Scientific knowledge cannot contradict religious beliefs because science has nothing to say for or against religious realities or religious values" (Francisco Ayala, quoted in Bybee 2004).

The following Q&A piece appears on NSTA's website at www.nsta.org/evresources. We hope it helps to dispel major misconceptions related to this ongoing and divisive issue. We invite you to share this information with parents and students who also have questions about the teaching of evolution.

Q: Why is the teaching of evolution such a controversial subject in the United States?

A: In short, some Americans believe strongly and passionately that evolution is an assault on or in direct conflict with their religious beliefs. In response, anti-evolution groups are attempting to position evolutionary theory as flawed because of so-called questionable or missing evidence.

Q: What do anti-evolution groups want?

A: The answer is complicated because many groups hold different beliefs about the history and nature of life on Earth. These groups are demanding that various nonscientific ideas be included in the science classroom. Groups on one end of the spectrum seek to replace or "balance" the teaching of evolution with a literal biblical interpretation of creation, which is that God created the Earth and all the living things in it and all appear the same today as they did then. To sidestep the overtly religious argument, other groups are calling for teaching the so-called "weaknesses" of evolution. Still others believe that a myriad of ideas—scientifically supported or not—should be taught out of "fairness."

Q: Why have challenges to the teaching of evolution increased so dramatically in recent years?

A: Throughout the 20th century, special-interest groups have worked to prohibit, deemphasize, or neutralize the teaching of evolution in the nation's public schools. Recently, cultural, religious, judicial, legal, and other factors have shaped the nature, intensity, and success of these efforts and challenges. The generally strong presence of biological evolution in the national and state science standards and science textbooks has catalyzed the actions of special-interest groups who currently have considerable political influence and question the legitimacy of biological evolution and its place in the science curriculum and public thought.

Q: What is NSTA's position on the teaching of evolution?

A: NSTA strongly supports the premise that evolution is a major unifying concept in science and should be included in the K–12 education frameworks and curricula. This position is consistent with that of the National Academies, the

American Association for the Advancement of Science, and many other scientific and educational organizations. For a copy of NSTA's position statement on evolution, visit www.nsta.org/position.

Q: In general, how should I address questions from students and parents about alternative theories of biological evolution?

A: It is important to first acknowledge that different viewpoints and ideas exist regarding the history and nature of life on Earth. In the discussion that may ensue, you should define the word *theory* as it is used in the scientific community. In particular, you should note that a theory is a well-substantiated explanation that incorporates facts, laws, inferences, and tested hypotheses, and theories can be tested, modified, and rejected. Theories are valuable because of their explanatory power and their usefulness in making and testing predictions. The alternative "theories" that typically serve as the springboard for student and parental questions tend not to be scientific theories because they cannot be tested, they lack explanatory power, and they do not provide the basis for additional research. That is why these alternative "theories" are being omitted from the curriculum, not because of censorship or unfairness.

Q: How do I respond when parents say it's only fair that we present all theories and let students make up their own minds?

A: Most people strive to be fair with one another. This probably explains why a 2004 CBS poll found that 65% of the adults responding favored teaching both evolution and creationism in science classes. But being "fair" indicates that the items being given equal time are equivalent or comparable. There is no comparing science and religion because they explain different realms. Students bring many and varied beliefs into the classroom that are neither theories nor testable, and science does not emphasize questions that cannot be tested.

In the 1970s, for example, a few individuals sought to have educators give the satanic view of the origins equal time with the teaching of evolution. Based on fairness and inclusiveness, they asked, why not? The bottom line is that fairness and inclusiveness are not good criteria to use in deciding the content of a science curriculum.

Above all, content and concepts must be included in the science curriculum based on their value in explaining the natural world. Nonscientific viewpoints can provide insight into past and present thinking, but they have little value in increasing students' knowledge of the natural world. Finally, it is not the role of schools or teachers to force students to choose between science and religion, or evolution and religion.

Q: How do I respond to the "evolution is just a theory" argument?

A: A theory is a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses, while a fact is an observation that has been repeatedly confirmed (National Academy of Sciences 1998). Thus, a scientific theory is not just a hunch or guess. Scientific theories continue to change as new observations and discoveries are made. Based on research, testing, and observation, the theory of evolution is the best scientific explanation we have for how life on Earth has changed and continues to change.

Q: How should I approach the topic of evolution to alleviate students' concerns or questions about it?

A: You may not be able to alleviate student concerns about how biological evolution fits into their mental models concerning the history and nature of life on Earth. It is important to acknowledge the existence of these concerns. Some state and school district policies permit alternative assignments or some other mechanism that allow students to avoid studying topics they consider offensive. Teachers should inform students and parents of such policies where they exist. Teachers should also indicate that their responsibility is to plan and provide instruction that reflects the current knowledge and thought existing within the scientific community. At this time, evolution is the best and most complete scientific explanation we have for how life on Earth has changed and continues to change. As a result, teachers should strive to provide students with multiple opportunities to learn about current scientific thinking regarding biological evolution and the history of life on Earth. Because effective science instruction is characterized by inquiry and student questions, students' questions about biological evolution should be encouraged.

Q: Some say that evolution cannot be proven because we were not there to see it happen. How do I respond?

A: Science allows us to study past events and life even though we were not present to observe them. We know, for example, that ancient cultures existed because we can study artifacts that have been left behind, and we know where bodies of water used to exist based on the information we find in the layers of soil and rock, as is currently being done by unstaffed vehicles on Mars. In addition, scientists are using cosmic microwaves to develop an understanding of the beginning seconds of the universe's existence. Scientists use the data from these microwaves to develop basic parameters that characterize the universe, including its age, geometry, composition, and weight.

As these examples show, data derived by different means are used as evidence to support scientific theories. It is also important to recognize that scientific theories and laws are subject to change as a result of new evidence. Thus, the goal of science is not to prove, but to explain.

Q: Why not appease the anti-evolution folks and teach the “controversy” or the so-called “strengths and weaknesses” of evolution, which will clearly demonstrate why evolution is the most complete explanation about how life on Earth has changed and continues to change?

A: This strategy was conceptualized by the leaders of the Discovery Institute’s Center for Science and Culture as a ploy to avoid the theological implications of intelligent design and require teachers to discuss the evidence that supports and that which refutes the theory of evolution (Shaw 2005). This may be an attractive solution for those who wish to avoid confrontation with certain special interest groups. First, there might be a “political” controversy about evolution, but there is none within the scientific community. Evolution is supported by a robust body of scientific evidence and has universal support from scientists and reputable science organizations, including the National Academies and the American Association for the Advancement of Science. No evidence exists that refutes evolution, and the weaknesses often identified by proponents of “teach the controversy” tend to be “straw men” that can be easily blown away, earlier conclusions that eventually were rejected by scientists, misinterpretations of data, and unanswered questions that do not threaten the integrity of existing conclusions regarding biological evolution.

The “strengths and weaknesses” argument has gained momentum because it appears to be a “fair” solution. Evidence shows, however, that it is a tactic designed to protect certain religious tenets. To justify the inclusion of the “teach the controversy” approach in the Kansas Science Standards, for example, it was argued that the purpose was “not to insert the supernatural, but rather to replace a bias against any scientific explanation or criticism that might favor one class of religious beliefs,” which would result in “nothing more than scientific objectivity that should be religiously neutral” (Kansas State Department of Education website). Overall, there is no evidence that this strategy has been designed to improve science education and student understanding about the history and nature of the natural world. But the strategy undoubtedly provides an opening for the tenets of intelligent design to be inserted in the curriculum.

Q: Why do some say that gaps exist in the fossil record, which indicates a weakness in the theory of evolution?

A: It is important to recognize that fossils are only one source of evidence of the occurrence and history of evolution. Despite the consistency in the fossil record, it does appear that some species appear abruptly.

Gould (*The Structure of Evolutionary Theory* 2002) noted different proposals for explaining the abrupt appearance of some species and the resulting apparent gaps in the fossil record. One explanation is that the fossil record is imperfect. Soft-shelled organisms, for example, which make up the majority of marine fauna, are not likely to be fossilized. Even organisms with hard bodies are unlikely to be fossilized normally. Many ancient species or lineages are represented by only a few specimens or fragments.

Even when conditions favor the fossilization of an organism, a later event, such as erosion or metamorphism of sedimentary rocks, may destroy the fossil. When evolution is viewed as a continuous linear process that results in a “ladder of life,” gaps in the fossil record appear. But the fossil record can be seen and represented as a branching bush with numerous short branches, many of which are evolutionary dead ends. Thus, a linear succession of organisms does not develop or exist as speciation events branch out.

Scientists readily admit that the fossil record cannot adequately explain or document the complete history of life on Earth. However, when combined with biochemical, genetic, and structural evidence, the fossil record provides convincing evidence that life has evolved through time.

Q: Evolution conflicts with my religion, which says God created the world as it appears today. Therefore, I cannot “believe” in evolution.

A: Many kinds of questions can be asked. “Does God exist?” is a question of faith, while “What’s the best movie currently showing?” is a question of opinion. “Should federal funds be used to support stem-cell research?” is a question of debate. “How are the genomes of the wolf and the dog similar?” is an empirical question. Empirical questions like this one are settled primarily by using the theory of evolution. “Has biological evolution occurred?” is an empirical question that has been answered within the scientific community through the accumulation of evidence over an extended period of time. “Has biological evolution occurred?” is not a question of faith in which one’s beliefs are the focus.

The relationship between science and religion, or between evolution and religion, has varied historically and has been characterized at one time or another by conflict, independence, dialogue, and integration. Currently, many religious leaders acknowledge that evolution is a core component of human knowledge, and it does not conflict with religious beliefs. Science and religion can and do coexist. In fact, within many religions, people believe that God works through the process of evolution. That is, God created a world that is ever changing. As stated earlier, “Scientific knowledge cannot contradict religious beliefs because science has nothing to say for or against religious realities or religious values” (Francisco Ayala, quoted in Bybee 2004).

The goal of science instruction is to teach science, not religious beliefs. A quality science education must include the theory of evolution, which shows that the universe has a history and that change through time has taken place. It is the

basis of biology. You can't teach science without teaching evolution; it's like trying to teach reading without teaching students the alphabet.

Q: I cannot accept the fact that I am descended from an ape; therefore, I do not support the theory of evolution.

A: Evidence does not support the assertion that humans evolved from an ape. Evidence does, however, indicate that modern apes and humans are closely related and are descendants of a common ancestor.

Q: Some argue that a sudden appearance of "modern groups" of animals in the Cambrian explosion disproves evolution. Is this correct?

A: No. Young Earth creationists assert that the Earth is 6,000 to 10,000 years old, and life resulted from a burst of creation that occurred during a six-day period. Other creationists have varying positions on the age of the Earth and the length of time of the creation process. Creationist tenets have not been included in the science curriculum because of their lack of supporting evidence. As a result, creationists consider the Cambrian explosion as a single event and as evidence that certain forms of life appeared on Earth abruptly. But they fail to note that "abrupt" in terms of geologic time is still a very long period of time and that the Cambrian explosion was not a single event, but a process that occurred over a 15- to 20-million-year period. The diversity of the fauna, which varied during this period, peaked about 535 million years ago as evidenced by fossils found in the Burgess shale formation in Canada. Overall, the evidence that "modern groups" appeared in a very short time is unsupported by the Cambrian explosion nor by the overall fossil record of Earth's life.

Q: I've heard that intelligent design is proven to be a valid scientific idea and should be included in science instruction.

A: According to the Intelligent Design Network (www.intelligentdesignnetwork.org), "certain features of the universe and of living things are best explained by an intelligent cause rather than an undirected process such as natural selection." This claim may be fascinating and appealing, but it cannot be tested; and as a result, it has no status as a scientific theory or concept.

Currently some of the leading advocates of intelligent design assert that this theory is not "ready" to be emphasized in the science curriculum. Stephen Meyer of the Discovery Institute supports this in his quote in a March 2005 article in the *Seattle Times*: "The School Board in Dover, Pennsylvania, however, got it wrong, Meyer said, when it required instruction in intelligent design. (The matter is now in court.) Intelligent design isn't established enough yet for that, Meyer says."

Similarly, an April 2005 article in the *Seattle Post-Intelligencer* quotes John West, a senior fellow at the Discovery Institute: "The Discovery Institute does not—does not—favor trying to require the teaching of intelligent design, and we are not pushing for the teaching of intelligent design in public schools, period," he said. "We advocate teaching more about evolutionary theory.

"That means all of the evidence that favors it...but students also need to know the areas of the theory which have legitimate scientific controversies."

Q: If polls indicate that some favor teaching other ideas along with evolution, shouldn't we just include these ideas?

A: As mentioned earlier, a 2004 CBS poll found that 65% of the adults responding favored teaching both evolution and creationism, while 37% favored teaching creationism only. The lack of public understanding of evolution and its importance in the science curriculum shows that evolution has not been taught in an effective and comprehensive manner in American schools. It is encouraging, however, that biological evolution is being emphasized in state science standards, which tend to be developed by professionals and approved through a political process. As such, these standards provide valuable insight into what the public expects students to know.

Justifications for the inclusion of creationism in the science curriculum tend to be religious in nature rather than sectarian. For this reason, courts have ruled that mandates requiring creationism to be included in the science curriculum are unconstitutional. Despite public support for the teaching of creationism, the lack of scientific evidence for it, and the range of nonscientific viewpoints concerning the history and nature of life on Earth, it is unlikely that viable and sectarian reasons will emerge to justify the teaching of creationism or intelligent design.

Q: Local communities and states should have the universal power to decide what should be taught to their students. If a community wants to include evidence against evolution, shouldn't it be their prerogative?

A: NSTA supports parental and community involvement in establishing the goals of science education and in securing the support needed to achieve them. Local communities and states should and currently do have a role in shaping science curricula. Currently, all states but Iowa have developed science standards that define with varied degrees of specificity what students should know and be able to do. These standards typically are approved through a political process that provides extended opportunity for public input. Communities and states, however, do not have "universal power" in developing curriculum frameworks and standards that emphasize evolution, as judicial decisions have stated

that the teaching of evolution cannot be prohibited and that inclusion of creationism in the curriculum cannot be mandated.

Evidence that reveals weaknesses in any given theory should be emphasized in the science curriculum as appropriate. The weaknesses, however, should be those recognized and subject to debate within the scientific community. Overall, science curriculum and instruction must be informed by and shaped by the knowledge gained through investigation and evidence, and at the same time directed toward achieving goals established through a collaborative process that involves educators, community participants, parents, and policy makers.

Q: I'm frustrated at the amount of time and attention being devoted to the evolution issue, especially when I have so many other demands and challenges in the classroom. Shouldn't we all just keep a low profile and hope the issue goes away?

A: We understand your frustrations. We've heard from many of you that the dialogue on this issue is causing undue stress and usurping valuable time. Now more than ever, we need the voice of the nation's science teachers to be heard. The stakes are simply too high. We recommend that you use this opportunity to educate and inform students, school leaders, and community members about the nature of science and what it can and can't tell us about the world around us. Rest assured you are not alone in this effort. NSTA stands ready to support you in any way and is working at the national level to keep evolution—and sound science—in its rightful place in the science curriculum.

Q: Where can I find more resources to help me respond to questions from parents and students?

A: Visit www.nsta.org/evresources, which contains NSTA publications, articles, and links to valuable resources and websites, including a link to the National Center for Science Education's website at www.ncseweb.org.

References

CBS News/*New York Times* Poll conducted November 18–21, 2004, among a nationwide random sample of 885 adults interviewed by telephone. www.cbsnews.com/stories/2004/11/22/opinion/polls/main657083.shtml

Bach, D. *Seattle Post-Intelligencer*. 2005. Evolution Debate Has New Player. April 2.

Bybee, R. 2005. *The nature of science and the study of biological evolution*. Arlington, VA: NSTA Press and BSCS. <http://store.nsta.org/showItem.asp?product=PAK006X1>

Bybee, R. 2005. *Galapagos: An inquiry into biological evolution, student field log*. Arlington, VA: NSTA Press and BSCS. <http://store.nsta.org/showItem.asp?product=PAK006X2>

Bybee, R. 2004. *Evolution in perspective: The science teacher's compendium*. Arlington, VA: NSTA Press. <http://store.nsta.org/showItem.asp?product=PBI81X>

Gould, S. J. 2002. *The structure of evolutionary theory*. Cambridge, MA: Harvard University Press.

Kansas State Department of Education website. *2005 science education standards: Findings of fact from the science hearings*. www.ksde.org/outcomes/scstdhearingfindfact.html

National Academy of Sciences (NAS). 1998. *Teaching about evolution and the nature of science*. Washington, DC: National Academy Press.

Shaw, L. *Seattle Times*. 2005. Theory of Intelligent Design: A Debate Evolves. March 31.