

How Do You Know—SCIENTIFICALLY SPEAKING?

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“Science requires the testing of explanations of the natural world against nature itself and discarding those explanations that do not work. What distinguishes science from other ways of knowing is its reliance upon the natural world itself as the arbiter of truth.”

Eugenie Scott, 2004

Have you ever asked your students the simple question – “How do you know?” There are many ways that we know what we know but they may not be scientific ways of knowing. Explanations about how the natural world changes based on cultural stories, personal beliefs, religious values, superstition, or authority can be personally useful and socially relevant, but they are not scientific. Throughout history, developing stories to explain nature has become part of cultural ways of knowing. And developing an artistic appreciation for nature is part of an aesthetic way of knowing. But to answer the question – “How do you know?” in a science class, challenges students to think about what they understand scientifically.

A scientific way of knowing is based not just only on evidence from extensive observations and experiments but is also based on inferences made by the scientists. Their prior knowledge, training, beliefs, experiences, expectations and how a scientist conducts an experiment can influence how he or she interprets their observations. To understand how we know what we know *scientifically* means that teachers must teach about science as a way of knowing. So that students can understand the way things work in nature, educators must teach inquiry and the nature of science. But when and how do students learn about a scientific way of knowing?

Young children begin by making observations of the world around them and asking questions to help them understand. Why does ice float? What do plants need to survive? Where do shadows come from? Helping students to develop their science inquiry abilities should start in elementary grades. To begin to understand the nature of science and a scientific way of knowing, student questioning and observing should be taught and encouraged. It is helpful to have students work in teams and share their finding with others. Presenting science as

a dynamic body of knowledge is a balancing act for teachers since students look to the teacher to provide the “right” explanation. Isolating and controlling variables and making a fair comparison of the data, are activities that will help the students’ understanding what science is and is not.

At the middle level, students should be confronted with a variety of questions about how science works: What is a theory? What is the difference between a theory and a fact? What is the role of evidence? As educators we must choose our words carefully. Clearly, an understanding of the terms “theory,” “fact,” “hypothesis,” and “evidence” are needed. Equally important is an understanding of the terms “belief” and “opinion.” Teachers need to model the correct use of the terms for their students. Do not ask “What is your theory about...?” but rather “What is your explanation based on the evidence concerning...?” Do not ask “What is your belief...?” but rather “What is your thinking...?” Middle school students tend to use personal experiences to help them evaluate evidence and they do not always evaluate their evidence correctly. This is often the case when the evidence conflicts with the students’ beliefs. Providing opportunities for students to talk about their ideas and have their thinking challenged and discussed by the other students is critical to their understanding of a scientific theory.

In high schools, teaching about the nature of science can’t happen without the teaching of scientific theories like biological evolution. Scientific explanations must meet certain criteria. “First and foremost, they must be consistent with experimental and observational evidence and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations about how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.” *National Science Education Standards* (National Research Council, 1996, pp.200-204.) Simply said, students can maintain their religious beliefs AND learn the

scientific foundations of evolution. Opposition to teaching and learning about evolution can stem from confusion about the nature and processes of science. Opposition to teaching and learning about evolution can stem from confusion about the nature and processes of science. Teachers should respect diverse beliefs, but to teach about what science is and is not involves teaching about scientific theories including a theory's mechanisms and principles.

Teachers must teach good science. That includes lessons on the nature of science that are appropriate for all of their students. A way of knowing is a process that humans use to understand. To have students that are scientifically astute, and prepared for the 21st century, learning a scientific way of knowing should be the goal of every science teacher.

To be fair to our students, shouldn't they be able to answer the question—"How do you know—scientifically speaking?"

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