Theoretically Speaking

Laura Henriques
California State University, Long Beach

A federal judge in Georgia recently ruled to remove these stickers from science textbooks:

> *This textbook contains material on evolution. Evolution is a theory, not a fact, regarding the origin of living things. This material should be approached with an open mind, studied carefully and critically considered.*

People claiming "it's just a theory" don't fully understand the nature of science. Science educators can respond in a couple ways. We can urge the sticker advocates to add additional stickers saying "Atoms and gravity are theories, too!" or we can do a better job teaching the nature of science.

Below are a few activities to help students better understand key aspects of the nature of science. Scientists use the word theory differently than the way it's used in everyday life. To a scientist a theory is a well-substantiated *explanation*, strong enough to be useful for making predictions. To the general public a theory is merely a hunch (often lacking substantial support).

Check It Out! Using canceled checks to teach the nature of science

There are variations on this activity but all are similar. Students are given a set of checks, from the same account, with which to construct a plausible story about the people writing the checks. As students see more checks, they change their story, *i.e.*, as new data becomes available, the explanation changes.

With one set of checks (resource #1, check set C) we see checks from a checking account initially owned solely by Paul. After a check to a jeweler, the account has two names, Paul and Leslie. Other checks include one to a hospital, a doctor, and checks to ballet school five years later and high school 13 years after that. Most students conclude that a child was born—even though they weren't present to witness the event.

Students using these checks invariably develop stories influenced by their own lives and societal/cultural norms. As students gather additional checks they either flesh out the details of their story or they throw out their story and start again. This happens when they get checks with different addresses (could there be a divorce or a new family business?) or when they get the first check related to children (hospital, ballet school, high school). This activity models real science in many ways. Usually new data add details to our understanding. We throw out our stories (theories) only when the data leaves no other choice. Like real science, students never know for sure if their story is true—but some story lines seem more plausible and better supported than others. Evolution is similar. Evolution is by far the most probable explanation for current data and hence the theory that is accepted by the scientific community.

Cubes, Footprints and C.S.I.

In 1998 the National Academy Press published a book titled *Teaching About Evolution and the Nature of Science.* Several activities help students understand evolution and the nature of

science. It's all available on-line (http://www.nap.edu/readingroom/books/evolution98/). Students examine data, make inferences, hypothesize and see how a theory is developed. As a result of activities where students examine a series of footprints, and make predictions about the hidden side on a set of cubes, students gain working definitions for theory.

A major objection to evolution is that no witnesses were present. All the evidence we have to support evolution is indirect. The check activity is a low stakes way to use indirect evidence in developing an explanation. Similarly, court cases use indirect evidence to convict criminals for crimes lacking witnesses. C.S.I. is one of the highest rated television shows and crime scene science is making its way into classrooms everywhere. It's an excellent vehicle for teaching about the nature of science. Students easily accept indirect evidence to build a case. No one saw the crime being committed yet evidence (data) is used to support or negate claims.

We don't have disclaimer stickers on our court cases nor should we in science classes. A jury is not 100% sure, but they are sure *beyond a reasonable doubt*. The theories now in use are our best explanation of the data. We don't know them to be 100% correct, but they are the most probable explanation given current knowledge and data – they work beyond a reasonable doubt. Court cases are overturned as new data or new ways to understand the data (*i.e.,* DNA testing) emerge. The same is true with scientific theories. They change based on new evidence and the power of the new theory to better explain the data. Helping students understand how scientific knowledge develops and changes through time will go a long way to helping them understand that a theory in science is more than "just a theory"!

Resources:
Sources of checks and directions for the activity:

#1 http://www.indiana.edu/~ensiweb/lessons/chec.lab.html
#2 http://www.csmate.colostate.edu/cltw/cohortpages/viney/checkthisout.html
#3 http://biology.umt.edu/biol101S03/labs/Wyrick_s03/1_nature_of_science

The November 2004 issues of *Science Scope* and *The Science Teacher* were devoted to the nature of science. NSTA members can access both journals on-line.