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Words (Just Might) Hurt Me: The Trouble with “Theory”

by [Megan Rulison](#)

Scope Correspondent

Malissa Hunt’s classroom appears haphazardly decorated from a science fair rummage sale: purple plastic models of the nervous system share a corner with shiny posters depicting the burning stages of stellar evolution. A bored-looking skeleton sporting a white lab coat ponders two periodic tables pasted on the opposite wall. But the room is actually a shared space between Hunt, a young biology teacher, and Chris Collins, an astronomy teacher. The two may bicker, to the amusement of their students, over the superiority of red blood cells or red dwarf stars, but in this split classroom there is at least one lesson the two subjects share, one that cannot be taught with plastic bones, atomic numbers, or satellite images.

Every year during the first week of school, Hunt uses a fun experiment to introduce her budding ninth and tenth graders to the scientific method. After a week of hypotheses, observations, and dreaded lab reports, she asks, “Okay, now what do we do with all this info?” And with that, Hunt presents them with what she considers one of the paramount concepts they will learn in her class, the definition of a scientific theory.

It seems strange that a teacher would construct an entire lesson to teach the meaning of a word, but theory is a small word that has caused big problems. “Theory” does not mean the same thing in science as it does in everyday speech, and snowballing incidences of its misuse have resulted in an avalanche of tension and arguments between scientists and the public. Established scientific fields, evolution in particular, are attacked by critics belittling the science, calling it “just a theory;” science education is jeopardized by misconceptions of the word causing conflict in the classroom; and widespread confusion over this single, simple term casts a shadow of public doubt over scientific authority.

In everyday language, a theory is a guess, a conjecture. We use the word without a second thought. “What’s your theory about the stock market dip?” “I have a theory why she missed my party.” So when the word is used in science, it’s easy to conclude, “Ah, a scientific guess!” assuming the idea to be a hypothesis or, more comically, a SWAG (Scientific Wild-Ass Guess). But, in science, a theory is more important than a hypothesis, a fact, even a law.

According to one leading biology textbook, a theory is a “well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses.” A scientific theory is the pinnacle of a mountain of ideas and experiments. It is an explanatory framework that makes logical predictions for future experiments. Without theories, scientists couldn’t do their day-to-day work. But most people don’t know that, and well-supported theories in science such as the big bang theory, the theory of special relativity, and the theory of evolution are doubted and criticized by the public simply because of the confusion surrounding this little word.

In fact, a lot of words in science have alternate colloquial meanings. In an introductory physics class, you might be confronted with the words “force,” “work,” and “energy,” all of which have specific physical definitions different than their everyday counterparts. But “theory” causes conflict unknown to those benign examples because its two meanings, the scientific and common ones, are directly opposed.

“Theory” comes from the Latin *theoria* and Greek *theorin*, meaning contemplation or speculation, literally “to look at,” a definition similar to the current colloquial meaning of the term. But in the middle of the 17th century and into the 18th, the meaning of the word split in two. When it came to scientific subjects, theory no longer referred to a guess, an opinion without evidence, but its opposite, an idea encompassing multiple observations. An author in 1812 described theory as a way of comprehending a group of facts, and by 1879, writers were referring to the Copernican “theory.” Since then, the prevalence of the word in science has only grown, and it now holds a defined and dedicated place in the literature and language of science.

“They’re the big ideas in science,” explains Niles Eldredge, a paleontologist at the Museum of Natural History. “They’re taken very, very seriously.” Eugenie Scott, executive director of the National Center for Science Education, says, “Theories explain laws and facts. They’re the most important thing we do in science.” And Ken Miller, a biologist at Brown University and well-known lecturer on evolution, says a theory is the result of large collections of facts put into an explanatory framework.

Miller commonly uses a baseball metaphor to make his point. Suppose someone asked why the Red Sox won the World Series this year. No single fact correctly answers that question. They did not win because Big Papi had a .332 batting average or because rookie Dustin Pedroia had a .990 fielding percentage. For a scientific theory of why the Sox won, you need to compile the facts into a fitting framework, as sports writers often do. Maybe the Red Sox won because of overall good defense or because their relief pitching is the best in the league. In this or any example, Miller says, it’s important to recognize that a theory is a higher level of explanation in science than a hypothesis, a fact, or even a law. Of course, just because a theory is an explanation doesn’t mean it’s right. Only well-established theories, those that make successful measurable predictions and have been

empirically verified over and over, are accepted in the scientific community and acknowledged as truth.

In Hunt's class, most students don't know the scientific meaning of theory. "It's not in their lexicon," she says, but that's why it's taught. All twenty-two teachers in her department, not just the biologists, Hunt emphasizes, teach the scientific definition of theory and consider it an "essential piece of information for the students to learn and appreciate." Each of three textbooks on a shelf in Hunt and Collins's classroom addresses the definition of the word within the first fifty pages. One of them, *Astronomy Today*, emphatically includes, "We have all heard the expression, 'Of course, it's only a theory,' used to undermine an idea that someone finds unacceptable. Don't be fooled by this abuse of a concept!"

Surely with enthusiastic textbooks and teachers like Hunt and Miller, the confusion around the word should be resolved by now. But because the two conflicting definitions of theory are so engrained in their respective vocabularies, even scientists can't always keep them straight. In the pages of *Physics Today*, one scientist admits that he and his colleagues are as loose with the words as everyone else, referring to scientific ideas that are purely hypotheses as theories. And even supporters of evolution sometimes get tongue-tied when a critic asks, "If it's true, then why is it called a theory?" It doesn't help that the big bang theory, quantum theory, and the theory of evolution are all big ideas backed by complex data that is not easy to summarize in casual conversation.

But though definitions are often an issue, sometimes they're not. Less controversial theories are rarely contested: cell theory, atomic theory, plate tectonics, gravity, electromagnetism, and more. Use of the word theory is most hotly debated when there's more at stake than just terminology.

Nowhere is the fight more intense than over evolution. Despite rock-hard evidence and universal acceptance of evolution by the scientific community, more than fifty percent of Americans either firmly reject or doubt evolution. Part of this number is likely a consequence of the misconception that evolution is "just a theory," a common phrase used by creationist groups. In a documentary aired on PBS about the 2005 Dover High School intelligent design trial, residents of the rural town in Pennsylvania engaged in an argument over the right to include "alternate views" in the classroom. Many of those supporting that right used terminology misleading about the importance of facts and theories. "It is a theory," said Alan Bonsell, a member of the Dover school board referring to evolution. "It isn't a law of science. It isn't, you know, a fact. It is a theory." Another member of the board, beneath dark glasses and a baseball cap, echoed Bonsell's statement, "It's not Darwin's law or Darwin's fact. It's Darwin's theory."

Evolution is consistently yanked out of the scientific arena where it earned the rank of theory and thrust into popular terminology where that honor is suddenly a demotion. In public conversations, evolution's great success in science is regularly exploited as its greatest weakness. Even Ronald Reagan, during his 1980 presidential campaign, was quoted as calling evolution "just a theory." And though Hunt spent the first few weeks of class going over the meaning of "theory," she always repeats the lesson before beginning evolution. Otherwise, "just a theory" is a major issue in class.

But worse than a general misunderstanding of "theory" in evolution is the expert exploitation of the confusion. Well-spoken and highly educated proponents of intelligent design (ID), who debate evolutionists regularly, use the colloquial meaning to further their agenda. Miller, who took the stand at Dover as an expert for the plaintiffs, is familiar with their tactics. "The professionals," as he labels them, "know very well the scientific definition of theory, and they are exploiting the popular use of the term." Miller responds to them with the humor of an old pro; he agrees. "It's not the use of 'theory' I object to, it's the use of the word 'just.' You won't say, 'It's just atomic theory,' or 'It's just germ theory.' Go ahead, blow your nose and shake hands with somebody."

So how should the rest of us deal with the professionals? "Call them on it," says Leah Ceccarelli, a rhetorician of science at the University of Washington in Seattle. Yet she regrets that few people, including scientists, actually do. While teaching a course on public debate, Ceccarelli was shocked that not a single biologist in the Seattle area would come debate ID proponents in a classroom setting. "That's not an issue of controversy," they'd say. Yet most of Ceccarelli's students had never been taught why ID shouldn't be included in class, and suddenly no one was willing to tell them. "Scientists need to be willing and capable of debating in a public setting," Ceccarelli argues. "If [evolution] is debated, scientists will win because they're right." But first, they have to show up.

Ceccarelli says language debates in any field of science can be resolved several ways. An academic who studies language for a living, she proposes three solutions to a word problem in science. One: define the term for the audience. Two: change the term you're using. Or three: supplement the term with metaphors or other words to compliment its meaning. But not all are pertinent to this debate, she says. When the goal is to overcome multiple meanings of a word, such as theory, the best bet is strategy number one: stop and define.

Many scientists and teachers, including Hunt, agree with Ceccarelli; the scientific meaning of theory must be taught. But there is a growing group of dissenters. These critics argue that no quantity or quality of education will shift the colloquial meaning of the word. They propose a more radical solution to the problem.

In a *Wired* essay last November, science and technology writer Clive Thompson took a stand for the radical alternative. "It's time to realize that we're simply never going to school enough of the public in the precise scientific meaning of particular words," he wrote. Instead, he throws in his towel with the ranks of those advocating "a neat bit of linguistic jujitsu;" stop using the word theory in science.

Overhauling a scientific term is not without precedent. If the scientific community were to rally in an effort to change or delete theory from scientific vocabulary, the timing might be right. Recently, Pluto was stripped of its major planet status and demoted to a dwarf planet. In that case, a major organization made the change; the International Astronomical Union decided "planet" was too big a name for a chunk of nitrogen ice only about one percent the mass of Earth. Along with stirring up a lot of media attention, jokes, and "Save Pluto" bumper stickers, the change in term communicated an important clarification in scientific thought to the public: here's what a planet is, and here is why Pluto isn't one. It was a major change in scientific classification. Could "theory" be the next Pluto?

But Pluto wasn't wiped out of textbooks altogether; its description was modified from "planet" to "dwarf planet." Likewise, in place of a well-accepted "theory," a familiar term is suggested, "law." Advocates argue that the general public thinks anything called law is a solid description of truth and anything named a theory is a guess that's yet to be proven, and scientists should

just accept this. Then, by replacing theory with law, the former gains the reputation of the latter. Thompson offered the following example: if someone says, "I don't believe in the theory of evolution," it's hard to fault him. If he must say, "I don't believe in the law of evolution," he sounds insane.

Others have pointed out that a change is justified; since the Greek origin of the term is "speculation," it is scientists that commandeered the term for their own uses, not the public. But detractors, like Miller, argue that "law" comes as a loaded term with its own definition. Surprisingly, it's not evolutionists but physicists jumping on the replacement bandwagon.

In early 2007, a heated debate began in the pages of *Physics Today*. Richard Kadel, a physicist at Lawrence Berkeley National Laboratory, wrote a spirited letter to the magazine proposing that for the 100th anniversary of its publication, Einstein's special theory of relativity should be renamed as Einstein's laws of special relativity. A fundamental explanation of space and time, Einstein's theory has been validated for over a hundred years and is rooted in modern physics and astronomy. However, because of its "theory" label, it falls prey to the same doubts and criticism of evolution.

In a clever way to get the ball rolling, Kadel suggested definitions for "Einstein's laws of special relativity." He also addressed the consequences of renaming a theory as a law. First, he stated, Nature does not care. Second, the change could "help us impress upon students and nonscientists" the importance of special relativity and its role in advances in science.

Responses flooded into *Physics Today*. Their sheer volume is a clue to the sensitivity of the scientific community to language problems. Their tone is one of urgency. The magazine received so many responses to Kadel that a special letters section called "Language of science: Theories and laws" was created. One respondent from Florida "wholeheartedly agrees" with Kadel and went so far as to offer suggestions of who should make the official decision: the American Physical Society, perhaps, or the International Union of Pure and Applied Physics. Only two of the replies disagreed. Kadel added an additional response to the batch, noting that "Einstein's laws" was apparently already used all across the Internet, so perhaps "the general public may be ahead of us—or at least me—in this discussion."

But lost in the physics and biology cacophonies are urgent voices advocating for a different change, one that has nothing to do with words. To them, the language conflict is a symptom of a much larger and scarier issue: public misunderstanding of science. Why quibble over words when the very understanding of the nature of science is at stake?

Ken Miller, for one, the Brown evolutionist with baseball metaphors, has tried to steer the ship away from a rhetoric argument and toward a better understanding of science. Science is often perceived as a process that attains absolute certainty about the natural world, Miller says, but that's not how it works.

"You might say that a fact is something of which we are very sure and a theory isn't, but we aren't sure of either one. In science, nothing is ever certain." A fact, for example, is defined by a National Academy of Science publication as "an observation that has been repeatedly confirmed." Neither facts nor laws nor theories have absolute certainty; science shies away from claiming absolute truth.

So it's possible that much of the conflict over "theory" comes from everyone debating what's more certain—laws, facts, or theories—when they should be debating what has the highest level of explanation. Ideas that do the best job explaining the most phenomena while standing up to investigation and skepticism, such as cell theory and the big bang theory and so on, are the most highly respected concepts in science. If science is recognized to work in this fashion, then it's possible that debate about which are truer, facts or theories, might just disappear. Unfortunately, many scientists and educators do not teach this nature of science; some justifiably fear that any mention of uncertainty, even healthy skepticism, will be ammunition for those attacking science.

But that doesn't include Hunt. She loves teaching the nature of the scientific process to her ninth and tenth graders. Leaning in close to the desks, she whispers, "Scientists do not trust each other!" Pulling back, she tosses her ponytail and points critically at the air next to her. "They say, 'I'm gonna test that!' and they try to prove the other guy wrong." Skepticism and competition are why theories are constantly re-tested, Hunt teaches, and if they survive, we consider them to be truer; theories that offer the most explanations without being proven wrong are the celebrated, like evolution. Those that don't make the cut are thrown out. It's with this method, Hunt emphasizes, that science attains good quality work, work that has been tested and re-tested, which gathers into a grand accumulation of evidence, which supports and maintains a scientific theory.

Setting philosophical concerns of certainty aside for the moment, a well-established scientific theory is considered, for all practical purposes, truth in science. Theories predict measurable outcomes that scientists test through the scientific process; no other concept in science is as solid or important as an established scientific theory.

It may be that sometime soon another word will be adopted to better describe this concept and disperse a lot of the confusion. Or maybe more successful techniques to teach the definitions will be used in the future, calming the frustration. Or maybe one side will just eventually become exhausted and give up. Anybody have a different theory?

Tags: [Darwin](#), [Evolution](#), [hypothesis](#), [theory](#)