Understanding Science: How Science Really Works

Scientist Stereotypes
(yes, even scientists pigeon-hole...)

- Science is a solitary pursuit.
- Science is done by "old, white men."

Roadblocks to Learning Science

- Science is boring.
- Science isn't important in my life.
- I am not good at science

Misinterpretations of the scientific process

Science is a collection of facts.

The Truth: A lot of what we learn in the world of science comes from textbooks, which means that sometimes it's easy to fall into the line of thinking that that's all there is: facts on a page. It's true that science can be learned in textbooks but at the same time, it's an ongoing, dynamic process.

Science is complete.

The Truth: Most science courses start out with teachings that were "new" in the 19th and 20th centuries. This leads some to believe that science is finished - we've made all the important discoveries so what else is there? This is completely untrue. The purpose of scientific research is inherently to explore new ideas, developing new questions and rehashing old hypotheses with new research. Science will never really be complete.

There is a single Scientific Method that all scientists follow.

The Truth: The "Scientific Method" that is taught in virtually all science courses is a very, very simplified version of what actually happens in scientific research. In reality, science is unpredictable, complex and involves a lot of people all working on different things, in different orders, often all at once.

The process of science is purely analytic and does not involve creativity.

The Truth: It's possible that this myth stems from the linearity of the Scientific Method. Actually, science is not a series of steps but rather, a creative thinking process used to develop new or alternative hypotheses or seeing old data in a new light. Creativity is not limited to artists and musicians; scientists need to be creative, too!

When scientists analyze a problem, they must use either inductive or deductive reasoning.

The Truth: The truth is that scientists are always using a variety of reasoning when conducting research. The important thing to realize is that it's not about what type of reasoning but rather how scientists use reasoning to observe how evidence supports or does not support ideas.

Experiments are a necessary part of the scientific process. Without an experiment, a study is not rigorous or scientific.

The Truth: This is another example of how the Scientific Method has been used to stereotype scientific research. If there is not a linear arrangement of steps, it must not be true science, right? In reality there are many ways to test any scientific idea and experimentation is just one of those ways.

"Hard" sciences are more rigorous and scientific than "soft" sciences.

The Truth: As with any field of study, lines are often drawn in an attempt to classify "types" of research. In this case, pitting chemistry and physics ("hard science") against psychology and sociology ("soft"). The reasoning is that hard science requires more rigorous study methods and, therefore, is more trustworthy. However, the rigor of a well-laid out scientific study depends more on the investigator's approach than with the discipline.

Scientific ideas are absolute and unchanging.

The Truth: This misconception harkens back to the textbook idea - that because science textbooks often go fairly unchanged year after year, the ideas within those texts must not be changing either. Even established, well-supported ideas are subject to minor changes based on new evidence. Some research can't even be put into a textbook because it is so new, so cutting edge and these ideas are always changing and evolving as scientists come up with ways to explain these new phenomena.

Because scientific ideas are tentative and subject to change, they can't be trusted.

The Truth: In this fast-paced, connected world we live in, it sometimes seems like scientists are always changing their minds. One day, chocolate is bad for you, the next, it's touted as a health food, full of antioxidants and lack of trans-fats. What to believe? Part of this stems from the media, drawing attention to disagreements or conflicting ideas. Another issue at hand is that new science is constantly changing as scientists make new discoveries and test hypotheses. What you need to know is that change in science due to new evidence is a normal part of the scientific process.

Scientists' observations directly tell them how things work (i.e., knowledge is "read off" nature, not built).

The Truth: Observations, while critical to science, are not the only thing considered when conducting research. They are actually just one part of a complex process that involves coming up with ideas about how the natural world works and seeing how their observations can be used to back up

those ideas. So the truth is that scientists are actually always building off of their observations: trying new ideas, running those ideas by their peers and modifying text in order to present a clear and accurate picture for what we observe in the natural world.

Science proves ideas.

The Truth: The concept of "proof" in the world of science is not actually very scientific. Science is based on the idea that any idea or hypotheses could be put into question tomorrow, if there was supporting evidence, no matter how widely accepted it is today. So, science can accept or reject ideas based on evidence but it doesn't prove or disprove them.

Science can only disprove ideas.

The Truth: Much like in the previous misconception ("science proves ideas") this idea follows the line of thinking that science has something to disprove, falsify or reject; that science can't find evidence to support one idea over another. In science, ideas can never be absolutely proved or disproved, they can only be accepted or rejected based on supporting or refuting evidence.

If evidence supports a hypothesis, it is upgraded to a theory. If the theory then garners even more support, it may be upgraded to a law.

The Truth: The idea that hypotheses, theories and laws are on the same, level playing field is a myth that probably found its origins in introductory lab classes, where hypotheses were presented as "things we're not quite sure of yet" and therefore only discussed proven and accepted theories. In reality, hypotheses are explanations that are limited in scope, applying to fairly narrow range of phenomena. The term *law* is sometimes used to refer to an idea about how observable phenomena are related — but the term is also used in other ways within science. Theories are deep explanations that apply to a broad range of phenomena and that may integrate many hypotheses and laws.

Scientific ideas are judged democratically based on popularity.

The Truth: The media can be partially blamed for this myth when it makes statements like "most scientists agree that human activity is the culprit behind global warming." The public might be led to believe that scientists all congregate to agree or disagree on hot button issues. The reality is that scientific ideas are judged on their supporting or refuting evidence. A scientific theory comes to be accepted by the scientific community only after years of study and careful scrutiny. And, even a hypothesis that is accepted by "most scientists" may not be "liked" by all scientists but it is one that the scientific community has judged likely to be most accurate based on evidence.

The job of a scientist is to find support for his or her hypotheses.

The Truth: It's possible that this myth probably got its start in introductory lab classes, as they often emphasize getting the "right" answer and rewarding those who have had the "correct" hypothesis all along. In the real world, science gains as much or more from figuring out which hypotheses might be incorrect as it does from those that are supported by evidence. Scientists strive to remain unbiased in their findings.

Scientists are judged on the basis of how many correct hypotheses they propose (i.e., good scientists are the ones who are "right" most often).

The Truth: In science, it's not always about getting it right. While being right or coming up with hypotheses that end up being proven correct is appreciated, the scientific community also values those scientists who can spot a flaw in a given argument or test. This is how new ideas happen and how research is furthered.

Investigations that don't reach a firm conclusion are useless and un-publishable.

The Truth: This myth is another that has its roots in the Scientific Method. The last step in this process is always some form of "draw a conclusion." So it's very easy to see how scientific studies that don't reach a firm conclusion might be deemed useless and un-publishable. The truth is that most scientific studies don't reach an exact conclusion - often times there are limits to the tests performed and this leads scientists to offer up alternative hypotheses for what they observed. That's just the nature of scientific knowledge: it is constantly in-flux and evolving.

Scientists are completely objective in their evaluation of scientific ideas and evidence.

The Truth: Scientists strive to remain as unbiased as possible when they consider different ideas and opposing hypotheses, but they are only human. Each scientist has their own beliefs and goals and as a result, might favor different hypotheses for various reasons. This is why the scientific community must remain robust: we can keep our peers in check and help balance the bias.

Science is pure. Scientists work without considering the applications of their ideas.

The Truth: While some science focuses on just the pure science and no application, this is not true for the vast majority of scientific research. Sometimes, even basic research that is performed without a potential application in mind might later end up being extremely useful to that particular field of study.

Adapted from: http://undsci.berkeley.edu/teaching/misconceptions.php#b6