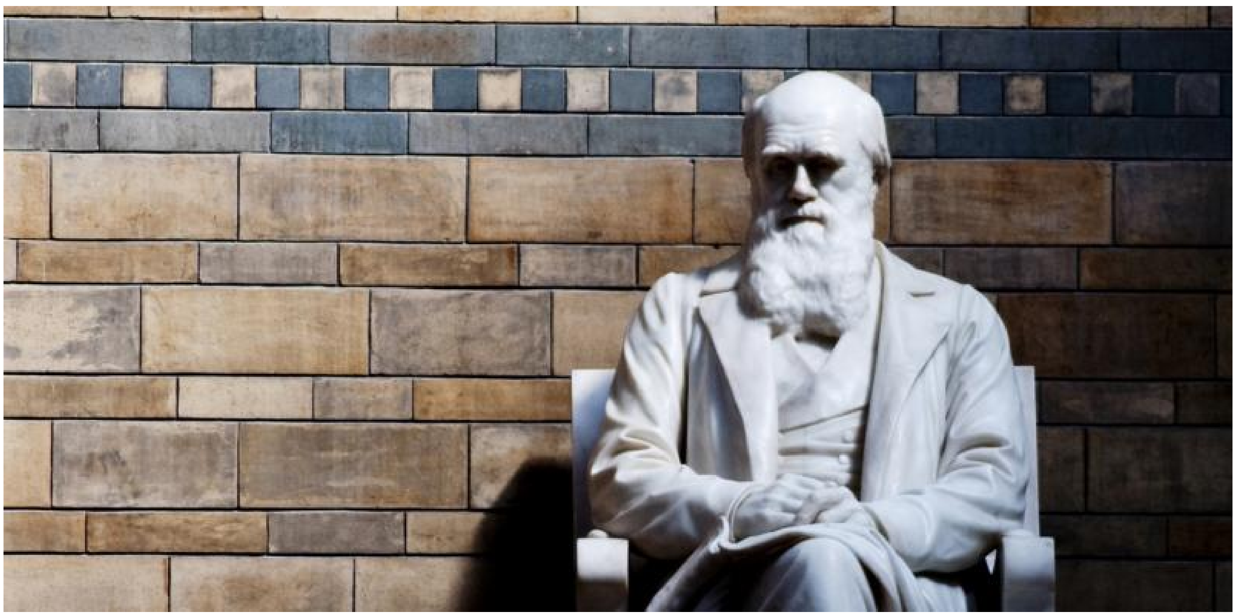
Scientific theories aren't mere conjecture – to survive they must work

March 8 2017, by Tom Solomon



There wouldn’t be statues acclaiming Darwin and his theory if it couldn’t stand up to decades of testing. Credit: CGP Grey, CC BY

"The evidence is incontrovertible. Global warming is occurring." "Climate change is real, is serious and has been influenced by anthropogenic activity." "The scientific evidence is clear: Global climate change caused by human activities is occurring now, and is a growing threat to society."

As these scientific societies' position statements reflect, there is a clear scientific consensus on the reality of climate change. But although public acceptance of climate theory is improving, many of our elected leaders still express skepticism about the science. The theory of evolution also shows a mismatch: Whereas there is virtually universal agreement among scientists about the validity of the theory, only 33 percent of the public accepts it in full. For both climate change and evolution, skeptics sometimes sow doubt by saying that it is just a "theory."

How does a scientific theory gain widespread acceptance in the scientific community? Why should the public and elected officials be expected to accept something that is "only a theory"? And how can we know if the science behind a particular theory is "settled," anyway?

Does the theory deliver?

In science, there are successful theories and unsuccessful theories. The word "theory" has nothing to do with the validity of a scientific principle or lack thereof. In contrast to general parlance where a theory "is a proposed explanation whose status is still conjectural," a scientific theory is only conjectural until it is tested experimentally.

The issue is not whether a scientific theory is settled, but rather whether it works. Any successful scientific theory must be predictive and falsifiable; that is, it must successfully predict outcomes of controlled experiments or observations, and it must survive tests that could disprove the theory.

A scientist advocating a particular theory must propose an experiment and use her theory to predict the results of that experiment. If the experimental results are inconsistent with her predictions, then she must admit that her theory is wrong. To gain acceptance for a theory, a scientist must be willing to subject it to a falsifiable test.

If an experiment produces results that are consistent with a scientist's predictions, then that's good news for her theory. Just one successful test, though, is not usually enough. And the more controversial a theory is, the more experimental verification is required. As Carl Sagan said, "Extraordinary claims require extraordinary evidence."

Wide acceptance comes from repeated, different experiments by different research groups. There is no threshold or tipping point at which a theory becomes "settled." And there is never 100 percent certainty. However, near-unanimous acceptance by the scientific community simply doesn't occur unless the evidence is overwhelming.

Scientific theories are repeatedly put to the test

As an example, in 1905, Albert Einstein published two papers on what we now call the Special Theory of Relativity. In these papers, he made a series of arguments that dramatically altered our notions of how the universe works. He argued that different observers measure the passage of time differently; they also measure different lengths for moving objects. He also showed that matter and energy are different forms of the same thing and theoretically can be converted into each other.

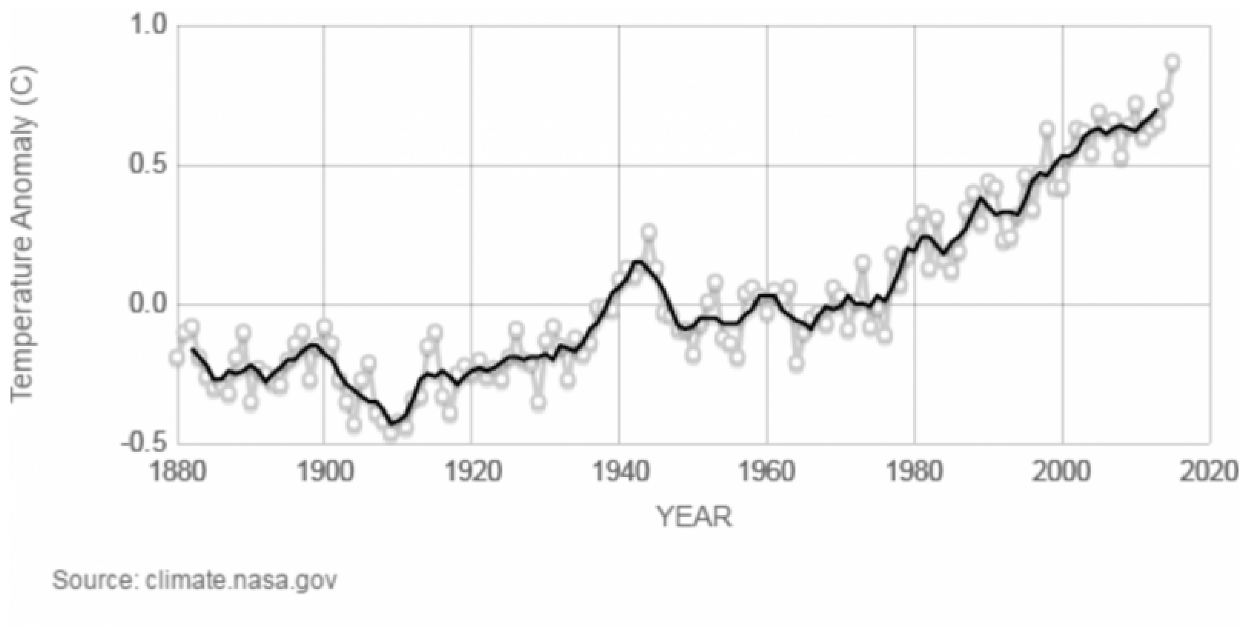
But Einstein didn't just make these statements. His theory made detailed, quantitative and falsifiable predictions that could be tested experimentally. Einstein was prepared to drop the entire theory if even one experiment convincingly contradicted his predictions. It took a long time for many of these predictions to be tested. In fact, the first direct measurements of gravity waves – one of Einstein's predictions – came just last year.

Every single confirmed experimental test of relativity has agreed (eventually) with Einstein's predictions. And relativistic theory has also been used as the basis for several technological advances, including GPS satellites, nuclear power and (unfortunately) nuclear bombs. There is absolutely no doubt among anyone in the physics community about the validity of the Theory of Relativity.

For an example of an unsuccessful theory, consider the announcement in March 1989 of a mechanism for nuclear fusion in a table-top configuration. This discovery of "cold fusion" was met with tremendous excitement since cost-effective nuclear fusion could hold the key to society's future power needs. But follow-up experiments by other scientific groups had results that disagreed with the cold fusion theory. Despite the initial excitement, there was near-unanimous consensus in the scientific community by the end of 1989 that the cold fusion theory was incorrect. When the evidence isn't there, the theory won't hold up.

Like relativity, the Theory of Evolution by Natural Selection has been tested extensively. The body of experimental data that supports evolution is overwhelming. Of course, the fossil record supporting evolution is impressive and complete. But evolution has also been tested in real time with populations of organisms that can mutate and evolve over measurable time scales.

Evolution has been subjected to many falsifiable tests and has emerged unscathed in every one. Yes, evolution is a "theory" – it is a theory that works and works very well, an overwhelmingly successful and correct theory.



Change in global surface temperature relative to 1951-1980 average temperatures. Although they fluctuate from year to year, average global temperatures have been rising for decades. Credit: NASA/GISS, CC BY

Scientific agreement, political controversy

Theories of climate change are also supported by an extensive body of evidence. Of course there's the continuing upward drift of global average temperatures over the past few decades. But climate change models are also supported by numerous laboratory experiments that have provided compelling verification of the mechanisms by which carbon dioxide gas traps heat in our planet's atmosphere.

And, crucially, theories of global warming have passed falsifiability tests. Quantitative predictions of global warming were first made in the 1970s. Had there not been a clear increase in average global temperatures since then, climate scientists would have been forced to admit that climate change theory was wrong. In fact, several scientists in the 1960s who had predicted global cooling later had to admit that their theory was incorrect. Even a supposed pause in the increases in the 2000s (which were exaggerated by a spike in the average global temperature in 1998) has been followed by a strong upward trend during the past three years.

Tellingly, skeptics of both evolution and climate change theory have been unwilling or unable to subject their arguments to the same rigorous testing undergone by the very theories they're criticizing. To make a scientific argument, critics must propose an experiment or measurement that can distinguish their alternative theory from evolutionary and climate change theories, and they must make a specific prediction for its outcome. And, like the scientists they're criticizing, they must be willing to admit they are wrong if the results disagree with their prediction. Absent any falsifiable tests, why should the public or our elected officials believe their counterarguments?

These issues are important from more than just a purely scientific perspective. An understanding of evolution is critical for developing any valid strategy for combating the spread of diseases, especially since microbes responsible for diseases can mutate so rapidly. And an understanding and acceptance of climate change theory is critical if we are to take the necessary steps to avoid potential catastrophe from a continuation of the global warming trend.

Scientific theories aren't mere conjecture. They are subject to exhaustive, falsifiable tests. Some theories fail these tests and are jettisoned. But many theories are successful in the face of these tests. It is these theories – the ones that work – that achieve consensus in the scientific community.

This article was originally published on The Conversation. Read the original article.

Provided by The Conversation

Citation: Scientific theories aren't mere conjecture – to survive they must work (2017, March 8) retrieved 17 July 2024 from https://phys.org/news/2017-03-scientific-theories-mere-conjecture-survive.html