Burden of proof

Some theories, which are often called over-arching theories, are particularly important and reflect broad understandings of a particular part of the natural world. Evolutionary theory, atomic theory, gravity, quantum theory, and plate tectonics are examples of this sort of over-arching theory. These theories have been broadly supported by multiple lines of evidence and help frame our understanding of the world around us.

> The great tragedy of science: the slaying of a beautiful hypothesis by an ugly fact.
>
> – Thomas Huxley

Such over-arching theories encompass many subordinate theories and hypotheses, and consequently, changes to those smaller theories and hypotheses reflect a refinement (not an overthrow) of the over-arching theory. For example, when punctuated equilibrium was proposed as a mode of evolutionary change, and evidence was found supporting the idea in some situations, it represented an elaborated reinforcement of evolutionary theory, not a refutation of it.

Over-arching theories are so important because they help scientists choose their methods of study and mode of reasoning, connect important phenomena in new ways, and open new areas of study. For example, evolutionary theory highlighted an entirely new set of questions for exploration: How did this characteristic evolve? How are these species related to one another? How has life changed over time?

> "If the argument has been reduced to inserting god into the gaps of scientific knowledge, god simply becomes an ever-receding pocket of scientific ignorance."
>
> – Neil deGrasse Tyson

Be curious! Look things up!

– Skeptics everywhere

Curious? Contact us!

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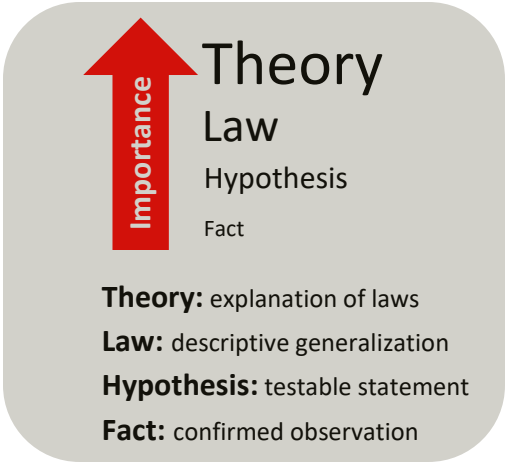
Scientific Terms

In science:



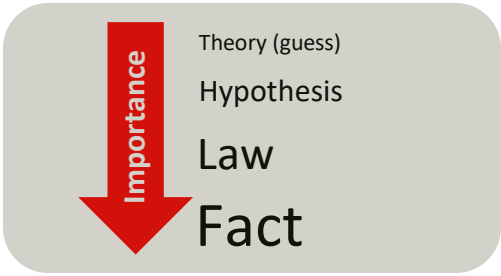
Theory: explanation of laws

Law: descriptive generalization

Hypothesis: testable statement

Fact: confirmed observation

In common usage:



https://www.youtube.com/watch?v=-M1hxGj5bMg&t=85s
(YouTube: *Eugenie Scott: Scientific Theories*)

"Science is the magic of reality."

– Richard Dawkins

Hypotheses, theories, and laws

"I've narrowed it to two hypotheses: it grew or we shrunk."

Hypotheses are proposed explanations for a fairly narrow set of phenomena. These reasoned explanations are not guesses – of the wild *or* educated variety. When scientists formulate new hypotheses, they are usually based on prior experience, scientific background knowledge, preliminary observations, and logic.

For example, scientists observed that alpine butterflies exhibit characteristics intermediate between two species that live at lower elevations. Based on these observations and their understanding of speciation, the scientists hypothesized that this species of alpine butterfly evolved as the result of hybridization between the two other species living at lower elevations.

Theories, on the other hand, are broad explanations for a wide range of phenomena. They are concise (i.e., generally don't have a long list of exceptions and special rules), coherent, systematic, predictive, and broadly applicable. In fact, theories often integrate and generalize many hypotheses. Theories are the most important category in science.

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For example, the Theory of Natural Selection broadly applies to all populations with some form of inheritance, variation, and differential reproductive success – whether that population is composed of alpine butterflies, fruit flies on a tropical island, a new form of life discovered on Mars, or even bits in a computer's memory.

This theory helps us understand a wide range of observations (from the rise of antibiotic-resistant bacteria to the physical match between pollinators and their preferred flowers), makes predictions in new situations (e.g., that treating AIDS patients with a cocktail of medications should slow the evolution of the virus), and has proven itself time and again in thousands of experiments and observational studies.

While scientific theories and laws are both based on hypotheses, a scientific theory is an explanation of the observed phenomenon, while a **scientific law** is a description of an observed phenomenon.

Kepler's Laws of Planetary Motion, for example, describe the motions of planets but do not provide an explanation for their movements. Like theories and hypotheses, laws make predictions (specifically, they predict that new observations will conform to the law), and can be falsified if they are found in contradiction with new data.

Both scientific laws and theories are supported by a large body of empirical data; both help unify a particular field of scientific study; and both are widely accepted by the vast majority of scientists within a discipline.

Just a theory?

Occasionally, scientific ideas (such as biological evolution) are written off with the putdown "it's just a theory." This slur is misleading and conflates two separate meanings of the word theory: in common usage, the word theory means just a hunch, but in science, a theory is a powerful explanation for a broad set of observations.

To be accepted by the scientific community, a theory (in the scientific sense of the word) must be strongly supported by many different lines of evidence. So biological evolution is a theory (it is a well-supported, widely accepted, and powerful explanation for the diversity of life on Earth), but it is not "just" a theory.

Words with both technical and everyday meanings often cause confusion. Even scientists sometimes use the word *theory* when they really mean *hypothesis* or even just a *hunch*. Many fields have similar vocabulary problems – for example, both the terms *work* in physics and *ego* in psychology have specific meanings in their technical fields that differ from their common uses. However, context and a little background knowledge are usually sufficient to figure out which meaning is intended.

Peer review

Scholarly peer review (also known as refereeing) is the process of subjecting an author's scholarly work, research, or ideas to the scrutiny of others who are experts in the same field, before a paper describing this work is published in a journal or as a book. Peer review does NOT mean you asked your friends to give your idea the thumbs-up.