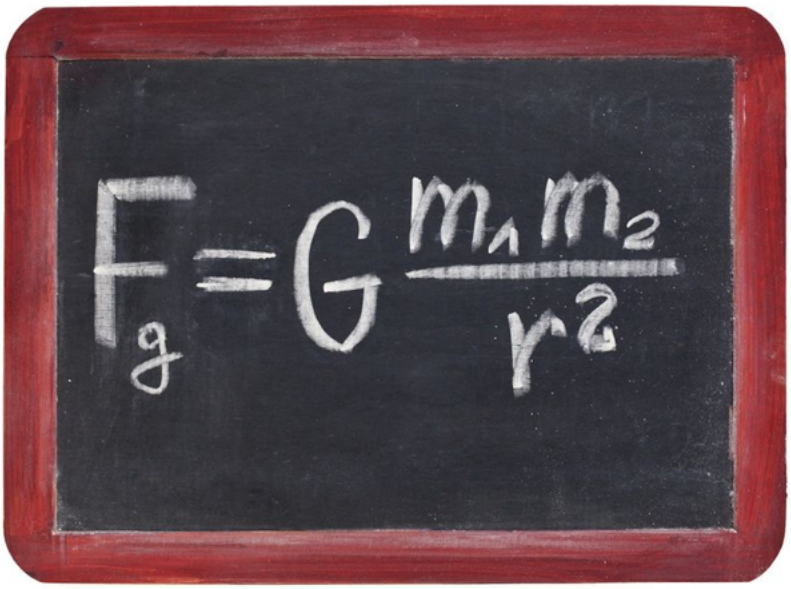
What Is a Law in Science?

By Alina Bradford - Live Science Contributor July 29, 2017



In equations formulated by Sir Isaac Newton, the force of gravity grows with the mass of two objects and gets weaker the more distant the objects are from each other.
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In general, a scientific law is the description of an observed phenomenon. It doesn't explain why the phenomenon exists or what causes it. The explanation of a phenomenon is called a scientific theory. It is a misconception that theories turn into laws with enough research.

"In science, laws are a starting place," said Peter Coppinger, an associate professor of biology and biomedical engineering at the Rose-Hulman Institute of Technology. "From there, scientists can then ask the questions, 'Why and how?'"

Scientific law vs. theory and facts

Many people think that if scientists find evidence that supports a hypothesis, the hypothesis is upgraded to a theory and if the theory if found to be correct, it is upgraded to a law. That is not how it works at all, though. In fact, facts, theories and laws — as well as hypotheses — are separate parts of the scientific method. Though they may evolve, they aren't upgraded to something else.

"Hypotheses, theories and laws are rather like apples, oranges and kumquats: one cannot grow into another, no matter how much fertilizer and water are offered," according to the University of California. A hypothesis is a limited explanation of a phenomenon; a scientific theory is an in-depth explanation of the observed phenomenon. A law is a statement about an observed phenomenon or a unifying concept, according to Kennesaw State University.

"There are four major concepts in science: facts, hypotheses, laws, and theories," Coppinger told Live Science.

Though scientific laws and theories are supported by a large body of empirical data, accepted by the majority of scientists within that area of scientific study and help to unify it, they are not the same thing.

"Laws are descriptions — often mathematical descriptions — of natural phenomenon; for example, Newton's Law of Gravity or Mendel's Law of Independent Assortment. These laws simply describe the observation. Not how or why they work, said Coppinger.

Coppinger pointed out that the Law of Gravity was discovered by Isaac Newton in the 17th century. This law mathematically describes how two different bodies in the universe interact with each other. However, Newton's law doesn't explain what gravity is, or how it works. It wasn't until three centuries later, when Albert Einstein developed the Theory of Relativity, that scientists began to understand what gravity is, and how it works.

"Newton's law is useful to scientists in that astrophysicists can use this centuries-old law to land robots on Mars. But it doesn't explain how gravity works, or what it is. Similarly, Mendel's Law of Independent Assortment describes how different traits are passed from parent to offspring, not how or why it happens," Coppinger said.

Another example of the difference between a theory and a law would be the case of Gregor Mendel. Mendel discovered that two different genetic traits would appear independently of each other in different offspring. "Yet Mendel knew nothing of DNA or chromosomes. It wasn't until a century later that scientists discovered DNA and chromosomes — the biochemical explanation of Mendel's laws. It was only then that scientists, such as T.H. Morgan working with fruit flies, explained the Law of Independent Assortment using the theory of chromosomal inheritance. Still today, this is the universally accepted explanation (theory) for Mendel's Law," Coppinger said.

The difference between scientific laws and scientific facts is a bit harder to define, though the definition is important. Facts are simple, basic observations that have been shown to be true. Laws are generalized observations about a relationship between two or more things in the natural world. The law can be based on facts and tested hypothesizes, according to NASA.

For example, "There are five trees in my yard" is considered a fact because it is a simple statement that can be proven. "The apples fall down from the tree in my back yard and not up" is a law because it describes how two things in nature behave that has been observed in a certain circumstance. If the circumstance changes, then the law would change. For example, in the vacuum of space, the apple may float upward from the tree instead of downward.

Laws and mathematics

Many scientific laws can be boiled down to a mathematical equation. For example, Newton's Law of Universal Gravitation states:

$F_g = G (m_1 \cdot m_2) / d^2$

F_g is the force of gravity; G is the universal gravitational constant, which can be measured; m1 and m2 are the masses of the two objects, and d is the distance between them, according to Ohio State University.

Another example of where mathematics influences scientific law is probabilities. "My favorite scientific law is that we live in a probabilistic world, not a deterministic one. With large numbers, probability always works. The house always wins," said Dr. Sylvia Wassertheil-Smoller, a professor at Albert Einstein College of Medicine. "We can calculate the probability of an event and we can determine how certain we are of our estimate, but there is always a trade-off between precision and certainty. This is known as the confidence interval. For example, we can be 95 percent certain that what we are trying to estimate lies within a certain range or we can be more certain, say 99 percent certain, that it lies within a wider range. Just like in life in general, we must accept that there is a trade-off."

Do laws change?

Just because an idea becomes a law, doesn't mean that it can't be changed through scientific research in the future. The use of the word "law" by laymen and scientists differ. When most people talk about a law, they mean something that is absolute. A scientific law is much more flexible. It can have exceptions, be proven wrong or evolve over time, according to the University of California.

"A good scientist is one who always asks the question, 'How can I show myself wrong?'" Coppinger said. "In regards to the Law of Gravity or the Law of Independent Assortment, continual testing and observations have 'tweaked' these laws. Exceptions have been found. For example, Newton's Law of Gravity breaks down when looking at the quantum (sub-atomic) level. Mendel's Law of Independent Assortment breaks down when traits are "linked" on the same chromosome."

Additional resources

- Midwestern State University: What to Expect, the Scientific Method and Metrics
- Kennesaw State University: Scientific Laws and Theories
- National Center for Science Education: Definitions of Fact, Theory, and Law in Scientific Work