

## Biology as a Science



The Nature of Science: methods, laws & theories

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- Science is a **system** for acquiring knowledge based on observation and experimentation.
- Scientists **observe** phenomenon or their effects and then attempt to explain the cause of those effects.
- The goal of science is to produce useful **models** of reality.

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### Etymology

The word science comes from the Latin word scientia-for knowledge, which in turn comes from scio - I know.

Despite having "I **Know**" as part of their job title. Scientists never claim to possess absolute knowledge. Unlike a mathematical proof, a proven scientific theory is always open to falsification, if new evidence is presented.

Even the most fundamental theory may turn out to be imperfect if new observations are inconsistent with them.

Isaac Newton's law of gravity is an example of an established law that was later found not to be universally true (by Einstein) as it does not hold in experiments involving motion at speeds close to the speed of light or in close proximity of strong gravitational fields.

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## The Sun Revolves Around the Earth

- For over 10,000 years, people believed the sun rotated around the earth
- It wasn't until Copernicus proposed his heliocentric in the early 1500s universe that people began to think otherwise.
- Throughout history, people have sought ways to understand nature



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Polish Astronomer Copernicus: Conversation with God painted by Jan Matejko (1872)

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Copernicus book On the Revolutions of the Celestial Spheres in 1543 was a major contribution to the Scientific Revolution. As his model of the universe had the Sun at its center...

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Interestingly the Catholic Church did oppose his work until seventy-three years later, when it was revisited by Galileo. Galileo would spend the rest of his life under house arrest for supporting heliocentrism.

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## The Scientific Method

- **Science** - an organized process of learning about the world.
- A process is...

A goal-directed, interrelated series of actions, events, mechanisms, or steps

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- What are examples of process in your life?
- At School, Work, Home?
- Describe the process of getting to school.

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## The Scientific Method

Starts with

- **Observations**
  - Observations are the “heart” of science because they may lead to questions, new discoveries
  - Can be informal or formal
  - Can lead to the development of a **question or problem to be investigated**

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## Relating data and the hypothesis

- **Hypothesis** predicts possible outcome, identifies variables and the control, and relates to the data
- **Data** is collected from observations and experiments
- **Conclusions** are made after scientists interpret data and use reasoning.

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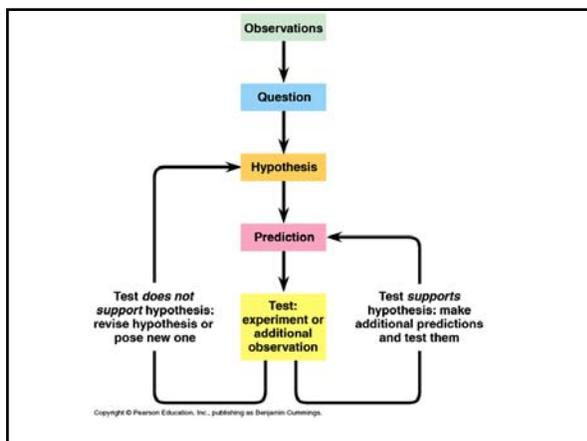
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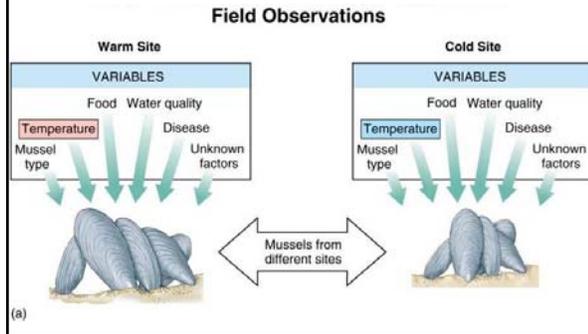
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In this experiment a Marine Biologist wants to test the effect of water temperature on mussel growth.



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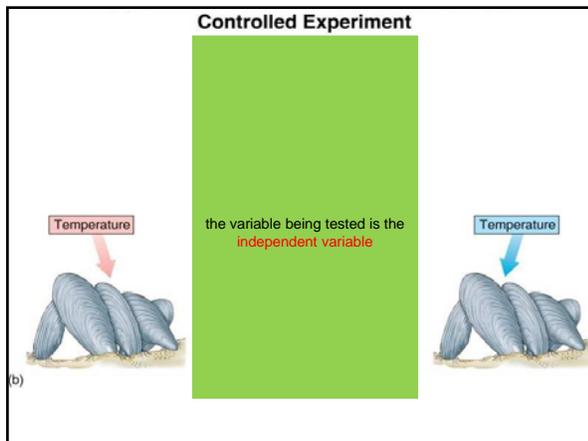
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A **Controlled Experiment** only changes 1 variable



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**Experimental groups** must keep all variables the same as the control group except for one.

The **independent** variable.

The **dependent** variable is the change that results from changing the independent variable.

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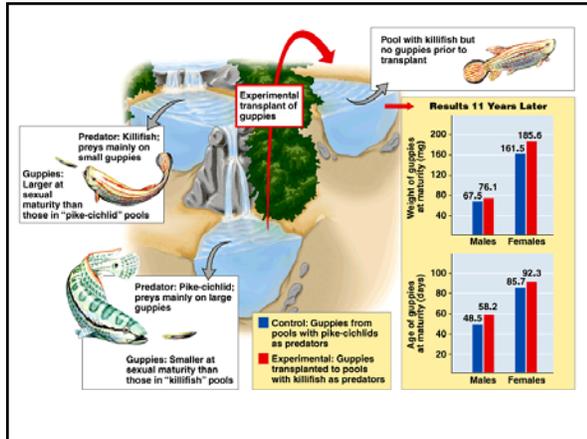
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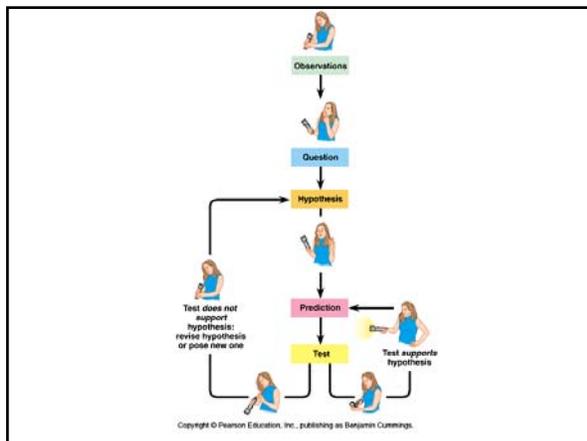
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## Hypothesis vs. Theory vs. Law

- A hypothesis often has **short-term** results
- A theory has lasted for **many** years
  - Example: Evolution, relativity
- **Laws** describe events that happen in nature –
- Scientists use **theories** to explain **laws**

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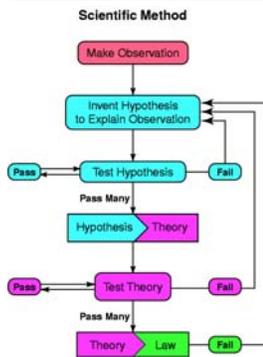
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## Theories & Laws



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## Theory vs. Law

- **Scientific Law:** This is a statement of fact meant to describe, in concise terms, an action or set of actions.
- It is generally accepted to be true and universal, and can sometimes be expressed in terms of a single mathematical equation.
- Laws don't really need any complex external proofs; they are accepted at face value based upon the fact that **laws have always been observed to be true.**

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## Theory vs. Law

- Specifically, scientific laws must be simple, true, universal, and absolute.
- Laws represent the cornerstone of scientific discovery, because if a law ever did not apply, then all science based upon that law would collapse.

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- **Theory:** A theory is an **explanation of** a set of related **observations** or events based upon hypotheses supported by large groups of **data** and **verified multiple times** by detached groups of researchers.
- One scientist cannot create a theory; she can only create a hypothesis.

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- In general, both a scientific theory and a scientific law are accepted to be true by the scientific community as a whole.
  - Both are used to make predictions of events.
  - Both are used to advance technology.
- In fact, some laws, such as the law of gravity, can also be theories when taken more generally

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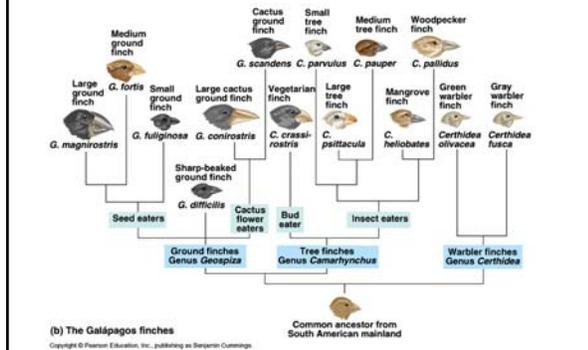
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The Galapagos finches are an example of his theory of evolution through natural selection.




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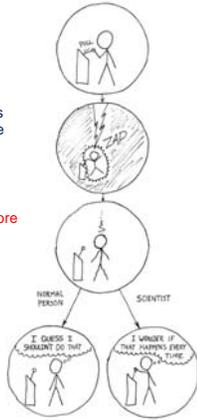
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### THE DIFFERENCE

A scientist would pull the lever again to see if it was just a coincidence or if the lever actually caused the bolt of lightning.

Science requires that results be repeatable before it accepts the results.




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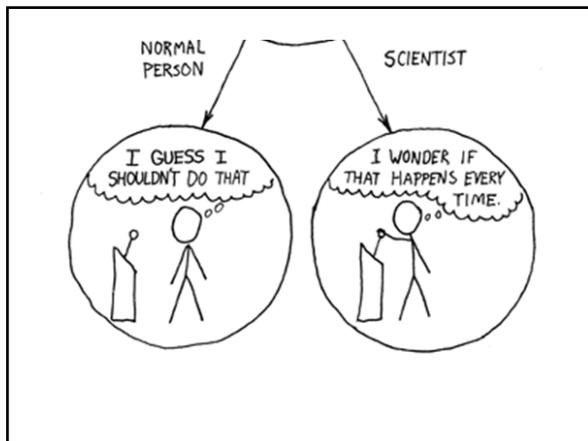
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