The Scientific Method

Unit: Laboratory & Measurement

MA Curriculum Frameworks (2016): SP1, SP2, SP6, SP7

AP® Physics 2 Learning Objectives: N/A

Mastery Objective(s): (Students will be able to…)

- Explain how the scientific method can be applied to a problem or question.

Success Criteria:

- Steps in a specific process are connected in consistent and logical ways.
- Explanation correctly uses appropriate vocabulary.

Tier 2 Vocabulary: theory, model, claim, law, peer

Language Objectives:

- Understand and correctly use terms relating to the scientific method, such as "peer review".

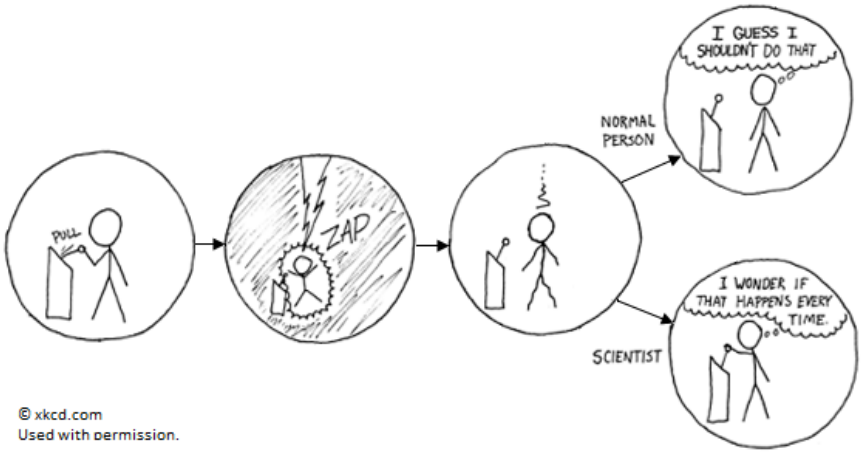
Tier 2 Vocabulary: N/A

Notes:

The scientific method is a fancy name for "figure out what happens by trying it."

In the middle ages, "scientists" were called "philosophers." These were church scholars who decided what was "correct" by a combination of observing the world around them and then arguing and debating with each other about the mechanisms and causes.

During the Renaissance, scientists like Galileo Galilei and Leonardo da Vinci started using experiments instead of argument to decide what really happens in the world.



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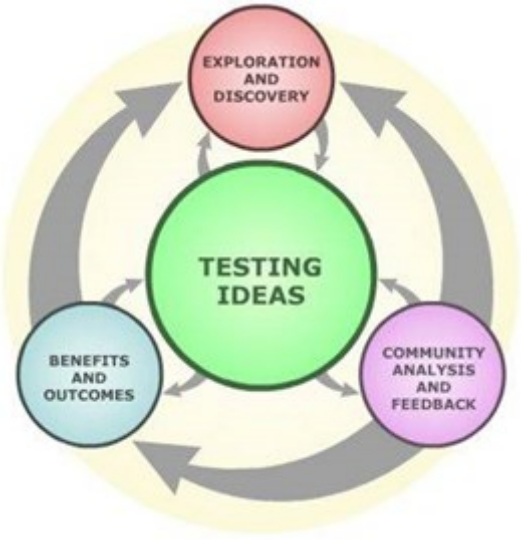
A Mindset, Not a Recipe

The scientific method is a mindset, which basically amounts to "let nature speak". Despite what you may have been taught elsewhere, the scientific method does not have specific "steps," and does not necessarily require a hypothesis.

The scientific method looks more like a map, with testing ideas (experimentation) at the center:



from the *Understanding Science* website[1]

[1] Understanding Science. 2018. University of California Museum of Paleontology. 1 July 2018 http://www.understandingscience.org. Used with permission.

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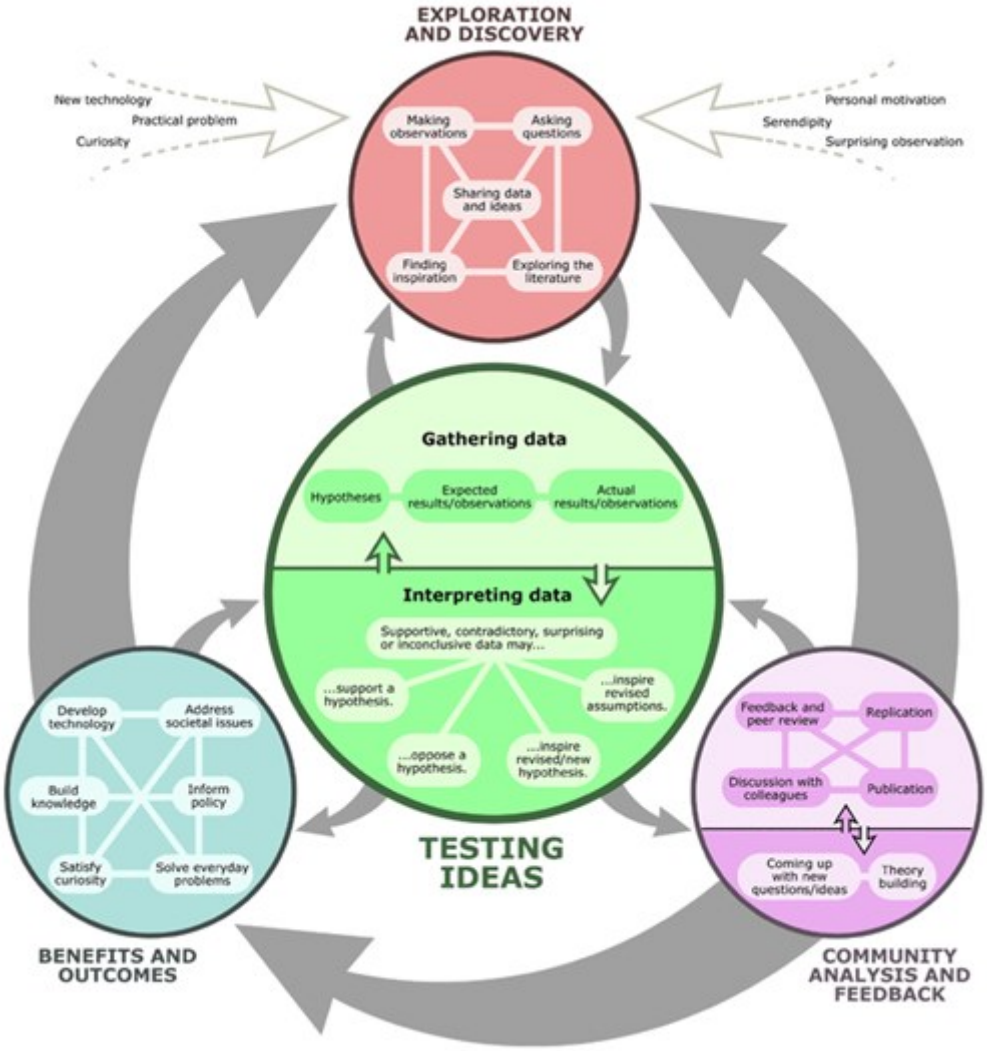
Each of the circles in the above diagram is a broad area that contains many processes:



from the *Understanding Science* website

Use this space for summary and/or additional notes:

When scientists conclude something interesting that they think is important and want to share, they state it in the form of a ***claim***, which states that something happens, under what conditions it happens, and in some cases gives a possible explanation.

Before a claim is taken seriously, the original scientist and any others who are interested try everything they can think of to disprove the claim. If the claim holds up despite many attempts to disprove it, the claim gains support.

peer review: the process by which scientists scrutinize, evaluate and attempt to disprove each other's claims.

If a claim has gained widespread support among the scientific community and can be used to predict the outcomes of experiments (and it has *never* been disproven), it might eventually become a theory or a law.

theory: a claim that has never been disproven, that gives an explanation for a set of observations, and that can be used to predict the outcomes of experiments.

model: a way of viewing a set of concepts and their relationships to one another. A model is one type of theory.

law: a claim that has never been disproven and that can be used to predict the outcomes of experiments, but that does not attempt to model or explain the observations.

Note that the word "theory" in science has a different meaning from the word "theory" in everyday language. In science, a theory is a model that:

- *has never failed* to explain a collection of related observations
- *has never failed* to successfully predict the outcomes of related experiments

For example, the theory of evolution *has never failed* to explain the process of changes in organisms caused by factors that affect the survivability of the species.

If a repeatable experiment contradicts a theory, and the experiment passes the peer review process, the theory is deemed to be wrong. If the theory is wrong, it must either be modified to explain the new results, or discarded completely.

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Theories *vs.* Natural Laws

The terms "theory" and "law" developed organically over many centuries, so any definition of either term must acknowledge that common usage, both within and outside of the scientific community, will not always be consistent with the definitions.

Nevertheless, the following rules of thumb may be useful:

A *theory* is a model that attempts to explain *why* or *how* something happens. A *law* simply describes or quantifies what happens without attempting to provide an explanation. Theories and laws can both be used to predict the outcomes of related experiments.

> For example, the *Law of Gravity* states that objects attract other objects based on their masses and distances from each other. It is a law and not a theory because the Law of Gravity does not explain *why* masses attract each other.
>
> *Atomic Theory* states that matter is made of atoms, and that those atoms are themselves made up of smaller particles. The interactions between these particles are used to explain certain properties of the substances. This is a theory because we cannot see atoms or prove that they exist. However, the model gives an explanation for *why* substances have the properties that they do.

A theory cannot become a law for the same reasons that a definition cannot become a measurement, and a postulate cannot become a theorem.

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