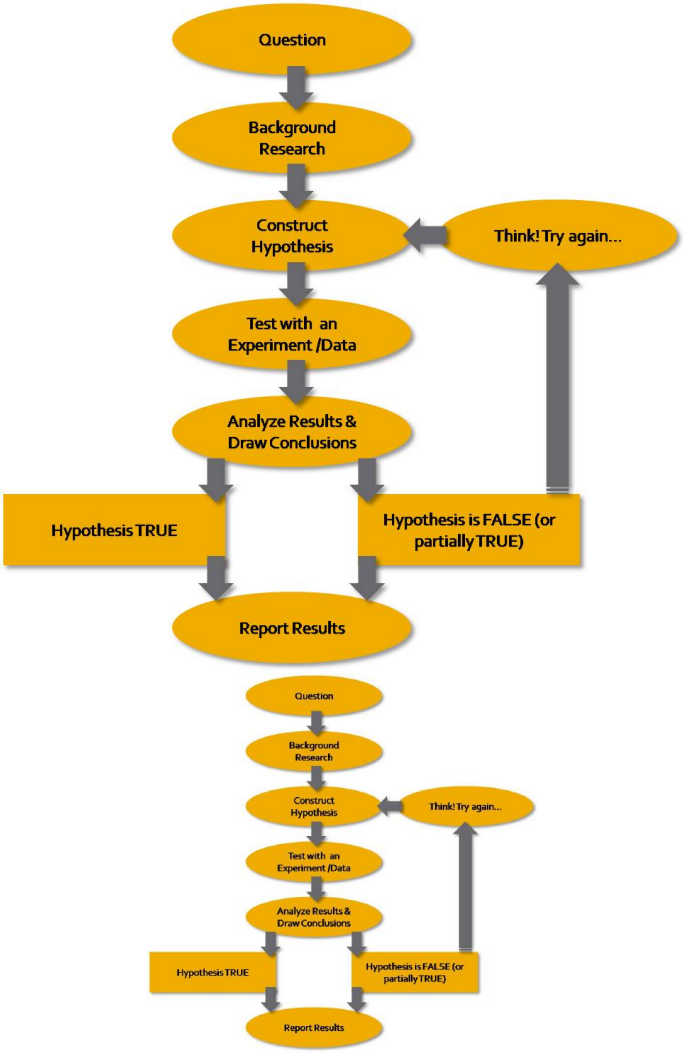
Scientific Method

Skills to Develop

- Understand what is the scientific method and how to apply it

You know what science is. A **method** is a way to do something. The **scientific method** is how scientific knowledge is produced. You have probably learned science before as a set of knowledge that is just given to you, and you have to memorize facts and procedures to follow to get answers. This way of learning that you have probably experienced is completely different from how science professionals think of science and do science. Now it is time to learn science like a scientist. Because scientists create new knowledge, they have to be able to think independently. Even if this seems very hard or unfamiliar, you can learn to make new scientific conclusions yourself.



General flowchart describing the various stages of the scientific method.

The basic steps of the scientific method involve *collecting* observations about what actually happens, *thinking* about what the observations mean, making *guesses* about what will be observed in the future, and then making *observations* to see if the guesses are right. The **observations** are evidence or **data**, the results of experiments. The guesses are usually called **hypotheses**. If the hypotheses fit a lot of data and seem to work well, then they are called **theories**. In science, a **law** describes a pattern of consistent results. For instance, you know that when you drop things, they fall. That could be called the law of gravity. If we had a good explanation of why that happens, we would call that a theory of gravity. Gravity is easy to describe (in Newton's law, which describes how things move on Earth and how planets and moons and stars moves in space) but very hard to explain: how can objects that are very far apart feel a force towards each other?

The real test of whether something is science is whether it works reliably. An experiment is good and useful if you can *repeat it* (if someone different can repeat it) and *get the same result*. There will be some small differences in the data because measurements are always a little imprecise and there might be some small differences in the way the experiment was done, but the data should be the same within the "error range." Likewise, a law is good if observations always follow it within the context it describes. And a theory is good if it explains all the available evidence. For theories, it's also important that it be possible to prove the theory wrong, that it makes predictions that can be tested. Otherwise, it might be true but it isn't useful.

A useful skill for learning science is building "mental models" of how things work. A **model** is a bigger or smaller version of something, depending on the size of the original object, that shows all its parts and how they are related. For instance, an architect builds a small 3-D model of a new building before people start constructing the building. The architect also has complex computer models of the building showing how it stays up, how the doors don't bump into each other, etc. These models help the architect predict whether their design will be successful or not.

3-D model of a building

Summary

The **scientific method** is a structured approach to gathering and analyzing data, and drawing conclusions about various subjects or phenomena. **Observations** consist of evidence or data that may verify or falsify ideas about what actually happens in a given event. These ideas are usually **hypotheses**, educated guesses about how or why the particular event occurred which could lead to experiments to test the guesses. If a hypothesis seems reasonable and fits with a lot of data through rigorous testing, the hypothesis evolves into a **theory**. Good experiments have replicable results, meaning that other scientists should be able to come up with the same results or conclusions after repeating the experiment. A **scientific law** describes what will be observed in the future given a pattern of consistent results on the phenomenon. A **model** is a visualization of something to show how all of its parts are related.

Other Links

- SciShow: The Times and Troubles of the Scientific Method (11 min)

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