ASHG
American Society of Human Genetics

Understanding the Scientific Method

Scientists in all fields of science use a dynamic, open-ended approach to answer questions. This is known as the scientific method, a logical, problem-solving strategy to find answers that are supported by evidence.

The scientific method is essential because it provides an objective, standardized approach to conducting experiments. Using the scientific method limits the influence of bias and preconceived notions and improves the quality of results.

There are five steps to the scientific method:

1) Make an observation

A scientific investigation usually starts with an observation that catches the scientist's eye and makes them wonder and interested in seeking answers.

2) Ask a question

Observations often lead scientists to ask why something is the way it is.

Example: The Clinical Genome (ClinGen) Resource is an effort funded by the federal government in which scientists ask if certain genes are associated with disease. Beginning with that question, researchers look for answers by using the resources available to them, such as experiment results from other groups who study the gene and disease in question. If they can find multiple examples of a link between a gene and a disease, the strength of the evidence can help to identify the connection between gene and disease to be "definitive," meaning multiple other groups have all found evidence.

3) Form a hypothesis, or testable explanation

A hypothesis is a plausible answer to a question. Scientists form a hypothesis and make predictions that can be tested to challenge the hypothesis.

It is common for a first hypothesis to be wrong — and that's okay! If the evidence does not support one hypothesis, scientists come up with a different hypothesis to test.

4) Gather and analyze data

Scientists can collect evidence, or data, by observing the world around them, performing an experiment, or running a model (a physical, mathematical, or conceptual representation of a real phenomenon). Whatever methods are used, scientists make sure that what was done can be reproduced so other scientists can evaluate their findings. Arriving at the same result when an experiment is repeated is called replication. If research results can be replicated, this adds strength to the evidence and suggests that the findings are more likely than not to be correct.

After the data collection process is completed, scientists organize and analyze the data, looking for patterns and drawing conclusions about whether or not their hypothesis stands.

Example: before the human genome was sequenced, some scientists hypothesized that humans would have many more genes than animals considered to be simpler than humans. With the publication of the Human Genome Project in 2001, we learned that humans have approximately 30,000 genes — about the same number as a mouse!

5) Iterate: Use the results to make new hypotheses

Typically, scientists present their results for review by other scientists at conferences and in scientific journals. People who study human genetics do this at the ASHG Annual Meeting! It can take years to evaluate ideas, replicate data, and confirm a hypothesis.

The Scientific Method in Action

You may have noticed the scientific method in action with public health events like the COVID-19 pandemic. In this case, the need for scientific understanding and solutions has been urgent, so hypotheses have been reported to the public before being fully tested, sometimes leading to contradictions in study results and frequent changes in order to continually update our understanding of the virus and the diseases updates to our understanding of the virus. *What hypotheses have you seen from scientists?*

Although this is how science works, the public usually does not get a front row seat to the process. Now, individuals can follow our scientific understanding of COVID-19 as it unfolds in real time.

The scientific method is a powerful way to understand our world. But one experiment is not definitive — science is an ongoing process, much like pieces of a puzzle coming together to create a complete picture. It takes time to arrive at the best answer based on the knowledge available at the time. As scientific knowledge grows, so will our understanding of the world.