

Scientific Method

A scientific method is a series of steps that help scientists investigate, verify, or construct reliable information about any natural phenomena.

The scientific method has played an important role in the history of mankind as it helps in solving different problems and making discoveries in the world of science. From Galileo's experiment in the year 1500s to current research in the field of medical science, biotechnology, and genetic engineering.

Solving a Problem

In the field of biology, new theories have been formed and older theories modified or altered based on experimentation. The exact steps of the scientific method may vary according to the situation but they generally include the following steps in solving a biological problem:

- ❖ Making Observations
- ❖ Asking questions
- ❖ Formulating the hypothesis
- ❖ Experimentation
- ❖ Analyze Data
- ❖ Conclusions and Results

The details of the steps are as follows:

Making Observations Asking Questions

The first step of solving a biological problem is making an observation and identifying a question. Biologists observe the situation and recall the old observations and make new ones by the use of the five senses smell, taste, hearing, vision, and touch. Observations are of two types: qualitative observations and quantitative observations. Quantitative observations are more reliable and

Man has always been a biologist. Early humans existed in hunter-gatherer societies where observations about animals and their habitats were made. Humans also learn to grow fruits and vegetables as well as they became able to differentiate between edible and non-edible plants. This was achievable by using the scientific method and experimentation, although it may have been less formal than it is today.

accurate than qualitative observations because quantitative are measurable. They can be further understood with the help of the following examples (shown in Fig 1):

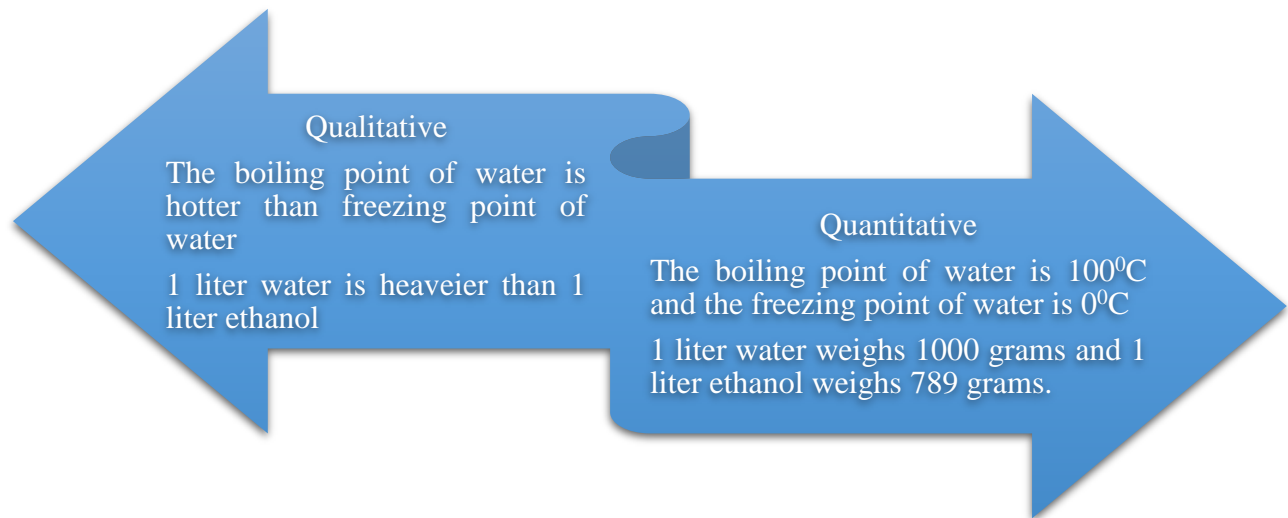


Fig 1. Examples of Qualitative and Quantitative Observations

Asking Questions

After making observations, scientists develop a question about their observation. For example, a scientist may wonder why some plants in their garden are dying while others are not even though they are getting the same amount of water.

- Observation-Some plants are dying.
- Questions-Why are some plants dying and others not?

Research

After the observation and question are formed, scientists conduct research to determine what is already known about the question. Researching the specific topic helps scientists understand what was done in the past regarding the topic and the scientific knowledge that already exists.

- Research- A scientist could research the nutrients that plants need or diseases that plants get to determine if they could be the cause of the plants dying.

Formulating the Hypothesis

A hypothesis can be described as a proposed explanation for the way a particular aspect of the natural world functions.

- The hypothesis should agree with the available observations
- The hypothesis should be testable and potentially falsifiable which means that there should be a way to prove that hypothesis is incorrect or false.
- A hypothesis is often written as an “if-then-because” statement.

Example: If the dying plants are given nitrogen fertilizer then they will survive because nitrogen is a critical plant nutrient.

Biologists can not always apply the hypothesis in every situation. For example, if the hypothesis is “all plant cells have a nucleus” then it will be difficult for biologists to study every plant cell on the earth, hence biologists will deduce the hypothesis in such a way that can prove his point as “if we examine the blade of a grass then each plant cell will have a nucleus”. It is a logical reasoning

Experimentation

It is the most basic and important step in biological problem-solving. A biologist will perform controlled experiments based on the hypothesis to determine if the hypothesis is true or false.

Control in Experiments When experimenting, a biologist will have two groups control group and an experimental group. The two groups will be treated equally except for one variable which is being tested. The control group **serves as a standard for comparison** so the scientist can determine if the variable had any effect on the experimental group.

Example: The scientists split the dying plants into two groups. One group gets nitrogen fertilizer while the other group does not. In this example, the control group is the group that does not receive the nitrogen fertilizer.

Recall

Photo means “light” and synthesis means “making of” so the term “Photosynthesis” is the making of food with the help of

Analyze Data

After conducting an experiment scientists will analyze the data. Scientists use the data to determine if the hypothesis is true or false. Scientists organize data into tables, charts, and graphs to help them see and communicate patterns more easily.

Conclusion and Results

Biologists gather all the quantitative and qualitative and come to a conclusion. Biologists publish their findings and conclusions in articles and journals after their peers have reviewed their work to ensure it is repeatable. Publishing the results is a crucial step as it will give other scientists access to work on the same or different related biological problems and will help in understanding the situations.

Theory and Hypothesis

When a hypothesis is given repeated exposure and has supported evidence from different experiments then it becomes a theory. The hypothesis that stands the test of time (often tested and never rejected) is known as theory. An example is the theory of evolution.

Review

1. What are the steps of the scientific method?

- ❖ Making Observations
- ❖ Asking questions
- ❖ Formulating the hypothesis
- ❖ Experimentation
- ❖ Analyze Data
- ❖ Conclusions and Results

2. What is the importance of a control in an experiment?

Controls serve as a standard for comparison. It is important because it allows the scientist to know if the independent variable had an effect.

3. Differentiate between

a. Qualitative and Quantitative Observations

Qualitative observations are based on observations made with the senses whereas quantitative observations are based on measurements done with tools and often involve quantities or numbers.

b. Theory and Hypothesis

A hypothesis that stands the test of time can become a theory after it is well tested.

4. Write a hypothesis about an observation you made recently.

Answers will vary

References

<https://www.sciencebuddies.org/science-fair-projects/science-fair/steps-of-the-scientific-method>

<https://byjus.com/physics/scientific-methods/>