**Definition of Terms, Branches of Science, Scientific method and its Limitations**

**I. DEFINITION OF TERMS**

**SCIENCE**

Science may be defined as the system of knowledge of the natural world gained through the scientific method. It was originally called “ philosophy of the natural world” since it is stemmed from the ancient Greeks’ to know about nature. Thus,  the first scientists were called “ philosophers of nature. ” They sought to discover the truth behind material things and natural things. It was the task of philosophers to  observe the world and beyond, and to discover what makes materials the same and what makes them different (McNamara et al., 2018).

**TECHNOLOGY**

Meanwhile, the term technology comes from the Greek words “tekhne” which means “art or craft”, and “logia”, which means “subject or interest.” Taken together, the term has come to mean the applications of what we know about nature” using scientific principles for the betterment of human situation **(McNamara et al., 2018).**

**SOCIETY**

The term society emerged in the fifteenth century and is derived from the French *société*. The French word, in turn, had its origin in the Latin *societas*, a "friendly association with others," from *socius* meaning "companion, associate, comrade or business partner." Essential in the meaning of society is that its members share some mutual concern or interest, a common objective or common characteristics, often a common [cultureLinks to an external site.](https://www.newworldencyclopedia.org/entry/Culture" \t "_blank).

A society is characterized by common interest and may have distinctive culture and institution. It might be a nation such as the Philippines, a particular ethnic group like Igorot, a broader cultural group like Eastern Society or Western Society. A society may also include an organized group of people with political, cultural, religious, patriotic and other purposes (New World Encyclopedia).

**ABOUT SCIENCE, TECHNOLOGY AND SOCIETY (STSC)**

Science, Technology & Society (STSC) examines the social contexts and consequences of science and technology.

* In a wide array of courses, STSC students learn to think critically about questions such as: Why does modern science look the way it does?
* How and why do particular technologies and technological systems emerge, expand and become obsolete?
* How do science and technology sometimes exacerbate race, gender and class inequalities, and how might they be changed to reduce them?
* How do science and technology shape society, and how does society shape science and technology?

**STS courses teach students to:**

1.Analyze the interplay of social factors that have resulted in particular scientific and 2. technological outcomes both in the present and in the past.

2.Read scientific, technological and historical texts critically, assessing their social, cultural and political origins and ramifications.

3.Pursue research projects using published sources, technical and scientific data and unpublished archival materials.

4.Deploy evidence and reasoning to build strong arguments about the relationships between science, technology and society.

**II. BRANCHES OF SCIENCE**

The Broad area of science can be categorized according to the following table with four main branches

|  |  |  |  |
| --- | --- | --- | --- |
| Natural Science  or Pure science  Pure Science is a science that derives theories and predictions.  Pure sciences deals with the study of natural phenomena through observation, experimentation and use of scientific methods | Formal Science  Deals with abstract concepts; uses mental faculties | Social Science  behavior of individuals and groups | Applied Science  "Technology" focuses on developing a product that can be used in solving world problems |
| Examples: | | | |
| 1.Physical Science-non living things      Physics      Chemistry      Earth Science      Astronomy  2. Life Science-living things      Biology      Zoology      Botany     Microbiology      Molecular           Biology | Mathematics  Logic  Statistics | History  Economy  Sociology  Law  Science education  Archaeology  Political Science  Psychology | Engineering  Civil  Electrical  Chemical  Industrial  electronics  Mechanical  Computer science  Medicine  Pharmacy  Dental care |

**Interdisciplinary science**

Science isn’t always easily divided into branches as there is much overlap between them. When we consider all of the different science subject areas. It can introduce a new study area by combining two of these science subjects.

1. Biology and Chemistry = Biochemistry
2. Geology and Physics =Geophysics
3. Astronomy + Biology + Physics =Astrobiophysics
4. Study life in outer space = Astrobiology
5. Geology and biology =Geobiology

Moreover, Branches of science may also overlap with subjects outside of the natural science field, such as mathematics, social sciences and philosophy.

Biology from natural sciences and statistics =Biostatistics

**III.  SCIENTIFIC METHOD**

The **SCIENTIFIC METHOD** is step- by- step method used to solve problems and explain phenomena. The development of the scientific method coincided with changes in philosophy underpinning scientific discovery, radically transforming the views of society about nature.

During the European Renaissance, individuals such **as Francis Bacon, Galileo, and Isaac Newton** formalized the concept of the scientific method and put it into practice. Although the scientific method has been revised since its early conceptions, much of the framework and philosophy remains in practice today.

**Step 1: The Observation and Question**

Prior to investigation, a scientist must define the question to be addressed. This crucial first step in the scientific process involves observing some natural phenomena of interest. This observation should then lead to a number of questions about the phenomena. This stage frequently requires background research necessary to understand the subject matter and past work on similar ideas. Reviewing and evaluating previous research allows scientists to refine their questions to more accurately address gaps in scientific knowledge. Defining a research question and understanding relevant prior research will influence how the scientific method is applied, making it an important first step in the research process.

An everyday example: You are trying to get to school or work and your car won’t start. The thought process that most people go through in that situation clearly mirrors the official scientific method (after you are finished getting upset). First, you make an observation: my car won’t start! The question that follows: why isn’t it working?

**Step 2: The Hypothesis**

The next step is making a hypothesis, based on prior knowledge. A hypothesis is an “**uncertain explanation”** or an unproven conjecture that seeks to explain some phenomenon based on knowledge obtained while executing subsequent experiments or observations. Generally, scientists develop multiple hypotheses to address their questions and test them systematically.

All hypotheses must meet certain criteria for the scientific process to work. First, a hypothesis must be testable and falsifiable. This aspect of the hypothesis is critical and of much greater importance than the hypothesis being correct. A testable hypothesis is one that generates testable predictions, addressed through observations or experiments. A falsifiable hypothesis is one that, through observation of conflicting outcomes, can be proven wrong. This allows investigators to gain more confidence over time, not by accumulating evidence showing that a hypothesis is correct, but rather by showing that situations that could establish its falsity do not occur.

**Hypotheses come in two forms:**

1. The **null hypothesis** is tested against the alternative hypothesis and reflects that there will be no observed change in the experiment.
2. The **alternative hypothesis** is the predicted outcome of the experiment. If the null hypothesis is rejected, then this builds evidence for the alternative hypothesis.

**An everyday example:**Maybe it is freezing outside and therefore it is fairly likely that your car battery is dead. Maybe you know you were low on gas the night before and therefore it is likely that the tank is empty.

**Step 3: Experimentation and Data Collection**

Either way, the next step is to make more observations or to conduct experiments leading to conclusions. Following the formulation of hypotheses, scientists plan and conduct experiments to test their hypotheses. These experiments provide data that will either support or falsify the hypothesis.

**Data can be collected from quantitative or qualitative observations.**

**Qualitative information** refers to observations that can be made simply using one's senses, be that through sight, sound, taste, smell, or touch.

**In contrast, quantitative observations** are ones in which precise measurements of some type are used to investigate one's hypothesis.

An experiment is a procedure designed to determine whether observations of the real world agree with or refute the derived predictions in the hypothesis. If evidence from an experiment supports a hypothesis, that gives the hypothesis more credibility. This does not indicate that the hypothesis is true, as future experiments may reveal new information about the original hypothesis.

**Experimental design** is another critical step in the scientific method and can have a great effect on the results and conclusions one draws from an experiment. Careful thought and time should be devoted to experimental design and minimizing possible errors. The experiment should be designed so that every variable or factor that could influence the outcome of the experiment be under control of the researcher.

**Two types of variables are used to describe the conditions in an experiment:**

1. **The independent** variable is directly manipulated or controlled by the scientist and is generally what one predicts will affect the dependent variable.
2. **The dependent, or response, variable thus depends** on the value of the independent variable.

Experiments are generally designed so that one specific factor is manipulated in the experiment in order to illuminate cause and effect relationships.

**An everyday example:** Does the car still have all of its parts? Is this the right key? What does the gas gauge say? Does a jump start help?

Another important aspect in experimental design is the role of the **control treatment**, which represents a non-manipulated treatment condition.

 The control treatment is kept in the same conditions as the experimental treatment, but the experimental manipulation is not applied to the control. For example, if a researcher were testing the effects of soil salinity on plant growth, the soil in the control treatment would have no added salt. The control provides a baseline of “normal” conditions with which to compare the experimental treatments.

**Experimental design** should also incorporate replicates of each treatment. Repeatability of experimental results is an important part of the scientific method that ensures the validity and accuracy of data. It is quite difficult to control all aspects of an experiment so there is inherent variation in results that cannot be controlled for even under the most carefully designed and controlled experiments. Having replicates enables an investigator to estimate this inherent variation in results. Precise recording and measurement of data is also of great importance for ensuring the accuracy of results and the conclusions one draws from the results.

When direct experimentation is not possible, scientists modify the scientific method. In fact, there are probably as many versions of the scientific method as there are scientists!

But even when modified, the goal remains the same: to discover cause and effect relationships by asking questions, carefully gathering and examining the evidence, and seeing if all the available information can be combined in to a logical answer.

**Step 4: Results and Data Analysis**

The next step in the scientific method involves determining what the results from the experiment mean. Scientists compare the predictions of their null hypothesis to that of their alternative hypothesis to determine if they are able to reject the null hypothesis. Rejecting the null hypothesis means that there is a significant probability that values of the dependent variable in the control versus experimental treatments are not equal to each other. If significant differences exist, then one can reject the null hypothesis and accept the alternative hypothesis. Conversely, the investigator may fail to reject the null hypothesis, meaning the treatment has no effect on the results. Before scientists can make any claims about their null hypothesis from their experimental data or observations, statistical tests are required to ensure the validity of the data and further interpretation of the data. Statistical tests allow researchers to determine if there are genuine differences between the control and experimental treatments. From there, they can create figures and tables to illustrate their findings.

**Step 5: Conclusions**

The last portion of the scientific method involves providing explanations of the results and the conclusions that can be logically drawn from the results. Generally, this step of the scientific process also requires one to revisit scientific literature and compare their results with other experiments or observations on related topics. This allows researchers to put their experiment in a more general context and elaborate on the significance of particular results. Additionally, it allows them to explain how their work fits into a larger context in their discipline.

The scientific process does not stop here! The scientific process works through time as knowledge on topics in science accumulate and drive our understanding of particular mechanisms or processes explaining natural phenomena. If we fail to reject our null hypothesis, then it becomes necessary to revisit the initial stages of the scientific method and try to reformulate our questions and understand why an anticipated result was not attained.

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**Step 6. Communicate Results.** Communicate your results to others in a final report and/or a display board. Professional scientists do almost exactly the same thing by publishing their final report in a scientific journal or by presenting their results on a poster or during a talk at a scientific meeting.

**Step 7. Formulate Theory and Law** ( not all researches reaches this step).

A **scientific theory** is a broad explanation that is widely accepted because it is supported by a great deal of evidence. Because it is so well supported, a scientific theory has a very good chance of being a correct explanation for events in nature. Because it is a broad explanation, it can explain many observations and pieces of evidence. In other words, it can help connect and make sense of many phenomena in the natural world.

**Scientific theories** are more overarching explanations of how nature works and why it exhibits certain characteristics.

**Scientific Laws** are descriptions — often mathematical descriptions — of natural phenomenon; for example, Newton's Law of Gravity or Mendel's Law of Independent Assortment. These laws simply describe the observation. Not how or why they work.

**Theories** explain why we observe what we do and laws describe what happens.

**Application of the Scientific Method**

The only difference between the use of this method in every-day life and in the laboratory is that scientists carefully document their work, from observation to hypothesis to experiment, and finally conclusions and peer review. In addition, unlike problem solving outside the lab, the scientific method in the lab includes controlled conditions and variables.

Let’s investigate the scientific method using an example from the lab. It is known that plant growth is affected by microbes, such as bacteria and fungi, living in their soil. It is possible to figure out what microbes have which effects by potting plants in completely sterile soil, then adding in microbes one at a time, or in different combinations and measuring the growth of the plant. Now let’s fit this into the terms used to describe the scientific method:

**Observation and Question**: There are microbes in the soil…do these affect plant growth?

**Hypotheses:**

**Experimental:** One particular microbe of interest will cause the plants to grow more slowly.

**Null**: The presence or absence of microbes will have no effect on plant growth.

**Experiment**: Set- up groups of plants in 1) sterile soil, 2) soil with the microbe added in, and 3) natural soil.

Measure the growth of the plants over time, using a ruler. Present and analyze data.

**Group 1** is a**control** which shows the plants can grow in the sterile soil.

**Group 2** is the experimental group. It would be possible to add different amounts of the microbe, or different microbes, to introduce more variables. The main point is that the researcher has something to which to compare the experimental group- the control group. If the experiment included only group 2 and the researcher determined that the plants “looked sick,” that would be a matter of opinion.

**Group 3** is a control that shows the plants can grow under normal conditions.

The only way to make that observation scientific is to have healthy plants to measure. The type or amount of microbe used is the **independent variable**, because the researcher has control over it. The size of the plant at the end of the experiment is the **dependent or response variable** because it is the result.

**Conclusion**: if the plants in group 2 grow more slowly than the other two, the hypothesis is supported. This needs to be backed up with statistical analysis from many plants to be considered significant. An experiment like this is not legitimate with just one plant per group.

 Ultimately, work like this is published in scientific journals so that other researchers can read about the methods used and conclusions drawn. Publications like this are subject to peer-review, which means that an article won’t be published in a journal until other researchers have checked it out and agree it is well-done. As a community of scientists, general concepts are developed based on observed patterns in the experiments that individual scientists conduct. This results in the development of a scientific **theory**. This term means that there is a consensus among researchers that a particular concept or process exists. It is important to note that the word theory does not mean the same thing as hypothesis. Once scientists label a concept with this term, it is considered to be true, considering all currently available data. Of course, if a large body of experimentation demonstrates information to the contrary, theories can be modified.

**Example A. Steps of Scientific Method**

1. **Observation:** My toaster doesn’t work.
2. **Question:** Is something wrong with my electrical outlet?
3. **Hypothesis:** If something is wrong with the outlet, my coffeemaker also won’t work

             when  plugged into it.

1. **Experiment:** I plug my coffeemaker into the outlet.

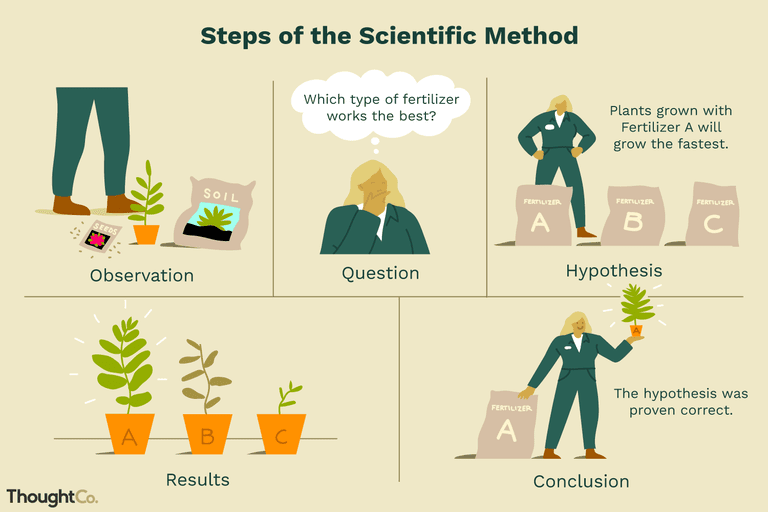
             Result: My coffeemaker works!

1. **Conclusion:** My electrical outlet works, but my toaster still won’t toast my bread.

             Refine the hypothesis: My toaster is broken.

From this point, the process would be repeated with a refined hypothesis.

**Example B. Steps of Scientific method**



**IV. LIMITATIONS OF THE SCIENTIFIC METHOD**

Clearly, the scientific method is a powerful tool, but it does have its limitations. These limitations are based on the fact that a hypothesis must be testable and falsifiable and that experiments and observations be repeatable. This places certain topics beyond the reach of the scientific method.

Science cannot prove or refute the existence of God or any other supernatural entity. Sometimes, scientific principles are used to try to lend credibility to certain nonscientific ideas, such as [intelligent designLinks to an external site.](https://people.howstuffworks.com/intelligent-design.htm). Intelligent design is the assertion that certain aspects of the origin of the universe and life can be explained only in the context of an intelligent, divine power. Proponents of intelligent design try to pass this concept off as a scientific theory to make it more palatable to developers of public school curriculums. But intelligent design is not science because the existence of a divine being cannot be tested with an experiment.

Science is also incapable of making value judgments. It cannot say [global warmingLinks to an external site.](https://science.howstuffworks.com/environmental/green-science/global-warming.htm) is bad, for example. It can study the causes and effects of global warming and report on those results, but it cannot assert that driving SUVs is wrong or that people who haven't replaced their regular [light bulbsLinks to an external site.](https://home.howstuffworks.com/light-bulb.htm) with compact [fluorescentLinks to an external site.](https://home.howstuffworks.com/fluorescent-lamp.htm" \t "_blank) bulbs are irresponsible. Occasionally, certain organizations use scientific data to advance their causes. This blurs the line between science and morality and encourages the creation of "pseudo-science," which tries to legitimize a product or idea with a claim that has not been subjected to rigorous testing.

And yet, used properly, the scientific method is one of the most valuable tools humans have ever created. It helps us solve everyday problems around the house and, at the same time, helps us understand profound questions about the world and universe in which we live.