

TENNESSEE

Miller & Levine
Biology

Lesson Overview

1.1 What Is Science?



What Science Is and Is Not



What are the goals of science?



One goal of science is to provide natural explanations for events in the natural world. Science also aims to use those explanations to understand patterns in nature and to make useful predictions about natural events.

What Science Is and Is Not

Biology is not just a collection of never-changing facts or unchanging beliefs about the world.

Some scientific “facts” will change soon—if they haven’t changed already – and scientific ideas are open to testing, discussion, and revision.

Science as a Way of Knowing

Science is an organized way of gathering and analyzing evidence about the natural world.

For example, researchers can use science to answer questions about how whales communicate, how far they travel, and how they are affected by environmental changes.

Science as a Way of Knowing

Science deals only with the natural world.

Scientists collect and organize information in an orderly way, looking for patterns and connections among events.

Scientists propose explanations that are based on evidence, not belief. Then they test those explanations with more evidence.

The Goals of Science

The physical universe is a system composed of parts and processes that interact. All objects in the universe, and all interactions among those objects, are governed by universal natural laws.

One goal of science is to provide natural explanations for events in the natural world.

Science also aims to use those explanations to understand patterns in nature and to make useful predictions about natural events.

Science, Change, and Uncertainty


Despite all of our scientific knowledge, much of nature remains a mystery. Almost every major scientific discovery raises more questions than it answers. This constant change shows that science continues to advance.

Learning about science means understanding what we know and what we don't know. Science rarely “proves” anything in absolute terms. Scientists aim for the best understanding of the natural world that current methods can reveal.

Science has allowed us to build enough understanding to make useful predictions about the natural world.

Scientific Methodology: The Heart of Science

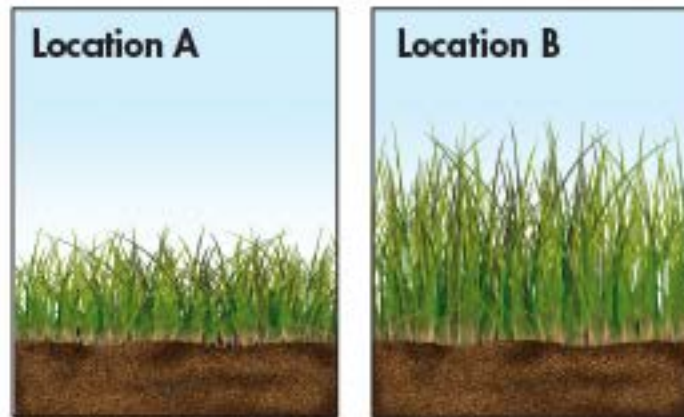
 What procedures are at the core of scientific methodology?

 Scientific methodology involves observing and asking questions, making inferences and forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions.

Observing and Asking Questions

Scientific investigations begin with **observation**, the act of noticing and describing events or processes in a careful, orderly way.

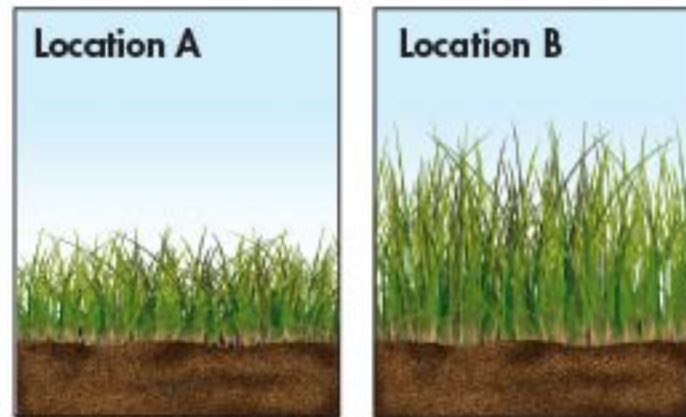
For example, researchers observed that marsh grass grows taller in some places than others. This observation led to a question: Why do marsh grasses grow to different heights in different places?



Inferring and Forming a Hypothesis

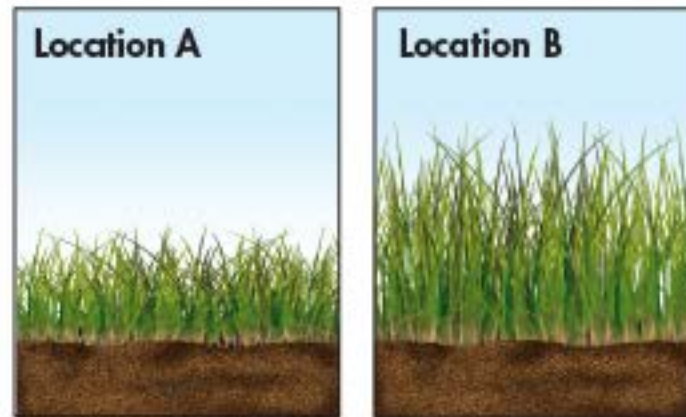
After posing questions, scientists use further observations to make **inferences**, or logical interpretations based on what is already known.

Inference can lead to a **hypothesis**, or a scientific explanation for a set of observations that can be tested in ways that support or reject it.



Inferring and Forming a Hypothesis

For example, researchers inferred that something limits grass growth in some places. Based on their knowledge of salt marshes, they hypothesized that marsh grass growth is limited by available nitrogen.



Designing Controlled Experiments

Testing a scientific hypothesis often involves designing an experiment that keeps track of various factors that can change, or variables. Examples of variables include temperature, light, time, and availability of nutrients.

Whenever possible, a hypothesis should be tested by an experiment in which only one variable is changed. All other variables should be kept unchanged, or controlled. This type of experiment is called a **controlled experiment**.

Controlling Variables

It is important to control variables because if several variables are changed in the experiment, researchers can't easily tell which variable is responsible for any results they observe.

The variable that is deliberately changed is called the **independent variable** (also called the manipulated variable).

The variable that is observed and that changes in response to the independent variable is called the **dependent variable** (also called the responding variable).

Control and Experimental Groups

Typically, an experiment is divided into control and experimental groups.

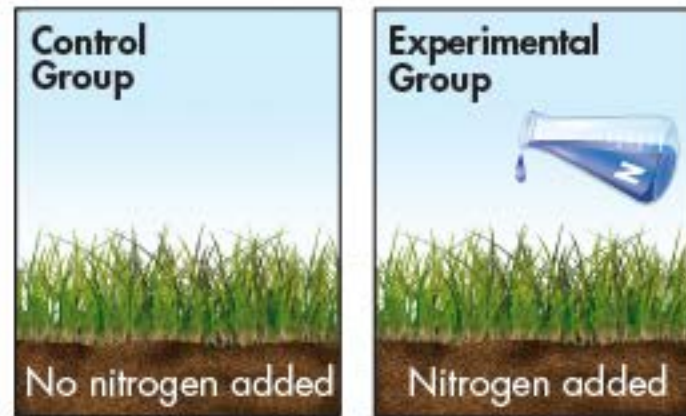
A **control group** is exposed to the same conditions as the experimental group except for one independent variable.

Scientists set up several sets of control and experimental groups to try to reproduce or replicate their observations.

Designing Controlled Experiments

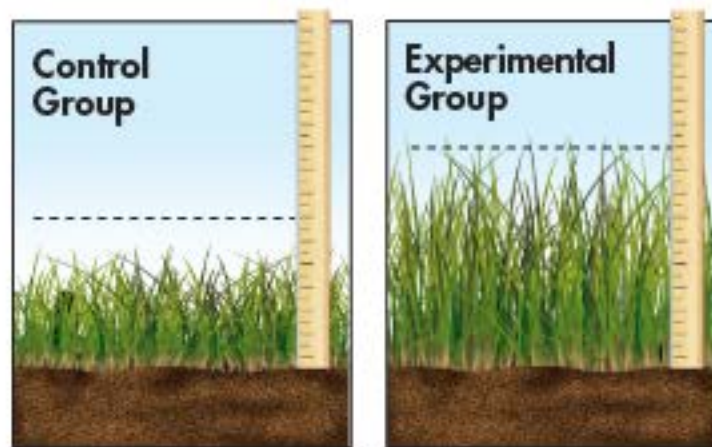
For example, the researchers selected similar plots of marsh grass. All plots had similar plant density, soil type, input of freshwater, and height above average tide level. The plots were divided into control and experimental groups.

The researchers added nitrogen fertilizer (the independent variable) to the experimental plots. They then observed the growth of marsh grass (the dependent variable) in both experimental and control plots.



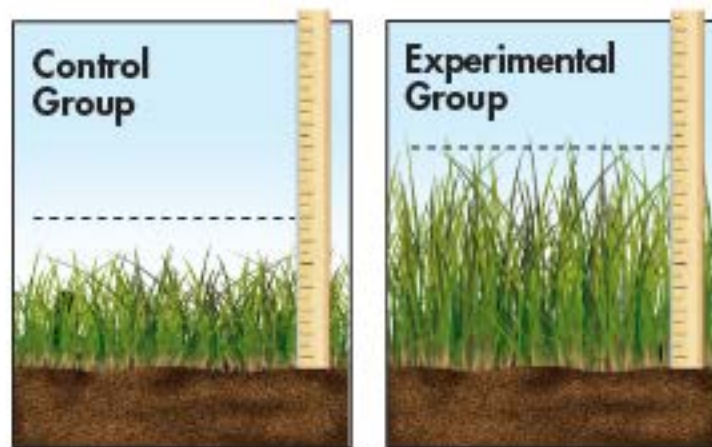
Collecting and Analyzing Data

Scientists record experimental observations, gathering information called data. There are two main types of data: quantitative data and qualitative data.



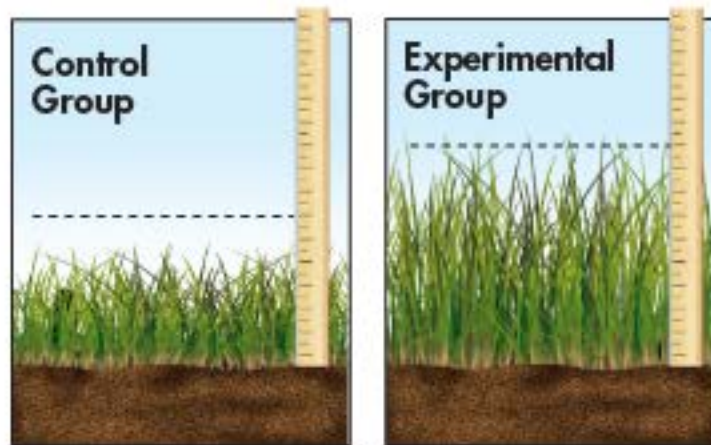
Collecting and Analyzing Data

Quantitative data are numbers obtained by counting or measuring. In the marsh grass experiment, it could include the number of plants per plot, plant sizes, and growth rates.



Collecting and Analyzing Data

Qualitative data are descriptive and involve characteristics that cannot usually be counted. In the marsh grass experiment, it might include notes about foreign objects in the plots, or whether the grass was growing upright or sideways.



Research Tools

Scientists choose appropriate tools for collecting and analyzing data. Tools include simple devices such as metersticks, sophisticated equipment such as machines that measure nitrogen content, and charts and graphs that help scientists organize their data.

Sources of Error

Researchers must be careful to avoid errors in data collection and analysis. Tools used to measure the size and weight of marsh grasses, for example, have limited accuracy.

Data analysis and sample size must be chosen carefully. The larger the sample size, the more reliably researchers can analyze variation and evaluate differences between experimental and control groups.

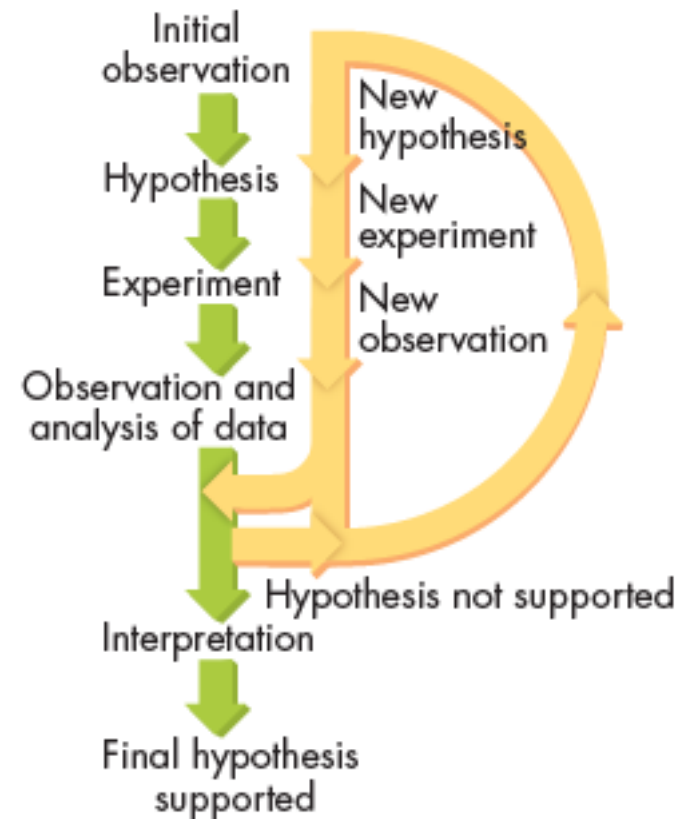
Drawing Conclusions

Scientists use experimental data as evidence to support, refute, or revise the hypothesis being tested, and to draw a valid conclusion.

Drawing Conclusions

New data may indicate that the researchers have the right general idea but are wrong about a few particulars. In that case, the original hypothesis is reevaluated and revised; new predictions are made, and new experiments are designed.

Hypotheses may have to be revised and experiments redone several times before a final hypothesis is supported and conclusions can be drawn.



When Experiments Are Not Possible

It is not always possible to test a hypothesis with an experiment. In some of these cases, researchers devise hypotheses that can be tested by observations.

Animal behavior researchers, for example, might want to learn how animal groups interact in the wild by making field observations that disturb the animals as little as possible. Researchers analyze data from these observations and devise hypotheses that can be tested in different ways.

When Experiments Are Not Possible

Sometimes, ethics prevents certain types of experiments—especially on human subjects.

For example, medical researchers who suspect that a chemical causes cancer, for example, would search for volunteers who have already been exposed to the chemical and compare them to people who have not been exposed to the chemical.

The researchers still try to control as many variables as possible, and might exclude volunteers who have serious health problems or known genetic conditions.

Medical researchers always try to study large groups of subjects so that individual genetic differences do not produce misleading results.