

## Objectives

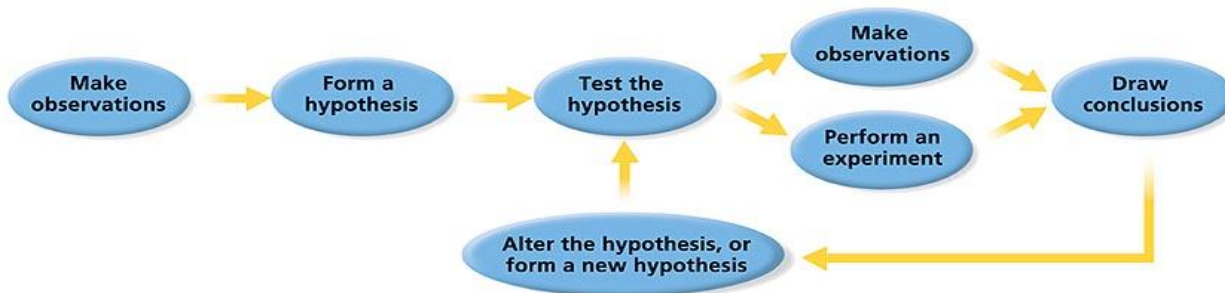
- Explain how science is different from other forms of human endeavor.
- Identify the steps that make up scientific methods.
- Analyze how scientific thought changes as new information is collected.
- Explain how science affects society.

## Behavior of Natural Systems

- The goal of science is to explain natural phenomena.
- Scientists ask questions about natural events and then work to answer those questions through experiments and examination.
- Scientists start with the assumption that nature is understandable.
- Scientists also expect that similar forces in a similar situation will cause similar results.
- Scientists also expect that nature is predictable, which means that the future behavior of natural forces can be anticipated.

## Scientific Methods

- Over time, the scientific community has developed organized and logical approaches to scientific research. These approaches are known as *scientific methods*.
- Scientific methods are not a set of sequential steps that scientists always follow. Rather these methods are guidelines to scientific problem solving.
- The diagram below shows a basic flowchart of scientific methods.



## Ask a Question

- **observation** the process of obtaining information by using the senses; the information obtained by using the senses
- Scientific investigations often start with observations.
- Observations commonly lead to questions.
- Simple questions have fueled years of scientific research and have been investigated through scientific methods.

## Form a Hypothesis

- **hypothesis** an idea or explanation that is based on observation and that can be tested
- Once a question has been asked and basic information has been gathered, a scientist may propose a tentative answer, which is also known as a hypothesis.
- Most hypotheses are based on known facts about similar events.

## Test the Hypothesis

- After a hypothesis is proposed, it is commonly tested by performing experiments. An experiment is a procedure that is carried out according to certain guidelines.
- **independent variable** in an experiment, the factor that is deliberately manipulated
- **dependent variable** in an experiment, the factor that changes as a result of one or more other factors (the independent variables)

## Draw Conclusions

- After many experiments and observations, a scientist may reach conclusions about his or her hypothesis.
- If the hypothesis fits the known facts, it may be accepted as true.
- If the experimental results differ from what was expected, the hypothesis is changed or discarded.
- The results of scientific inquiry may lead to new knowledge and new methods of inquiry that further scientific aims.

## Scientific Measurements and Analysis

- Measurement is the comparison of some aspect of an object or event with a standard unit.
- Scientists around the world can compare and analyze each other's measurements because scientists use a common system of measurements called the *International System of Units*, or SI.

## Accuracy and Precision

- *Accuracy* refers to how close a measurement is to the true value of the thing being measured.
- *Precision* is the exactness of the measurement.

## Error

- Error is an expression of the amount of imprecision or variation in a set of measurements.
- Error is commonly expressed as percentage error or as a confidence interval.

## Observations and Models

- In Earth science, using controlled experiments to test hypotheses is often impossible.
- When experiments are impossible, scientists make additional observations to gather evidence.
- The hypothesis is then tested by examining how well the hypothesis fits or explains all of the known evidence.
- Scientists also use models to simulate conditions in the natural world.
- A model is a description, representation, or imitation of an object, system, process, or concept.
- Scientists use several types of models, including physical models, graphical models, conceptual models, mathematical models, and computer models.

## Acceptance of Scientific Ideas

- Scientific understanding moves forward through the work of many scientists, who build on the research of the generations of scientists before them.
- When scientists reach a conclusion, they introduce their findings to the scientific community.

## Publication of Results and Conclusions

- Scientists commonly present the results of their work in scientific journals or at professional meetings.

- Results published in journals are usually written in a standard scientific format.

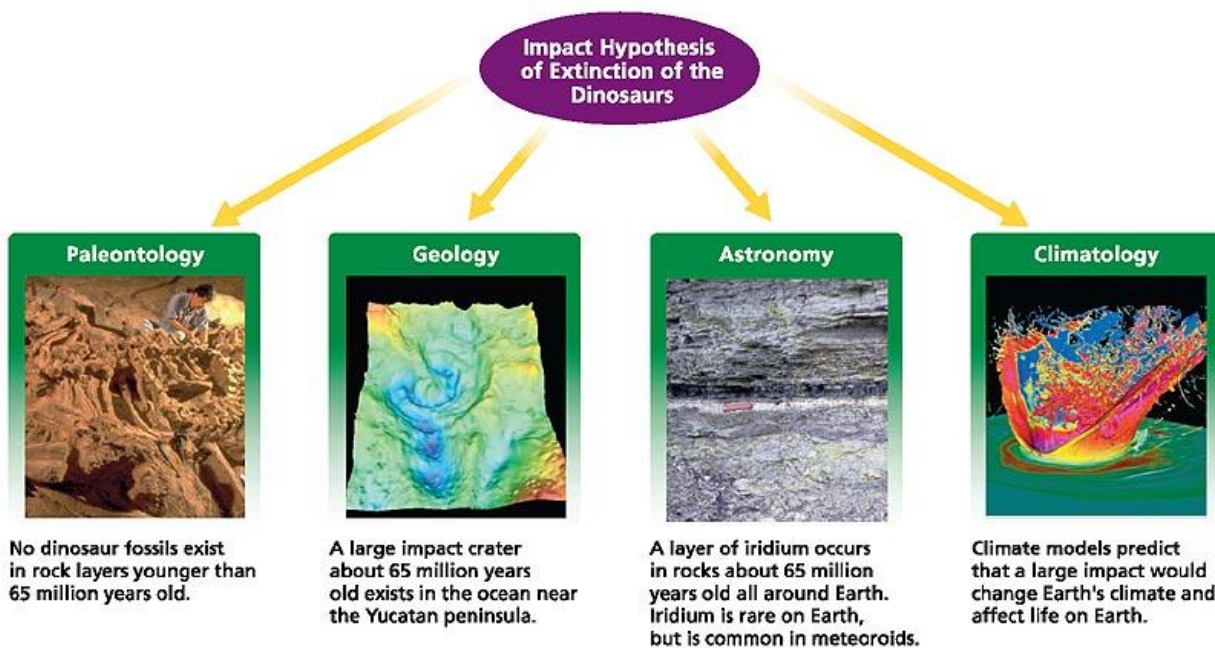
### Peer Review

- Scientists follow an ethical code that states that only valid experimental results should be published.
- To reduce bias, scientists submit their ideas to other scientists for peer review.
- **peer review** the process in which experts in a given field examine the results and conclusions of a scientist's study before that study is accepted for publication

### Formulating a Theory

- When an idea has undergone much testing and reaches general acceptance, that idea may help form a theory.
- **theory** the explanation for some phenomenon that is based on observation, experimentation, and reasoning; that is supported by a large quantity of evidence; and that does not conflict with any existing experimental results or observations
- A scientific law is a general statement that describes how the natural world behaves under certain conditions and for which no exceptions have been found.
- Theories and scientific laws can be changed if conflicting information is discovered in the future.

The diagram below shows how interdisciplinary science helped develop the impact hypothesis of the extinction of the dinosaurs.



### Science and Society

- The work of people, including scientists, is influenced by their cultural and personal beliefs.
- Science is a part of society, and advances in science can have important and long-lasting effects on both science and society.
- Science is also used to develop new technology, including new tools, machines, materials, and processes.
- Sometimes technologies are designed to address a specific human need.
- In other cases, technology is an indirect result of science that was directed at another goal.