

The Tools of Science

(Prologue)

Student Learning Outcomes: Differentiate between science and non-science, apply the scientific method, and develop some tools for interpreting data.

1. *What is science?*
2. *How is science done?*
3. *How is technology different from science?*
4. *What is the measurement system used in science?*
5. *Why are units, equations, and math used in science?*
6. *What do graphs show?*

What is science?

- ❖ A collection of knowledge
- ❖ General rules of nature
- ❖ Laws that have been tested through experimentation
- ❖ **A method of understanding what is observed**

Question: What is the goal of science?

How is science done?

- ❖ The scientific method is an objective, circular process.
- ❖ Laws and observations must be confirmed and reconfirmed.
- ❖ **Each scientist must be able to obtain the same results.**
- ❖ The idea of the **scientific method** is to explain how and why systems work in some consistent manner.
- ❖ Any subject that cannot be tested in a repeatable manner is called **pseudoscience** (non-science).

Observation	Identify patterns. Recognize a question that is not understood.
Hypothesis	Formulate a possible explanation for what has been observed (an educated guess).
Prediction	Use the hypothesis to make predictions.
Experiment	Create an experiment or observation that will provide an answer to the question.
Theory	Formulate a general explanation.
Law	Establish consistency throughout the universe. (theory becomes law)

Example: Setting Sun

Questions:

- 1) What makes the scientific method circular?
- 2) What do you think happens if scientists cannot obtain the same results?
- 3) Can the scientific method be used to answer all questions?
- 4) What are some examples of pseudoscience?

How is technology different from science?

- ❖ Science is the process of understanding how and why the natural world behaves as it does.
 - Science is the basis of new technology.
- ❖ Technology is the use of science to create new tools and products.
 - Technology is often used to advance scientific knowledge.

What is the measurement system used in science?

- ❖ Measurements are an objective tool in science.
- ❖ Measurements can be understood in any language, and can be compared.

❖ Standard units used in science utilize the **metric system**.

Unit	Multiple
kilometer	1 km = 10^3 m
meter	
centimeter	1 cm = 10^{-2} m
millimeter	1 mm = 10^{-3} m
micron	1 μ m = 10^{-6} m
nanometer	1 nm = 10^{-9} m

Questions:

- 1) How many meters are in a millimeter?
- 2) How many centimeters are in 1 kilometer?
- 3) How many nanometers are in a centimeter?

Why are units, equations, and math used in science?

❖ Units are the description of what was measured (mph, inches, lbs, etc).
Units give meaning to numbers.

Example: 60

❖ English units are non-standard in science.

Common measurement	Metric Conversion
mile	1 mile = 1609 meters
	1 mile = 1.609 kilometers
inch	1 inch = 2.54 centimeters
pounds	2.2 pounds = 1 kilogram

Questions:

- 1) A car on the freeway is traveling at 65 mph. How many km/hr is this? How many m/s is this?

2) American astronauts plan to carpet a lounge on the space station. The Americans measure the room and find it to be 10 feet by 12 feet. China will be making the rug and charging \$8 per square meter. How many square meters of carpet need to be purchased?

- ❖ Equations are shorthand for physical concepts. They show how quantities are related (**F = ma**).
- ❖ Measurements, equations, and mathematics describe the universe in the most objective way possible (quantitatively).

Example: Size of a desk

What do graphs show?

- ❖ One way to understand scientific data is to understand the relationship between two sets of numbers.
- ❖ Graphs show how data is related.
- ❖ Three basic relationships are:
 - Linear
 - Quadratic
 - Inverse Square

Example: Brightness and distance

Question: What is the relationship of the graph for the information in the following table? How would you interpret the graph?

Speed (mph)	Time (sec)
15	1
28	2
47	3
62	4
78	5