

**Objectives**

- Define science
- List the steps of the scientific method
- Define and contrast observation and inference
- Record observations of an event
- Create inferences from an observation
- Define and contrast theory and law

Pete Ower 9/5/08 9:35 AM

**Comment:** Explain to the students the purpose of the objectives:

1. Will guide our learning throughout the year.
2. Are the basis for creating test questions.

**The BIG Idea**

- Science is a system of acquiring knowledge based on the scientific method and research.

Pete Ower 9/5/08 9:37 AM

**Comment:** Explain to the students the purpose of the BIG idea:

1. It is the overlying theme that will guide us through this set of notes and usually the entire unit we'll be working on.

**Key Concepts**

- Scientific investigation is how scientists gather information.
- The scientific method is a process.

Pete Ower 9/5/08 9:37 AM

**Comment:** Explain to the students the purpose of the key concepts:

1. These are like the BIG ideas, but they are just for the notes.

**Science is a system**

- The word "science" has many, many definitions. However, we will focus on one general definition. Science is the **human effort to understand** the history of the **natural world** and how the natural world **works** with observable **physical evidence** that supports these ideas.
- Whew! That can be a hard definition to understand. So, in short, science is a system (the process) of people trying to understand how the world works. And, we support our ideas of how the world works with evidence.
- People who study their environments are called **scientists**.
- The terms science and scientist are used to define several jobs and fields.
- For example, this year in science, we will study and explore **earth** and **life** sciences.
  - Earth science focuses on the science of our planet. This includes the study of minerals, **rocks**, oceans, volcanoes, and the **atmosphere**. Scientists often refer to earth science as **geology**

Pete Ower 9/5/08 9:42 AM

**Comment:** Ask, what is a system?

A: A system is a collection of parts that interact with each other to produce an outcome or accomplish an objective.

Pete Ower 9/5/08 9:46 AM

**Comment:** This refers to the data that we can collect. It can be qualitative (descriptive) or quantitative (numerical).

- or **geoscience**. Scientists who study geology are called **geologists**.
- Life science focuses on the science of living organisms. Scientists often to refer to life science as **biology**. Scientists who study biology are called **biologists**.
  - There are many other types of sciences, too.
    - **Physical** science is the opposite of life science. It focuses on the non-**living** side of science. Sciences that are classified as physical science include **physics**, **chemistry** and **astronomy**.
  - Scientists study their environment by asking **questions**.
  - Scientists then find answers to these questions by using **observations**, **inferences**, and the **scientific method**.
  - We often refer to these three things as **investigation**, the process of collecting **evidence**.



What is science?

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Pete Ower 9/5/08 9:48 AM

**Comment:** Explain to the students that we will stop periodically through the notes. During this time we will be reviewing the information that we have learned.

### Scientific investigation is how scientists gather information

- The two most important forms of investigation are **experimenting** and **observing**.
- An experiment is an organized **procedure** to study something under controlled conditions.
- For example, a scientist who finds a rock by the river might notice that it is lighter in color where it is chipped. This scientist might design an experiment to determine why the rock is a different color on the inside.
- Observing is the act of noting and **recording an event**, **characteristic**, or anything else detected with an **instrument** or with the **senses**.
- Observing is when you use one or more of your five sense to gather information about the world around you.

- Hearing a dog bark, counting twelve green seeds, and smelling smoke are all observations.
- An observation must be **factual** and **accurate**—an exact report of what your senses detect.
- This can be very difficult for some people to do. (Which is why we will be practicing it a lot very soon!)
- Let's look at this image.  
What observations can we make about what we see in this picture?



- Read the following statements. Put an "X" next to the statements that are observations.
  - \_\_\_ There is a chicken on the road.
  - \_\_\_ The chicken is crossing the road to get food.
  - \_\_\_ There is a road in the picture with a solid line and a dashed line in the middle of it.
  - \_\_\_ It is a very hot day in the picture.
  - \_\_\_ The chicken escaped from a farm.
- You can see through these examples what it means to be very factual and accurate when making observations. If you do not know something for sure OR if you are making a guess about something, then it is not an observation.
- In fact, when you are explaining or interpreting an observation, you are making an **inference**.
- For example, the statement "the chicken is crossing the road to get food," is an inference. Why? Because it tries to explain WHY there is a chicken on the road. You do not know if the chicken is moving across the road, you do not know if the chicken is going for food (you don't even know if there is food for the chicken!). If you are not 100% absolutely certain that it is true, then you cannot call it an observation.

- When you form an inference about an observation, it is best to use what is called **Ockham’s Razor**. This states that all things being **equal**, the **simplest** explanation is often the best one.
- In other words, keep your inferences simple and realistic. For example, let’s make an inference on this observation: *there is a chicken in the road*. The following are examples of inferences using Ockham’s Razor:
  - The chicken is crossing the road.
  - The chicken is running.
  - The chicken is finding food.
  - The chicken is escaping danger.
- All of these are good examples of a simple inference. They are simple and realistic. Here is what you would get if you did not use Ockham’s Razor (bad examples of inferences):
  - The chicken is a robot designed to attack farmers.
  - The chicken is crossing the road because there is a mad Colonel Sanders trying to make it into the next KFC meal.
  - The chicken is an alien and it is planning to attack the earth.
  - The chicken is about to be run over by a huge semi.

Pete Ower 9/5/08 9:53 AM

**Comment:** Ask the students:

What is another inference you could make that follows Ockham’s Razor?

Explain to the students:  
\*\*Notice how each of these can be a reflection of our observations. Your inferences must match your observations.

Pete Ower 9/5/08 9:53 AM

**Comment:** Notice how these inferences are “out there.” They do not connect well to the observations we made.



What are the two most important ways scientists investigate?  
\_\_\_\_\_

Which of your senses did you use to make an observation about the picture? \_\_\_\_\_



How are an observation and an inference different? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## The scientific method is a process

- The scientific method, also known as scientific **investigation**, is the standard process scientists use to find out more about an observation, idea, or event.
- While the process can vary between scientists, they typically do the following:
  1. **Observe** and **ask a question**. (Also know as the purpose)
  2. Determine what is known through **research**.
  3. Pose a **hypothesis**.
  4. Investigate or **experiment**.
  5. Interpret results or **analyze**.
  6. Form a **conclusion** and **share** results.
- The scientific method is referred to as a **cycle**. Often a scientist will find that their conclusions do not match their hypothesis. Therefore, they will repeat most of the process to see if there were errors. This also means that you change your hypothesis and repeat the process!
- Let's look at each step in more detail.
  1. **Observe and ask a question**
    - This is pretty straightforward. You saw something and now you ask a question about it. (Water takes a long time to freeze. If salt is added to water, will it freeze faster?)
  2. **Determine what is known through research**
    - When beginning an inquiry, scientists find out what is already known about a question. They study **results** from other scientific investigations, read journals, and talk with other scientists, and collect **data**.
  3. **Pose a hypothesis**
    - Forming hypotheses and making predictions are two other skills involved in scientific investigation.
    - A hypothesis is a tentative explanation for an **observation** or scientific problem that can be tested by further investigation. Many hypotheses are written as If-

Pete Ower 9/5/08 9:58 AM

**Comment:** A cycle is never-ending. Even though a scientist may conclude their experiment and come to a correct answer, the process can be started again by another scientist.

If the method "ended," we could never make new discoveries, revise old ideas, and that would just be awful.

Then statements. (Example: If salt is added to water, [then] the water will freeze faster.)

- A prediction is an expectation of what will be **observed** or what will happen. All predictions are **inferences** because you do not know if it is true or not. (Example: Adding salt to the water will make the water freeze faster.)

#### 4. Investigate or experiment

- An experiment is an organized **procedure** to study something under **controlled** conditions.
- An experiment that is controlled is an experiment in which all factors except **one** are kept **constant**. (Example: In this experiment, we will have three containers. 1 – 100 mL water with 10mg salt, 2 – 100mL water with 20mg of salt, 3 – 100mL water with no salt.)
- In our example, we also see what we call **variables**. In this experiment, the **manipulated variable** is the amount of salt added to each container. Other factors, such as the amount of water in each container, the size of the container, and the temperature each container will be exposed to, are constant.
- All of this information would be explained in the **procedure** of the experiment. Here is what the procedure would look like for this experiment.

Pete Ower 9/5/08 9:59 AM

**Comment:** Never-changing, always remains the same.

Pete Ower 9/5/08 9:58 AM

**Comment:** The variable that is being changed.

1. Fill 3 250mL beakers with 100mL of water at 40° F.
2. Add 10g of salt to Container 1; stir.
3. Add 20g of salt to Container 2; stir.
4. Add no salt to Container 3.
5. Place the 3 containers in a freezer.
6. Check the containers every 15 minutes. Record the temperature of the water in each container. Record the appearance of the water in each container.

### 5. Interpret Results or Analyze

- As scientists investigate, they analyze their evidence, or **data**, and begin to draw conclusions.
- Analyzing data involves looking at the evidence gathered through **observations** or **experiments** and trying to identify any **patterns** that might exist in the data.
- Let's look at the data from our experiment.

Temperature of Water in 15-minute intervals

| Time/Cont. | #1    | #2    | #3    | Notes                                                                    |
|------------|-------|-------|-------|--------------------------------------------------------------------------|
| 0 min      | 40° F | 40° F | 40° F | Look the same.                                                           |
| 15 min     | 35° F | 35° F | 35° F | Container 3 is all slushy, other containers are still water.             |
| 30 min     | 30° F | 30° F | XX    | #1 and #2 are slushy. Could not record temperature of #3; it is all ice. |

- What patterns do we notice in the data? We see that every **15** minutes, the temperature of the water is dropping by **5** degrees.
- Patterns aren't always about numbers. For example, we can easily tell that there is a relationship between salt water and the rate at which something freezes.
- What can we determine from our observations? Is the salt making the water freeze faster or slower?
- How does this information compare with the hypothesis?
- As we can see, our hypothesis is **wrong**. So, we need to redo the experiment and **change** our **hypothesis** to reflect the data. (Example: If salt is added to water, *[then]* it will take longer to freeze.) If we find the same data and results, and our hypothesis reflects these results, then we know our hypothesis is true!

## 6. Form a conclusion and share results

- Now we can form our conclusion. (Example: Water with salt takes longer to freeze than water without salt.)
- We can share these results with other scientists. They can test our findings. If they get the same results as we did, then we know that our conclusion is correct. Now, we can call our conclusion a **theory**. (We'll get into what exactly this very soon! It's not what you think it means!)
- We're not done quite yet! We must **repeat** these steps many times (even if we believe we have the correct conclusion). We must do this to ensure that we made no **errors** and that we get the same **results**.



Using the numbers 1-6, put the following steps of the scientific method in the correct order.

- \_\_\_ Investigate or experiment
- \_\_\_ Form a conclusion and share results
- \_\_\_ Interpret results or analyze data
- \_\_\_ Pose a hypothesis
- \_\_\_ Observe and ask a question
- \_\_\_ Determine what is known through research

### A theory is different from a law

- There is a lot of confusion by people on what a theory is in science. This is due to the definition commonly used for theory. In everyday life a theory is a guess. In science, it has a much different meaning.
- In science, a theory is a set of **observations** that have been recorded many times by many different people. It also can be used to explain several events or ideas, not just one.
- For example, there is the theory of relativity. It's a very simple theory and we can talk later about what it is. But more importantly, we can record what it says, observe its effects, and so on. Many, many

people have made these observations and every time the results have been the same. Therefore, we have a theory!

- The same applies to the theory of evolution, the theory of relativity, the big bang theory.... (again, we're not guessing about these things, but experiments and observations have been done by several people and the same conclusions have been met.)
- A scientific law is a statement of **fact** meant to explain an **action** or **set** of **actions**. It usually explains only one **idea** or one **event**.
- All scientific laws must be **true** and **universal** (they must be the same everywhere in the universe) and **simple**.
- Scientific laws can be expressed through mathematical equations. For example, the equation listed here that of Newton's law of gravitation.

$$F = G \frac{m_1 m_2}{r^2},$$



Define theory. \_\_\_\_\_

\_\_\_\_\_

Define law. \_\_\_\_\_

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Sources: McDougal Littell "Earth Science" © 2006.

Prentice Hall "The Nature of Science" © 1993.