Scientists want to understand how the world works. To learn more about the world, they conduct experiments. They use the results to guide their thinking. As new evidence becomes available, their ideas about the world may change. This means that our scientific knowledge is always changing and improving.

**Thinking Like a Scientist:**
Scientists make observations, inferences, predictions, and conclusions.

- **observation**: a statement of what you see, feel, taste, hear, or smell (using the five senses)
  
  *example*: My ice cream has sprinkles on top.

- **inference**: an explanation of something based on your background knowledge and your observations
  
  *example*: My friend grabbed her forehead right after she took a bite of ice cream. I infer that she has “brain freeze.”

- **prediction**: an “educated guess” about what may happen in the future (based on facts)
  
  *example*: Ice cream left outside on a hot day will melt.

- **conclusion**: a summary statement based on the results of an experiment
  
  *example*: Frosty’s ice cream melts the fastest.

**The Scientific Method:**
Scientists conduct experiments in order to answer their questions about the world. They follow a set of procedures known as the **scientific method** (or scientific process). The steps of the scientific method are:

1. **Ask a question**: Scientists ask a question.
2. **Do research**: Scientists research to learn about the topic or problem.
3. **Form a hypothesis**: Scientists form a **hypothesis**, or an “educated guess,” about what they think will happen.
4. **Perform an experiment**: Scientists design and conduct an experiment to test the hypothesis. This might involve several **trials**. They record their **data** (results).
5. **Analyze the data**: Scientists organize and analyze the data.
6. **Draw a conclusion**: Based on the data, scientists will try to draw conclusions about the problem they studied. They may decide to use what they learned to perform a new experiment.
7. **Share the results**: Scientists share their results and conclusions with others.
**Variables:**
Before a scientist can conduct an experiment, he/she has to design how it will work. Every experiment involves variables. **Variables** are factors in the experiment that change or can be changed. They affect the data.

- **independent variable (IV):** the factor that **is changed** by the experimenter (on purpose)
- **dependent variable (DV):** the factor that **changes** because of the independent variable. This is what the experimenter measures.
- **constants:** other factors that can affect the data. The experimenter must keep them constant, or the same, to make sure they don’t influence the results.

When the experimenter forms a hypothesis, he/she is making a prediction about how the independent variable will affect the dependent variable. The hypothesis is usually stated as a cause-and-effect relationship (“if…then”).

**Experimental Design Diagram:**
An experimental design diagram can be used to organize information about a scientific experiment.

For example, someone might ask the question, “Would a lighter toy car travel farther than a heavier toy car when pushed?” To find out, he/she could design an experiment like the one below. In this experiment, the experimenter is changing the weight of a toy car by taping washers on top of it.

<table>
<thead>
<tr>
<th>Title</th>
<th>The Effect of the Weight of a Toy Car on the Distance the Toy Car Travels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypothesis</strong></td>
<td>If the weight of the toy car is increased, then the distance it travels will decrease.</td>
</tr>
<tr>
<td><strong>Independent Variable (IV)</strong></td>
<td>weight of a toy car</td>
</tr>
<tr>
<td><strong>Levels of the IV</strong></td>
<td>0 washers</td>
</tr>
<tr>
<td><strong># of Trials</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Dependent Variable (DV)</strong></td>
<td>distance the toy car travels (when pushed)</td>
</tr>
<tr>
<td><strong>Constants</strong></td>
<td>- toy car</td>
</tr>
<tr>
<td></td>
<td>- type of washer</td>
</tr>
<tr>
<td></td>
<td>- surface the toy car is on</td>
</tr>
<tr>
<td></td>
<td>- starting point of the toy car</td>
</tr>
<tr>
<td></td>
<td>- force of the push</td>
</tr>
<tr>
<td></td>
<td>- meter stick</td>
</tr>
</tbody>
</table>

Other parts of the experiment that need to be considered include the procedures, materials needed, and how and where to record the data.
Types of Data:
Scientists can collect qualitative or quantitative data.
- **Qualitative data** is observable through the senses (i.e., color, texture, smell)
- **Quantitative data** is measurable (i.e., length, time, number of people). It is often displayed in bar graphs and line graphs.

Units of Measurement:
Scientists need to take measurements when they collect quantitative data. For example, they might measure the length, mass, volume, or temperature of an object. The chart below shows different instruments that scientists often use.

<table>
<thead>
<tr>
<th>Scientists Measure…</th>
<th>Metric Units</th>
<th>Instruments</th>
</tr>
</thead>
</table>
| Length               | • millimeters (mm)  
                     | • centimeters (cm)   
                     | • meters (m)          
                     | • kilometers (km)     | • centimeter ruler  
                     | • meter stick         |
| Mass                 | • grams (g)     
                     | • kilograms (kg)     | • scale             
                     | • balance            |
| Volume               | • milliliters (mL)  
                     | • liters (L)         | • graduated cylinder
                     | • beaker             |
| Temperature          | • degrees Celsius (°C) | • Celsius thermometer |
| Elapsed Time         | • days          
                     | • hours          
                     | • minutes        
                     | • seconds        | • stopwatch         
                     | • clock          |

Displaying Data:
Scientists often display data using charts, graphs, and pictures.

<table>
<thead>
<tr>
<th>Month</th>
<th># of Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>20</td>
</tr>
<tr>
<td>May</td>
<td>25</td>
</tr>
<tr>
<td>June</td>
<td>52</td>
</tr>
<tr>
<td>July</td>
<td>95</td>
</tr>
</tbody>
</table>

Book Sales in 2015

<table>
<thead>
<tr>
<th>Month</th>
<th># of Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>20</td>
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<tr>
<td>May</td>
<td>25</td>
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<tr>
<td>June</td>
<td>52</td>
</tr>
<tr>
<td>July</td>
<td>95</td>
</tr>
</tbody>
</table>
Name: ______________________________________

Scientific Investigations Review

**Directions:** Read each statement. Write “O” if it is an observation or “I” if it is an inference.

1. ______  My sister is holding her stomach. She is frowning and groaning.  
   ______  My sister isn’t feeling well.

2. ______  At recess, some children were playing baseball. I heard one of them shout, “Catch it!” When I looked at them, I saw that they were standing still. They were looking at the fence at the back of the baseball field.  
   ______  The ball must have gone over the fence.

**Directions:** Read the sentences. What inference can you make?

3. All of the teachers and students are standing outside of the school in lines.  
   ____________________________

4. On my birthday, my mom told me to stay out of the basement.  
   ____________________________

**Directions:** Use the word bank to complete the sentences below.

- milliliters  stopwatch  temperature
- scale  meter stick  centimeters

5. Scientists measure elapsed time with a ______________________________.

6. A ______________________ or balance can be used to measure an object’s mass.

7. We measured the distance between two apples and recorded the amount in ________________________________.

8. The volume of an object can be measured in ________________________________.

9. You can use a ______________________________ to measure length.

10. ________________________________ is measured in degrees Celsius.
11. Number the steps of the scientific process from first to last.

   ______  Analyze the data.   ______  Form a hypothesis.
   ______  Do research.   ______  Draw conclusions.
   ______  Perform an experiment.   ______  Ask a question.
   ______  Share the results.

Directions: Match the experiment terms with their definitions.

12. ______ constant  
13. ______ dependent variable  
14. ______ independent variable  
15. ______ trial

A. the factor that is changed on purpose by the experimenter
B. the number of times the experiment is repeated
C. the factor that is measured by the experimenter
D. a factor that is controlled by the experimenter so it doesn’t affect the results

Directions: Read the scenario below and answer the questions that follow.

Jackson wants to grow tomato plants in his backyard, but he isn’t sure which brand of potting soil will be the best to help the tomato plants grow. He decided to perform an experiment to find out.

Jackson bought 2 baby tomato plants and 2 identical, large pots. The tomato plants were the same type and the same height. He also bought 2 different brands of soil. “Soil A” had 10 cups of nutrients added to the soil. “Soil B” did not have any extra nutrients added to the soil.

Jackson labeled the pots “Soil A” and “Soil B.” He filled each pot halfway with its type of soil. Then, he planted a baby tomato plant in each pot. He put the pots in the same place in his backyard.

Over the next four weeks, Jackson watched the plants grow. Every day, he watered the pots with the same amount of water. At the end of the four week period, he used a meter stick to measure the height of the plants. He recorded the measurements in the chart below.

<table>
<thead>
<tr>
<th>Brand of Soil</th>
<th>Starting Height</th>
<th>Height after 4 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil A</td>
<td>4 cm</td>
<td>15 cm</td>
</tr>
<tr>
<td>Soil B</td>
<td>4 cm</td>
<td>13 cm</td>
</tr>
</tbody>
</table>

© Alyssa Teaches
Directions: Use the word bank to complete the sentences below. Hint: Not all of the words/phrases will be used!

constant    dependent    independent    conclusion    hypothesis

16. Jackson used 2 different types of potting soil in his experiment. The type of soil is the __________________________ variable.

17. He measured the height of the plants to see which one grew the tallest. The height of the plant is the __________________________ variable.

18. “If a tomato plant is planted in soil with extra nutrients, then it will grow taller than the plant in soil without extra nutrients.”

This statement most likely shows Jackson’s _________________________.

Directions: Answer the questions below.

19. What variables did Jackson keep constant?

____________________________________________________________

____________________________________________________________

20. What other variables could have influenced the growth of the plants?

____________________________________________________________

____________________________________________________________

____________________________________________________________

21. What tool did Jackson use to measure the height of the plants?

____________________________________________________________

22. Look at Jackson’s data. What conclusion could he make at the end of his experiment?

____________________________________________________________

____________________________________________________________

____________________________________________________________

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Scientific Investigations Review

Directions: Read each statement. Write “O” if it is an observation or “I” if it is an inference.

1. ____ My sister is holding her stomach. She is frowning and groaning.
   ____ My sister isn’t feeling well.

2. ____ At recess, some children were playing baseball. I heard one of them shout, “Catch it!” When I looked at them, I saw that they were standing still. They were looking at the fence at the back of the baseball field.
   ____ The ball must have gone over the fence.

Directions: Read the sentences. What inference can you make?

3. All of the teachers and students are standing outside of the school in lines.
   ___________________________________________________________________
   They are having a fire drill.

4. On my birthday, my mom told me to stay out of the basement.
   ___________________________________________________________________
   There is a present or a surprise in the basement that she doesn’t want me to see.

Directions: Use the word bank to complete the sentences below.

| milliliters | stopwatch | temperature |
| scale       | meter stick | centimeters |

5. Scientists measure elapsed time with a __________ stopwatch.

6. A __________ or balance can be used to measure an object’s mass.

7. We measured the distance between two apples and recorded the amount in __________ centimeters.

8. The volume of an object can be measured in __________ milliliters.

9. You can use a __________ meter stick to measure length.

10. __________ Temperature is measured in degrees Celsius.
11. Number the steps of the scientific process from first to last.

   5. Analyze the data.  3. Form a hypothesis.
   2. Do research.  6. Draw conclusions.
   7. Share the results.

**Directions:** Match the experiment terms with their definitions.

12. **D** constant  
    A. the factor that is changed on purpose by the experimenter
13. **C** dependent variable  
    B. the number of times the experiment is repeated
14. **A** independent variable  
    C. the factor that is measured by the experimenter
15. **B** trial  
    D. a factor that is controlled by the experimenter so it doesn’t affect the results

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16. Jackson used 2 different types of potting soil in his experiment. The type of soil is the _____ independent ________________ variable.

17. He measured the height of the plants to see which one grew the tallest. The height of the plant is the _____ dependent ________________ variable.

18. “If a tomato plant is planted in soil with extra nutrients, then it will grow taller than the plant in soil without extra nutrients.”

This statement most likely shows Jackson’s _____ hypothesis ________________.

Directions: Answer the questions below.

19. What variables did Jackson keep constant?

   type of tomato plant, starting height of plant, amount of soil, kind of pot, location in backyard, amount of water, meter stick

20. What other variables could have influenced the growth of the plants?

   temperature, amount of sun/rain, animals, the location he chose for the pots, the kind of tomato plant he used, how deep in the soil he planted the plants, etc.

21. What tool did Jackson use to measure the height of the plants?

   a meter stick

22. Look at Jackson’s data. What conclusion could he make at the end of his experiment?

   Tomato plants planted in soil with added nutrients grow taller than those in soil without extra nutrients. *He should do more trials to be more sure of the results.*
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