

# 2010

## Interactive Laboratory Activities for Secondary Education: Teacher Manual



Office of Her Royal Highness  
Princess Maha Chakri  
Sirindhorn's Projects



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## Table of Contents

Introduction .....	1
Seasons Modeling .....	2
Gravity is a Hammer.....	11
What’s in My Food? .....	18
Precipitation Reactions .....	34
The Colors of the Sun .....	43
References .....	51

## Introduction

The laboratory activities included in this manual were developed as part of a project sponsored by the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects, Chulalongkorn University, and Worcester Polytechnic Institute. The subjects covered include: Astronomy, Physics, Chemistry, and Biology. All materials used in these activities are inexpensive and easily obtained. The activities were designed to promote student engagement, interaction in the classroom, and critical thinking skills. These activities were developed and conducted at the Baan Na Yao School and proven effective. The laboratory activities can be incorporated into any upper secondary education classroom throughout Thailand.

## Seasons Modeling

Adapted from “The Seasons Explained by Refutational Modeling Activities.”(Frede, 2008)

### Teacher Preparation

Begin by reading through the background with the class and having a thorough discussion to insure that they understand the material. The students are provided the same background information that you are, but it is important to cover the information in class to insure they have a complete understanding of the subject matter. After the discussion, have the students complete the pretest independently. They are allowed to use the background as a reference while taking the test. The pre test is intended to measure how well the students’ understood the background material as well as measure their previous knowledge of the subject area.

To conduct the laboratory activity, split the students into groups of 3-4 and provide each group with the materials required to complete the laboratory activity. Read through the procedure aloud so that all the students know what they need to do. While the students are conducting the laboratory activity periodically check in with each group to assist if they have questions.

Once all the groups have completed the activity the students should individually take the post test. The post test is intended to gauge how much the learned from the activity. The students are allowed to use the background as a reference while taking the post test.

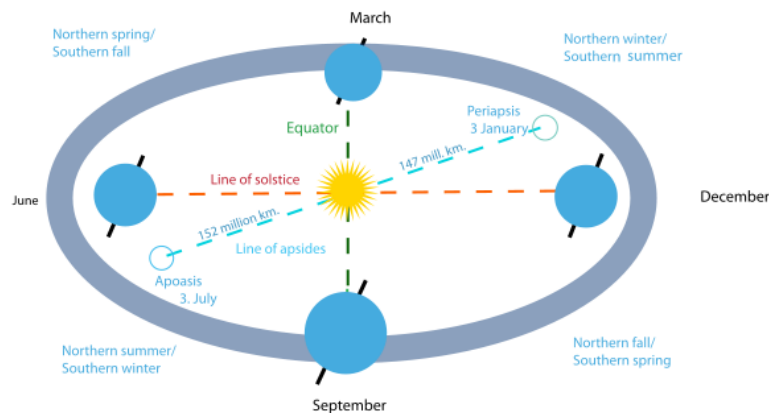
## “Seasons Modeling” Activity

### Concepts

- Seasons
- Earth’s revolution around the Sun

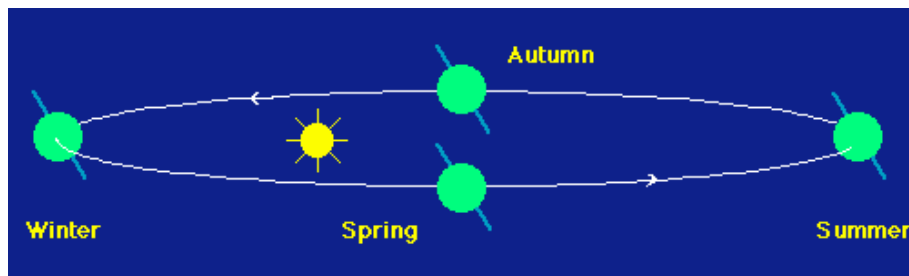
### Background

Seasons result from the yearly revolution of the Earth around the Sun and the tilt of the Earth’s axis relative to the plane of revolution. In the temperate and polar regions, the seasons are marked by changes in the intensity of sunlight that reaches the Earth’s surface, which generate four seasons: spring, summer, autumn, and winter. In the tropical and subtropical areas, there are three seasons: hot, rainy, and cool.



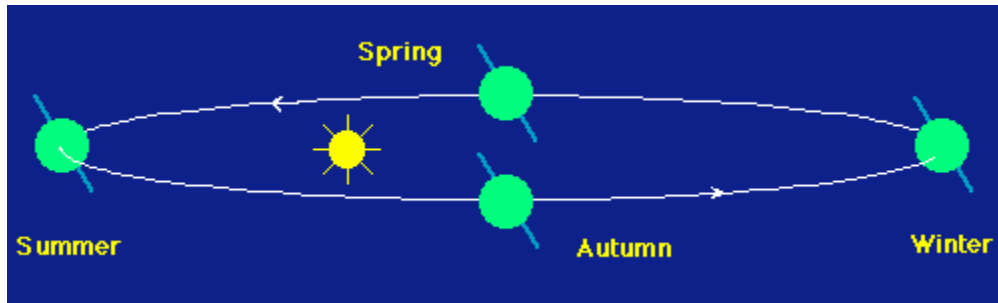
The  $23.5^\circ$  obliquity of the Earth’s rotational axis to its orbital plane.

The earth’s axis is tilted to its orbital plane by an angle of approximately  $23.5^\circ$ , which makes the Northern and Southern Hemispheres have opposite seasons. The Earth goes around its orbit so that the Northern Hemisphere is at various times oriented more toward and more away from the Sun. Therefore, the Sun rises higher in the sky and is above the horizon longer, so the rays of the Sun strike the ground more directly. Likewise, in the Northern Hemisphere in winter, the hemisphere is oriented away from the Sun, the Sun only rises low in the sky, is above the horizon for a shorter period, and the rays of the Sun strike the ground more obliquely. The seasons in the Southern Hemisphere are determined from the same reasoning, except that they are out of phase with the Northern Hemisphere seasons because when the Northern Hemisphere is oriented toward the Sun the Southern Hemisphere is oriented away, and vice versa.



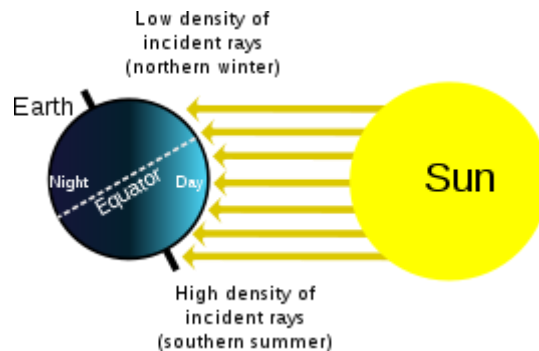
Seasons in the Northern Hemisphere

## "Seasons Modeling" Activity



### Seasons in the Southern Hemisphere

The elliptical orbit of the Earth can cause seasonal differences between hemispheres. Thus, the Earth orbits closest to the Sun in January and is farthest from the Sun in July. The changes in the amount of sunlight will affect seasonal weather in temperate and polar zones, while there is no noticeable change in the amount of sunlight in the tropical zone.



### The flux of solar energy to the Earth.

The hemisphere which is tilted toward the Sun receives a greater flux of solar energy than the hemisphere tilted away, resulting in higher temperatures. For example, the North Pole will be dark and the South Pole will be illuminated in the picture above. The effect of incidence angle on solar flux is well-known to everyone, since the day is warmest when the Sun is overhead and then cools as the Sun nears the horizon.

## “Seasons Modeling” Activity

### Materials

1. Light source (can be a light bulb or flashlight depending upon the lighting situation in the room) 1 per group
  - To stimulate night and day on earth.
2. Ball 1 per group
  - Represents the earth.
3. String 2 or 3 per group
  - Will be placed on a parallel of the earth.
  - Divided into 24 equal segments representing the 24 time zones.

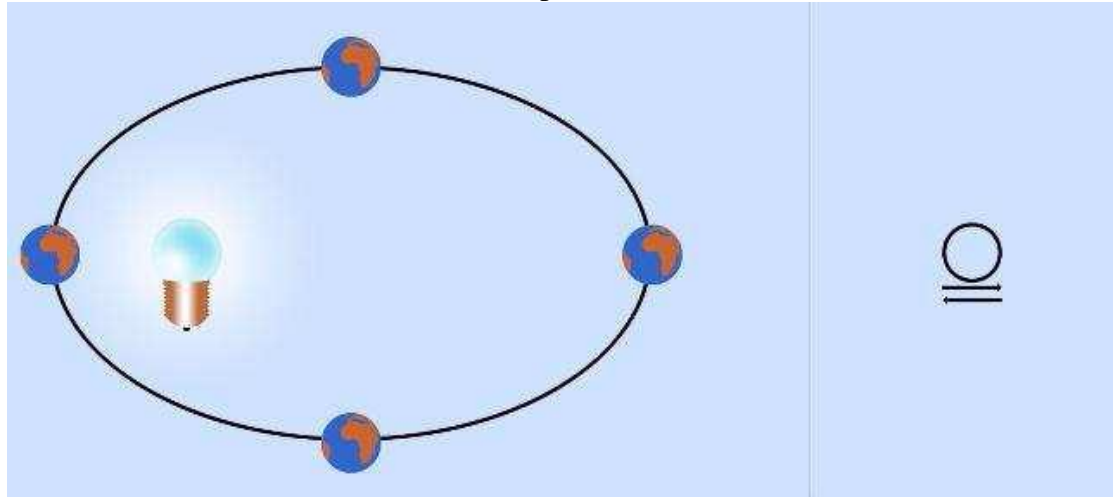


4. 1 Box per group with a hand sized hole cut out of the top
  - Only needed if the classroom cannot be made sufficiently dark for a light bulb to effectively portray day and night on the globe.

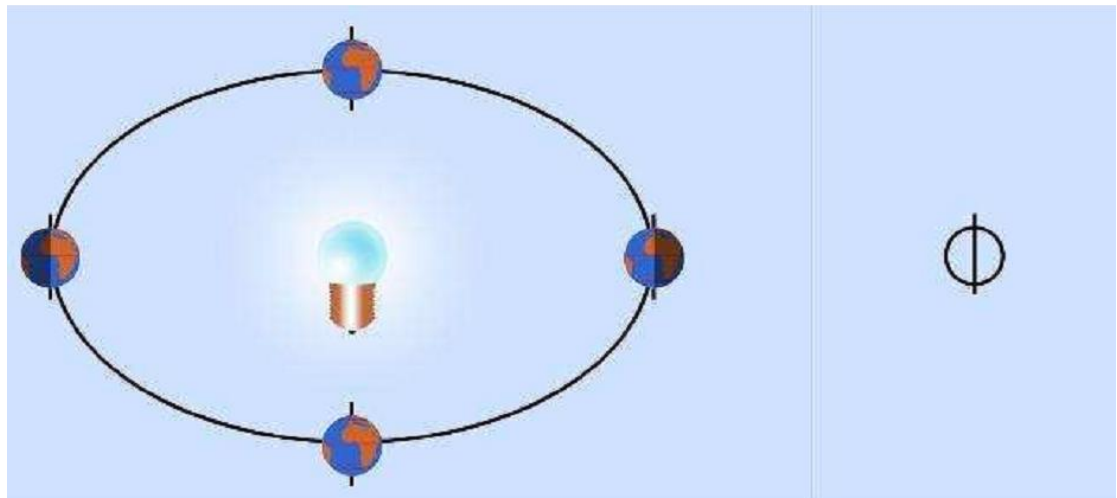
### Student Procedure

1. Come up with your own hypothesis. Which parameter can cause the different seasons?
2. Model and observe the four hypotheses that will explain the seasons.

- **Model of the distance dependence with no consideration for the tilt of the Earth.** To model this hypothesis you need to keep the Earth perpendicular to floor and have the Earth circle the sun in an elliptical orbit.



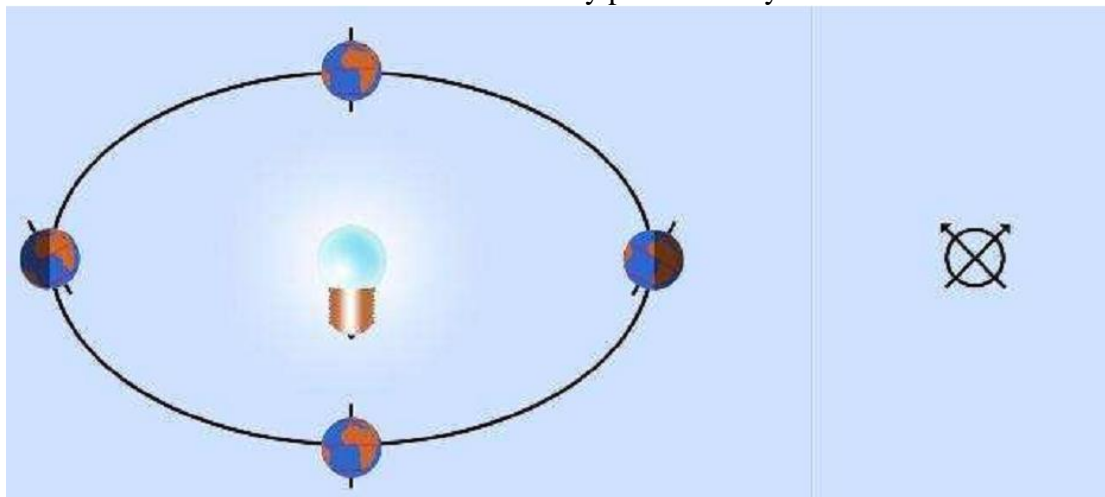
- **Model without factoring in the tilt of the Earth.** To model this hypothesis you need to keep the Earth perpendicular to floor and have the Earth circle the sun in a circular orbit.



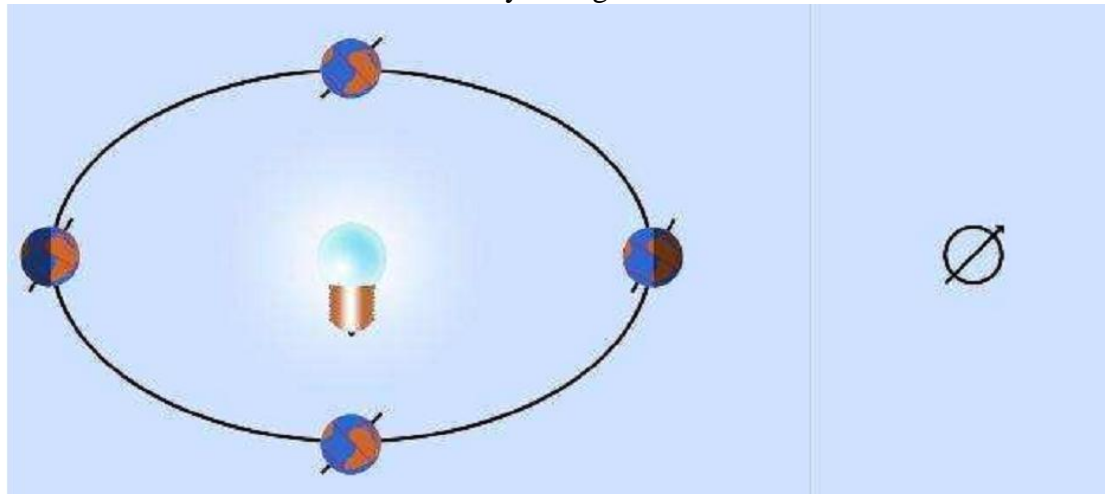


## “Seasons Modeling” Activity

- **Model oscillatory movement of the Earth’s axis.** Rotate the Earth around the Sun in a circular orbit. Keep the poles at a 23.5 degree tilt from the perpendicular to the floor and have the North Pole constantly pointed away from the Sun.



- **Model a constant tilt of the Earth’s axis.** Rotate the Earth around the Sun in a circular orbit. Keep the poles at a 23.5 degree tilt from the perpendicular to the floor and have the North Pole constantly facing the same direction.



3. Discuss to find arguments for supporting or refuting the each modeling hypotheses.

## Pre Test

Choose the correct answer

1. What is the tilt of the Earth’s axis in degree?
  - A. 22
  - B. 22.5
  - C. 23
  - Ⓓ 23.5
2. The different seasons that we observe each year are mainly due to:
  - A. The variation of distance between the Sun and the Earth.
  - B. The variation of tilt of the rotation axis of the Earth on orbit plane.
  - Ⓒ The constant tilt of the Earth’s rotation axis on the orbit plane.
  - D. The varied distances between the Earth, Moon, and Sun.
3. Seasons result from both revolution of the Earth around the Sun and the tilt of the Earth’s axis relative to the plane of revolution. *True*
4. The seasons are caused by the elliptical path of the Earth around the Sun. *False*
5. The Northern and Southern Hemispheres have opposite seasons because the earth’s axis is tilted to its orbital plane. *True*
6. Earth’s rotation takes one year and that it revolves around the Sun in 24 hours. *False*
7. There is no significance between the distances from the Sun to the Earth to the seasons. *True*
8. The hemisphere which is tilted toward the Sun receives a greater flux of solar energy than the hemisphere tilted away. *True*

## Worksheet

Answer the following questions

1. Explain why it is hotter in summer and it is colder in winter.  
*As a result of the Earth's tilt, that hemisphere is receiving more sunlight in the summer when the pole is facing the sun.*
2. If you change the distance between the Sun and the Earth, does it act on the parameter in the expected way?  
*Nothing happens because the variation in distance from the sun has very little effect compared to the effect of changes in the angle of incoming sunlight (tilt of the earth's axis).*
3. If you change the tilt of the earth, does it act on the parameter in the expected way?  
*If the tilt of the earth is greater than  $23.5^\circ$ , the Southern Hemisphere will be hotter in summer and colder in winter. If the tilt of the earth is less than  $23.5^\circ$ , the Northern Hemisphere will be hotter in summer and colder in winter.*
4. If the Earth's axis is not tilted, what will happen to the seasons?  
*The seasons in the Northern and Southern Hemispheres would be the same.*
5. What are the parameters that effect different seasons each year?  
*The earth's orbit around the sun and the tilt of the earth's axis.*

## Post Test

1. What is the tilt of the Earth’s axis in degrees?
  - A. 22
  - B. 22.5
  - C. 23
  - Ⓓ 23.5
2. The different seasons that we observe each year are mainly due to:
  - A. The variation of distance between the Sun and the Earth.
  - B. The variation of tilt of the rotation axis of the Earth on orbit plane.
  - Ⓒ The constant tilt of the Earth’s rotation axis on the orbit plane.
  - D. The variation distances between Earth, the Moon, and the Sun.
3. Seasons result from both revolution of the Earth around the Sun and the tilt of the Earth’s axis relative to the plane of revolution. *True*
4. The seasons are caused by the elliptical path of the Earth around the Sun. *False*
5. The Northern and Southern Hemispheres have opposite seasons because of the earth’s axis is tilted to its orbital plane. *True*
6. Earth’s rotation takes one year and that it revolves around the Sun in 24 hours. *False*
7. There is no significance between the distances from the Sun to the Earth to the seasons. *True*
8. The hemisphere which is tilted toward the Sun receives a greater flux of solar energy than the hemisphere tilted away. *True*
9. The changes in the intensity of sunlight that reaches the Earth’s surface cause 3 seasons in the temperate and polar regions *False*
10. Days are longer in summer than in winter in Thailand because:
  - A. The rotation axis oscillates from  $+23.5^\circ$  in summer to  $-23.5^\circ$  in winter on the perpendicular to the orbit plane.
  - B. The Earth is closer to the Sun in summer.
  - C. The Earth has a tilted rotation axis of  $90^\circ$  on the orbit plane.
  - Ⓓ The Earth has a tilted rotation axis of  $23.5^\circ$  on the perpendicular to the orbit plane.

## Gravity is a Hammer

Adapted from “If I had a Hammer”(Hutton, 2009)

### Teacher Preparation

The first step in this laboratory activity is to read through and discuss the background with the students. It is important to have a class discussion of the topics to get the students thinking about the physics involved. Once that discussion is concluded, administer the pretest to each student. They should be working individually and are allowed reference to the background during this test. It is just meant to take a measure of their knowledge of the subject prior to the laboratory activity.

Once the students have completed the pretest split them into groups of 3-4 and hand out all of the student materials to each group. Read through the procedure aloud with the class and make sure that everyone understands what they need to do. During the experiment walk around the classroom to aid when necessary if the students get confused or distracted.

After the students have completed the lab experiment and finished all of the analysis charts, administer the post test. This post test is also individual so that each student’s understanding can be measured. The students may use the background and lab findings to complete the post test.

### Laboratory Preparation

Before the lab prepare a set of supplies for each group. Each group will need: 1 nail, 1 block of foam, one water bottle, one piece of poster paper, and a ruler/meter stick. Each team must also have access to a mass scale (one or two for the entire class will be sufficient). Cut the papers ahead of time so that each group has either a tall piece or a short piece (either 40 x 43 cm or 40 x 46.5 cm). Two different heights are used so that the students can compare results to analyze. Label the height of the paper on each sheet. Also, assign each group a different volume of water (either none, 75 mL, or 120 mL). The ideal set up for groups is shown in the Table below.

Group	Height of Paper	Volume of Water in Bottle (mL)
1	43	0
2	43	75
3	43	120
4	46.5	0
5	46.5	75
6	46.5	120

If the class only has enough students for 5 groups, do not give any group both the largest mass and taller height.

These heights and weights are only recommendations; other variables can be used if desired. Other materials can be used in the place of foam as well in order to examine varied frictional effects.

## “Gravity is a Hammer” Activity

### Concepts

- Newtonian Mechanics
- Energy and Work

### Background

One of the most basic skills in carpentry is the ability to hammer nails. It is important to understand the concepts behind this simple task so that you can be able to calculate the amount of work used in hammering a nail. The work needed is defined as the amount of energy transferred from the hammer to the nail in order to push the nail into the foam. These basic concepts can be applied to any objects moving by force.

The basic concepts of Newtonian mechanics and energy can be used to form equations to predict the amount of work needed to hammer the nail. Through this activity your team will use the given materials to show the relationship between force and work. The necessary equations to complete this laboratory activity are:

1.  $F=ma$
2.  $W=\Delta E$
3.  $W=Fd$
4.  $KE=1/2 mv^2$
5.  $PE=mgh$
6.  $v^2 = v_0^2 + 2a(X - X_0)$



Equation 1 is Newton’s second law and explains the relationship between force, mass, and acceleration. Equations 2 and 3 show that work is equal to both the change in energy of a system and the force times the displacement of a moving object (This means that if you hit a nail with a hammer and the nail does not move no work, was done on the nail). The 4th and 5th equations illustrate the two types of energy possessed by the hammer, kinetic and gravitational potential energy. Equation 6 shows the kinematic relationship between velocity, acceleration, and distance. These relationships will be used to calculate the impact force of the hammer on the nail. In the case of this experiment the hammer will be represented by a mass you will drop on the nail.

## “Gravity is a Hammer” Activity

### Materials

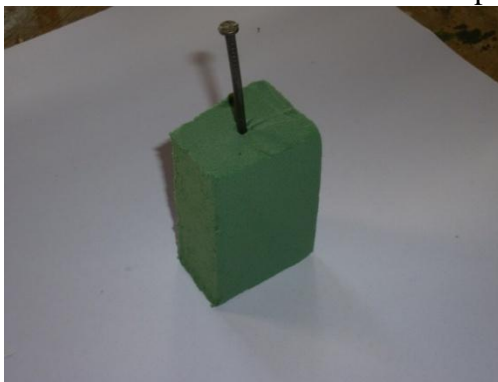
- Nails (1 per group)
- Block of foam (1 per group)
- Water bottle used as weight (1 per group)
- Access to tap water
- Mass scale (1-2 per class)
- Ruler or Meter stick (1 per group)
- Tape (1 roll)
- Poster Paper
- Graduated Cylinders or Syringes (1 per group)



### Student Procedure

As you collect data record it in the tables below.

1. Fill your bottle with the amount of water as assigned by the teacher. Then measure the mass on the electronic scale.
2. Roll the paper into a cylinder and tape it together. This will act as the guide for the falling water bottle. Be sure to roll the paper in the correct direction to get the desired drop height.
3. Carefully insert the nail in the foam such that approximately 6 cm is sticking out.
4. Measure the exact initial height of nail head above foam block. Also measure the height of the foam block above the ground and the length of the water bottle. These lengths will be needed to calculate the drop height from the bottom of the bottle to the nail head.
5. Place the tube over the nail. Full setup is shown below:



# “Gravity is a Hammer” Activity

- Drop the bottle inside the tube, making sure that it is dropped from the top of the tube. The cap of the bottle should be aligned with the top of the cylinder. As seen to the right:
- Remove the tube and bottle putting them aside for later use.
- Measure the new height of the nail sticking out of the foam (if the nail begins to go in sideways, push it back to an upright position).
- Repeat steps 3-6 until the nail is completely driven into the foam or you have completed 10 trials, whichever comes first.

Mass of bottle with water \_\_\_\_\_kg

Length of cylinder (drop height)\_\_\_\_\_m

Initial length of nail sticking out of foam \_\_\_\_\_m

Foam Height \_\_\_\_\_m

Bottle Length \_\_\_\_\_m



Trial #	New nail height L (m)	Change in nail height $\Delta L$ (m)	Total change in nail height $\sum \Delta L$ (m)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



## Analysis

1. Complete the data table below (show your calculations for the first trial). Note that you are not required to calculate the work velocity and force for every trial, just the first 3 and the final cumulative values.

### Hints for Calculations:

In calculating work assume that all the kinetic energy of the mass is transferred into the nail through the friction with the foam ( $W=mg(\text{drop height})$ ). For each trial the work calculated is cumulative.

$$W = mgh - \left( \frac{1}{2}mv^2 + mgl \right) = mg \text{ (Cylinder height-(bottle+foam+nail height))}$$

To find the impact velocity you will use kinematic equation 6 from the background.

$$v^2 = v_0^2 + 2a(X - X_0)$$

$$v_0 = 0, \quad a = 9.81 \frac{m}{s^2}, \quad X - X_0 = h - l$$

$$v_{\text{impact}} = \sqrt{2 * 9.81 * (\text{drop height})}$$

The force of the mass on the nail is found from the work and displacement of the nail using equation 3 from the background.

$$F = W / \sum \Delta L$$

2. Make a graph of the force vs. cumulative distance that the nail has been driven into the block of foam. Estimate the area under the curve and compare it to the cumulative work.

Trial #	Cumulative Work (J)	Impact velocity (m/s)	Force of mass on nail (N)
1			
2			
3			
Final Trial			

## Pre Test

1. Gravitational Energy is:

- a. Proportional to the speed an object is moving
- b. *Dependent on the object's height above the ground***
- c. The only type of energy involved in this experiment
- d. All of the above

2. Kinetic Energy is:

- a. *Proportional to the speed an object is moving***
- b. Dependent on the object's height above the ground
- c. The only type of energy involved in this experiment
- d. None of the above

3. When will the mass have most potential energy, when will it have the most kinetic energy?

*Max potential energy is at the top of the cylinder, max kinetic is at the moment it hits the nail (when it has the highest velocity).*

4. Explain in terms of the physics involved, why does the nail move when the mass hits it?

*The kinetic energy of the nail is entirely converted into work to push the nail into the foam against friction.*

## Post Test

1. Gravitational Energy is:
  - a. Proportional to the speed an object is moving
  - b. Dependent on the object's height above the ground**
  - c. The only type of energy involved in this experiment
  - d. All of the above

2. Kinetic Energy is:

- a. Proportional to the speed an object is moving**
  - b. Dependent on the object's height above the ground
  - c. The only type of energy involved in this experiment
  - d. None of the above
3. When will the mass have most potential energy, when will it have the most kinetic energy?

*Max potential energy is at the top of the cylinder, max kinetic is at the moment it hits the nail (when it has the highest velocity).*

4. Explain in terms of the physics involved, why does the nail move when the mass hits it?

*The kinetic energy of the nail is entirely converted into work to push the nail into the foam against friction.*

5. How does the estimated area under the force vs. distance graph compare to the cumulative work done on the nail? Why are these values comparable?

*Work is equal to the force applied to the nail times the distance that the nail moves ( $W=Fd$ ). This graph is of the function of the force over the distance. So the area under the function is equal to the force times the distance.*

6. Why is the force calculated in each trial slightly different?

*There is error involved in this lab including: slightly inconsistent drop height, possible bending of the nail, and error in measurement. There is also inherently a slightly longer drop of the mass with each trial as the nail moves down but also more displaced foam under the nail as it digs deeper adding more resistance to the nail's movement.*

7. Why did each group have different results (consider the varied masses and heights that each team used)? Select all answer(s) that apply:

- a. A larger mass will create a larger impact force and therefore perform more work and push the nail into the foam in fewer trials.**
  - b. Some of the groups did not measure correctly; everyone should have had the same results.
  - c. The increased drop height gives the mass more potential energy which is converted into more kinetic and then performs more work on the nail.**
  - d. The mass loses energy as it falls, so those dropped from a greater height do less work on the nail

## What’s in My Food?

Adapted from “Ramapo High School Food Lab”(Schott, n.d.)

### Teacher Preparation

Pre lab instructions

1. Acquire all materials needed for the lab, enough for one set of materials per group (see materials list)
2. Before class prepare each food as necessary. For example foods that need to be peeled should be peeled. Larger food should be cut into appropriate sized pieces. Place prepared in a common location for student access.
3. Supply each group with 8 test tubes
4. Prepare for each test:

#### Testing for Complex Carbohydrates

1. Make sure each group has paper towels, a mortar and pestle, and some Lugol’s Iodine solution.
2. Supply water as needed for each group.

#### Testing for Simple Carbohydrates

1. Boil water in a large pot. When each group is ready pour water into smaller pots for group use.
2. Supply Benedict’s Solution to students as needed.
3. Supply hot/ boiling water as needed for each group.
4. Make sure a clock is visible to each group or that each group has a stopwatch.

#### Testing for Lipids

1. Distribute pieces of brown paper for use by each group (white paper works too).
2. Have mineral oil available for student use.
3. Make sure a clock is visible to each group or that each group has a stopwatch.
5. Go over the background with the students.
6. If desired you can lead a discussion with the students before they begin the laboratory activity or before each individual section is conducted about what nutrients they think each food will contain. This will get the students to start making predictions and begin critical thinking before the activity begins.
7. Have the students fill out the pre lab worksheet.
8. Split the students up into groups of 3-4 students.

## “What’s in My Food” Activity

### Lab instructions

1. Have students follow laboratory procedures
2. Specific to testing for proteins
  1. Supply Biuret’s Solution to students as needed.\*
  2. If Biuret’s Solution is not obtained from a stock bottle tell them the color they should observe in a stock bottle would be blue.

### Post Lab

1. Have students clean up their equipment
2. Lead a discussion with the students on their observations
3. Have the students hand in observations and measurements
4. Have students individually fill out post tests and hand them in

## “What’s in My Food” Activity

### Concepts

- Carbohydrates
- Protein
- Lipids
- Laboratory Skills

### Background

Substances in food that can be used by organisms for energy or growth and repair are called nutrients. Nutrients include carbohydrates, lipids, proteins, minerals, and vitamins. Cells of all organisms contain these nutrients as well as water. There are several chemical tests that can be used to determine which nutrients, if any, are present in substances. These nutrients should be included in a daily diet. A recommended diet is displayed in the provided food pyramid, in the categories; grains, vegetables, fruits, milk, meats, and other (fats, oils, and sweets).



**Food Pyramid**

### Serving Sizes

Type of Food	Serving size
Grains	15g of carbohydrates
Fruits	15g of carbohydrates
Vegetables	1 cup if raw 1/2 cup if cooked
Meats	2.5 ounces of protein
Milk	12g carbohydrates and 300mg of calcium

## Carbohydrates

Carbohydrates are the body's most preferred source of energy. Most carbohydrates come from foods of plant origin. Chemically, carbohydrates are organic molecules in which carbon, hydrogen, and oxygen are bonded together

Carbohydrates are the component of our food which:

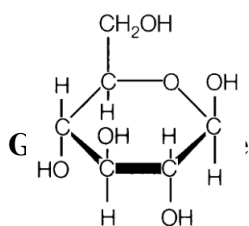
1. supplies the energy for the body's automatic activity and for the performance of our daily tasks. The more physical work we perform daily, the more carbohydrates we must proportionately consume.
2. plays a vital part in the digestion, assimilation (metabolism) and oxidation of protein and fat. If we take in more carbohydrate than is needed for immediate use the unused portion is stored in the liver or converted into fat and deposited in the tissues for future use.

### *Simple Carbohydrates (sugars)*

Simple carbohydrates are quick energy sources, but they do not usually supply any other nutrients or fiber. Simple carbohydrates are made up of one or two sugar molecules linked together.

## SUGARS

1. **Sucrose:** commonly known as table sugar, beet sugar, or cane sugar. Sucrose occurs in many fruits and some vegetables
2. **Fructose:** known as fruit sugar. Most plants contain fructose, especially fruits and saps.
3. **Glucose:** sometimes known as blood sugar, sometimes as grape sugar. Nearly all plant foods contain glucose. Glucose is the main type of simple sugar and is the basic source of energy for all living things. It supplies the body with quick energy.



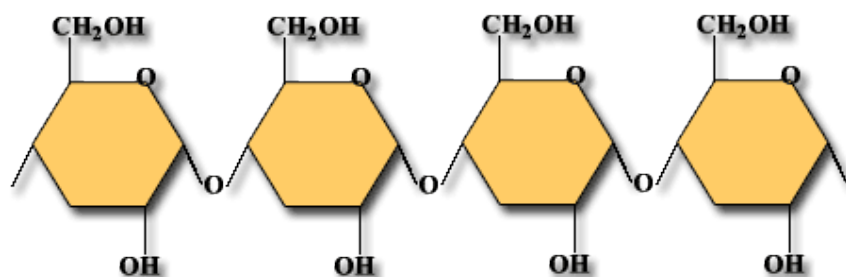
4. **Maltose:** known as malt sugar. Found in grains.
5. **Lactose:** commonly known as milk sugar. It is the principal carbohydrate found in milk.

### *Complex Carbohydrates*

Complex carbohydrates are chains of three or more single sugar molecules linked together. Carbohydrates, long chains of sugar molecules, are called starches and they serve as the storage form of energy in plants. Branched complex carbohydrates called cellulose form the structural components that give plants their shape. Glycogen is another form of complex carbohydrates used by animals to store energy.

Starch provides a steady release of energy into the body while also providing more of what each of us need from our daily diets. Starch present in the body breaks down into simple sugars. The body has to break down all sugar/starch into glucose to use it. Starch supplies the body with long, sustained energy.

All starchy foods are plant foods. Seeds are the richest source; 70 percent of their weight is starch. Many human societies have a staple grain from which their people derive their food energy. These include wheat, corn, millet, rye, barley, and oats. Starch is also found in beans, peas, potato, yam, and cassava. These staple foods are the major source of food energy for people around the world.



## Starch Molecule

## *Proteins*

### *Proteins in the Body*

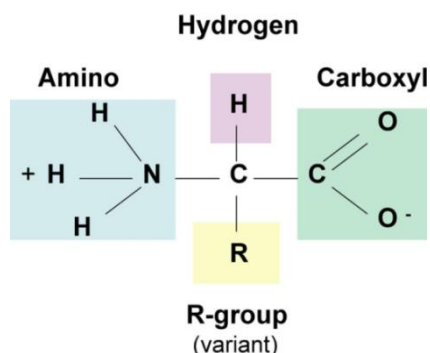
Proteins are extremely important biomolecules that affect very important functions in the human body. Some of these functions include muscle repair, tissue growth, hormone regulation, metabolism control, and illness defense. Proteins consist of half the non water mass of the human body. Proteins are building blocks in ligaments, tendons, muscles, hair, nails, skin, teeth, tissue, organs, and bones. A typical person needs 1 gram of protein daily for each kilogram that they weigh.

### *Structure of proteins*

Proteins are made up of amino acids which are made up of carbon, nitrogen, hydrogen, and oxygen atoms. There are 22 amino acids that make up the proteins that are found in our body. Hundreds of proteins can be formed from these basic building blocks. Amino acid consists of the same basic structure an amino group, a carboxyl group, and a hydrogen group. The group that differentiates the amino acids is the “R” group which depending on the structure of the group affects the properties of the amino acid.



## “What’s in My Food” Activity

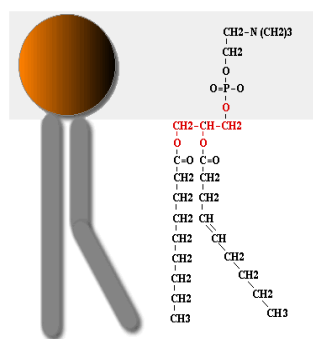


## Amino Acid Structure

Of the 22 amino acids that make up the proteins in the body only 14 can be made by the human body itself. The other 8 amino acids need to be obtained from sources outside the body. The 8 amino acids that the body cannot produce are called “essential amino acids”. Proteins cannot be stored so if the essential amino acids are not used they will either be burned for energy or stored in fats.

## *Lipids (Fats)*

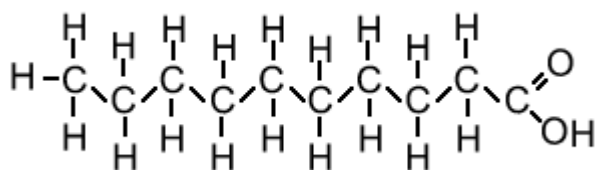
Lipids are another set of extremely important biomolecules that are critical in proper body function. One important function of fats, also known as lipids, is energy storage. Fats contain an abundance of calories and can be stored easily for when they are needed. Lipids function in structural components of cells especially in the cell membrane where phospholipids make up the majority of cell membranes.



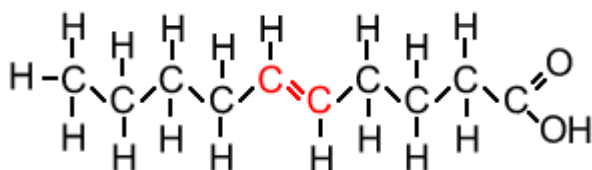
## Phospholipid Structure

Fats can be broken down into two main groups, saturated fats and unsaturated fats. Saturated fats have the maximum number of hydrogen atoms bonded to carbon as possible. An unsaturated fat has double bonds between at least one if not more than one of the carbon bonds in the main chain.

## "What's in My Food" Activity



### Saturated Fat



### Unsaturated Fat

## *Solutions Used in Lab*

### *Lugol's Iodine Solution*

This solution is used to test for the presence of starch. Lugol's is a yellow-brown color. When it reacts chemically with starch a blue-black colored substance will form called iodine of starch.

### *Benedict's Solution*

This solution of sodium and copper salts is a clear-blue color. It is used to test for the presence of simple sugars. In the presence of simple sugars, when heated, Benedict solution changes color to green, yellow, orange, red, and brown, depending on the amount of sugar. Blue (no glucose present), green, yellow, orange, red, and then brick red or brown (high glucose present).

### *Biuret's Solution*

This solution is used to indicate the presence of proteins in a solution. Biuret's solution is blue in color but changes to purple in the presence of proteins due to a chemical reaction. The solution consists of allophanamide treated with cupric sulfate and sodium hydroxide.



## Procedure

### Testing for Complex Carbohydrates (Starch)

#### Part A

1. Label 1 test tube *control*.
2. Measure out 5mL of water in a graduated cylinder.
3. Add the 5 mL of water to the *control* test tube.  
With a dropper add 1 drop of Lugol’s solution to the 5mL of water in the *control* test tube. \*keep the Lugol’s Iodine off your skin. It WILL stain your skin\* If any Lugol’s iodine solution is spilled on your skin wash area thoroughly with water and notify your teacher.
4. What color is the water?\_\_\_\_\_
5. Place a small quantity of rice on a paper towel.
6. Place 2 drops of iodine solution on the rice.
7. What happened to the color of the iodine?\_\_\_\_\_



#### Part B

1. Place a small quantity of each of the foods, in separate piles, on foil paper.
2. Label each pile of food.
3. Mash each food pile with the mortar and pestle. Clean the mortar and pestle between the mashing of each food.
4. Using the same procedure as you did with the rice, test each food for starch and record your results in the following chart.

Food	Color	Starch Present?	
		Yes	No
Water			
Rice			
Carrots			
Peanuts			
Oranges/ Apple-nose			
Butter			
Green Vegetable			
Candy			
Bread			

5. Clean the test tubes thoroughly for use in the next part of the experiment.

*Testing for Simple Carbohydrates (Sugars)*

Part A

1. Prepare 5% glucose solution by measuring out 5mL of water with a graduated cylinder. Measure out 0.45 grams of glucose and add it to the water and mix thoroughly.
  2. Pour the 5mL solution into a test tube and label it S, for sugar solution, and place it into a test tube rack.
  3. Measure out 5mL of water and pour it into a test tube and label it C for control.
  4. With a dropper add 5 drops of Benedict solution to each of the 2 test tubes prepared above.
  5. Mix the contents of each tube by swirling them gently.
  6. What color is the solution in test tube S? \_\_\_\_\_
  7. What color is in test tube C? \_\_\_\_\_
  8. Carefully place both test tubes into a boiling water bath for 3 minutes. During the heating, observe the contents of each test tube for any color changes.  
\*be careful! The water is HOT! Never touch the test tubes used in this experiment with bare hands.\*
  9. After 3 minutes remove both test tubes and place them in your test tube rack.
  10. Observe the colors of the solutions. Describe what happened to the colors of the solution in each test tube.
- 
- 

Part B

1. Measure out 5mL of water into each of the remaining test tubes in your rack
2. Mash each of the foods with the mortar and pestle and add them to the remaining test tubes. Clearly label each test tube with the name of the food that it contains. Clean the mortar and pestle between the mashing of the different foods.
3. With a dropper add 5 drops of Benedict solution to each of the test tubes and mix the contents by gently swirling them
4. What is the color of the control tube C? \_\_\_\_\_
5. What color are the solutions in the other test tubes? \_\_\_\_\_
6. Carefully place all test tubes in a boiling hot water bath for 3 minutes. During the heating observe the contents of each tube for any color changes.
7. After 3 minutes remove the test tubes from the water and place them in the test tube rack.
8. Observe the color of the solutions. Describe what happened to the colors of the solutions in each of the tubes. Be specific about each food.
9. Clean each test tube thoroughly so that they can be used later in the experiment.



**“What’s in My Food” Activity**

Food	Color	Sugar Present?	
		Yes	No
Water			
Rice			
Carrots			
Peanuts			
Oranges/ Apple-nose			
Butter			
Green Vegetable			
Candy			
Bread			

**Testing for Lipids (fats)**

1. Place two drops of mineral oil on a piece of brown paper. This mineral oil contains lipids. Place two drops of water on another section of the same paper.
2. Hold the paper up to the light and look through the water spot and the oil spot. Note that the oil spot is greasy and translucent while the water spot is not. This indicates the presence of lipids.
3. Reexamine the spots after several minutes. The water spot will evaporate and disappear. The oil (lipid) spot does not disappear.
4. Test the other foods for the presence of lipids. If the food is a solid rub it into the brown paper and allow it to dry for a few minutes. If the spot is still there the food contains lipids the spot will remain. If it is a liquid proceed to follow steps 1 through 3.
5. Record the results in the following data table.



Food	Color	Lipids Present?	
		Yes	No
Water			
Rice			
Carrots			
Peanuts			
Oranges/Apple-nose			
Butter			
Green Vegetable			
Candy			
Bread			

*Testing for Proteins*

1. Describe the color of Biuret’s solution in its stock bottle\*.

---

\*If you do not have Biuret’s solution from a stock bottle receive the answer from the teacher for this question.

2. Add 5mL of water to each of the 8 test tubes.
3. Mash each of the food with the wooden sticks and add them to the test tubes. Label each test tube with the name of the food it contains.
4. Add 5mL of \*Biuret’s Solution to each of the test tubes. Observe the color changes in each of the test tubes. Record your results on the following chart.

\*If you do not have Biuret’s Solution add 2 drops of 10% NaOH to the test tube. Then add 10 drops of the 1% CuSO<sub>4</sub> solution to the same test tube.

Food	Color	Proteins Present?	
		Yes	No
Water			
Rice			
Carrots			
Peanuts			
Oranges/Apple-nose			
Butter			
Green Vegetable			
Candy			
Bread			

5. Clean each test tube thoroughly once the experiment is completed.

## Pre Test

1. What are some of the main nutrients needed in a daily diet?

---

*Carbohydrates, Proteins, Lipids, Vitamins and Minerals*

2. What is the bodies most preferred source of energy?

---

*Complex Carbohydrates*

3. The more physical work you perform daily the more complex carbohydrates you must consume.

*True* or False

4. Simple carbohydrates supply a significant amount of nutrients and fiber.

True or *False*

5. What is your favorite food that has a lot of simple carbohydrates?

- 
6. Which of the following foods is the best source of carbohydrates?

- a. Nuts
- b. Rice**
- c. Mangoes
- d. Milk

7. What are the building blocks of proteins?

---

*Amino acids*

8. Name one thing proteins do in the body.

---

*Muscle repair, tissue growth, hormone regulation, metabolism control, illness defense*

9. Which of the following foods is the best source of proteins?

- a. Nuts**
- b. Rice
- c. Mangoes
- d. Milk

10. What is an important function of lipids?

---

*Energy storage*



11. How could you tell if a food is abundant in lipids?

---

*If the food leaves an oily spot on a piece of paper that doesn’t evaporate.*

12. Lipids should be a large part of your diet.

True or ***False***

13. Why would water be used as a control when testing for nutrients?

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*Water would be used as a control in the experiments because it contains none of the nutrients that are being tested for and therefore will not react with the testing reagents.*

## Post Test

1. What are some of the main nutrients needed in a daily diet?

---

***Carbohydrates, Proteins, Lipids, Vitamins Minerals***

2. What is the bodies most preferred source of energy?

---

***Complex Carbohydrates***

3. The more physical work you perform daily the more complex carbohydrates you must consume.

***True*** or False

4. Simple carbohydrates supply a significant amount of nutrients and fiber.

True or ***False***

5. What is your favorite food that has a lot of simple carbohydrates?

- 
6. Which of the following foods is the best source of carbohydrates?

- a. Nuts
- b. Rice***
- c. Mangoes
- d. Milk

7. What are the building blocks of proteins?

---

***Amino acids***

8. Name one thing proteins do in the body.

---

***Muscle repair, tissue growth, hormone regulation, metabolism control, illness defense***

9. Which of the following foods is the best source of proteins?

- a. Nuts***
- b. Rice
- c. Mangoes
- d. Milk

10. What is an important function of lipids?

---

***Energy storage***

11. How could you tell if a food is abundant in lipids?

*If the food leaves an oily spot on a piece of paper that doesn’t evaporate.*

12. Lipids should be a large part of your diet.

True or **False**

13. Why would water be used as a control when testing for nutrients?

---

---

---

---

*Water would be used as a control in the experiments because it contains none of the nutrients that are being tested for and therefore will not react with the testing reagents.*

14. Match each indicator with the nutrient it is used to test for. Place the correct letter on the line provided next to each listed solution.

Lugol’s Solution \_\_\_\_ **c** a. Simple Sugars

Benedict’s Solution \_\_\_\_ **a** b. Proteins

Biuret’s Solution \_\_\_\_ **b** c. Starch

15. Circle the correct color which indicates a positive result for each solution listed:

Lugol’s Solution	Yellow-brown	<b>Blue-black</b>
Benedict’s Solution	<b>Yellow, orange, red</b>	Clear Blue
Biuret’s Solution	Blue	<b>Purple</b>

16. Did any of the results obtained for each test surprise you? Which ones surprised you? Why did they surprise you?

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## Precipitation Reactions

Adapted from “Department of Chemistry IPST” (สถาบันส่งเสริมการสอนวิทยาศาสตร์และเทคโนโลยี (สสวท.), n.d.)

### Teacher preparation

Before running the laboratory activity, the teacher goes over and discusses the background information with the students. When finished the background information, let the students do the pre test to check of their knowledge about the subject in this laboratory activity. The students should do the pre test individually. After the students completed the pre test, let the students split into groups of 3-4 students and hand in all of materials and chemicals to each group. Then, have the students begun the laboratory activity. After the students finished the experiment, the students do the post test which it is also individual to measure the understanding of the subject matter of this activity.

## Concept

- Double replacement reaction
- Properties of Alkali and Alkali Earth metals

## Background

To understand the concept of precipitation, first of all we should know some of physical and chemical properties of alkali and alkaline earth metal.

### Group 1 Alkali Metals

The Group 1 elements are all alkali metals that are grouped together on the periodic table according to their similar properties. Group 1 alkali metals include lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr). These metals, like all metals, are ductile, malleable, good conductors of heat, and good conductors of electricity. However, they are softer than most other metals and can easily be cut by a knife. Group 1 alkali metals also differ from most other metals because they have low melting and boiling temperatures and have low densities. All these metals have one valence electron and in their ionic state have a +1 charge. These metals are silvery in color and are very reactive. The reactivity increases descending down the periodic table. The least reactive is lithium and the most reactive is francium. All group 1 alkali metals are too reactive to be found naturally in their elemental form and therefore must be obtained from other sources. An example is sodium which can be found in abundance in salt (NaCl) from sea water. These metals are so reactive that they cannot be displaced by another element so in order to isolate them electrolysis of their molten salts must be performed. When storing these chemicals they must be stored under oil because they react with the oxygen in air which taints the metal.

### Group 2 Alkaline Earth Metals

The Group 2 elements are alkaline earth metals that are grouped together on the period table according to their properties. Group 2 alkaline earth metals include beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra). These metals are silvery-white in color. They are ductile, malleable, good conductors of heat, and good conductors of electricity. Alkaline earth metals are highly reactive but not as reactive as the Group 1 alkali metals. Group 2 metals are denser and harder than group 1 metals and have stronger metallic bonding due to an additional valence electron. They also have higher boiling points than the Group 1 alkali metals. Metals in the group 2 column all have 2 valance electrons and in their ionic state have a +2 charge. The alkaline earth metals become more electropositive descending the group from beryllium to radium. As with Group 1 metals Group 2 metals are highly reactive and therefore cannot be found in their elemental form in nature but can be found in various rock structures. There are various processes involved in obtaining these metals in their elemental form. Some of the techniques used are precipitation and electrolysis. Due to their reactivity these elements must be carefully stored.

## Precipitation reaction

Precipitation reactions are a type of reaction called double replacement reaction. A double replacement reaction is a chemical reaction between compounds in which the elements in the reactants recombine to form two different compounds, each of the products having one element from each of the reactants. Precipitation reactions occur when ions in solution react to form a chemical that is not soluble in the solution in which they are mixed. This causes the chemical produced from the reaction to fall out of solution and form what is

## “Precipitation Reactions” Activity

called a precipitate. There are certain rules that can be memorized in order to predict whether mixing two chemicals in a solution will create a precipitate or not.

1. All Nitrates ( $\text{NO}_3^-$ ), Acetate ( $\text{C}_2\text{H}_3\text{O}_2^-$ ), Chlorates ( $\text{ClO}_3^-$ ), and Perchlorate ( $\text{ClO}_4^-$ ) salts are soluble
2. All Group 1 metal salts are soluble
3. All Ammonium ( $\text{NH}_4^+$ ) Compounds are soluble
4. All Chloride ( $\text{Cl}^-$ ), Bromide ( $\text{Br}^-$ ), and Iodide ( $\text{I}^-$ ) salts are soluble except Silver ( $\text{Ag}^+$ ), Lead II ( $\text{Pb}^{+2}$ ) and Mercury I ( $\text{Hg}_2^{+2}$ ) chloride, bromide, or iodide salts which are insoluble
5. All sulfate ( $\text{SO}_4^{-2}$ ) salts are soluble except Calcium ( $\text{Ca}^{+2}$ ), Strontium ( $\text{Sr}^{+2}$ ), Barium ( $\text{Ba}^{+2}$ ), Lead II ( $\text{Pb}^{+2}$ ), Mercury I ( $\text{Hg}_2^{+2}$ ), and Silver ( $\text{Ag}^+$ ) sulfates which are insoluble
6. All Carbonates ( $\text{CO}_3^{-2}$ ), Chromates ( $\text{CrO}_4^{-2}$ ), Oxalates ( $\text{C}_2\text{O}_4^{-2}$ ), and Phosphates ( $\text{PO}_4^{-3}$ ) are insoluble except those of Group I elements and Ammonium salts which are soluble
7. All Sulfide ( $\text{S}^{-2}$ ) salts are insoluble except those of Group 1 and Group 2 elements and Ammonium ( $\text{NH}_4^+$ )
8. All Hydroxides ( $\text{OH}^-$ ) and Oxides ( $\text{O}^{-2}$ ) are insoluble except for Group 1 and Group 2 salts which are soluble.

### Materials

$\text{MgCl}_2$   
 $\text{CaCl}_2$   
 $\text{NaCl}$   
 $\text{Na}_2\text{CO}_3$   
 $\text{Na}_2\text{HPO}_4$   
 $\text{Na}_2\text{SO}_4$   
 $\text{KNO}_3$   
Water  
Test tubes (10 per group)  
Test tube rack (1 per group)  
Droppers (7 per group)  
Graduated cylinder (1 per group)  
Beakers (1-2 per group)

## “Precipitation Reactions” Activity

### Safety and caution

- All chemicals are irritating to the skin, eyes, and harmful if swallowed or inhaled.
- Keep potassium nitrate ( $\text{KNO}_3$ ) away from source of ignition.
- None of the solutions should be disposed of down the drain. The waste solution should be collected in provided waste container.
- Wash hands immediately upon contact with the chemicals. Also, wash hands after the experiment.

## "Precipitation Reactions" Activity

### Procedure for students

1. Prepare each solution with concentration of 1 M 20 ml. Let molecular weight of H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, P = 31, S = 32, Cl = 35.5, K = 39, and Ca = 40.

Calculation:

$$\text{MW MgCl}_2 = 95 \text{ g/mol}$$

$$g = 1M \times 20 \times 10^{-3}l \times 95 \text{ g/mol} = 1.90$$

$$\text{Mass of MgCl}_2 = \dots\dots\dots 1.9 \dots\dots\dots \text{ g}$$

$$\text{MW CaCl}_2 = 111 \text{ g/mol}$$

$$g = 1M \times 20 \times 10^{-3}l \times 111 \text{ g/mol} = 2.22$$

$$\text{Mass of CaCl}_2 = \dots\dots\dots 2.22 \dots\dots\dots \text{ g}$$

$$\text{MW NaCl} = 58.5$$

$$g = 1M \times 20 \times 10^{-3}l \times 58.5 \text{ g/mol} = 1.17$$

$$\text{Mass of NaCl} = \dots\dots\dots 1.17 \dots\dots\dots \text{ g}$$

$$\text{MW Na}_2\text{CO}_3 = 106 \text{ g/mol}$$

$$g = 1M \times 20 \times 10^{-3}l \times 106 \text{ g/mol} = 2.12$$

$$\text{Mass of Na}_2\text{CO}_3 = \dots\dots\dots 2.12 \dots\dots\dots \text{ g}$$

$$\text{MW Na}_2\text{HPO}_4 = 142 \text{ g/mol}$$

$$g = 1M \times 20 \times 10^{-3}l \times 142 \text{ g/mol} = 2.84$$



## "Precipitation Reactions" Activity

Mass of  $\text{Na}_2\text{HPO}_4$  = .....2.84..... g

MW  $\text{Na}_2\text{SO}_4$  = 142 g/mol

$$g = 1M \times 20 \times 10^{-3}l \times 142 \text{ g/mol} = 2.84$$

Mass of  $\text{Na}_2\text{SO}_4$  = .....2.84..... g

MW  $\text{KNO}_3$  = 101 g/mol

$$g = 1M \times 20 \times 10^{-3}l \times 101 \text{ g/mol} = 2.02$$

Mass of  $\text{KNO}_3$  = .....2.02..... g

2. Add a few drops of  $\text{MgCl}_2$  into each 5 test tubes.
3. Add few drops of  $\text{NaCl}$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{Na}_2\text{SO}_4$ , and  $\text{KNO}_3$  to the test tube that has  $\text{MgCl}_2$  solution.
4. Observe the results and record the results into the following table.
5. Repeat step 2-4 but using  $\text{CaCl}_2$  instead of  $\text{MgCl}_2$ .

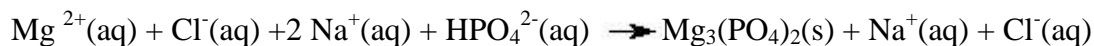
	$\text{NaCl}$	$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{HPO}_4$	$\text{Na}_2\text{SO}_4$	$\text{KNO}_3$
$\text{MgCl}_2$	-	-	Precipitation occurs	Precipitation occurs	-
$\text{CaCl}_2$	-	-	Precipitation occurs	Precipitation occurs	-

### Discussion and Conclusion

When the solution of  $\text{MgCl}_2$  and  $\text{Na}_2\text{HPO}_4$  was mixed,  $\text{MgHPO}_4$  will precipitate and  $\text{Na}^+$  and  $\text{Cl}^-$  are spectator ions. The chemical equation can be explained follow by:

Ions form in the solution:  $\text{MgCl}_2(\text{aq}) + \text{Na}_2\text{HPO}_4(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2\text{Na}^+(\text{aq}) + \text{HPO}_4^{2-}(\text{aq})$

Then the magnesium ion and the phosphate ion can combine to give the following:



The net ionic reaction:  $\text{Mg}^{2+}(\text{aq}) + \text{HPO}_4^{2-}(\text{aq}) \rightarrow \text{MgHPO}_4(\text{s})$

### “Precipitation Reactions” Activity

When the solution of  $\text{MgCl}_2$  and  $\text{Na}_2\text{SO}_4$  was mixed,  $\text{MgSO}_4$  will precipitate and  $\text{Na}^+$  and  $\text{Cl}^-$  are spectator ions. The chemical equation can be explained follow by:

Ions form in the solution:  $\text{MgCl}_2 (\text{aq}) + \text{Na}_2\text{SO}_4 (\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2 \text{Na}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

Then the magnesium ion and the sulfate ion can combine to give the following:

$\text{Mg}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2 \text{Na}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{MgSO}_4 (\text{s}) + \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$

The net ionic reaction:  $\text{Mg}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{MgSO}_4(\text{s})$

When the solution of  $\text{CaCl}_2$  and  $\text{Na}_2\text{HPO}_4$  was mixed,  $\text{CaHPO}_4$  will precipitate and  $\text{Na}^+$  and  $\text{Cl}^-$  are spectator ions. The chemical equation can be explained follow by:

Ions form in the solution:  $\text{CaCl}_2 (\text{aq}) + \text{Na}_2\text{HPO}_4 (\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2 \text{Na}^+(\text{aq}) + \text{HPO}_4^{2-}(\text{aq})$

Then the magnesium ion and the sulfate ion can combine to give the following:

$\text{Ca}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2 \text{Na}^+(\text{aq}) + \text{HPO}_4^{2-}(\text{aq}) \rightarrow \text{CaHPO}_4 (\text{s}) + \text{Na}^+ (\text{aq}) + \text{Cl}^-(\text{aq})$

The net ionic reaction:  $\text{Ca}^{2+}(\text{aq}) + \text{HPO}_4^{2-}(\text{aq}) \rightarrow \text{CaHPO}_4(\text{s})$

When the solution of  $\text{CaCl}_2$  and  $\text{Na}_2\text{SO}_4$  was mixed,  $\text{CaSO}_4$  will precipitate and  $\text{Na}^+$  and  $\text{Cl}^-$  are spectator ions. The chemical equation can be explained follow by:

Ions form in the solution:

$\text{CaCl}_2 (\text{aq}) + \text{Na}_2\text{SO}_4 (\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2 \text{Na}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

Then the magnesium ion and the sulfate ion can combine to give the following:

$\text{Ca}^{2+}(\text{aq}) + \text{Cl}^-(\text{aq}) + 2 \text{Na}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{CaSO}_4 (\text{s}) + \text{Na}^+ (\text{aq}) + \text{Cl}^-(\text{aq})$

The net ionic reaction:  $\text{Ca}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{CaSO}_4(\text{s})$

## "Precipitation Reactions" Activity

### Pre Test

- Which ions cannot be identified using precipitation reaction?
  - $\text{Cl}^-$ ,  $\text{I}^-$ , and  $\text{SO}_4^{2-}$
  - $\text{Al}^{3+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Pb}^{2+}$
  - $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ , and  $\text{Fe}^{3+}$
  - ☒  $\text{K}^+$  and  $\text{Na}^+$ , and  $\text{Li}^+$
  - $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ , and  $\text{Ba}^{2+}$
- Which ions can form a hydroxide which can dissolve in excess  $\text{NaOH}$ ?
  - $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ , and  $\text{Fe}^{3+}$
  - ☒  $\text{Al}^{3+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Pb}^{2+}$
  - $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ , and  $\text{Ba}^{2+}$
  - $\text{K}^+$ ,  $\text{Na}^+$ , and  $\text{Li}^+$
  - $\text{Be}^{2+}$ ,  $\text{Mg}^{2+}$ , and  $\text{Ca}^{2+}$
- Which of the following is a precipitation reaction?
  - $2 \text{H}_2(\text{g}) + \text{O}_2(\text{l}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$
  - ☒  $\text{CaBr}_2(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{CaSO}_4(\text{s}) + 2 \text{HBr}(\text{g})$
  - $2 \text{KNO}_3(\text{s}) \rightarrow 2 \text{KNO}_2(\text{s}) + \text{O}_2(\text{g})$
  - $2 \text{Al}(\text{s}) + 3 \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Al}_2(\text{SO}_4)_3(\text{aq}) + 3 \text{H}_2(\text{g})$
  - $2 \text{KBr}(\text{aq}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{KCl}(\text{aq}) + \text{Br}_2(\text{l})$
- According to the solubility rules, which of the following is true when solutions of  $\text{CuSO}_4(\text{aq})$  and  $\text{BaCl}_2(\text{aq})$  are mixed?
  - $\text{CuCl}_2$  will precipitate, and  $\text{Ba}^{2+}$  and  $\text{SO}_4^{2-}$  are spectator ions.
  - $\text{CuSO}_4$  will precipitate, and  $\text{Ba}^{2+}$  and  $\text{Cl}^-$  are spectator ions.
  - ☒  $\text{BaSO}_4$  will precipitate, and  $\text{Cu}^{2+}$  and  $\text{Cl}^-$  are spectator ions.
  - $\text{BaCl}_2$  will precipitate, and  $\text{Cu}^{2+}$  and  $\text{SO}_4^{2-}$  are spectator ions.
  - No precipitate will form.
- Which of the following is the correct net ionic equation for the reaction that occurs when solutions of  $\text{Pb}(\text{NO}_3)_2$  and  $\text{NH}_4\text{Cl}$  are mixed?
  - $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{NH}_4\text{Cl}(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{aq}) + \text{PbCl}_2(\text{s})$
  - ☒  $\text{Pb}^{2+}(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow \text{PbCl}_2(\text{s})$
  - $\text{Pb}^{2+}(\text{aq}) + 2 \text{NO}_3^-(\text{aq}) + 2 \text{NH}_4^+(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow 2 \text{NH}_4^+(\text{aq}) + 2 \text{NO}_3^-(\text{aq}) + \text{PbCl}_2(\text{s})$
  - $2 \text{NO}_3^-(\text{aq}) + 2 \text{NH}_4^+(\text{aq}) \rightarrow 2 \text{NH}_4\text{NO}_3(\text{aq})$
  - None of the above.

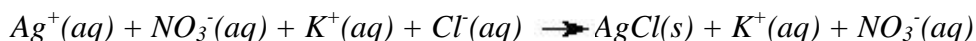
## "Precipitation Reactions" Activity

### Post Test

- Which ions cannot be identified using precipitation reaction?  
A.  $\text{Cl}^-$ ,  $\text{I}^-$ , and  $\text{SO}_4^{2-}$   
B.  $\text{Al}^{3+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Pb}^{2+}$   
C.  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ , and  $\text{Fe}^{3+}$   
☒ D.  $\text{K}^+$  and  $\text{Na}^+$ , and  $\text{Li}^+$   
E.  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ , and  $\text{Ba}^{2+}$
- Which ions can form a hydroxide which can dissolve in excess  $\text{NaOH}$ ?  
A.  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$ , and  $\text{Fe}^{3+}$   
☒ B.  $\text{Al}^{3+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Pb}^{2+}$   
C.  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ , and  $\text{Ba}^{2+}$   
D.  $\text{K}^+$ ,  $\text{Na}^+$ , and  $\text{Li}^+$   
E.  $\text{Be}^{2+}$ ,  $\text{Mg}^{2+}$ , and  $\text{Ca}^{2+}$
- Which of the following is a precipitation reaction?  
A.  $2 \text{H}_2(\text{g}) + \text{O}_2(\text{l}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$   
☒ B.  $\text{CaBr}_2(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{CaSO}_4(\text{s}) + 2 \text{HBr}(\text{g})$   
C.  $2 \text{KNO}_3(\text{s}) \rightarrow 2 \text{KNO}_2(\text{s}) + \text{O}_2(\text{g})$   
D.  $2 \text{Al}(\text{s}) + 3 \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Al}_2(\text{SO}_4)_3(\text{aq}) + 3 \text{H}_2(\text{g})$   
E.  $2 \text{KBr}(\text{aq}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{KCl}(\text{aq}) + \text{Br}_2(\text{l})$
- According to the solubility rules, which of the following is true when solutions of  $\text{CuSO}_4(\text{aq})$  and  $\text{BaCl}_2(\text{aq})$  are mixed?  
A.  $\text{CuCl}_2$  will precipitate, and  $\text{Ba}^{2+}$  and  $\text{SO}_4^{2-}$  are spectator ions.  
B.  $\text{CuSO}_4$  will precipitate, and  $\text{Ba}^{2+}$  and  $\text{Cl}^-$  are spectator ions.  
☒ C.  $\text{BaSO}_4$  will precipitate, and  $\text{Cu}^{2+}$  and  $\text{Cl}^-$  are spectator ions.  
D.  $\text{BaCl}_2$  will precipitate, and  $\text{Cu}^{2+}$  and  $\text{SO}_4^{2-}$  are spectator ions.  
E. No precipitate will form.
- Which of the following is the correct net ionic equation for the reaction that occurs when solutions of  $\text{Pb}(\text{NO}_3)_2$  and  $\text{NH}_4\text{Cl}$  are mixed?  
A.  $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{NH}_4\text{Cl}(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{aq}) + \text{PbCl}_2(\text{s})$   
☒ B.  $\text{Pb}^{2+}(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow \text{PbCl}_2(\text{s})$   
C.  $\text{Pb}^{2+}(\text{aq}) + 2 \text{NO}_3^-(\text{aq}) + 2 \text{NH}_4^+(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow 2 \text{NH}_4^+(\text{aq}) + 2 \text{NO}_3^-(\text{aq}) + \text{PbCl}_2(\text{s})$   
D.  $2 \text{NO}_3^-(\text{aq}) + 2 \text{NH}_4^+(\text{aq}) \rightarrow 2 \text{NH}_4\text{NO}_3(\text{aq})$   
E. None of the above.
- Please write down the chemical reaction when mixing the solution of  $\text{AgNO}_3$  and  $\text{KCl}$ .

Ions form in the solution:  $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{Ag}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) + \text{K}^+(\text{aq}) + \text{Cl}^-(\text{aq})$

Then the silver ion and the nitrate ion can combine to give the following:



The net ionic reaction:  $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$

## The Colors of the Sun

### Teacher Preparation

This lab will be conducted over a three week period of time. The first week will be spent allowing the plants their initial growth. Weeks two and three will be spent recording the growth of the plants once a day.

#### Pre lab instructions

1. Acquire all materials needed for the lab, enough for one set of materials per group (see materials list)
2. Teach background information
3. Allow students to discuss or ask questions about the background information
4. Have students individually fill out pre tests and hand them in
5. Split students into groups of three

#### Lab instructions

1. Have students follow laboratory procedures

#### Post lab instructions

1. Have students clean up their plants
2. Lead a discussion with the students on their observations
3. Have the students hand in observations and measurements
4. Have students individually fill out post tests and hand them in



On the left: plant grown in the dark for 1 week.  
On the right: plant grown in the light for 1 week.

## Concepts

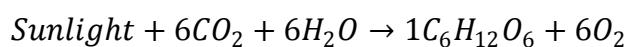
- Photosynthesis
- Sunlight Wave Lengths

## Background

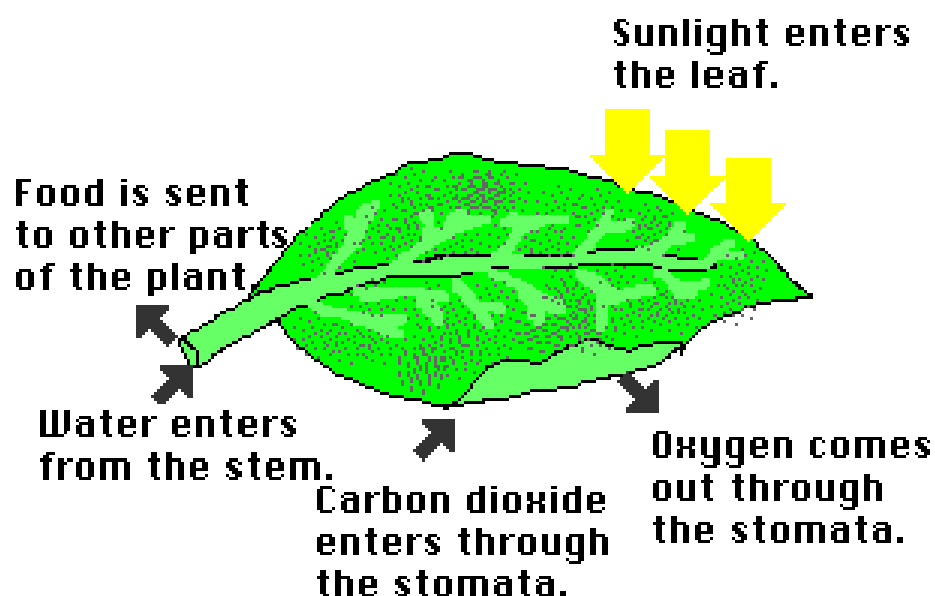
### PHOTOSYNTHESIS

Photosynthesis is the process in which plants use energy obtained from sunlight to turn carbon dioxide molecules ( $\text{CO}_2$ ) and water molecules ( $\text{H}_2\text{O}$ ) into glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) and oxygen molecules ( $\text{O}_2$ ).

Balanced photosynthesis equation:



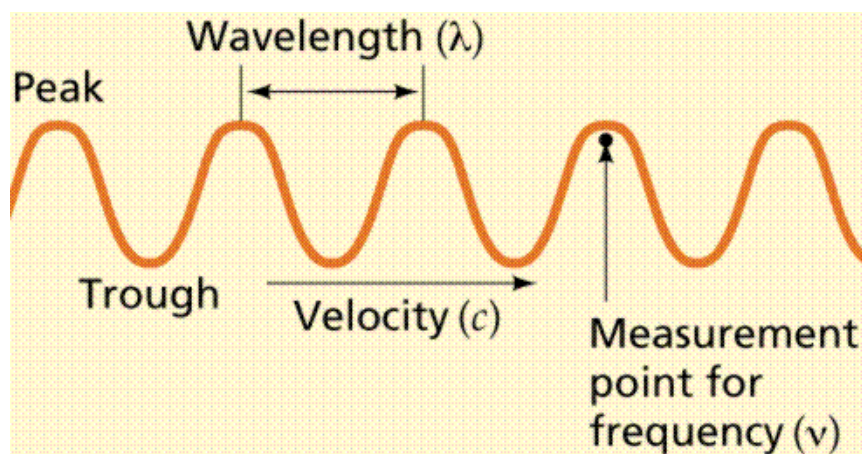
- Water enters leaves from the leaves stems’.
- Carbon dioxide enters the leaves through stomata.
- Photosynthesis takes place in the chloroplast which is an organelle in all plant cells
- Chlorophyll in the chloroplast enables the plant to take the energy from sunlight and turn it into glucose.
- The energy from this Photosynthesis is stored as glucose, a type of sugar.
- Oxygen is a byproduct of photosynthesis which is needed for animals to survive.
- Oxygen exits the cell through the stomata.
- Glucose is sent to other areas of the plant through the leaf stems.



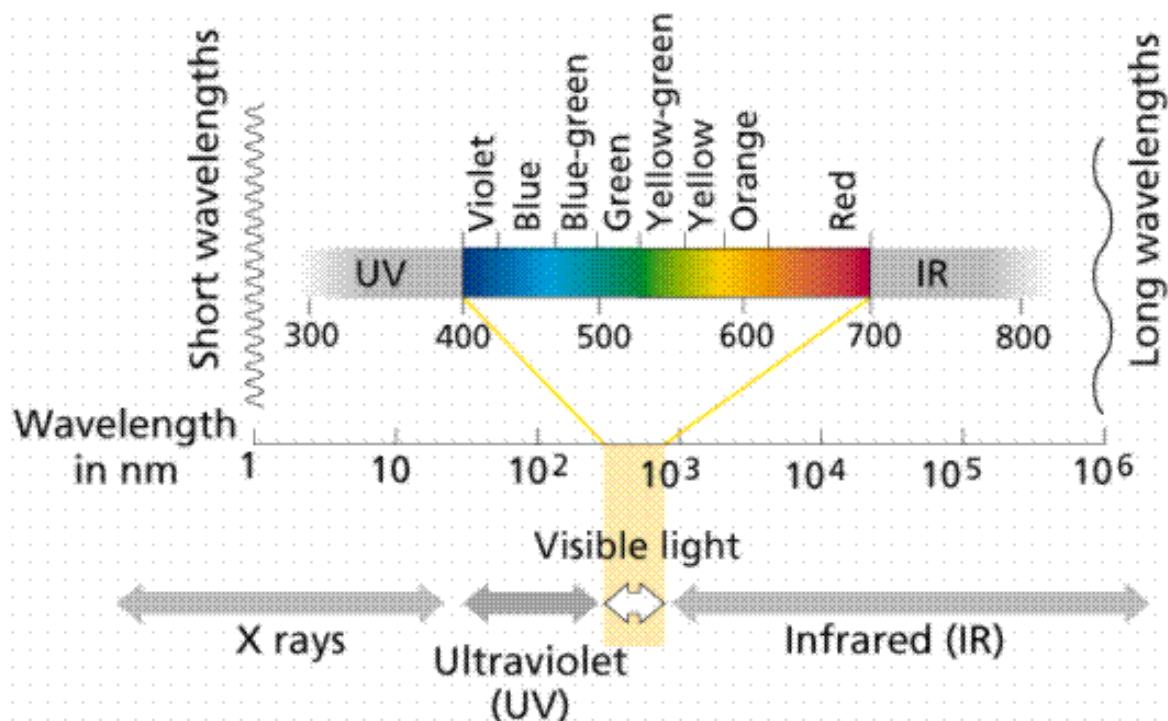
## LIGHT SPECTRUM

### Photosynthesis and Light

White light is separated into the different colors (wavelengths) of light by passing through a prism. Wavelength is defined as the distance from peak to peak (or trough to trough). The energy of is inversely proportional to the wavelength: longer wavelengths have less energy than do shorter ones.

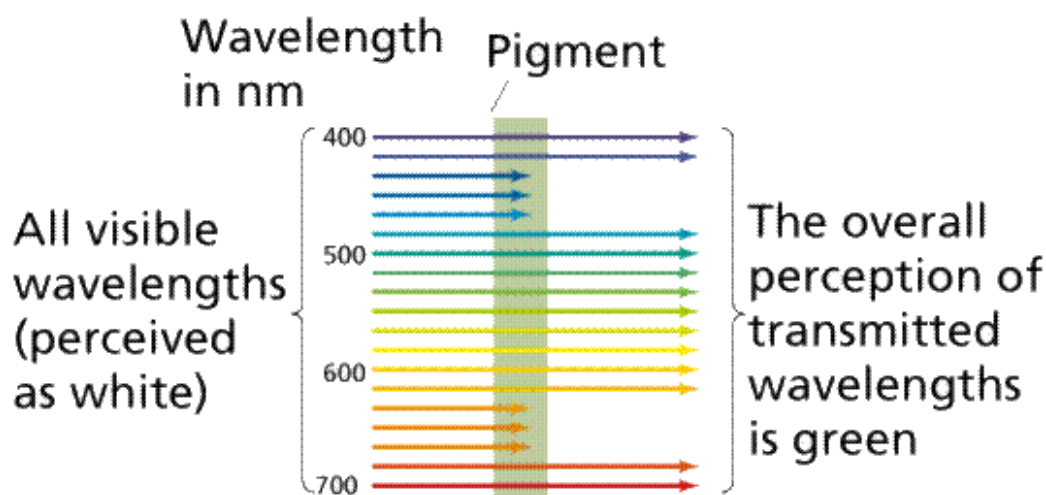


The order of colors is determined by the wavelength of light. Visible light is one small part of the electromagnetic spectrum. The longest the wavelength of visible light is red. Likewise the shortest wavelength visible is violet. Wavelengths longer than red are referred to as infrared, while those shorter than violet are ultraviolet.



## Chlorophyll and Pigments

A pigment is any substance that absorbs light. The color of the pigment comes from the wavelengths of light reflected (those not absorbed). Chlorophyll, the green pigment common to all photosynthetic cells, absorbs all wavelengths of visible light except green, which it reflects to be detected by our eyes. Black pigments absorb all of the wavelengths that strike them. White pigments/lighter colors reflect all or almost all of the energy striking them. Pigments have their own characteristic absorption spectra, the absorption pattern of a given pigment.



## LIGHT SOURCE

Three principal characteristics of light affect plant growth:

- *quantity*
- *quality*
- *duration*

### *Quantity*

Light quantity refers to the intensity, or concentration, of sunlight. It varies with the seasons. The maximum amount of light is present in summer and the minimum in winter. Up to a point, the more sunlight a plant receives, the greater its capacity for producing food via photosynthesis.

You can manipulate light quantity to achieve different plant growth patterns. Increase light by surrounding plants with reflective materials, a white background, or supplemental lights. Decrease it by shading plants with cheesecloth or woven shade cloths.

### *Quality*

Light quality refers to the color (wavelength) of light. Sunlight supplies the complete range of wavelengths and can be broken up by a prism into bands of red, orange, yellow, green, blue, indigo, and violet.

Blue and red light, which plants absorb, have the greatest effect on plant growth. Blue light is responsible primarily for vegetative (leaf) growth. Red light, when combined with blue light, encourages flowering. Plants look green to us because they reflect, rather than absorb, green light.



## “Colors of the Sun” Activity

Knowing which light source to use is important for manipulating plant growth. For example, fluorescent (cool white) light is high in the blue wavelength. It encourages leafy growth and is excellent for starting seedlings. Incandescent light is high in the red or orange range, but generally produces too much heat to be a valuable light source for plants. Fluorescent grow-lights attempt to imitate sunlight with a mixture of red and blue wavelengths, but they are costly and generally no better than regular fluorescent lights.

### *Duration*

Duration, or photoperiod, refers to the amount of time a plant is exposed to light. Photoperiod controls flowering in many plants. Scientists initially thought the length of light period triggered flowering and other responses within plants. Thus, they describe plants as short-day or long-day, depending on what conditions they flower under. We now know that it is not the length of the light period, but rather the length of uninterrupted darkness, that is critical to floral development.

## Materials

- 8 seeds per pot (32 per group)
- 4 pots/water bottles per group. Each pot must be at least 25 cm tall to allow for plant growth (per group)
- Water
- 2 pieces of transparent green paper (per group)
- 2 pieces of transparent red paper (per group)



## Student Procedure

1. Wrap the sides of one pot in green colored paper and one in red colored paper, so that all light going to the plant must go through the paper. Leave two pots unwrapped
2. Place 2 layers of paper towel in the bottom of each of the 4 pots. (dirt can be used in place of paper towels)
3. Place 8 seeds in each pot on top of the paper towels.
4. Place 2 more layers of paper towels on top of the seeds.
5. Water your seeds enough to moisten the paper towels.
6. Using the colored paper create a top for the green and red colored pots, making sure that you can remove it easily to water the plants
7. Place the green, red, and one of the plain pots in the sun. Put the remaining pot in a dark place where it will receive no light.
8. Water the plants daily or as needed
9. Measure and record the plants' heights and stem colors daily beginning seven days after planting. Measure for a total of two weeks.

### Pre Test

1. What does a plant need to conduct photosynthesis? Circle all that apply
  - a. ***Sunlight,***
  - b.  $O_2$
  - c.  $CO_2$
  - d.  $H_2O$
  - e. Rice
2. What colors of light do plant leaves absorb?
  - a. All colors
  - b. Red only
  - c. Violet
  - d. ***All colors but green***
  - e. Green
3. What part of a plant cell is responsible for photosynthesis?
  - a. The stomata
  - b. ***Chloroplasts***
  - c. The stem
  - d. The roots
4. What color light has the longest wave length?
  - a. ***Red***
  - b. Violet
  - c. Yellow
  - d. Green
5. What do you think will happen to the plant in the dark?  
***It will grow quickly at first but then die. While it is alive it will lack much green coloring.***

## Post Test

1. What does a plant need to conduct photosynthesis? Circle all that apply
  - a. **Sunlight,**
  - b. O<sub>2</sub>
  - c. CO<sub>2</sub>
  - d. H<sub>2</sub>O
  - e. Rice
2. What colors of light do plant leaves absorb?
  - a. All colors
  - b. Red only
  - c. Violet
  - d. **All colors but green**
  - e. Green
3. What part of a plant cell is responsible for photosynthesis?
  - a. The stomata
  - b. **Chloroplasts**
  - c. The stem
  - d. The roots
4. What color light has the longest wave length?
  - a. **Red**
  - b. Violet
  - c. Yellow
  - d. Green
5. Which plant(s) were the healthiest and why?
  - a. The plants covered by tissue paper
  - b. **The one in the sunlight and the one in the green paper.**
  - c. The plant in the dark
  - d. The plant in the dark and the plant covered in red paper

**Why? This is because the one in the dark and the one in the red were not receiving enough light.**
6. Why did the plant in the dark grow in the way it did?

**The plant in the dark grew quickly in the beginning as it was attempting to reach sunlight, but then died due to a lack of sunlight. While it was alive it should have also had less green coloring than any of the other plants.**
7. Why is the green plant growing almost as well as the plant with no filter?

**It is because the green filter is absorbing the light the plant would reflect naturally so nearly the same amount of light is reaching the plant wrapped in green paper.**

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