Worcester Polytechnic Institute and
Chulalongkorn University

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

Teacher's Guide

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1. EXPERIMENTS

1.1. How to run experiments

This section outlines how to apply active teaching methods to our experiments.

When to run experiments

According to an educational mindset called *constructivist pedagogy*, students shape what they are learning by what they have already known and experienced. These experiments are supposed to present information building on top of what students have already learned in the National Thai curriculum. Thus, the experiment should be run during the same week as the topics being presented in the background section is being covered in class.

Step 1: Teachers Instructions: Preparing for the class

Before the experiment is run, the teacher must make sure that all the required materials are collected and prepared. These preparations are outlined in the **Teacher's Instructions.** This can be done in previous periods or the night before. Preparing all needed material beforehand will make the experiments run smoother and easier in class.

Step 2: Review Background

The Background Section included with each experiment should be a review for the class. By presenting it before the experiment is run, this will give students enough information to make concrete hypothesis. Because the experiments are meant to run in conjuncture with class, the background section is meant to be used as a review, and to expand specific topics addressed in lab. This section can be presented to students using your normal in class techniques.

In addition, this section briefly explains how the topics are applied to local problems. This follows an active teaching method called *place-based instruction* makes the lesson more pertinent to the students, and thus they are more likely to remember the topics covered. The connection between the topic and student's daily lives should be covered with the background.

Step 3: Review the Student Instructions

The next important step is to review the Student Instruction with the class. By making sure the class is familiar with the class before you run it, it will allow the students to perform more of the experiments on their own.

Each step of the lab should be gone over one by one, and explained to the students. One effective way of showing the class what to do is to demonstrate the set up procedures to the class. While this is an effective way to show set up, care should be taken not to reveal the results of the experiment. For example, the Combustion Experiment tests the burning of fuels. The teacher should show how to set up the test for viewing the different fuels, but the fuels should not be lit in front of the class.

Step 4: The Hypothesis Worksheet

At this point, teachers should divide the class into groups. Groups of 4-6 work best for these types of activities. By having students work in these groups, teachers encourage *cooperative learning*. Students of varying levels and knowledge can work together to learn and understand topics.

These groups should be assigned to complete the *hypothesis* section of the lab. This section is an important step in the *scientific method*. Students need to develop a statement in which to test during the experiment. The Hypothesis Worksheet thus asks students to make an educated guess about the results of the experiment.

It will be helpful to tell the students that the answer to hypothesis questions does not have to be right or wrong. They are a best guess, and will be confirmed or refuted by the experiment.

Step 6: The Experiment

In this section, students will run through the **Student Instructions**. Through doing this, students will experience *hands-on* learning.

Students should be allowed to run the experiment on their own as much as possible. The teacher should walk around the class and observe each group, making sure they are on tasks and performing the experiment correctly.

While running the experiments, students should fill out information on the **Observation Worksheet.** This will make a record of what happened in the experiment to be used for the conclusions section.

Step 7: The conclusions

Students are finally asked to run through the **Conclusions Worksheet**. This worksheet can be used to determine the students' observation and success in running the lab.

1.2. Equipment

This sections aims to provide extra information on how to use specialized equipment such as the microscope and the balance. This information is meant to supplement the instructions provided for each of the experiments. It is important to also note that there may be variations among different models of microscopes and also the triple beam balance.

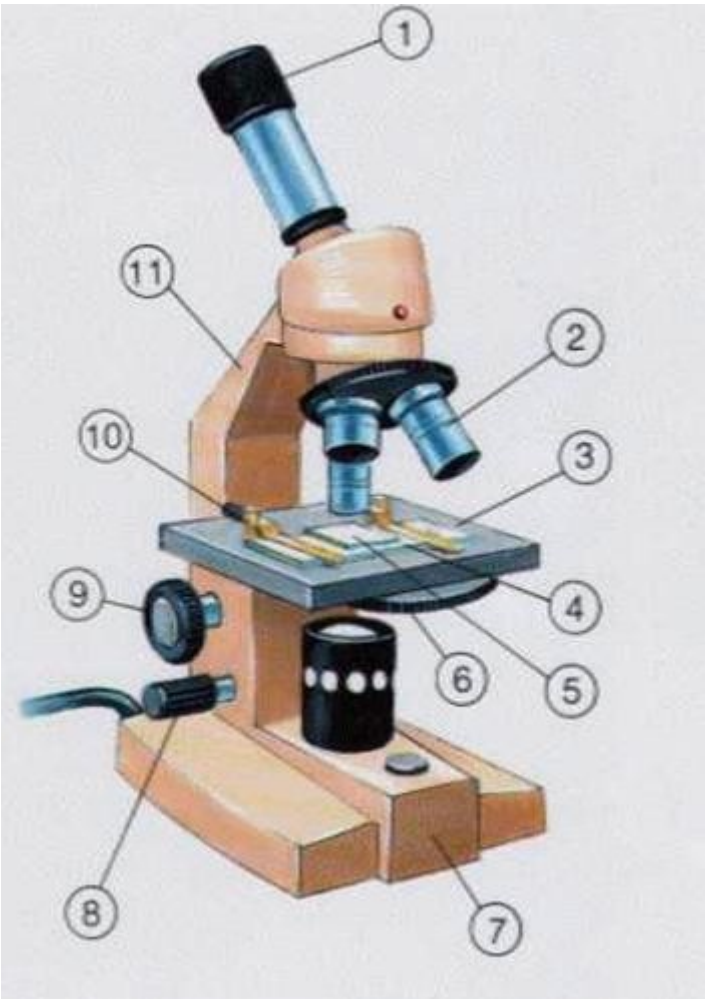
Instructions on how to use a microscope:

1. Set the microscope on a flat and stable surface and plug the power cord into the outlet in order to start the electric light. Switch on the light source.
2. Adjust the diaphragm (Part 6) so that it would allow the largest amount of light to pass through.
3. Rotate the objective lens (Part 2) to lowest magnification (Usually 4x for a standard microscope). This will give 40x magnification. It is important to start with the lowest setting as it would give a wider view of the sample.
4. In the case that the sample is a liquid, prepare the microscope slide by using a pipette to drop the sample onto the center of the slide and placing a cover slip over it. In the case that the sample is a solid, make sure that the sample is flat on the slide before placing a cover slip on it.

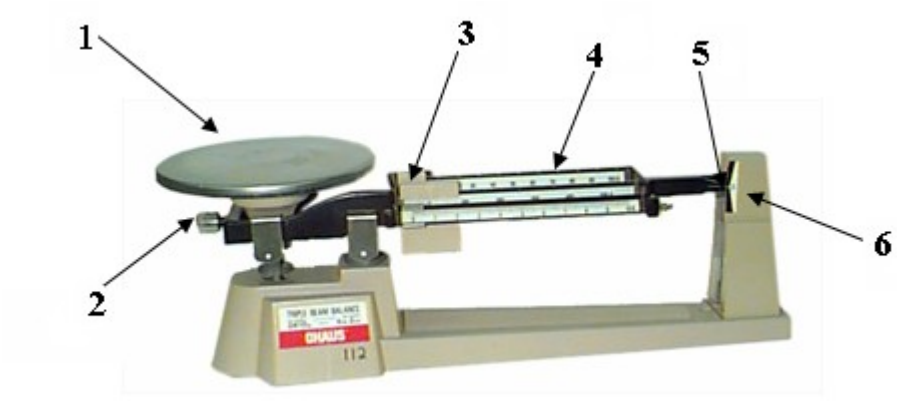
Preparation of a slide: A pipette is used to place the sample on the center of the slide and the cover slip is placed over the sample (Al-Quds University, 2009)

5. Place the slide onto the stage (Part 3) using the stage clips (Part 10). Move the slide until the sample is at the center of the lens.
6. Adjust the coarse focus knob (Part 9) until the sample is in focus. Move the slide to center the sample if necessary.
7. Adjust the fine focus knob (Part 8) until the sample is clearly in focus and adjust the diaphragm (Part 6) to get the best lighting. Start with the largest amount of light and gradually lower it so that the sample image has a sharp and clear contrast.
8. Scan around the surrounding areas of the sample to get a general overview of the sample as for at the center of the sample, higher power should be used.

9. Rotate the lens (Part 2) to the 10x objective. This will give 100x magnification. Gradually refocus the image using *only* the fine focus knob. This is very important as using the coarse focus knob could cause damage to the lens. As more light is needed for higher magnifications, adjust the lighting until the image is clear. Repeat the same process when adjusting to the 40x or 400x, magnification.



Parts of a microscope (Al-Quds University, 2009)



A triple beam balance (Southern Methodist University, 2008)

Instructions on how to use a triple beam balance:

The triple beam balance can measure samples very precisely. The reading error is only around 0.05 gram. The instructions on how to use a triple beam balance are as follows:

1. Every time the balance is taken out, move the three sliders (Part 3) to the far left of the beams so that the balance reads to zero. When the indicator is not aligned to zero, the balance can be calibrated by turning the set screw on the left under the pan (Part 2).
2. After the balance has been calibrated, place the sample onto the pan (Part 1).
3. Move the slider on the 100 gram beam along to the right until the indicator (Part 5) drops below the center mark on the far right (Part 6), and then move the slider back one slot.
4. Move the slider on the 10 gram beam along to the right until the indicator (Part 5) drops below the center mark on the far right (Part 6) and then move the slider back one slot.
5. Move the slider on the 1 gram beam (smallest beam) until the indicator (Part 5) is aligned to the center of the center mark on the far right (Part 6).
6. In order to get the mass of the object on the pan, add up the numbers from the three beams.

1.3. Our Experiment

1.3.1. The Effect of Salinity on Plant Growth

Teacher Instructions

Background

Diffusion is the process by which particles, whether solid, liquid, or gas, move from an area of high concentration to an area of low concentration to achieve balance. One way to imagine this happening is two rooms separated by a doorway. One of the rooms is filled with girls. The other room is filled with boys. As long as the door remains shut, the girls will stay in their room and the boys will stay in their room. However, once the door is opened the forces that be cause the boys and girls to want to move away from each other. They will keep moving making it so that there are evenly distributed. This motion can be described as diffusion.

Molecules in nature are a lot like these boys and girls. They usually want to move far away as possible from each other, unless something holds them together. When molecules move from high concentration to low concentration, the process is called diffusion. When you open a bottle of something smelly in a room, the thing that brings the smell all around the room is diffusion.

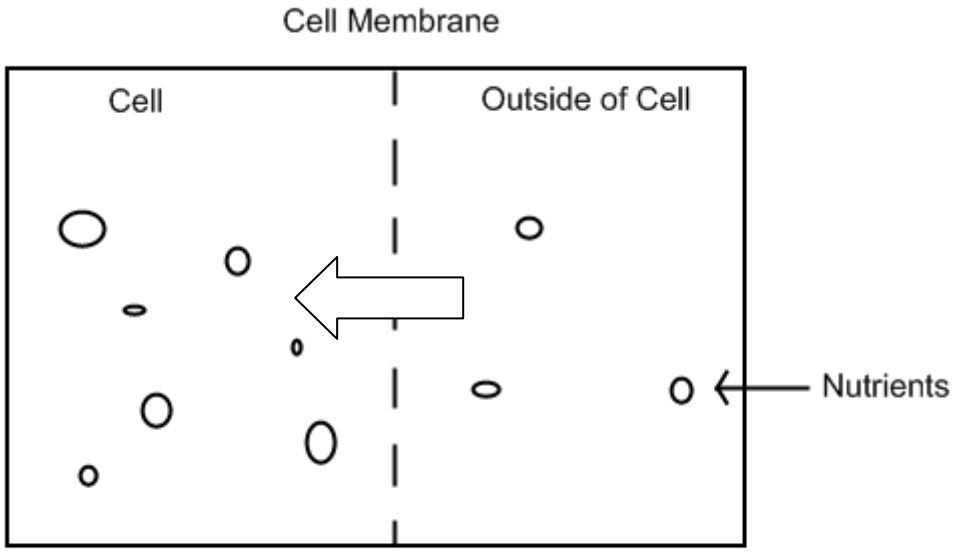
Osmosis is a type of diffusion. Osmosis is the diffusion of water molecules. Although all osmosis processes are diffusion, not all diffusion processes are osmosis. If instead of girls and boys in the separate rooms, there was one room filled with pure water and one room filled with sugar water. Because there are sugar water molecules in the water, taking the place of water molecules, the sugar water can be said to have a lower concentration of water. If door would open, the same thing would happen as when it was girls and boys. Water molecules from the room containing pure water would move into the sugar water room. Sugar molecules from the room containing sugar water would move into the room with the pure water. This would continue until there is the same amount of sugar and water is on both sides of the doorway. This is Osmosis.

If there was chlorine gas on one side of the door, and hydrogen gas on the other side of the door, the same process would happen if the door was opened. The amount of chlorine and hydrogen would balance between the two rooms. However, this is not osmosis. Although it is the same process, this example does not include water. Therefore, it is not osmosis.

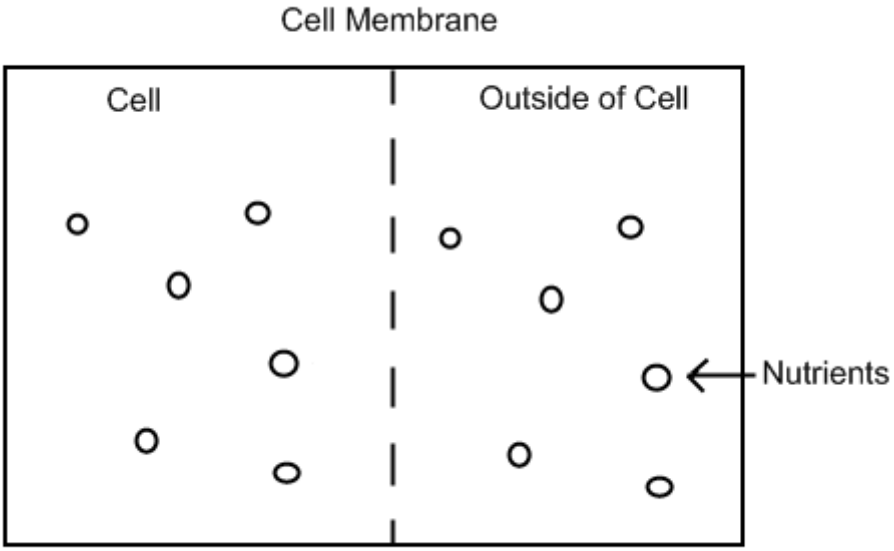
What is salinity? Salinity is the amount of salt dissolved in a given body of water or soil, generally expressed as a concentration in parts per thousand (ppt); all bodies of water have a certain salt concentration. Whereas some bodies of water naturally have a high salinity, such as the ocean and the Dead Sea, most do not. This is because most organisms cannot survive in an environment with a high salt concentration. Normal water has a salt concentration of 0.5 ppt. The Dead Sea in Israel has an average salt concentration of 500 ppt, the greatest known in any body of water. This concentration is so high that nothing can live in the waters, including plants. Many plants have a hard time surviving in soils with high salt concentrations.

Think about when you eat or drink something really salty. Does it make you thirsty? It does make you thirsty because the salt concentration of the water in your body is less than the one in the water of what you ingest, so concentrations have to balance and the food ends up drawing water out of your cells, leaving them dehydrated. This process is called reverse osmosis. Cells are made up mostly of water. The cell membrane around the cells lets water and nutrients pass through. When there is a higher concentration of salt on one side of the membrane, fluid passes out of the cell to bring balance back.

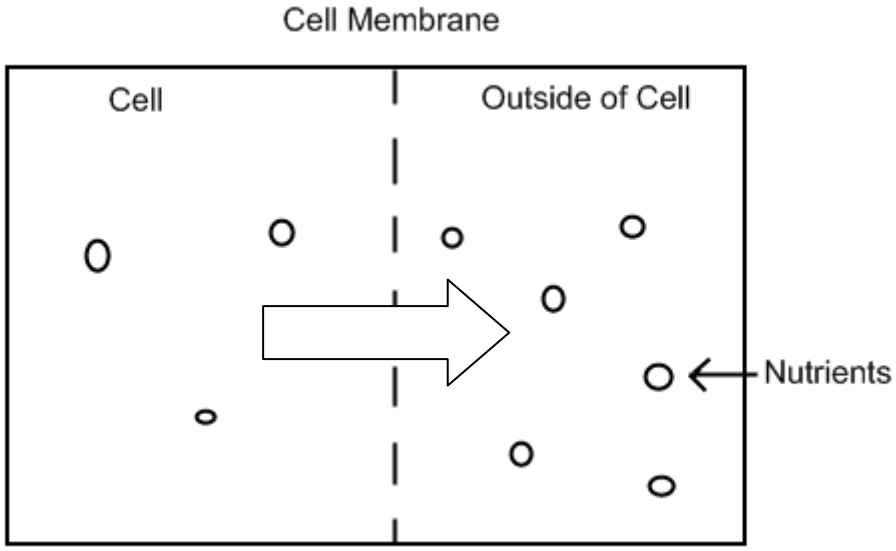
The following diagram shows osmosis. There are more nutrients inside the cell, so water flows into the cell to balance the concentration of nutrients inside the cell with the concentration of nutrients outside the cell.



The following diagram shows balance. No osmosis is taking place because there are equal concentrations of nutrients and water both inside and outside the cell.



The following diagram shows reverse osmosis. There are more nutrients outside of the cell, so water travels out of the cell to give the same concentration of water to nutrients outside of the cell as there is inside the cell.



When salt collects in the soil, it makes it harder for plants to draw water out of the soil through their roots. The more water the plant draws out of the soil, the harder it is to for the plant to draw more water out of the soil. This is because the concentration of salt in the soil is increasing, and the process begins to act in reverse. As the amount of water decreases, the amount of salt is staying the same, leading to an increase in soil salinity. Like a human would become thin and unhealthy when living on

scarce or non-nutritious food, so too do plants become when unable to draw enough water out of the soil.

This is relevant to Sakon Nakhon because the groundwater in Sakon Nakhon is becoming increasingly salty. Since people in Sakon Nakhon use groundwater as their main water source to water crops, the soil which is used for farming is being exposed to salty water. This is a problem because the salt in the water becomes stuck in the soil and builds up. Any plants that are grown in this soil will not grow as well as they would were they to be planted in soil that is not salty.

A scientific experiment works through reasoning and gradually going to conclusions. It is a method that is used to work out if a particular variable is the main factor leading to a conclusion. For example, if there are two variables (X and Y), an experiment would have to determine whether X is the course of Y to occur. Looking in a wider perspective scientific experiments are used to provide a better understanding of natural phenomena. It is probably the most commonly used method in scientific research.

The three main variable used in the scientific method are known as the independent variable, the dependent variable and the control variable.

The independent variable is the variable that researchers use to work out whether something is the "cause" of a phenomenon. In this experiment, the independent variable is the amount of salt used.

The dependent variable is the variable that is used to work out whether the reasoning actually leads to the conclusion. In this experiment, the dependent variable is the growth of the plants.

The control variable is the variable which researchers can derive methods to control it. In this experiment, the control variable is the amount of water used.

The Experiment

Educational Goals

- To provide an experiment that shows the effect of biotechnology on local agriculture
- To stimulate students interest in biotechnology outside regular classroom procedures
- To teach students how to make predictions
- To teach students how to cooperatively work in groups
- To actively engage students in the subject of biotechnology

Introduction

In this experiment, the student will investigate the effect of salinity on plant growth. They will first complete the hypothesis exercises with your team. Then the student will plant his seeds in cups, place them in an area that receives sunlight, and add clean water to them every day. After germination, the student will water each plant with water that contains a different amount of salt and daily record observations as to the growth or sickness of the plant. At the end of a week following germination, the student will complete the individual worksheets which you will receive from the teacher.

Relevance

Students will be able to see the topic of biotechnology in action. This experiment will engage them in the subject matter because it relates to their daily lives. Students who do this experiment will be able to understand that there are positive effects to biotechnology.

Materials Required Per Class

1. A large source of soil
2. About 1 Liter of bottled or purified water per group of 4 students
3. About 1 Liter of local water (from well or pump) per group of 4 students
4. About 1 Liter of mildly salty water per group of 4 students
5. About 1 Liter of very salty water per group of 4 students
6. 4 large buckets to store soils and water in
7. 4 plastic or Styrofoam drinking cups for every group of 4 students
8. A roll of masking tape
9. Dry Measuring Cups
10. 4 seeds of a fast sprouting crop for every group of 4 students
11. Area in class room or school that is exposed to sunlight (window)
12. 1 plastic or Styrofoam cup for watering per group of 4 students

Materials Required Per Group of Students

1. 4 plastic or Styrofoam drinking cups
2. Masking Tape
3. Dry Measuring Cups (at teacher station)
4. 4 seeds (of a fast sprouting crop)
5. 1 Liter Bottled of purified Water
6. 1 Liter Local Water
7. 1 Liter of mildly salty water

8. 1 Liter of very salty water
9. 1 cup of soil
10. Area that is exposed to sunlight
11. 1 plastic or Styrofoam cup for watering

Procedure for Teacher

Preparation for first day

1. Fill a large bucket with soil.
2. Cut approximately 1 foot of masking tape off of the roll for each group and place it at each groups station
3. Place set of measuring cups at the front of the class room next to buckets
4. Fill one large bucket with local groundwater (from tap or well)
5. Fill one large bucket with clean water (bottled or purified)
6. Prepare the mildly salty water solution. Per group of 4 students, mix 17.5 mL (38 grams) with 1 L of water. For the entire class, multiply the amount of salt and amount of water by the number of groups.
7. Prepare the mildly salty water solution by mixing
8. Prepare the very salty water solution. Per group of 4 students, mix 35 mL (76 grams) with 1 L of water. For the entire class, multiply the amount of salt and amount of water by the number of groups.
9. If running water is not available, place one large bucket full of water at the front of the classroom
10. Place 5 plastic or Styrofoam cups at each groups station
11. Place 12 seeds at each groups station
12. Either Make one copy of worksheet 1 for each group and place at each groups station, or write questions from worksheet 1 on the blackboard or whiteboard for students to write in their notebooks and answer.
13. Find an area that is exposed to sunlight where all the plants can be stored

Preparation for Every Day until the Seeds Have Sprouted

1. Have clean water available every morning for the students to water their plants.
2. Have a cup for each group to transport water in every morning.
3. When the plants are approximately 2.5 cm tall, it is time to move to the next set of instructions

Preparation for After Seeds Sprout – Continue for Two Weeks

1. Have clean water available every other morning for the students to water their plants
2. Have local water available every other morning for students to water their plants
3. Have mildly salty water available other every morning for students to water their plants

4. Have very salty water available every other morning for students to water their plants
5. Place buckets of water at front of class
6. Have a cup for each group to transport water in every morning.
7. Either make one copy of worksheet 2 for every group and hand out to each group, or write the instructions on the blackboard or whiteboard for the students to write into their notebooks and answer. Complete Observations three times a week.

Preparation for end of 1 week after sprouting

1. Either make one copy of worksheet 3 for every student or write questions onto the black or whiteboard for students to write into their notebooks and answer.

Optional Instructions - Measuring Salt Concentration of Local Water

In order to determine the concentration of salt in local groundwater, it is possible to take a sample of groundwater and boil off all of the water. In this way, it can be determined how salty the groundwater is compared to the pure water used in the experiment and the salt water solutions used in the experiment.

1. Clean and dry a pot to boil water in.
2. Weigh the pot – write down the weight of the pot
3. Measure out 250 mL of local water and put in the pot
4. Boil the water until all water is gone
5. Weigh the pot again. Subtract the 1st measurement of the weight of the pot from the weight measured in this step.
6. Calculate concentration by dividing grams of salt by liters of water

Expected Answer to Student Worksheets

Worksheet 1 – Expected Student Answers

Hypothesis

1. What sample do you think will show the most growth after the end of the experiment? List the samples ("A" "B" "C" "D") in order from most growth to least growth.

   A, B, C, D

2. Are there any samples that you think won't grow by the end of the experiment?

   Sample D will die

   Sample C will become sick and/or die

3. Draw pictures of what you think sample A will look like at the end of the experiment:

   (Pictures of plants)

4. Draw pictures of what you think sample B will look like at the end of the experiment:

   (Pictures of plants)

5. Draw pictures of what you think sample C will look like at the end of the experiment:

   (Pictures of plants)

6. Draw pictures of what you think sample D will look like at the end of the experiment:

   (Pictures of plants)

7. In question 1 of this worksheet you listed a sample as the one that will show the most growth over 3 weeks. Why do you think this plant will show the most growth?

   I chose sample A, because this is the sample that doesn't have any salt added to the water. This sample will grow the best because the salt in the other

solutions of water will draw the water out of the cells in the plants and cause them to die.

Worksheet 2 – Expected Student Answers

Observations

Draw a picture of sample A

Measure the height of sample A:

Date of observation:

Draw a picture of sample B

Measure the height of sample B

Date of observation:

Draw a picture of sample C

Measure the height of sample C

Date of observation:

Draw a picture of sample D

Measure the height of sample D

Date of observation:

Worksheet 3 – Expected Student Answers

Individual Conclusions

1. Which plants grew the best? Why? What type of water were they getting?
   I chose sample A, because this is the sample that doesn't have any salt added to the water. This sample will grow the best because the salt in the other solutions of water will draw the water out of the cells in the plants and cause them to die.

2. What happened to the plants that were receiving other concentrations of salt water?
   The plants that were receiving the very salty and mildly salty concentrations of salt water died. The sample receiving very salty water died faster than the plan receiving mildly salty water.

3. Did any of the plants die?
   Yes – Samples C and D

4. If you were to grow a garden, what type of water would you want to use to water your plants?
   I would use clean water to water my plants, to prevent them from dying.

5. What happens to the soil after it has been watered with salty water? Do you think anything will grow in the soil?
   After the soil has been watered with salty water, it becomes salty as well. Nothing will grow in the soil for a long time after this happens.

Student Instructions

Background

Diffusion is the process by which particles, whether solid, liquid, or gas, move from an area of high concentration to an area of low concentration to achieve balance. Imagine two rooms separated by a doorway. One of the rooms is filled with girls. The other room is filled with boys. As long as the door remains shut, the girls will stay in their room and the boys will stay in their room. However, once the door is opened, girls and boys will begin to move in and out of each room until there are the same amount of girls and boys in each room. In moving between rooms so that the amount of girls on each side of the doorway is the same, they are diffusing between rooms.

Osmosis is the diffusion of water molecules. Although all osmosis processes are diffusion, not all diffusion processes are osmosis. If instead of girls and boys in the separate rooms, there was one room filled with pure water and one room filled with sugar water, and the door would open, the same thing would happen as when it was girls and boys. Water molecules from the room containing pure water would move into the sugar water room. Sugar molecules from the room containing sugar water would move into the room with the pure water. This would continue until there is the same amount of sugar and water is on both sides of the doorway. This is Osmosis.

If there was chlorine gas on one side of the door, and hydrogen gas on the other side of the door, the same process would happen if the door was opened. The amount of chlorine and hydrogen would balance between the two rooms. However, this is not osmosis. Although it is the same process, this example does not include water. Therefore, it is not osmosis.

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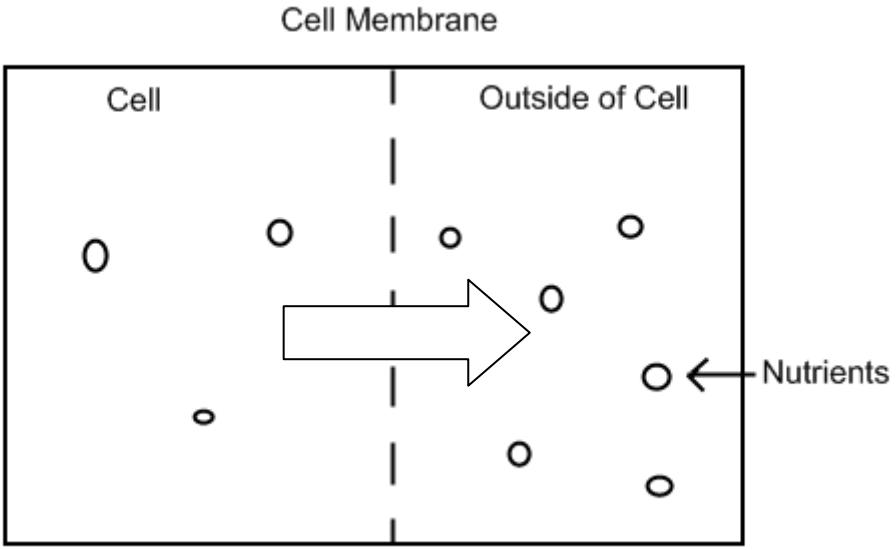
Think about when you eat or drink something really salty. Does it make you thirsty? It does make you thirsty because the salt concentration of the water in your body is less than the one in the water of what you ingest, so concentrations have to

balance and the food ends up drawing water out of your cells, leaving them dehydrated. This process is called reverse osmosis. Cells are made up mostly of water. The cell membrane around the cells lets water and nutrients pass through. When there is a higher concentration of salt on one side of the membrane, fluid passes out of the cell to bring balance back.



When salt collects in the soil, it makes it harder for plants to draw water out of the soil through their roots. The more water the plant draws out of the soil, the harder it is to for the plant to draw more water out of the soil. This is because the concentration of salt in the soil is increasing. As the amount of water decreases, the amount of salt is staying the same, leading to an increase in soil salinity. Like a human would become thin and unhealthy when living on scarce or non-nutritious food, so too do plants become when unable to draw enough water out of the soil.

This is relevant to Sakon Nakhon because the groundwater in Sakon Nakhon is becoming increasingly salty. Since people in Sakon Nakhon use groundwater as their main water source to water crops, the soil which is used for farming is being exposed to salty water. This is a problem because the salt in the water becomes stuck in the soil and builds up. Any plants that are grown in this soil will not grow as well as they would were they to be planted in soil that is not salty.

The Experiment

Introduction

In this experiment, you will investigate the effect of salinity on plant growth. You will first complete the hypothesis exercises with your team. You will then plant your seeds in cups, place them in an area that receives sunlight, and add clean water to them every day. After germination, you will water each plant with water give each plant water that contains a different amount of salt and daily record observations as to the growth or sickness of the plant. At the end of a week following germination, you will complete the individual worksheets which you will receive from the teacher.

Relevance

The quality and salinity of the water used to irrigate crops with has a large impact on the productivity and health of the crops themselves. Using salinated water to irrigate crops leads to salination of soils. This can hinder plant growth, or even cause the plants to die. You will investigate the effects that different concentrations of salt in water have on plant growth.

Materials Required Per Group of Students

1. 4 plastic or Styrofoam drinking cups
2. Masking Tape
3. Dry Measuring Cups (at teacher station)
4. 4 seeds (of a fast sprouting crop)
5. 1 Liter Bottled of purified Water
6. 1 Liter Local Water
7. 1 Liter of mildly salty water
8. 1 Liter of very salty water
9. 1 cup of soil
10. Area that is exposed to sunlight
11. 1 plastic or Styrofoam cup for watering

Procedure for Students

<u>First Class</u>

1. Read the Background, Intro and Relevance sections of this activity
2. Complete Worksheet 1 with your team
3. Gather the Materials Needed
4. Poke 3 small holes in the bottom of each cup, excluding the water cup

5. Label the cups with your group number
6. Label cups “A” “B” “C” “D”
7. Add one cup of soil to “A” “B” “C” and “D”
8. Add 1 seed to “A” “B” “C” and “D” about 1 inch deep
9. Ensure all seeds are covered by the soil
10. Fill the cup for watering 1/3 full of water and pour the water on “A”
11. Fill the cup for watering 1/3 full of water and pour the water on “B”
12. Fill the cup for watering 1/3 full of water and pour the water on “C”
13. Fill the cup for watering 1/3 full of water and pour the water on “D”
14. Place all 4 cups in an area that is exposed to sunlight

<u>Every Morning before sprouting</u>

1. Fill the cup for watering 1/3 full of water and pour the water on “A”
2. Fill the cup for watering 1/3 full of water and pour the water on “B”
3. Fill the cup for watering 1/3 full of water and pour the water on “C”
4. Fill the cup for watering 1/3 full of water and pour the water on “D”

<u>Every morning after sprouting</u>

1. Fill the cup for watering 1/3 full of bottled water and pour the water on “A”
2. Fill the cup for watering 1/3 full of local water and pour the water on “B”
3. Fill the cup for watering 1/3 full of mildly salty water and pour the water on “C”
4. Fill the cup for watering 1/3 full of very salty water and pour the water on “D”
5. Record observations on Worksheet 2

<u>At the end of 1 week after sprouting</u>

1. Complete Worksheet 3 individually

Student Worksheets

Worksheet 1

Hypothesis

1. What sample do you think will show the most growth after the end of the week? List the samples ("A" "B" "C" "D") in order from most growth to least growth.

2. Are there any samples that you think won't grow by the end of the week?

3. Draw pictures of what you think sample A will look like at the end of 1 week:

4. Draw pictures of what you think sample B will look like at the end of 1 week:

5. Draw pictures of what you think sample C will look like at the end of 1 week:

6. Draw pictures of what you think sample D will look like at the end of 1 week:

7. In question 1 of this worksheet you listed a sample as the one that will show the most growth over 3 weeks. Why do you think this plant will show the most growth?

Worksheet 2

Observations

Draw a picture of sample A

Measure the height of sample A:

Date of observation:

Draw a picture of sample B

Measure the height of sample B

Date of observation:

Draw a picture of sample C

Measure the height of sample C

Date of observation:

Draw a picture of sample D

Measure the height of sample D

Date of observation:

Worksheet 3

Individual Conclusions

1. Which plants grew the best? Why? What type of water were they getting?

2. What happened to the plants that were receiving other concentrations of salt water?

3. Did any of the plants die?

4. If you were to grow a garden, what type of water would you want to use to water your plants?

5. What happens to the soil after it has been watered with salty water? Do you think anything will grow in the soil?

Pre – Test

1. What effect does a high salt concentration in soil have on plants?

2. Reverse osmosis, which causes water to move out of a body, interferes with plant growth. How do you think it will occur during the experiment?

Post – Test

1. What happens to plants when they are exposed to a high salt concentration in soil?

2. If reverse osmosis interferes with plant growth by pulling water out of a plant, how will water flow if a plant is exposed to high concentrations of salt?

Budget

Material	Groups per class	Quantity required per group (4 students)	Student per class	Cost per item	Cost per class
Soil	10	N/A	40	35	350
Bottled Water	10	1 Liter	40	20	200
Empty Bottles	10	3	40	N/A	N/A
Salt	10	1	40	40	400
Plastic Drinking cups	10	5	40	5	250
Masking tape	10	N/A	40	35	350
Dry measuring cups	10	N/A	40	50	500
Package of Seeds	10	N/A	40	40	400
Total Cost of lab:					2,450

1.3.2. Incomplete Combustion and Air Pollution

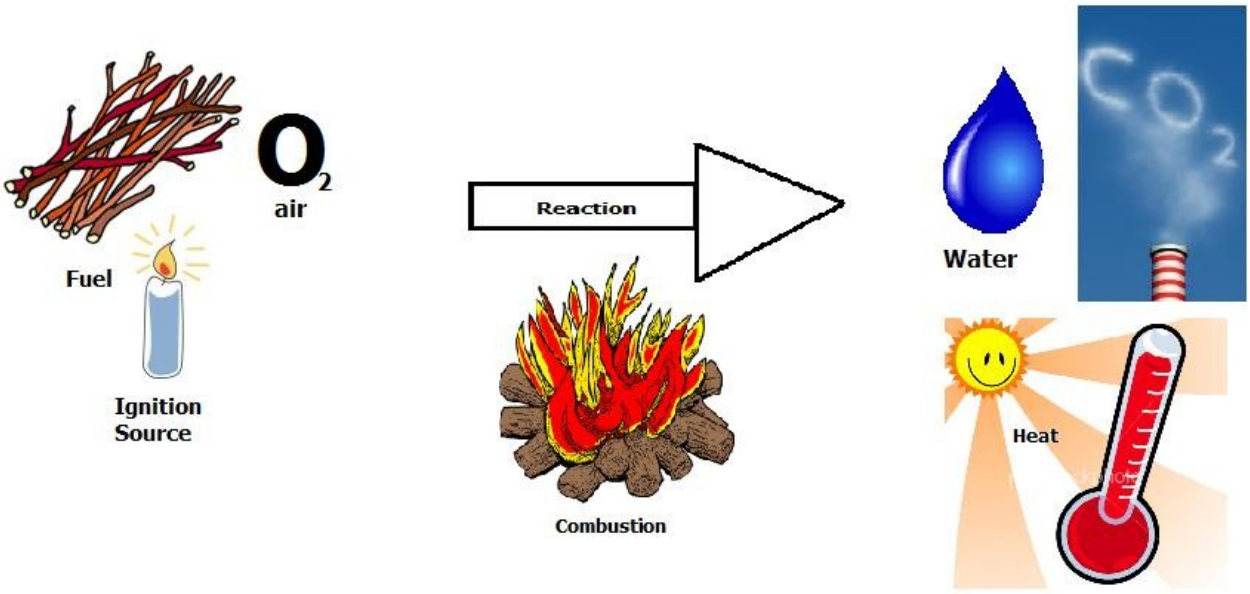
Teacher Instructions

Background

Combustion is what happens when an object or material burns. For example, this material could be a bunch of wood being burned for a campfire. All of the components of the wood burn, leaving only one behind. The component left behind is the element carbon. This carbon can be left behind either on the ground, in the form of ash or soot, or in the air, in the form of dirty smoke. This dirty smoke, which pollutes the air, can be produced by both manmade and natural materials. The smoke, which is often called air pollution, is made up on small pieces of pollen and dirt called *particulate matter*. Normally air has a natural amount of particulates getting into the air. One way this can happen is dust getting stirred into the air on a windy day in the dry season. When there is too much dust or dirt in the air, our bodies cannot filter the dust out, and we get sick.

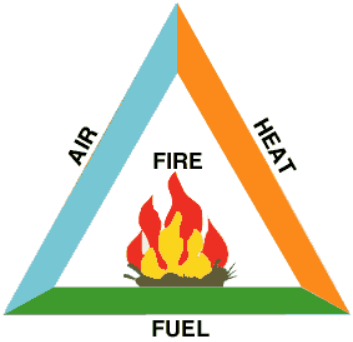
When you burn, or combust, things, it produces heat, a transparent gas known as carbon dioxide, and water, which can be in the form of water vapor. This transformation occurs through a chemical reaction. A chemical reaction is when you combine two substances to get an entirely new substance. This is different from a physical change. A physical change is when you mix two materials together to form a mixture. An example of this is when you mix ground coffee and sugar. If you were to taste this dusty mix, you can easily taste the coffee and the sugar as different flavors. This occurs because the coffee and the sugar are still the same substances they were before.

In order for combustion to occur, several different ingredients are necessary. Think of when you try to start a fire. You cannot start a fire without anything to burn. This is called fuel. Fuel, such as wood or cloth, is necessary to create fire. Air is also necessary for starting fires. Fire consumes air – it needs the oxygen in order to sustain itself. Think of when you are frying something and the oil catches on fire. Have you ever smothered a fire by placing a lid over the flame? The fire goes out almost immediately, because it runs out of oxygen and dies. You also need something to start the fire with, such as a lighter or a match. This is called the *ignition source.*



All materials are composed of different amounts of basic ingredients, named elements. One of these elements is carbon. Carbon requires a lot of oxygen to be burned, especially when combined with other elements. Therefore, fuel that is made of up of mostly carbon will burn more completely than fuel that has more impurities. Combustion can occur in two different ways. In one way, known as *complete combustion*, the fuel and the oxygen are completely consumed by the reaction. Since everything that is reacted (fuel and oxygen) is transformed into heat, carbon dioxide, and water, it does not form anything else. This includes soot or ash. The other way is known as *incomplete combustion.* This occurs when there is not enough oxygen to burn up all the fuel. Because there is fuel left over, it remains after the reaction is complete as soot or ash.

When fire goes out of control it can be very dangerous. Fire can quickly burn tables, books, and houses, and can trap people inside rooms and suffocate them. It is very important to prevent it from spreading. Fire needs two things to keep on burning: oxygen and fuel.



As it can be seen in the safety triangle, if you keep fire from receiving one of them it will stop burning. If you drop water on the fuel source, it stops being a fuel so it cannot keep on burning. The same will happen if you cover the fire so it cannot receive air anymore. If the fire in your experiment begins to spread outside the candle, cover it with the glass jar or water it.

The Experiment

Educational Goals for Teacher

- To allow students to see what a combustion reaction is
- To show that chemical reactions can have negative environmental effects
- Identify what air pollution is
- To show that some types of fuel burn cleaner than others

Introduction

In this experiment your team will investigate the combustion of three different types of fuels: Methanol, Vegetable Oil and Motor Oil. All of these reactions produce different amounts of ash depending on their properties. Your team will investigate what happens when these fuels are combusted and you will consider the side effects of combustion.

Teacher Relevance

Students who do this experiment will be working with a combustion reaction. They will be able to relate the material that they read in an academic book to what actually happens in life. They will see a chemical reaction in person. The students will learn that some reactions can have a negative environmental effect.

Teacher Materials Required

1. Methanol
2. A bottle of motor oil
3. A bottle of Vegetable Cooking Oil
4. A roll of cotton rope, 5 mm thick
5. Large glass jars (2 per group of students)
6. Small glass jars (2 per group of students)
7. Large paper clips (2 per group of students)
8. 4 Wood Pieces
9. Lab pipette or straw (2 per group of students)
10. Glass of water
11. Pair of scissors (1 per group of students)

Teacher Procedure

1. Place containers of methanol, vegetable oil and motor oil on front table
2. Cut each group a 5 cm piece of cotton rope and place at group stations
3. Place 2 paper clips, 2 small glass jars, 2 large glass jars, 2 pipettes or straws and 1 pair of scissors at each group station

When groups have their station setup

1. Ensure students stay away from cotton rope that is lit
2. One member has to make sure the cotton rope is soaked in water after being burnt

Expected Answer to Student Worksheets

Worksheet 1 – Expected Student Answers

Hypothesis

1. Do you think the combustion of the motor oil will be a complete or incomplete reaction?

   (Complete) Incomplete

2. Do you think the combustion of the vegetable oil will be a complete or incomplete reaction?

   Complete (Incomplete)

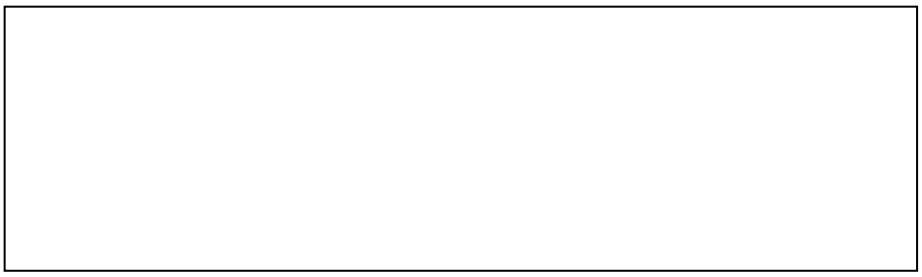
3. Do you think the combustion of the methanol will be a complete or incomplete reaction?

   Complete (Incomplete)

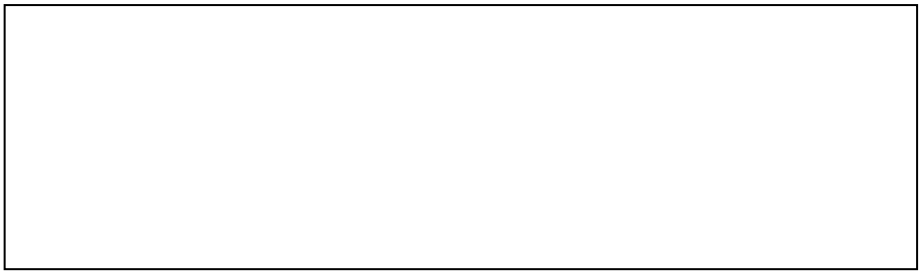
4. Which ones would you think have the most impurities?

5. Knowing that incomplete combustion causes the formation of particulate matter, what do you think the glass jars will look like? Draw pictures of what you think the jars will look like at the end of the experiment:

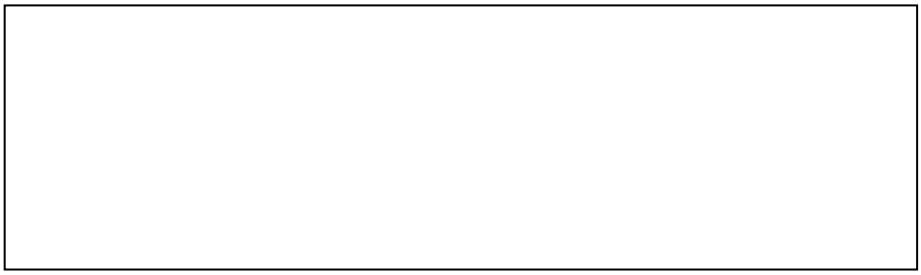
   -
   - Methanol jar



Vegetable jar



Motor Oil jar



Worksheet 2 – Expected Student Answers

Observations

Draw a picture of the methanol flame

Draw a picture of the methanol jar

Draw a picture of the vegetable oil flame

Draw a picture of the vegetable oil jar

Draw a picture of the motor oil flame

Draw a picture of the motor oil jar

Worksheet 3 – Expected Student Answers

Individual Conclusions

1. Was your hypothesis about what the jars would look like correct? Explain the similarities or differences.

2. Which material burned cleaner? From this observation, do all materials cause the same amount of pollution?

   Methanol burned cleaner than vegetable oil and vegetable oil burned cleaner than motor oil. They cause different amounts of pollution.

3. Why is combustion where there is a lot of pollution harmful to the environment?

   Because it produces Carbon Dioxide, which is a greenhouse gas.

4. Can you think of any ways to reduce the amount of pollution that goes into the environment?

   Burn less or use a clean fuel.

Student Instructions

Background

Combustion is what happens when an object or material burns. For example, this material could be a bunch of wood being burned for a campfire. All of the components of the wood burn, leaving only one behind. The component left behind is the element carbon. This carbon can be left behind either on the ground, in the form of ash or soot, or in the air, in the form of dirty smoke. This dirty smoke, which pollutes the air, can be produced by both manmade and natural materials. The smoke, which is often called air pollution, is made up on small pieces of pollen and dirt called *particulate matter*. Normally air has a natural amount of particulates getting into the air. One way this can happen is dust getting stirred into the air on a windy day in the dry season. When there is too much dust or dirt in the air, our bodies cannot filter the dust out, and we get sick.

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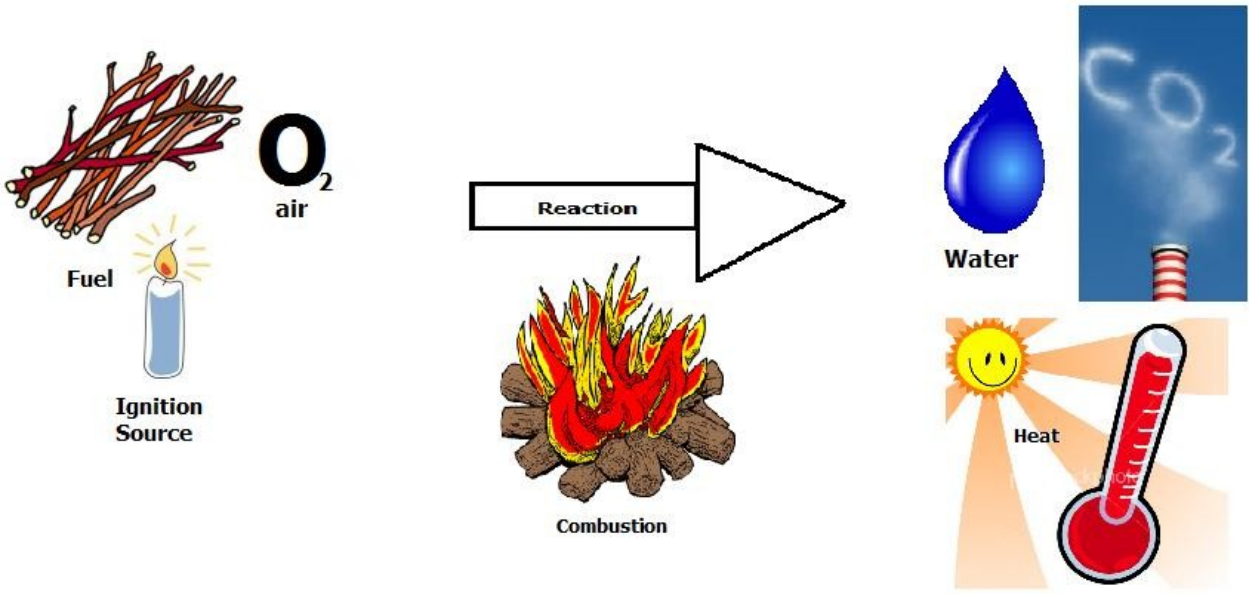

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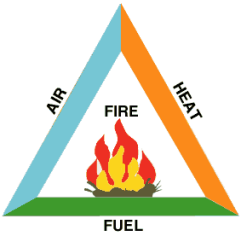


As it can be seen in the safety triangle, if you keep fire from receiving one of them it will stop burning. If you drop water on the fuel source, it stops being a fuel so it cannot keep on burning. The same will happen if you cover the fire so it cannot receive air anymore. If the fire in your experiment begins to spread outside the candle, cover it with the glass jar or water it.

The Experiment

Student Relevance

Combustion happens any place material is burned. Combustion happens at a factory in a city and inside the engine of a farm tractor. There are many possible solutions to regulate the amount of ash released into the atmosphere. Applying them in order to keep air quality high is important because an excess of ash in the air can cause respiratory diseases like asthma or lung cancer.

Student Materials Required

1. 6 cm long piece of cotton rope
2. 2 large paper clips
3. 2 large glass jars
4. 2 small glass jars
5. 4 Wood Pieces
6. 3 Pipettes or straws
7. 1 cup of water
8. Methanol
9. Vegetable Oil
10. Motor Oil
11. Scissors
12. Candle

Student Procedure

<u>Part 1</u>

1. Place the two wood pieces in a stable location, parallel to each other separated by two and a half centimeter.
2. Bend the paper clip so that it looks like this: 
3. Cut 6 cm length of the thick cotton rope
4. Weave the paper clip in and out of the outer most layer of the 6 cm long piece clothesline so it looks like this: 
5. Bend the bottom piece of the paper clip so it can stand on its own
6. Fill one small jar with a sample of methanol from the front of the classroom

7. Using the pipette put 20 drops of methanol on the clothes line that is attached to the paper clip
8. Place the clip in between the wood pieces and put the glass jar facing downwards over the wood pieces
9. When finished setting up ask the teacher to light the clothes line with a candle
10. Let the clothesline burn until the flame disappears and place the smoking remains of the paper clip in a cup of water
11. Complete portions of worksheet 2 concerning methanol
12. Repeat step 1-10 by using vegetable oil instead of methanol
13. Complete portions of worksheet 2 concerning vegetable oil
14. Repeart step 1-10 by using motor oil instead of methanol
15. Complete worksheet 2

<u>Part 2</u>

1. When experiment is finished complete worksheet 3 individually

Worksheet 1

Hypothesis

1. Do you think the combustion of the motor oil will be a complete or incomplete reaction?

   Complete Incomplete

2. Do you think the combustion of the vegetable oil will be a complete or incomplete reaction?

   Complete Incomplete

3. Do you think the combustion of the methanol will be a complete or incomplete reaction?

   Complete Incomplete

4. Which ones would you think have the most impurities?

5. Knowing that incomplete combustion causes the formation of particulate matter, what do you think the glass jars will look like? Draw pictures of what you think the jars will look like at the end of the experiment:

Methanol jar

Vegetable jar

Motor Oil jar

Worksheet 2

Observations

Draw a picture of the methanol flame

Draw a picture of the methanol jar

Draw a picture of the vegetable oil flame

Draw a picture of the vegetable oil jar

Draw a picture of the motor oil flame

Draw a picture of the motor oil jar

Worksheet 3

Individual Conclusions

1. Was your hypothesis about what the jars would look like correct? Explain the similarities or differences.

2. Which material burned cleaner? From this observation, do all materials cause the same amount of pollution?

3. Why is combustion where there is a lot of pollution harmful to the environment?

4. Can you think of any ways to reduce the amount of pollution that goes into the environment?

Pre-Test Questions

1. Do you think that by inhaling the products of burning a material like motor oil you could be sick?

2. Do you think burning a substance causes noticeable difference in the air?

Post-Test Questions

1. Would you have been worried about your health if you inhale the smoke from motor oil?

2. Do burning fuels cause noticeable difference in the quality of the air we breathe?

Budget

Material	Groups per class	Quantity required per group (4 students)	Students per class	Cost per item	Cost per class
Box of Paper clips	10	N/A	35	20	20
Clothes line	10	1/2 metre	35	25	875
Drinking Glasses	10	2	35	10	200
Plastic Drinking Cups	10	3	35	5	150
1 mL pipette	10	N/A	35	40	40
Pair of scissors	10	1	35	40	400
Bottle of motor oil	10	N/A	35	60	60
Candle	10	1	35	2	20
Bottle of vegetable oil	10	N/A	35	25	25
Bottle of methanol	10	N/A	35	55	55
Pieces of wood	10	2	35	7.50	150
Total Cost of lab:					2,120

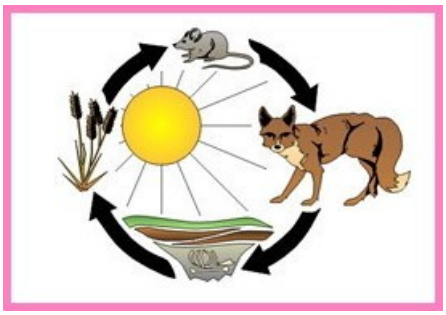
1.3.3. Algae Bloom and Local Ecology

Teacher Instructions

Teacher Background

Food Chains

A food chain is process showing the relationship between organisms in a community where each member is eaten in turn by another member. The relationship starts from the producer going to the primary consumer and then to the secondary consumer. This relationship is known as a food chain.



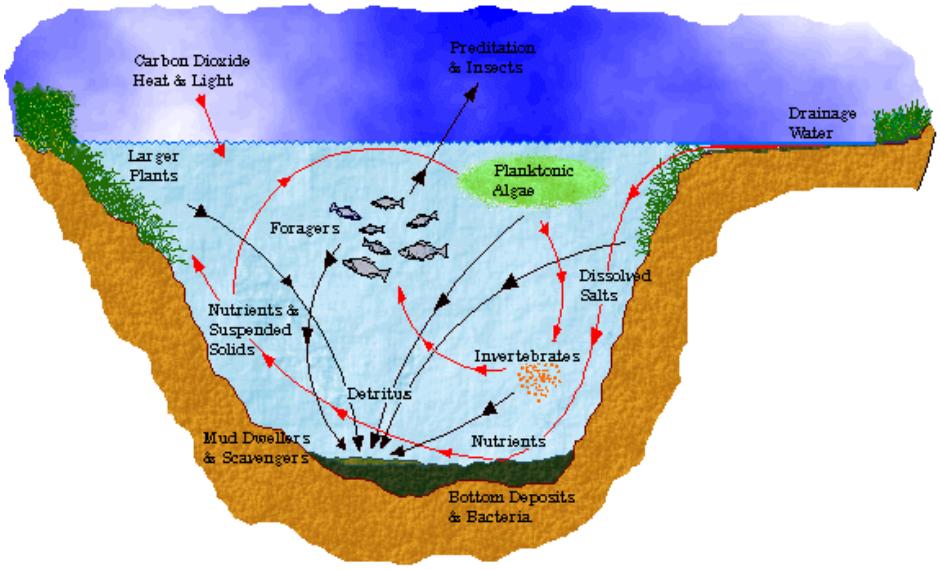
Food webs

Food webs are a graphical representation of the way organisms interact in an ecosystem. In these diagrams arrows typically show how a bigger organism consumes a smaller one. Food webs work as chains, if one of the links in the web gets disturbed, it cuts the whole chain. As you can see in the diagram, all organisms are interconnected and rely on each other as food sources. The most basic species in a food chain, the basal species, is the one that doesn't feed from other organisms. The following species forming the chain are called intermediate species. Finally the organism with no predator above it is, which ends the chain, is named the top predator. Humans are the top predator in most food webs. For example, in your local pond, from which we fish for lunch, we, humans are the top predator of its food chain.

When the food chain becomes unbalanced, it occurs due to an overabundance or scarcity of an organism in the food web and the entire chain is affected. One example of a basal species is algae. Algae are plant organisms that live in water, and mainly consume minerals dissolved in the water. They are eaten by different intermediate organisms. When the algae grows too much, and becomes overabundant, it unbalances the ecosystem. This is called an algae bloom.

Algae blooms often occur due to an overabundance of food, such as fertilizers that come in run-off from farms. These blooms are very harmful to the local ecology of a pond. Although at first, the population of organisms in the pond which feed on the algae grow very fast, eventually the algae grows too big and cuts off sunlight and resources in the water. The algae in the pond die, forming large amounts of dead plant material. When the dead material begins to decompose, it draws too much oxygen out of the water. Starved of oxygen, the fish and other organisms in the pond, which depend on oxygen to survive, die as well.

Example Food Web



Agricultural runoff

Agricultural runoff is any form of chemical used in agriculture that gets into ponds. This should be prevented because the pond won't be able to support as many fish as it could if the chemicals didn't affect some species in the food web. Chemicals that may be used in local agricultural practice could be:

Herbicides- A chemical that kills plants or inhibits their growth; intended for weed control.

Pesticides- A chemical used to kill pests, especially insects

Fertilizers- Organic or inorganic plant foods which may be either liquid or granular used to amend the soil in order to improve the quality or quantity of plant growth.

Using Microscopes

Microscopes can be used in this experiment to show a difference between the amounts of organisms in water with an algae bloom as opposed to water without. Water with an algae bloom, before the algae bloom decomposes, will have a much higher number of organisms. After the algae bloom decomposes, there will be a much lower number of organisms.

The Experiment

Educational Goals (Teacher Only)

- To provide an experiment that shows the food chain of a local pond
- To provide an experiment that shows the effect of run-off on water plants

- To stimulate students interest in local ecology outside regular classroom procedures
- To teach students how to make predictions
- To teach students how to cooperatively work in groups
- To actively engage students in the subject of local ecology

Introduction

In this experiment you will investigate the food chain of local ponds. You will observe a natural food chain in a local pond. Then your group you will investigate further into the side effects of agricultural runoff on algae, a basal species, and the intermediate microorganisms that feed on the algae. This will be done through the growth of algae using water collected from local ponds through exposing the water to a sample of agricultural runoff. The algae will grow very thickly. Though the experiment will not go for long enough to watch the algae die and cause the organisms in the water to suffocate, you will see the effect that fertilizer has on the growth and death of plants and organisms in a local pond. Microscopes can be used to observe the number of organisms in the water, both before and after the algae bloom has occurred.

Teacher Relevance

Students will see that agricultural chemicals which get into the water supply will cause plants to grow too fast and too much, leading to a population of organisms to expand rapidly and later starve. Students will see that this occurs with other plants, such as duckweed, and not just algae. Students will relate this to good and bad agricultural practices.

Teacher Materials Required

1. A large source of pond water (fish pond)
2. About 2 Liters of pond water per group of students
3. 2 small buckets
4. Empty bottles for gathering samples – 2 per group
5. A roll of masking tape
6. Fertilizer
7. Microscope – 1 per group if possible
8. Microscope Slides – 2 per group
9. 1 mL plastic pipette – 2 per group
10. Dry Measuring Cups
11. Area in class room or school that is exposed to sunlight (window)

Procedure

Preparation for first day

1. Cut approximately 1 foot of masking tape off of the roll for each group and place it at each groups station
2. Place set of measuring cups at the front of the class room next to buckets
3. Place 2 small buckets at each groups station
4. Make one copy of worksheet 1 for each group and place at each groups station
5. Make one copy of worksheet 2 for each student and place at each groups station
6. Find an area that is exposed to sunlight where all the plants can be stored
7. Prepare liquid agricultural run-off by mixing 5g of fertilizer with 1L of water.

Preparation for every day

1. Have a cup for each group to transport water in every morning.
2. Make one copy of worksheet 3

Preparation for end of the week

1. Make one copy of worksheets 3 and 4 for every student
2. Conduct discussion with students on the effects of algae blooms
    2.4 Go over results – more organisms than when first started
    2.5 Explain how this number will continue to increase until the algae dies, after which all of the organisms will die.
    2.6 Explain why the organisms die
    2.7 Explain the importance of preventing agricultural run-off

Expected Answer to Student Worksheets

Worksheet 1 – Expected Student Answers

Hypothesis

1. What do you think will happen to the water and organisms when exposed to agricultural runoff?

   Plants and algae grow faster and cover the surface of the local pond.

2. Will the color change?

   Yes, it will turn green.

3. Will the number of organisms change?

   Yes, there will be more organisms.

4. Will the amount of plants change?

   Yes, there will be more plants.

Worksheet 4 – Expected Student Answers

Conclusions

Individual Student Worksheet

1. Did the plants and organisms respond to the agricultural run off as you expected?

_____
_____
_____

2. Are organisms affected by agricultural run off? How are they affected?

   (Possible Answer) Yes, the number of organisms increased in the beginning. However, once the algae covered the surface the organisms died.

3. How can this affect the organisms at the top of the food chain?

   The top predator will have no food to consume.

4. Is this an issue that affects you? Are you at the top of the food chain?

   Yes it does affect us because we are at the top of the food chain (top predator).

5. How can agricultural run-off be prevented?

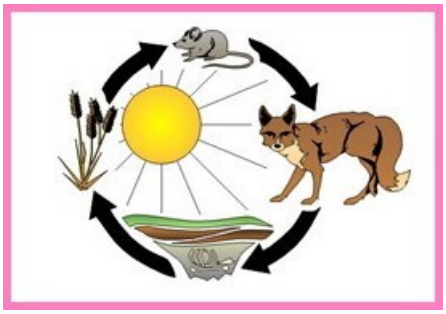
   Limiting the addition of fertilizer to soil during rainy periods and/or being aware of where you put fertilizer in relation to bodies of water.

Student Instructions

Student Background

Food Chains

A food chain is process showing the relationship between organisms in a community where each member is eaten in turn by another member. The relationship starts from the producer going to the primary consumer and then to the secondary consumer. This relationship is known as a food chain.



Food webs

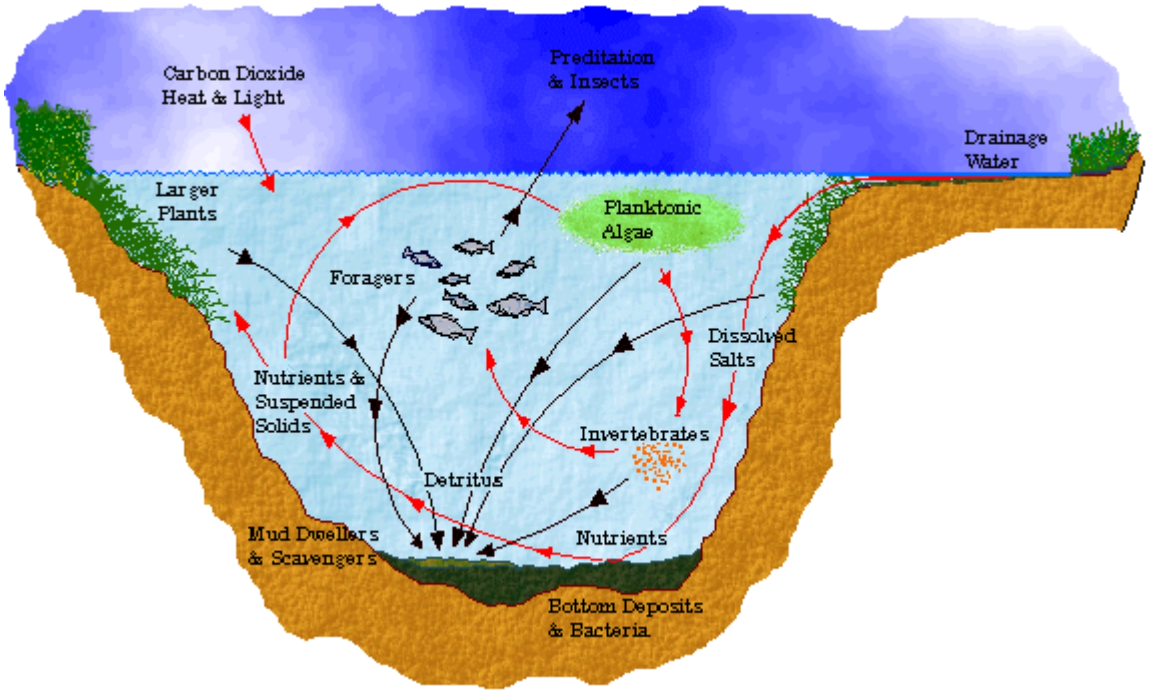
Food webs are a graphical representation of the way organisms interact in a pond. Arrow typically shows what organism consumers a smaller organism. If one organism is a food web is affected by something then because every organism is. This is because all organisms are interconnected and rely on each other as food sources. The very bottom species of a food chain is defined as a basal species. Then the chain progresses through intermediate species. Finally the organism with no predator above it is named the top predator. Humans are the top predator in most food chains. Humans are the top predator in a local pond if people eat fish from it.

When the food chain becomes unbalanced, whether due to an overabundance or scarcity of an organism in the food chain, the entire chain is affected. One example of a

basal species is algae. Algae is a plant organism that lives in water, and is eaten by other organisms. When the algae grows too much, and becomes overabundant, it unbalances the ecosystem. This is called an algae bloom.

Algae bloom often occurs due to an overabundance of nutrients, such as fertilizers in run-off from farms. These blooms are very harmful to the local ecology of a pond. Although at first, the population of organisms in the pond which feed on the algae grow very fast, eventually the algae grows too big and cuts off sunlight. The algae in the pond die, forming large amounts of dead plant material. When the dead material begins to decompose, it draws too much oxygen out of the water. Starved of oxygen, the fish and other organisms in the pond, which depend on oxygen to survive, die as well.

Example Food Web



Student Relevance

Your impact on even the smallest species of a food chain has larger impacts on the abundance of even the top predators. Your experiment will show the impact on a food chain because of improper storage and containment of agricultural runoff. One of the larger species in a pond system is fish.

Student Materials Required

1. About 2 Liters of pond water
2 Small buckets
3. Masking tape

4. Fertilizer
5. Microscope
6. 2 Microscope Slides
7. 1 mL plastic pipette – 2 per group
8. Area in class room or school that is exposed to sunlight (window)

Procedure

1. Review Background, Intro and Relevance
2. Complete Worksheet 1 with your group
3. When teacher is ready go to a local pond
4. Using the sample jars, take several samples near vegetation in the pond
5. Use the magnifying glass to observe the organisms in the water
6. Observe the intermediate sized species in the pond
7. Bring organisms back to class room or other observation area
8. Using microscope observe the microorganisms (basal species)
9. Using magnifying glass observe the intermediate species
10. Begin Worksheet 2 with your group
11. Prepare liquid agricultural run-off by mixing 5g of fertilizer with 1L of water.
12. Place buckets in the sun
13. Complete worksheet 2.

<u>Everyday</u>

1. Complete worksheet 3.
2. Observe water with magnifying glass
3. Observe water with microscope

<u>End of the week</u>

1. Observe water with magnifying glass and microscope
2. Complete worksheet 3
3. Complete worksheet 4 with your group

Work Sheets for Students

Worksheet 1

Hypothesis

5. What do you think will happen to the water and organisms when exposed to agricultural runoff?

_____
_____
_____

6. Will the color change?

_____
_____
_____

7. Will the number of organisms change?

_____
_____
_____

8. Will the amount of plants change?

_____
_____
_____

Worksheet 2

Observation

Daily Observations – Date _____ (Day 1)

1. What types of organisms did you find in the pond? Where do they fit in the food chain?

_____
_____
_____

2. Draw pictures of the plants and organisms you found in the pond

3. What color was the water? Clarity?

_____
_____
_____

4. Are there any plants or algae growing in the water?

_____
_____
_____

Worksheet 3

Daily Observations – Date _____ (Day 2 – 5)

1. What types of organisms did you find in the pond? Where do they fit in the food chain?

_____
_____
_____

2. Draw pictures of the plants and organisms you see in the water

3. What color was the water? Clarity?

_____
_____
_____

4. Are there any plants or algae growing in the water?

_____
_____
_____

Worksheet 4

Conclusions

Individual Student Worksheet

1. Did the plants and organisms respond to the agricultural run off as you expected?

_____
_____
_____

2. Are organisms affected by agricultural run off? How are they affected?

_____
_____
_____

3. How can this affect the organisms at the top of the food chain?

_____
_____
_____

4. Is this an issue that affects you? Are you at the top of the food chain?

_____
_____
_____

5. How can agricultural run-off be prevented?

_____
_____
_____
_____
_____

Pre Test

1. Organize the following animals according to their position in the food chain.

    - Krill and Jellyfish
    - Mineral
    - Crab and Squid
    - Killer whales
    - Tuna and Shark

2. Why does one action on the food chain have many different effects throughout the food chain?

Post Test

1. Organize the following animals according to their position in the food chain

    - Gecko
    - Grass
    - Cat
    - Mineral
    - Grasshopper

2. How would lowering the population of one member of a food chain affect the other animals in the food chain?

Budget

Material	Quantity per group	Cost per item	Number of groups	Cost per class
Small Bucket	2	25	8	400
Empty Bottles	2	N/A	8	N/A
Microscope Slide	2	75	8	1,200
Masking Tape	N/A	35	8	35
1 mL Plastic Pipette	2	10	8	160
Fertilizer	N/A	100	8	100
Dry Measuring Cup	1	50	8	400
Total Cost per of lab:				2,295

2. FUN ACTIVITIES

2.1. Osmosis Game

This fun activity will help to explain the concept of osmosis and reverse osmosis to the students. By assuming that boys are water molecules and girls are salt particles, the students will move around to represent the process of osmosis.

Procedure:

1. Separate the class room into 2 zones, representing the outside and the inside the cell.
2. In the case where boys are fewer than girls, allocate an equal number of boys and girls inside the cell and more girls than boys outside of the cell.
3. Explain that there is a higher concentration of salt outside of the cell (fewer water molecules outside of the cell compared to inside of the cell). Therefore, boys inside the cell need to move out of the cell in order to make the number equal.
4. Once there is equal number of boys outside and inside the cell, nothing moves as everything is balanced.
5. On the other hand, if there are more water molecules outside the cell, boys need to move into the cell. This will in turn show the process of reverse osmosis.

2.2. Food Web Game

The food web game will allow the students to understand the concept of food webs and food chains. Also, it will allow students to distinguish the difference between them.

Materials required:

1. Pictures of plants
2. Pictures of organisms
3. Pictures of animals
4. Arrow signs
5. Tape

Procedure:

1. Put all of the pictures (plants, organisms, animals) and arrows on the board.
2. Explain the rules that students need to put their hands up in order to answer.
3. Ask the students to make a food chain by arranging the order from producer to top predator through using arrows.
4. Once the students have made several food chains, further ask students if any of the animals can eat across the food chains. Drawing arrows across the food chain will form a food web.

3. BRIEF DESCRIPTION ON HOW TO DESIGN AN EXPERIMENT

Information on many scientific experiments, which are applicable to the middle school level, can be found from many sources such as textbooks and websites from the internet. These sources can be used as an initial guide to the implementation of science experiments to the classroom.

An important part in the development of science experiments especially if they are being used for teaching purposes is that the experiments should be tested out and modifications should be made to supplement the curriculum requirements. Also, some experiments may take a long time and this may not be suitable for a class time that is around an hour.

Another important aspect is the availability of equipment. When information on an experiment is gathered, the teacher should consider the availability of materials and also the budget in buying the equipment. In order to make the laboratory sustainable, the budget must be affordable to the schools. For example, if the experiments were written in a foreign country, some materials may not be readily available in Thailand. In a case like this, the teacher would have to try to find supplementary materials, which can be found in Thailand. Also, some experiments may need expensive equipment such as microscopes, which some schools may not be able to afford.

In order to implement applicable science experiments to the classroom, the main factors that have to be considered are the level that the students are at, alignment to the national curriculum and also the time constraints

4. MORE EXPERIMENTS

Other science topics that can be shown through experimentation

This section intends to provide a list of other science experiments, which can also be used as experiments in class. Most importantly, the experiments listed are mostly related to the student's local environment. A point to note is that the section is broken into two parts, where the first part shows experiments which already has teachers and students guide as well as student worksheets.

Experiments that have teacher and student material provided

Water Table – The Effects of Soil and Groundwater Contamination

In this experiment, students will learn that groundwater, which for the Kusuman region is the main source of water, can be contaminated easily by substances such as pesticides and fertilizers.

Effects of Fertilizer on Plant Growth

The experiment will show students the effect of biotechnology on local agriculture as through the experiment, the students will be able to determine the best fertilizer for plants. As the area is agricultural based, learning about the use of fertilizers to enhance plant growth will be very useful.

The Chemistry of Photosynthesis

The experiment was designed to show students the effect of chemical reactions to their local environment. It will show that if plants lack any of the conditions required for photosynthesis, they will not grow. Most importantly, students can learn about chemical reactions through looking at an example that they can clearly see in nature.

List of other topics that can be used as experiments in class

- *Soil composition:* The main components of soil will be separated and the properties will be evaluated. Through the experiment, the students will understand more about soil, which is very important for an agriculture based area.

- *Soil moisture and permeability:* The permeability of different soil components such as sand, clay and mixed ground will be looked at. The students will learn that certain soils are better than keeping water than others so this would help them understand how soil effects irrigation.

- *Soil erosion:* Soil erosion is a big problem in agriculture. The model in the experiment will show the students how erosion occurs.

- *Soil profile:* The experiment will allow students to understand that soil has many different layers. This will give them an understanding of what happens as the roots of a plant go down into the soil.

- *Hydroponic systems:* This experiment or demonstration will show the students how to grow plants without using soil. This will enhance the student's knowledge in new methods in agriculture.

- *Soil ecosystem:* Students will understand the role certain organisms such as earthworms and centipedes, which live in the soil.

- *Culture of protists:* Students will understand how microorganisms such as algae and protozoa, which can be found in local pond water breed.
  Production of oxygen by photosynthesis: Students will visually see that oxygen is one of the important products, which are produced by plants.

- *Respiration in plants and animals:* The opposite process to photosynthesis will be shown. Respiration is an important energy releasing process for humans and other organisms.

- *Lung model:* The experiment will show students how the human lung works. This will make it easier for students to understand an important aspect on the topic of how the human body works.

- *Extraction of the chlorophyll:* Different pigments from chlorophyll will be extracted. Students will learn different extraction techniques. The topic will be useful as chlorophyll takes an important role in the process of photosynthesis

- *Paper chromatography:* Students will learn about separation techniques, which are important for the purification of substances.

- *Cellular division:* Students will understand how cells divide to promote the growth of organisms.
- *Model of mitosis:* The demonstration will illustrate to students very clearly on how the process of mitosis occurs.

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