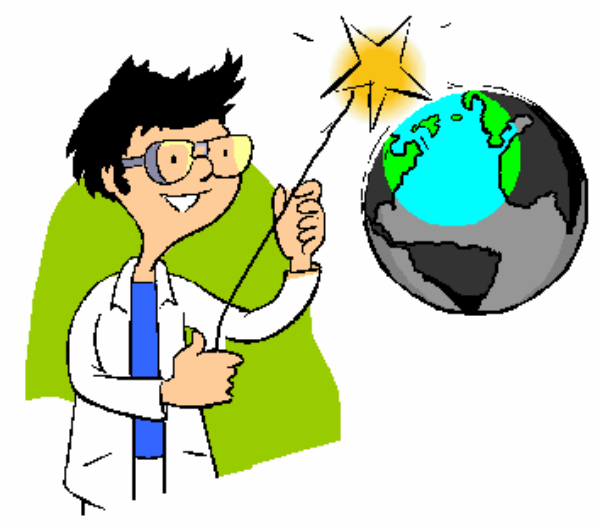
6th Annual
USF STARS Summer Camp
Green Scientists



STARS is a NSF Funded GK-12 Program

Visit us at http://stars.eng.usf.edu

JUNE 9-20, 2008

CAMP LESSONS

NAME:

TEAM:

Hillsborough County PUBLIC SCHOOLS *Excellence in Education*

STARS

WM WASTE MANAGEMENT Recycle America

National Science Foundation WHERE DISCOVERIES BEGIN

USF UNIVERSITY OF SOUTH FLORIDA COLLEGE OF ENGINEERING

ABOUT STARS

USF STARS Team
Left to right, front row: **Wilkistar Otieno** Co-Project Manager, Department of Industrial Engineering; **Johnathan Hollingshed**, Fellow, Department of Global Health; **Javier Fuentes**, Fellow, Department of Industrial Engineering; **Ophir 'GG' Ortiz**, Fellow, Department of Electrical Engineering; **Jorge Lallave**, Fellow, Department of Mechanical Engineering; **Jessica Weber**, Fellow, Department of Mechanical Engineering; **David Walker**, Fellow, Department of Chemical Engineering; **Second row**: **Diana Prieto**, Co-Program Manager, Department of Industrial Engineering; **Vishnu Nanduri**, Co-Project Manager, Department of Industrial Engineering; **Dr. O. Geoffrey Okogbaa**, Professor, PI, Department of Industrial Engineering; **Courtney Feliciani**, Fellow, Department of Industrial Engineering; **Dayna Martinez**, Fellow, Department of Industrial Engineering.
Not in the above photograph:

Dr. Tapas Das, Associate Provost, Professor, PI, Department of Industrial Eng.

Dr. Alex Savachkin, Asst. Professor, Co-PI, Department of Industrial Eng.

The USF Students Teachers and Resources in the Science (S.T.A.R.S.) program is a National Science Foundation (NSF) grant awarded to the University of South Florida to infuse higher-level science & math concepts in grades 3-5. We have partnered with 7 local elementary schools including Edison, Lawton Chiles, Maniscalco, Shaw, Lockhart, Lomax, and Tampa Palms Elementary schools.

As an extension of the NSF initiative, the STARS Fellows have organized a summer camp for elementary school kids throughout Hillsborough County. Students will participate in a series of lessons and activities that focus on aspects of sustainability with respect to energy, water, atmosphere, and much more. The "Green Scientists" Summer Camp will culminate with an all-encompassing Olympiad Competition on June 20th.

Table of Contents

Materials

What's in a Building?

Planet Earth

Introduction:

As part of our camp theme on 'going green,' it is important to understand the impact that humans have on ecosystems around them and why they are worth saving. In this summer camp, you will learn about different eco-friendly technologies that help to protect our planet and all the living things that we share it with. You will learn about clean sources of energy, how to clean polluted water and air, how to make eco-friendly houses, how to recycle different types of garbage, cleaner forms of transportation and about alternatives to using gasoline and oil.

In 2007, the BBC released an 11 part series called *planet earth* which attempted to capture some of the most astonishing sights on our planet on film. The series takes the viewer to a different ecosystem in every episode in an attempt to capture rare and endangered wildlife on film.

Directions:

As you watch the short compiled video list record the different ecosystems that you see and the animals that inhabit those places in your planet earth journals. After that, list things that you could do to help save those animals.

Each day of the summer camp, you will learn something new and perform an activity that could help save the animals that you saw in the video. After each lesson, take time to summarize what you learned and how it can help the environment in your journal. Draw pictures and diagrams; discuss your ideas with the teachers, fellows, and other students. When you read your journal at the end of the camp, you will be amazed at how much you have learned!

My Planet Earth Journal

Name: _____

School: _____

Date: _____

Day One

Date: _____

Today I watched a video about our planet. I saw a lot of different animals from all over the world. They lived in many different ecosystems and habitats. Most of the animals I saw were rare or endangered of becoming extinct. I recorded information about each ecosystem. I listed what type of animals that live there, and I wrote down things that I could do to help save those animals.

Ecosystem: _____

Animals: _____

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What I Can Do: _____

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Ecosystem: _____

Animals: _____

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What I Can Do: _____

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Ecosystem: _____

Animals: _____

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What I Can Do: _____

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Ecosystem: _____

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Ecosystem: _____

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What I Can Do: _____

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Ecosystem: _____

Animals: _____

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What I Can Do: _____

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Lesson One

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Two

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Three

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Four

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Five

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Six

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Seven

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Eight

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Nine

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Ten

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Eleven

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Twelve

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Thirteen

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Fourteen

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Fifteen

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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Lesson Sixteen

Title: _____

Date: _____

What I Learned: _____

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This Will Help:

Ecosystems _____

Animals _____

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The Last Day

Date: _____

What Have You Learned From This Camp?_____

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How to Make Green Water

Name _____ Date _____

Background

Water is essential to life on earth. We need water to grow food, keep clean, provide power, control fire, and last but not least, we need it to stay alive!

If water is constantly being cleaned and recycled through the earth's water cycle, why do we need to conserve it? The answer is that people use up our planet's fresh water faster than it can naturally be replenished.

To provide enough clean fresh water for people, water is cleaned at drinking water treatment plants before it is used. And after water is used, it is cleaned again at wastewater treatment plants or by a septic system before being put back into the environment.

When water is used wisely, it helps the environment**.** Also water is saved for fish and animals. It helps preserve drinking water supplies, ease the burden on wastewater treatment plants—the less water that is sent down the drain, the less work these plants have to do to make water clean again. Another benefit would be that energy could be saved as well**.** This includes the energy that the water supplier uses to treat and move water to you, and the energy your family uses to heat your water. Thirdly, last thing that you can save is money. Your family pays for the water you use. If you use less water, you'll have more money left to spend on other things.

Water in lakes, rivers, and swamps often contain impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from most surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes:

- aeration;
- coagulation;
- sedimentation;
- filtration, and
- disinfection.

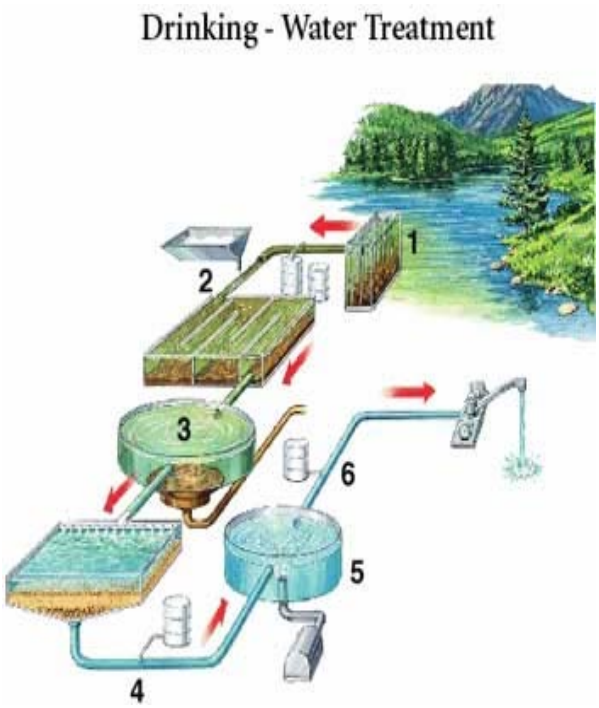
Demonstration projects for the first four processes are included below.

Water treatment describes a process used to make water more acceptable for a desired end-use. These can include use as drinking water, industrial processes, medical and many other uses. The goal of all water treatment process is to remove existing contaminants in the water, improving it for subsequent use.

The goal may be to allow treated water to discharge into the natural environment without adverse ecological impact. These processes may be physical such as settling, chemical such as disinfection or coagulation or biological such as slow sand filtration or activated sludge.

Objectives

To demonstrate the procedures that municipal water plants may use to purify water for drinking.

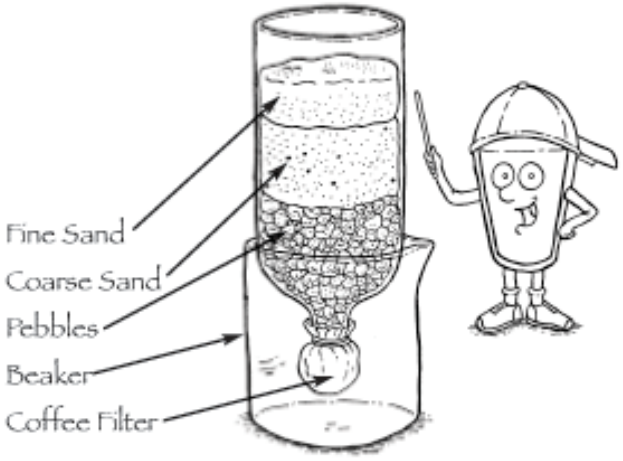


Materials Needed

- 5 Liters of "swamp water" (or add 2 1/2 cups of dirt or mud to 5 liters of water)
- 1 Two liter plastic soft drink bottle with its cap (or cork that fits tightly into the neck)
- 2 Two liter plastic soft drink bottles, one with its bottom cut off and one with the top cut off
- 1 large beaker (2 cups) or measuring bowl that will hold the inverted two liter bottle or you can use another two liter plastic soft drink bottle with its top cut off so the other bottle will fit inside of it.
- 2 tablespoons of alum (potassium aluminum sulfate available in the spice isle at grocery stores)
- 1 1/2 cups fine sand (white play sand or beach sand)
- 1 1/2 cups coarse sand (multi-purpose sand)
- 1 cup small pebbles (washed, natural color aquarium rocks work best)
- 1 coffee filter
- 1 rubber band
- 1 tablespoon (for the alum)
- 1 large spoon (for stirring)
- A clock with a second hand or a stopwatch

Procedure

1. Pour your "Swamp Water" into the two liter bottle with a cap. Have students describe the appearance and smell of the water.
2. **Aeration** the first step in the treatment process, adds air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and vigorously shake the bottle for 30 seconds. Continue the aeration process by pouring the water into another bottle or the beaker, then pouring the water back and forth between them about 10 times. Once aerated, gases have escaped (bubbles should be gone). Pour your aerated water into your bottle with its top cut off.
3. **Coagulation** is the process by which dirt and other suspended solid particles chemically "stick together" into floc (clumps of alum and sediment) so they can easily be removed from water. Add two tablespoons of alum to the aerated water. Slowly stir the mixture for 5 minutes. You will see particles in the water clinging together to make larger clumps. This makes it harder for them to get through a filter at the plant.



4. **Sedimentation** is the process that occurs when gravity pulls the particles of floc to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Observe the water at 5 minute intervals for a total of 20 minutes. Write down what you see - what is the appearance of the water now? At a treatment plant, there are settling beds that collect floc that floats to the bottom, allowing the clear water to be drained from the top of the bed and continue through the process.
5. Construct a filter from the bottle with its bottom cut off as follows:
   a. Attach the coffee filter to the outside neck of the bottle with a rubber band. Turn the bottle upside down placing it in a beaker or cut-off bottom of a two liter bottle. Pour a layer of pebbles into the bottle - the filter will prevent the pebbles from falling out of the neck.
   b. Pour the coarse sand on top of the pebbles.
   c. Pour the fine sand on top of the coarse sand.
   d. Clean the filter by slowly and carefully pouring through 3 L (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.

6. **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment have settled on the bottom of the bottle of swamp water, carefully - without disturbing the sediment - pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water back into the collection container. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.
7. The final step at the treatment plant is to add disinfectants to the water to purify it and kill any organisms that may be harmful. Because the disinfectants are caustic and must be handled carefully, it is not presented in this experiment. The water that was just filtered is therefore unfit to drink and can cause adverse effects. It is not safe to drink!

Questions

1. Can you list all the steps of the water treatment process? _____

   _____
   _____
   _____

2. Why is the aeration step necessary in the water treatment process? _____

   _____
   _____
   _____

3. What does the disinfection step consist of and why are you NOT allowed to do it personally? _____

   _____
   _____
   _____

4. Why should we use water wisely? --_____

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   _____
   _____

5. What materials do you need in order to make an appropriate water filter?

   _____
   _____
   _____

6. What makes water look or smell bad? --_____

_____

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How YOU Can Conserve Water

Here are some ways you can use water more efficiently. Share these tips with your family.

1. Wash Hands Efficiently

Turn off the water while you soap your hands, and rinse briefly.

2. Brush Teeth Wisely

Turn off the water while you brush your teeth and save 4 gallons a minute. That's 200 gallons a week for a family of four.

3. Flush Only When Necessary

Put paper, insects, hair, and other such waste in a trash can rather than in the toilet.

4. Don't Waste Drinking Water

Instead of running water to make it cold, keep a pitcher of water in the fridge.

5. Use Less Water for Dishes

Scrape your dishes clean to reduce rinsing. Run the dishwasher only when it's full.

6. Take Half-Full Baths

Try bathing in a tub that's only half full to save water and the energy used to heat it.

7. Shorten Your Showers

Shorter showers save both energy and water—keeping your shower under 5 minutes can save up to 1,000 gallons a month!

8. Stop Leaks

Turn off water faucets tightly so they don't drip. Tell an adult about any leak you find indoors or outside.

9. Wash Clothes Wisely

Make sure your clothes are truly dirty before putting them into the hamper. Wash clothes only when you have a full load, and use cold water whenever possible.

10. Don't Overwater

Remind adults to water the lawn only every 3 to 5 days in the summer and avoid watering driveways, sidewalks, and gutters.

11. Sweep to Save

Use a broom, rather than a hose, to clean off sidewalks and driveways.

12. Wash Cars Wisely

Use a hose nozzle and turn the water off when soaping up your car. You can save over 100 gallons this way.

Activity Website

http://www.epa.gov/safewater/kids/flash/flash_filtration.html Water Treatment
http://www.epa.gov/OGWDW/kids/activity_grades_4-8_waterpurification.html
Activity 1
http://www.epa.gov/OGWDW/kids/activity_grades_4-8_nonpoint_pollution.html
Activity 2
http://www.epa.gov/OGWDW/kids/activity_grades_4-8_plantsinwaterfiltration.html
Activity 3
http://www.epa.gov/OGWDW/kids/grades_k-3_thirstin_builds_an_aquifer.html
Activity 4
http://www.epa.gov/OGWDW/kids/grades_4-8_water_filtration.html
Activity 5

Interactive Internet Activity
http://www.wonderville.ca/v1/activities/watertreatment/wateractivity.html
http://www.epa.gov/OGWDW/kids/flash/flash_watercycle.html Water Cycle
http://www.epa.gov/OGWDW/kids/pdfs/activity_grades_k-3_activitybook.pdf Booklet

Name_____ Date_____

Plants are Greener than you know?

BACKGROUND:

Dissolved materials can move through soil and enter a groundwater aquifer. But soil and plants have a dual role in this process. Depending on whether materials are dissolved or suspended in the water, soils and plant roots can remove some or all of this material as the water moves down through soil. *Most suspended materials will adhere to the soil*. These may then be broken down and used as food by the plants. Dissolved nutrients, such as nitrogen or phosphorus, chemically bond with some types of soil particles. They are then taken up by plants, thus removing them from the soil before they can enter an aquifer.

For the plants, these elements are food, for an aquifer, they are pollution. Not all materials are absorbed by plants and not all water pollutants are food for plants. However, sediments from eroding soil, nutrients in human and animal wastes, and some components of household wastewater ("gray water") are excellent plant nutrients. Plants also use different nutrients at different rates, so that the *amount of material they take up will depend on how much is dissolved in the water and how fast the water moves through*. This experiment is a very simplified way to show whether plants will take up certain kinds of materials from water moving relatively quickly through their root systems.

OBJECTIVE:

To understand the role of plants in filtering the water moving through a watershed.

MATERIALS NEEDED:

- Six potted plants, with pots roughly six to eight inches in diameter, and holes in the bottom. These plants need to be moderately dry, as if they had not been watered for a couple days. Plants with saturated soil will not absorb water, and very dry plants will absorb it all.
- Six clear containers, such as cups, which will support the plants and allow drainage to be viewed. You will need separate plants and cups for each of the materials in the water.
- Soil from outside (anywhere). The best soil is *loamy*, with smaller particles than sand.

- Unsweetened powdered drink mix, preferably grape or cherry for color.
- Vegetable oil.
- One or two different household cleaners (such as Comet/Ajax and Dish or Laundry soap). One should be liquid and the other powder.

PREPARATION:

Set up the potted plants, each in its own cup. Slowly pour six to eight ounces of clean water through the pot, and check the percolation rate through the pot. Loosen or tighten the soil so that water percolates at about one ounce per minute. The rate should be fast enough to prevent long waiting periods, but slow enough not to carry very much soil through the pot.

PROCEDURE:

1. Place the potted plants into the top of their cups. Pour clean water slowly through one of the pots and watch it percolate through the bottom of the pot. The water should look as clean as what was poured.
2. Add a gram or so of soil to 6-8 ounces of water and stir so that the soil is well suspended and distributed in the water. Pour slowly into another flower pot. The water percolating through should look *much* cleaner than the dirty water poured.
3. Add about one ounce of vegetable oil to 6-8 ounces of water, stir (they won't mix completely) and pour into a third pot. See if the vegetable oil percolates through or is caught up by the plant roots.
4. Add some powdered drink mix to 6-8 oz. of water and pour through a fourth pot. See if the water percolating through retains the color.
5. Add some powdered cleanser to 6-8 oz. of water and pour through a fifth pot. Is the cleanser retained in the soil?
6. Add some liquid soap to the water (an ounce or so in 6-8 oz. water). Does the soap percolate through the soil?
7. Using the “contaminated” plants, pour some clean water at the same rate through each one (simulating a rain shower). Is more of the “pollutant” rinsed away from the soil by the clean water?

QUESTIONS:

1. In what ways can plants and soil benefit drinking water quality?
   _____
   _____
   _____
2. We saw plants and soil remove some types of impurities from water. How might the plants remove larger quantities? _____
   _____
   _____
   _____

3. Can plants and soil remove any type of impurity from water?
   _____
   _____
   _____
   _____
4. What other organisms in the soil-plant system might aid the uptake of water pollutants? _____
   _____
   _____
   _____
5. What is the role of rainwater moving through contaminated soil?
   _____
   _____
   _____

Objectives: The objectives of this activity are to learn about how water becomes polluted and how to test for these pollutants in the water. Water samples will be tested for the following- pH levels, nitrogen levels, phosphorus levels, and turbidity.

Introduction: Most of the water on the earth is salty- too salty for humans to drink. Less than 1 % of all the water on earth's surface is available to meet the drinking water needs of all the people, plants and animals on this planet! How do we know it is safe for us to drink? There are people that perform tests on water in order to measure the amounts of various substances that may not be safe for human consumption. The people that test water can be chemical or civil/ environmental engineers. Today we are going to act like engineers and perform four tests on water:

1- ***pH***- stands for "potential of hydrogen", and tells you how acidic a liquid is. A pH level of 7 means the liquid is neutral, while above 7 the liquid is considered "basic", and below 7 a liquid is considered "acidic". For example, lemon juice has a pH value of 2, while milk of magnesia has a pH value of 12. The U.S. Environmental Protection Agency (EPA) recommends that the pH of public water systems be maintained between 6.5 and 8.5.

2- ***nitrogen***- nitrogen in drinking water is normally bonded to oxygen, making NO_3 (nitrate) and NO_2 (nitrite). One of the common reasons for increased levels of nitrogen in drinking water is from fertilizers which run off the lawn and end up in the drinking water systems. Other sources of nitrogen in water are from leaking sewer lines and from manure storage areas. Recommended levels of nitrates in drinking water are 10ppm (parts per million), while for nitrites these are 1ppm.

3- ***phosphorus***- phosphorus in drinking water is also due to fertilizers containing this additive. The fertilizer can get into the drinking water system after water has run off from a drive way and reaches the storm drain. According to the EPA, phosphorus levels in drinking water should not go above 15 micrograms per liter.

4- ***turbidity***- an optical characteristic or property of a liquid which describes the clarity, or haziness of the liquid. If a sample of water has low turbidity, this means that the sample has a low level of suspended particles. If the turbidity is high, then

the water sample has a high level of suspended particles, which could make the water unsafe for human consumption.

Materials:

- testing kit
- water samples from various sources
- notebook and pencil for writing down data

Procedure:

1. Measure the pH of the water sample(s) and write them down in the results section.
2. Test the nitrogen levels in the water sample. Write the outcome down in the results section.
3. Test the levels of phosphate in the water sample(s). Write the outcome down in the results section.
4. Test the turbidity of the water sample(s) and write down the clarity levels in the results section.

Results:

Discussion:

1. According to the pH measurements, were the water samples acidic, neutral, or basic?

2. Were the nitrogen levels high in the water samples? Did one water sample have a higher level than another?

3. Were the phosphate levels high in the water samples? Did one water sample have a higher level than another?

4. According to the turbidity measurement, were the water samples low or high turbidity? Was one sample clearer than the other?

Conclusions:

The Digital Multimeter:

A Tool for the Emerging Engineer

Objective:

The objective of this activity is to learn how to use a digital multimeter. Learning how to use this device is a useful skill that allows you to check if an electrical appliance or computer is working properly based on the voltage or current output. Electricians and computer hardware technicians use this tool on a regular basis for this purpose. Electrical engineers also use this tool when designing complex circuits.

> Note: Do NOT try to measure anything at your house!!! You could accidentally electrocute yourself!!!!

Vocabulary:

Voltage- potential difference between two points, measured in "*volts*"
Resistance- the opposition to the flow of electricity, measured in "*ohms*"
Current- the flow of electricity, measured in "*amperes*"

Materials:

- Battery (one per group)
- Multimeter (one per group)
- Alligator clips (2 per group)
- Resistors (various values)

Procedure:

1. Turn on your multimeter. Turn the dial to measure voltage in DC. Measure the voltage of your battery by placing the red lead of the voltmeter on the positive terminal of the battery, and the black lead on the negative terminal. What is the voltage of your battery?

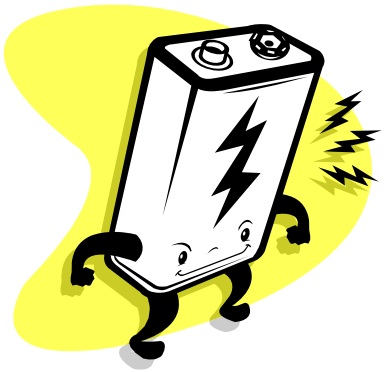
   _____
   _____
   _____

2. Turn the dial of the multimeter to measure resistance. What is the value of the resistor?

3. Obtain a second resistor and measure the resistance.

4. Connect the first and second resistor together, and measure the resistance of both in series. What is this resistance?

Conclusions:



Solar Panel Activity

Objectives:

1. Learn the definition of a solar panel
2. Learn how solar panels work
3. Investigate how the angle between the light source and the solar panel affects the voltage output

Introduction:

Have you ever heard of "solar panels"? Solar panels allow people to use energy from the sun to power a number of appliances, which include water heaters and lawn lights. The main benefit of harnessing energy from the sun is that solar energy is *renewable*. This means that the energy source does not run out. How is this different from using *non-renewable* energy sources? Well, energy from fossil fuels (such as coal) will run out one day, plus they are very harmful to the environment.

In order to get the most energy from the sun, the solar panels must be placed "perpendicular" to the sunlight (Figure1). In this activity, we will investigate how the output voltage of the solar panel changes when the incident angles are varied.

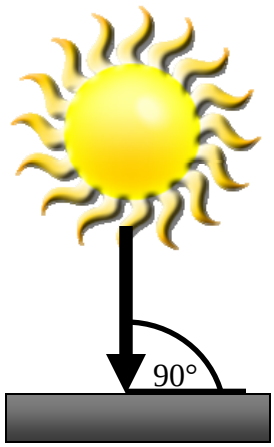


Figure 1: The sun rays are at a perpendicular angle (90°) relative to the solar panel.

Materials:

- Solar panel
- Digital multimeter
- Lab notebook/ pencil

Procedure:

1. Connect the multimeter to the solar panel.
2. Take your materials and go outside.
3. Place the solar panel to make a 90° with the sun rays (remember: this is going to vary depending on what time of the day you are doing this). Record the voltage output in the table below.
4. Now vary the angle of the solar panel to 45° and record the voltage output.
5. Vary the angle again so that the angle is 10° relative to the sun rays, and record the voltage output.

Results:

Angle	Voltage Output
10°	
45°	
90°	

Discussion/ Conclusions:

1. Explain if the voltage output changed when you changed the angle of the solar panel.

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   _____
   _____

2. If you were to keep the solar panel at the same angle during the whole day without changing the angle, do you think the amount of energy that could be obtained from it would change?

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3. What are some of the benefits of using solar panels instead of fossil fuels?

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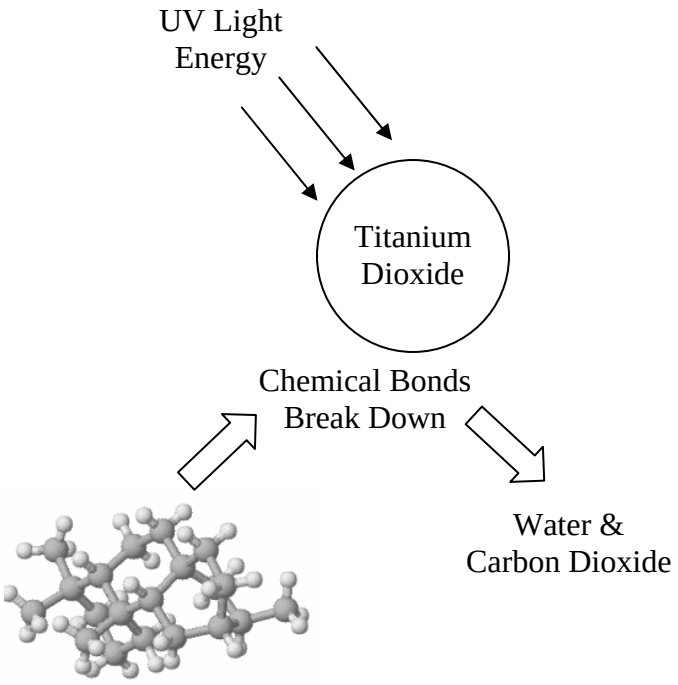
Photocatalytic Oxidation

Introduction:

Photocatalytic Oxidation is a technique which can be used to destroy contaminants in waste water. Typically, water purification techniques only move the pollution from one place to another and never get rid of the pollution. Photocatalytic oxidation is an important and interesting process because it is able to destroy the contaminants; not just move them.

Photocatalytic Air Purifier

The word photocatalytic can be broken down into two parts for a better understanding. The first part of the word, photo, is the Latin word meaning light. The second part of the word is catalytic or referring to a catalyst. A catalyst is a chemical that can be used to speed up the chemical reaction. When putting the two words together to make photocatalytic, we are talking about a material that can speed up a chemical reaction when it is exposed to light. The word oxidation refers to a type of chemical reaction where the products of the reaction contain more oxygen atoms than before the reaction.



In our process, we will examine the photocatalytic properties of titanium dioxide. This is a very common and cheap material, that when exposed to ultraviolet light

causes other chemicals near by to break down into water and carbon dioxide. In a waste water treatment system, contaminated water is mixed with a titanium dioxide powder and exposed to ultraviolet (UV) light. The energy of the light is changed by the titanium dioxide into a form that attacks the chemical bonds which hold the atoms of the pollutant together. The carbon atoms of the pollutant become carbon dioxide and the hydrogen atoms of the pollutant become water.

This technology doesn't just have to be used to treat water. Researchers are currently working to make paint out of these materials. The idea is that the same reaction which breaks down the chemical bonds of a pollutant could break down the chemical bonds that make up dirt, bacteria or fungi. To clean a surface with this type of paint on it, you would just have to expose it to some UV light (or let it sit out in the sun). Can you imagine what it would be like to have a car, windows or house siding that would clean itself just by sitting out in the sun? People wouldn't need to use harmful chemicals to clean things: just some light from the sun!

Photocatalytic House That Cleans Itself!

Experimental Write-Up Sheet

Date:_____

Title of Experiment: _____

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Materials: _____

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Procedure: _____

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Results and Conclusions:

Diagrams:

Industrial Air and Water Treatment

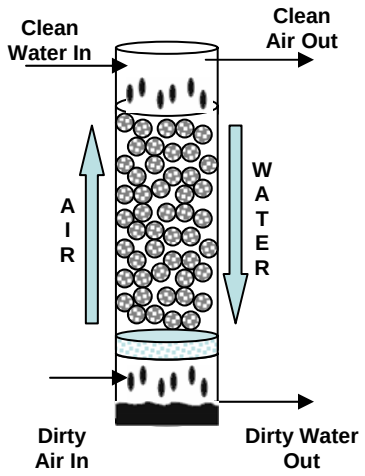
Introduction:

Every time you flick on a light switch you are contributing to industrial pollution. You might not see a smoke stack or any hazardous chemicals nearby, but these things can be found at the local power plant where your electricity was produced. For every bit of electricity that you use, a power plant must produce more air and water pollutants. Power plants are not the only industrial process that threatens our environment. Chemical plants across the world produce a great deal of air and water pollution every day. You might not think of it, but almost everything around us has some component that originally came from one of these pollution producing plants. All plastics come from a chemical plant, glues, chemicals to preserve our foods, paint, paper; almost everything. Take a moment to look around you: try to find something that does not have any plastic in it. You can easily begin to see that almost everything that we use once came from a chemical plant where pollution was produced in order to make the things we desire.

With all the pollution industrial plants produce making energy, plastic or any other product you can imagine, the plant needs a way to capture that pollution so that it can not harm the surrounding environment. The Environmental Protection Agency (EPA) sets strict limits on how much pollution a plant can give off every year. The amount of pollution being generated is monitored by a sensor. A sensor is a device that can see and report changes in something that that you want to measure. Think of a smoke detector: when ever it sees allot of smoke it reports this change by sounding an alarm. In a chemical plant, sensors work in a similar way and report information on air and water pollution. Automated control systems are developed to control the amount of pollution

that a plant generates and releases into the environment. An automated control is a computer system that that automatically controls how the plant operates to meet a certain goal. In this case, the goal of an automated control is to keep the pollution under a certain level set by the EPA.

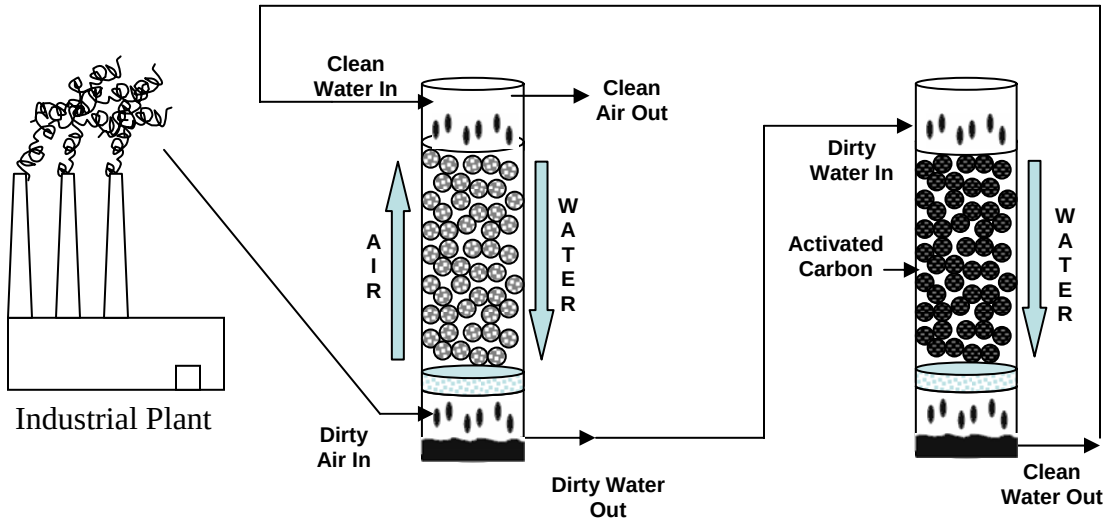
In a plant, pollutants are typically removed from air through the use of scrubbers. The term scrubber comes from the idea of scrubbing something clean. Think of cleaning dirty dishes or doing laundry: in those processes you put what ever is dirty into water and let the dirt leave the clothes or dishes and transfer into the water. In a scrubber, dirty air is blown up a chamber while water is sprayed down over the chamber. When the air and water drops come into contact, the pollutants leave the air and go into the water droplet. After this process, the air is much cleaner and most of the pollutants are moved into the water. Automated controls can be used to control how much water is needed to clean the air and to keep the amount of air pollution below EPA standards.



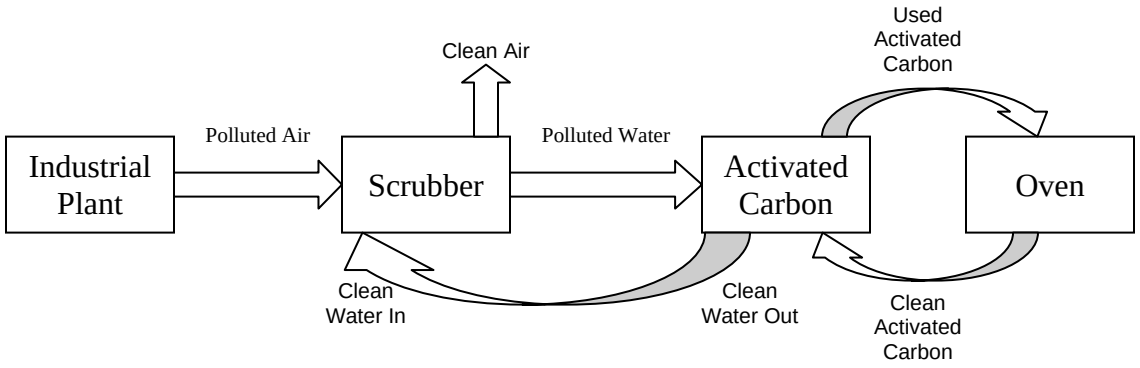
Scrubber Schematic

After the air has been cleaned, we are left with a new problem: we know have polluted water that must be cleaned. There are many ways to clean the dirty water but one of the most common ways is to use a compound called activated carbon. Activated carbon is a material that soaks up certain chemicals like a sponge. The carbon can be as large as a marble or as small as a grain of sand and has many small holes that are called pores. When the dirty water is passed over activated carbon all of the pollution is pulled out of the water and sticks to the surface of the activated carbon inside the pores. After the activated carbon absorbs as much pollution as it can hold, it is put into an oven and the pollutants are burned off, leaving the activated carbon behind to be reused.

Activated Carbon Pore



In the schematic above, you can see how pollution from a smoke stack would typically be sent to a scrubber where the dirty air is mixed with clean water. Leaving the scrubber unit is clean air and dirty water. The polluted water is then mixed with activated carbon which soaks up the pollution, like a sponge, and the clean water is sent back to the scrubber. After the activated carbon is full of pollutants, the carbon is sent to an oven where the pollutants are burned off and the activated carbon is then reused.



Experimental Write-Up Sheet

Date:_____

Title of Experiment: _____

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Materials: _____

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Procedure: _____

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Results and Conclusions:

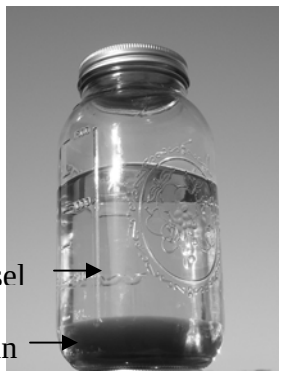
Diagrams:

Biodiesel

Introduction:

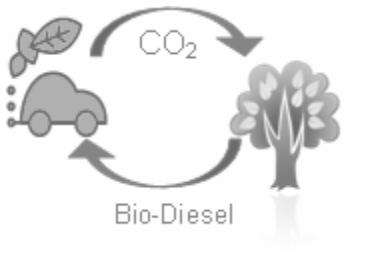
Biodiesel is an alternative fuel made from natural oils. These oils can be made from corn, soybean, flax, sunflower, animal fats, or algae. Algae used to create biodiesel can be grown from waste materials such as sewage, thereby reducing the amount of waste produced. Biodiesel is a renewable form of fuel which can replace normal diesel which is usually derived from petroleum.

The oil used to create biodiesel can come from many sources. Many people use vegetable oil that thrown away by fast food companies. In this case, the oil must first be cleaned in order to remove everything that is not pure oil. When the oil is mixed with methanol and a catalyst a chemical reaction occurs producing biodiesel and glycerin. A catalyst is a chemical that can be used to speed up the chemical reaction. Glycerin is commonly used to make soap, and is much denser than the biodiesel. The glycerin will settle at the bottom of the container, and the biodiesel will form as a layer on top of the glycerin. The fuel is then collected from the top of the container. Most of the production and usage of biodiesel occurs in Europe; however, it is gaining popularity in North America.



Biodiesel may be used in pure form or mixed with regular diesel. When regular diesel is replaced with biodiesel in an engine, many of the harmful pollutants given off by the engine are removed including nitrogen and sulfur oxides. These pollutants have been shown to contribute to smog, and acid rain. Like

normal diesel, when biodiesel is burned in an engine it releases carbon dioxide into the environment. Carbon dioxide is a greenhouse gas, and too much of this in the atmosphere can help to contribute to global warming and climate change.



The advantage of biodiesel is that it is a carbon neutral cycle. In this cycle, the carbon dioxide released by burning the biodiesel is captured by plants. The plants then use this same carbon to make energy for the plant in the form of glucose through the process known as photosynthesis. Glucose is then transformed into sugars and oils by the plant which can be harvested to create more biodiesel. Since excess carbon dioxide is reused in this process, there is no extra carbon dioxide being produced. By using a carbon neutral cycle, we can reduce the impact of carbon dioxide in our environment.

The use of biodiesel has many benefits such as:

- Biodiesel produces more energy than regular diesel
- Biodiesel reduces wear and tear on the engine
- Biodiesel is a renewable resource
- Biodiesel gives off less harmful emissions when burned
- Biodiesel gives off 80% less carcinogenic compounds (compounds that cause cancer) than normal diesel.

The disadvantages of biodiesel include:

- Biodiesel can clogs fuel lines at lower temperatures in not mixed with regular diesel.
- Biodiesel needs land to grow crops for making biodiesel
- Biodiesel can unclog a cars filter, but this can cause the fuel lines to clog. Because of this, it is recommended that your filters be replaced when switching to biodiesel.

Experimental Write-Up Sheet

Date:_____

Title of Experiment: _____

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Materials: _____

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Procedure: _____

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Results and Conclusions:

Diagrams:

Name:_____ Date:_____

Alternative Fuels

A Student's Guide

But, what is an alternative fuel vehicle?

An alternative fuel vehicle is a vehicle that runs on alternative fuels. So, what is an alternative fuel? "Alternative fuels" are vehicle fuels that are derived from resources other than petroleum. Some are produced domestically, reducing our dependence on imported oil, and some are derived from renewable sources. Often, they produce less pollution than gasoline or diesel. Almost all of the fuel we use for transportation is made from petroleum. Gasoline and diesel fuel account for all but about one-fourth of one percent of Florida's transportation fuel. Most Florida gasoline does contain a small amount of ethyl alcohol (also called ethanol), which increases the oxygen content of the gasoline for cleaner burning. Air quality concerns have increased the importance of alternative fuels and advanced transportation technologies like electric vehicles.

Alternative Fuels

There are many kinds of fuels that vehicles can run on that are not made from petroleum. The United States Department of Energy officially recognizes this list of alternative fuels:

Ethanol is produced domestically from corn and other crops and produces less greenhouse gas emissions than conventional fuels.

Biodiesel is derived from vegetable oils and animal fats. It usually produces less air pollutants than petroleum-based diesel.

Natural gas is a fossil fuel that generates less air pollutants and greenhouse gases.

Propane, also called liquefied petroleum gas (LPG), is a domestically abundant fossil fuel that generates less harmful air pollutants and greenhouse gases.

Hydrogen can be produced domestically from fossil fuels (such as coal), nuclear power, or renewable resources, such as hydropower. Fuel cell vehicles powered by pure hydrogen emit no harmful air pollutants.

1979 Gas Shortage

The fact that Florida is nearly 100 percent dependent on petroleum for transportation could cause a serious problem, like it did in 1973 and 1979 when the gas supply was limited and the prices went up. By increasing alternative fuel use, such as natural gas and electricity, consumers could have fuel choices that compete with gasoline and diesel, broaden our supply base, and lower environmental impacts. Natural gas is the basic energy source for some of the alternatives to petroleum. On one hand, this is good because most of the natural gas we use comes from friendly North American countries, if not the United States itself. And at the present, there seems to be a plentiful supply of natural gas. So, the supply of natural gas is relatively stable and reliable. On the other hand, natural gas is a non-renewable fossil fuel, just like petroleum and coal, and so, it too will some day be used up if people continue to use a lot of it.

Ethanol

Ethanol is an alcohol-based fuel made by fermenting and distilling starch crops, such as corn. It can also be made from "cellulosic biomass" such as trees and grasses. The use of ethanol can reduce our dependence upon foreign oil and reduce greenhouse gas emissions.

- E10 (also called “gasohol”) is a blend of 10% ethanol and 90% gasoline sold in many parts of the country. All auto manufacturers approve the use of blends of 10% ethanol or less in their gasoline vehicles.
- E85, a blend of 85% ethanol and 15% gasoline, can be used in flexible fuel vehicles (FFVs), which are specially designed to run on gasoline, E85, or any mixture of the two. FFVs are offered by several vehicle manufacturers.

Cost varies regionally. It is cheaper than gasoline in some areas, such as the Midwest, and more expensive in others. Several hundred filling stations in the U.S. sell E85, and that number is increasing rapidly. There is no noticeable difference in vehicle performance when E85 is used. FFVs operating on E85 usually experience a 20-30% drop in miles per gallon due to ethanol’s lower energy content.

Advantages & Disadvantages of E85

Advantages	Disadvantages
• Domestically produced, reducing use of imported petroleum • Lower emissions of air pollutants • More resistant to engine knock • Added vehicle cost is very small	• Can only be used in flex-fuel vehicles • Lower energy content, resulting in fewer miles per gallon • Limited availability • Currently expensive to produce

Biodiesel

Biodiesel is a form of diesel fuel manufactured from vegetable oils, animal fats, or recycled restaurant greases. It is safe, biodegradable, and produces less air pollutants than petroleum-based diesel. Biodiesel can be used in its pure form (B100) or blended with petroleum diesel. Common blends include B2 (2% biodiesel), B5, and B20. B2 and B5 can be used safely in most diesel engines. However, most vehicle manufacturers do not recommend using blends greater than 5% — using higher blends will void some engine warranties. Biodiesel prices vary across the country and tend to be slightly higher than those for petroleum diesel. Note: You should never fuel your vehicle with clean or used grease or vegetable oil that has not been converted to biodiesel. It will damage your engine.

Biodiesel Compared to Petroleum Diesel

Advantages	Disadvantages
• Domestically produced from non-petroluem, renewable resources • Can be used in most diesel engines, especially newer ones • Less air pollutants (other than nitrogen oxides) and greenhouse gases • Biodegradable • Non-toxic • Safer to handle	• Use of blends above B5 not yet warranted by auto makers • Lower fuel economy and power (10% lower for B100, 2% for B20) • Currently more expensive • More nitrogen oxide emissions • B100 generally not suitable for use in low temperatures • Concerns about B100's impact on engine durability

Natural Gas

Natural gas, a fossil fuel comprised mostly of methane, is one of the cleanest burning alternative fuels. It can be used in the form of compressed natural gas (CNG) or liquefied natural gas (LNG) to fuel cars and trucks. *Dedicated* natural gas vehicles are designed to run on natural gas only, while *dual-fuel* or *bi-fuel* vehicles can also run on gasoline or diesel. Dual-fuel vehicles allow users to take advantage of the wide-spread availability of gasoline or diesel but use a cleaner, more economical alternative when natural gas is available. Since natural gas is stored in high-pressure fuel tanks, dual-fuel vehicles require two separate fueling systems, which take up passenger/cargo space. Natural gas vehicles are not produced commercially in large numbers — the Honda GX CNG is the only new vehicle available in the U.S. However, conventional gasoline and diesel vehicles can be retrofitted for CNG.

Advantages & Disadvantages of Natural Gas

Advantages	Disadvantages
• Nearly 87% of U.S. natural gas used is domestically produced • 60-90% less smog-producing pollutants • 30-40% less greenhouse gas emissions • Less expensive than gasoline	• Limited vehicle availability • Less readily available than gasoline & diesel • Fewer miles on a tank of fuel

Propane

Propane or liquefied petroleum gas (LPG) is a clean-burning fossil fuel that can be used to power internal combustion engines. LPG-fueled

vehicles produce fewer toxic and smog-forming air pollutants. LPG is usually less expensive than gasoline, and most LPG used in U.S. comes from domestic sources. No LPG-fueled light-duty passenger cars or trucks have been produced commercially in the U.S. since the 2004 model year, but gasoline and diesel vehicles can be retrofitted to run on LPG in addition to conventional fuel. The LPG is stored in high-pressure fuel tanks, so separate fuel systems are needed in vehicles powered by both LPG and a conventional fuel such as gasoline.

Advantages & Disadvantages of LPG

Advantages	Disadvantages
• Fewer toxic and smog-forming air pollutants • 85% of LPG used in U.S. comes from domestic sources • Less expensive than gasoline	• No new passenger cars or trucks commercially available (vehicles can be retrofitted for LPG) • Less readily available than gasoline & diesel • Fewer miles on a tank of fuel

Hydrogen

Hydrogen (H_2) is being aggressively explored as a fuel for passenger vehicles. It can be used in fuel cells to power electric motors or burned in internal combustion engines (ICEs). It is an environmentally friendly fuel that has the potential to dramatically reduce our dependence on foreign oil, but several significant challenges must be overcome before it can be widely used. Some of the many benefits are that it is produced domestically and environmentally friendly. Hydrogen can be produced domestically from several sources, reducing our dependence on petroleum imports.

Hydrogen produces no air pollutants or greenhouse gases when used in fuel cells; it produces only NOx when burned in ICEs. There are a few challenges as well. Hydrogen is currently expensive to produce and is only available at a handful of locations, mostly in California. Fuel cell vehicles are currently far too expensive for most consumers to afford, and they are only available to a few demonstration fleets. Hydrogen contains much less energy than gasoline or diesel on a per-volume basis, so it is difficult to store enough hydrogen onboard a vehicle to travel more than 200 miles. Other challenges include fuel cell performance, customer acceptance, and hydrogen transport and bulk storage.

Electricity

Electric vehicles (EVs) are propelled by an electric motor (or motors) powered by rechargeable battery packs. Electric motors have several advantages over internal combustion engines (ICEs):

- **Energy efficient.** Electric motors convert 75% of the chemical energy from the batteries to power the wheels—internal combustion engines (ICEs) only convert 20% of the energy stored in gasoline.
- **Environmentally friendly.** EVs emit no tailpipe pollutants, although the power plant producing the electricity may emit them.

Electricity from nuclear-, hydro-, solar-, or wind-powered plants causes no air pollutants.

- **Reduce energy dependence**. Electricity is a domestic energy source.
- **Performance benefits.** Electric motors provide quiet, smooth operation and stronger acceleration and require less maintenance than ICEs.

The Down Side: Batteries

EVs face significant battery-related challenges:

- **Driving range.** Most EVs can only go 150 miles (or less) before recharging—gasoline vehicles can go over 300 miles before refueling.
- **Recharge time.** Fully recharging the battery pack can take 4 to 8 hours.
- **Battery cost:** The large battery packs are expensive and usually must be replaced one or more times.
- **Bulk & weight:** Battery packs are heavy and take up considerable vehicle space.

Researchers are working on improved battery technologies to increase driving range and decrease recharging time, replacement frequency, weight, and cost. These factors will ultimately determine the future of EVs.

Investigation

Question: How do hydrogen fuel cell vehicles work?

Hypothesis: _____

_____

Materials:

- Thames & Kosmos Fuel Cell Car Experiment Kit
- Summer Camp Packet
- Pencil and Eraser
- Ruler
- Stop Watch
- Light

Procedure:

1. Assign team roles
2. Gather materials
3. Remove and Assemble Fuel Cell Car
    - Follow the instructions of the presenter
4. Fill the car with energy from the fuel pump.
5. Look at how the hydrogen and oxygen are produced.
6. Allow the car to run and analyze what is occurring.
7. Disassemble and put away the vehicle as well as clean up your area and put all materials away
8. Answer the questions

Questions

1. Describe examples on how we can reduce on dependencies on petroleum.

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2. What is an alternative fuel?

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3. List six alternative fuel types.

a) c) e)

b) d) f)

4. Compare one of the alternative fuels to gasoline.

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5. What conclusions could be made about your experiment?

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Battery Electric Vehicles (BEV) use electric motors instead of internal combustion engines to provide motive power. In BEVs, the power is stored on board in rechargeable battery packs.

Advantages: BEVs are efficient, quiet, have excellent acceleration, and are inexpensive to operate and maintain on a daily basis. They have no pollution from the tailpipe, reduce emissions even when electricity is generated by today's power plants and can easily use renewably produced electricity. Electricity is domestically produced and the infrastructure (electric grid) is already in place.

Disadvantages: Current battery capacity and/or cost limit driving distances to 100 miles or less. Proper manufacture and disposal of certain batteries must be developed to avoid pollution. Replacement batteries could be expensive. If electricity is generated from coal, full-cycle emissions would be high. Emergency response people need to receive training.

Biodiesel is a liquid fuel produced from new or used vegetable oils. It can be used in traditional diesel engines or in diesel hybrid vehicles alone or mixed with diesel. Note: Biodiesel is not to be confused with salad or fryerlator oil, which can be used as a feedstock for biodiesel. Fryerlator oil may also be used directly in diesel engines but has a high flash point so that it cannot be used to start the engine. It also congeals at a high temperature so that it cannot be left in the engine when the vehicle is not in use.

Advantages: Biodiesel is a domestically produced renewable fuel with an energy content similar to conventional diesel. It can be used in traditional diesel engines and refueling is the same as with diesel fuel. Compared to traditional diesel vehicles, it reduces carbon dioxide emissions by 78%, reduces sulfur oxide by 100%, reduces particulate emissions by 30-50%, reduces carbon monoxide by 50%, reduces ozone-forming and toxic hydrocarbons by 50-75% respectively, and is less dangerous because its flashpoint is over 300 degrees F compared to 150 degrees F. Its characteristics suggest it would be a good fuel choice for heavy-duty vehicles.

Disadvantages: Compared to regular diesel, it causes a 13% increase in nitrogen oxide emissions and it is harder to ignite at low temperatures. It is expensive to produce. It takes a lot of land to produce the plant source for biodiesel so that the U.S.DOE expects that the total amount of available biodiesel will be limited.

Ethanol is a renewable liquid fuel made by fermenting any plant matter high in carbohydrates. It can be used alone or mixed with gasoline in conventional engines.

Advantages: Ethanol is a domestically produced renewable fuel. It can be used in traditional internal combustion engines with few modifications. Refueling is the same as with gasoline. If produced from corn, although it reduces fossil energy use by 50-60% and carbon dioxide emissions by 20-30%, one study shows that it takes more energy to produce it than it produces. Ethanol produced from biomass would reduce greenhouse gas emissions even more, require less energy produce, and be manufactured from material that is now burned or buried such as corn husks, saw grass, and wood chips. Ethanol itself contains no sulfur, which would help emissions control devices work better, thereby reducing emissions from other pollutants. However, sulfur is emitted in the production of corn based ethanol so that overall it increases sulfur emissions by 77%. Many feel that ethanol made from cellulose could be cost competitive in the future.

Disadvantages: Compared to gasoline, it contains only 80% of the energy per gallon, resulting in slightly lower driving range. It is more flammable than gasoline, is corrosive, and degrades some elastomers and metals. It is hard to start vehicles in cold temperatures and formaldehyde is emitted at the tail pipe. If used in large volume, it would require large volumes of land to produce crops for energy production. Current production methods are energy intensive and expensive.

Hybrid Electric Vehicles use both electrical and mechanical energy. They combine the efficiency of electric drive systems with the longer driving range provided by liquid or gaseous fuel. Today all hybrids on the market use gasoline as their liquid fuel, but they could use some other fuel to gain additional advantages.

Advantages: In comparison to a traditional gasoline vehicle, a hybrid electric drive system can increase fuel efficiency by 20-50%, provide comparable or better performance, and increase driving range. It can use readily available gasoline or be designed to use any targeted fuel, and all its emissions are lower. Exact emissions depend on fuel type and on-board emission controls. Several automakers are marketing hybrid vehicles to the general public.

Disadvantages: Maintenance is more complicated. They are more expensive to build than conventional cars.

more - over

Hydrogen (H_2) is a gas. It can be produced by extracting hydrogen atoms from a hydrocarbon fuel, such as natural gas, or from water. It can be used in internal combustion engines or in fuel cells.

Advantages: Hydrogen is a domestically produced gas that can be produced from many fuels. It can be burned in an internal combustion engine or used in a fuel cell. Hydrogen refueling systems could be similar to natural gas or propane. If used in a fuel cell, its emissions on a per-mile basis can be reduced because of the high energy efficiency of fuel cells and electric vehicles. Emissions from its full life cycle can be zero if produced from renewably produced electricity and water.

Disadvantages: Hydrogen's energy density is low unless compressed or liquefied (which takes energy), which could adversely affect vehicle range. Hydrogen storage systems are not well developed. Hydrogen distribution and dispensing are not widely established. Safety codes and standards must be developed. Hydrogen causes metal embrittlement. Hydrogen, if produced from coal or nuclear power plants, could increase the number of these plants which have their own unique disadvantages.

Methanol (CH_3OH) is a colorless, odorless liquid fuel produced from any carbon-based material, such as natural gas, coal, or biomass.

Advantages: It can be domestically produced from just about anything containing carbon, including landfill gas, which is renewable and would have the added benefit of reducing methane, a greenhouse gas 20 times as potent as carbon dioxide. Methanol's octane rating is high. It can be used in internal combustion engines with few modifications or in fuel cells. Emissions can be somewhat lower, depending on the feedstock.

Disadvantages: It is highly toxic and it is water soluble, so there is a great potential for water contamination. It is very corrosive to metal, rubber, and plastic. Formaldehyde is a by-product, which is a suspected carcinogen. Methanol conducts electricity. Its energy density is half that of gasoline, which reduces driving range. Vehicles have a hard time starting at low temperatures and the capital cost to produce methanol is high.

Natural Gas (CH_4) is a naturally occurring fossil fuel found by itself or near crude oil deposits. It is usually used in either compressed (CNG) or liquid (LNG) form.

Advantages: It is non-toxic, non-corrosive, non-carcinogenic, has high thermal efficiency, and is already in extensive use for heating and cooking. Compared to a gasoline vehicle, it has low engine maintenance, reduces most emissions, including carbon dioxide by about one third. Global and US natural gas supplies are more plentiful than those of oil and it has the lowest projected full-cycle cost of all the alternative fuels. It is well suited to heavy-duty vehicles. Several car, bus, and truck manufacturers offer CNG vehicles for sale.

Disadvantages: It is not renewable. Low energy density makes it necessary to compress or liquefy which takes energy, and usually reduces driving range by 50%. It has a cumbersome fuel tank. It is lighter than air so that it could cause explosions in enclosed areas. Fueling stations would need to be modified. New supply strategies would be necessary, as present distribution system is separate from gasoline distribution.

Propane (LPG) is a by-product of natural gas processing and oil refining. Although it is a non-renewable fossil fuel, it is already used as cooking gas.

Advantages: LPG is currently the third most commonly used transportation fuel. It's used primarily by fleet vehicles such as fork lifts and school buses. It can be used in internal combustion engines with minor modifications and it is well suited to heavy-duty vehicles. It delivers comparable performance to gasoline vehicles, tends to be safer in a car crash, reduces engine maintenance, reduces criteria emissions from 20-70%, reduces carbon dioxide emissions by 15%, and is not a threat to groundwater. Over 90% of the LNG used in the US is domestically produced. Fueling stations are common and it is currently available at low prices.

Disadvantages: LPG is a non-renewable fossil fuel, so supplies are limited and subject to price shocks. It is heavier than air and has a low flashpoint, so it poses safety hazards if it leaks. It has a high coefficient of expansion so that temperature changes could cause tank rupture. In comparison to gasoline vehicles, it has a low energy density which reduces driving range. It has a cumbersome fuel tank and it can be hard to start at cold temperatures.

For more information:
Electric Drive Transportation Association www.electricdrive.org
Green Car Club www.GreenCarClub.org
Methanol Institute www.methanol.org
Northeast Sustainable Energy Association www.nesea.org
National Biodiesel Board www.biodiesel.org
National Ethanol Vehicle Coalition www.e85fuel.com
Natural Gas Vehicle Coalition www.ngvc.org
Propane Vehicle Council www.propanevehicle.org
Renewable Fuels Association www.ethanolrfa.org
U.S. Fuel Cell Council www.usfcc.com

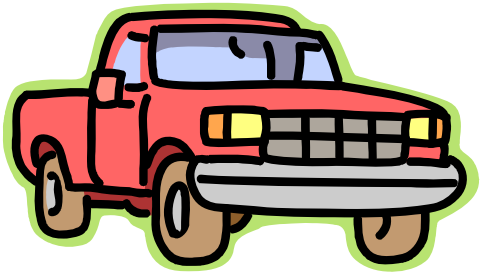
Northeast Sustainable Energy Association, 50 Miles Street, Greenfield, MA 01301 (413)774-6051 www.nesea.org

Name:_____ Date:_____

What's that Smell?

Gas Emissions

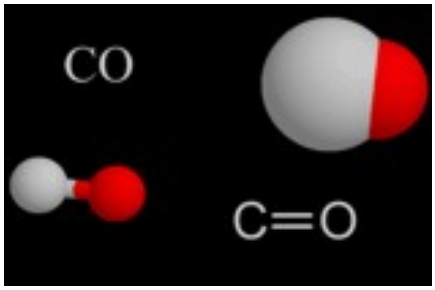
Background



Reducing the environmental damage caused by individuals' use of cars and light trucks (minivans, sport utility vehicles, and pickups) should be a top priority for our nation. Many recent studies have analyzed all the many things that consumers buy and do. It concluded that "personal use of cars and light trucks is the single most damaging consumer behavior." Not only does car use cause many types of air pollution and a large share of the greenhouse gases contributing to global warming, but indirectly it is a major source of water pollution (through manufacturing of cars, gasoline production, and runoff from highways) and ecologically harmful land use (for the road network).

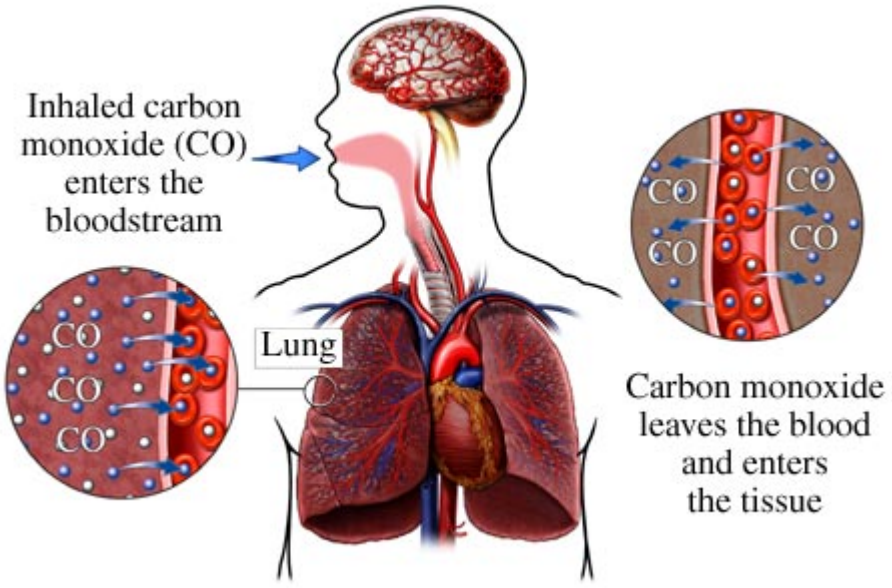
What is Carbon Monoxide?

Carbon monoxide (CO) is a colorless, odorless, poisonous gas. A product of incomplete burning of hydrocarbon-based fuels, carbon monoxide consists of a carbon atom and an oxygen atom linked together.



Why is Carbon Monoxide a Public Health Problem?

Carbon monoxide enters the bloodstream through the lungs and forms carboxyhemoglobin, a compound that inhibits the blood's capacity to carry oxygen to organs and tissues. Persons with heart disease are especially sensitive to carbon monoxide poisoning and may experience chest pain if they breathe the gas while exercising. Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive. Carbon monoxide can affect healthy individuals, impairing exercise capacity, visual perception, manual dexterity, learning functions, and ability to perform complex tasks. In 1992, carbon monoxide levels exceeded the Federal air quality standard in 20 U.S. cities, home to more than 14 million people.



How is Carbon Monoxide Formed?

Carbon monoxide results from incomplete combustion of fuel and is emitted directly from vehicle tailpipes. Incomplete combustion is most likely to occur at low air-to-fuel ratios in the engine. These conditions are common during vehicle starting when air supply is restricted ("choked"), when cars are not tuned properly, and at altitudes where "thin" air effectively reduces the amount of oxygen available for combustion. Nationwide, two-thirds of the carbon monoxide emissions come from transportation sources, with the largest contribution coming from highway motor vehicles. In urban areas, the motor vehicle contribution to carbon monoxide pollution can exceed 90 percent.

What Has Been Done to Control Carbon Monoxide?

The Clean Air Act gives state and local governments primary responsibility for regulating pollution from power plants, factories, and other "stationary sources." The U.S. Environmental Protection Agency (EPA) has primary responsibility for "mobile source" pollution control. The EPA motor vehicle program has achieved considerable success in reducing carbon monoxide emissions. EPA standards in the early 1970's prompted automakers to improve basic engine design. By 1975, most new cars were equipped with catalytic converters designed to convert carbon monoxide to carbon dioxide. Catalysts typically reduce carbon monoxide emissions upwards of 80 percent. In the early 1980's, automakers introduced more sophisticated converters, plus onboard computers and oxygen sensors to help optimize the efficiency of the catalytic converter. Today's passenger cars are capable of emitting 90 percent less carbon monoxide over their lifetimes than their uncontrolled counterparts of the 1960's. As a result, ambient carbon monoxide

levels have dropped, despite large increases in the number of vehicles on the road and the number of miles they travel.

Steps we can take to reduce environmental damage

In terms of our personal lives, there are many possible actions we can take, but most of them boil down to driving less and purchasing environmentally friendly cars. In addition, you can use driving and maintenance strategies to reduce air pollution from your family's car. We can also move beyond personal actions to try to establish government policies that encourage manufacturers to produce cleaner cars and give incentives to consumers to buy them.

5 Steps to Determine Annual Greenhouse Gases

Step 1: Determining the CO_2 produced per gallon of gasoline

A gallon of gasoline is assumed to produce 8.8 kilograms (or 19.4 pounds) of CO_2.

Step 2: Estimating the fuel economy of passenger cars and light trucks

The EPA uses a computer model for estimating emissions for highway vehicles. It can calculate an average fuel economy across any fleet, based on their annual fuel trends. The average fuel economy of passenger cars and light trucks was calculated to be 23.9 miles per gallon (mpg) for passenger cars and 17.4 mpg for light trucks. An overall average fuel economy for passenger vehicles of 20.3 mpg for passenger cars and light trucks combined can be used.

.

Step 3: Determining the number of miles driven

The number of miles driven per year is assumed to be 12,000 miles for all passenger vehicles. This number is based on several sources. Calculations from EPA's model show an average annual mileage of roughly 10,500 miles per year for passenger cars and over 12,400 miles per year for light trucks across all

vehicles in the fleet. However, these numbers include the oldest vehicles in the fleet (vehicles 25 years of age and older), which are likely not used as primary vehicles and are driven substantially less than newer vehicles. Since this calculation is for a typical vehicle, including the oldest vehicles may not be appropriate. Therefore for all vehicles up to 10 years old, the annual average mileage is 12,000 miles per year for passenger cars, and 15,000 miles per year for light trucks.

Step 4: Determining the emissions of greenhouse gases other than CO_2

In addition to carbon dioxide, automobiles produce methane (CH_4) and nitrous oxide (N_2O) from the tailpipe, as well as Hydrofluorocarbons (HFC) emissions from leaking air conditioners. The emissions of CH_4 and N_2O are related to vehicle miles traveled rather than fuel consumption. On average, CH_4, N_2O, and HFC emissions represent roughly 5 - 6 percent of the green house gas (GHG) emissions for passenger vehicles, while CO_2 emissions account for 94-95 percent, accounting for the global warming potential of each greenhouse gas. To simplify, it is assumed that CH_4, N_2O, and HFCs account for 5 percent of emissions, and the CO_2 estimate is multiplied by 100/95 to incorporate the contribution of the other greenhouse gases.

Step 5: Calculating the resulting annual greenhouse gases

1. Metric tons of CO_2 emissions for the average passenger vehicle =

$$\left(\frac{VMT}{MPG}\right)\times\left(\frac{CO_2}{gallon}\right)\times\left(\frac{1\ \ kg}{1000\ \ g}\right)=\left(\frac{12{,}000}{20.3}\right)\times(8.8)\times\left(\frac{1\ \ kg}{1000\ \ g}\right)=5.20$$

   Average passenger vehicle = 5.20 metric tons of CO_2 emissions

2. Metric tons of GHG emissions for the average passenger vehicle =

$$(CO_2\ emissions)\times(GHG\ \ \ Conversion)=(5.20)\times\left(\frac{100}{95}\right)=5.48$$

   5.48 metric tons of GHG emissions for the average passenger vehicle

Investigation

Question: Does the path and vehicle you drive impact the environment?

Hypothesis: _____

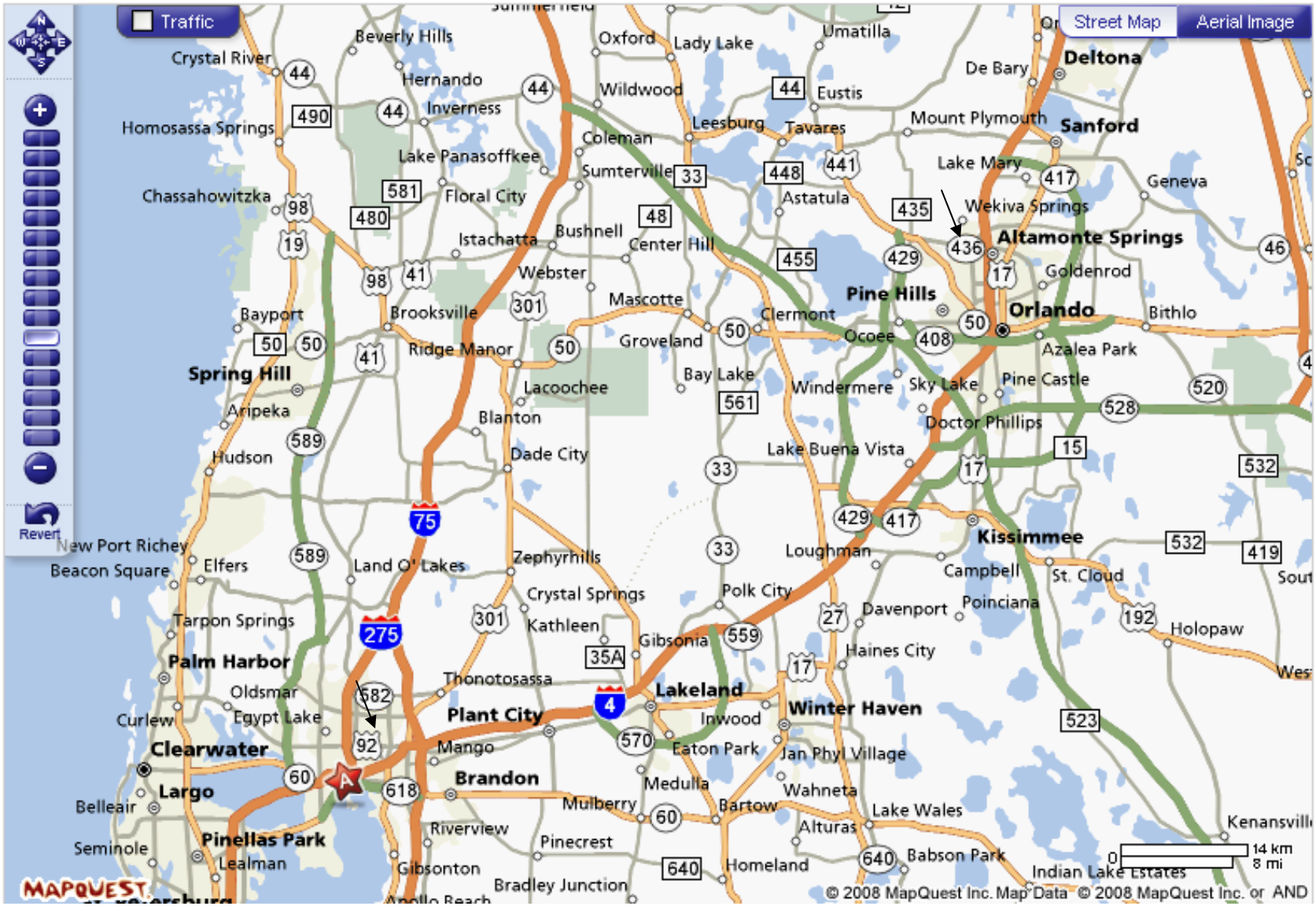
_____

Materials:

- Map
- Summer Camp Packet
- Pencil and Eraser
- Ruler
- Calculator
- Cards

Procedure:

1. Assign team roles
2. Gather materials
3. Select a card to determine vehicle and path
4. Determine gas emissions following the above procedure: _____
5. Clean up your area and put all materials away
6. Answer the questions


Traffic
Street Map
Aerial Image
Revert
Crystal River
Beverly Hills
Hernando
Inverness
Homosassa Springs
Chassahowitzka
Lake Panasoffkee
Floral City
Istachatta
Bushnell
Webster
Brooksville
Bayport
Ridge Manor
Spring Hill
Aripeka
Hudson
Oxford
Lady Lake
Wildwood
Coleman
Sumterville
Leesburg
Tavares
Eustis
Umatilla
De Bary
Deltona
Mount Plymouth
Sanford
Lake Mary
Geneva
Astatula
Wekiva Springs
Altamonte Springs
Goldenrod
Pine Hills
Orlando
Bithlo
Azalea Park
Pine Castle
Sky Lake
Windermere
Ocoee
Clermont
Mascotte
Groveland
Center Hill
Bay Lake
Lacoochee
Blanton
Dade City
Lake Buena Vista
Doctor Phillips
Kissimmee
Loughman
Campbell
St. Cloud
Poinciana
Davenport
Haines City
Polk City
Crystal Springs
Kathleen
Gibsonia
Zephyrhills
Land O' Lakes
Elfers
Beacon Square
New Port Richey
Tarpon Springs
Palm Harbor
Oldsmar
Egypt Lake
Curlew
Clearwater
Largo
Belleair
Seminole
Pinellas Park
Lealman
Gibsonton
Bradley Junction
Riverview
Pinecrest
Mulberry
Medulla
Brandon
Thonotosassa
Mango
Plant City
Lakeland
Inwood
Winter Haven
Eaton Park
Jan Phyl Village
Wahneta
Bartow
Alturas
Lake Wales
Homeland
Babson Park
Indian Lake Estates
Kenansville
Holopaw
14 km
8 mi
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MAPQUEST

Questions

1. Describe examples on how to reduce green house gas emissions.

2. What are some green house emissions and what percentage of them are produced from driving a passenger car?

3. Solve for metric tons of GHG emissions given VMT = 15,000 and MPG = 29.8.

4. Compare your results with those in the reading.

Name:_____ Date:_____

Air Quality & Your Body

Purpose

To determine what students know about the effects of indoor air pollution on the body.

Objective

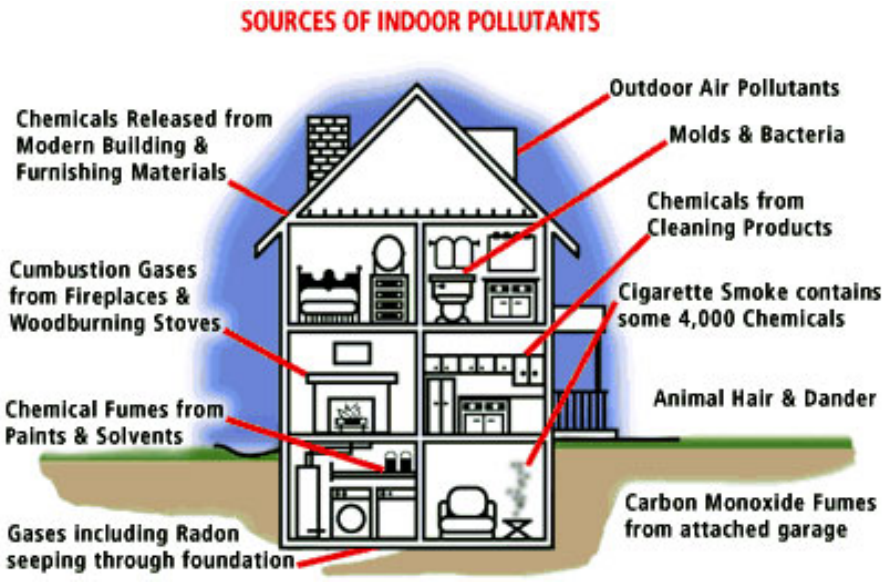
Students will be able to list indoor air pollutants, their health effects, and the part(s) of the body that they affect.

Background

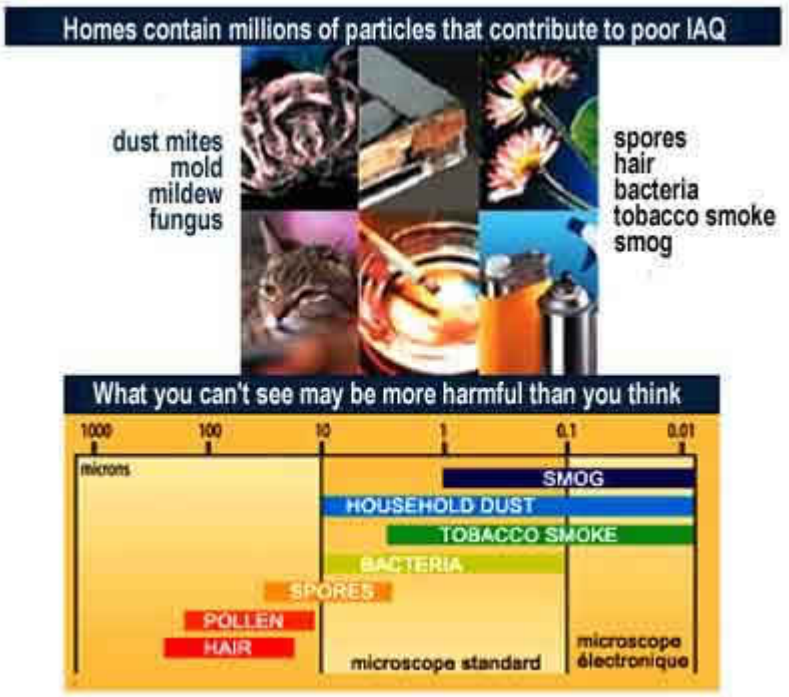
We breathe air into our lungs. Our lungs process every breath we take, about 16,000 quarts of air each day for adults. Our lungs, along with our nose, act as filters, removing some of the larger particles in the air before they get too far into our bodies and harm us. Our lungs also provide oxygen to the blood and remove carbon dioxide from the blood. Whenever we breathe pollutants, our health may be affected. Most people are aware that outdoor air pollution can make them sick, but

they may not know that indoor air can be harmful too. Studies show that indoor air pollution levels are typically two to five times, and occasionally more than 100 times, higher than outdoor levels. Indoor air pollution has been ranked among the top five environmental risks to our health.

Some pollutants, such as tobacco smoke, get past the "filters" and penetrate deep into the lungs. Health effects caused by these pollutants can either be immediate or show up years later. People may feel sick after a single exposure or after repeated exposures. Immediate symptoms include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Most immediate effects are short-term and can be treated. Many of the immediate health effects caused by indoor air pollution are similar to those of a common cold, the flu, or stress. This makes it hard to tell if a person is feeling bad because of an air quality problem, or if there is some other cause. Also, many of the pollutants have similar effects, so it can be hard to pin down which one is causing the problems.



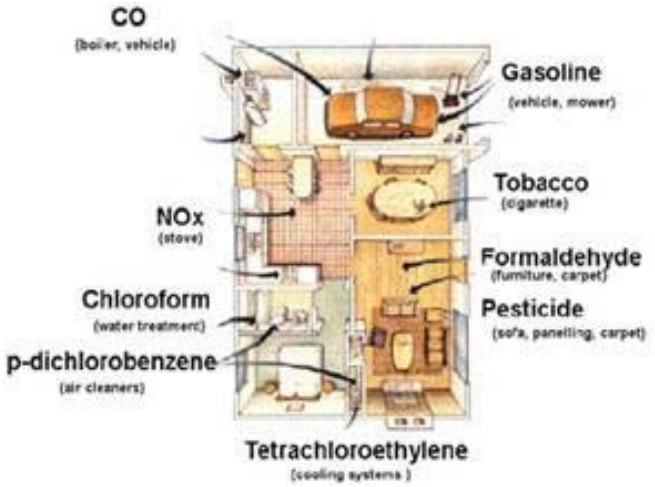
Some pollutants (lead, for example) can affect the brain and the central nervous system. Potential side-effects of lead poisoning in children include delays in mental development, lower intelligence test levels, shortened attention span, behavioral problems, and, at high levels, brain damage, seizures, and coma. In adults, lead poisoning can cause nerve damage, clumsiness, sleep problems, and, at high levels, uncontrollable shaking of the hands, hallucinations, brain damage, and coma. Other health effects from indoor air pollutants may show up years after exposure has occurred or only after long or multiple exposures. These effects include damage to the liver and central nervous system, hallucinations, some breathing diseases (e.g., asthma, emphysema), heart disease, and cancer. Can pollutants enter the body in other ways? Yes. Pollutants can be ingested (swallowed) or absorbed when they come in contact with your skin. You should never put any chemicals, cleaning products, or pesticides in your mouth. Follow the product's directions carefully and wash your hands thoroughly after using these products.



Is there any way to improve the quality of the air?

Three methods reduce the amounts of pollutants in indoor air. They are listed in order of effectiveness:

1) Removing the source or controlling the emissions. Prevention is the key.
2) Increasing the amount of air flowing through the area (ventilation).
3) Using certain air cleaners (which filter out pollutants) that do not cause indoor air quality problems themselves.



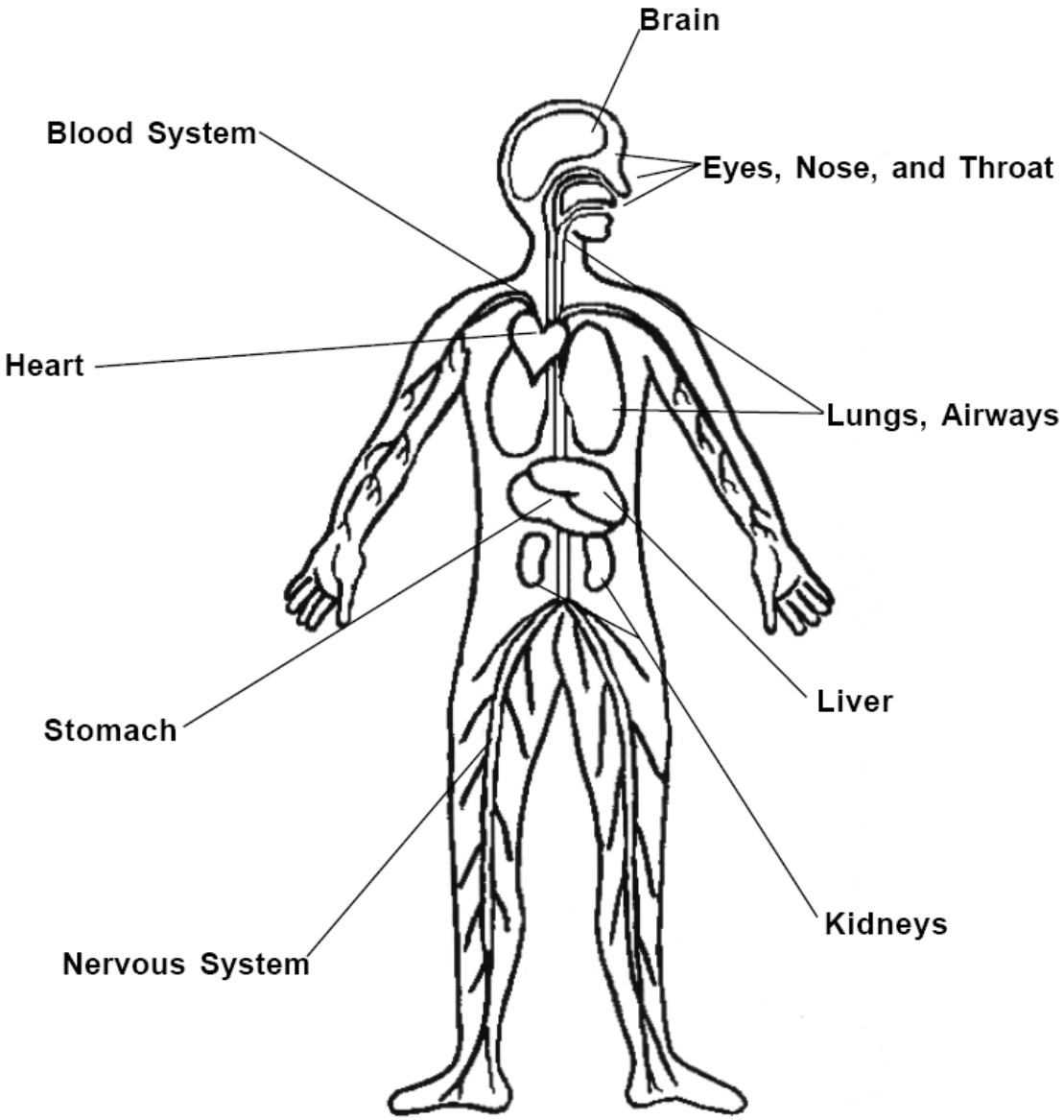
Common Indoor Air Pollutants found in a home

To reduce the levels of indoor air pollution you can:

- never allow smoking indoors
- use less toxic cleaning products
- make certain that the indoor space is properly ventilated
- reduce levels of cockroach and dust mite particles
- reduce pet dander
- avoid or minimize use of pesticides indoors
- use low toxicity paints, sealers and caulks
- reduce the use of solvent-based dry cleaning and/or air out dry-cleaned clothes thoroughly before bringing into one's home
- avoid idling an internal combustion engine, such as a car, lawn mower or fork lift, in an enclosed space or near the entrance to one's home or workplace
- change air filters frequently

Body Parts Diagram

Write down the pollutants that affect each part of the body and some of their possible effects.



Investigation

Question: Does indoor air contain pollutants and if so, how much?

Hypothesis: _____

_____

Materials:

- Petroleum Jelly
- Summer Camp Packet
- Pencil and Eraser
- Wax Paper
- Paper towels
- Magnifying Glass
- Spoons
- Cardboard box

Procedure:

7. Assign team roles.
8. Gather materials.
9. Take a piece of wax paper and apply petroleum jelly on it using the spoon. Make sure to apply an even layer.
10. Place the wax paper into the cardboard box.
11. Examine the jelly and notice that there are no particles.
12. Place the box in a location within the classroom.
13. Clean up your area and put all materials away
14. After an hour, examine the wax paper using the magnifying glass.
15. Answer the questions.

Questions

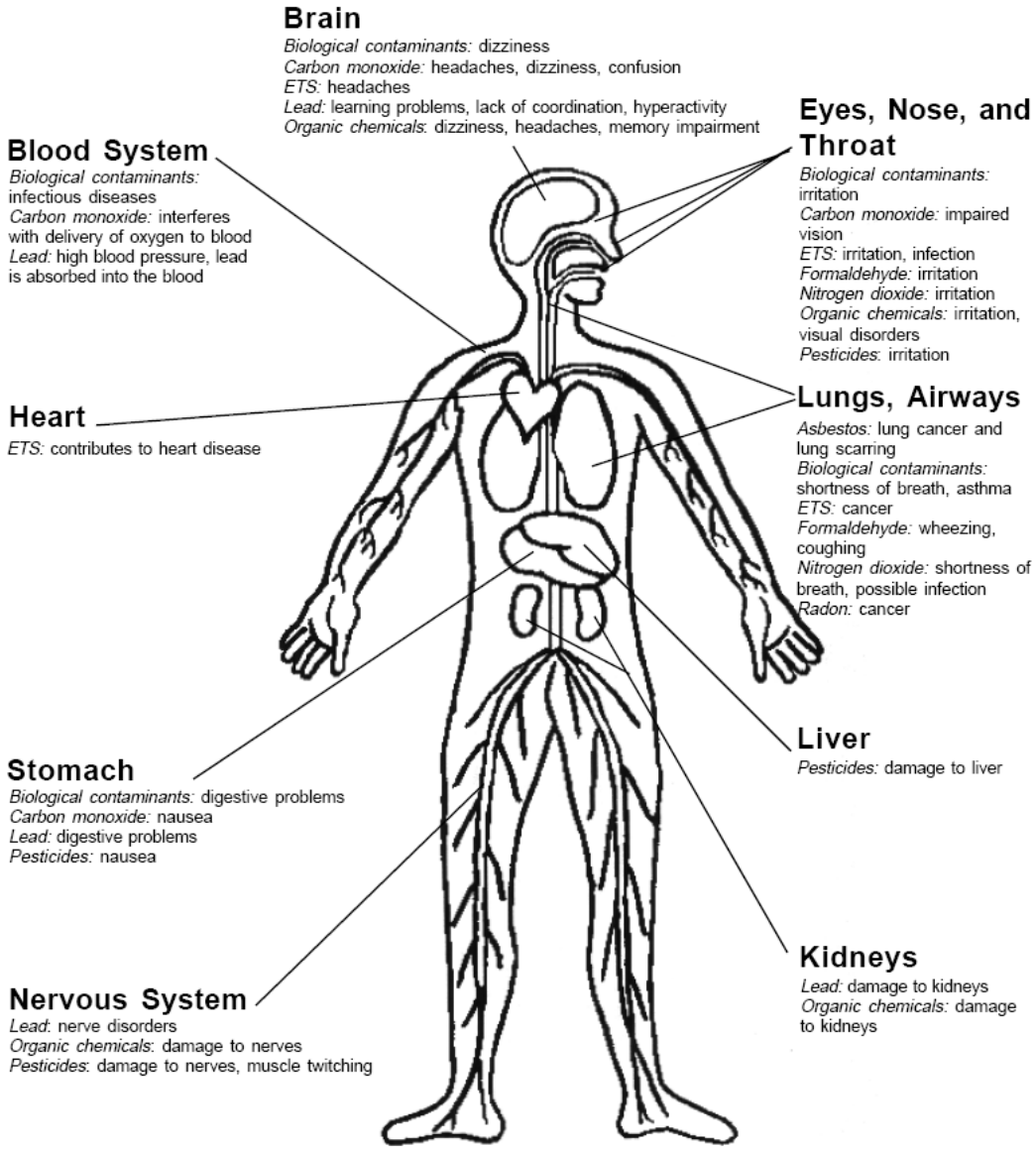
1. Describe examples of indoor air pollutants.

2. What are some medical side affects that are caused by air pollutants?

3. Draw what you saw on the wax paper after an hour.

4. What are some ways to improve indoor air quality?

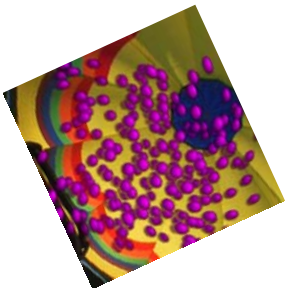
Answer Key


Brain
Biological contaminants: dizziness
Carbon monoxide: headaches, dizziness, confusion
ETS: headaches
Lead: learning problems, lack of coordination, hyperactivity
Organic chemicals: dizziness, headaches, memory impairment
Blood System
Biological contaminants: infectious diseases
Carbon monoxide: interferes with delivery of oxygen to blood
Lead: high blood pressure, lead is absorbed into the blood
Eyes, Nose, and Throat
Biological contaminants: irritation
Carbon monoxide: impaired vision
ETS: irritation, infection
Formaldehyde: irritation
Nitrogen dioxide: irritation
Organic chemicals: irritation, visual disorders
Pesticides: irritation
Heart
ETS: contributes to heart disease
Lungs, Airways
Asbestos: lung cancer and lung scarring
Biological contaminants: shortness of breath, asthma
ETS: cancer
Formaldehyde: wheezing, coughing
Nitrogen dioxide: shortness of breath, possible infection
Radon: cancer
Liver
Pesticides: damage to liver
Stomach
Biological contaminants: digestive problems
Carbon monoxide: nausea
Lead: digestive problems
Pesticides: nausea
Kidneys
Lead: damage to kidneys
Organic chemicals: damage to kidneys
Nervous System
Lead: nerve disorders
Organic chemicals: damage to nerves
Pesticides: damage to nerves, muscle twitching

Name: _____ Date:_____

Indoor Air Quality Improvement

Objective:

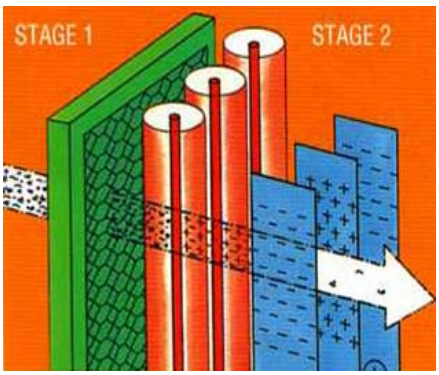


Students should learn how to work in groups.
Student will improve their communication skills.
Students have to design their own air filter using different mediums.

Purpose:

Students should be able to select different materials to make an air filter.
Students should be able to test their air filter and compare with other groups.
The best air filter wins!

Main Idea



A specific filter frame or box is going to be given and students should be able to design their own HEPA filter.

Materials:

Duct tape
Scissors
Medium 1
Medium 2
Corrugate paper
Shoe box or frame
Wire
screen
Markers
Black pepper
Sand
Dust particles

Vocabulary Words

HEPA filter	Particles
Humidity	Pollutant
Medium	Pollution
Micron	Porosity
Mildew	UV light
Mold	Ventilation
Ozone	Wave length

Instructions

1. This is going to be an inquiry based activity where the students have to design their own air filter as a group.
2. Students should select different construction materials, and mediums to build their air filter.
3. Once all the filters are done a testing phase is going to be set to observe which group has the best filter.

What is Indoor Air Pollution?

Indoor air pollution consists of toxic gases or particles that can harm your health. These pollutants can build up rapidly indoors to levels much higher than those usually found outdoors. This is especially true if large amounts of a pollutant are released indoors.

There are fourth basic strategies to improve indoor air quality

1. Source Control

The most effective way to improve indoor air quality is finding the source of pollution. Pollutants like: asbestos, aerosol sprays, solvents, glues, paints, detergents, pesticides, dust particles, gas appliances, mold , bacteria's, and virus

are the most common. Eliminate individual sources of pollution or reduce their emissions are very important. In many cases, source control is also a more cost-efficient approach to protecting indoor air quality than increasing ventilation because increasing ventilation can increase energy costs.

2. Improved Ventilation

The second approach consists of lowering the concentrations of indoor air pollutants in your building or home. These options basically increase the amount of outdoor air coming indoors. Most building or home heating and cooling systems, do not mechanically bring fresh air into the house or buildings. Opening windows and doors, operating window or attic fans, when the weather permits, or running a window air conditioner with the vent control open increases the outdoor ventilation rate. Local bathroom or kitchen fans (extractors) that exhaust outdoors remove contaminants directly and also increase the outdoor air ventilation rate.

It is very important to take as many of these steps as possible while you are involved in short-term activities that can generate high levels of pollutants. Some activities like painting, paint stripping, cooking, or bathroom cleaning with detergents, and other activities such as welding, or sanding can generate high levels of pollutants.

Temperature Reliability and Humidity Control

Improve insulation of buildings and maintain a humidity level between 30% and 60%, or below 50% to prevent the growth of mold, dust mites, bacteria and viruses. Under conditions of high humidity, the evaporation of sweat from the skin is decreased and the body's efforts to maintain a normal body temperature may be significantly reduced. Excessively high humidity causes corrosion in electronics and malfunction. Low humidity causes static electricity and spontaneous shutdown of servers in data centres and brittle materials.

How we can control the following air quality indoor parameters?

To control temperature reliability it is necessary to have good thermostat settings and good quality insulation. Reflection of sunlight is very important to control the heat of a building. Humidity control can be achieved with the used of water chillers in buildings, ventilators, desiccant and air conditioning units as possible mechanism in house or small buildings.

3. Air cleaners

Many particles of different types and sizes are carried in the air we breathe. Some large particles may settle on the walls and furniture in your home. Other large particles are ingested by your nose and mouth when you inhale. Smaller particles may even get lodged in the lungs. Particle Control- can be achieved by using air filters in ducts, and Air Conditioning inlets.

Table 1 Air Filter Media Type

Acrylic	Acrylic fibers are produced by long-chain synthetic polymers.
Activated Carbon	Traps particles on a chemical basis. It reacts with odors and heavy gases.
Aluminum Screen Wire	An aluminum screen can be used in the fan filter assembly to allow maximum airflow.
Electrostatic	The dust particles in the air are charged and attracted to oppositely-charged pads within the filter.
Fiberglass	The gradient density of fiberglass traps particles of progressively smaller sizes.
Paper	Paper filters are made from compressed fibers. The microscopic spaces between fibers allows air pass through.
Polyurethane	Is used for many filter applications. Is non-allergenic, non-toxic, and detergent resistant.
Polyester	Is a synthetic polymer with high tensile strength; wrinkle and abrasion resistances.
Poly / Cotton Nonwoven Media	The filter media is a blend of polyester and cotton fibers that are chemically-bonded. It provides excellent filtration.

Name: _____ Date:_____

Lets Start!

First it's necessary to draw your air filter design.

Second, list the selected materials that are going to be used by the group to make their air filter.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Write down a procedure of how the group plans to assemble the air filter step by step.

Step 1.

Step 2.

Step 3.

Step 4 .

Questions and Conclusions

1. List different mediums that could be use for air filters.

1. _____ 4. _____

2. _____ 5. _____

3. _____ 6. _____

2. What is the range of humidity required for human comfort?

_____

_____

3. How can we control the indoor temperature reliability of a building?

_____

_____

4. What is a HEPA filter?

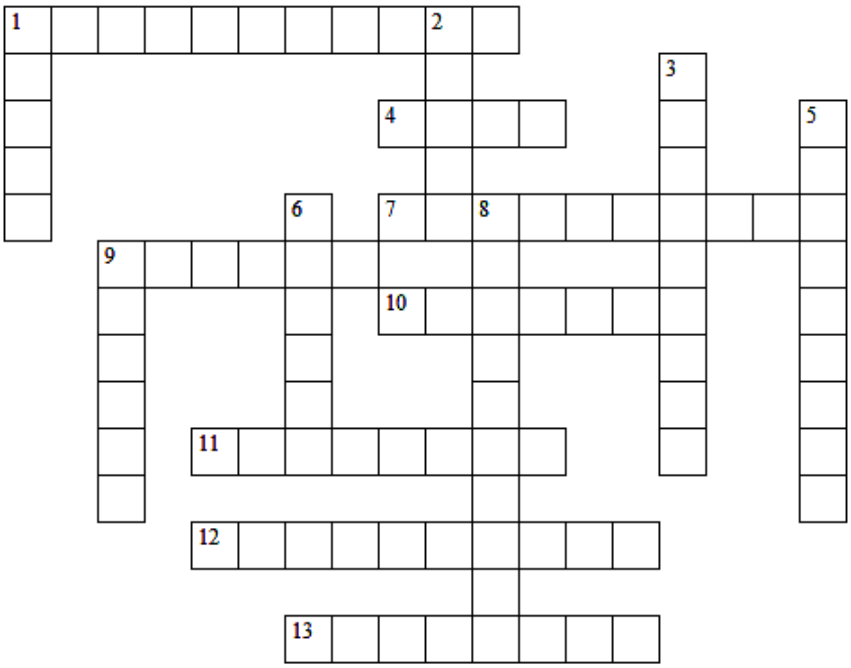
_____

_____

_____

Name: _____ Date: _____

Indoor Air Quality Crossword Puzzle



ACROSS

1 Process of circulating indoor air to the outside and bringing fresh air from outdoor.
4 Fungi that often cause disintegration of organic matter.
7 Trap at least 99.97 percent of particles of up to 0.3 microns.
9 Discoloration of organic materials, such as cloth, paper, or leather, caused by fungi.
10 Spectrum of the light that looks violet and had a wavelength 254 nm.
11 Amount of water vapor in air.
12 The distance between one peak of a wave and the next peak.
13 Voids or flaws such as pinholes on the surface of a material.

DOWN

1 Volatile Organic Compounds, paints, adhesives, detergent, cosmetics, pesticides and air fresheners.
2 It forms in the atmosphere through the process of photolysis,O_3.
3 Harm caused to the natural environment.
5 A very small piece or part; a tiny portion or speck.
6 Specific type of material.
8 A substance or condition that contaminates air, water, or soil.
9 A unit of length equal to 1 millionth ($1x10^{-6}$) of a meter.

Name: _____ Date: _____

Indoor Air Quality Word Search

Can you find these indoor air pollutants and their health effects?

Mold	Dust	Thinners
Bacteria	Carbon Monoxide	Solvents
Pesticides	Detergents	Paint
Lead	Tobacco Smoke	Asbestos
Radon	Virus	Gas Appliance

T R F T H I N N E R S J A D J E

R S T N E G R E T E D I K L X D

A B G G M S L M N F R T G O T I

D F R Z X P O A P E R A T M K X

O N R E N P S L T D S V T Y S O

N L R L K B R C V A B W X U F N

P Y L K E O A G P E W M R M K O

Y K Q S B B M P Z K N I C R N M

T Q T X H X L S W L V T M P R N

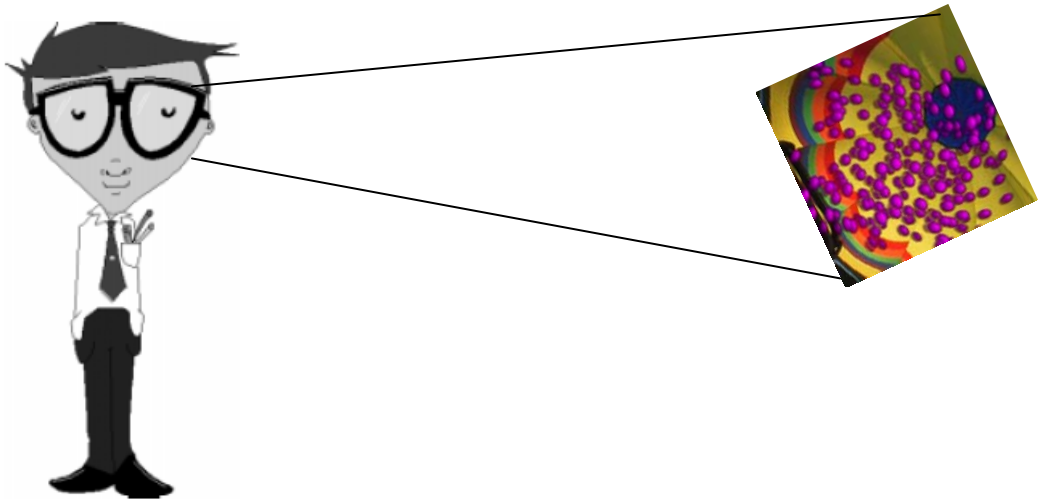
K O N Q C I N D O C E N S N N O

S G P G A L F R Q C Q A H F T B

P B T N R P E S T I C I D E S R

Name: _____ Date:_____

Breathing Green!



Objective:

Students should learn how to work in groups.
Student will improve their communication skills.
Students have to design their own air purifier using different materials.

Purpose:

Students should be able to select different materials to make an air purifier.
Students should be able to test their air purifier compare with other groups.
The best air purifier wins!

Main Idea

A specific filter frame or box is going to be given and students should be able to design their own air purifier.

Materials:

Duct tape
Scissors
Medium 1
Medium 2
Corrugate paper
Card board box
Wire screen
Markers
20" Box Fan
Black pepper
Sand
Dust particles

Vocabulary Words

Asthma
Biological Contaminants
Concentration
Merv
Monitoring
Ozone
Particulates
Prediction
Purifier
Radon
Respiration
Secondhand Smoke
UV light
Wavelength

Instructions

4. This is going to be an inquiry based learning activity where students have to build their own air purifier as a group.
5. Students should select different materials to build their air purifier.
6. The best air purifiers design wins!

Hints:

1. Drill a small hole in the cardboard box.
2. Put the PVC pipe in the hole.
3. Place your filter material or mediums on the outside of the pipe. This will keep out insects, pollen, and other particulates.
4. Attach the air filter to the cardboard box.
5. You need to mount the fan inside the box.

Note: Every group have to make their own drawing and figure out where to use duct tape, scissors and other materials.

Background

Since the energy crisis of the 1970s, the strategy of re-circulating indoor air and minimizing the need to heat, cool or condition of outside air has been implemented to save energy and reduce costs. Although considerable savings are realized with this strategy, unwanted contaminants become trapped in these tight enclosures.

Dust, pollen, pet dander, mold, and dust mite can act as allergens, triggering allergies in sensitive people. Smoke particles and volatile organic compounds (VOC's) like: paint adhesives, aerosol sprays, solvents, detergents, Pesticides, and air fresheners can pose a risk to health. In addition, the developments of new construction materials have resulted in the use of more synthetics and composites, which can affect air quality.

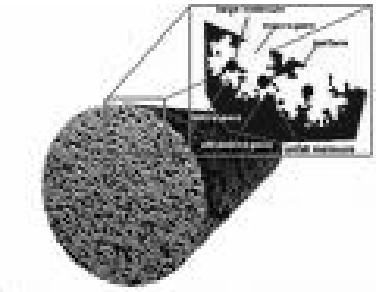
All these factors could potentially affect the health of many people. It gets more complicated by the fact that people are spending more time than ever indoors, up to 90 percent according to estimates by the U.S. Environmental Protection Agency (EPA). It is easy to understand why there is a growing concern about the quality of the air we breathe. To stay healthy and avoid further complications like allergies and asthma it is necessary to purify the air we breathe. This reduces the concentration of these airborne contaminants and the need of frequent household cleaning.

Purifying techniques

Several processes with different effectiveness can be used to purify air. Processes that may remove different contaminants, so there is advantage in using more than one process to purify the air.

Filtration- airborne particles are trapped by size exclusion. Air is forced through a filter and particles are physically captured by the filter. A good example is a **HEPA filter,** it removes at least 99.97% of 0.3-micrometer particles, and is usually more effective for particles which are larger. They are effective down to 0.01 micrometers in many cases, but become very ineffective for particles smaller than 0.01 micrometer.

Activated carbon is a highly porous material that can absorb volatile chemicals on a molecular basis, but does not remove larger particles. It is normally used along with other filters like HEPA purifiers.



Photocatalytic oxidation (PCO) uses short-wave ultraviolet light (UV), for killing 99.9% of germs, bacteria and viruses. Microorganisms contain nucleic acid which reacts with UV- wave length of 253.7 nm range. This results in the destruction of DNA of the organism causing its failure to reproduce or infect causing its death. UV in-duct units can be mounted to an existing forced-air Heating and Ventilation Air Condition system. PCO is not a filtering technology, as it does not trap or remove particles. It is sometimes coupled with other filtering technologies for air purification. UV sterilization bulbs must be replaced about once a year; manufacturers may require periodic replacement as a condition of warranty.

Ionizer purifiers use electrically charged surfaces or needles to generate ions. Ions bond with airborne particles which are then electrostatically attracted to a collector plate. This mechanism produces trace amounts of ozone and other oxidants as by-products. Most ionizers produce less than 0.05 ppm of ozone, an industrial safety standard.

Ozone generators produce **ozone**, and are sometimes sold as whole house air cleaners. Unlike ionizers, ozone generators are designed to produce significant amounts of **ozone**, a strong oxidant gas which can oxidize many other chemicals. The only safe use of **ozone generators** is in unoccupied rooms. Shock treatment of commercial ozone generators that produce over 3000 mg of ozone per hour are used by contractors to remove smoke odors after fire damage, musty smells after flooding, mold and the stench caused by decaying flesh which cannot be removed by bleach or anything else except for ozone. However, it is not healthy to breathe ozone gas, and one should use extreme caution when buying a room air purifier that also produces ozone.

Consumer concerns

When selecting air purifiers, consumers are influenced by several factors besides cleaning ability. These include possible hazardous gaseous by-products, noise level, frequency of filter replacement, electrical consumption, and visual appeal. Ozone production is typical for ionizing purifiers and has received much attention recently. Although high concentration of ozone is dangerous, most ionizers produce less than 0.05 part per million of ozone. The noise level of a purifier can be obtained in decibels (dB) through the customer service department of each company. The noise levels for most purifiers are low

compared to many other home appliances and don't cause hearing loss. However, purifiers are expected to operate over long periods of time and can be disturbing to some people. Frequency of filter replacement and electrical consumption are the major operational costs for any air purifier. There are many different types of filters; some can be cleaned by water, by hand or by vacuum cleaner, while others need to be replaced every few months or years. Some purifiers are certified as energy standard efficient.

Air ionizers and Ozone

There is some controversy surrounding the claims of certain companies, specifically involving **ionic air purifiers**. Ionic air purifiers can generate ozone (an energetic allotrope of oxygen) and NO_x as pollutants. Both gases can be toxic at higher concentrations. People who have asthma and allergy are most prone to the adverse effects. Increasing **Ozone** concentration can increase the risk of asthma attacks.

Due to potential health risks, consumer reports have advised against using ozone generators. The use of in-home ozone generators will require testing and certification to verify that they don't generate too much ozone. This law will take effect in 2009.

Name: _____ Date: _____

Lets Start!

First it's necessary to draw your air purifier design.

Questions and Conclusions

1. What is so important to keep an excellent indoor quality of air?

_____

_____

_____

2. What percent of time people spent inside of a building or home?

A. 25 %

B. 75 %

C. 50 %

D. 90 %

E. None of the above

3. List what other equipments could be used to prevent mold or mildew?

1. _____
2. _____
3. _____

4. List all possible consumers concerns when they are selecting an air purifier.

a. _____
b. _____
c. _____
d. _____
e. _____
f. _____

5. How often do UV lights need to be replaced in an air purifying equipment?

A. 6 months
B. 3 years
C. Monthly
D. yearly
E. None of the above

6. What type of smell can be removed with Ozone generators?

_____
_____
_____

Name: _____ Date: _____

Indoor Air Quality Knowledge

Check True or False for each question

1. The air inside our homes is always safe. ❑ True ❑ False
2. Indoor air pollution may be more hazardous to your health than outdoor air pollution. ❑ True ❑ False
3. You can't see, smell, or taste many indoor air pollutants. ❑ True ❑ False
4. Indoor air pollutants can make you sick right away or not for weeks, months, or years. ❑ True ❑ False
5. Lead hurts young children and pregnant women more than other people. ❑ True ❑ False
6. Pets are a source of pollution (for example, dander). ❑ True ❑ False
7. You can't do anything to prevent indoor air quality problems. ❑ True ❑ False
8. Indoor air pollutants can be either natural or artificial. ❑ True ❑ False
9. Spending more time outdoors will always relieve the symptoms of an indoor air quality problem. ❑ True ❑ False
10. It is very easy to tell if someone is sick because of bad indoor air. ❑ True ❑ False
11. People typically spend an average of 90 percent of their time indoors. ❑ True ❑ False
12. Radon smells like rotten eggs. ❑ True ❑ False
13. All indoor air pollutants are artificial. ❑ True ❑ False
14. Carbon monoxide comes from burning fuels. ❑ True ❑ False
15. Carbon monoxide is an odorless, colorless gas that causes serious health problems. ❑ True ❑ False
16. Formaldehyde is a gas that can come from building materials and furnishings. ❑ True ❑ False
17. Opening a window will always solve an indoor air pollution problem. ❑ True ❑ False
18. Secondhand cigarette smoke can cause cancer. ❑ True ❑ False
19. Pesticides only hurt the pests they were designed to kill. ❑ True ❑ False
20. Carbon monoxide comes from electricity. ❑ True ❑ False
21. Smoking is only dangerous to the person who is smoking. ❑ True ❑ False
22. Radon can cause lung cancer. ❑ True ❑ False
23. Every home, no matter what size or shape or where it is located, should be tested for radon. ❑ True ❑ False

Material adapted from National Safety Council Environmental Health Center

Name: _____ Date: _____

Indoor Air Pollutants To Its Sources Matching Game

Draw a line to match the Source of each air pollutant

Environmental Tobacco Smoke	Uranium in soil
Pesticides	Paint, dust, and pipes
Lead	Cleaning products, disinfectants
Biological Contaminants	Cigarettes and exhaled smoke
Formaldehyde	Stoves, furnaces, and fireplaces
Organic Chemicals	Fibers in insulation and flooring
Asbestos	Pet dander, mold, mildew, viruses
Radon	Pressed wood building materials
Carbon Monoxide	Sprays and powders used on the lawn and garden or around the house

Material adapted from National Safety Council Environmental Health Center

Name: _____ Date: _____

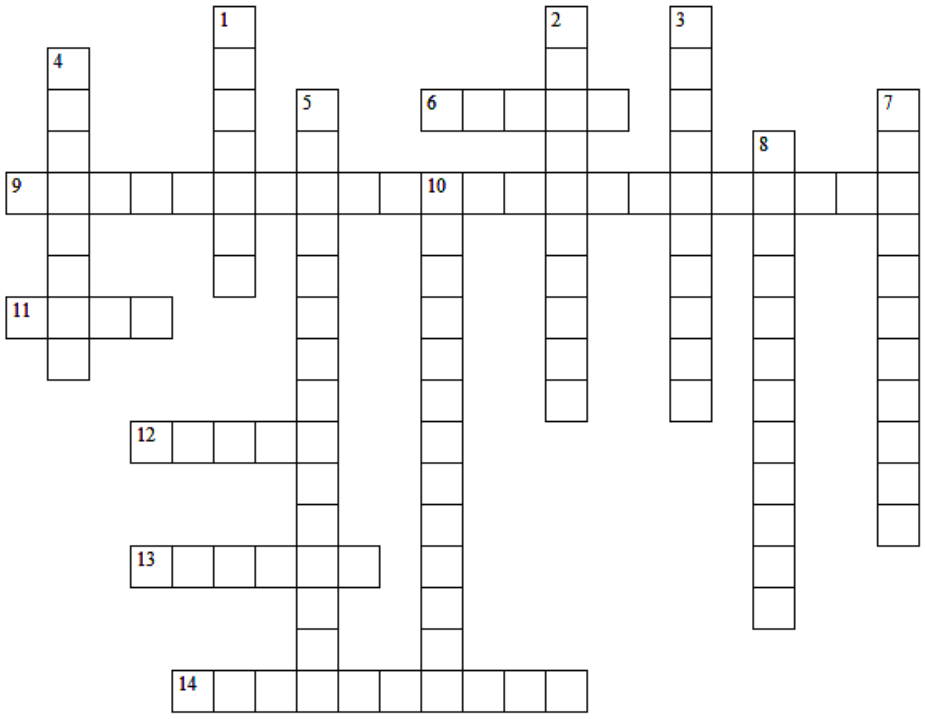
Indoor Air Pollutants and Their Health Effects Word Search

Allergic Reactions	Fatigue	Nausea
Asthma	Fever	Pneumonia
Bronchitis	Headaches	Respiratory
Coughing	Influenza	Infections
Emphysema	Lung Cancer	

S N O I T C E F N I Y R O T A R I P S E R
K K K R E V E F K P K L Z J N P J D M K B
T M H C V W S C B W N W K Z V Z L Y R Q G
M B X Y J C J E M W T E N L C M L K W F F
H R S Q T Z O R H N D J U B K W T T Y V N
N G N R T M R U T C R N X M W N L N W Q X
X B O A W M C C G Q A D L Z O R Z V Z G V
V T I Z R L R T F H K D A R R N T Y L R L
V H T N K N Z R L T I M A X Q G I C M G E
L M C E K D R R Y Q H N C E H Q N A R D M
F R A U R D Y T T T D G G R H V C E Q B P
K X E L L Y D X S N A U S E A R C K D F H
T F R F Q T T A L N Q M T N R N T Q H T Y
K T C N X L H J R C D F Y R A K Z N R V S
M P I I M T Q J F K A F L C M X T K C L E
R N G R Z R Q R Z T B L G T X K Y M C Z M
D Q R L N H N Q I R K N Q V M R J X G K A
T B E M K G R G W W U R G F Q F Z V F L M
L F L K T F U L P L Q H H Y M W L G D K Q
W F L C T E W G T Y J Z D L W M F H L J P
J L A M F K B R O N C H I T I S R R D M T

Name: _____ Date: _____

Breathing Green Crossword Puzzle



ACROSS

6 It's form in the atmosphere through the process of photolysis, O3.
9 Include bacteria, molds, mildew, viruses, animal dander, house dust mites, cockroaches, and pollen.
11 Stand for the Minimum Efficiency Reporting Values of air filters.
12 Is a naturally occurring colorless, odorless, and tasteless radioactive gas.
13 Is an illness that causes a temporary blockage of the small airways in the lungs.
14 The distance between one peak of a wave and the next peak.

DOWN

1 Spectrum of the light that looks violet and had a wavelength 254 nm.
2 Periodically or continuously watching or testing to collect information.
3 Is a statement of a future event? That statement may be based on observation or experience.
4 Device that cleans particulates, viruses and microscopic organisms from air.
5 Smoke inhaled by an individual not actively engaged in smoking.
7 Breathing that supplies cells with oxygen and take away carbon dioxide.
8 Small pieces of a matter, such as dust or powder.
10 Is the amount of a substance contained in a given volume (grams/ml).

Name: _____ **Date:**_____

Green Materials Compost

Objective:

Students should learn how to work in groups.
Student will improve their communication skills.
Students have to design their own compost bin using different materials.

Purpose:

Students should be able to understand why is important to compost?
Each group has to compare their compost bin with other groups.
What materials could be compost?
The best compost bin wins!

Main Idea

Students should be able to design their own compost bin in group.

Materials:

Apple peels
Coffee grounds
Grass clippings
Leaves
Newspaper or regular paper
Plants
7 Plastic bins
Soil
Twigs
Water
Wood

Vocabulary Words

Aeration
Aerobic decomposition
Anaerobic decomposition
Biodegradable
Carbon
Compost

Fertilizer
Humus
Moisture
Mulch
Nitrogen
Recycling

Instructions:

7. The students have to design their own compost bin as a group.
8. Students should select different materials to build their own compost bin.
9. Students should remember that they need to set their bin in the yard close to a source of water.
10. We will provide various containers with different ingredients like: leaves, twigs, grass clippings, coffee grounds, recycled wood, and top soil.
11. For the compost recipe it is necessary to use the above ingredients or material in layers to have an even mix of brown stuff and green stuff.
12. In addition, the compost recipe needs air, soil and water to live and work. It is necessary to add plant parts, apple peels, newspaper or regular paper and soil together and in time you will have a good compost mix!
13. It is important to wet each layer as you build it. Repeat each of the layers until the bin is full.

Why make Compost?

Compost is one of nature's best mulches and soil amendments, and you can use it instead of commercial fertilizers. Best of all, compost is cheap. You can make it without spending a cent. Most gardeners have long understood the value of this rich, dark, earthy material and how it improves the soil and create a healthy environment for plants.

Advantage of using composts:

1. Compost improves soil structure, and texture.
2. The aeration of soil increases.
3. The soil's water-holding capacity increases.
4. Improves soil fertility and stimulates healthy root development in plants.
5. Provides food for microorganisms, which keeps the soil in a healthy, balanced condition. Nitrogen, potassium, and phosphorus will be produced naturally, so few or no soil amendments will be needed.
6. Reduce waste disposal and helps to conserve our environment.

Note: Don't throw away materials when you can use them to improve your lawn and garden! Start composting instead. For more reference you can visit the following site: http://www.compostguide.com/

What to compost?

A great variety of things can be composted at home, saving them from a one-way trip to the landfill, and turning them into a valuable soil amendment for home use. This list describes some of the items you may want to add to your home compost pile.

The following items can be added to your compost pile:

1. Grass clippings (Thin layers or thoroughly mix with other ingredients.)
2. Hay (Farmers thoroughly mix with other ingredients.)
3. Twigs (Is a good material to keep a compost pile aerated it create lots of passageways for air to get into the pile.)
4. Leaves (An excellent compost ingredient that needs to be used in thin layers or thoroughly mix.)
5. Kitchen waste like: Fruit or vegetables peels, tea bags, and coffee grounds or similar materials are great stuff to compost.

6. Weeds or other garden wastes (No seeding or sick plants.)
7. Wood Chips and Sawdust (Recycle wood or regular not painted or chemical treated.)
8. New green materials are been developed like: recyclable wood, soy insulators, sea grass mats, biodegradable rugs and cotton products.

Carbon sources

On composting the brown stuff is dead and high in the element carbon. For example dry leaves, twigs, newspaper, and sawdust with the highest content. Layers can go up to 6 inches in height.

Nitrogen sources

On the other hand, the green stuff is fresh, usually quite soft and moist with high content of the element *nitrogen.* For example kitchen waste like vegetables and fruit peels, grass clippings, and green weeds or old plants. Layers can go up to 2 to 3 inches in height. The greener the compost material looks the more nitrogen it contains.

What not to compost?

Whether because of toxins, plant or human diseases, or weed troubles, there are some things that shouldn't be put into compost piles. Avoid composting the following materials:

Bones	Diseased Plants	Milk
Cheese	Fats	Oils
Chemical treated wood	Meat	Pet or human droppings

How you know your compost is finished?

There is no single point at which compost is finished -- it's a bit more subjective than that. For many outdoor garden applications, for instance, it can be fine to use compost that still has a few recognizable bits of leaves or other products that will finish rotting in the soil. Generally, finished compost is dark

in color and has an earthy smell (like the smell of soil). Usually, it's difficult to recognize any of the original ingredients, although bits of hard-to-decompose materials sometimes can be seen.

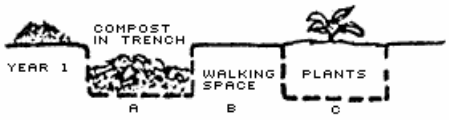
How can I use my finished compost?

You can use compost as mulch around garden plants. In addition, compost can be uses on lawns (soil amendment), landscapes, and potting soil. Compost can be used by combining equal parts of compost and water and letting it sit for a while. The liquid can help to provide a 'quick boost' to ailing houseplants or young seedlings and transplants (I recommend diluting it quite a bit for use on seedlings).

Possible Composting Systems:

1 to 3 staggers bins system is the simplest way to make a compost pile, and is a great way to get started. If you plan to make a lot of compost, one bin may not be enough. You may need to add more bins.

A **Rotating or Tumbling system** is a barrel-shaped container with a framework to allow the bin to be rotated or tumbled by hand. This tumbling aerates the decomposing organic matter causing more rapid development of compost for your garden.



Trench Composting is the most primitive technique used for composting. It consists of digging a one-foot-deep trench. One the system is done you can start to bury the food wastes(green stuff) and brown stuff into the soil then cover with at least 8 inches of additional soil. Depending on soil temperature, and the amount of microorganisms in the soil the decomposition will occur in one month to a year.

Name: _____ **Date:**_____

Lets Start!

First it is necessary to draw your compost design.

Second list the selected materials that are going to be used by the group to make their compost bin.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Write down a procedure of how the group will set their compost bin step by step.

Step 1.

Step 2.

Step 3.

Step 4 .

Questions and Conclusions

List 4 advantage of composting

1. _____
2. _____
3. _____
4. _____

What not to compost? Why?

_____

_____

_____

What is the main element on the Brown and Green materials?

_____

_____

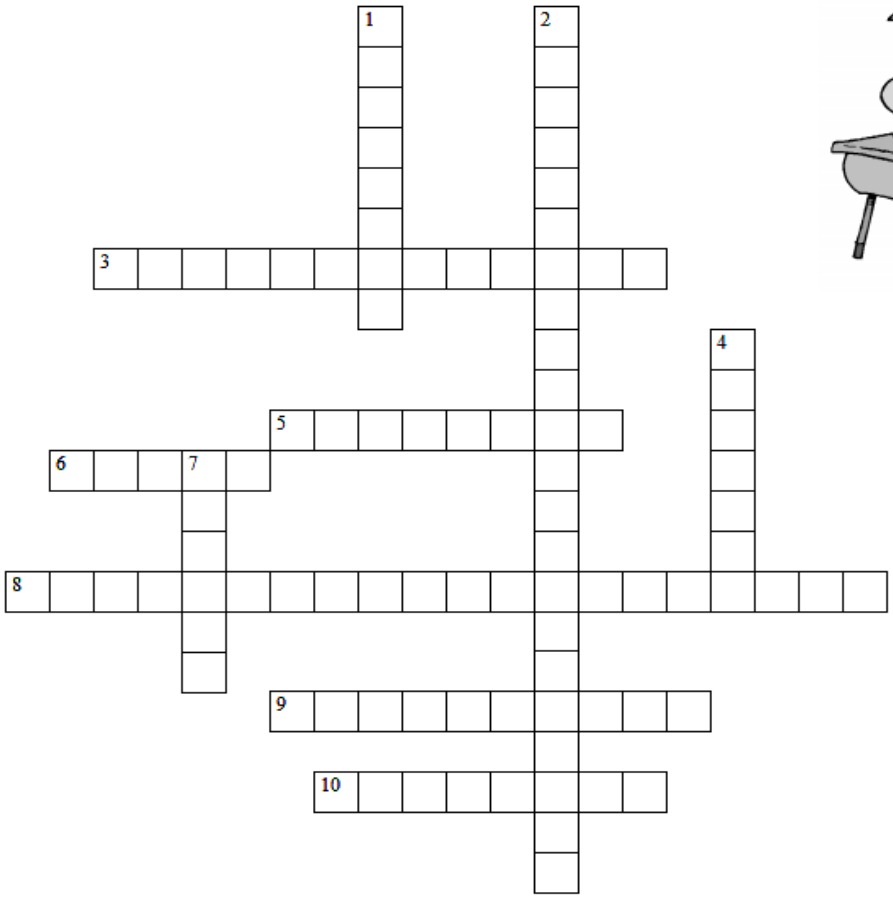
_____

Which of the following is not a composting system?

F. Trenching
G. Stationary Bin
H. Scavenging
I. All of the above

Name: _____ Date: _____

Green Material Compost Crossword Puzzle



ACROSS

3 Matter capable of being decomposed by biological agents, especially bacteria.

5 An odorless, almost inert diatomic gas, N2 that constitutes nearly four-fifths of the air by volume. Recycling / Process were useful materials are reuse or pass through a cycle for further treatment.

6 A protective covering of organic matter spread to reduce evaporation and soil erosion.

8 Process that requires oxygen to decompose organic matter.

9 A large number of natural and synthetic materials spread into soil to increase its capacity to support plant growth.

10 To supply air.

DOWN

1 Condensed liquid on the surfaces of objects.

2 Process that decompose organic matter with the absence of oxygen.

4 A mixture of decaying organic matter, used to improve soil and provide nutrients.

7 Natural, nonmetallic element that occurs in all organic compounds and can be found in all known forms of life.

Name: _____ Date: _____

Green Material Compost Word Scramble

Unscramble these words about Composting:

1. AAOENTRI _ _ _ _ _ _ _ _
2. ACBIAERT _ _ _ _ _ _ _ _
3. BUSG _ _ _ _ _
4. ONACBR _ _ _ _ _ _ _
5. OOCMPST _ _ _ _ _ _ _
6. CLCYE _ _ _ _ _
7. OOIMPINOSDTEC _ _ _ _ _ _ _ _ _ _ _ _ _
8. UNGIF _ _ _ _ _
9. ASG _ _ _
10. UOTSIERM _ _ _ _ _ _ _ _
11. MLUHC _ _ _ _ _
12. NINTGEOR _ _ _ _ _ _ _ _
13. LEPI _ _ _ _
14. SUERE _ _ _ _ _
15. LSOI _ _ _ _
16. TEMMRREOEH _ _ _ _ _ _ _ _ _ _
17. SUUHM _ _ _ _ _

Aeration / To supply air.
Aerobic decomposition / Process that requires oxygen to decompose organic matter.
Anaerobic decomposition / Process that decomposes organic matter with the absence of oxygen.
Biodegradable /Matter capable of being decomposed by biological agents, especially bacteria.
Carbon / Natural, nonmetallic element that occurs in all organic compounds and can be found in all known forms of life.
Compost / A mixture of decaying organic matter, used to improve soil and provide nutrients.
Fertilizer / A large number of natural and synthetic materials spread into soil to increase its capacity to support plant growth.
Moisture / Condensed liquid on the surfaces of objects.
Mulch / A protective covering of organic matter spread to reduce evaporation and soil erosion.
Nitrogen / An odorless gas that constitutes nearly four-fifths of the air by volume.
Recycling / A process were useful materials are reused or pass through a cycle for further treatment.

Properties of Building Materials

Introduction

Almost every building is passively heated to some extent, just not always when you need or even want a heated house. Heat from the sun penetrates the roof and the walls of the buildings and is stored in the materials that make up the roof or wall.

Purpose

The purpose of this experiment is to see which building materials absorb the most heat.

Materials

Styrofoam box
A variety of building materials, preferably of similar volume / size (e.g. dark colored house bricks, light colored house bricks, wood, limestone or similar rocks . . .)
Clear plastic sheeting, adhesive tape
Thermometers
Sunlight
Graph paper

Procedure

1. Place your group's building material in the Styrofoam box.
2. Carefully tape a thermometer inside the box so that it is not directly exposed to sunlight and is easily readable.
3. Cover the box with plastic sheeting.
4. Take your box outside and place it in direct sunlight.
5. Use a stop watch and record the temperature inside your box every 2 minutes for 20 minutes.
6. Graph your results when we get back inside.

DATA SHEET

The building material our group tested was _____										
Time										
Test Box Temp.										

Compare the results of all the groups by completing the following table:

Building Material	Initial Temperature	Final Temperature	Difference
Control Box			
Material _____			
Material _____			
Material _____			
Material _____			

Graph Your Results

Crafting Models of Efficiency

Green Houses vs. Non-green Houses

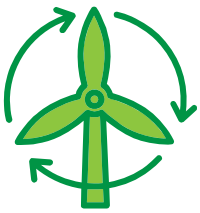
Purpose

The purpose of this experiment is to allow students to use their knowledge on energy to build energy-efficient and non-energy efficient model houses. The class will be divided in ½ and then put into smaller groups and be told which model to make. The models will then be taken outside and tested for "green-ness".

Materials

Each group should have the following in their kit:

1 solar panel
1 motor with fan blade
1 light bulb
1 battery
connection wires
paint
1 cardboard base to build on
different types of recycled cardboard and/or Styrofoam insulation
1 small window
glue
scissors
tape
thermometer



Procedure

1. Depending on which group you're in, build your model classroom. Be creative – there is no right or wrong way to build your model as long as it stands up in the end!
2. Once everyone is finished, we will take the models outside and test their efficiency.
3. Put your model in a sunny spot and see if the solar panel can power up the ceiling fan.

4. Wait 5 minutes and take the air temperature inside the model with the thermometer.
5. Record your results below.

DATA SHEET

1. What type of classroom did you build – Green or Non-green?

_____

2. What was the air temperature inside the classroom after 5 minutes in the sunlight? Remember to record the correct units.

_____

3. What was the air temperature outside in the sun?

_____

4. What color did you choose for your roof?

_____

Discussion & Conclusions

With the whole class, complete this table once we get back inside.

Type of Classroom	Roof Color	Type of Insulation	Outside Air Temperature	Inside Air Temperature	Average Inside Air Temp.
Green					
Non-Green					

What's In a Building?
A Lot of Trash!

The Garbage Bag Investigation

Purpose
The purpose of this experiment is to determine what we are throwing out, what we are recycling, and how much of each. We will also learn how we could reduce our waste and increase recycling.

Materials
One garbage bag full of trash per group
Gloves
Scale

Procedure
Complete this data sheet by examining your bag of trash. Make sure to put gloves on! Answer all the questions.

DATA SHEET

1. Measure the total weight of your garbage bag with the scale. Don't forget to include the proper units (pounds, ounces, grams or kilograms).

_____

2. What is the total weight of all the garbage bags of the class? We can add the weights up on the board.

_____

3. Look inside your garbage bag and complete the table below.

Type of Garbage	*What is it?*	*Is it recyclable?*
Plastic		
Glass		
Aluminum		
Paper		
Food Item		

Discussion & Conclusions

With the whole class, determine the total amount of recyclable things that were thrown away.

Think about what kinds of changes could be made at your school and home to reduce the amount of garbage and to reduce the amount of recyclable items that are being thrown away.

Name _____ Date _____

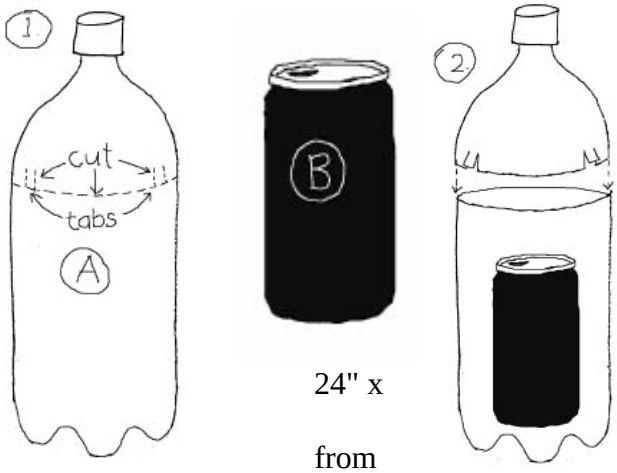
HEAT IT UP!!!

There are many essentials within any household that requires electricity. Whether you want to take a hot shower, cook supper, watch television, or blow dry hair each appliance or tool must be plugged up to an outlet and withdraw an electric current. **Water heating** is a thermodynamic process using an energy source to heat water above its initial temperature. Typical domestic uses of hot water are for cooking, cleaning, bathing, and space heating. In many countries the most common energy sources for heating water are fossil fuels: natural gas, liquefied petroleum gas, oil or sometimes solid fuels. These fuels may be consumed directly or by the use of electricity (which may derive from any of the above fuels or from nuclear or renewable sources). Alternative energy such as solar energy, heat pumps, hot water heat recycling, and sometimes geothermal heating, may also be used as available, usually in combination with backup systems supplied by gas, oil or electricity.

In some locales, solar powered water heaters are used. Their solar collectors are installed outside dwellings, typically on the roof or nearby. Nearly all models are the direct-gain type, consisting of flat panels in which water circulates. Other types may use dish or trough mirrors to concentrate sunlight on a collector tube filled with water, brine or other heat transfer fluid. A storage tank is placed indoors or out. Circulation is caused by natural convection or by a small electric pump. At night, or when insufficient sunlight is present, circulation through the panel can be stopped by closing a valve and/or stopping the circulating pump, to keep hot water in the storage tank from cooling. Depending on the local climate, freeze protection, as well as prevention of overheating, must be addressed in their design, installation, and operation.

TOOLS and EQUIPMENT:

- Scissors
- Knife
- Glue
- Thermometer*



MATERIALS:

- 1 or 2 liter clear plastic soda bottle.
- 12 oz. aluminum soda can
- Piece of corrugated cardboard 1/4" x 24" x 32"
- Aluminum foil or reflective plastic from inside chip bags, etc...

INSTRUCTIONS:

From a 1 or 2 liter clear plastic soda bottle (A) cut off the top, 1" below where it becomes straight.

Cut 4 tabs 1/2" wide x 1" long into the top (fig.1)

Paint a 12 oz. aluminum can (B) with black paint. It is also possible to coat the can with carbon black from a candle or wood fire.

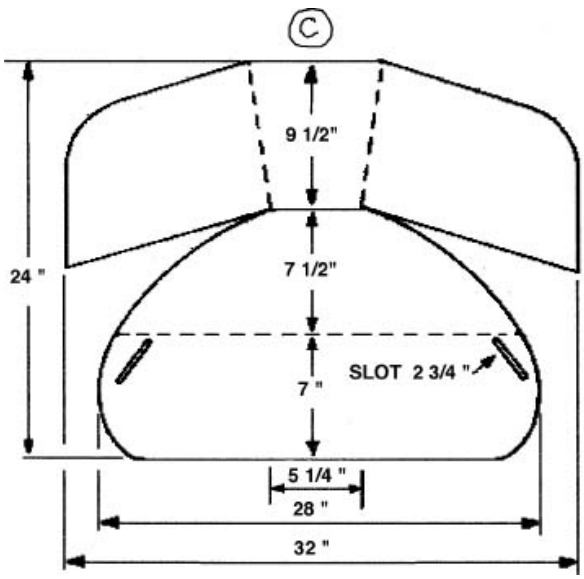
Put the can filled with water into the plastic bottle bottom and insert top with tabs folded out (fig.2).

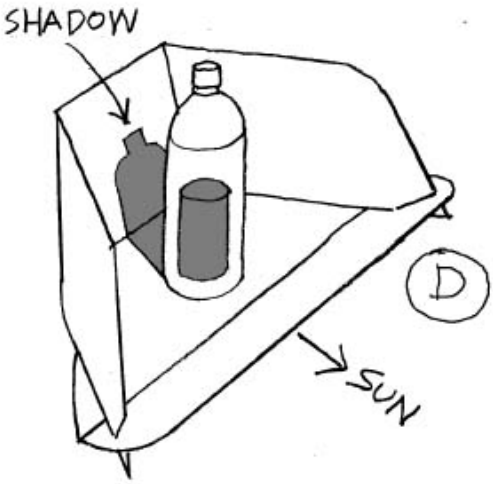
To make the reflector (C), start with a piece of corrugated cardboard 1/8" x 24" x 32".

Cover the cardboard with aluminum foil or potato chip bags with silver coating facing out (use wheat paste, glue or tape to adhere to cardboard).

Cut and fold cardboard as shown. Make slots a little too small and narrow so that tabs fit snuggly.

Place bottle on reflector (C) and place in sun. Keep bottle shadow centered on back of solar panel (D).





To pasteurize, water must be heated to 158 degrees F for at least 15 minutes.

Questions

1. What do we use water heating in our households? _____

   _____

   _____

2. What are some energy sources used for heating water?_____

   _____

   _____

3. What are some alternative sources? _____

_____

_____

4. Why is solar power better than electric? _____

_____

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