

**CLASS 2:  
AIR POLLUTION**

**I. Intro - Collect homework. Write our names on board.**

- A. There are handouts to go with this talk (attached).
- B. Note that we'll do a vocab exercise later and put words on board as we go along. (The underlined words in this outline are the vocabulary words.)

**II. PARTICULATE MATTER**

- A. Particulate matter comes from soots, dust, smoke. It's very easy to imagine this - it's like dirt in the air. It can even *be* dirt, like when farmers plow the soil so they can plant seeds, and some of the dirt floats into the air. It's tiny bits of solid materials released into the air and floating around. The bits can come from burning fuel, especially trucks and buses - I bet you've seen the black smoke that comes out of them sometimes. They can also come from burning garbage, building roads, bulldozing, mining, and burning wood (in a fireplace or outside).
- B. Particulate matter can cause eye, nose and throat irritation and can get into our lungs and cause permanent damage. Can lessen visibility (i.e. for pilots, for enjoyment of scenic views).

**III. OZONE**

- A. Ozone in the Atmosphere
  - 1. There are two different ozone problems, which causes some confusion. Depending on where in our atmosphere it is, ozone can be good or bad for us.
  - 2. Do you all know what the atmosphere is? It's the mass or body of gases surrounding the earth. (Draw a picture on the board.)
  - 3. There are different layers to our atmosphere that have different amount and types of gases. (Draw layers.) For example, as you may know, if you climb high up on a mountain, it is harder to breath because there is less oxygen there. Ozone plays different roles depending on which layer of the atmosphere it's in.
- B. Ground-level ozone
  - 1. In the lower atmosphere (shade in lowest layer of gases), called the troposphere (about 0-10 miles above the ground), ozone is the main ingredient of smog.

2. Smog is the dark, hazy, dirty-looking air that you sometimes see over a city, especially during the summer.
3. Effects of ozone in the troposphere
  - a. It can make our eyes itch, burn, and water. It can cause a stuffy nose, it can hurt our lungs, and it can give us a headache. It lowers our resistance to colds and pneumonia.
  - b. It damages plants, including food crops.
  - c. It can weaken some materials, like plastic, paint, and rubber. For example, have you ever noticed that a rubber band that's been left outside gets sort of hard and loses its elasticity?
4. Smog Formation
  - a. Ozone isn't what's actually given off by the cars and the factories, rather, other pollutants given off by cars and factories mix to form ozone. (Handout of smog formation.)
  - b. VOCs and NO<sub>x</sub>
    - 1) Two key pollutants are nitrogen oxides (we call them NO<sub>x</sub>) and volatile organic compounds (we call them VOCs). These compounds are emitted by cars, factories, chemicals used by dry cleaners and paint shops, and whenever gas or fuel are combusted. (Emitted means released into the atmosphere; the gas or compound emitted into the atmosphere is called an emission. Combustion is burning. When you drive a car, the engine burns, or combusts gas, which gives it the energy to make it go.)
    - 2) Power plants burn or combust fuel to provide us with energy to heat our homes and watch tv and turn on lights. The combustion or burning process gives off these emissions. VOCs also come from paint fumes and gas stations when you pump gas, and consumer products like charcoal starter fluid, plastic popcorn packaging, and hair spray.
  - c. VOCs and the NO<sub>x</sub> mix in the air, and the sun shines on them, heating them up. It all mixes up like soup and chemical reactions occur. The reactions form ozone. This process is a photochemical process, meaning that chemical changes are occurring as the energy of the sun acts on air pollutants.
  - d. Role of Weather

- 1) Weather plays an important role in the formation of smog. Wind blows the pollutants away from their sources and, while the pollutants are being blown along, they undergo the chemical reactions. Hours after the smog-forming pollutants have been released from their sources, smog may pollute the air miles away from the place where the smog-forming pollutants were released. Smog is worst when it settles over a city and there isn't enough wind to blow it away.
- 2) Temperature inversion makes smog the worse. This occurs when weather causes warm air to get trapped near the ground under a layer of heavy colder air instead of rising, and the winds are calm, so the pollutants remain in one place for a long time.

### C. Ozone in the Stratosphere - The Ozone Hole Problem

1. Good ozone is in the upper part of the atmosphere, in a layer called the stratosphere. (go back to board and shade in.)
2. There, high above the earth, the ozone forms a protective shield, preventing some of the sun's harmful rays from reaching the earth (ultraviolet B). These rays cause eye damage and skin cancer (sun burns), and may have harmful effects on animals as well as people (frog species have been disappearing).
3. Some pollutants make a hole in the ozone layer, allowing more of the ultraviolet B rays to reach the earth. (draw the protective shield with rays bouncing off)
4. The most important of these pollutants is chlorofluorocarbons or (CFCs). They are mainly used in refrigerators and air conditioners. They used to be used in aerosol sprays, CFCs are also produced during the manufacture of styrofoam cups.
5. This problem is a world-wide, international problem, since ozone holes are forming in a number of places around the world. To address the problem countries met together and signed a treaty called the Montreal Protocol, agreeing to phase-out the production and use of CFCs, or reduce their use over time. In the United States, we have adopted the Protocol and we now have provisions or sections of our Clean Air Act that specifically put the Montreal Protocol into effect in our country. So we are working on stopping producing these pollutants, and this treaty has been quite successful. (pass around shaving cream bottle that says "contains no CFCs")

#### IV. GLOBAL WARMING / CLIMATE CHANGE

- A. This is in the news an awful lot, and there's a lot of controversy about it. Everyone knows that there is something called the greenhouse effect. The greenhouse effect is the process by which heat-trapping gases warm the earth.
- B. Here's how the greenhouse effect works. There are lots of gases in the atmosphere. (Draw molecules of gases). Sunlight enters the atmosphere, some bounce off the atmosphere (off the molecules of gases), but many go through the atmosphere and hit the surface of the earth. When the sunlight hits the earth, it turns into infrared or heat rays. Some of the heat rays bounce back out into space, but heat-trapping gases, carbon dioxide, methane, water vapor, nitrous oxide, and CFCs trap some of the infrared rays, and they stay within the earth's atmosphere, increasing the temperature of the earth.
- C. The greenhouse effect is actually very important for us - it makes the Earth warm enough to support life, and without it, it would be cold on Earth. The problem is that many scientists now believe that humans are adding too many greenhouse gases / heat-trapping gases to the atmosphere, increasing the temperature and disrupting the climate and weather as we know it. (Climate is the average weather conditions on earth, taking into account how much it rains, average temperatures, and wind.)
- D. Some scientists believe that by continuing to add human-produced heat-trapping gases to the atmosphere, by the year 2100 (101 years from now), the average temperature will be over 5 degrees Fahrenheit warmer than it was in 1990. On the other hand, the scientists predict that if we reduce the amount of greenhouse gases we're adding to the atmosphere by 33 percent, temperatures will rise by less than 2 degrees F.
- E. Can you think of the reasons we worry about the earth warming up? (ski resorts, farming patterns, water rising). Some areas of the earth will become hotter and drier, causing droughts (not enough water) and making some areas that are now covered with grasses become deserts. Other regions might become wetter, and crop growing areas may shift north. Rainfall may increase in the tropics causing flooding and threatening coastal areas and islands.
- F. Addressing the Problem
1. The main pollutant that causes global warming is carbon dioxide, which is given off when we make energy. We have been emitting massive amounts of carbon dioxide into the Earth's atmosphere by combustion of fossil fuels (oil, coal, natural gas). Over 6 billion tons each year.
  2. Global warming has become a major international issue, and countries are trying to make international law to prevent or reduce this problem. They are working on an agreement that would set limits to the amount of carbon dioxide they can emit.

3. Another part of the solution will involve planting and preserving forests. Trees remove carbon dioxide from the atmosphere during photosynthesis - the process by which trees convert sunlight to energy they can use. So the more trees there are, the more carbon dioxide gets sucked up. All over the world people have been cutting down forests (deforestation), so there are fewer trees to take up carbon dioxide.

## V. ACID RAIN

- A. You've already learned a lot today, but now I will discuss the problem most relevant to the work we will do in the rest of our class - acid rain.
- B. I mentioned earlier a pollutant called NO<sub>x</sub>, nitrous oxide. This pollutant is part of the acid rain problem. The other pollutant which causes acid rain is called sulfur dioxide (SO<sub>2</sub>). The main source of SO<sub>2</sub> is power plants. SO<sub>2</sub> is produced when the power plants combust coal.
- C. Coal is burned and these pollutants are released from the smokestacks of the power plants. They react with the gases in the atmosphere and form various acidic compounds. These compounds can fall to the ground as dry particles, or mix with water in the air and fall as rain, snow or fog. (Acid rain handout)
- D. Most of the big coal burning plants are in the middle of the U.S., and the wind carries these pollutants to the northeast U.S. and Canada, where they fall to the earth as acid rain or snow.
- E. The rain falls on soils and the lakes and makes them acidic. Acid in lakes and streams can kill the fish.
- F. The acid can also strip soil of nutrients, reducing food for trees. Acid rain damages trees more directly as well, making them susceptible to damage (they turn brown - you can see it when you go hiking in the Adirondacks in New York, where I grew up - lots of the needles on the spruce trees are brown.)
- G. The nutrients and metals released by the acid from the soil, in addition to the acid itself, can be carried along by rain water or melting snow into the lakes and streams. These nutrients and metals can be toxic to fish as well.
- H. Acid rain can hurt peoples' lungs and cause respiratory problems.
- I. Also, acid air pollution can eat away stone buildings and statues. The dry acidic compounds fall on buildings and statues and make them dirty. (Show pictures of statues) It can also affect painted surfaces - in one storm in New England, readings as acidic as vinegar were reported. It was reported that rain falling on a car leached away the yellow in the green paint, leaving blue rain drop shaped spots on the car.)

- J. The Clean Air Act has sections designed to stop the acid rain problem in a number of ways, which will be discussed later on in future classes.

**VI. Chalk Demonstration**

- A. A team leader will bring a container of vinegar and a piece of chalk to each table.
- B. Statues and buildings slowly deteriorate as weak acid rain falls on them over time. If the stone is limestone or has limestone in it, the deterioration will be more rapid. Vinegar is an acid and chalk is limestone. This project demonstrates the effect of acid on limestone. Drop in the chalk and see what happens! (Discuss)

**VII. Overnight Acid Rain Demonstration [TIME PERMITTING]**

- A. Set up leaves, paper clips, and egg shells in water and in vinegar and cover tops. You will look at these tomorrow and write down your observations. Ask for predictions - what will happen to the objects? (Handout homework assignment)

**VIII. Vocabulary-Building Collage Project**

- A. Hand out one piece of posterboard, a pile of magazines, scissors, glue, and markers to each group. Give each group of a set of vocabulary words from the list below. The group makes a collage related to the terms on their list. At the end, two student representatives from each group present their group's poster to the class, explaining why they chose the pictures.
- B. Hand out the words (see attachment)