Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
1991 Volume VI: Global Change

Earth's Changing Atmosphere

Curriculum Unit 91.06.04
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The purpose of this unit is to investigate the Earth's changing atmosphere. The unit will deal primarily with the degassing of the planet, the atmosphere: past and present, how our atmosphere compares with other planets, the troposphere, the greenhouse effect and acid deposition.

It is my aim to provide students with information and hands-on experiences on the subject of global warming. The students will become aware of career related fields.

Included in the unit will be a description of the Earth's core, mantle and crust as it relates to degassing of the planet. A variety of biological and geological processes can result in the emission of gases from Earth's surface to the atmosphere. These emissions, which can have a major effect on atmospheric composition, appear to be different in both the types of species released and the rates at which they are emitted into the atmosphere.

Pollution and acid rain have always been an issue, but the war in the Persian Gulf reminded us of how devastating the problem is. The effect of this pollution as the result of the burning of the oil fields in Kuwait will be looked at.

This curriculum is designed as a challenge to Middle School students grades five through eight. The unit will include lesson plans, laboratory exercises, teacher and student resources, a reading list for students and teachers, field trips and a bibliography.

It is my hope that this unit will add dimension to the science curriculum and will be meaningful to both students and teachers. Teachers who teach history can also effectively utilize this unit.

The Formation of Planet Earth and the Other Inner and Outer Planets

Earth is a small habitable planet moving in orbit around a medium size star which is one of hundreds of billions of stars composing our galaxy. The formation of the Earth was the greatest global change.

Our star, born about 4.5 billion years ago, formed a Solar System to get rid of its angular momentum or spin. If Jupiter, as the largest planet in our Solar System, to be an unlit star, the concept of the binary star revolving system is a reality. The sun contains most of the mass, the planets do virtually all of the spinning and the planets are grouped into the inner planets; Mercury, Venus, Earth, and Mars, and the other planets: Jupiter, Saturn, Uranus, Neptune and Pluto, the outermost planet.

The space between mass and Jupiter is filled with debris that is the source of many meteorites hitting the Earth, the asteroid belt. Comets describe orbits which indicate supply from a zone at the fringe of the Solar System, the Oort belt.

The sun formed a disc of matter extended from its equator in a plane described by the present day orbits of the planets. Collision of small particles in the swirling and rotating disc made larger particles. Finally, several large bodies formed attracting the debris encountered in each swing around the sun.

The outer planets were so cold that the ubiquitous gases, hydrogen and helium, which make up the sun, condensed into large bodies. The inner planets did not trap these gases and formed early on as the rocky, jagged planets we see today. [1]

Each of the planets in our solar system has a different kind of atmosphere. Earth has a comparatively mild climate and a life-giving atmosphere of oxygen and nitrogen. The planets Jupiter and Saturn have cold, heavy poisonous atmospheres of hydrogen and methane gas. The planet Mercury has no atmosphere at all, while Venus is very hot under clouds of carbon dioxide.

The gas in an atmosphere is held to the planet's surface by gravity, that natural force or pull toward the center of the planet. The molecules of this gas are in constant motion. They bump into each other and bounce away repeatedly as if they were trying to get as far apart as possible.

Out in space between the planets, where there is very little gas, the molecules are so far apart that they bump into each other much less often. But close to the planet's surface, the pull of gravity packs them closely together into a useful atmosphere. The larger the planet, the more gas its gravity can hold. The high planet Jupiter has a strong force of gravity, which holds a deep, heavy atmosphere. The small planet Mercury has such a weak force of gravity that it could not keep the gas molecules from bouncing off into space. As a result, Mercury has no atmosphere.

The planet Mercury has lost its atmosphere because of its high temperature.

On warmer planets, those close to the sun, the bouncing gas molecules move faster and are likely to escape. On colder planets, those farther from the sun, the gas molecules moves more slowly and are more easily held by gravity.

Many scientists believe that our solar system was formed from a great cloud of dust and gas that contracted to form the sun, the planets, and their moons. The gas contained a large amount of hydrogen, with some helium, the two lightest gases in the universe. Also included was water vapor, ammonia, and methane. See figure 1.

(figure available in print form)

Because Jupiter and Saturn have strong gravities and are very cold, these high planets were probably able to hold most of these original gases in their atmospheres.

Mars, Venus and Earth with their weaker gravities and warmer climates, quickly lost the lighter gases, hydrogen and helium, into space. The heavier gases that remained were slowly changed, according to one theory, by the sun and chemical reactions. See figure 2.

(figure available in print form)

Ultraviolet radiation poured into the atmosphere. These strong radiations broke molecules of water (H2O) down into molecules of hydrogen (H) and oxygen (O). The hydrogen quickly escaped into space, leaving the heavier oxygen in the atmosphere to combine with the other gases and with the materials of Earth's crust.

This free oxygen (O) split apart the methane (CH4) molecules and then combined with the carbon (C) atoms to make carbon dioxide (CO2) and with the hydrogen (H) atoms to make water (H2O). See figure 3.

(figure available in print form)

The oxygen also split apart ammonia (NH3) and then combined with the hydrogen to make water, releasing the nitrogen (N) into the atmosphere. The methane and ammonia in the atmosphere of the small planets slowly changed, over billions of years, into carbon dioxide and nitrogen. More carbon dioxide and other gases were added to the atmosphere by erupting volcanoes. The free nitrogen slowly combined with minerals in the planet's crust, leaving only carbon dioxide as the major gas in the atmospheres.

When the free oxygen had used up all the methane and ammonia, a small amount of free oxygen accumulated. The ultraviolet rays from the sun changed it into ozone. Ozone then blocked most of the ultraviolet rays from penetrating into the lower atmosphere, just as it does today. With only a small amount of ultraviolet left to split water molecules into hydrogen and oxygen, very little more free oxygen was produced. The atmosphere became stable, remaining mostly carbon dioxide, with only a very small amount of oxygen and other gases.

Mars and Venus are believed to have atmospheres of these gases today. The atmosphere of Mars is very thin because of its weak force of gravity; that of Venus is much heaver because of its greater gravity. Because carbon dioxide holds heat in the atmosphere of Venus makes this planet very hot. [2]

Development of Earth's Atmosphere

The Earth's atmosphere began forming when volcanoes released gases just as they do now. These gases were held close to the Earth's surface by gravity. In addition, as the Earth formed by accretion, the energy of impact of each body released some of the volatiles including water and gaseous compounds of carbon and nitrogen. On heating and venting these chemical species made their way to the Earth's surface.

The Earth is the only one of the inner planets with a single large moon. The moon may have been formed by the major collision with the moon-forming body, which is about the size of Mars, soon after accretion and core formation changed all that. The volatiles at the surface and much at depth were lost by the energy of the collision. The atmosphere of the ocean and the atmosphere has been the result of degassing since then.

Other evidence for outgassing today is found in the ocean ridge systems where a unique isotope of helium, He-3, characteristic of the primitive Earth forming material, has been discovered venting into the ocean. Outgassing is also seen in the presence of radiogenic Ar-40, an isotope of argon which is the third most abundant gas in the atmosphere.

Because of the higher heat production in the Earth early in its history compared to the present, mantle convection has been slowing down. The rate of volatiles remain in the Earth's interior and it is getting harder and harder for them to get out. It is believed that the atmosphere and oceans must have been in place about 2.5 billion years ago. Some of the more reactive volatiles like carbon, water or the oxygen produced from the dissolutions of water and nitrogen may be returned to the mantle by the subjection process at plate boundaries. [3]

The growing ocean and atmosphere at first was composed of methane, water and nitrogen either ammonia or molecular nitrogen. The methane in the presence of water and sunlight would be transformed into carbon dioxide; water would be dissociated to hydrogen gas and oxygen gas. As hydrogen was lost from the planet, only hydrogen and helium are lost from the Earth's gravity field, the oxygen remaining was quickly used up to oxidize iron and sulfide as well as the methane. Thus, the oxygen level was always maintained low.

But the Earth's atmosphere, as we know, is oxygen and nitrogen, not carbon dioxide. The change in the Earth's atmosphere is that life caused it to change. The first living organisms probably developed in the oceans while the Earth's early atmosphere was changing from poisonous gases into carbon dioxide. These living things later developed into forms similar to today's algae, which are lower forms of plant life. These forms of life used the energy of visible light to break down water and carbon dioxide to produce food, by a process called photosynthesis releasing free oxygen as a waste product. Other organisms took nitrogen into the air. [4]

The Earth's oxygen-nitrogen atmosphere, thus, was built by countless billions of tiny living organisms over a very long period in the Earth's history. The arrival of the first photosynthetic organism, possibly around 3.9 billion years ago, resulted in the accelerated formation of oxygen. When the rate of production exceeded the rate of oxidation of iron and sulfide the oxygen began to accumulate earnestly in the atmosphere. This resulted in the development of an ozone shield around the world which diminished the ultraviolet rays reaching the Earth's surface. In this new oxygen-rich atmosphere protected from deadly high energy rays of the sun the eukaryote cell developed and the future of nonbacterial life on Earth was assured. This seems to have occurred about 1.4 billion years ago. [5]

The atmosphere since then has been maintained more or less, with its present mix of gases controlled by the life processes on the Earth's surface. See figure 4.

(figure available in print form)

The Structure of the Earth

The Earth itself provides the principal means by which we can solve the mystery of its internal structure. The heat reaching the surface of our planet from the interior is gravitational heat produced by radioactive decay of primary isotopes. The loss of this heat from the Earth's interior is principally effected not by conduction or radiation but by convection.

The interior of the Earth is composed of a central iron nickel core, mainly molten, surrounded by a mantle of crystallic silicates, composed of magnesium, iron and calcium as well as silicon for the most part. Every year a number of earthquakes occur in many different parts of the globe. Each of them releases suddenly a tremendous amount of energy. This energy travels from the focus, or source of the disturbance in the form of waves through all parts of the Earth, including the very deepest part. As a wave travels from one medium to the other its velocity may increase or decrease depending on the nature of the medium it leaves and the one it enters.

The two types of waves that penetrate deep in the Earth are P waves or Primary waves and S waves or Secondary waves. P waves travel through both solid and liquid parts of the earth's interior. S waves travel at about two thirds of the speed of P waves in solid regions and do not travel at all through fluid regions.

When the waves reach a boundary between layers of the earth, they may be reflected, passing upward toward the surface. They may be refracted, or bent, as they pass on to the next layer, as well as reflected. This means that they penetrate this layer, changing their direction. The waves that reach the Earth's crust are reflected downward again.

Because of the behavior of the type of rock making up the mantle, changes in density and changes in the way the materials reacts to deforming stresses the velocity of a seismic wave in the mantle with increasing depth. Thus, rays spreading spherically around an earthquake focus reach the surface ultimately at various distances depending on the path followed, because the Earth is spherical. As the rays descends deeper and deeper the medium is transmitting the seismic ray at a greater and greater velocity so it is bent more and more and eventually reaches a point where it intersects the surface. This happens to all the rays emitted in a sphere around the focus of the earthquake unless it encounters a medium in which the velocity is lower. The most deeply descending rays do encounter a discontinuity where the velocity decreases sharply and as a result of a shadow zone occurs at the surface where no record of the earthquake is present.

Based on the average density of the Earth and of rocks and iron-nickel metal and our knowledge of meteorites that this discontinuity is between the deep rock-like mantle with low density and high seismic velocity and the iron-nickel core with high density and low velocity. Also, we know the core is molten because shear waves do not make it through this medium but are transformed to weak compressional waves.

The Earth is cooling down because of the decrease in radioactivity over time by the radioactive decay of the long lived primary isotopes. The amount of heat produced within the Earth today is about half of that produced 4.5 billion years ago. Because of this decrease the pulse of the Earth is slowing and the processes driven by the escape of the Earth's internal heat are also slowing down.

Convection taken the form of the movement of deep, hot mantle towards the surface, cooling at the surface by conduction, radiation and volcanic action and return of cool mantle to depth just as in atmospheric circulation or in a beaker of water heating on a hot plate. Just as convection occurs in the mantle so also does it occur in the molten iron-nickel core. The energy for core convection comes from crystallization of the iron-nickel, chemical reaction at the core-mantle boundary and interactions with the magnetic field of the sun. [6]

The Troposphere

The troposphere is the layer of the atmosphere extending from Earth's surface to an altitude of 10 to 16 km. It contains the air we breathe. From it falls the water we drink. And through it passes the life producing energy of the sun. It is also the seat of weather and climate. Given the diversity of ecosystems on the Earth, it is likely that the natural troposphere is highly inhomogeneous in its chemical composition.

As the heat energy from sunlight travels through the atmosphere, only a small part of it is trapped by the atmosphere. Most of the heat energy is absorbed by the ground. The ground then warms the air above it. The warm, less dense air rises and is replaced by cooler, dense air. Currents of air that carry heat up into the atmosphere are produced. These air movements are called convection.

There is more water vapor and carbon dioxide in the troposphere than in any other layer. This fact is important because the two gases in question affect the heat balance of the Earth, particularly in the infrared radiation coming from the sun. Water vapor trap much of the infrared that is being reradiated from the sun heated ground. The troposphere, therefore, is heated by the ground as well as by the sun.

Temperature decreases with increasing altitude in the troposphere. The temperature of the troposphere drops about 6.5 degrees Celsius for every kilometer above the Earth's surface. But at an altitude of about 12 kilometers, the temperature seems to stop dropping.

Much of the solar radiation reaching the Earth is absorbed by the ground, air, clouds, water and ice. The rest is reflected back into space. Much of the short wave radiation from the sun and outer space-ultraviolet, X-rays and cosmic rays is absorbed or scattered in the upper atmosphere before it reaches the troposphere or the ground.

There is increasing evidence that the climate of the Earth is becoming warmer. For one thing, many of the glaciers and ice sheets in the mountains and polar regions seem to be melting away. An increase in the carbon dioxide contained in the atmosphere may be one factor, for this gas behaves as an insulator, retaining much of the sun's heat that reaches the earth.

The Greenhouse Effect

The greenhouse effect has to do with the sun's heat. But it rests on changes in the Earth's atmosphere, rather than changes in the sun. The sun's heat and light pass through the atmosphere. Changes in the atmosphere can affect them.

We live in a global greenhouse. Earth's atmosphere acts like the greenhouse roof. Heat and light from the sun pass freely through the atmosphere. Then it gives off heat in the form of infrared rays and holds the heat, rather than letting it escape into space. It reduces the change in temperature between day and night, summer and winter. The heat rays of the sun penetrate the air and warm the Earth's surface during the day. The overlying atmosphere traps this heat so that it escapes more slowly into space, moderating the cold of night. For this reason, the Earth is much warmer than it would be without the greenhouse effect of the atmosphere.

The Earth is surrounded by a blanket of invisible gases such as water vapor, and carbon dioxide that cause the atmosphere to act just like a greenhouse. The sun shines in, and the blanket of gases traps the heat keeping it close to the planet and keeping the surface of the planet warm.

A change in the amount of carbon dioxide would certainly affect Earth's climate. In fact it is possible that an increase is causing the present warming up of the climate.

Factories, electric power plants, and cars are producing carbon dioxide faster than it can be taken up by the oceans or plants. These added gases are, therefore, capable of trapping more and more of the sun's heat.

If the Earth's temperature gets hotter by just a few degrees, it could change the weather all over the planet in big ways. Places that grow most of our food could get too hot to grow crops anymore. [7]

The Ozone Layer

Up in the sky, above the air we breathe, there's a layer called the stratosphere. Ozone is produced in the stratosphere by the action of ultraviolet light on oxygen. It helps us by blocking out rays from the sun that can harm our skin, and by letting the rays that are good for us from unwanted amounts of radiation.

Now the ozone layers is being diminished at the poles by gases that people have made. The gases are called chloroflurocarbons or CFC's, and halons. They are used in refrigerators, fire extinguishers, air conditioners, plastic, and other things.

The CFC's are not easily destroyed in the troposphere and, therefore, make their way up to the stratosphere where the layer of ozone is and react to destroy the ozone. Scientists are concerned about the ozone layer, because a lot of it has gone away in just a few years.

Stability is what makes CFC's a threat. Chemicals which contain fluorine and chlorine may resist breakdown for decades. Eventually, they drift into the stratosphere, some 10 to 32 kilometers, or 6 to 20 miles above the Earth. There the sun's unfiltered ultraviolet rays destroy CFC molecules, releasing the chemicals chlorine atoms.

The release of chlorine, in turn, triggers a more threatening reaction. Chlorine atoms can catalyze the destruction of 100,000 molecules of ozone. If uncontrolled, it is predicted that CFC's could destroy a significant part of the vital ozone layer in a hundred years. For this reason we have virtually stopped production of the persistent CFC's.

At ground level, ozone is the major pollutant and health threat. But in the stratosphere, it protects us by absorbing the sun's ultraviolet rays. Unfiltered by ozone, those rays could seriously damage animals and plants. Without the ozone layer, life itself may not be possible. [8]

Air Pollution

Pollution can affect climate. As a result of air pollution, the atmosphere has more haze and more clouds than it once had. The large amount of condensation nuclei added to the atmosphere by smoke probably causes some of the haze and clouds. Water vapor and clouds can affect the climate of the Earth in different ways. Clouds reflect radiant heat from the sun back into space, producing a warmer climate.

Carbon dioxide in the atmosphere has an important effect upon climate. Radiant heat from the sun readily passes through the atmosphere on the way to the Earth's surface. When the Earth reradiates this heat back toward space, the carbon dioxide acts like the glass of a greenhouse to prevent the heat from escaping.

A small increase in the amount of carbon dioxide in the atmosphere could raise the Earth's temperature to melt the polar ice caps. The water released could raise the level of the oceans by as much as sixty feet, flooding many coastal areas. Billions of tons of carbon dioxide are produced by respiration in animals and by combustion of coal and oil each year. The carbon dioxide may stay in the atmosphere for several years before it is absorbed by ocean organisms or green plants and converted back into carbon compounds and oxygen.

The most common and widespread pollutants currently emitted by human activities are sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide, volatile organic compounds, particulates or tiny solid particles or liquid droplets, and lead. In addition, dozens of toxic chemicals are commonly found in the air surrounding urban areas.

Air pollution, damage to living organisms, and global climate change are complex and diverse problems. Yet they all share a common root called energy consumption. To slow damage to plants and animals and to avoid destructive climate, change will require fundamental changes in energy policy. [9]

Acid Deposition

Acidic fallout has become one of the damaging and controversial forms of air pollution in the industrialized world. Acid deposition are sulfur and nitrogen oxides released from electrical power plants, industrial boilers, mineral smelting plants, and motor vehicles that burn fossil fuels. Sulfur and nitrogen oxides combine with moisture in the atmosphere and return to earth as sulfuric and nitric acids.

A good example is the result of the Persian Gulf War. More than 500 Kuwait oil wells were on fire, spreading sulfureous gases and toxic particles over a vast region extending from Turkey in the north to Iran in the east. The air pollution has produced black rain, a vile greasy precipitation laden with sulfuric acid and petroleum compounds. Black rain has been reported in Adana, Turkey; in Baghdad, Iraq; and in Busheler, Iran. Environmentalists fear that the black rain could fall, affecting millions of people dependent on that food. [10]

The effects of acid fallout can be seen throughout ecosystems. Acid deposition damages leaf surfaces, preventing some tree species from retaining water. Acidic water can leach minerals such as calcium, magnesium, and potassium from leaves and from the soil, which can damage tree roots, block nutrient absorption and impair water transport making trees more susceptible to drought, insects and other sources of stress.

Acidified water itself can kill many of the fresh water fingerlings and larvae. That disrupts the food chain. In saltwater, nitrates from acid deposition can boost the nitrogen content of coastal estuaries, creating algae blooms that cause oxygen depletion and the suffocation of fish and other aquatic plants.

We are learning that pollutants in the atmosphere can be very damaging. Soot and smoke particles washed from the air by rain may blacken and discolor buildings. Sulfur oxides from the combustion of coal combine with rainwater to make sulfuric acid, which can peel paint, rust bridges, and slowly eat away stone monuments and stone buildings. Atmospheric pollutants can also harm crops and people.

Certain weather conditions can bottle up pollutants in a small area, with disastrous effects. In 1948 an atmospheric condition called a “temperature inversion” caused tragedy to Donora, Pennsylvania. The first air pollution episode in the United States. A layer of warm air slid into the valley between the cool air on the ground and the cold air above. Cooler air above, could not rise into the layer of warm air, but instead was trapped into the valley. Exhaust fumes, smoke and gases from autos, trains, steel mills, and other industries poured into the trapped air until they shut out the sun. People with respiratory diseases were struck down by the burning atmosphere. Before a wind blew away the inversion layer and cleared the air four days later, over one-third of the population became seriously ill, and twenty people died. [11]

Lesson Plan I

Experiment: Investigating the Warming of the Earth by Radiant Energy.

Problem: Are sand and water warmed equally by the sun?

Objective: The student will see how water and sand are affected by the sun.

Procedure: Obtain two identically shaped aluminum pie pans about 20 centimeters in diameter. In one pan place 500 grams of sand; in the other, place 500 milliliters of water. Then place a thermometer in each pan so that the thermometer bulbs are submerged to the same depth. Using two 100-watt electric light bulbs, suspend one bulb above each pan at a height of 15 centimeters from the top of the pan. Record the temperature of the sand and of the water in their respective pans. Then turn on the lamps and record the temperature readings taken at 5 minute intervals over a 30 minute time period. Analyze the data collected on the basis of the comparative study, draw a conclusion relating to the warming of sand and water at the beach on a sunny day.
Source: Allen, Dorothea, *Elementary Science Activities for Every Month of the School Year* , Parker Publishing Co., NY, 1981, p. 158.

Lesson Plan II

Air Pollution

Objective: The student will investigate air pollution and changes in the physical environment.

Activities:

1. Make as complete a list as you can of the factors that would affect daily or seasonal air pollution patterns in your community. Be sure to consider how human activity patterns change.
2. Study climatic information for your community. Predict which months and/or days of the year the worst air pollution conditions might occur in your community. Describe the weather conditions during these periods.
3. Prepare a more complete report describing the debate among scientists on whether or not air pollution is causing the earth to warm up or cool down. Tell what information they use to support their hypothesis.

a. Find articles and reports discussing how air pollution could affect daily, seasonal, or regional weather patterns. Report what you find to the class.

b. Read articles how carbon dioxide or particulates could affect global weather and climate. Report to the class.

Source: Young, Donald B., *Air Pollution, Foundational Approaches in Science* Teaching Curriculum Research and Development Group, 1986, p. 87.

Lesson Plan III

Problem: How much oxygen in the air?

Objective: The student will find out how much oxygen there is in a milk bottle full of air.

Background: Air composed approximately of one-fifth oxygen and four-fifths nitrogen, with traces of a few other gases. Experiments with convection currents prove that a flame must have a constant supply of air if it is to remain alight.

Materials: Candle, empty milk bottle, dish of water.

Procedure: Fill dish with water, light a stub of candle and carefully float it in the dish. When the flame has established itself and is burning steadily, cover it with the upturned milk bottle.
What do you observe? Write in your journal your own observation.

Conclusion: The candle will continue to burn for a few seconds because it has a small supply of oxygen available in the air now trapped inside the bottle. The flame will use this oxygen quite quickly and then be extinguished. At the same time, because the oxygen content of the bottle has been used, an area of low pressure will result. The outer air, pressing down upon the surface of the water in the dish in its endeavor to enter, will instead, force water up into the bottle, thus indicating the amount of the oxygen which has been used.

Lesson Plan IV

Greenhouse Effect

Objective: The student will make am plastic bag greenhouse.

Procedure: Place a clear plastic garment bag of the type used by dry cleaners over a house plant in a hanging planter. Gather the plastic around the top center to close the opening, and tape it to the hanger. Next, gather the plastic at the lower end, twisting it until a loose knot can be tied, thus closing the bottom end also. Hand the plant in an area of moderate heat and light to leave it over a weekend or school vacation period when no personal care can be given. Similarly cover plants in regular planters with plastic bags that can be taped and tied closed, thus fashioning for each an individual greenhouse. Plants treated in this manner thrive in their individual greenhouses until the vacation period is over.

Observation: Write in your journal your own observations of your greenhouses.

Lesson Plan V

Investigating Acid Rain

Objective: The student will observe that all rainwater will show acidity due to the chemical union of water with carbon dioxide in the atmosphere.

Procedure: During a rainstorm place a clean enamelware pan in an open area and collect some rainwater. Transfer the water collected to a clean glass jar. Then place a small sample of the rainwater in a dish or saucer and dip one end of a strip of blue litmus paper into the sample near its edge. Examine the color of the wet end of the litmus paper. Also observe the wetted end of a strip of red litmus paper, similar applied to another edge of the sample. A red color will indicate the presence of an acid; a blue color will indicate a base.

Record your observation:

ACID BASE
Enamelware

Glass Jar

Dish

Samples of rainwater collected from areas where smoke, smog, and other air pollutants such as gases containing oxides of sulfur and nitrogen are also present show a proportionately higher acid concentration. The more gases present unite chemically with the water, the more acid the rain.

Lesson Plan VI

Make Water Denser

Objective: The student will see how it is possible to increase the density of water and thereby improve its floating powers.

Procedure: Place a fresh egg in a jug of clean water and the egg will sink to the bottom. Stir salt into the jug of water, about an eggcupful of salt to half a pint of water. Replace the egg and this time it will float because you have increased the density of the water. If you have a block of ice, float this in the salt water and you will notice that more of the ice shows above the brine than when it floated in fresh water.

Observation: Write your observations in your journal for both fresh and salty waters.

Challenge: If you are a swimmer, you have noticed how much easier it is to semi in the sea; provided it is calm than in fresh water. Why should this be?

Lesson Plan VII

Carbon

Objective: The student will investigate what happens to carbon when it unites with other substances.

Materials: A candle and a piece of metal

Do This: Hold the metal or a can lid in the flame and it is soon covered with soot. Why?

Here's Why: The flame heats the wax of the candle, producing from it carbon, water and several other substances. When the candle burns undisturbed, the carbon unites with oxygen from the air, producing colorless carbon dioxide. But if the flame is cooled by the metal, much of the unburned carbon, which cannot unite with oxygen at a reduced temperature, is deposited in the metal as soot.

Notes

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1. Karl K. Turekian, *Seminar on Global Environmental Change* . "First, make an Earth," Lecture 2, Yale New Haven Teachers Institute, 1991.
2. Ibid., p. 3.

3. Ibid., p. 4.
4. Norman F. Smith, *The Atmosphere* . Stech-Vaugh Company, Austin, Texas, pp. 6-13.
5. Karl K. Turekian, *Seminar on Global Environmental Change* . "The Structure of the Earth," Class Lecture 7, Yale New Haven Teachers Institute, 1991.
6. Ibid., pp. 1-2.
7. Global Tomorrow Coalition, *The Global Ecology Handboo* k, "The Greenhouse Effect," Beacon Press, Boston, 1990, pp. 230-1.
8. Ibid., pp. 222-3.
9. Ibid., p. 221.
10. Harold Wilshire, *U.S. Geological Survey* , Doug Prose, KRTN, Associated Press. The Hartford Courant, "Toxic tangle," March 7, 1991, Section E1.
11. Global Tomorrow Coalition, *The Global Ecology Handbook* , "Acid Deposition," Beacon Press, Boston, 1990, p. 224.

Student Reading List

Robinson, W. Wright, *Incredible Facts About the Ocean: The Restless Blue Salt Water* , Dillion Press, Inc., 1986.

Smith, Normal F., *The Atmosphere* , Stech-Vaugh Company, Austin, Texas, 1975.

Stambler, Irvin, *Breath of Life: The Story of our Atmosphere* , G. P. Putnam, New York, 1963.

Teacher Resources

Our Global Greenhouse , April Koral. Watts, 1989. Describes the Greenhouse Effect in simple terms. Explores possible solutions and alternative energy sources. Contains four experiments that can be performed in the classroom to illustrate the impact of the Greenhouse on our environment.

The Future for the Environment . Mark Lambert. Wayland Ltd., 1986. A broad overview of such topics as overpopulation, pollution, animal extinction and the Greenhouse Effect. An excellent starting point with a helpful glossary.

Ozone , Kathlyn Gay. Watts, 1989. Gay teaches readers about ozone's links to explorers national and international efforts to save the ozone layer and suggests ways to preserve our earth for future generations. A final chapter list organizations readers can contact if

they want to join the fight.

Global Warming , Laurence Pringle. Areade Publishing, 1990.

Discusses the causes of Global Warming and the problems that arise because of it, as well as possible solutions which emphasize as possible solutions which emphasize a world-wide awareness of the threat.

Fifty Simple Things Kids Can Do to Save the Earth , The Earth Works Group, 1989. A resource of information encouraging children's involvement in making the world a better, healthier place.

Field Trips

New Haven: East Rock Park—647 acres of natural beauty on a rock 359 feet high which overlooks the entire city of New haven. Picnic facilities—free.

West Rock Nature Center—Wintergreen Avenue, West Rock Park, zoo, nature house, 40 acres of trails, ponds and picnic area; historic Judges Cave.

Yale University Peabody Museum of Natural History—Whitney Avenue and Sachem Street, geologic and biologic displays.

Rocky Hill: Dinosaur State Park, West Street, Rocky Hill, CT 06067.

Groton: Project Oceanology, Avery Point, Groton, CT 06340, 445-9007.

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