The Air Out There:
What Direction Will Air Quality Take in Houston in the 21st Century?

Christine Johnson
Waltrip High School

INTRODUCTION

"The Air Out There" has been designed for my Advanced Placement Environmental Science course being offered for the first time in the fall of 2009. The Houston Teachers Institute seminar topic, "Health Issues in the 21st Century," is the context for this course. Multi-disciplinary research on the human impact on the environment and subsequent consequences to health is readily available via the Internet. Students enrolled in the AP Environmental Science course will be expected to learn major sources of atmospheric pollutants on a global, national, and local level. This unit will focus on those pollutants present in Houston air that are directly caused by human activities or natural ones that are magnified by human activities.

Why should high school students be concerned about the air they breathe when they have so many competing concerns in their lives? Making concepts like air pollution and health topics worthy of their attention is a difficult task that needs a well thought out instructional plan. Merely discussing potential health effects resulting from compromised air quality does not register with their consciousness. Symptoms such as burning and irritated eyes, noses, and throats, difficulty breathing, an increase in reported cases of asthma, and aggravated heart and respiratory problems are simply not on their radar. Until students can make personal connections, they will remain unaware of these effects. My intent for this unit is to provide students with opportunities to discover these personal connections themselves.

OBJECTIVES

This curriculum unit will include standards for both science processes and science concepts as described by Texas Education Agency (TEA):

> **§112.66. Advanced Placement (AP) Environmental Science (One to One and One-Half Credits).**
>
> (a) General Requirements. Students can be awarded one to one and one-half credits for successful completion of this course. Recommended prerequisites: Algebra I, two years of high school laboratory science including one year of life science and one year of physical science.
>
> (b) Content Requirements. Content requirements for Advanced Placement (AP) Environmental Science are prescribed in the College Board Publication Advanced Placement Course Description: Environmental Science, published by The College Board. (TEA)

The following course description is provided by The College Board for an AP Environmental Science course; bold face print is added by this author to designate topics addressed in this unit:

> The goal of the AP Environmental Science course is to provide students with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems

both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them.

Environmental science is interdisciplinary; it embraces a wide variety of topics from different areas of study. Yet there are several major unifying constructs, or themes, that cut across the many topics included in the study of environmental science. The following themes provide a foundation for the structure of the AP Environmental Science course:

Science is a process.
- **Science is a method of learning more about the world.**
- **Science constantly changes the way we understand the world.**

Energy conversions underlie all ecological processes.
- Energy cannot be created; it must come from somewhere.
- As energy flows through systems, at each step more of it becomes unusable.

The Earth itself is one interconnected system.
- **Natural systems change over time and space.**
- **Biogeochemical systems vary in ability to recover from disturbances.**

Humans alter natural systems.
- Humans have had an impact on the environment for millions of years.
- **Technology and population growth have enabled humans to increase both the rate and scale of their impact on the environment.**

Environmental problems have a cultural and social context.
- **Understanding the role of cultural, social and economic factors is vital to the development of solutions.**

Human survival depends on developing practices that will achieve sustainable systems.
- A suitable combination of conservation and development is required.
- Management of common resources is essential.

RATIONALE

Background information for students is necessary so they will be able to see the big picture painted by the actions of governments, corporations, and individuals contributing to atmospheric pollution. This unit will begin with an introduction to the atmosphere. Students will be able to describe the composition, structure and function of Earth's atmosphere. They will research the contribution of solar energy and atmospheric gases to the world's climates and weather and will examine the processes involved in global climate change. The "Big Picture" will be completed when the students research primary and secondary atmospheric pollutants, examine the historic development of polluted air, identify the economics and politics of air pollution, and participate in a seminar pulling together the various stakeholders (industry, local, state, and federal governments; health departments; citizen groups; etc) in the issue.

UNIT BACKGROUND

When we try to pick out anything by itself, we find it
hitched to everything else in the universe.
John Muir

Earth's Atmosphere

This wise statement by environmentalist John Muir very much sums up the evolution of my curriculum unit. I should have been prepared for the never-ending connections between topics, concepts, and data in my unit. When I attended Sul Ross State University, I earned a B.S. and M.S. in Range Management after changing my major from Wildlife Management. I came to realize that you could not manage the animals if you didn't manage and preserve their environment. My degree plan required coursework in hydrology, soil genesis and classification,

population dynamics, agrostology, entomology, wildlife management, rangeland management, economic botany, and animal reproduction, for a few. I know connections. But I was still frustrated and stonewalled when I started writing this background unit because I kept "pulling strings" on the sweater—where to start? The problem of air quality is a holistic, complex, and integrated problem. Health issues are a result of poor air quality, all right, but why is the air quality poor? Well, is it poor because "people" are irresponsible and have their heads in the sand? Is it only human causes, or does nature have a hand in it? Why do people not recognize the impact of their actions on the environment? Are economic issues relevant?—of course. Are there opposing views from 'experts'?—most likely. Whom should the general public believe in wading through the controversies? Would a more educated citizenry help?—undeniably, yes. I concluded that the most efficient starting point for this unit is in the least controversial: the basic science of air. Although the 4+ billion years of atmospheric development is a bit much history to cover in this unit, students need at least a fundamental understanding of the major parts of the atmosphere and how these parts are woven together.

The earth's atmosphere is composed of gases found in layers above the planet's surface. We can thank gravity for, among many other things, holding our atmosphere close to us. The bottommost layer, the troposphere, is where the most important gaseous components of the atmosphere—namely, oxygen, nitrogen, carbon, water, and sulfur—interact with each other. This layer extends from ground level to about 10 miles above Earth's surface. Temperatures decrease with altitude and there is a large amount of vertical mixing of gases. The troposphere is a region where approximately 75% of the mass of the atmosphere is held. It is a thin layer of rising and falling air currents and winds. The troposphere is the generator of Earth's weather. Certain substances that enter this layer, including pollutants, can be chemically altered and returned to the surface by precipitation. Life occurs in this portion of the atmosphere. The boundary of the troposphere is the tropopause. From 10 miles to 40 miles above the surface, is the stratosphere. The percentages of the gaseous components of the stratosphere are similar to that of the troposphere with three exceptions. There is less matter in the stratosphere, and you'll find one thousand times less water vapor and one thousand times more ozone by volume. The most important component in this unit is ozone. This topic will be examined in more detail in a later section of this background unit. Temperatures increase with altitude in this layer due to the presence of ozone that absorbs radiation from the sun. Substances, including pollutants, in this layer may remain here a long time due to the lack of vertical mixing of the gases (Wright 510). All of the chemical reactions that we are concerned with in regards to atmospheric pollutants occur in our troposphere and stratosphere. The general characteristics of these layers are:

Troposphere	**Stratosphere**
Extent: Ground level to 10 miles (16 km)	Extent: 10 miles to 40 miles (16 km to 65 km)
Temperature normally decreases with altitude, down to -70 F (-59 C)	Temperature increases with altitude, up to +32 F (0 C)
Much vertical mixing, turbulent	Little vertical mixing, slow exchange of gases with troposphere, via diffusion
Substances entering may be washed back to Earth	Substances entering remain unless attacked by sunlight or other chemicals
All weather and climate take place here	Isolated from the troposphere by the tropopause

(Wright 511)

The manner in which solar energy is absorbed as it travels downward through the atmosphere accounts for the variations in temperatures between the four layers. Rising air warmed at the Earth's surface by sunlight and subsequently descending when its thermal energy is radiated back into space account for the vertical movement of matter in the atmosphere. A circulating flow results and is called convection.

Once substances have been placed in the atmosphere, there are processes that remove these materials from it. Four processes responsible for removing particles and chemicals that are the result of human activities are:

1) Sedimentation: gravity results in heavier particles settling back to Earth.

2) Rain out: various types of precipitation physically (condensation of water droplets on small pollutant particles) and chemically (carbon dioxide reacting with water vapor to produce carbonic acid, acid rain) "flush" material out of the atmosphere.

3) Oxidation: oxygen combines chemically with other substances (combining with sulfur dioxide, sulfuric acid is formed)

4) Photodissociation: radiation from the sun breaks down bonds between atoms (ozone, O_3, breaks down to O_2)

Atmospheric conditions that characterize a region of earth for a long period of time (seasons, years, decades) are called **climate**. Those conditions that remain for shorter periods of time (hours, days, weeks) are referred to as the **weather** (Botkin 498). An understanding of "normal" climate in a region is important when we begin to consider whether climate change is occurring.

What is meant when "climate change" is discussed? Warming and cooling trends lasting for a year or two seem to be the norm, globally. They generally do not last an extended period of time. It is when these trends are not reversed and last upwards of three decades that a designation of "climate change" is applied (Botkin 498).

According to the National Oceanic and Atmospheric Administration (NOAA), eleven of the years between 1995 and 2006 were among the twelve warmest since the mid-1800s. Other indicators of increase in global temperatures include the following: 1) phenological spring and autumn dates (when buds of specific plants in the Northern Hemisphere open and leaves change) have changed, 2) extreme heat stress events with unusually hot and humid summer days and nights have resulted in an increase of deaths among vulnerable populations, 3) sea levels have increased, accompanied by similar increases of glacial retreat, and 4) extreme weather events like severe rainstorms are occurring with greater frequency in certain regions (Raven 485).

Atmospheric Pollutants and Their Sources

The gases that comprise most of our atmosphere are nitrogen (78.08%), oxygen (20.95%), argon (0.93%) and carbon dioxide (0.04%). Any other materials, excluding water vapor, are called pollutants, and they include various gases and particles. Any gases, liquids or solids present in high enough concentrations to cause harm to living organisms or non-living materials are called air pollution. Although there are natural causes for air pollution, this unit will focus on those causes that are associated with densely populated areas.

Generally, air pollution is identified as either primary or secondary air pollutants. Primary pollutants, including carbon and nitrogen oxides, sulfur dioxide, and particulate matter, enter the atmosphere directly as clear air moves across the surface of the Earth and picks up material from human sources (such as auto exhaust and industrial by-products) and from natural sources (like dust storms, volcanic eruptions and particles from weather caused grassland and forest fires). Secondary pollutants are those that form from reactions of other substances that find their way into the atmosphere. Ozone and sulfur trioxide are examples of products of these reactions.

Major Classes of Air Pollutants:

Primary:

1. Particulate matter – (PM) found in both solid (dust) and liquid (mist) forms, can include soil particles, soot, heavy metals like lead, asbestos, salts, smoke, organic chemicals and sulfuric acid droplets. Particulates contribute to reduced visibility by scattering sunlight. These particles are classed according to size, PM-10, particulate matter less than 10 micrometers, and PM-2.5, particulate matter less than 2.5 micrometers.

2. Nitrogen oxides – (NO_x) are gases produced by reactions between nitrogen and oxygen present in the atmosphere in the presence of high temperatures. Nitrogen oxides are primary pollutants and inhibit plant growth, aggravate asthma, deplete ozone in the stratosphere, contribute to global warming, and corrode metals.

3. Volatile Organic Compounds – (VOC) are the result of solvent and gasoline evaporation; industrial emissions and incomplete combustion of fossil fuels.

4. Carbon Monoxide – (CO) is produced by incomplete fossil fuel combustion

5. Sulfur oxides – (SO_x) is formed when sulfur containing fossil fuels like coal are burned.

Secondary:

6. Ozone – (O_3) results from photochemical reactions between NO_x and VOC's in the stratosphere, preventing much of the solar UV radiation from reaching Earth's surface, a good thing for us. However, ozone in the troposphere is a man made pollutant and causes health problems. Ozone is formed in the stratosphere as a product of oxygen molecules reacting with lightning and the sun's UV radiation. It is broken down or degraded naturally and also when it reacts with certain man made pollutants that are able to find their way into the stratosphere. Chlorofluorocarbons (CFC's) are one of these molecules and react with ozone to break it down to molecular oxygen. When the reversible processes of creating and destroying ozone are in balance, the average concentrations of ozone in the atmosphere remains constant. It is when it is out of balance due to high concentrations of CFC's that we start to have problems. Earth needs ozone in the stratosphere to remain in higher concentrations in order to act as a barrier to harmful ultra violet radiation. The effects on health of UV radiation are discussed in the next section.

Impacts on Health

Every one of the primary and secondary air pollutants is capable of negatively affecting human health, especially the respiratory system. Their effects are exhibited in both acute and chronic forms. Acute forms are those that result in rapid damage or tissue destruction upon short exposures while chronic effects are those that accumulate over long periods of time causing gradual deterioration (Wright 556).

Acute effects generally occur in individuals who are already compromised in their circulatory and respiratory systems. This group includes the elderly and asthmatic. On the other hand, almost everyone residing in urban air pollution areas suffers from some chronic effect(s). Exposure over long periods to sulfur dioxide can lead to bronchitis; long term exposure to ozone caused inflammation and eventually fibrosis (scarring) of lung tissue, permanently reducing lung function (Wright 556). Adverse effects of a loss of stratospheric ozone include severe sunburn, skin and eye cancers, and cataracts. Humans are not the only animals adversely affected. During my work in Range Management in far West Texas, I observed that cattle, especially those with lighter skin and hair on the face, would develop cataracts and tumors around the eye area. Land animals are not the only organisms affected; aquatic organisms and plant species are also negatively impacted. Higher concentrations of ozone found in the stratosphere is a good thing, as

previously noted; however, when those concentrations decline, more UV radiation is able to penetrate to the surface of the Earth and the negative effects of that radiation become apparent.

Carbon monoxide reduces the blood's ability to carry O_2 by binding permanently with iron in the blood's hemoglobin, leading to heart disease. At medium concentrations, carbon monoxide causes headaches and fatigue. As the concentration increases, a person's reflexes slow and sleepiness occurs. At a certain higher level, carbon monoxide can cause death. Segments of the population at greater risk are pregnant women, infants, and people with compromised respiratory systems. A four-year study in seven U.S. cities—Chicago, Detroit, Houston, Los Angeles, Milwaukee, New York, and Philadelphia—linked carbon monoxide concentrations in the air to higher hospital admissions for congestive heart failure (Raven, 462). Exposure to NO_x is known to affect the immune system, resulting in lungs that are vulnerable to bacterial and viral infections. Airborne particulate material (PM) can lead to respiratory and cardiovascular disorders. Many of these chronic disorders can lead to Chronic Obstructive Pulmonary Disease (COPD), which is the fourth leading cause of death in the U.S. (Wright 556). The Environmental Defense Fund estimates that 360 people out of every million Americans develop cancer as a result of air toxins, although the cancer rate varies widely from region to region (Raven 462).

Overall, air pollution caused diseases and disorders are more frequent than most of our students are probably aware. Their research on the topic will be made more personally relevant during the third lesson of this unit.

Air Quality and Public Policy

By the mid 1960s, it had become apparent to the average citizen of the U.S. that the atmosphere's ability to naturally cleanse itself had been seriously eroded. Under pressure from citizen groups, Congress enacted the Clean Air Act (CCA) of 1970 which allows the Environmental Protection Agency (EPA) to set limits on certain air pollutants in the U.S. Individual states are able to pass more stringent standards, but not allowed to weaken the standards (Raven 465).

The EPA manages six air pollutants (lead, particulate matter, sulfur dioxide, carbon monoxide, nitrous oxides, and ozone) and established maximum acceptable concentrations of each. Some improvement has been shown. Lead concentrations in the atmosphere between 1970 and 2006 decreased by 98%, presumably due to the switch from leaded gasoline to unleaded. During the same period, sulfur dioxide emissions decreased by 55% at the same time that miles traveled nearly tripled in this country and energy consumption increased by 47% due to more vehicles on the road. This is most likely attributed to the development and usage of "super clean" vehicles producing lower emissions (Raven 465).

By 1997, it was evident that standards set by the CCA in 1970 and subsequent amendments (1977 and 1990) were not low enough in the case of ground-level ozone and particulate materials to protect U.S. citizens adequately. Standards for both were revised, resulting in an outcry from industries such as the Chemical Manufacturer's of America and the American Trucking Association on the grounds that the costs were prohibitive to business. However, the U.S. Supreme Court ruled that the EPA must set standards based on the health benefits to U.S. citizens, not on cost.

LESSON PLANS

Lesson 1 – Introduction to the Unit

Objectives:

1. Students will be able to diagram the layers of the Earth's atmosphere by examining changes in temperatures at different altitudes and constructing a labeled graph to represent the data.

2. Students will summarize the processes that result in the different layers of the atmosphere.

3. Students will differentiate between climate and weather and discuss criteria that may indicate climate change.

Materials:

Data table of Temperatures and Altitudes provided by the teacher, graph paper, textbook

Procedures:

Students will be given the Temperature and Altitude data table to graph. After their individual graphs are complete, they will examine the graphs to try to determine the approximate boundaries between the different layers of the atmosphere. They will indicate these boundaries on their graphs. At this point, they will go into groups of 3-4 and compare their graphs, discuss their boundary choices and come to a consensus for the group. They will post their agreed upon graphs on the board and all graphs for the class will be examined. Students will answer questions about the graphing activity: What were the criteria for identifying the boundaries between the layers?

Using their textbooks, students will read the appropriate sections discussing the processes in place that result in the different layers of the atmosphere and take notes in the Cornell method*. Students will answer additional questions about the graphing activity: Does the temperature increase or decrease with altitude for each layer? What is the approximate altitude and temperature range for each layer? What causes the temperatures to increase or decrease with altitude?

*Overview of Cornell method:

Success in any class, especially the sciences, depends on a student's ability to take concise, relevant, and organized notes. A good set of notes will allow a student to review class material outside of the classroom. Good notes are not a word for word record of everything the teacher said during class. Students who attempt this note taking style do not have the opportunity to process the information and look for the main ideas or concepts the teacher is emphasizing. In my classes, I encourage my students to practice and use the Cornell Method for taking notes. This method was developed in 1949 by Walter Pauk at Cornell University, to be used as a study guide for tests. Since then, it has been adopted by many major law schools, the AVID (Advancement Via Individual Determination) program, and many individual middle and secondary schools and teachers.

The idea is rather simple and most students have no problem understanding the system after a good demonstration and some practice. Their notes can be entered on notebook paper or on pre-printed templates the teacher has prepared. I give the students the template for the first three weeks and after that they use their own notebook paper. My instructions to the students for their own paper go like this:

> Make a fold, lengthwise on the left side about 2 inches from the edge of the paper. Make a similar fold, about 2 inches wide on the bottom of the page. Using a pencil or marker, draw a line on the bottom fold and on the side fold from the bottom fold to the top of the page. Write your name, the course name, and today's date at the top right hand corner. The first section, the largest, on the right side of the paper, should be titled "NOTES," the narrower left hand section is titled "KEY WORDS" or "MAIN IDEA," and the bottom section is titled "SUMMARY."

The "NOTES" section is where the student writes the day's notes, either from lecture, text, PowerPoint, video, or discussion. The notes can be in outline, bulleted, or paragraph form, but they should be sequential and as detailed as necessary. The "KEY WORD" section will be used

to record key words or phrases that allow the student to recall the "NOTES" section's main ideas. The last or third section, the "SUMMARY," is where the student will summarize the lesson in his/her own words. At this point I sometimes ask the students to pair up and compare their notes, looking for gaps or areas they can expand.

Using their textbooks, students will read the appropriate sections discussing climate, weather, and climate change (particularly global warming). They will take notes in the Cornell method. Using the notes they have taken, students will choose two of the "Thinking Maps"* graphic organizers to communicate information they deem "significant" to their understanding of the sections.

Overview of "Thinking Maps":

About ten years ago I had the opportunity to attend a workshop for training in a new (to me, anyway) method to help students organize their thoughts about a topic and get them down on paper. Thinking Maps give students a set of shared visual tools that are based on brain research and best practices. A set of eight learning tools, Thinking Maps are presented sequentially to students to introduce them to or enhance their skills in the following:

1. Circle Map – defining in context
2. Bubble Map – describing qualities
3. Double Bubble Map – comparing and contrasting
4. Tree Map – classifying
5. Brace Map – determining parts and subparts of a whole
6. Flow Map – sequencing
7. Multi-Flow Map – determining cause and effect
8. Bridge map – assessing analogies

Beginning in August, I introduce a couple of maps a week to my classes and post completed maps around the room so the students are surrounded by their visual representations of our class work. Early on, I use the maps for formative assessments only, but soon we're using them for summative also.

Assessment: Graphs, Questions, Thinking Maps

Lesson 2 – Atmospheric Pollutants

Objectives:

1) Students will collect, organize, and display information about the major classes of air pollutants.

2) Students will demonstrate their ability to conduct classroom and field labs, collecting observations and data, analyzing data, and communicating results.

3) Students will use Internet resources to determine the types of pollutants, amounts, and areas affected in Houston, Texas.

Materials: textbook, oversized paper for display, colored pencils, teacher directed web sites, large index cards, 1.5 inch square hole punch, 0.25 inch circle hole punch, clear packing tape, string, hand lens and/or microscope, sticky notes, Hubbard Scientific Air Pollution kit

Procedures:

Using their textbooks and Internet sources, students will research the major classes of atmospheric pollutants. They will take notes in the Cornell method. Using the notes they have taken, students will work in pairs to construct a display (maximum size is 11 x 17 inches) that creates a visual representation of the information they gathered. Students will use the rubric below to organize their display. Displays will be placed on the board for students to examine and

using “sticky” notes they will place comments and/or questions on the displays. Each group will take turns to address the “sticky” notes.

Assessment: Students will follow the criteria set in the following rubric:

Category	4	3	2	1
Content/Accuracy	At least 10 accurate facts are displayed on the poster.	7-9 accurate facts are displayed on the poster.	6-4 accurate facts are displayed on the poster.	Less than 4 accurate facts are displayed on the poster.
Graphics/Clarity	Graphics are all in focus and the content is easily viewed and identified 4 feet away.	Most graphics are in focus and the content easily viewed and identified from 4 feet away.	Most graphics are in focus and the content is easily viewed and identified from 3 feet away.	Many graphics are not clear or are too small.
Graphics/Relevance	All graphics are related to the topic and make it easier to understand. All borrowed graphics have a source citation.	All graphics are related to the topic and most make it easier to understand. All borrowed graphics have a source citation.	All graphics relate to the topic. Most borrowed graphics have a source citation.	Graphics do not relate to the topic OR several borrowed graphics do not have a source citation.
Labels	All items of importance on the display are clearly labeled with labels that can be read from at least 3 feet away.	Almost all items of importance on the display are clearly labeled with labels that can be read from at least 3 feet away.	Several items of importance on the display are clearly labeled with labels that can be read from at least 3 feet away.	Labels are too small to view OR no important items were labeled.
Use of Class Time	Used time well during class. Focused on getting the project done. Never distracted others.	Used time well during class. Usually focused on getting the project done and never distracted others.	Used some of the time well during class. There was some focus on getting the project done, but occasionally distracted others.	Did not use class time to focus on the project OR often distracted others.
Organization	The display is exceptionally attractive in terms of design, layout, and neatness.	The display is attractive in terms of design, layout and neatness.	The display is acceptably attractive though it may be a bit messy.	The display is distractingly messy or very poorly designed. It is not attractive.
Response	Students respond accurately to all comments and questions in a thorough and respectful manner.	Students respond to most questions and comments accurately and are respectful.	Students respond to most questions and comments, but some answers are inaccurate. They are respectful.	Students do not respond to all questions or comments OR are not respectful to those questioning.

*created using: Rubistar.4teachers.org

Students will conduct the following labs:

1) Particulate Matter Collection:

Students will acquire a large index card from their teacher.

Using the 1.5 inch square hole punch, punch a square in the center of the card.

Using the clear packing tape, cover the hole. One side will be sticky, the other side will not.

Punch a circular hole in the top of the card and tie a string, leaving 3-4 feet free.

Write your name, class period, location, description, and teachers' name on the card.

Choose a location to hang your monitoring card and hang the card so that it moves freely.

Each day, accessing the Internet, record the direction of the prevailing winds and the average wind speeds.

The card will remain in its location for four days.

Remove the card after four days.

Using a hand lens or microscope, observe the particulate material on the stick part of the card. Sketch the different shapes and sizes of matter and estimate percents for each shape and size.

Using the web site provided by your teacher, identify as many particulate types as possible. Write a short report detailing your findings, include sketches.

2) Demonstrating Air Pollution:

Students will conduct the laboratory investigation kit "Demonstrating Air Pollution" by Hubbard Scientific. Plants are used to illustrate how air pollution affects living things; in this case, a common pollutant, SO_2, (sulfur dioxide) is used. Squash and marigold seedlings were chosen because they respond differently to the pollutant and they are easily cultivated. There is a certain amount of preparation that needs to be done prior to the exposure to the pollutant, so some planning is necessary.

Students will use the Internet to investigate the types and concentrations of pollutants in Houston, Texas. They will also examine the areas of the city/county that are affected by each. This information is available from several sources. They will be working in groups of 3-4 and each group will be responsible for 1) a general report that covers the city/county and 2) a report that covers a portion of the city/county of their choosing, (for example, Northwest, Ship Channel, Pasadena, Southeast). The report will be at least 4 pages in length and include maps of their area and tables or graphs that the student groups found at various web sites.

Lesson 3 - Health Implications Resulting From Compromised Air Quality

Objective:

Students will research a disease or disorder caused by or aggravated by an atmospheric pollutant. They will present their findings in a written report.

Materials: Internet access

Procedures:

Students will be given a short survey to take home that addresses questions about the incidence of respiratory ailments that family members or family friends have experienced. This will allow the student to choose one disease or disorder to research that has an effect on someone they know, if not themselves. Classes will meet in the media lab for two class periods, the first to acquire information and the second period for writing the report. Criteria for the report will be given to the students at the beginning of the assignment.

Assessment: Written report.

Lesson 4 – Economics and Policies of Atmospheric Pollution

Objective:

Students will evaluate the positions of various stakeholders in the realm of the economic impact and governmental policies of atmospheric pollution in a closed forum.

Material: Readings on the various stakeholders' positions

Procedures:

Students will work in teams assigned to a chosen stakeholder group (groups include public health organization, different levels of governmental organizations, concerned citizen watch dog group, and a combined industry group). An effort will be made to have at least three members on each group. The members of each team will read and discuss the readings they have for their stakeholder group. Teams will work together to write a position statement that they will present during a class forum.

Teams will be chosen in random order to present their position statements. After each statement, other teams will discuss the position just presented and may propose questions to the presenting team. This will continue until each group has presented their position statements. At this time, students will be asked if anyone of them was persuaded by other presentations to change or alter their opinions.

Assessments:

Students will be given the criteria for the presentations when they are given their readings. Grades will consider their participation (particularly their respectful consideration of the other groups during the forum segment of the assignment) and the written position statement.

ANNOTATED BIBLIOGRAPHY

Works Cited

Botkin, Daniel B., and Edward A. Keller. *Environmental Science: Earth as a Living Planet*. Hoboken: John Wiley & Sons, 2007.
This textbook provides basic chapters on the Earth's resources including the atmosphere. In addition, chapters addressing pollution and impacts on living organisms and the environment are included.

Environmental Science Course Description. AP Central. 2009. College Board. March 15, 2009. <http://apcentral.collegeboard.com/apc/public/courses/teachers_corner/2128.html >.
Includes course descriptions discussed in the Objectives section of the unit.

Raven, Peter H., *Environment*. Hoboken, NJ: Johns Wiley & Sons, Inc., 2008.
This textbook provides basic chapters on the Earth's resources including the atmosphere. In addition, chapters addressing pollution and impacts on living organisms and the environment are included.

Wright, Richard T. *Environmental Science: Toward A Sustainable Future.* Upper Saddle River: Pearson/Prentice Hall, 2008.
This textbook provides basic chapters on the Earth's resources including the atmosphere. In addition, chapters addressing pollution and impacts on living organisms and the environment are included.

Supplemental Sources (Students and Teachers)

<http://www.k12science.org/curriculum/airproj/activitymap.html >.
This site contains a glossary and links to many related web sites, including the EPA's Air Quality Index charts.

<http://airnow.gov/index.cfm?action=airnow.fcsummary&stateid=51>.
This site allows easy access to atmospheric information provided by federal, state and local agencies.

<http://www.houstontx.gov/health/Environmental/airqualitypage.html>.
This site provides local information on its network of air quality monitoring instruments across the Houston and Harris County area.

< http://www.epa.gov/air/data/repsst.html?st~TX~Texas>.
Provided by the EPA has numerous reports and maps for the state of Texas, including emissions by county and site.

<http://www.tceq.state.tx.us/about/tceqhistory.html >.
The Texas Commission on Environmental Quality (TCEQ) provides air quality and ozone forecasts, maps of the current day's predictions, information about the state implementation plans, attainment status by region reports, and history of air pollution issues in the state.