Grades 6-8

Good

Moderate

Unhealthy for Sensitive Groups

Unhealthy

Very Unhealthy

Key Messages: Grades 6-8

AQI
AIR QUALITY INDEX

■ Breathing polluted air is unhealthy. For example, you might find it more difficult to breathe, you might cough or wheeze, or your chest might feel tight.

■ You can't always tell if the air is polluted by how it looks. The Air Quality Index, or AQI, can help.

■ Two main types of air pollution are ozone pollution and particle pollution.

■ The ozone we breathe at ground level is bad. But very high in the atmosphere (the stratosphere) is a natural layer of ozone that is good because it helps protect us from the sun's harmful ultraviolet rays. A rhyme that can help you remember this is: "Ozone: Good up high, bad nearby."

■ You can protect your health in three ways when the air is polluted:

1. Find out the air quality each day.

   • You can do this by checking the AQI (the Air Quality Index), just like checking the weather report. The AQI uses color-coded maps and health messages to tell you how clean or polluted the air is. For example, green means the air is clean. Red means the air is unhealthy for everyone.

   • You can always find the AQI on the Internet at a site called AIRNow at: www.airnow.gov. You also might hear about the AQI on TV during the weather forecast or on the radio, or you might see it on the weather page in the local newspaper.

2. If you're outside when you know the air is polluted, you can protect your health by taking it easier. It's important to exercise and be active to maintain good health. But when the air is polluted, you can reduce the time you spend exercising, walk instead of run, take frequent breaks, or go outside at another time or on another day when the air is cleaner.

3. If you notice any symptoms when you're outside like coughing, pain when you take a deep breath, chest tightness, or wheezing, stop your activity and tell an adult. This is especially important if you have asthma.

■ Both people's activities (such as transportation, energy use, and materials production) and nature (such as forest fires and volcanic eruptions) can cause air pollution.

■ You can help reduce pollution. For example, turn off lights and equipment that use energy when you don't need them. Walk, bike, carpool, or use public transportation when possible instead of having someone drive you.

Lesson Plans

Symptoms Scenario

Learning Objectives

Students will:

- Identify some of the health symptoms associated with specific air pollutants (ozone and particle pollution).
- Identify preventive measures that people can take to protect their health.
- Understand which segments of the population are most at risk from air pollution.

Grade Level: Grades 6-8

Estimated Time: 2 hours

Background Summary

Breathing clean air is important to maintain our health. Millions of Americans live in areas where the air is sometimes considered unhealthy to breathe because it is polluted. One common air pollutant is ground-level ozone. The effects of ground-level ozone pollution are different than the effects of the ozone layer high up in the atmosphere, which helps protect us from receiving too much of the sun's ultraviolet radiation. At ground level, ozone can cause breathing difficulties, aggravate lung diseases, such as asthma, and may cause permanent lung damage. An easy way to remember the different types of ozone is: "Good up high, bad nearby." Ground-level ozone pollution is formed when certain pollutants, known as precursors, are released from vehicles, industries, and power plants, and in the presence of sunlight and heat react together to form ozone.

Another common air pollutant is particle pollution, which can cause breathing difficulties, aggravate heart disease as well as lung disease, and may cause chronic bronchitis or reduced lung function in children. Particle pollution consists of tiny particles of dust, dirt, smoke, and liquid droplets that contain chemicals.

In this lesson, students first read background materials about the health impacts of air pollution, followed by a teacher-led discussion. Students then role-play realistic case studies, as patients with health symptoms and their family members. The rest of the class interviews the patient and family members to try to determine which air pollutant may have caused the symptoms. The class then discusses what they can do to protect their health when air quality is poor.

Materials Needed

(one copy of each of the following materials is included in this lesson)

- Background Reading: What Are the Health Impacts of Air Pollution? (one for each student)

- Pollutants Chart: Sources and Effects of Air Pollutants (one for each student)

- Group Task Cards (one set for each of three groups; cut to card size before distributing)

- Symptoms Scenarios A, B, and C (a different scenario for each of the three groups)

- Student Worksheet #1: What Are the Health Impacts of Air Pollution? (one for each student)

- Student Worksheet #2: Which Pollutant? (one for each student)

- Teacher Answer Sheet #1: What Are the Health Impacts of Air Pollution?)

- Teacher Answer Sheet #2: Which Pollutant?

Key Questions

- Do you think that air pollution levels in your area could be high enough to affect people's health? If so, what might some sources of air pollution be in your area? (See Step 1 below.)

- What do you think some of the health effects are that people living in areas with high levels of air pollution might experience? (*Answer:* Ozone can cause breathing difficulties, aggravate lung diseases, and may cause lung damage. Particle pollution can cause breathing difficulties, aggravate heart disease or lung disease, and may result in chronic bronchitis or reduced lung function in children.)

Vocabulary

Ethical—Behavior considered good or right.

Susceptible—Vulnerable or predisposed to certain effects. A member of a population who is at risk of getting a disease or illness if exposed to something that causes the disease or illness.

Ozone pollution—Ozone is an air pollutant when near the Earth's surface. (In contrast, in the Earth's upper atmosphere, ozone protects people from receiving too much ultraviolet radiation from the sun.)

Particle pollution—Tiny particles of dust, dirt, smoke, and liquid droplets in the air.

Precursor—A compound that participates in a chemical reaction that produces another compound.

React—When two or more chemicals interact and form a new product.

Steps

1. If you haven't already done so, ask students if they think air pollution levels in your area could be high enough to affect people's health. If so, what might some sources of air pollution be? Hold a brief class discussion of their answers.

   (*Possible answers:* Cars and other vehicles, dust from construction sites, smokestacks from factories and power plants, yard burning, fireplaces and wood stoves. Also see the enclosed Pollutants Chart: Sources and Effects of Air Pollutants.)

2. Either as homework the night before or in-class, have students read Background Reading: What Are the Health Impacts of Air Pollution? and Pollutants Chart: Sources and Effects of Air Pollutants. Then have them complete Student Worksheet #1: What Are the Health Impacts of Air Pollution? Tell students to keep all three of these items for future use.

3. Hold a brief class discussion of the reading, chart, and students' Worksheet #1 responses. Discussion could include teacher prompts such as: Did you know about the health effects of air pollution discussed in the Background Reading and the Pollutants Chart? Were you surprised at any of these health effects? Have you or anyone you've known experienced any of these effects?

4. Select 12 students and divide them into three groups of four students each for role-playing.

Distribute materials (below), some to the groups and others to the rest of the class, as indicated:

To the three groups of role-playing students:

- Symptoms Scenario (hand out Scenario A to one group, Scenario B to a second group, and Scenario C to the third group)

- Group Task Cards (after cutting them to size, give a full set of 4—Patient, Family Member (or Second Patient), Class Monitor, and Scribe—to each group)

  To the rest of the class:

- Student Worksheet #2: Which Pollutant? (one for each student)

- Background Reading, Pollutants Chart, and Student Worksheet #1 (previously distributed; provide to students who don't have these with them, if done as homework)

5. While the rest of the class is reviewing the materials distributed in Step 4, explain to students in the three role-playing groups that each member of their group will choose and assume a specific responsibility, as defined on the Group Task Cards, and will present their Scenario to the class.

   Explain that one "patient" and one "family member" (or, "second patient") from each group will introduce themselves to the class (acting skills welcome!) based on the information in their Symptoms Scenario. Another group member will act as class monitor, maintaining order during questions and answers; and another will act as scribe, writing answers on the board. Each of the cards describes the tasks in more detail.

6. Give the groups time to prepare (5 to 10 minutes), allowing them to briefly read and discuss their Symptoms Scenario and Group Task Cards amongst themselves to prepare for their presentations, while the rest of the class continues to review the materials distributed in Step 4 and proceeds with Step 7.

7. Tell students in the audience that they are going to be "doctors" trying to determine the pollutant most likely associated with or causing the symptoms presented. Tell them to listen carefully to each of the three presentations and make doctor's notes on Worksheet #2: Which Pollutant? as they listen. Tell them they will be asking the patient and family member in each group questions to help the class come up with answers.

8. Have the first group present its Symptoms Scenario to the class. Assist the group as needed.

9. After the presentation, tell the rest of the class to go ahead and ask "doctor" questions to try to determine possible causes of the symptoms. Tell them they can use their Student Worksheet #2: Which Pollutant?, the Pollutants Chart, and the background reading as guides. Have the presenters respond. Assist the class as needed in asking targeted questions to obtain pertinent information included in the Symptoms Scenarios.

   Each presenter should respond as best they can, based on their Scenario. Other members of their group (e.g., family member, class monitor, scribe) can help them answer questions.

10. At the beginning of this Step, give the role-playing groups the Pollutants Chart and Student Worksheet #2 so they have the same information as the rest of the class.

   After a reasonable amount of time questioning the Scenario presenter group, have the class as a whole (presenting group, other groups, and audience) together continue to try to determine the pollutant associated with or causing the symptoms, as well as identify health prevention measures, with teacher guidance—but don't tell students yet which pollutant it is or possible preventive measures.

   See Teacher Answer Sheet #2: Which Pollutant? for information on symptoms and other "hints" of information that might be shared with the class at this point.

   Discourage students from arriving at answers too quickly. Encourage questions about other aspects of the patient's life (e.g., cigarette smoking) that could also be an influence. Inform students that even when air pollution is a primary factor, many other factors can still influence our health.

11. Have students write down their answers on Student Worksheet #2: Which Pollutants?

12. Using Teacher Answer Sheet #2: Which Pollutants?, share and discuss the answers with the class, including the pollutant most likely associated with or responsible for each group's symptoms/illness, and precautions that people can take to protect their health.

13. Repeat Steps 8 through 12 with each of the other two groups.

Adaptation

If time is limited, have only one or two groups make presentations. (Note: Two groups, one group illustrating ozone symptoms and a second group illustrating particle pollution symptoms, is preferable.)

For Further Exploration

1. Imagine that you and a friend started working out and running together a few weeks ago, meeting each day at 5:00 p.m. Today your friend proposes trying a new jogging route. One possibility is at a large park on the outskirts of town, and another is along a major highway. Explain which route you prefer and why.

   Answer: The park would be preferable. This would help avoid exposure to high levels of air pollutants, especially from motor vehicles.

2. Imagine that you have been training for a bicycle race, and the day of the race is here. The Air Quality Index (AQI) value for today in the area where the race is taking place is 215, based on ground-level ozone. One group of cyclists is asking the race committee to reschedule the race. Another group of cyclists is upset that the race may be rescheduled. Explain which group you agree with, and why the group requesting rescheduling might be asking for this change in plans.

   Tell students to look at the AQI chart in the Background Reading material, What Are the Health Impacts of Air Pollution? to help them make a decision about the bike race.

   Answer: Many athletes would probably want the race to be rescheduled so they could avoid strenuous exercise when the AQI has reached a value of 215, which is considered "Very Unhealthy"—see the AQI chart in the Background Reading material, What are the Health Impacts of Air Pollution? According to the AQI chart, "health alerts" begin at an AQI value of 201, up to 300. At this level, the chart tells us that "everyone may experience more serious health effects." EPA guidelines for the "Very Unhealthy" AQI category for ground-level ozone suggest that "active children and adults, and people with lung disease such as asthma, should avoid all outside physical activities. Everyone else, especially children, should significantly cut back on outside physical activities."

Acknowledgments/Resources

National Science Education Standards

Science as Inquiry
Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
Personal Health

Background Reading: What are the Health Impacts of Air Pollution?

Air Pollution and Our Health

Every minute of every day, we breathe six to ten liters of air. If the air carries unhealthy levels of pollutants, those pollutants can enter our bodies and affect us in many ways. Millions of Americans live where the air is often unhealthy to breathe. Enough people are affected so that the health impacts of air pollution costs us millions of dollars every year.

Air pollution is especially harmful to the very young and old. Infants and children are at risk because their lungs are not fully developed until they are about 18 years old and because they breathe faster. The elderly are at risk because they are more likely to have undiagnosed heart or lung disease.

Since the respiratory system comes in direct contact with the air we breathe, it is the body system most likely to be affected by air pollutants. People who already have asthma, emphysema, or other respiratory conditions, as well as people with heart or other circulatory problems, are especially susceptible to the effects of air pollution.

Even healthy people can be affected by air pollution. Air pollution can affect anyone. Healthy teenagers, young adults, and strong athletes can suffer negative effects from high pollution levels, especially when exercising outdoors.

A Tricky Question

It's a real challenge for scientists to study the health effects of different air pollutants. It wouldn't be ethical for researchers to put people in a lab and expose them to high levels of a pollutant. Also, outside the lab, people who live in heavily polluted areas are exposed to not just one pollutant but to many pollutants. And, the concentration of each pollutant changes during the day. All of this makes it difficult to separate out the effects of each pollutant.

In addition, how susceptible people are to the effects of air pollutants can vary widely. Think about a roomful of healthy people who are all exposed to the same cold virus. Some will develop a bad cold, others a mild cold, and others no cold at all. In a similar way, susceptibility to pollutants can vary greatly even among a group of healthy individuals.

Finally, there are always many influences on our health. If you develop symptoms that might be caused by air pollution, it's often difficult to be sure that pollution was "the"

cause. Just as with other health problems, there are likely to be several factors affecting your health.

How Much Do We Know?

One way to study the relationship between air pollution and health is to compare hospital records and death records to pollutant levels. Researchers have found that during extreme air pollution events, hospital admissions for respiratory problems increase. Death rates also increase, especially among the elderly and those who already have circulatory or respiratory problems.

Another type of research involves evaluating the physiological effects of exposure to pollution. In general, we know that exposure to irritants in the air can cause inflammation and bronchioconstriction of the airways and reduce the effectiveness of bacteria-destroying white blood cells. Irritants can also increase production of mucous, which, although annoying, helps the cilia clear out the airways. Normally, the cilia of the epithelial cells in the airways make sweeping movements to keep the airways clean. The cilia move mucous, along with germs and dirt caught in the mucous, out of the respiratory tract. Air pollutants can irritate or kill the cells with cilia, so that the cilia's protective action slows down or even stops. This leaves sensitive tissues unprotected. Then microorganisms and bits of foreign matter in the air are more likely to remain in the lungs and can cause infections.

Although the part of our bodies most affected by air pollution is the respiratory system, the circulatory system can also be affected. Exposure to unhealthy levels of air pollutants can result in low oxygen levels in red blood cells, abnormal heart rhythms, and increased risks of blood clots and narrowing of blood vessels. These effects can lead to worsening of heart diseases such as heart failure and increased risks of heart attacks or strokes.

The *Pollutants Chart: Sources and Effects of Air Pollutants* summarizes the sources and health effects of two air pollutants: particle pollution and ground-level ozone. When we inhale particle pollution (dust, soot, dirt, and liquid droplets, which may or may not be visible), tiny bits of foreign matter can travel deep into the lungs where they become lodged in the alveoli, which are small balloon-like sacs in which oxygen exchange occurs. This is where carbon dioxide from the blood is exchanged for oxygen from the air. Some particles can be exhaled or moved out by the cilia; other particles may sink into underlying tissue or move into the blood stream. Health effects from particles range from coughing and aggravated asthma to chronic bronchitis and even premature death. For people with heart disease, exposure to particle pollution can cause serious problems in a short period of time—even heart attacks—with no warning signs.

Ozone pollution, which is invisible, can irritate the respiratory system, reduce lung function, inflame and damage the lining of the lungs and the cilia, and cause structural damage of the lungs. Ozone pollution can also reduce the number and functioning ability of bacteria-destroying white blood cells. Ozone pollution can aggravate asthma and increase people's susceptibility to respiratory illnesses like pneumonia and bronchitis. Symptoms to watch for when ozone is in the air include coughing, pain when taking a deep breath, and breathing difficulties, especially when active or exercising outdoors. But ozone damage can also occur without any noticeable signs. For some people, several months of repeated exposure to ozone can permanently damage the lungs.

It is important to know that ozone can have two very different effects, depending on where it is in the atmosphere. "Good" ozone occurs naturally high up in the atmosphere (the stratosphere), where it helps protect us from receiving too much of the sun's harmful ultraviolet rays. "Bad" ozone at ground level is air pollution, as we have been discussing, and can result in health and environmental problems. An easy way to remember the difference is: "Ozone: good up high, bad nearby."

The Air Quality Index (AQI)

The Air Quality Index (AQI) provides information about the current day's and the next day's air quality and includes descriptions of associated health effects. Ground-level ozone and particle pollution are two of the five pollutants for which the U.S. Environmental Protection Agency calculates an AQI. The AQI is like a yardstick that runs from 0 to 500. The higher the number, the greater the air pollution. The AQI has six color-coded categories ranging from "Good" to "Hazardous." Each category corresponds to a different level of health concern. The chart below lists the AQI categories, their corresponding colors and numerical values, and associated health concerns for each category.

(Source: *Students For Clean Air. Clean Air Program*, Pima County Department of Environmental Quality, Tucson, Arizona)

Air Quality Index (AQI)

The Air Quality Index (AQI)

AQI Category	Color	Numerical Value	Health Concerns
Good	Green	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	Yellow	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	Orange	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	Red	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	Purple	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	Maroon	>300	Health warnings of emergency conditions. The entire population is more likely to be affected.

More information about the AQI is available at www.airnow.gov

Pollutants Chart:
Sources and Effects of Pollutants

Pollutant	Sources	Possible Effects on Humans	Other Effects	Comments
Particle pollution (also called particulate matter, or PM)	• Dust • Motor vehicle exhaust • Factories • Burning of coal for power • Natural sources: forest fires, volcanoes	• Irritates nose & throat • Difficult or painful breathing • Coughing, chest tightness • Reduces lung function • Lowers resistance to respiratory infection • Aggravates asthma and existing lung & heart disease • Chronic bronchitis or reduced lung function in children (long-term exposure) • Premature death	• Reduces visibility • Discolors statues, buildings, painted surfaces • Interferes with photosynthesis, may damage crops • May alter climate	• 75% from motor vehicles • Usually refers to particles less than 10 (PM_{10}) or 2.5 ($PM_{2.5}$) microns 1 micron = 1/1,000,000 of a meter) Particle pollution is often worse in winter, and near busy roads or factories.
Ground-level Ozone (O_3)	• Formed when nitrogen oxides (NO_x) and volatile organic chemicals (VOCs) react in heat and sunlight • Sources of NO_x and VOCs include vehicle exhaust, industrial emissions, gasoline vapors, and chemical solvents.	• Coughing, wheezing, pain with deep breathing, shortness of breath • Nausea • Irritates respiratory system, chest tightness • Damages lung tissue • Reduces lung function • Aggravates existing lung diseases, including asthma • Structural changes (long-term exposure) • Premature death	• Deteriorates rubber, paint, some building materials • Damages fruits and seeds • Injures crops and trees • Affects whole ecosystems by altering wildlife habitat	Ozone pollution is often worse in warmer weather, in late afternoons and early evenings. Ozone is good up high in the upper atmosphere where it helps protect us from too much of the sun's harmful ultraviolet rays. Ozone is bad at ground level where it can result in health and environmental problems. Remember: "Ozone: good up high, bad nearby".

Symptoms Scenario A

Patient: Francisco (if man) or Francesca (if woman) Grijalva
Family Member: Jorge Grijalva (cousin)

Patient—_Use this information to introduce yourself and your family member to the class:_

My name is Francisco (or Francesca) Grijalva. I used to be a runner years ago. I stopped for a few years, but took it up again last year. Lately I've been feeling short of breath in the middle of my run. This is my cousin Jorge, who is also my roommate. He'll tell you that I'm a pretty serious runner.

Patient and Family Member—_Use this information to answer class questions about the patient:_

- 34 years old

- Lives and works in _____ [fill in name of nearby city or town]

- Works as a computer programmer

- Works with a small, independent company

- The office building he works in is well-ventilated

- Running is an important personal interest

- Other hobbies include hiking, bird-watching, and surfing the Net

- Smoked from age 14 to 16, but "I quit when I got smart enough to know better"

- Roommate smokes, but only outside, so Francisco is not breathing Jorge's smoke

- Ran pretty regularly from age 20 to around age 30

- Started running again last year, in December

- Ran in the early morning, about 6:00 to 6:30 a.m., all winter

- In April, started working an early schedule and running after work, around 2:00 pm

- Last winter, felt refreshed and really "up" after running, just like years ago

- Has been running very regularly and is confident he's in good shape

- Lately has been feeling short of breath halfway through a run

- He also notices that he seems to cough and needs to spit while running, which didn't happen before

- Has never had any lung or respiratory problems in the past

- Cousin Jorge will vouch that Francisco has been running as regularly as he says—five or six times a week, for over a year—so this can't be happening because he's in poor shape

Symptoms Scenario B

Patient: Chris Chapman
Family Member: Rose Chapman (his wife)

Patient—Use this information to introduce yourself:

My name is Chris Chapman. I have been having chest pain and chest tightness for the last two or three months. Since these problems don't seem to be going away, I went to see my doctor last week. She told me that I have arrhythmia, which is an irregular heartbeat. I had a minor heart attack when I was 56, but have felt pretty good since then.

Patient and Family Member—Use this information to answer class questions about the patient:

- Chris is 62 years old

- He retired early, at age 50

- Never smoked cigarettes or anything

- Used to work for the city as a technician installing and repairing traffic lights

- They live in the city of _____ [fill in nearby city] because they like living near their children and grandchildren

- Love kids

- Every Monday through Friday, ever since retiring, Chris volunteers as a school crossing guard at a busy intersection, helping kids get across the street

- He does this for an elementary school and a middle school, that start at two different times, so he's out there almost two hours early each morning and two hours each afternoon

- Likes to wear white shirts, even though they always look really dirty after doing the crossing guard work

- They live in an apartment near the same intersection

- Several factories are nearby

- His hobbies include bowling, going to grandchildren's soccer and softball games, babysitting for the youngest granddaughter, and staying in close touch with world news

- Not really into exercise or working out

- Rose and Chris take a walk around the neighborhood a couple of times each week, usually right after he finishes crossing guard duty

Symptoms Scenario C

Patient: Jerry Wolak
Second Patient: Dot Wolak

Patient: *Use this information to introduce yourselves:*

My name is Jerry Wolak and this is my wife Dot. We live in _____ [fill in nearby city or town]. We came back from our afternoon walk feeling just awful.

Patient and Second Patient: *Use this information to answer class questions about the patients:*

- He's 58 years old

- She's 48 years old

- They take a brisk walk together almost every day, in mid-afternoon

- Usually walk two miles, along a local canal, where it's quiet and there's no traffic

- Jerry's interests include cooking, woodworking, and fishing

- Dot's interests include painting and playing drums with a jazz band

- Today was a beautiful sunny day and the first really hot day of spring

- Today they took a different route than usual

- The traffic was backed up for several blocks on one road, and they were curious why, so they decided to turn up that road and see for themselves

- Ended up sitting by the road for an hour in the middle of the walk, talking with a friend who was stuck in the giant traffic jam

- Near the end of the walk, both Jerry and Dot started wheezing and coughing

- Dot was feeling some nausea

- Jerry felt like his asthma was acting up for the first time in years

Group Task Cards

GROUP TASK CARD

PATIENT

You will play the role of the primary character described on the Symptom Scenario card. Using information on the card, you will introduce yourself to the class and then answer questions from them. A member of your family will help you answer questions. After some time has passed, if you feel that there is important information on your Scenario card that has not been covered by the questions, you may decide to volunteer that information.

GROUP TASK CARD

FAMILY MEMBER (or SECOND PATIENT)

You will play the role of someone in the patient's family. The patient will introduce you to the class, using information on the Scenario card. You will then help the patient answer questions from the class. If questions are asked which are not answered on the Scenario card, you will consult with the patient about how to best answer the questions (in a way that would not alter the conclusion reached by the class).

GROUP TASK CARD

CLASS MONITOR

It is your responsibility to maintain order and designate whose turn it is to ask a question. Call on those with their hand raised so that they can ask questions one at a time and everyone can hear the answers. You will want to pace the questions so that the Scribe has time to write the answers on the board.

GROUP TASK CARD

SCRIBE

You are responsible for writing information on the board as the patient and his or her family member answer questions from the class. Making a list of this information will make it easier for the class to focus on what they know so far, choose good questions to ask next, and determine the pollutant that is associated with or causing the patient's symptoms.

Student Worksheet #1:
What are the Health Impacts of Air Pollution?

Name: _____

Complete this worksheet after reviewing *Background Reading: What Are the Health Impacts of Air Pollution?* and the *Pollutants Chart: Sources and Effects of Air Pollutants.*

Use the back of this page if more space is needed.

1. How much air do we breathe every minute?

2. Which body system is most likely to be affected by air pollutants?

3. Who is affected by air pollution?

4. Why is it difficult to determine the health effects of different air pollutants?

5. Briefly explain how researchers study the health impacts of air pollution.

6. Which system, besides the respiratory system, can be affected by air pollution?

7. Describe the health effects of particle pollution.

8. Describe the health effects of ground-level ozone.

Name: _____

Refer to the *Background Reading: What Are the Health Impacts of Air Pollution?* and the *Pollutants Chart: Sources and Effects of Air Pollutants* as needed as you try to determine the following information about the "patients" in each group. Enter your answers for each patient below during group presentations and afterwards during class question and answer sessions. You will be seeking information about:

- **Symptoms—**Note key symptoms or behaviors in the patient.

- **Pollutant most likely to be associated with or causing symptoms—** Note the pollutant most likely to be associated with or cause these symptoms.

- **Health Precautions—**Note precautions that could have been taken to prevent or decrease the likelihood of the problem arising.

1. Francisco (or Francesca) Grijalva (young adult runner)

Symptoms:

Pollutant most likely to be associated with or causing symptoms:

Health Precautions:

2. Chris Chapman (crossing guard)

Symptoms:

Pollutant most likely to be associated with or causing symptoms:

Health Precautions:

3. Jerry and Dot Wolak (middle-aged walkers)

Symptoms:

Pollutant most likely to be associated with or causing symptoms:

Health Precautions:

Teacher Answer Sheet #1:
What are the Health Impacts of Air Pollution?

[Instruct students to complete Worksheet #1 after reviewing the *Background Reading: What Are the Health Impacts of Air Pollution?* and the *Pollutants Chart: Sources and Effects of Air Pollutants*]

1. How much air do we breathe every minute? *Answer:* 6 to 10 liters of air.

2. Which body system is most likely to be affected by air pollutants?

   Answer: Since the respiratory system comes in direct contact with the air we breathe, it is the body system most likely to be affected by air pollutants.

3. Who is affected by air pollution?

   Answer: Air pollution can affect anyone. People with lung disease (and heart disease, for particle pollution), children, adults who are active outdoors, and older adults are at greater risk from air pollution. But even healthy teenagers, young adults, and strong athletes can experience negative health effects from high levels of air pollution, especially when exercising outdoors.

4. Why is it difficult to determine the health effects of different air pollutants?

   Answer: First, it would not be ethical for researchers to put people in a lab and expose them to high levels of a pollutant. Second, people who live in heavily polluted areas often are exposed to more than one pollutant. In addition, the concentration of each pollutant changes during the day. All of this makes it difficult to separate out the effects of each pollutant. Also, some people are more susceptible to the effects of air pollutants than other people.

5. Briefly explain how researchers study the health impacts of air pollution.

   Answer: One way to study the relationship between air pollution and health is to compare hospital records and death records to pollutant levels. Researchers have found that during extreme air pollution events, hospital admissions for respiratory problems increase. Death rates also increase, especially among the elderly and those who already have circulatory or respiratory problems.

6. Which system, besides the respiratory system, can be affected by air pollution?

   Answer: The circulatory system.

7. Describe the health effects of particle pollution and ground-level ozone.

   Answer:

   When we inhale particle pollution, tiny particles get deep into the lungs.
   Particle pollution can:

   - Irritate the eyes, nose, and throat
   - Produce coughing and phlegm
   - Result in chest tightness and breathing difficulties
   - Aggravate lung disease (including asthma) or heart disease
   - Reduce lung function in children (long-term exposure)
   - Cause chronic bronchitis (long-term exposure)
   - Result in premature death

   When we inhale ozone, we may experience:

   - Coughing, wheezing, shortness of breath
   - Throat irritation, chest tightness
   - Pain with deep breathing
   - Reduced lung function
   - Aggravated lung disease, including asthma
   - Structural changes of the lungs (long-term exposure)
   - Premature death

   Aggravation of heart or lung disease can lead to:

   From exposure to ozone–

   - Increased medication use
   - Increased school absences
   - More doctor visits

   From exposure to both particle pollution and ozone–

   - More symptoms of ill health
   - More emergency room visits
   - Increased hospital admissions
   - Increased number of deaths

Note: Instructions to students on Student Worksheet #2 are: Refer to the *Background Reading: What Are the Health Impacts of Air Pollution?* and the *Pollutants Chart: Sources and Effects of Air Pollutants* as needed as you try to determine the following information about the "patients" for each group. Enter your answers for each patient below during group presentations and afterwards during class question and answer sessions. You will be seeking information about:

• **Symptoms—**Note key symptoms or behaviors in the patient

• **Pollutant most likely associated with or causing symptoms—**Note the pollutant this is most likely to be associated with or causing these symptoms

• **Health Precautions—**Note precautions that could have been taken to prevent or decrease the likelihood of the problem arising

1. Symptoms Scenario A: Francisco (or Francesca) Grijalva (young adult runner)

Symptoms: Feeling short of breath, coughing and spitting while running, symptoms occurring during outdoor exercise on summer afternoons

Pollutant most likely associated with or causing symptoms: Ground-level ozone

Health Precautions: Exercise outdoors in the early morning before ozone levels begin to rise

Teacher Notes for Discussion of Symptoms Scenario A: Exposure to high ground-level ozone concentrations can affect even healthy teens and active adults. In this scenario, the time of day and time of year during which the problem occurs provide clues that ground-level ozone, rather than another pollutant, is likely to be responsible.

2. Symptoms Scenario B: Chris Chapman (crossing guard)

Symptoms: Chest pain and chest tightness, previous heart attack, white shirt gets dirty after crossing guard work

Pollutant most likely associated with or causing symptoms: Long exposure to high levels of air pollutants, especially particle pollution, from work installing traffic lights, working as a crossing guard, and taking walks in the area

Health Precautions: Check the AQI when particle pollution is "Unhealthy." Be sure to take walks on less busy roads with less traffic pollution. (And don't wear white shirts!)

Teacher Notes for Discussion of Symptoms Scenario B: The busy traffic intersection and the presence of several factories in the area are indications that high amounts of particle pollution may be present. Also, particle pollution can be high at any time of day or year, even early mornings, and in winter (while ozone is usually higher in the afternoons and evenings, in warmer weather.)

3. Symptoms Scenario C: Jerry and Dot Wolak (middle-aged walkers)

Symptoms: Wheezing and coughing, feeling queasy, asthma acting up

Pollutant most likely associated with causing symptoms: Ground-level ozone

Health Precautions: Avoid exercising along busy roads. Avoid exercising during the times of day when ozone levels are highest (which is late afternoon or early evening).

Teacher Notes for Discussion of Symptoms Scenario C: The time of day (mid-afternoon) and the fact that it's a warm, sunny day are clues that ozone is the problem, in addition to the actual physical symptoms. Even young, trained endurance athletes can suffer similar symptoms at unhealthy ozone levels.

Tracking Air Quality

Learning Objectives

Students will:
- Observe air quality changes and the impact of weather on air quality.
- Demonstrate data gathering and analysis skills and graphing skills.
- Apply techniques of comparison and critical thinking.

Grade Level: Grades 6–8

Estimated Time: 30 minutes – 1 hour per session (6 sessions, optional)

Background Summary

In this activity, students locate and study color-coded maps from the Internet showing air quality data for their area. By graphing the data from these maps and discussing the results, they learn how clean or polluted the air they breathe is, the extent of the ozone season in their area, and the relationship between weather and air pollution. While learning about air pollution, they build their research, graphing, and critical thinking skills.

Through this activity, they also become familiar with the Air Quality Index—a standard index for reporting daily air quality to the public. Students learn how the different colors of the AQI scale correspond to different levels of health concern. They also learn who may be affected at different levels of ozone pollution and particle pollution and what steps can be taken to protect health from air pollution.

Materials Needed

- Internet access
- Student Worksheets (included)
- Colored pencils/markers in black, green, yellow, orange, red, and purple

Key Questions

See questions posed in Activities 1 through 6.

Vocabulary

Ozone—A gas that occurs naturally in the Earth's upper atmosphere (stratosphere) and also at ground level. Ozone can be "good" or "bad" for people's health and the environment, depending on its location. High up in the atmosphere, ozone helps protect people from too much ultraviolet radiation from the sun.

Near the Earth's surface, ozone is an air pollutant that can result in breathing difficulties.

React—When two or more chemicals interact and form a new chemical.

Elevated—Increased in amount or degree.

Episode—Exceeding usual conditions.

Forecast—Predict in advance.

Particle pollution—Tiny particles of dust, dirt, smoke, and liquid droplets in the air.

General Directions

This activity has a number of variations, all of which involve accessing, observing, and gathering data from AQI color-coded air quality maps on the Internet. Students can be assigned an activity on their own, if they have individual access to the Internet. Or, they can work in teams; each team will need Internet access. If teams are used, the work can be divided in a number of ways. For example, each team can graph data for a different year (in which case three teams can be used) and then the teams can compare their data. Or, each team can focus on air quality data for a particular month in each of the three years. The team then can summarize the data for that month and note any trends.

Accessing and Navigating Air Quality Maps

1. Explain that students will research and graph daily changes in ground-level ozone levels for their geographic area. Inform students that the effects of ground-level ozone are different than those of the ozone layer high up in the atmosphere (the stratosphere). The ozone layer helps protect us

from too much ultraviolet radiation from the sun. In contrast, ground-level ozone is a pollutant that can result in breathing difficulties.

2. Provide students with copies of the graph of "Air Quality Versus Time" (Student Worksheet #1). (This graph has an "x" axis labeled "date" with a scale of 31 days and a "y" axis labeled "Air Quality Index" with a scale of 0 to 300. Note: The AQI scale actually runs to 500, a hazardous level that would trigger health warnings of emergency conditions, but pollution levels in the U.S. virtually never rise above 300.)

3. Have each student/team access the following Internet data:

   Air quality maps at: www.airnow.gov - Under "Local Air Quality Conditions and Forecasts" below the national map shown on the left, enter your state and click "Go." On the next screen, click on "Archives" on the left side under "National Overview," then:

a) Click on your geographic area on the map.

b) On the next screen, in the blue box near the top, make sure that for "Pollutant," "Ozone" is selected (the pollutant selected is in white and bold; the unselected pollutant is in dark blue and not bold). For "Map Area," select the available option that best describes your location. For "Map Date," have students select a hypothetical month, day, and year to be researched. For "Map Type," place check marks next to "8-hour AQI Loop" and also "8-Hour Peak AQI." (Make sure other selections are not checked.) Click on "Display Maps Below."

c) The first map displayed will be the "8-hour AQI Loop" and the second map will be the "8-Hour Peak AQI". The activities in this lesson will focus on these two maps: The first map, "Ozone – 8-hour AQI Loop," shows a "movie" of the progression of ozone pollution throughout the day; the second map, "8-Hour Peak AQI," shows the highest ozone reading for the day.

d) Return to the blue box at the top of the page and click on "Switch to Monthly Thumbnail Overview." The screen will display data for all days in the month/year previously selected. Click on another day in that month, and the same two types of maps as discussed above (3c) will be displayed for that day (if a third map at the bottom of the page appears, students should ignore it).

4. Ask students to observe the color-coded AQI scale to the right of the maps. Each color corresponds to a segment of the AQI scale. Ask students to use colored markers to mark these segments on the "y" axis of their Student Worksheet #1 graph as follows: green = 0 to 50; yellow = 51 to 100; orange = 101 to 150; red = 151 to 200; purple = 201 to 300. Have students label these segments as indicated in the key: good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy (alert).

5. Ask students to click on any of the colors displayed on the AQI scale to the right of the maps. This will take them to the Air Quality Guide for Ozone. Ask them to look at this guide and notice that the right-hand column has specific messages about how people can protect their health at each different level of ozone pollution.

6. Now students are ready to research and record data on their graphs. To do this, students will need to go back and forth between the two map pages: (1) the page that allows you to choose and view the different sets of maps for a particular day by selecting the desired pollutant, region, month, day, year, and map types and displaying the selected maps; and (2) the page which shows all maps for a single month.

Activity 1: Graph Ozone Levels for the Warm Months of the Year

Estimated Time: 1 hour *(or more depending on the number of students and the number of questions you ask them)*

Summary: At ground level, ozone forms when the chemicals nitrogen oxides (NO_x) and volatile organic compounds (VOC) react in the presence of heat and sunlight. Therefore, ground-level ozone pollution tends to form in warm weather. Each area's ozone season will be as long or as short as the number of warmer months. For this activity, students observe how ozone levels change over several consecutive months and record their observations on the graph "Air Quality Versus Time" (Student Worksheet #1). Students should have a separate graph for each month. If possible, ask students to gather data for all warmer months (i.e., months when temperatures tend to be consistently in the 70s or higher), as well as the cooler month just before and after the warm months. They can gather each month's data fairly quickly by observing the AIRNow Web page that displays all maps for that month (see Step 3 above under "Accessing and Navigating Air Quality Maps"). Though the maps are small, the colors can be observed reasonably well. If there is any question about what the colors are on the map, students can click on the map to observe it in a larger size. For each day of each month, ask students to record on their "Air Quality Versus Time" graph for that month the highest AQI color they see. For example, if they see the colors green, yellow, and orange on a map, they should record that day as "orange" by marking the highest AQI level on the "orange" segment of the "y" axis (i.e., all orange days are marked as "150" which is the highest AQI level for orange; all green days are marked as "50" which is the highest AQI level for green, etc.).

Now ask students to fill out the table "Total Number of Days Each Month with Elevated Ozone Levels" (Student Worksheet #2) to record the total number of days in each month with ozone levels that were green, yellow, orange, and red.

After preparing the graphs and table, students can be asked any or all of the following questions:

1. What was the first day for that year when ozone levels were elevated (i.e., yellow or higher)?

2. What was the last day for that year when ozone levels were elevated?

3. Which month had the most green days?

4. Which month had the most yellow days?

5. Which month had the most orange days?

6. Which month had the most red days?

7. Which month had the most purple days?

8. What was the longest ozone "episode"? In other words, what was the most number of days in a row that ozone was elevated in any of these months?

9. Which month of the year was the worst month for ozone (i.e., had the most days when ozone was higher than green)? Which was the next worse ozone month?

10. Rank the months according to how bad they were for ozone, starting with the worst month at the top and the best month at the bottom. Now think about how hot these months are. What do you notice about ozone levels in hotter months?

11. How many total days over all these months were ozone levels elevated (i.e., higher than green)?

12. What percentage of days over these months were ozone levels elevated?

13. Who are the people that must be careful when ozone is at an orange level ("Unhealthy for Sensitive Groups") or above? (Refer students to the health messages on the Air Quality Guide for Ozone which can be accessed by clicking on one of the AQI colors to the right of the maps students are using [see Step 5 above under "Accessing and Navigating Air Quality Maps"] or at: www.airnow.gov —search the Web site for "Air Quality Guide for Ozone." Note—The answer is: People with lung disease [such as asthma], and children and adults who are active outdoors.)

Activity 2: Compare Ozone Levels Over Three Years

Estimated Time: 30 minutes *(to answer the questions below after students have prepared the graphs and table as described under Activity 1)*

Ask students to create the graphs and table described under Activity 1 for three archived years of ozone data. For each of the questions under Activity 1, have students compare the answers for the three years to answer these additional questions:

1. Which year had the longest ozone season (i.e., the time period from the first day ozone was observed to the last day)?

2. When you ranked the months from worst to best based on number of days of elevated ozone, were the results the same for each year or different? Does there seem to be any pattern to when ozone levels are elevated in this area? How would you describe that pattern?

3. Children can be sensitive to ozone when it reaches orange levels (see Activity 1, Step 13). During what time period of the year might it be a good idea to check the AQI forecast regularly?

Activity 3: Graph and Compare Ozone Levels in One Region of the U.S. versus Another

Estimated Time: 20 minutes *(after students have prepared the graphs and table as described under Activity 1 for both regions)*

Summary: Different areas of the U.S. have significantly different ozone seasons depending on a number of factors, including climate, pollution sources, and regional transport of pollution away from one area and into another. For this activity, students will create the graphs and table as described under Activity 1 for the same year for two very different areas of the United States. They will answer the questions listed under Activity 1 for each area, and then compare the two areas by answering these additional questions. This will be most interesting if you pick an area that contrasts with your region. For example, if you live in an area where ozone is less often a problem (for example, the Northwest or Hawaii), have students compare that to areas with more frequently elevated ozone levels (such as California, the South and Southwest, and the Mid-Atlantic and Northeast states)—or vice versa. Once the graphs and table have been prepared, ask students to use the data to answer the following questions:

1. Which region has the longest ozone season? By how much do the two seasons differ? Do you think this is related to temperature in these areas?

2. Compare the total number of days in each region that ozone was elevated. How much worse was ozone pollution in one region versus the other?

3. Compare the length of the longest ozone episode in the two regions. Was the longest ozone episode in the region during the longest ozone season?

Activity 4: Graph and Compare Ozone Levels Over the Course of the Day

Estimated Time: 45 minutes

Summary: Ozone levels tend to be lowest in the morning, rise during the afternoon, and then decline later in the evening. This is because (1) temperature and sunlight catalyze the formation of ozone, and (2) the pollutants from human activities (such as transportation) that react to form ozone tend to increase during the day and early evening.

For this activity, students will hypothesize what they expect to observe about ozone levels over the course of a day based on an understanding of how ozone is formed. They will then observe actual ozone levels over the course of three days to test whether their hypothesis is correct. They will record their observations on the table called "Daily Air Quality for _____" (Student Worksheet #3). The rows of the table are marked off in 1-hour increments. The columns correspond to the ozone level (as indicated by the AQI color) for each day.

Start the activity by explaining that ozone at ground level is not emitted directly. Rather, it is formed when two types of pollutants (nitrogen oxides and volatile organic compounds) react in the presence of heat and sunlight. Explain that sources of nitrogen oxides and volatile organic compounds include cars, power plants, and chemical plants. Ask students: If ozone needs heat and sunlight to form, when during the day do you think ozone levels will be highest? Then ask them to record data, as described below, to test their hypothesis.

For this exercise, students should use ozone maps from an area of the U.S. that tends to have unhealthy ozone levels in warm months (California and the South are good choices). Ask students to go to the AIRNow Web page showing maps of one of these areas for July or August (see Step 3 above under "Accessing and Navigating Air Quality Maps"). From this month, ask them to click on a map that shows ozone at an orange or preferably red level. When they click on that map, they will go to the page that shows three larger maps of this area for that day. For this exercise, ask them to focus on the top map: Ozone: 8-Hour AQI Loop. This map loops through the ozone levels for that day in 20-minute increments. The date and time are shown at the bottom of the map. The animation is rapid, but tell students they can freeze the animation by clicking on the "escape" button on their keyboard. By doing so, they can record the highest AQI level (color) for each hour (i.e., 8 a.m., 9 a.m., etc.) starting with the earliest time ozone levels are provided and ending with the latest time. After they have recorded the ozone level, they will need to click the "back" key and then the "forward" key at the top of the

browser to start the animation again. After the students have filled out all the ozone levels for one day, they should pick another day that has red or orange levels and do the same thing. Then, they should repeat for a third day. At this point, they should have enough data to answer the following questions:

1. Of the three days, what was the earliest time that ozone was elevated (i.e., above green)?

2. Of the three days, what was the latest time that ozone was elevated?

3. For each day, what time of day was the ozone level the highest?

4. For each day, what time of day was ozone at the green level (i.e., not elevated)?

5. Based on these data, was your hypothesis about ozone correct?

6. When ozone levels are elevated, especially starting at an orange or red level, it's a good idea to take it easier when you're outside (so you don't breathe as much or as deeply). You can cut back on vigorous outdoor activities. If the air quality forecast predicts ozone pollution for a summer day, what time of day should you think about taking it easier?

Activity 5: Graph Real-Time Ozone Data for a Month During Ozone Season

Estimated Time: 20 minutes the first day, 5 minutes per day after that, and 20 minutes for discussion on the final day.

If school is in session in your area during the ozone season, students can track the actual ozone forecast and levels each school day for a month. They can compare the forecast data to the actual data to see how accurate the forecasts are. They can also track the peak temperature each day to see whether there is a correlation between ozone levels and temperature.

Each day, at the same time of day if possible, have students record the following data on the "Daily Ozone Forecast, Peak Ozone Level, and Daily Peak Temperature" table (Student Worksheet #4):

- Ozone forecast. Ask students to visit the AIRNow Web site at: www.airnow.gov . Ask them to record the day's forecast by going to the section "Local Air Quality Conditions and Forecasts" which is below the national map shown on the left, entering their state, clicking "Go," then clicking on the city/region of interest. This will bring them to a page that provides "Current Air Quality Conditions," "Today's Forecast" and "Tomorrow's Forecast" for the city. Students should record both forecasts (as available) for ozone on the Worksheet table.

- Yesterday's peak ozone level. Then ask students to record the peak ozone level for that city for the prior day. Students can access yesterday's peak level data for the area by beginning with the same page used to obtain forecast data (see above bullet), and clicking on "yesterday's summary" under the column "Current Air Quality Conditions" for "Ozone". They can then view and record the highest color AQI level for their city on that day.

- Yesterday's peak temperature. Ask students to record the peak temperature by going to www.wunderground.com then entering the city name and state in the box at the top of the page, and clicking on the icon just to the right of the box. This will take them to a page of data for that city. Ask them to scroll down the page to an area called "History & Almanac." In this box, for most cities, they will find yesterday's maximum temperature, which they should record on their tables. For cities for which yesterday's temperature is not provided, they can click on "Yesterday's Official Weather and Almanac" for nearby areas.

Once students have gathered a month's worth of data, they can answer the following questions:

1. For each day of the month, compare the forecast ozone level with the actual ozone AQI level. For how many days did the forecast accurately predict the day's ozone level? For how many days did the forecast predict that ozone levels would be higher than they were? For how many days did the forecast predict ozone levels would be lower than they were?

2. Calculate the average temperature for all days when the ozone level was green. Then calculate the average temperature for all days when the ozone level was yellow, for all days when the ozone level was orange, and for all days when the ozone level was red. What do you notice about temperature and ozone levels?

3. What ideas do you have for reducing ozone pollution during the day? (Possible answers include: drive less by walking, biking, carpooling, or using public transportation. Turn off lights and equipment when you aren't using them; conserving electricity means less pollution generated by power plants. Every little bit helps!)

Activity 6: Compare Ozone and Particle Pollution

Estimated Time: 30 to 60 minutes depending on how many months of data are gathered.

Summary: Particle pollution and ground-level ozone behave in very different ways. Ground-level ozone forms in warm weather and is generally highest in the afternoon and early evening. Particle pollution can be high at any time of year and any time of day. It can be particularly bad in winter during inversions, when warm air traps pollution in a location for a period of time. For this activity, students will gather data for levels of particle pollution throughout the year and compare these data with what they have observed for ozone in the earlier activities.

Tell students that they will access particle pollution data for an entire year. From the www.airnow.gov Web page, under "Local Air Quality Conditions and Forecasts" below the national map shown on the left, tell students to enter your state and click "Go." On the next screen, click on "Archives" on the left side under "National Overview," then click on your geographic area on the map. On the next screen, in the blue box near the top, make sure that for "Pollutant," **"Particles (PM2.5)"** is selected (the pollutant selected is in white and bold; the unselected pollutant is in dark blue and not bold). For "Map Area," select the available option that best describes your location. For "Map Date," select the month (January), day (1st), and year (2004) to be researched. For "Map Type," place check marks for "24-hour AQI Loop" and also "Daily 24-hour AQI (midnight to midnight)" (make sure other selections are not checked). Click on "Display Maps Below."

Have students review the first map on the page. Ask them what difference they observe between the particle pollution maps and the ozone maps. (*Answer:* Particle pollution readings are given as dots/circles whereas ozone maps have continuous bands of color). Explain that this is because particle pollution is more localized than ozone, so you can't predict as accurately that the particle levels between two areas where they are measured will be the same as at the measured locations.

Ask students to look at the second map on the page and record on the table "Frequency of Particle Pollution" (Student Worksheet #5) the number of locations (i.e., circles) that reported yellow AQI particle levels, orange particle levels, red, and purple particle levels for that day (January 1, 2004). Then tell them they are going to record the same information for each day of that month. They do this by returning to the blue box at the top of the page, and clicking on "Switch to Monthly Thumbnail Overview." The screen will display data for all days in the month/year previously selected. Click on the second day in that month, and the same two maps will be displayed for that day (students can ig-

nore a third map at the bottom of the page). Have students record the number of locations reporting yellow, orange, red, and purple particle levels from the second map onto their worksheet. Then have students record this information for each day in the month.

Next have students do this for all twelve months of the year, if possible (or have them record for four months in different seasons: e.g., January, April, July, and October). (Ideally students can be divided into several teams and each record data for one or two months to cover the whole year.) Then have students answer these questions:

1. Were there any months when particle pollution was never elevated above the green level?

2. Are there any times of year when particle pollution appears to be worse? How does this compare with ozone?

Explain that particle pollution affects health in a different way than ozone, so the advice given to protect your health when particle pollution is elevated is different than the advice given for ozone. Have students access the *Air Quality Guide for Particle Pollution* by clicking on the AQI colors to the right of the particle pollution maps. Ask:

1. Who is "sensitive" to particle pollution?

2. How does this differ from who is sensitive to ozone pollution?

3.   If you have asthma, at what AQI level should you consider taking it easy when you are active outside? (Answer: Orange, unless you are unusually sensitive, in which case, yellow.)

For Further Exploration

If it is winter and you live in an area that tends to have inversions, students can track real-time air pollution data for particle pollution, as well as temperature and wind speed, as described for ozone under Activity 5. Also, have students track local weather reports for information on when temperature inversions are occurring and report back to the class.

- Ask students: What did you observe about particle pollution levels during the inversion? Is there a relationship between cold temperatures and inversions? Is there a relationship between wind speed and inversions?

- Have students write a report on what a temperature inversion is.

Also see the lesson plans on temperature inversions in this toolkit (Trapping Air Pollution: Temperature Inversions #1, for Grades 3-5; and Trapping Air Pollution: Temperature Inversions #2, for Grades 6-8).

Acknowledgments/Resources

Air Pollution: What's the Solution? See various URLs, including:

www.k12science.org/curriculum/airproj/ozonetomorrow.html

www.k12science.org/curriculum/airproj/ozonetracking.html

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Freiman. C. and N. Karkowsky. 1993. Weathering the Summer of 1993. Science World 50 (22) (October).

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National Science Education Standards

Unifying Concepts and Processes
Evidence, Models and Explanation
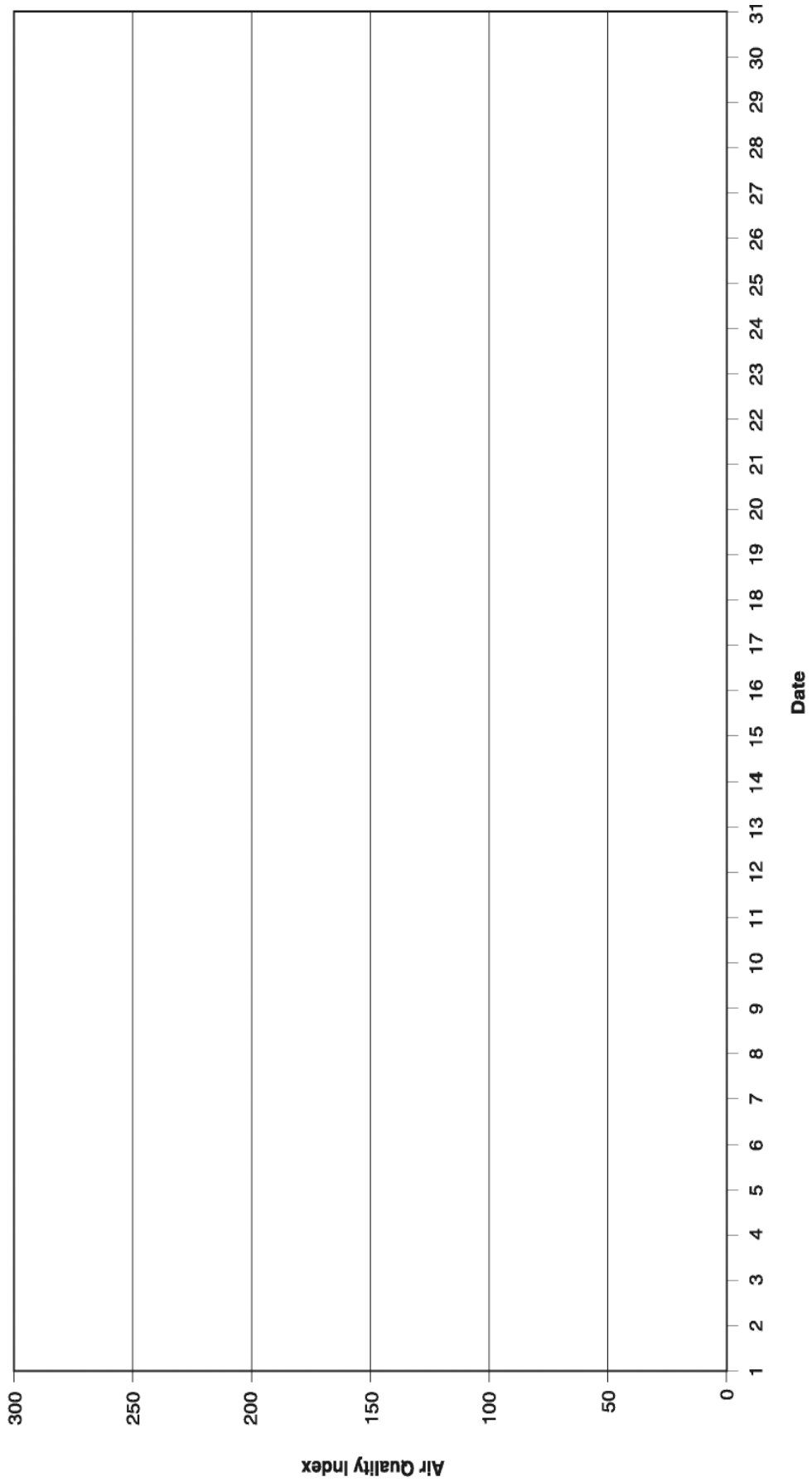
Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
Personal Health
Populations, Resources and Evironments
Risks and Benefits

Student Worksheet #1: Activities 1, 2, and 3

Air Quality vs. Time

(blank grid chart)

Air Quality Index — vertical axis: 300, 250, 200, 150, 100, 50, 0

Date — horizontal axis: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31

Month: _____

Total Number of Days Each Month with Elevated Ozone Levels

Green													
Yellow													
Orange													
Red													
Purple													
TOTAL DAYS Ozone was Above Green													

Daily Air Quality for _____

Time of Day	Highest AQI Color Observed on_____(Date)	Highest AQI Color Observed on_____(Date)	Highest AQI Color Observed on_____(Date)
12 a.m.			
1 a.m.			
2 a.m.			
3 a.m.			
4 a.m.			
5 a.m.			
6 a.m.			
7 a.m.			
8 a.m.			
9 a.m.			
10 a.m.			
11 a.m.			
12 p.m.			
1 p.m.			
2 p.m.			
3 p.m.			
4 p.m.			
5 p.m.			
6 p.m.			
7 p.m.			
8 p.m.			
9 p.m.			
10 p.m.			
11 p.m.			

Daily Ozone Forecast, Peak Ozone Level, and Daily Peak Temperature

Day of the Month	Ozone Forecast Today _____Tomorrow:_____	Actual Peak Ozone Level	Actual Peak Temperature
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			

Frequency of Particle Pollution

Day of the Month	Number of Monitors Showing Yellow AQI	Number of Monitors Showing Orange AQI	Number of Monitors Showing Red AQI	Number of Monitors Showing Purple AQI
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				

Smog Alert

Learning Objectives

Students will:
- Create artificial "smog" in a jar.
- Recognize that invisible air pollutants and weather conditions are involved in creating smog.
- Understand that not all air pollution is visible.
- Appreciate that human activities can cause air pollution.

Grade Level: Grades 6-8

(Note: With careful supervision, this activity can also be done with Grades 3-5)

Estimated Time: 20 minutes

Background Summary

The expression "smog" was first used in "Turn-of-the-Century" London to describe a combination of "smoke" and "fog." Smog occurred when water vapor in the air condensed on small particles of soot in the air, forming small smog droplets. Thousands of Londoners died of pneumonia-like diseases due to the poisonous air.

Ozone is a primary ingredient of smog. Ozone is formed when pollutants in the air, called "precursors" (notably nitrogen oxides, or NO_x, and volatile organic compounds, or VOCs), are heated by the sun and react chemically. The pollutants that form ground-level ozone are produced by sources such as automobile exhaust, industry and power plant smokestacks, and fumes from chemical solvents such as paint thinner or pesticides.

Ground-level ozone pollution is harmful to our health and environment; in contrast, the ozone layer that is high up in the atmosphere (the stratosphere) helps protect us from the sun's harmful ultraviolet radiation. An easy way to remember this difference is "Ozone: good up high, bad nearby."

Weather conditions such as the lack of wind or a "thermal inversion" can cause ozone to be trapped over a particular area. (A thermal inversion occurs when a layer of warm air in the Earth's atmosphere traps cold air and pollution, including ground-level ozone, below it). (**Note**: Also see *Trapping Air Pollution: Temperature Inversions* #1 and #2 lessons in this toolkit.)

Ground-level ozone can cause health problems such as difficulty breathing, aggravated asthma, reduced resistance to lung infections, colds, and eye irritation.

Severe smog and ground-level ozone problems often occur in many major cities, although wind can also carry it to more rural areas.

Materials Needed

- Clean, dry, wide-mouth glass jar (e.g., mayonnaise jar)
- Heavy aluminum foil
- Two or three ice cubes
- Ruler
- Scissors
- Stop watch or watch with second hand
- Matches

Key Questions

- Do you think you've ever seen smog? What do you think it's made of? What about ground-level ozone?
- Do you think smog can affect people's health? If so, how?

Vocabulary

Precursor—A compound that reacts and produces another compound.

Ozone—A gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone can be "good" or "bad" for people's health and the environment, depending on its location in the atmosphere. High up in the atmosphere, ozone helps protect people's health from too much ultraviolet radiation from the sun. Near the Earth's surface, ozone is an air pollutant that can result in breathing difficulties.

Model—A representation of a system that allows for investigation of the properties of the system.

Steps

> Check with the school principal or facilities manager to make sure this activity is allowed in the classroom. Be careful if you conduct this activity. The teacher may want to (or be required to) use matches instead of having the students do so. If students use the matches, they should do so only under teacher supervision.

1. Explain that the class will perform an experiment in which they will create artificial "smog" in a jar. Make sure that students understand that the jar is only a model, and models by nature are limited. For example, the purpose of this model is to illustrate the appearance and behavior of smog, not the composition or effects. It is important to understand that smog is not just a "smoky fog," but a specific phenomenon.

2. Select students to perform the experiment. Have a student cut a strip of paper about 6 inches by 2 inches. Fold the strip in half and twist it into a rope.

3. Have students make a snug lid for the jar out of a piece of aluminum foil. Shape a small depression in the foil lid to keep the ice cubes from sliding off. Carefully remove the foil and set it aside.

4. Have the students put some water in the jar and swish it around to wet all of the inside of the jar. Pour out the extra water.

5. The teacher (or possibly the students under teacher supervision, if school rules allow it) then lights the paper "rope" with a match and drops it and the match into the damp jar. Quickly put the foil lid back on the jar and seal it tightly. Put ice cubes on the lid to make it cold. (The ice cubes will make the water vapor in the jar condense.) Students must do this step very quickly, perhaps with some assistance.

6. Ask students to describe what they see in the jar.

How is this like real smog? What conditions in the jar produced "smog"? (*Correct answer:* Moisture and soot particles from the burning matches, plus carbon dioxide and other solvent vapors.)

7. Ask the students if they have ever seen smog (not fog).

For Further Exploration

Have students put a glass (not plastic) thermometer into the jar before they do the experiment. Have them record the temperature before proceeding to step 4. Have them record the temperature again during step 5. Ask them to describe what the temperature did and why. Let them try it again without adding water.

Assign students to small groups to answer the following questions and report back to class in two weeks. One group will consider the physical and chemical sciences and the other group will consider the health and ecological sciences. Each group should consider referring to several sources of information to answer the questions. Students could possibly interview a weather reporter or meteorologist at the local television or radio station or airport, or a health scientist from the city or county health department or air quality agency.

(a) What conditions are necessary to produce smog in the air? Under what circumstances will these conditions exist in the city? How often are they likely? Can they be predicted in advance?

(b) What are the health effects of smog on people? Why doesn't everyone in the city get sick or have similar symptoms from smog? What types of people are most sensitive to ground-level ozone? What types of people are sensitive to particle pollution?

Acknowledgments/Resources

Project A.I.R.E. (Air Information Resources for Educators), EPA Region 1: New England Educational Resources Library, Activity 14. URL: www.epa.gov/ne/students/pdfs/activ14.pdf

Easterbrook, G. 1993. Winning the War on Smog. Newsweek 122 (23) (August).

Pasternak, J. 1991. Long-Term Lung Damage Linked to Air Pollution; Respiratory Deterioration Is Found in Areas Where Air Is Dirtiest. Los Angeles Times (29), p. A1 (March).

Smog Blamed for Increase in Asthma Cases. 1991. Los Angeles Times (2), p. A1 (December).

Scott, G. 1992. Two Faces of Ozone. Current Health 19 (2), p. 24 (September).

National Science Education Standards

Unifying Concepts and Processes
  Evidence, Models and Explaination

Science as Inquiry
  Abilities Necessary to do Scientific Inquiry
  Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
  Personal Health

Trapping Air Pollution: Temperature Inversions #2

Learning Objectives

Students will:

- **Determine whether a temperature inversion has occurred in a specific location.**
- **Explore the AIRNow Web site for air quality (particle pollution) information and changes, and the Weather Underground Web site for related weather data.**
- **Learn how temperature inversions and wind can trap air pollutants, affect air quality, and impact health.**

Grade Level: Grades 6-8

Estimated Time: 1.5 hours

Background Summary

See the *Temperature Inversions, Weather, and Air Quality: Background Information* handout.

Materials Needed

- Internet access

- Copies of T*emperature Inversions, Weather, and Air Quality: Background Information* handout (one per student)

- Copies of *Temperature Inversion* graphic handout (one per student)

- Student Worksheet

- Teacher Answer Sheet

Key Questions

- Normally, do you think air temperature is cooler or warmer the higher up you go in the atmosphere? (*Correct answer:* The air is usually cooler higher up in the atmosphere.)

- What weather conditions do you think might contribute to temperature inversions? (*Possible answers:* temperature, wind, sky cover, length of night time, high pressure systems.)

- How can temperature inversions affect air quality and people's health? (*Possible answer:* Temperature inversions can trap air pollutants and make air quality worse. If people breathe in more air pollution, they may have trouble breathing and may have more health problems.)

Vocabulary

Temperature inversion—A layer of warm air that prevents the rise of cooler air and pollutants beneath it.

Stagnant—Not circulating or flowing.

Steps

1. Distribute the *Temperature Inversions, Weather, and Air Quality: Background Information* handout and the *Temperature Inversion* graphic handout to the class and discuss the information. Tell students that they can refer to these materials as they conduct the activities in this lesson.

2. Have students access the Air Quality Index (AQI) chart at the bottom of the following Web page (the last chart on the page): www.airnow.gov/index.cfm?action=static.aqi

   Discuss the AQI with the class: Tell students to think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. The AQI is divided into six categories, based on numerical values, as shown in the chart. Each category is assigned a specific color, indicating air quality levels ranging from good (green) to unhealthy (red) to hazardous (purple). The column on the right of the chart ("Meaning") explains the possible health effects associated with each AQI level. The AQI is reported daily for five major air pollutants. This lesson will explore the AQI for particles, one of these five pollutants.

3. Distribute the Student Worksheet. Have students

access the AIRNow "Particles" Web page for Salt Lake City, Utah on January 1, 2004. (Step 1 on the Student Worksheet.)

To do this, have each student/team access the AIRNow Web site at: www.airnow.gov. Under "Local Air Quality Conditions and Forecasts" below the national map shown on the left, enter the state "Utah" and click "Go." On the next screen, click on "Archives" on the left side under "National Overview," then click on "UT" on the map. On the next screen, in the blue box near the top, make sure that for "Pollutant," "Particle Pollution" is selected (the pollutant selected is in white and bold; the unselected pollutant is in dark blue and not bold). For "Map Area," Salt Lake City should already have been selected. For "Map Date," enter January 1, 2004. For "Map Type," place a check mark next to "8-Hour Peak AQI," which shows the highest particle pollution reading for the day. (Make sure other map types are not checked.) Click on "Display Maps Below."

Tell the class to look at the second map on the Web page. Tell students that particle pollution is expressed as colored circles that correspond to the AQI colors listed to the right of the map.

Ask the class: What Air Quality Index (AQI) level (color and corresponding meaning) was reached for particles on January 1, 2004, for Salt Lake City? Tell students to record the answer in Question #1 on their Student Worksheet. (See Teacher Answer Sheet for answers to all questions.)

4. Next have students access the Weather Underground Web site and tell them to obtain the following weather conditions: maximum and minimum actual temperatures (in Farenheight degrees) and maximum wind speed (in miles per hour) for Salt Lake City, Utah on January 1, 2004. (Students should ignore the other weather data.)

(If anyone has trouble accessing this Web page, the URL is: http://www.wunderground.com/history/airport/KSLC/2004/1/1/DailyHistory.html)

Tell the class to record the weather data (temperature and wind speed) for Salt Lake City on January 1, 2004 on their Student Worksheet in the blank chart, which is Question #2a of their Student Worksheet.

5. Ask the class if anyone skis or snowboards. Tell students to examine the weather conditions for Snowbird Ski Area on January 1, 2004 provided in the chart on their Worksheet Question #2b.

Ask students to compare the weather conditions (temperature and wind) for January 1, 2004 in Salt Lake City (Chart 2a of their worksheets) to the same weather conditions at Snowbird Ski Area (Chart 2b), which is just outside of Salt Lake City, on the same day.

Tell students to record their observations about the weather in the two locations (Salt Lake City and Snowbird) in Question #2c of their worksheets, as it relates to previous class readings and discussions about temperature inversions. Discuss students' answers for Student Worksheet Questions #2b and #2c and the correct answers.

6. Now have students graph the temperatures in Salt Lake City for January 1, 2004 as instructed on the blank graph in Question #3 of the Student Worksheet.

7. Next have students graph the temperatures at Snowbird for January 1, 2004 as instructed on the blank graph in Question #4 of the Student Worksheet.

Review and discuss students' graphs in Worksheet Questions #3 and #4 and the correct graphs (see Teacher Answer Sheet).

8. Tell students to access the AIRNow "Particles" Web page for another day: Salt Lake City, Utah, on January 9, 2004. Tell students to look at the map on the page.

To access this Web page, give students the same instructions as in Step 3, but have them enter "January 9, 2004" for "Map Date" instead of January 1, 2004.

Ask the class: What Air Quality Index (AQI) level (color and meaning) was reached for particles on January 9, 2004, in Salt Lake City? Tell students to record the answer in Question #5 on their Student Worksheet.

9. Have students access the Weather Underground Web site and obtain the weather conditions (temperature and wind speed) for Salt Lake City, Utah on January 9, 2004.

(In case anyone has trouble accessing this Web page, the URL is: http://www.wunderground.com/history/airport/KSLC/2004/1/9/DailyHistory.html)

Tell the class to record the weather data for Salt Lake City for January 9, 2004 on their Student Worksheet in the chart in Question #6a.

10. Tell students to examine the weather conditions at Snowbird Ski Area for January 9, 2004, which are provided in the chart in Question #6b on the Student Worksheet.

11. Have students compare the weather conditions (temperature and wind speed) for January 9, 2004 in Salt Lake City to the weather conditions at Snowbird Ski Area on the same day, and record their observations in Question #6c of the Student Worksheet, as it relates to previous class readings and discussions about temperature inversions. Discuss students' answers and the correct answer.

12. Have students graph the temperatures in Salt Lake City for January 9, 2004 on the blank graph in Question #7 as instructed on the Student Worksheet.

13. Have students graph the temperatures at Snowbird for January 9, 2004 on the blank graph in Question #8 as instructed on the Student worksheet.

Review and discuss students' graphs for Questions #7 and #8 and the correct graphs (see Teacher Answer Sheet).

14. *Final lesson discussion.* Proceed to either the *For Further Exploration* section of this lesson plan to include additional weather conditions that can impact air quality, or to the *Evaluation* section questions for the final class discussion.

Adaptation

Students could work in small groups rather than individually.

For a simpler lesson on temperature inversions, see *Trapping Air Pollution: Temperature Inversions #1* (included for Grades 3-5) in this Toolkit. If time permits, the class could first conduct the Temperature Inversion #1 lesson, and in following sessions conduct the more advanced *Trapping Air Pollution: Temperature Inversions #2* lesson.

For Further Exploration

Expand the discussion to include other weather conditions in addition to temperature and wind speed that can contribute to temperature inversions, such as clear skies, long nights, and high pressure systems.

(*Background for this discussion:* Clear skies increase the rate of cooling at the Earth's surface, resulting in lower temperatures near the ground. Long nights allow for cooling of the ground to continue over a longer period of time, resulting in a greater temperature decrease at the surface. Since the nights are longer in winter, inversions are stronger and more common during winter months. In addition, strong high pressure systems can also increase the likelihood of temperature inversions because in a high pressure system the air is stagnant, which keeps the air—and pollutants in the air—where they are.)

Proceed to the *Evaluation* questions below for the final class discussion.

Evaluation

To assess students' grasp of the information in this lesson, ask and discuss the following:

A. From the graphs for Snowbird ski area that you created in Worksheet Questions #4 and #8), what do you observe about the temperatures at the base and peak of the mountain at Snowbird on the two days observed (January 1 and January 9, 2004)? Explain.

Answer: On January 1, the temperature at the peak of the mountain was cooler than the temperature at the base of the mountain, which indicates normal temperature conditions. On January 9, the temperature at the peak of the mountain was warmer than the temperature at the base of the mountain, which indicates a temperature inversion. These conditions confirm the conditions the class discussed when comparing the Salt Lake City and Snowbird weather charts: that normal weather conditions existed on January 1, 2004, and that a temperature inversion occurred on January 9, 2004. The temperature inversion on January 9 helps explain why the AQI (Air Quality Index) for air quality was "red" or "unhealthy" for that day, since the cool air and any pollutants in it were trapped below the layer of warmer air above it, increasing air pollution. (Note that on January 1, 2004, the air quality was "green," or "good," under normal temperature conditions when a temperature inversion did not occur.)

B. What were the differences in wind speed on the two days? Explain.

Answer: On January 1, 2004, there were strong winds, both in Salt Lake City and at Snowbird.

These winds encouraged mixing and movement of air, and moving away of any air pollutants that might be present. On January 9, 2004, there was no wind (or only light winds) in both locations. So the trapped air from the temperature inversion would remain trapped and stagnant (would not be blown away by the wind), and any air pollutants present would remain in the air. This also helps explain why the AQI for January 1 was "green" or "good" and why the AQI for January 9 was "red" or "unhealthy."

C. List and explain some of the conditions that can contribute to the formation of a temperature inversion:

- A layer of warmer air above a layer of cooler air

- No or little wind

- Mountains nearby

- (If *For Further Exploration* was included in the lesson, also): clear skies, long nights, high pressure systems

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Personal Health

Temperature Inversions, Weather, and Air Quality: Background Information

What is a temperature inversion? Under normal weather conditions, air temperature is cooler as you go higher up in the atmosphere. This is because the sun's energy is converted to heat at the ground level, which in turn warms the air closer to the Earth's surface. The warm air cools as it rises in the atmosphere. When a temperature inversion occurs, the opposite is true: warmer air is above cooler air, and the cooler air is "trapped" below the warmer air.

How can temperature inversions affect air quality? Air temperature can have an important effect on air quality. During a temperature inversion, the warm air layer above the cooler air acts as a lid, trapping not only the cooler air below it, but also any pollutants that might be in the cooler air. Because the pollutants cannot rise and move away, they may build up, resulting in poor air quality, which may negatively affect people's health. These pollutants may come from vehicles, fireplaces and wood stoves, and industries that release pollutants into the air. In some locations, local governments ban the use of wood stoves and fireplaces under certain weather and pollution conditions.

How can wind and mountains influence temperature inversions and air quality? When there is no wind or only calm winds, air and any pollutants in it remain stagnant, which can contribute to maintaining temperature inversion conditions and to air pollution. On the other hand, a strong wind can move pollutants away from an area and clear the air. In addition, local topographical features, such as nearby mountains, can increase the formation of temperature inversions, especially in valleys. Cold air sinks to the valley floor or base of a mountain and becomes trapped there.

What is the Air Quality Index (AQI)? This lesson explores the Air Quality Index (AQI), which reports air quality levels every day for many locations in the U.S. Different AQI levels are color-coded and linked to different health concerns.

This lesson examines weather conditions to determine whether a temperature inversion exists and how weather and temperature inversions affect air quality.

Calm winds and the inversion result in poor air quality.

❶ The winter sun, low in the sky, supplies less warmth to the Earth's surface.

❷ Warmer air aloft acts as a lid and holds cold air near the ground.

❸ Pollution from wood fires and cars are trapped by the inversion.

❹ Mountains can increase the strength of valley inversions

Source: Air Pollution: What's the Solution?—Temperature Inversion
www.k12science.org/curriculum/airproj/pm_inversion.html

Student Worksheet:
Trapping Air Pollution: Temperature Inversions #2

Name: _____

1. Access the AIRNow "Particles" Web page for Salt Lake City, Utah on January 1, 2004.

   To access this Web page, go to the AIRNow Web site at: www.airnow.gov. Under "Local Air Quality Conditions and Forecasts" below the national map shown on the left, enter the state "Utah" and click "Go." On the next screen, click on "Archives" on the left side under "National Overview," then click on "UT" on the map. On the next screen, in the blue box near the top, make sure that for "Pollutant," "Particle Pollution" is selected (the pollutant selected is in white and bold; the unselected pollutant is in dark blue and not bold). For "Map Area," Salt Lake City should already have been selected. For "Map Date," enter January 1, 2004. For "Map Type," place a check mark next to "8-Hour Peak AQI," which shows the highest particle pollution reading for the day. (Make sure other map types are not checked.) Click on "Display Maps Below."

   What AQI level was reached for particles on January 1, 2004 in Salt Lake City?

2. Access the Weather Underground Web site and obtain the following weather conditions for Salt Lake City, Utah on January 1, 2004: minimum and maximum temperatures (in Farenheight) and maximum wind speed.

   Access at: Salt Lake City, Utah on January 1, 2004.

   (If you have trouble accessing this Web page, the URL is: www.wunderground.com/history/airport/KSLC/2004/1/1/DailyHistory.html)

   2a. Record the weather data in the chart below for Salt Lake City on January 1, 2004.

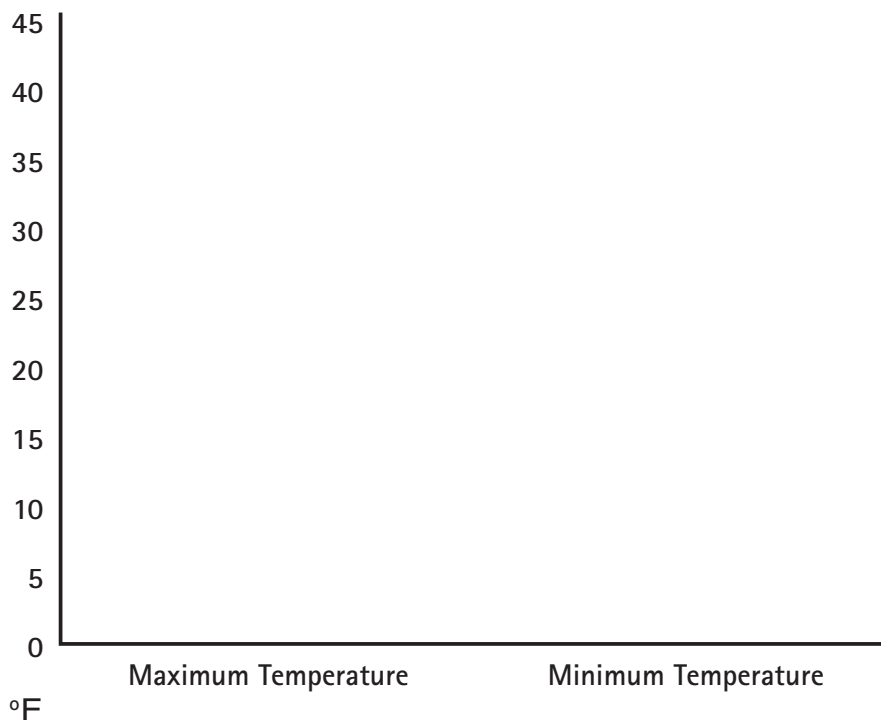| Max. Actual Temp.	Min. Actual Temp.	Max. Wind Speed

Name: _____

2b. Review the weather data in the table below for Snowbird Ski Area for January 1, 2004.

Snowbird Snow Report				January 1, 2004			
New Snow		**Snow Depth** Mid-Mtn.	**Snow Fall** Year to Date	**Temperature**			Wind Hidden Peak
24 hr	48 hr			Tram Base	Mid-Mtn.	Hidden Peak	
0"	0"	156"	412"	40F	32F	26F	51 mph
38 F		Hi: 40F		**Today's Forecast:** Overcast, unseasonably warm, with strong winds.			
		Lo: 33F					

2c. How do the weather conditions (temperatures and wind speed) in Salt Lake City compare to the conditions at Snowbird on January 1, 2004?

3. Graph the maximum and minimum temperatures for Salt Lake City for January 1, 2004. Draw a line from the maximum to the minimum temperature.

Salt Lake City Temperatures, January 1, 2004

```
45 ┤
   │
40 ┤
   │
35 ┤
   │
30 ┤
   │
25 ┤
   │
20 ┤
   │
15 ┤
   │
10 ┤
   │
 5 ┤
   │
 0 └──────────────────────────────────────
      Maximum Temperature      Minimum Temperature
°F
```

Name: _____

4. For Snowbird Ski Area, for January 1, 2004, graph the peak-mountain, mid-mountain, and base-mountain temperatures. Draw a line to connect these points.

Snowbird Ski Area Temperatures, January 1, 2004

```
45

40

35

30

25

20

15

10

 5

 0
     Base–Mountain Temp.    Mid–Mountain    Peak–Mountain Temp.
°F
```
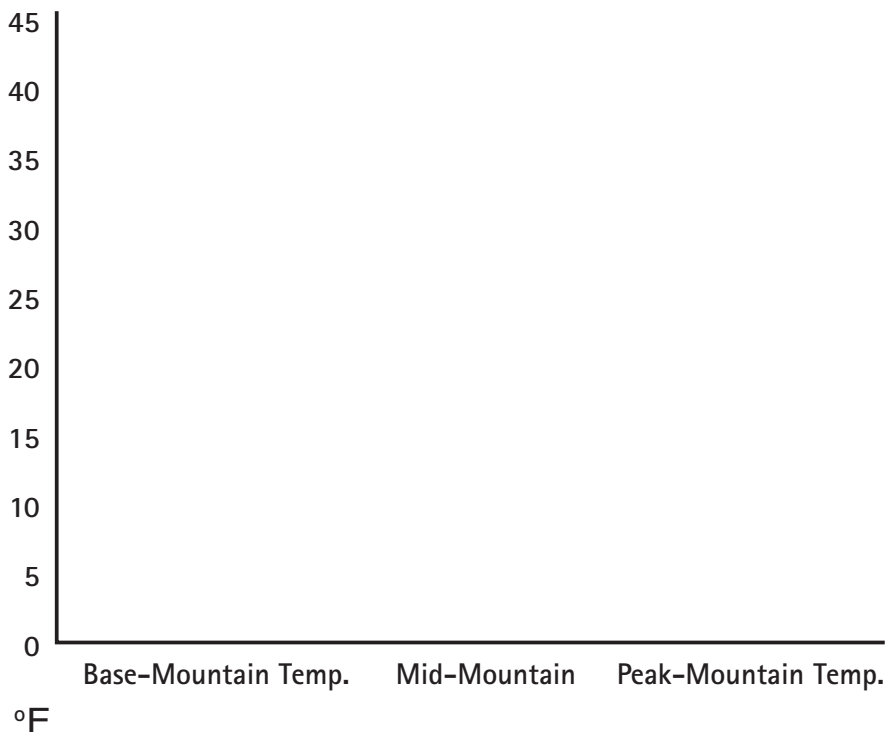
5. Access the AIRNow "Particles" Web page for Salt Lake City, Utah on January 9, 2004.

    To do this, follow the same instructions given in Step 1 of this Worksheet, but enter "January 9, 2004" for "Map Date" instead of January 1, 2004.

    What AQI level was reached for particles on January 9, 2004 in Salt Lake City?

Name: _____

6. Access the Weather Underground Web site and obtain the following weather conditions for Salt Lake City, Utah on January 9, 2004: maximum and minimum temperatures, and wind speed.

   Access at: Salt Lake City, Utah on January 9, 2004.

   (If you have trouble accessing this Web page, the URL is: http://www.wunderground.com/history/airport/KSLC/2004/1/9/DailyHistory.html)

6a. Record the weather data below for Salt Lake City on January 9, 2004.

Max. Actual Temp.	Min. Actual Temp.	Max. Wind Speed

6b. Review the weather data in the table below for Snowbird Ski Area for January 9, 2004.

Snowbird Snow Report				January 9, 2004			
New Snow		Snow Depth Mid-Mtn.	Snow Fall Year to Date	Temperature			Wind Hidden Peak
24 hr	48 hr			Tram Base	Mid-Mtn.	Hidden Peak	
0.12"	0.3"	158"	414"	20F	24F	36F	9 mph
17 F		Hi: 40F		Today's Forecast: Mostly Cloudy, 10% chance of snow, light to no wind.			
		Lo: 10F					

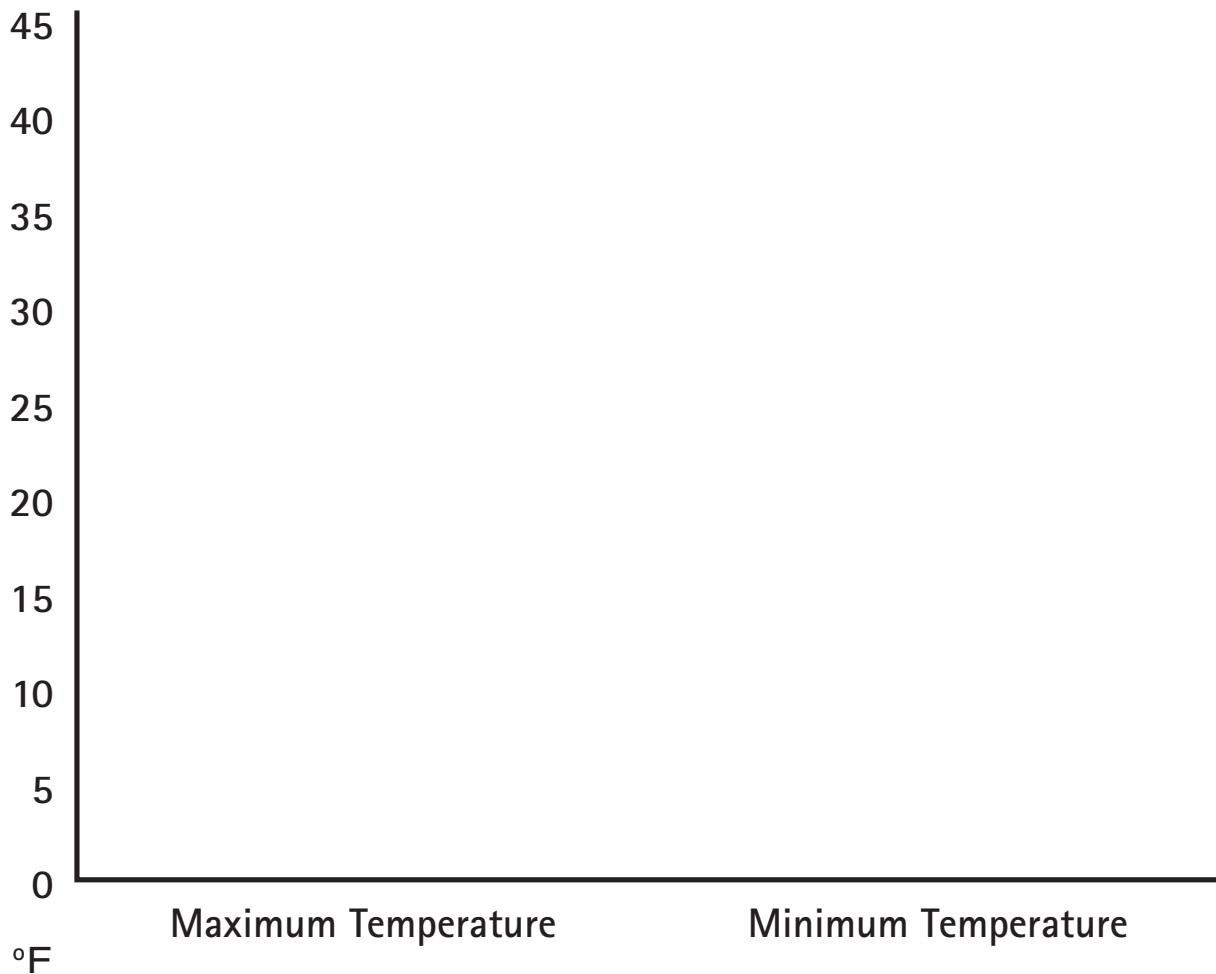6c. How do the weather conditions in Salt Lake City compare to the conditions at Snowbird on January 9, 2004?

Name: _____

7. Graph the maximum and minimum temperatures for Salt Lake City for January 9, 2004. Draw a line from the maximum to the minimum temperature.
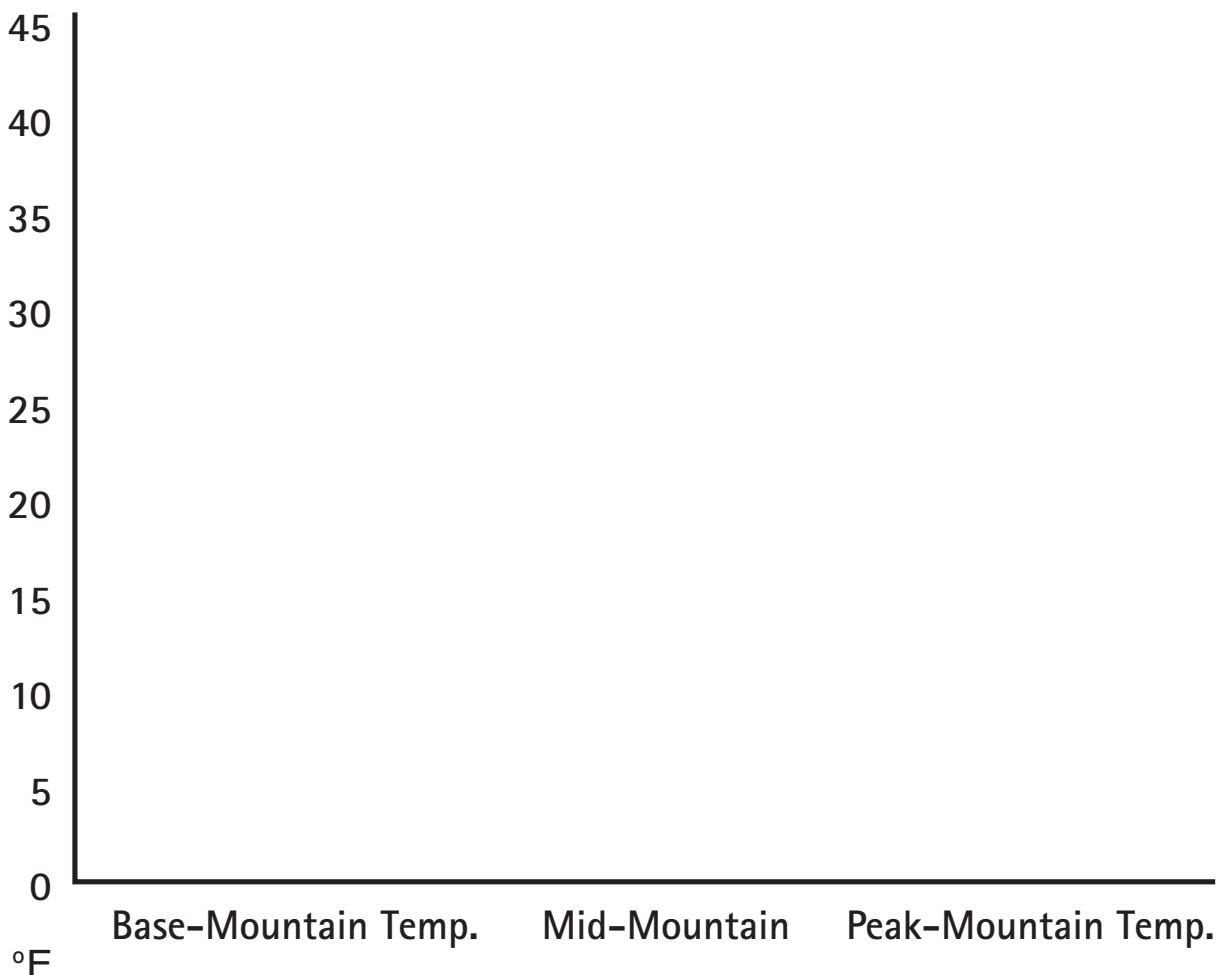
Salt Lake City Temperatures, January 9, 2004

```
45 ┤

40 ┤

35 ┤

30 ┤

25 ┤

20 ┤

15 ┤

10 ┤

 5 ┤

 0 ┼──────────────────────────────────────────
      Maximum Temperature        Minimum Temperature
°F
```

Name: _____

8. For Snowbird Ski Area, for January 9, 2004, graph the peak-mountain, mid-mountain, and base-mountain temperatures. Draw a line to connect these points.

Snowbird Ski Area Temperatures, January 9, 2004

```
45 |
   |
40 |
   |
35 |
   |
30 |
   |
25 |
   |
20 |
   |
15 |
   |
10 |
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 5 |
   |
 0 |_____
     Base-Mountain Temp.    Mid-Mountain    Peak-Mountain Temp.
°F
```

1. [Students access the AIRNow "Particles" Web page for Salt Lake City, Utah on January 1, 2004.]

    What AQI level was reached for particles on January 1, 2004 in Salt Lake City?

    Answer: Green, or Good

2a. Record the weather data below for Salt Lake City on January 1, 2004.

    [Answers:]

Max. Actual Temp.	Min. Actual Temp.	Max Wind Speed
42° F	35° F	43 mph

2b. Review the weather data in the table below for Snowbird Ski Area for January 1, 2004.

Snowbird Snow Report				January 1, 2004			
New Snow		**Snow Depth** Mid-Mtn.	**Snow Fall** Year to Date	**Temperature**			Wind Hidden Peak
24 hr	48 hr			Tram Base	Mid-Mtn.	Hidden Peak	
0"	0"	156"	412"	40F	32F	26F	51 mph
38 F		Hi: 40F		**Today's Forecast:** Overcast, unseasonably warm, with strong winds.			
		Lo: 33F					

2c. How do the weather conditions (temperature and wind speed) in Salt Lake City compare to the conditions at Snowbird on January 1, 2004?

    Answer: The temperatures in Salt Lake City were warmer, and the winds were calmer than at Snowbird. So cooler air and more wind in the mountains were above warmer and calmer air in the valley/city. These are normal weather conditions.
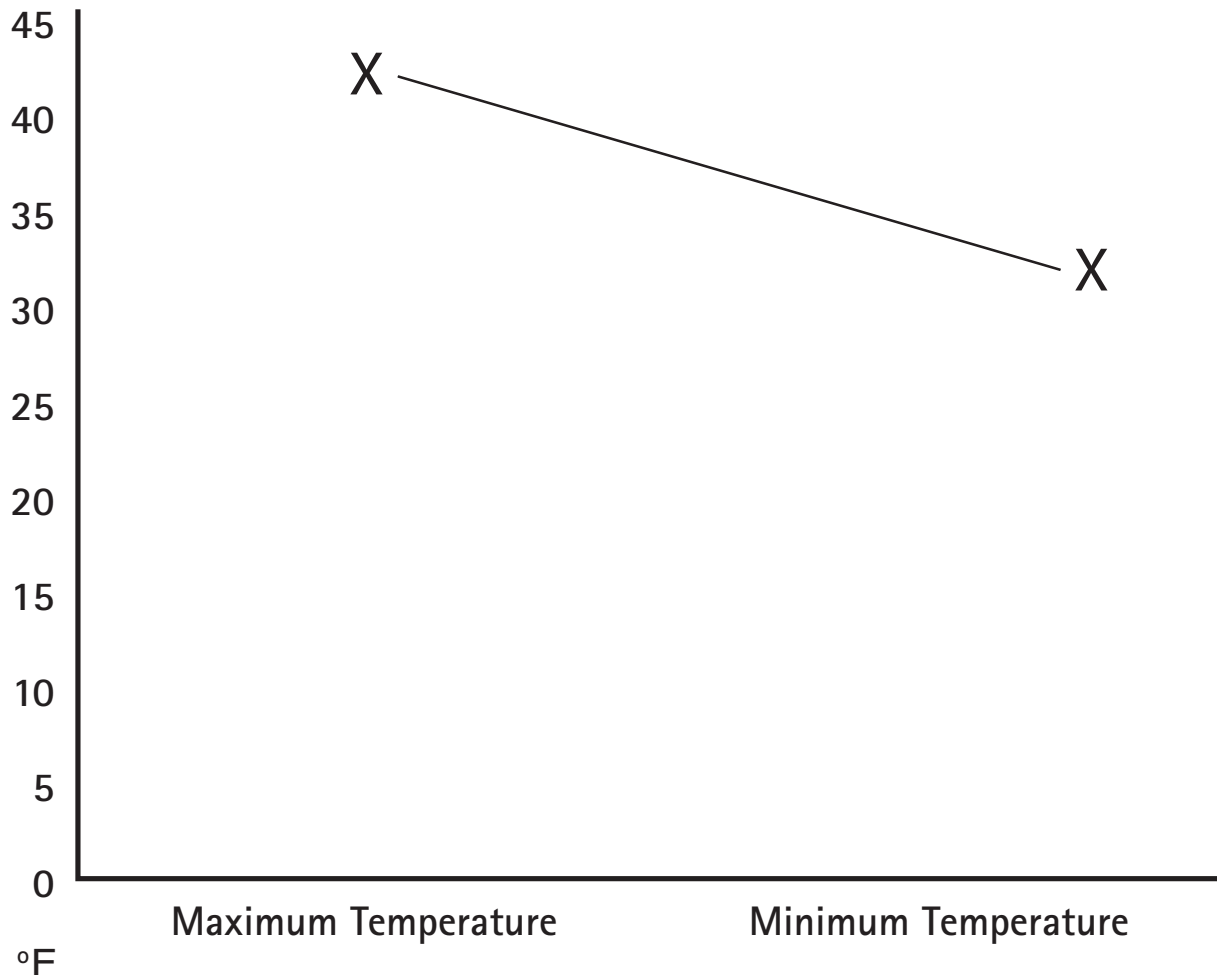
3. Graph the maximum and minimum temperatures for Salt Lake City for January 1, 2004. Draw a line from the maximum to the minimum temperature.

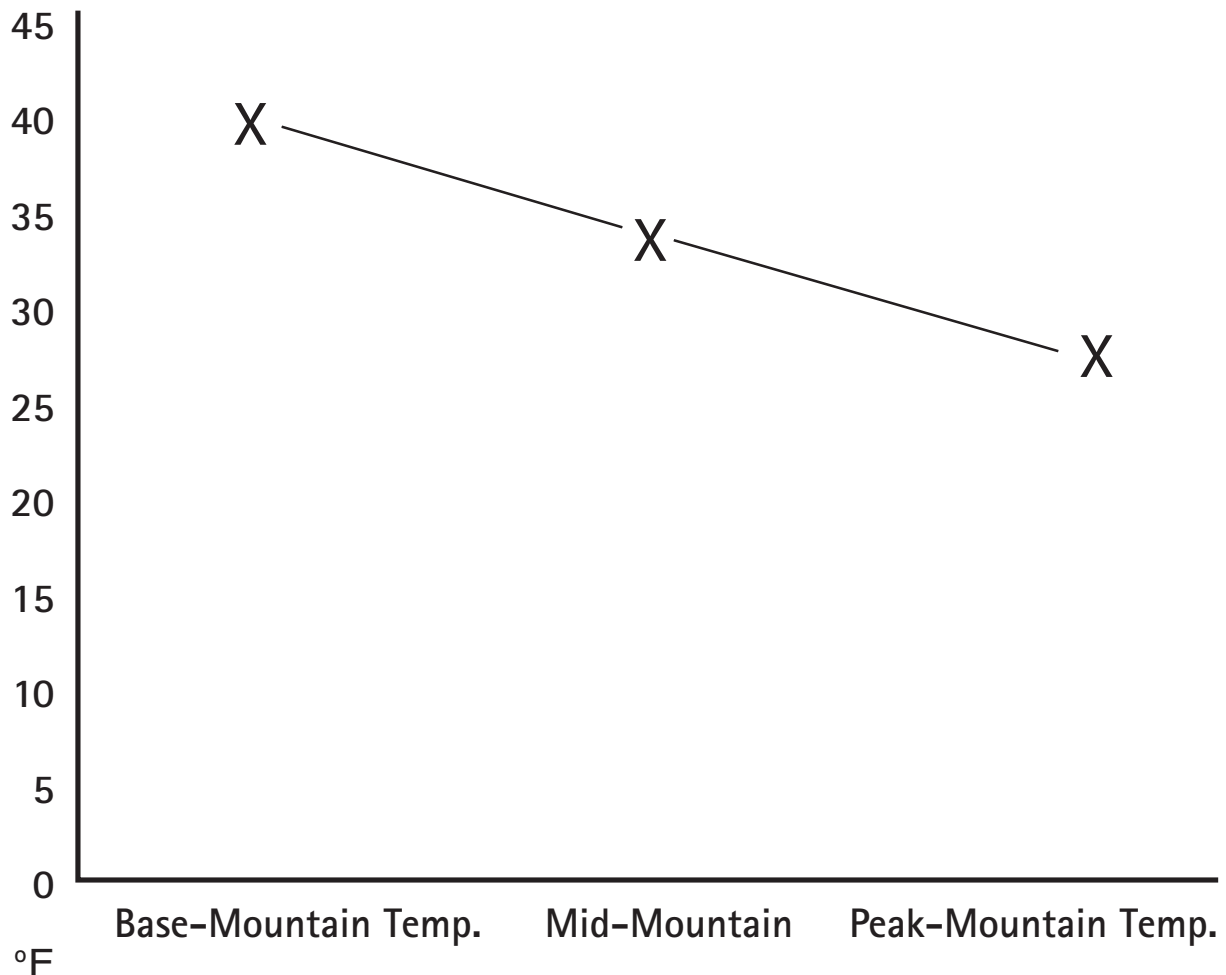**Salt Lake City Temperatures, January 1, 2004** *[Completed graph]:*

°F

4. For Snowbird Ski Area, for January 1, 2004, graph the peak-mountain, mid-mountain, and base-mountain temperatures. Draw a line to connect these points.

Snowbird Ski Area Temperatures, January 1, 2004 *[Completed graph]:*

5. What AQI level was reached for particles on January 9, 2004 in Salt Lake City?

   Answer: Red, or Unhealthy

6a. Record the weather data below for Salt Lake City on January 9, 2004.

   [Answers]:

Max. Actual Temp.	Min. Actual Temp.	Max Wind Speed
26° F	14° F	8 mph

6b. [Students review the chart below on weather conditions at Snowbird Ski Area for January 9, 2004]

Snowbird Snow Report				January 9, 2004			
New Snow		Snow Depth Mid-Mtn.	Snow Fall Year to Date	Temperature			Wind Hidden Peak
24 hr	48 hr			Tram Base	Mid-Mtn.	Hidden Peak	
0.12"	0.3"	158"	414"	20F	24F	36F	9 mph
17 F		Hi: 40F		Today's Forecast: Mostly Cloudy, 10% chance of snow, light to no wind.			
		Lo: 10F					

6c. How do the weather conditions in Salt Lake City compare to the conditions at Snowbird on January 9, 2004?

   Answer: The maximum temperature on the mountain at Snowbird was warmer than the maximum temperature in Salt Lake City. So there was warmer air on the mountain than in the valley (city). This reflects the conditions of a temperature inversion, with warmer air above cooler air. The cooler air, and any pollutants in it, are trapped below the warmer air. Also, there was no wind (or only little wind) to move the air and any pollutants in it away from this area.
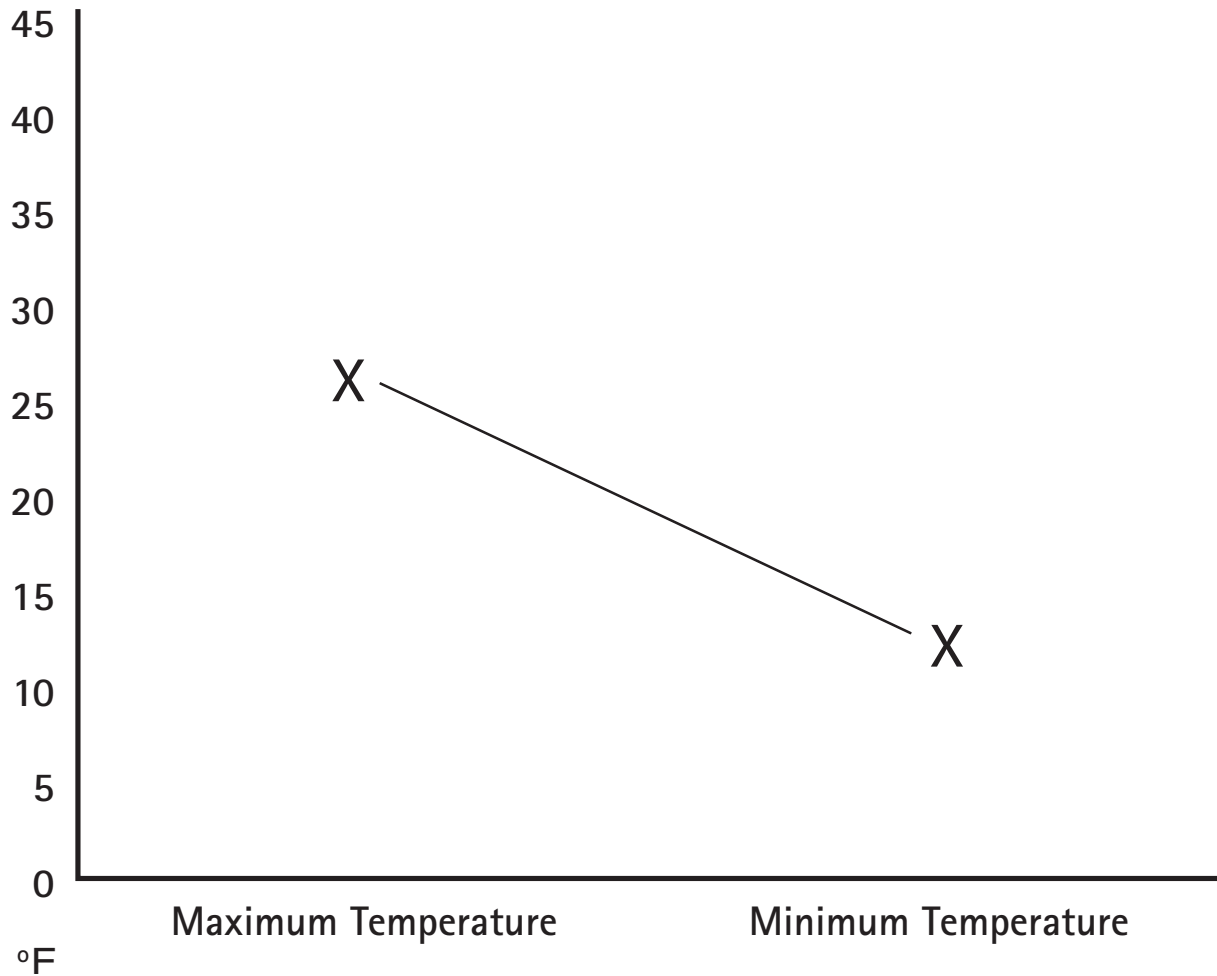
7. Graph the maximum and minimum temperatures for Salt Lake City for January 9, 2004. Draw a line from the maximum to the minimum temperature.

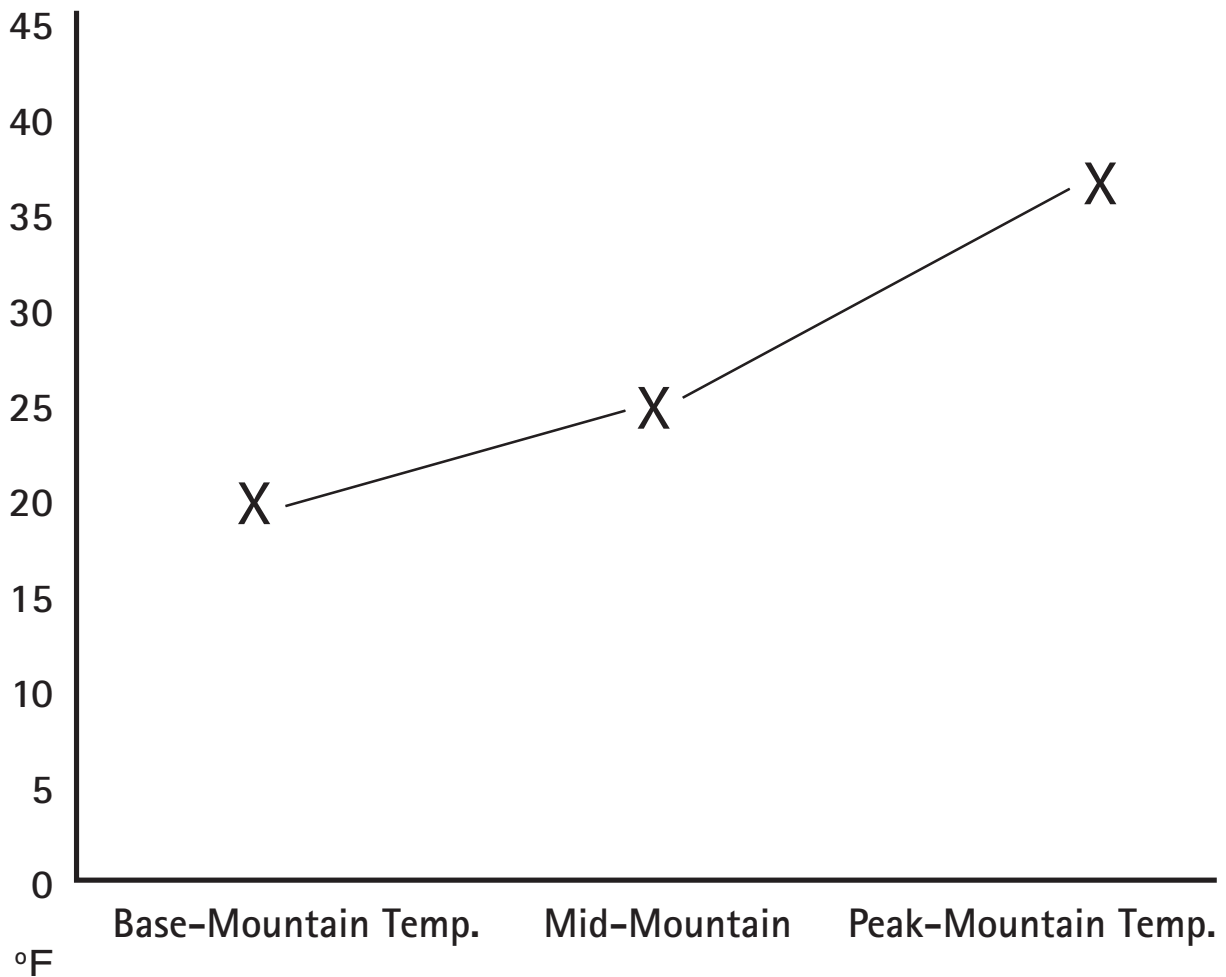**Salt Lake City Temperatures, January 9, 2004** *[Completed graph]:*

°F

8. For Snowbird Ski Area, for January 9, 2004, graph the peak-mountain, mid-mountain, and base-mountain temperatures. Draw a line to connect these points.

Snowbird Ski Area Temperatures, January 9, 2004 *[Completed graph]:*

9. See lesson plan, Step #14 and *Evaluation*, for final class discussion.

What's "Riding the Wind" in Your Community?

Learning Objectives

Students will:
- Identify particle pollution in the air that is carried and deposited by the wind.
- Determine the approximate direction from which particle pollution comes.
- Consider possible sources of particle pollution in the community and beyond.
- Understand the possible health effects of particle pollution.
- Learn how to check daily air quality.

Grade Level: Grades 6–8

Estimated Time: 1.5 hours (over 2 to 3 sessions)
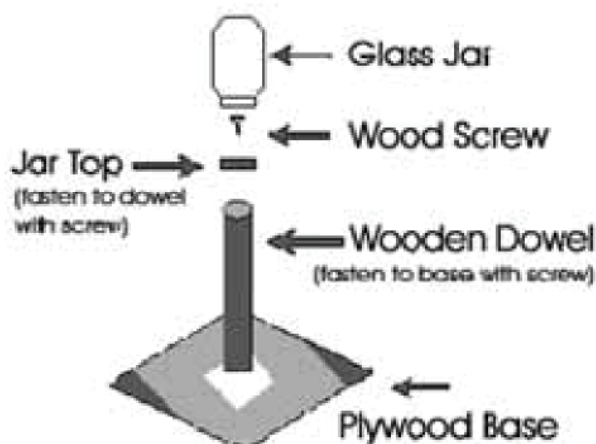
Background Summary

Ever wonder what's floating in the air? Sometimes the air contains particle pollution, which is made up of particles of dust, dirt, smoke, and liquid droplets. Wind can blow particle pollution in the air from nearby sources as well as from distant locations. The movement of wind-blown particles is more horizontal than vertical. Particle pollution that we can easily see ranges in size from approximately 20 to 100 microns. For comparison purposes, a human hair is approximately 70 microns in diameter. A good collecting surface is a vertical plane. Sticky paper wrapped around a jar can be used as a sample collector and will work well to capture the particles. By having students make and analyze their own sample collector, they will be able to see particle pollution in the air that may not generally be visible, learn which direction the particle pollution comes from, and determine what the sources of the particle pollution might be.

Materials Needed

- Small glass or plastic jar with a lid (several jars that fit the same lid will allow for the collection of several samples)

- Plywood base (approximately 24" x 24")

- Wooden dowel (approximately 3" diameter, 30" long)

- 2 Wood screws

- Compass

- Spray can of quick drying clear lacquer

- Double sided tape, or contact paper

- Blank directional graphic (included)

- Sample Data Table and Graph (included)

Key Questions

- Do you think you can always see air pollution? (*Answer:* No, sometimes particles are too small to see.)

- What do you think some sources of air pollution might be in your community? (*Possible answers:* Factory smokestacks, car/vehicle emissions, power plants, dust from construction sites, fireplaces and wood stoves, smoke from forest fires)

- Do you think air pollution can reach your community from far away? How? From what sources? (*Possible answers:* Yes. The most likely sources of this pollution might be power plants and factories.)

- Do you think the weather can affect air pollution levels? (*Answer:* Yes. Wind can blow air pollution from long distances away into a community. Also particle pollution is often greater in the winter time, and particularly when there is a temperature inversion.)

Glass Jar ←
Wood Screw ←
Jar Top → (fasten to dowel with screw)
Wooden Dowel ← (fasten to base with screw)
Plywood Base ←

- Do you think there are health effects associated with particle pollution? What health effects? (Answer: Yes. Particle pollution can cause breathing difficulties and aggravate heart disease or lung disease (including asthma). For people with heart disease, particle pollution has been linked to heart attacks.)

Vocabulary

Particle pollution—Tiny particles of dust, dirt, smoke, and liquid droplets in the air.

Temperature inversion—When cold air in the atmosphere (and any air pollution in it) is trapped under warmer air above it; this is a reversal of normal conditions, in which temperature decreases as you go higher in the atmosphere.

Steps

1. Assemble the sample collector stand as indicated in the picture above under "Materials Needed."

2. Place the stand for holding the glass jar on a flat and safe area of the school grounds or roof. Try to keep the sampler as far away from obstructions as possible.

3. Wrap one strip of double-sided tape around the jar. If using contact paper be sure that the sticky side is facing away from the jar. Fasten one edge to the jar with tape and be sure that the edges overlap and stick together so that the paper will stay on the jar. Mark the exposed edge as North.

4. Screw the jar onto the cap on the stand and use a compass to be sure that the edge marked "North" is facing North.

5. Leave the jar exposed for seven days. Then spray the paper with the lacquer to fix the particles collected and to avoid having additional particles adhere to the paper.

6. After the lacquer dries, remove the tape or contact paper from the sampler and divide it into eight equal parts. One section of the strip will represent each direction, i.e., North, Northwest, West, Southwest, South, Southeast, East, Northeast. Label each section.

7. Lay the tape on a flat surface and estimate the percent of particle coverage for each section. Use the table below to record the class's estimates.

8. Hand out copies of the Sample Data Table and Graphic and review it with the class. Then distribute the Blank Directional Graphic for Entering Data (included) and have the students, either individually or in groups, draw in the data from the table. For this lesson, assume that 2 cm = 10% coverage. The sample site will be at the center of the graph. Tell students to use the Sample Data Table and Graphic as an example of how to enter and interpret their data on the blank graphic.

9. When students have completed their directional graphics, they should be able to look at them and start to form simplified ideas regarding what general direction particle pollution, and possibly other pollutants that affect your community, come from.

10. After finishing the graphs, discuss with the class:

- From what direction did most of the particle pollution appear to come?

- Knowing your community, what do you think some of the sources of the particle pollution might be? (*Possible answers:* Nearby dirt driveways, vehicle exhaust, factory emissions, power plants, dust from construction sites, fireplaces and wood stoves, smoke from fires.) Mention that the wind may also have blown the particle pollution from far away to your area from some of these types of pollution sources.

- How do you think that weather might affect particle pollution? (*Answer:* Particle pollution can occur at any time of year, but it can be especially bad during winter, when the weather is calm, and especially when a temperature inversion exists, allowing particle pollution to build up. A temperature inversion occurs when cold air, and any air pollution in it, is trapped under warmer air above it; this is a reversal of normal conditions, in which temperature decreases as you go higher in the atmosphere.)

- Do you think particle pollution can affect our health? How? (*Answer:* Yes. Particle pollution, especially smaller particles, can penetrate deep into the lungs and even get into our bloodstream. Particle pollution can cause a range of health effects, from coughing to aggravated asthma and heart disease. For people with heart disease,

Direction	N	NW	W	SW	S	SE	E	NE
Estimated Coverage								

particle pollution has been linked to heart attacks. Many studies link high particle pollution with increased emergency room visits and hospital admissions. People that are particularly sensitive to particle pollution include people with heart or lung disease, older adults, and children.)

- How might we and our community reduce air pollution? (*Possible answers:* People could drive less and walk, bicycle, or take public transportation (e.g., buses, trains, subways) more often. They could carpool more. People could use wood stoves and fireplaces less often. We can turn off lights, TVs, computers, and other equipment when we're not using them. Factories and power plants could use cleaner fuels and other substances that produce less air pollution.)

- Do you think there are ways to check what the air quality is? (Answer: Yes. You can check the air quality each day and for the next day on the Internet at: www.airnow.gov which provides an Air Quality Index, or AQI. The AQI is also often part of the weather report in newspapers and on TV and the radio. The AQI provides information on five air pollutants, including particle pollution.)

Adaptation

For lower grades, see the How Dirty is the Air We Breathe? lesson plan in this Toolkit for Grades K-2 on preparing a simpler air pollution tester.

For Further Exploration

See the Trapping Air Pollution: Temperature Inversions #1, Trapping Air Pollution: Temperature Inversions #2, and Save Smog City 2 from Particle Pollution lesson plans in this Toolkit. Also, the last part of the Tracking Air Quality lesson plan in this Toolkit (Grades 6-8) focuses on particle pollution.

Acknowledgments/Resources

U.S. EPA and the Air and Waste Management Association. Adapted from the Air Pollution Control Association, Air Pollution Experiments for Junior and Senior High School Science Classes. Pittsburgh, PA.

National Science Education Standards

Unifying Concepts and Processes
 Evidence, Models and Explanation
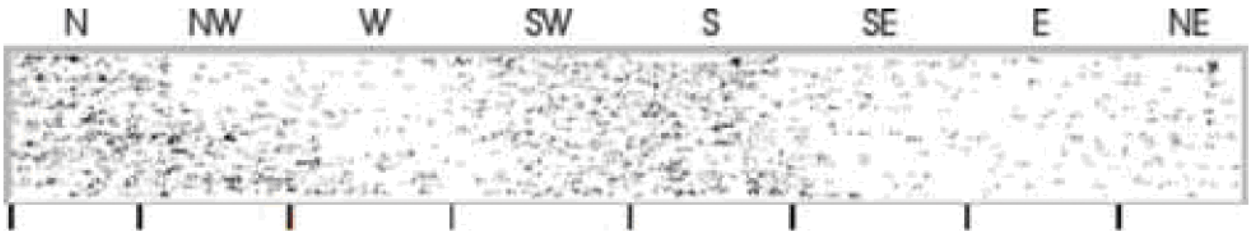
Science as Inquiry
 Abilities Necessary to do Scientific Inquiry
 Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
 Personal Health
 Changes in Environments
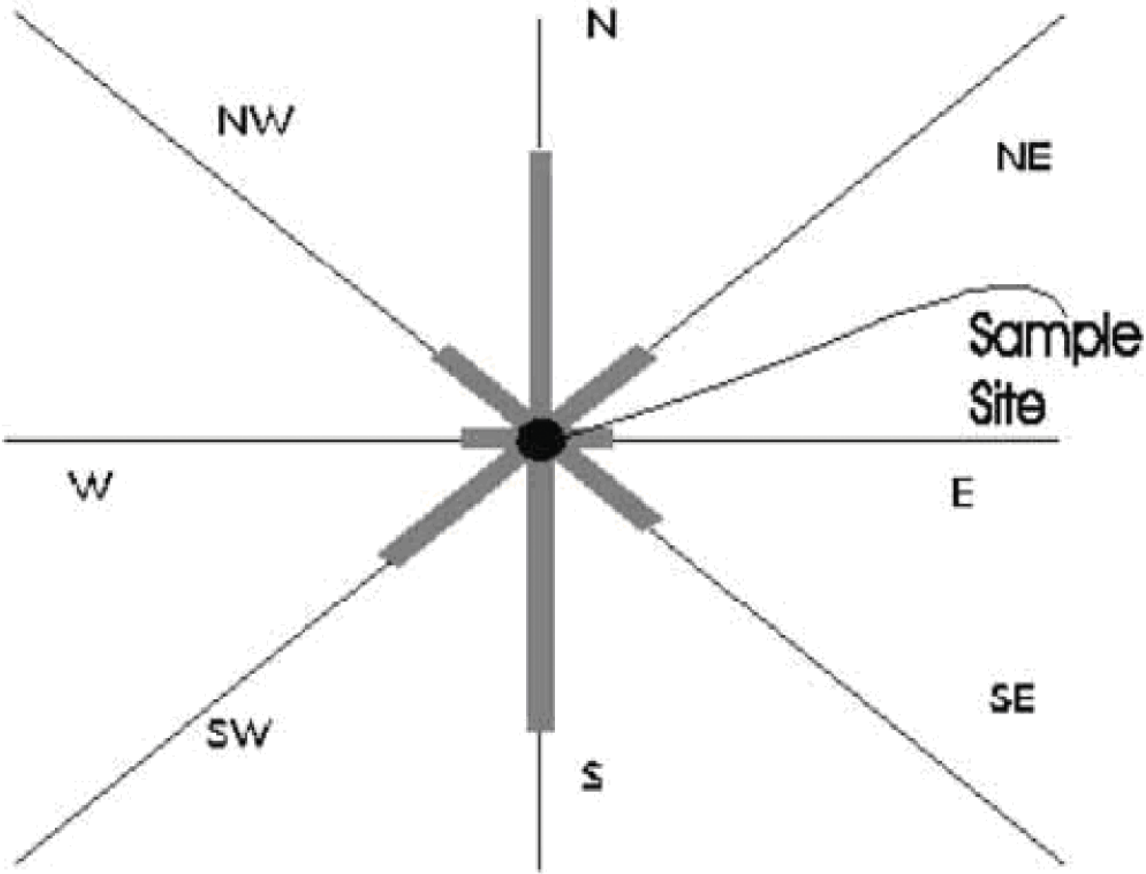
What's "Riding the Wind" in Your Community?

Sample Data Table and Graphic

| Direction	N	NW	W	SW	S	SE	E	NE
Estimated Coverage	25%	10%	5%	15%	25%	10%	5%	5%

For example we estimate the strip above is covered as indicated in the table below.

Start with the estimated particle coverage that came from the north, 25%. Since 2 cm on the graph represents 10% coverage, a 5 cm line will represent 25%. Draw a bar north extending 5 cm from the center of your directional graphic. A 2 cm bar should extend towards the northwest, and so on.

What's "Riding the Wind" in Your Community?

Blank Directional Graphic for Entering Data
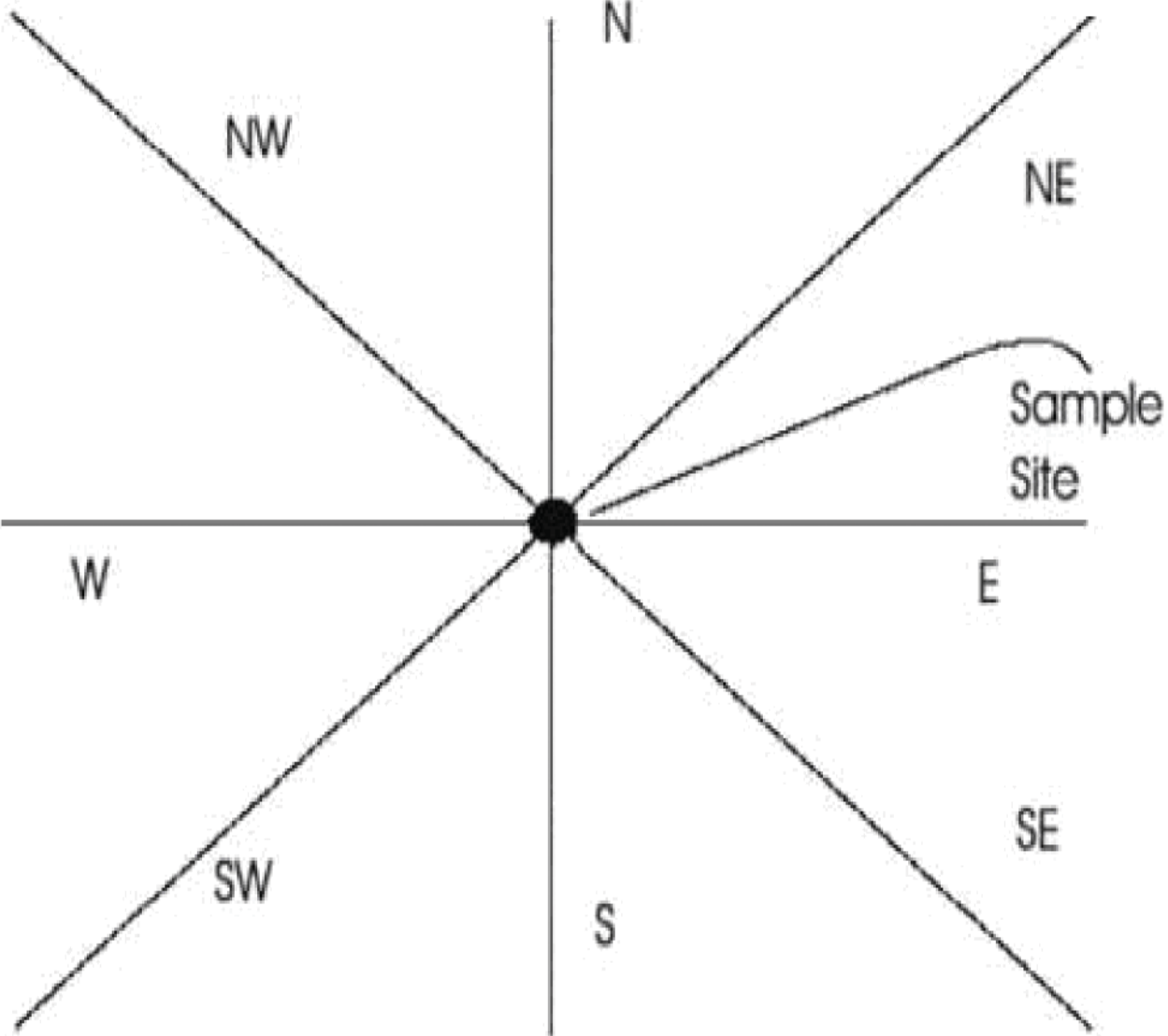
Data Collection Site _____

Data Collection Dates _____

Save Smog City 2 from Ozone

Learning Objectives

Students will:
- **Understand how weather and people's activities affect air pollution.**
- **Explore how changes in key variables can affect air pollution and health.**
- **Identify things people can do to reduce air pollution.**

Grade Level: Grades 6–8

Estimated Time: 1 hour

Background Summary

Ozone is made up of three oxygen atoms. Ozone in the air acts differently depending on where it is. The ozone layer high up in the atmosphere occurs naturally and helps protect us from receiving too much of the sun's harmful ultraviolet radiation. But when ozone is near the Earth's surface (at ground level), it is an air pollutant that can harm our health and our environment. You can remember this difference by thinking, "Good up high, bad nearby." Ground-level ozone pollution can irritate the throat and lungs, cause coughing, and make asthma worse.

Ground-level ozone forms when certain pollutants in the air are baked by the sun and undergo chemical reactions. These pollutants are volatile organic compounds (VOCs) and nitrogen oxides (NO_x). VOCs are emitted from gasoline, industrial chemicals, paints, household cleaners, and other products. NO_x is produced from burning certain fuels such as gasoline.

Many things can affect how much ground-level ozone pollution there is, including the weather, emissions released from cars and factories, and the population in a specific area. Ozone pollution is worse in the summer when there are high temperatures, calm winds, and lots of sunshine.

Make sure the class understands what emissions are, since this is an important concept of this lesson and the Smog City 2 Web site on which this lesson is based. *Ask the class* if they know what emissions are. Based on their responses, guide the class to understand that emissions are releases of pollutants, or other substances that can become pollutants, from vehicles, factories, power plants that make electricity, and even some products that we use at home, such as paints.

Tell the class that the Air Quality Index, or AQI, indicates how clean or polluted the air is in a specific location each day. Ozone is one of five major air pollutants that the AQI covers, and is one of the most common air pollutants in the U.S. The AQI has six levels for air quality: Good (green), Moderate (yellow), Unhealthy for Sensitive Groups (orange), Unhealthy (red), Very Unhealthy (Purple), and Hazardous (Maroon). Tell students that you will discuss the AQI more as the lesson continues.

Ozone is part of "smog"—a term that originally meant a combination of smoke and fog. These days, smog refers to a combination of particles, ozone, and other chemicals in the air. Tell students that they will be playing an online computer game called Smog City 2 about ozone that lets them change things like the weather, emissions from cars and power plants, and population to see how these changes affect ozone pollution.

Materials Needed
- Internet access
- Teacher Answer Sheet (included)
- Student Worksheet (included)

Key Questions
- What is smog? (*Answer:* Smog originally was a combination of smoke and fog. These days, smog refers to a combination of particles, ozone, and other chemicals in the air.)

- Is ozone good or bad? (*Answer:* Both. Good ozone is ozone up high in the atmosphere, where it helps protect us from too much of the sun's ultraviolet radiation, which can be harmful to our health. Bad

ozone is at ground-level, and is a pollutant that can cause breathing problems and lung irritation.)

- Can people's activities affect air pollution? How? (*Answer:* Yes. Vehicle emissions contribute to ozone pollution, as do power plant and factory emissions, and some household products, like paints.)

- Can the weather affect air pollution? How? (*Answer:* Yes. Ozone pollution is worse in hotter weather, when there is lots of sunlight and calm winds.)

- What can people do to protect their health from air pollution? (*Answer:* Take it easier outside when air is polluted. Tell an adult if it feels more difficult to breath.)

- What can people do to reduce air pollution? (*Possible Answers:* Drive less; take buses, trains, and subways instead of driving; share a ride with friends; walk and bicycle instead of driving; drive cars that make less emissions; use ATVs less or use bicycles instead.)

Vocabulary

Emissions—Substances discharged into the air. Releases of pollutants from a variety of sources and activities, including vehicles, factories, power plants that make electricity, and wood-burning stoves and fireplaces, among others.

Ozone—A gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone can be "good" or "bad" for people's health and the environment, depending on its location in the atmosphere. High up in the atmosphere, ozone helps protect people from too much ultraviolet radiation from the sun. Near the Earth's surface, ozone is an air pollutant that can result in breathing difficulties.

Air Quality Index (AQI)—A color-coded scale that provides daily air quality and health information.

Steps

1. Tell students to access the Smog City 2 Web site at www.smogcity2.org and click on "Save Smog City 2 from Ozone." Then have the class minimize the instructions box at the top right corner of the screen (this lesson covers some of the information in the box). Also, have students ignore the "Information" box at the bottom of the screen; they will be exploring several of these concepts in this lesson.

2. Tell the class not to click on anything until you tell them to (it's tempting!). Point out the main categories on the left of the screen with the class, including Weather, Emissions, and Population (you will be discussing these throughout the lesson). Also tell them to notice how each of the settings under these categories are pre-set to a certain level. Tell them that they will explore what happens when some of these settings are changed.

   Mention to students that the "Total Emissions" graph towards the bottom of the page reflects all the Emissions categories at the levels you set when you play the game (including energy sources, cars and trucks, off road vehicles, consumer products, and industry).

   (If students ask, tell them that the "Random Events" box is for learning about a different pollutant, called particle pollution, which you may cover in other lessons. *Note:* Several lessons in this Toolkit cover particle pollution.)

3. Tell the class they are first going to explore how weather conditions can affect ground-level ozone pollution and health. Tell students that in the real world we can't control the weather, but in Smog City 2 you can experiment with how the weather affects pollution levels by adjusting the controls.

4. Tell students to look at the black sign in the main picture to find out what the current temperature and AQI are. Remind students that the AQI tells how much air pollution there is. Tell them to observe the AQI (Air Quality Index) box in the lower right corner of the screen. The default setting is "Red" (see the top of this box, "Ground Level AQI" and the color itself at the bottom) and the corresponding health level is "Unhealthy" (see just below the colored graph where it says "Health.") Under this health level is a corresponding health message.

   Review the health message in the box for a Red, Unhealthy AQI with the class: "Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors."

5. Tell students to record the current temperature and AQI on Question #1 of their Student Worksheet.

6. Tell students to now increase the temperature to 110° F by moving the "Temperature" button as far to the right as it will go.

   Note: Tell students that settings can be changed by clicking on the new level they want. Remind them to wait until you tell them to change any of the settings.

7. Tell students to again check the black sign in the picture. Ask them if the temperature and the AQI changed. Ask students why they think this change in the AQI happened. Tell them to record this information in Question #2 of the Student Worksheet. Discuss the answers with the class.

   (*Correct answer:* The AQI increased from 175 to 202. Ground-level ozone increased because ozone levels are generally higher when temperatures are high.)

8. Have students click the "Reset" button on the bottom left of the screen so that everything returns to the original settings.

9. Tell students to observe the current "Clouds/Sky Cover" button setting (farthest to the left – the lowest setting), the main cityscape picture at this setting, and the AQI at this setting, and record these conditions in Question #3 on their Student Worksheet.

10. Tell students to move (increase) the "Clouds/Sky Cover" button to the far right setting (the highest setting), and to record the new "Clouds/Sky Cover" condition and the AQI on their worksheets, again in Question #3. Ask students whether changing the cloud conditions changed the AQI level, and to add why they think this happened to their Question #3 answers. Discuss the answers with the class.

    (*Answer:* The original Clouds/Sky Cover conditions at the lowest level were sunny—there was only one passing cloud in the sky in the picture—and the AQI was 175, Red, Unhealthy. When the Clouds/Sky Cover conditions were changed to the highest level, there were more clouds in the sky, and the AQI decreased to 119 and changed from Unhealthy to Unhealthy for Sensitive Groups. [Tell students that they will explore what "Unhealthy for Sensitive Groups" means later in the lesson.] Air pollution, and the AQI, decreased because ozone levels are highest when there is lots of sunshine, and adding clouds reduced the amount of sunshine, which reduced ozone formation.)

11. Have the class press the "Reset" button on the lower left side so that everything returns to the original settings.

12. Now explore changes in Emissions with the class. Tell students to observe the current emissions level for "Cars and Trucks" and record the current AQI on Question #4 of their Student Worksheet.

13. Tell students that the mayor of Smog City 2 has just purchased a whole new fleet of low-emission vehicles to replace all cars used by city government employees. So, the class needs to decrease the emissions level from Cars and Trucks to the second to lowest setting (from the current setting, which is the second to highest level) to reflect this change. Tell students to record the AQI level in Question #4 on their Student Worksheet, and if the AQI changed, why they think this occurred. Discuss the answers with the class.

14. Have the class press the "Reset" button on the lower left side so that everything returns to the original settings.

15. Tell students that a new, really awesome ATV (all-terrain vehicle) is now available in Smog City 2, and that lots of kids and their families are buying them. Under the Emissions category, have students increase emissions from "Off Road" vehicles to the highest setting (all the way to the right) and tell them to record what happens to the AQI in Question #5 of their Student Worksheet. Tell them to compare this AQI number to the Emissions number in Question #4, and if the AQI changed, why they think this happened. Discuss the answers with the class.

16. Have students press the "Reset" button.

17. Tell students that in Smog City 2, you can increase the population from near-zero to as high as about 2 million people. Tell students to observe the AQI under the current "Population" setting and record this information in Question #6 on their Student Worksheet.

18. Now tell students to change the "Population" control to the highest setting (farthest to the right). Ask students what happens to the AQI, and why they think this happened. Have students record this information in Question #6.

    After hearing some of the responses to Question #6, discuss with students that as population increases in an area, emissions and air pollution

usually also increase from the use of more energy, cars, consumer products, and industries.

19. Tell students that ozone can irritate the throat and lungs, cause coughing, and make asthma worse. Tell students to look at the top of the column on the left of the Save Smog City 2 from Ozone page and click on "Air Quality Index (AQI)" (the second heading).

    (*Note:* If the class is also studying particle pollution, you can mention that some of the health symptoms of ozone and particle pollution are similar, such as irritation of the throat, coughing, and aggravating asthma, but some health symptoms are different. For example, particle pollution can make heart disease worse.)

    Look at the color chart at the bottom of the AQI page with the class and review each different color's health message so that students understand how changes in air pollution, as reflected by changes in the AQI, can affect people's health.

20. Ask students what steps they think they or other people could take to reduce emissions and ozone pollution, and to record their answers in Question #7 on their Student Worksheet. Discuss the answers, as indicated below.

    (*Correct answers might include:* Drive less; take buses, trains, and subways instead of driving; walk and bicycle instead of driving; drive cars that produce less emissions; use ATVs less or use bicycles instead; use lawnmowers that don't use gasoline or electricity. Also, power plants could use wind power, solar power, or hydroelectric power instead of coal, oil, or natural gas. Factories can use cleaner technologies that produce fewer emis-

sions. Companies can make and sell fuels for cars from waste products instead of gasoline.)

For Further Exploration

Change some of the other settings in Save Smog City 2 from Ozone, such as Wind, Consumer Products, and Industry, and discuss with the class how these changes can affect ozone pollution, the AQI, and health.

Conduct some of the activities on particle pollution in Save Smog City 2 from Particle Pollution.

Explore the "Create Your Own Smog City 2 Experience" on the Smog City 2 Web site (best to do this after you have introduced particle pollution to students).

See the Temperature Inversion lesson(s) in this Toolkit (one for Grades 3-5, another for Grades 6-8) for more information on temperature inversions and air pollution.

Acknowledgments/Resources

Sacramento Regional Air Quality Management District and U.S. EPA.

Smog City 2 at: www.smogcity2.org.

National Science Education Standards

Unifying Concepts and Processes
Evidence, Models and Explanation

Science as Inquiry
Abilities Necessary to do Scientific Inquiry
Understandings About Scientific Inquiry

Science in Personal and Social Perspectives
Personal Health
Changes in Environments

Student Worksheet: Save Smog City 2 from Ozone

Name: _____

1. Record the current temperature and AQI in "Save Smog City 2 from Ozone":

   Current temperature:

   Current AQI:

Number	Color	Health Level

2. Record the AQI when the temperature is changed to 110^0 F:

Number	Color	Health Level

   If the AQI changed when you increased the temperature, why do you think this occurred?

3. Record the current "Clouds/Sky Cover" conditions and the current AQI.

   Current Clouds/Sky Cover:

   Current AQI:

Number	Color	Health Level

Name: _____

After you've changed the settings, record the new cloud conditions and the AQI under the new cloud conditions.

Clouds/Sky Cover when changed to highest level:

AQI when changed Clouds/Sky Cover to highest level:

Number	Color	Health Level

If the AQI changed when you changed the Clouds/Sky Cover to the highest level, why do you think this change occurred?

4. Record the AQI associated with the current Emissions level for Cars and Trucks:

Number	Color	Health Level

Now record the AQI when the Emissions level for Cars and Trucks was changed to reflect government use of low-emission vehicles (to second to lowest setting):

Number	Color	Health Level

Name: _____

If the AQI changed when you changed the Emissions level for Cars and Trucks, why do you think this occurred?

5. Record the AQI when new ATVs are bought and used (increase Off Road vehicles to highest level—far right). Compare this number to the Emissions numbers in Question #4.

Number	Color	Health Level

If the AQI changed when you changed the Emissions level for Off Road vehicles, why do you think this occurred?

6. Observe and record the AQI level at the current Population setting.

Current AQI:

Number	Color	Health Level

Name: _____

Then record the AQI when the Population level is changed to the highest setting.

AQI at highest Population level:

Number	Color	Health Level

If the AQI changed when the population increased, why do you think this occurred?

7. What steps do you think you or other people could take to reduce emissions and ozone pollution?

Teacher Answer Sheet: Save Smog City 2 from Ozone

1. Record the current temperature and AQI in "Save Smog City 2 from Ozone":

Current temperature: 90° F

Current AQI:

Number	Color	Health Level
175	Red	Unhealthy

2. Record the AQI when the temperature is changed to 110° F:

Number	Color	Health Level
202	Red	Unhealthy

Ask: If the AQI changed when you increased the temperature, why do you think this occurred?

Answer: Ground-level ozone increased because ozone levels are generally higher when temperatures are higher.

3. Record the current "Clouds/Sky Cover" conditions and the current AQI.

Current Clouds/Sky Cover: One cloud passing by

Current AQI:

Number	Color	Health Level
175	Red	Unhealthy

After you've changed the settings, record the new cloud conditions and the AQI under the new cloud conditions.

Clouds/Sky Cover when changed to highest level: More clouds

AQI when changed Clouds/Sky Cover to highest level:

Number	Color	Health Level
119	Orange	Unhealthy for Sensitive Groups

If the AQI changed when you changed the Clouds/Sky Cover to the highest level, why do you think this change occurred?

Answer: Air pollution, and the AQI, decreased because ozone levels are highest when there is lots of sunshine, and adding clouds reduced the amount of sunshine, which reduced ozone formation.

4. Record the AQI associated with the current Emissions level for Cars and Trucks:

Number	Color	Health Level
175	Red	Unhealthy

Now record the AQI when the Emissions level for Cars and Trucks was changed to reflect government use of low-emission cars (second to lowest setting):

Number	Color	Health Level
119	Orange	Unhealthy for Sensitive Groups

If the AQI changed when you changed the Emission level for Cars and Trucks, why do you think this occurred?

Answer: The AQI decreased from 175, Red, Unhealthy, to 119, Orange, Unhealthy for Sensitive Groups, because the lower emission vehicles released fewer NO_x and VOCs emissions, which decreased the formation of ozone pollution.

5. Record the AQI when new ATVs are bought and used (increase Off Road vehicles to highest level, far right). Compare this number to the Emissions numbers in Question #4.

Number	Color	Health Level
190	Red	Unhealthy

If the AQI changed when you changed the Emissions level for Off Road vehicles, compared to when you changed the Emissions level for Cars and Trucks for lower emission vehicles in Question #4, why do you think this occurred?

Answer: The AQI increased from 119, Orange, Unhealthy for Sensitive Groups in Question #4 (for lower emission vehicles) to 190, Red, Unhealthy, when the Emissions level for Off Road vehicles was increased for more ATV use. This occurred because the use of additional ATVs increased vehicle emissions, which contributed to increased ozone formation.

6. Observe and record the AQI level at the current Population setting.

Current AQI:

Number	Color	Health Level
175	Red	Unhealthy

Then record the AQI when the population level is changed to the highest setting.

AQI at highest Population level:

Number	Color	Health Level
215	Purple	Very Unhealthy

If the AQI changed when the population increased, why do you think this occurred?

Answer: As population increases in an area, emissions usually also increase from the use of more energy, cars, consumer products, and industries.

7. What steps do you think you or other people could take to reduce emissions and ozone pollution?

Answers: Drive less; take buses, trains, and subways instead of driving; walk and bicycle instead of driving; drive cars that make less emissions, such as hybrid vehicles and others that use less gasoline; use lawnmowers that don't use gasoline or electricity. Also, power plants could use wind power, solar power, or hydroelectric power instead of coal, oil, or natural gas. And, factories can use cleaner technologies that produce fewer emissions.

Student Handout

Be Air Quality Smart!

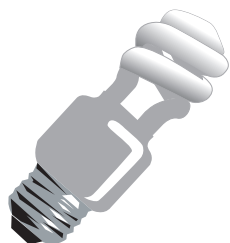# Four Things
You Can Do -
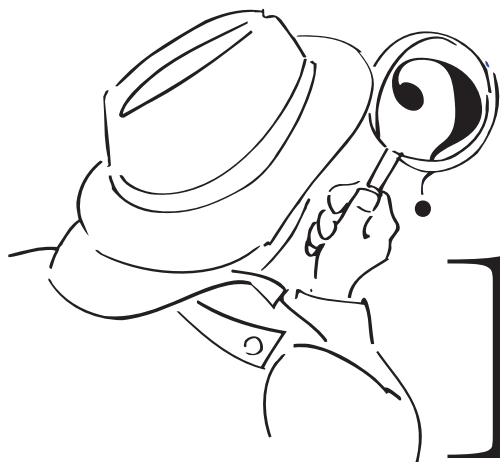
1 Check the Air Quality Index.

- Visit the AIRNow website at www.airnow.gov.
- Listen for air quality information on the radio or TV.

2 Protect your health when the air is polluted.

- Take it easier when you're outside.
- If it feels harder to breathe, tell an adult.

3 Help reduce pollution.

- Turn off lights and equipment when not using them.
- Walk or bike when air quality is good, or take a bus or train. But remember, your safety always comes first!

4 Have fun at the Smog City 2 Web site:
www.smogcity2.org

smog city 2

AQI
AIR QUALITY INDEX

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY