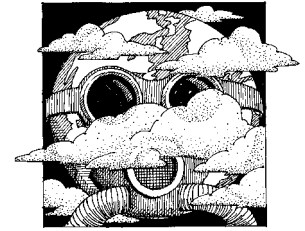


# TRANSPORTATION AND AIR QUALITY



## ESSENTIAL QUESTIONS

- ▲ How do automobile emissions affect our health and our planet?
- ▲ What are people doing to reduce harmful emissions?

## OBJECTIVES

The students will:

- Explain how automobiles contribute to air pollution.
- Research and understand the health effects of automobile pollutants.
- Recognize the importance of the individual, and that each person has the potential to make a difference.
- Understand a basic history of the environmental movement.
- Understand the role of the government, its affect on the individual and on the environment.

## ACTIVITIES

### WHO'S DRIVING CHANGE

Time: One or two 45-minute periods.

### AIR POLLUTION AND HEALTH

Time: Option A – 45 minutes.  
Option B – Two 45-minute periods.

### EMISSIONS AND THE EPA

Time: 45 minutes, follow-up discussion as needed

## STUDENT PREREQUISITES

- An understanding of percent change. Or this lesson can be used to reinforce a lesson on percent change.

## STANDARDS

**Technology:** Understand unintended effects of technology.

**Social Studies:** Understand the effect of inventions that have transformed daily life.

**Social Studies:** Recognize the importance of individual choices, actions and character.

**Health:** Research impacts of environmental factors on health.

**Civics:** Role of the individual in the political process.

**Civics:** Role of government agencies.

**Language Arts:** Identify basic facts from scientific literature; oral presentations; use electronic media for research (optional).

**Math:** Read and analyze tables, graphs and charts.

## TEACHING NOTES

After lesson #1 students should understand that automobiles play a major role in transporting Americans.

In this lesson students will learn about automo-

bile pollutants, their effect on human health, and the efforts of those who are working for change. Students will realize that reducing pollution from our transportation system is an on-going challenge and, even though much has already been accomplished, much still remains to be done.

In the activity *Who Cares*, students will reconstruct the history of the automobile and identify many of the causes and effects between automotive technology and society over the last century.

In the activity *Air Pollution and Health*, students will research and report on the adverse effects of the six criteria air pollutants and the greenhouse gas, carbon dioxide.

In the activity *Emissions and the EPA*, students will explore the significance and relative success of the EPA's efforts to reduce automotive emissions. They should discover that, although pollution controls have greatly reduced individual auto emissions, much of these gains have been offset by increased miles driven.

**Assessment:** Research skills, worksheets, oral presentations, class participation.

## BACKGROUND INFORMATION

The invention of the automobile transformed the world. It offered convenience, independence, and efficiency. Cars made it easier for people to live far away from their workplace and created new opportunities for leisure travel, adventure, and recreation. They even served as status symbols.

Today, travel by automobile also creates problems. We inadvertently damage air and water quality, and alter the global climate. Automobile pollutants significantly affect our health.

When a car's engine burns gasoline, several harmful compounds are emitted. These include carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOC), and particulates. Before the transition to unleaded gasoline, car engines also emitted lead. In the presence of sunlight, NO<sub>x</sub> reacts with VOC to form Ozone (O<sub>3</sub>), also known as smog. The United States Federal Clean Air Act identifies these six pollutants as having significant health impacts on humans. These are often referred to as the six criteria pollutants. For more information see the student information sheet, "Adverse Effects of Automobile Emissions."

Automobile use also significantly increases atmospheric levels of carbon dioxide (CO<sub>2</sub>), a recognized heat-trapping or "greenhouse" gas. One-third of the United States' CO<sub>2</sub> emissions come from the burning of fossil fuels for transportation. Increased CO<sub>2</sub> in our atmosphere traps more of the sun's energy, which is likely causing changes to the climate around the world. For more information, see the student information sheet "Adverse Effects of Automobile Emissions."

When automobiles were invented, no one could have predicted all the effects they would have on the environment, nor all the related issues they would raise, including traffic accidents, deaths, noise, loss of land to asphalt, disposal of junked cars, road-building costs, urban sprawl, and road rage. The automobile has truly been an invention with many unforeseen consequences – both negative and positive.

By the 1940's, car exhaust and emissions from oil refineries had produced periods of severe air pollution in Los Angeles and other cities. In 1950, scientists linked automobile exhaust to the creation of smog. As the number of cars continued to increase, the American public became more aware of the environmental problems that stemmed from our use of oil and man-made chemical compounds.

In 1962 Rachel Carson published *Silent Spring*, a book that described many of the suspected side-effects of using man-made chemical compounds. *Silent Spring* reached millions of people and raised the environmental consciousness of the American people.

On Thanksgiving weekend 1966 pollution, trapped by weather conditions in New York City, was blamed for the deaths of 168 people. In 1969 Cleveland's oily Cuyahoga River burst into flames, again, catching the attention of the American public. Public outrage over these and other environmental problems helped lawmakers establish, in 1970, the U.S. Environmental Protection Agency (EPA) along with the Federal Clean Air and the Clean Water Acts.

As an independent agency of the US government, the EPA's mission was to assume responsibility for environmental regulation and protection. In time, emission standards were established which limited the amount of pollution generated by motor vehicles. In Activity 2A is a timeline of events related to transportation and the environment. Use it to discuss the impact of the automobile on society and the environment.

## ACTIVITY 2.A

# WHO'S DRIVING CHANGE?

### OUTCOMES

At the end of this activity students should be able to:

- Identify groups of people who have influenced the design of the U.S.'s transportation systems over the last hundred years
- Propose how these groups influenced the U.S.'s transportation systems

### TIME REQUIRED

- One or two 45 minute periods.

### MATERIALS

- Student handout: Who's Driving Change?

For Option B

- A copy of the timeline cut into strips.

### TEACHER PREPARATION

Become familiar with the timeline and background information.

Cut timeline into strips.

## ACTIVITY OVERVIEW

While evaluating a timeline of events related to the development of the automobile students will begin to see how social pressures, economic influence, governmental action, and technology affected the development of our transportation systems. As a part of the discussion they will realize that the challenge of reducing pollution from our transportation systems is an on-going struggle and that, although much has been accomplished, much needs to be done.

During the activity they will place themselves in the shoes of their grandparents and parents. They will then step back into their own shoes and use what they have learned to form predictions on where the development of our transportation systems may go.

## ACTIVITY

Explain to students that they will be investigating the history of the automobile and air pollution. Let them know that they will be asked to think about why people throughout history changed the way they got around and what groups of people drove these changes. For example: why did people stop

using horse drawn carriages and start using trains to get from city to city? Why are automobile manufacturers trying to build cleaner cars?

Finally, they will be asked to think about the changes they might like to make in the way people get around today and predict what each change might do to the world of tomorrow.

Many students will find it helpful to have a large timeline of key events in the development of our nation's transportation systems available for their review during this activity. You may want to:

**Option A:** Hand out the background reading "Who's Driving Change?" and, as a reference source, the timeline "A History of Transportation and the Environment."

**Option B:** Have the class construct its own large-scale timeline that is posted somewhere in the room. Explain to the students that they will be participating in a class discussion concerning the history of the automobile and the environmental movement. To start, they will create, as a class, a timeline large enough to be displayed and used as a reference for this activity.

With a copy of the timeline cut into strips, separate the individual events. Randomly distribute one (or two) to each student.

Facilitate a discussion based on the timeline. Teacher background information is included.

Have the students share and post their event(s) on the timeline.

What other things happened during this time frame? Are they somehow related to this timeline? Can students place the birth years of their parents, grandparents, and great-grandparents?

Once students have a timeline available to them and have had a chance to review this timeline hand out to each student a copy of the background reading, “Who’s Driving Change?”

### **Who’s Driving Change: A Class Discussion**

Either through a class discussion or through small group discussions that then report to the class, have students respond to the discussion questions at the end of the handout “Who’s Driving Change?”

During the discussion emphasize:

- **Major changes occur** when many people either support a change (e.g. they buy and use a new technology or product) or they demand a change (e.g. they ask their government to lead the way to a change.)
- **The Environmental Protection Agency was started** because U.S. citizens wanted their government to monitor and help control pollution.
- **Use this discussion to introduce** the following activities:

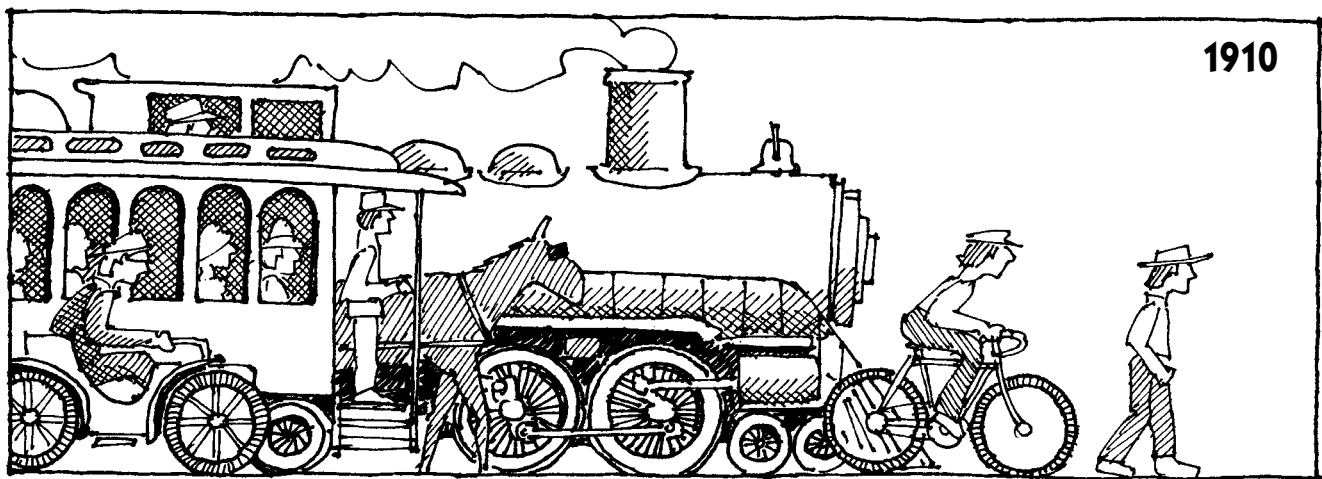
*Pollution and Health* where students will learn more about automotive emissions, and

*Emissions and the EPA* where students will analyze how successful the EPA has been in their efforts to reduce air pollution from cars.

# A History of Transportation and the Environment

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- 1825** First passenger railroad opens in England.
- 1860** First true bicycle, the “boneshaker,” becomes popular in Europe and America.
- 1869** U.S. Transcontinental railroad opens.
- 1885** Safety bicycle invented in England. Its popularity created a demand for better roads. Automobiles would take advantage of the better roads.
- 1887** First electric street railway opens in Richmond, Virginia
- 1890s** First electric and gasoline automobiles are developed and compete for popularity. Advantages of electrics: absence of noise and noxious odors; ease of control. Advantages of gasoline-powered vehicles: can travel longer distances without refueling, easier to refuel.
- 1890s** Most larger communities have electric streetcar systems (trolleys).
- 1899** Americans could buy electric automobiles from more than a dozen manufacturers.
- 1900s** Many early automobile owners fall in love with touring (driving out into the countryside). Gasoline automobiles, with their ease of refueling and range of travel without refueling, quickly become more popular than the electric automobiles.
- 1908** Henry Ford begins selling the Model T, designed for mass appeal.
- 1909** 124,000 cars manufactured. In comparison, 2,000,000 horse-drawn carriages manufactured.

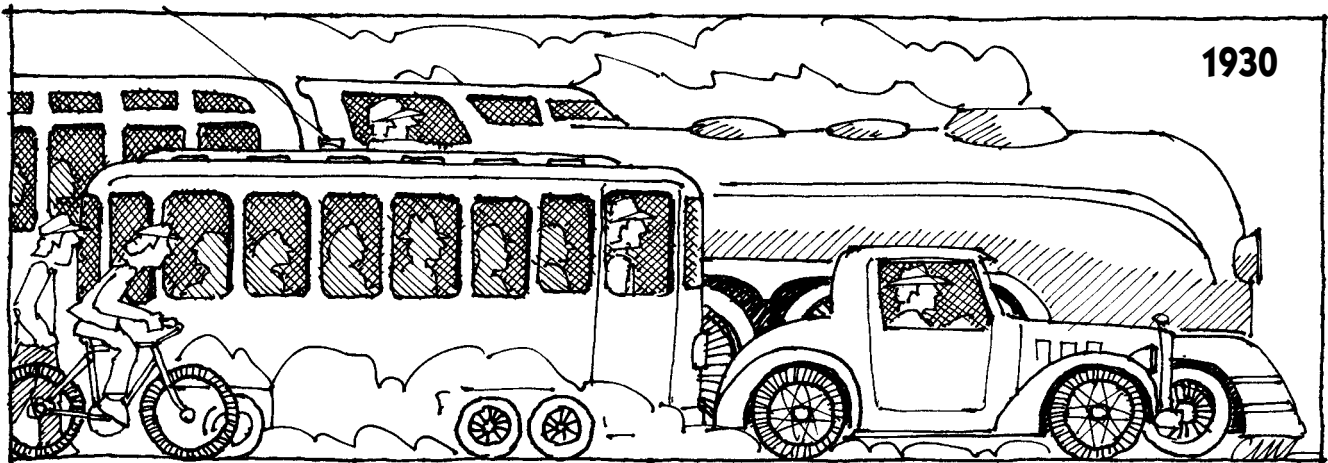


- 1914** Ford Motor Company introduces their new idea for increasing production, the moving assembly line. Model T, now costing \$360, becomes affordable to more Americans.
- 1916** The Federal Aid Road Act offers federal funds to the states for road-building.

## A History of Transportation and the Environment, page 2

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- 1920** Studebaker Company stops making horse-drawn wagons.
- 1920s** Outside cities, automobiles become the primary mode of travel. Suburbs based on automobile transportation begin to develop.
- 1929** Nearly five million cars manufactured. Americans own nearly one automobile for every five people.
- 1930s** Trolley lines begin to close down because of competition from buses and cars.

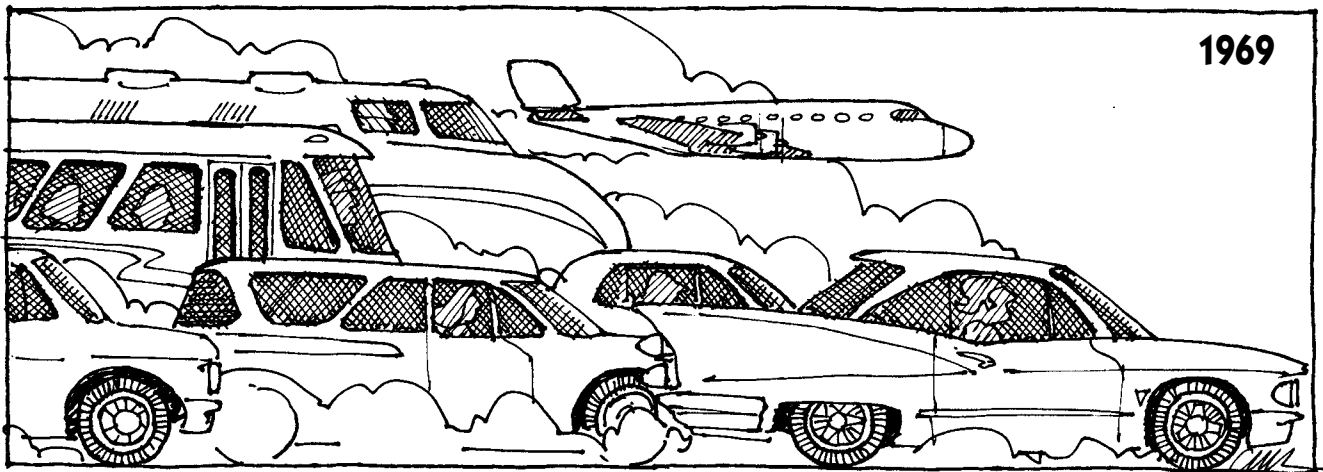


- 1940** First super highway opened.
- 1940s** Los Angeles and other cities begin to experience spells of severe air pollution, known as “gas attacks.” Automobile exhaust and petroleum refinery emissions trapped in low-lying areas are the cause.
- 1950** Automobile exhaust is linked to the creation of smog.
- 1954** In Los Angeles, dense smog is blamed for causing 2000 automobile accidents in a single day.
- 1956** Interstate Highway Act passed. It leads to 44,000 miles of new highways.
- 1960** Numbers of cars escalate causing air and noise pollution in cities to become a major concern.
- 1963** Clean Air Act recommends national air quality standards. Air quality remains primarily a local concern.
- 1964** California requires minimal emission control systems on 1966 model cars.
- 1965** Motor Vehicle Air Pollution Control Act provides money for researching impacts of automobile related pollutants. Recognized as a national issue, not a local one.
- 1966** On Thanksgiving weekend, weather conditions in New York City cause air pollution to build up for three days. Pollution levels are blamed for the deaths of 168 people.
- 1967** Clean Air Act Amendment requires states to implement air quality standards set out in the 1963 Clean Air Act.

## A History of Transportation and the Environment, page 3

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- 1969** A photograph of the earth, taken from space, shows a tiny, fragile ball of limited resources, floating in a huge expanse of space. It dramatically alters human perceptions of our world.
- 1969** Nationwide public outcry over an oil spill from offshore drilling in southern California.
- 1969** Cleveland's oily Cuyahoga River bursts into flames catching the attention of the American public. Public outrage over this and other environmental problems helps lawmakers establish the EPA, the Clean Air Act, and the Clean Water Act.



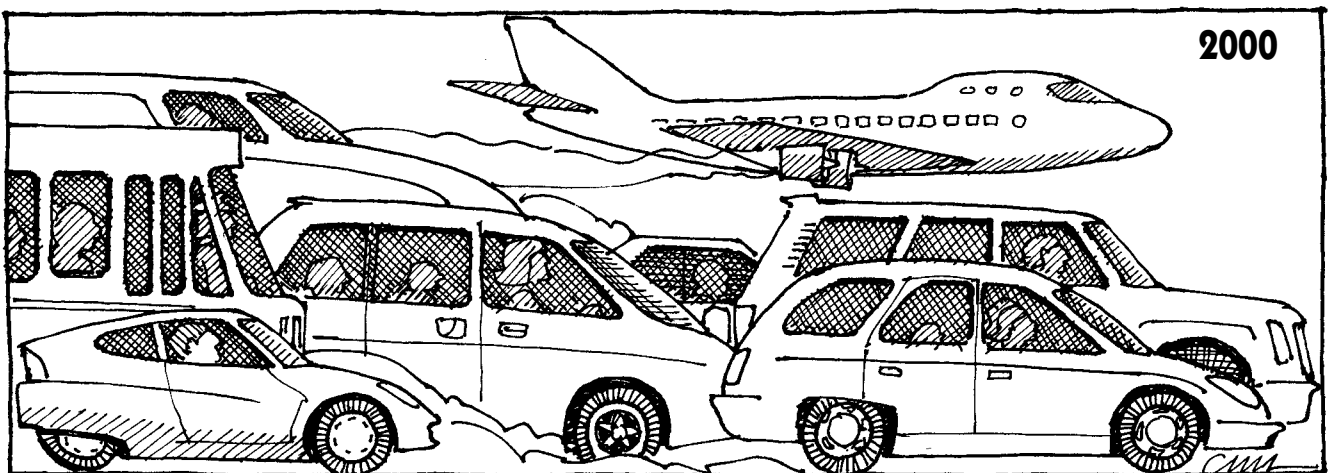
- 1970** Congress establishes the Environmental Protection Agency (EPA) as an independent agency of the US government and gives the new Agency broad responsibility for regulating motor vehicle pollution.
- 1970** The Clean Air Act of 1970 calls for 90 percent reductions in automotive emissions from new cars by 1976. As part of the Clean Air Act the U.S. Government requires for the first time that air quality in the U.S. meet clean air standards for six specified pollutants. Automobile exhaust includes all six of these pollutants. (These are known as the six criteria pollutants.)
- 1970** The first Earth Day. 100,000 people marched down 5th Avenue in New York City.
- 1973** Oil Producing Exporting Countries (OPEC) limit the amount of oil exported to the USA resulting in a gas shortage, high prices, and very long lines at gas stations.
- 1974** At the request of the auto industry, Congress delays some reductions in automotive emission standards until 1978.
- 1974** Energy Policy Conservation Act establishes the first fuel economy goals and the Corporate Average Fuel Economy (CAFE) program establishes a phase-in of more stringent fuel economy standards beginning with 1975 models.
- 1975** Unleaded gasoline and catalytic converters appear in response to hydrocarbon and carbon monoxide pollution standards.
- 1977** At the request of automakers, amendments to the Clean Air Act relax some of the 1970 guidelines.



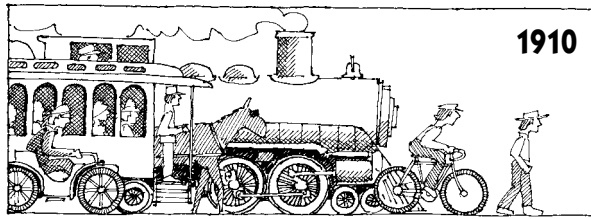
## A History of Transportation and the Environment, page 4

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- 1980s** Minivans, which are held to lower fuel economy standards than cars, become highly popular.
- 1981** New cars meet the amended Clean Air Act standards for the first time.
- 1985** EPA adopts stringent emission standards for diesel-powered trucks and buses, to take effect in 1991 and 1994.
- 1989** The supertanker, "EXXON Valdez" spills 11 million gallons of crude oil into the pristine waters of Alaska's Prince William Sound.
- 1990** Amendments to the Clean Air Act require stricter emissions designed to significantly improve air quality by 2005.
- 1990** California law requires automobile manufacturers to deliver zero-emission vehicles (electric vehicles) in the future.
- 1990s** Sport Utility Vehicles, which are held to lower fuel economy standards than cars, become highly popular.
- 1992** Earth Summit in Brazil brings increase international attention to global warming and other major environmental problems.
- 1994** Phase-in begins for cleaner vehicles required by the 1990 Clean Air Act.
- 1996** The first commercially produced electric vehicle in nearly 100 years goes on sale in California.
- 1997** An international treaty known as the Kyoto Protocol calls for mandatory reductions of the carbon dioxide emissions by industrial countries to slow global warming.
- 1998** U.S. EPA data shows that over 100 million people still live in counties with unhealthy air.
- 1999** The first electric-gasoline hybrid automobile goes on sale in America. It gets an average of 70 miles per gallon.
- 2000** Oil prices again rise sharply when OPEC nations limit the amount of oil they produce.



# Who's Driving Change?



Although the automobile has been around since the late 1800s it wasn't until the 1920s that it became a primary form of transportation for most Americans. Up until 1914, when Henry Ford introduced the moving assembly line and brought the price of the Model T down to \$360, cars had been too expensive for most Americans.

Until the late 1920s, you were more likely to ride an electric streetcar system (trolley), use a horse-drawn carriage, or ride a bicycle to get around town. That is, when you weren't walking. Roads outside of cities were poorly maintained and getting between the countryside and town was often difficult. Most people rode coal-powered passenger trains to get from town to town. During this time, bicyclists began to demand better town roads.

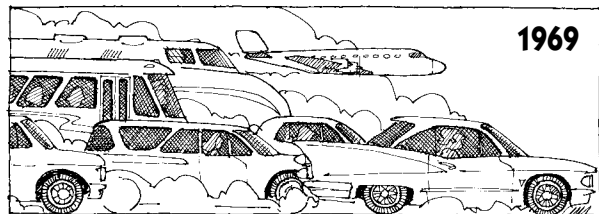
In 1916, the federal government made funds available for the first time for states to build and improve roads between towns. By 1929, with cars now affordable and roads improving, nearly one in five people had chosen to buy a car.

Throughout the 1930s increasing numbers of Americans choose the automobile as their preferred mode of transportation. The U.S. opened its first super highway in 1940.

In the 1940s, Los Angeles and other cities begin to experience spells of severe air pollution, known as "gas attacks." Automobile exhaust and petroleum refinery emissions trapped in low-lying areas were found to be the

cause. In 1950, automobile exhaust was linked to the creation of smog and, in 1954 dense smog was blamed for causing 2000 automobile accidents in Los Angeles in a single day. By 1960, the number of cars has escalated to the point where air and noise pollution in cities had become a major concern.

Throughout the 1960s, America's growing use of the automobile continued to contribute to air and water pollution. During the 1966 Thanksgiving weekend, 168 people in New York City died from air pollution trapped by adverse weather conditions. In 1969, Americans were shocked when Cleveland's oily Cuyahoga River burst into flames and an oil spill from offshore drilling in southern California threatened coastal wildlife.

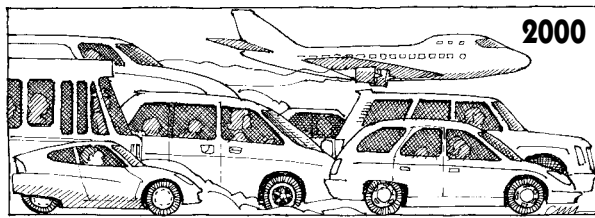


Public outrage over these and other environmental problems grew throughout the 1960s and, in 1970, 100,000 people marched down 5th Avenue in New York City for the first Earth Day. Public action finally spurred lawmakers into a period of action. In 1970 congress established the Environmental Protection Agency (EPA), the Clean Air Act, and the Clean Water Act.

Congress gave the EPA broad responsibility for regulating motor vehicle pollution and the Clean Air Act of 1970 called for 90 percent reductions in automotive emissions from new cars by 1976. Although some of these requirements were later delayed on request of the automobile manufactures, a period of actively cleaning up our air and water had begun.

## Who's Driving Change, page 2

By 1975, unleaded gasoline and catalytic converters had appeared in response to hydrocarbon and carbon monoxide pollution standards. Cities with large populations took steps to improve air quality by improving their public transportation systems including better buses and subway systems. Throughout the 1980s, automobile manufacturers begin producing cleaner gasoline-powered cars as clean air standards and pollution regulations were gradually phased in. Many manufacturers also begin to design cars that run on cleaner, alternative fuels such as electricity, propane, natural gas, and ethyl alcohol/gasoline mix. Manufacturers began to sell some of these alternatively fueled cars in limited quantities. In 1999, the first electric-gasoline hybrid automobile went on sale across America. It got an average of 70 miles per gallon thereby reducing the amount of fuel it burned.



Although air and water quality have improved greatly over the last 30 years, Americans continue to hear of environmental pollution as a result of our Nation's use of oil. Beginning in the mid 1980s, consumers began to buy more minivans, pickup trucks, and sport utility vehicles (SUVs), vehicles that burned more gasoline per mile. In 1989, the supertanker, "EXXON Valdez" spilled 11 million gallons of crude oil into the pristine waters of Alaska's Prince William Sound and 1997 U.S. EPA data showed that over 100 million people still lived in counties with unhealthy air. A new threat, global warming, has also entered the news.

### Discussion Questions:

During the following discussion, imagine living during each of the time-periods being talked about.

1. List the primary forms of transportation used in the U.S. from 1900 to 1930. What were some of the services or "wanted outputs" provided by these transportation systems? What do you think were some of the disadvantages or "unwanted outputs" of these transportation systems?
2. For the automobile to become widely used it had to be reasonably priced and sound roads had to exist on which to drive; neither of which was true in the early 1900s. In what ways do you think the general public helped bring about or support these changes?
3. As early as 1915, our country began to develop a system for moving cars. What were some of the advantages this system had over previous transportation systems? What disadvantages or "unwanted outputs" of this transportation system began to appear between 1940 and 1970?
4. In the early 1970s, automobile manufacturers began work on developing and marketing cleaner cars. In what ways did the general public help bring about or support this change? What role did the federal government play? What federal agency was given responsibility over regulating motor vehicle pollution?

## ACTIVITY 2.B

# AIR POLLUTION AND HEALTH

### OUTCOMES

At the end of this activity students should be able to:

- Identify the major pollutants resulting from gasoline-powered motors.
- Describe how these emissions impact human health.
- Describe how these emissions impact the environment.

### TIME REQUIRED

- Option A, using student handouts, 45 minutes.
- Option B, using suggested Internet sites, two 45-minute periods .

### MATERIALS

- Student handouts
- Student access to the web (optional)
- Teacher access to the web (optional)
- Student worksheets

### TEACHER PREPARATION

Assemble materials.

Read through background information.

Confirm Internet sites (optional).

Print out Internet sites (optional).

### ACTIVITY OVERVIEW

Through research, students will become familiar with the environmental and health effects of the six criteria pollutants identified by the U.S. EPA along with the greenhouse gas, carbon dioxide. Although student information handouts are supplied, we recognize that many students are more motivated to conduct research if they have to do a little digging themselves. For this reason we have also supplied a list of Internet sites containing sound information on this topic. Alternatively, you may want to assign this as a library research project or use a computer-based encyclopedia.

### ACTIVITY

Hand out the graphic showing the production of automobile pollution. Generate a discussion about air quality in your community. Ask the students:

- What is it that we are breathing? Do you think the composition or chemical makeup of our air has changed since the car was invented? How?

(Examples: Carbon dioxide levels have increased by 30%. Automobiles, as well as industrial processes, have increased the levels of harmful chemical compounds in our air.)

- What affects the quality of the air we breathe in this community? Consider manufacturing, electricity generation, residential factors, as well as transportation.
- What are fossil fuels? (They are naturally occurring fuels formed from the remains of prehistoric organisms.)
- Does anyone know what the biggest polluter of our air is? (Passenger cars and small trucks) There is one vehicle for every 1.7 people in this country. Almost all of them run on gasoline, a fossil fuel.
- What comes out the tailpipe when a car burns gasoline? List on the board the major pollutants/compounds resulting from gasoline-powered motors.

### **Carbon monoxide (CO)**

Results from incomplete combustion of fossil fuels

### **Carbon dioxide (CO<sub>2</sub>)**

Results from combustion of fossil fuels

### **Nitrous oxides (NO<sub>x</sub>)**

Results from burning fossil fuels at a high temperature

### **Volatile Organic Compounds (VOCs)**

Results from evaporation of gasoline and are released during the incomplete burning of fossil fuels

### **Particulate Matter (PM)**

Solid particles left over after combustion

**Lead (Pb)** Used to be contained in gasoline

### **Ozone (O<sub>3</sub>)**

Results when NO<sub>x</sub> and VOC react in the presence of sunlight

- How do you think these emissions impact our health?

Assign this last question as a research project. Working alone or in small groups, assign specific pollutants to be researched. The Air Quality Worksheet is for them to use to document their findings. Have the individuals or groups report back to the class. During student presentations, all students should be responsible for recording information on pollutants researched by other groups and individuals.

## **SOURCES OF INFORMATION**

**Option A:** Use the student background information sheet.

**Option B:** Internet or Library: These Internet sites have information on health effects of the major air pollutants.

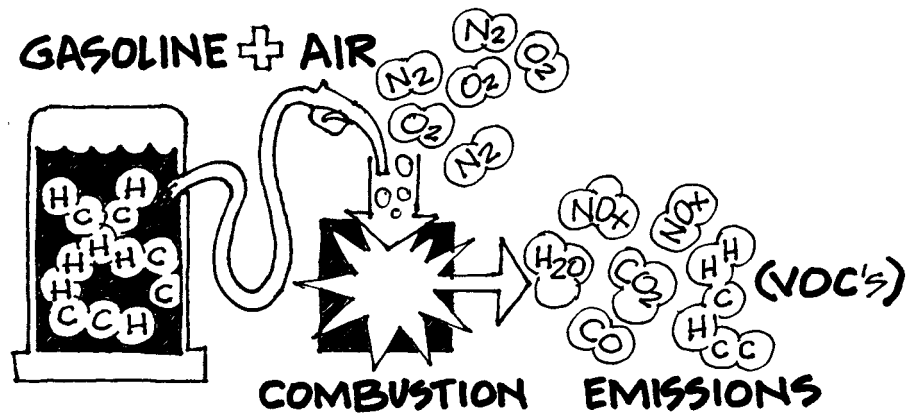
- **www.scorecard.org** (Environmental Defense). For a descriptive listing of the criteria air pollutants go to [www.scorecard.org](http://www.scorecard.org), (1) Click on "Criteria Air Pollutants," (2) find and click on it again, (3) find the pollutant listed, click on that.

This site also rates counties on emission levels of criteria air pollutants and health effects of air pollutants. Go to [www.scorecard.org](http://www.scorecard.org), (1) click on "Criteria Air Pollutants," (2) on the map, click on your state, (3) scroll down and click on the name of your state.

- **www.lungusa.org/air** (American Lung Association). Click on Outdoor Air Quality. Go to: Major Air Pollutants, Six major air pollutants
- **www.nsc.org/ehc/mobile/airpollu.htm** (National Safety Council). This site also has tips on what you can do to reduce air pollution.
- **http://www.epa.gov/oms/05-autos.htm** (US EPA Office of Mobile Sources). This site also has discussions on the combustion process, what has been done to control automobile emissions, and what emission control has meant for air quality.
- Information can also be found in online encyclopedias, although not as easily.

# Adverse Effects of Automobile Emissions

## TYPICAL COMBUSTION



Automobiles pollute the air. Although they are not the only source of air pollution, they are a major contributor. They discharge millions of tons of hazardous gases and particles every year. But even where it is not visible, the effects on our health are evident.

Air pollution can cause a wide range of problems from minor respiratory irritations and headaches to the more serious consequences of asthma, brain and nerve damage, cancers, birth defects, and even death. Unborn children, young children, and the elderly are especially at risk, along with those individuals with existing health problems.

The major air pollutants associated with cars and the burning of gasoline are: carbon monoxide, (CO), nitrogen oxides, (NO<sub>x</sub>), ozone (O<sub>3</sub>), volatile organic compounds, (VOC), particulate matter, (PM), and lead, (Pb). The burning of gasoline also produces

carbon dioxide (CO<sub>2</sub>), a heat-trapping, or “greenhouse” gas.

**Carbon monoxide (CO):** Carbon monoxide is a colorless, odorless, poisonous gas. It results from the incomplete combustion of gasoline. CO emissions are greatest when



starting the engine, running an untuned car, and when outside temperatures are low. Carbon monoxide can accumulate in areas where there is not adequate ventilation such as garages, tunnels, and even along roadsides when traffic is heavy.

When inhaled, CO inhibits oxygen from reaching the brain, heart, and body tissue. It decreases alertness and slows reflexes. Low concentrations can cause dizziness, headaches, and fatigue. High concentrations can cause

unconsciousness and death. People with heart and respiratory diseases are at greater risk.

### AIR

is made up of 75.5% nitrogen (N<sub>2</sub>), 23.2% oxygen (O<sub>2</sub>) and 1.3% other trace compounds.

### GASOLINE

is a mixture of many different hydrocarbons, molecules made up of hydrogen and carbon atoms. Trace amounts of other chemicals are added to adjust how it burns in car engines.

## PERFECT COMBUSTION

**GASOLINE**  
(hydrocarbons)

+

**AIR**

(mostly oxygen and nitrogen)

=

**CARBON DIOXIDE (CO<sub>2</sub>)**

**WATER (H<sub>2</sub>O)**

**UNAFFECTED NITROGEN (N<sub>2</sub>)**

## Adverse Effects of Automobile Emissions, page 2



**Carbon dioxide (CO<sub>2</sub>):** Carbon dioxide is a natural compound of air. We exhale it and plants need it for photosynthesis.

But, by burning fossil fuels, humans are raising the level of carbon dioxide found in our air. When oil is pumped out of the ground, processed into gasoline, and burned, the carbon once trapped in the underground oil deposits is moved into our air. For every gallon of gasoline burned in a car's engine, about 20 pounds of carbon dioxide are released into the atmosphere. Since the industrial revolution began, humans have burned enough gasoline, oil, coal, and other fossil fuel to raise the concentration of CO<sub>2</sub> in the atmosphere by 30%.

CO<sub>2</sub> is a heat-trapping, or "greenhouse," gas. As its concentration in the atmosphere increases, it traps more of the sun's heat much as a car's window traps heat inside the vehicle on a sunny day. Scientific evidence continues to accumulate suggesting that this heat-trapping property of CO<sub>2</sub> is causing the earth's average temperature to rise, resulting in changes to the climate. Although scientists cannot know the exact implications, they project flooding of coastal areas from rising sea levels and changes in precipitation and other local climate conditions that could alter forests, crop yields, and water supplies.

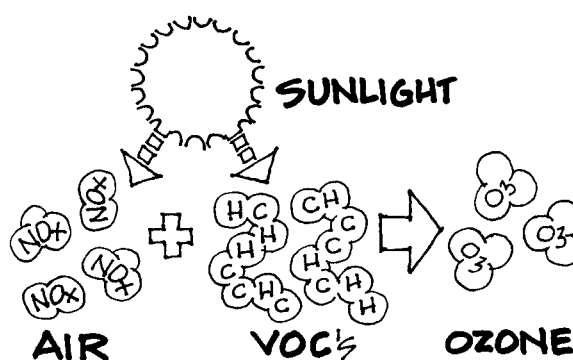


**Nitrous oxides (NO<sub>x</sub>):** Nitrous oxides include a variety of nitrogen compounds. These form when fuel is burned at high temperatures. They also play a major role in the formation of ozone, the primary component of smog.

Nitrogen dioxide, (NO<sub>2</sub>), It can irritate the lungs, particularly for those with asthma, and it may cause other respiratory diseases. As a gas, it is highly reactive with other compounds. As a solid, small particles can cause significant damage to air passages and lung tissues. It also reduces visibility.

**Ozone (O<sub>3</sub>):** Ozone is the most widespread air pollution problem. It is formed when NO<sub>x</sub> and VOC (Volatile Organic Compounds) react in the presence of sunlight.

The result is an intensely irritating gas that is the major component of smog. Warmer temperatures increase the amount of ozone formed. It is more problematic with higher temperatures during summer months.



**Note:** Harmful ground-level ozone should not be confused with beneficial ozone in the upper atmosphere. Automobile emissions contribute to ground-level ozone, but do not affect the ozone levels in the upper atmosphere. In the upper atmosphere, ozone is a naturally occurring compound that protects the earth from ultraviolet radiation. Ozone at ground level can damage lung tissue, decreasing air capacity. It can cause coughing and choking, chest pain, labored breathing, and nausea. It affects healthy individuals and it aggravates existing conditions relating to the lungs, heart and allergies.

**Volatile Organic Compounds (VOC):** VOCs are organic chemicals that produce vapors easily. Organic chemicals are the basic chemicals found in all living things and in all products derived from living things. Many organic compounds we use do not occur in

## Adverse Effects of Automobile Emissions, page 3

nature, but were synthesized by chemists in laboratories. At room temperature vapors readily escape from volatile liquid chemicals.

VOCs include gasoline, industrial chemicals such as benzene, solvents such as toluene and xylene, and perchloroethylene (principal dry cleaning solvent). VOCs are released from burning fuel, such as gasoline, wood, coal, and natural gas, and from solvents, paints, glues, and other products used at home or work. They are also released by evaporation of gasoline itself, such as while refueling at gas stations. Vehicle emissions are an important source of VOCs. Many VOCs are hazardous air pollutants; for example, benzene causes cancer.

VOCs react with nitrogen oxides in the presence of sunlight to form ozone, the major component of smog. (See ozone for more information).

**Particulate Matter (PM):** Particulate matter is made up of solid particles of various sizes, ranging from those visible to the human eye to those that are microscopic. Larger particles can be screened out by the nose and throat, but the smaller particles can find their way deep into the lungs and become trapped. There they can cause respiratory disease and lung damage, even cancer. Particles can also irritate the nose and throat and they can trigger breathing difficulties. For those people who already suffer from lung disease, heart disease or asthma, particulate matter are most harmful.

**Lead (Pb):** Lead is a toxic, heavy metal. It was once one of the most threatening air pollutants. Because of legislation requiring American automobiles to use unleaded gasoline, it is now less of a problem. However, it still continues to cause some concern as the soils along some roadsides remain contaminated. The unrelated issue of lead paint in older homes is a much more significant health concern.

Lead accumulates in the body so repeated exposure, as well as exposure to high concentrations, are both harmful. It affects the nervous, reproductive, digestive, kidney, and blood forming systems. High exposures can result in neurological disorders.

**Note:**

- Young children, the elderly, and those with compromised health are most at risk.
- Consideration must also be given to the effects of these pollutants in combination. It is generally assumed that the effects of these compounds acting together, add to the risk.



# Air Quality and the Automobile

Name: \_\_\_\_\_

Use this worksheet to record information about the major automobile air pollutants.



**POLLUTANT:** \_\_\_\_\_

**CHEMICAL NOTATION:** \_\_\_\_\_

**GENERAL INFORMATION:** \_\_\_\_\_

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**EFFECTS ON HUMAN HEALTH:** \_\_\_\_\_

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**POLLUTANT:** \_\_\_\_\_

**CHEMICAL NOTATION:** \_\_\_\_\_

**GENERAL INFORMATION:** \_\_\_\_\_

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**EFFECTS ON HUMAN HEALTH:** \_\_\_\_\_

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