AIR CARE

SECOND EDITION

# THE LAST GASP GAZETTE

THINK EARTH ENVIRONMENTAL EDUCATION PROGRAM



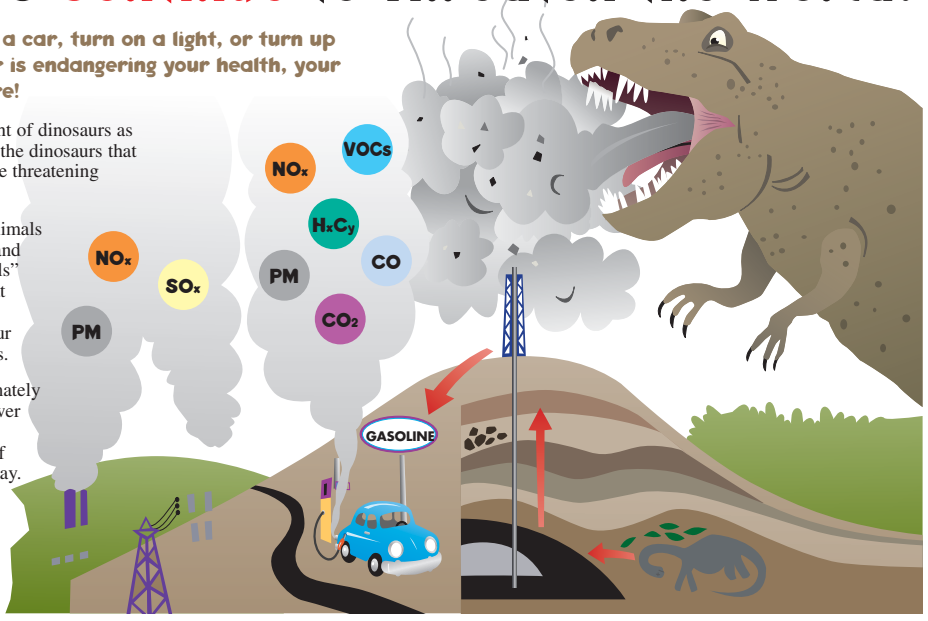
# Dinosaurs Continue to Threaten the World!

**Every time you ride in a car, turn on a light, or turn up the heater, a dinosaur is endangering your health, your planet, and your future!**

You've probably never thought of dinosaurs as a threat to today's world. Yet the dinosaurs that lived millions of years ago are threatening the world today. How?

The remains of prehistoric animals and plants became oil, coal, and natural gas. These "fossil fuels" are burned to power cars, heat buildings, run factories, and generate electricity to light our homes and run our appliances.

Fossil fuels provide approximately 80% of our energy! They power the world. But burning these fuels releases tons and tons of emissions into the air every day. And these emissions are polluting our air and also causing global warming.




CAUSES AND EFFECTS OF AIR POLLUTION

**FOSSIL FUELS: CAN'T LIVE WITHOUT THEM...CAN'T BREATHE WITH THEM!**

# Up, Up...But Not Away

Emissions – from vehicles, power plants, industries, homes, even natural sources like fires, volcanos, and decaying plants – go up into the air. Often you can't see them, but that doesn't mean that they aren't causing problems. Air pollution hurts people, plants, animals, buildings, statues, and fabrics.

## Smog

Gases, vapors, smoke, and particles combine with each other in sunlight and mix with oxygen and moisture to pollute the air we breathe.

**Caused by:**
- Ozone, which is formed from:
  - Nitrogen oxides (NOx)
  - Volatile organic compounds (VOCs)
  - Hydrocarbons (HxCy)
- Carbon monoxide (CO)
- Particulate matter (PM10, PM2.5)

**Immediate Effects:**
- causes chest pain, coughing, nausea, headaches
- stings eyes
- makes breathing difficult
- increases asthma attacks
- turns air brown
- decreases visibility
- injures leaves and stunts plant growth

**Long-Term Effects:**
- prevents proper lung development in children
- increases respiratory illnesses
- increases risk of cancer
- affects animals' health
- eats away plaster
- cracks rubber
- corrodes metals
- peels paint and fades color
- damages fabrics
- decreases property values and tourism
- hurts agriculture

## Global Warming

A natural, invisible layer of gases over the Earth traps some of the sun's heat that radiates from our planet back into space. These gases help keep the Earth warm and livable. But more and more of these gases are being released into the atmosphere from the activities of humans, so more and more heat is being trapped. This is increasing the average temperature on Earth.

**Caused by:**
- Carbon dioxide ($CO_2$)
- Other gases – methane, nitrous oxide, chlorofluorocarbons (CFCs)

**Effects:**
- melts glaciers, which could raise sea levels and flood coastal areas
- melts polar ice, which polar bears depend on to live
- disrupts ocean currents, which changes climate patterns and affects wildlife
- causes more hurricanes, tornadoes, and cyclones world wide
- changes and harms forests, crop lands, coral reefs, and wildlife habitats

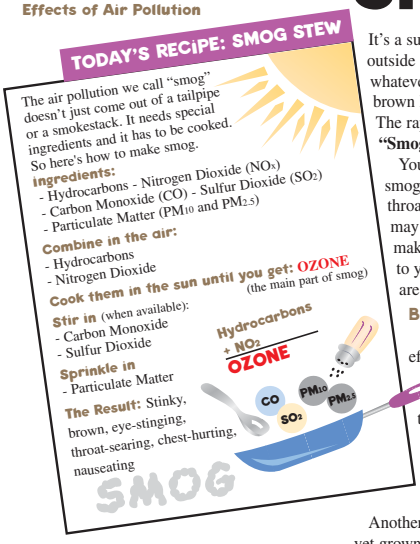
## Acid Rain

Emitted gases mix with water vapor and oxygen in sunlight to form water that is "acidic." This acidic water falls to Earth as either rain or snow or fog.

**Caused by:**
- Sulfur oxides ($SO_x$)
- Nitrogen oxides ($NO_x$)

**Effects:**
- damages forests and crops
- kills fish and plants
- eats away buildings and statues
- pollutes water supplies

# Smog..it'll Choke Ya!




It's a sunny summer day, so naturally you want to go outside and play – rollerblade, bike, shoot baskets, whatever. But as you look out, you see that familiar brown haze in the sky. It's a sunny summer *smoggy* day. The rap song starts to play through your head – **"Smog... it'll choke ya... Smog... it's no good."**

You know that when you play outdoors on a smoggy day, your eyes sting and sometimes your throat hurts and your chest feels tight. But what you may not know is that the smog could very well be making you sick and doing some permanent damage to your heart and to your lungs. And you, as a kid, are at greater risk.

### Bad for Me, Worse for You

Air pollution is harmful to everyone, but the effects are worse for young people. Why?

One reason is that children and teens breathe faster and take in more air in relation to their body weight and lung size. And when playing hard, kids, like everyone else, breathe through their mouths. That means the air doesn't pass through the natural filters in the nose; thus, the lungs are exposed to more pollutants.

Another reason that air pollution is harmful to those not yet grown-up is that they have not yet grown up. Bodies that are still growing and developing are more likely to be harmed from pollutants.

### Not Just an Irritation

Besides just irritating the eyes, nose, sinuses, throat, and bronchial tubes, air pollution can cause serious, long-term damage. For example, children brought up in smoggy cities have been shown to have 10 to 15% less lung capacity – for life! And studies indicate that as air pollution increases so do such illnesses as bronchitis and asthma. Other studies report that more people die on heavily polluted days than when the air is relatively clean. In California, it is estimated that each year more than 9,000 persons die prematurely as a result of illnesses aggravated by air pollution. Many more people are absent from school and work because of the effects of smog.

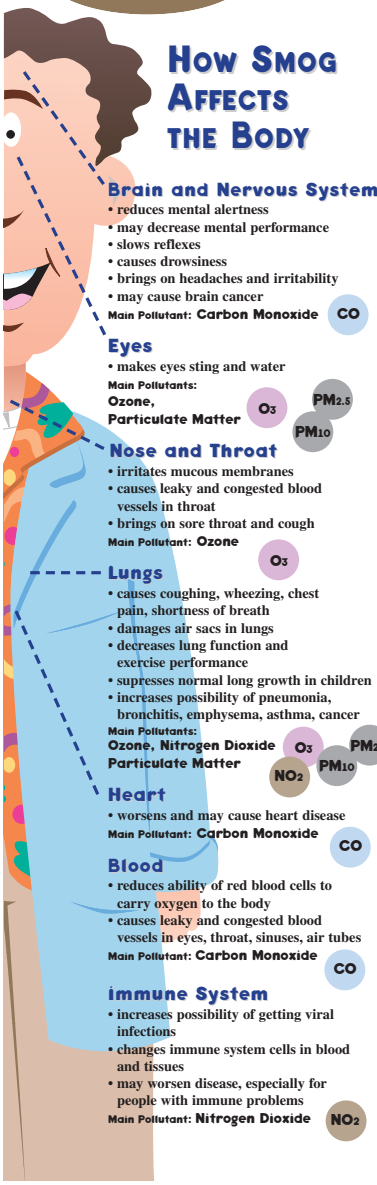
### Breathe Easy

So, it's a smoggy day ... what do you do? Some tips include:

- cut back on outdoor activity, especially in summer
- exercise in the morning, particularly in summer
- stay indoors if you have bronchitis, asthma, or heart disease.

And, of course, do your part to help reduce emissions that cause smog, so maybe your kids won't have to worry about playing outdoors on a smoggy day.

CAUSES AND EFFECTS OF AIR POLLUTION



## How Smog Affects the Body

### Brain and Nervous System
- reduces mental alertness
- may decrease mental performance
- slows reflexes
- causes drowsiness
- brings on headaches and irritability
- may cause brain cancer

Main Pollutant: **Carbon Monoxide** CO

### Eyes
- makes eyes sting and water

Main Pollutants: **Ozone,** $O_3$ **Particulate Matter** $PM_{2.5}$ $PM_{10}$

### Nose and Throat
- irritates mucous membranes
- causes leaky and congested blood vessels in throat
- brings on sore throat and cough

Main Pollutant: **Ozone** $O_3$

### Lungs
- causes coughing, wheezing, chest pain, shortness of breath
- damages air sacs in lungs
- decreases lung function and exercise performance
- supresses normal long growth in children
- increases possibility of pneumonia, bronchitis, emphysema, asthma, cancer

Main Pollutants: **Ozone, Nitrogen Dioxide** $O_3$ $PM_{2.5}$ **Particulate Matter** $NO_2$ $PM_{10}$

### Heart
- worsens and may cause heart disease

Main Pollutant: **Carbon Monoxide** CO

### Blood
- reduces ability of red blood cells to carry oxygen to the body
- causes leaky and congested blood vessels in eyes, throat, sinuses, air tubes

Main Pollutant: **Carbon Monoxide** CO

### Immune System
- increases possibility of getting viral infections
- changes immune system cells in blood and tissues
- may worsen disease, especially for people with immune problems

Main Pollutant: **Nitrogen Dioxide** $NO_2$

# What's Your AQI?

You snap on the radio and you hear, "The air quality index reported at noon today is 160. The air is unhealthy."

You know "unhealthy" is not good, but what is the "air quality index," and just what does that "160" mean?

### The Air Quality Index

The Air Quality Index (AQI) was developed by the Environmental Protection Agency (EPA). The AQI provides information about daily levels of air pollution. In all urban areas in the United States with populations more than 200,000, six major pollutants are measured:

- ozone
- carbon monoxide
- nitrogen dioxide
- sulfur dioxide
- particulate matter less than 10 microns–about 1/7 of the width of a human hair (PM10)
- particulate matter less than 2.5 microns–so tiny they are invisible to our eyes (PM2.5)

For each pollutant, EPA has established standards – National Ambient Air Quality Standards. When the amount of the pollutant in the air during a specified time (an hour to a day, depending on the pollutant) is over that standard level, the air is declared unhealthy.

The standards measure most pollutants in parts per million. For example, the National standard for ozone is 0.08 parts per million (ppm) averaged over an 8-hour period; that is, if more than 8/100 of one part of ozone appears in a million parts of air, the air is not considered clean. In California, the State standard for ozone, as well as for several other pollutants, is even tougher, 0.07 ppm.

The AQI converts these standards to a number on a scale of 0 to 300. The most important number on the scale is 100. An AQI over 100 indicates that a pollutant is in the unhealthy range. This means that health problems are a possibility, especially for "smog-sensitive" people, like those with existing heart or lung disease, those with asthma or emphysema, pregnant women, outdoor workers, children under 14, the elderly, and athletes. And it means that you should take precautions.

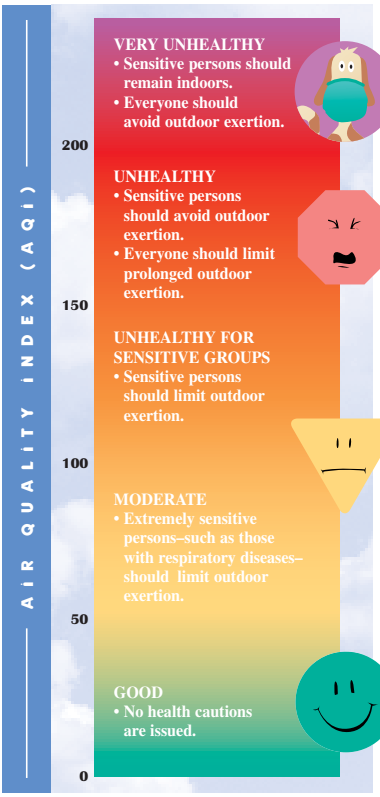
When the pollution index is reported as one number – like the "160" at the beginning of this article – it refers to the highest number of the six pollutants measured. In most newspapers, especially in cities where air pollution is a problem, forecasts are given for that day or the next. Most air quality management agencies show AQI reports on their websites for the areas they serve. Check your newspaper or the Air Quality Management District website (www.aqmd.gov).

### Change with Seasons

If you track the air quality index over time, you'll notice seasonal trends. For example:

- Carbon monoxide is higher in the fall and winter months. Cold weather makes it much more difficult for emissions control systems on cars to work efficiently. Also, CO is higher in the mornings and evenings because of rush hour traffic.
- Ozone is higher in the summer. Heat and sunlight transform the hydrocarbon and nitrogen dioxide emissions into ozone. In most areas, ozone is higher in the afternoon when the sunlight has had time to react with emissions.

**So what's your community's AQI….and what are you doing to improve it?**



# Combustion Chemistry

Air pollution comes from burning fossil fuels – in power plants, industries, vehicles. Today, air pollution is created mostly from the emissions from cars, trucks, planes, and trains.

To see just how vehicles create these emissions, we need to do a little "combustion chemistry." Don't worry, it's not hard.

### What Makes a Car Go?

First, let's look at how a car works. In a car's motor – called an internal combustion engine – four to eight pistons move up and down...

to turn a crankshaft...

that is connected to a drive train...

that eventually turns the wheels of the car.

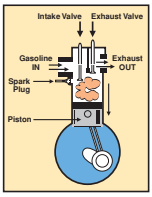
This is sort of like the pedals of a bicycle going up and down...

to turn a sprocket...

that is connected to a chain...

that eventually turns the wheel of the bike.

To push each piston down in its cylinder in the car's engine, small amounts of vaporized gasoline (which is made from oil, a fossil fuel) are exploded, or combusted (get it ... internal *combustion* engine), by a spark from the spark plug. The hot gas expands and pushes against the piston head. As the piston moves back up, it pushes the combusted gas out of the combustion chamber, making room for more vaporized gas to continue the process.




This action, of course, happens quickly over and over and over – just like the pedals on a bike going round and round and round.

The exhaust moves out of the combustion chambers, through the muffler, out the tailpipe, and into the air ... vehicle emissions.

### in a Perfect World

If combustion were complete – that is, if the gasoline were all burned – the emissions would not be such a problem. But combustion is rarely complete.


# Getting Dieseled

You're in your car at a stoplight, waiting behind an old yellow school bus. The light turns green, the bus moves out, and you are enveloped in a cloud of thick, black smoke. "Phew," you say, trying to cough and hold your nose at the same time. "This can't be good for me."

You've just been "dieseled" – and you're right, it's not good for you.

### Dirty Diesel

Diesel engines, which are internal combustion engines designed to burn diesel fuel, have always been dirtier than other engines. They produce more emissions, especially fine particulate matter. One older, heavy-duty diesel truck can spew out as much soot as 150 average new cars! And diesel emissions do more harm.

Studies have found that the particles in diesel exhaust can cause cancer. That's right. There's a cancer risk just breathing the air, especially when you're driving in heavy traffic or standing at a busy intersection. The tiny particles can be inhaled into the lungs, where they embed themselves. There, chemicals dissolve out of the particles and spread through the body. Even smaller particulate matter – nanoparticles, which are one thousandth the width of a human hair – are known to be able to cross into areas of the body that the larger particles cannot reach. Not good – especially over a lifetime.

### Workhorses

So why don't we just quit using diesels? Because diesel engines are like workhorses. They are powerful and reliable; they use less fuel than gasoline engines; and they are tough enough to be driven for years and years.

Ships and dock equipment that bring goods into ports, trains and trucks that haul products, tractors and bulldozers used on farms and in construction, and buses that transport people – all burn diesel fuel. Reducing diesel pollution without disrupting the many industries that depend on diesel engines is a big challenge.

### The Clean-Up

Only a small percentage of all our vehicles run on diesel fuel, but in the past these vehicles have accounted for a very high percentage of pollutants pumped into the air. So, three basic approaches have been taken to clean up diesel exhaust.

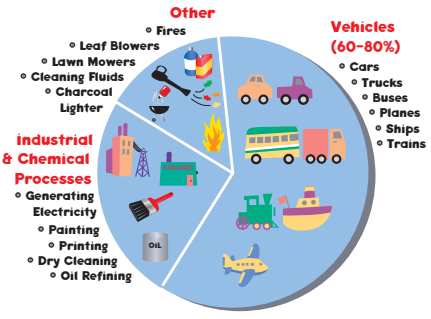
**1. Improve the diesel engine.**
Newly designed diesel engines are much cleaner than those sold 10 or 15 years ago. These new diesel engines use filters – particulate traps – that can reduce particulate emissions by 80 to 90 percent. Some also have oxidation converters – like catalytic converters on gasoline-powered cars – that can reduce nitrogen oxide emissions by 25 to 50 percent. But this doesn't mean that the air will be instantly cleaned up. The changes apply only to new engines. Many older diesel engines on our roads, railways, and waterways are still spewing out pollution. Government agencies are providing funding incentives to get these older vehicles replaced as soon as possible.

**2. Clean up diesel fuel.**
A new diesel fuel has been developed that has 97% less sulfur, a smelly element that affects both our health and the environment. The new fuel also reduces the emissions of particulate matter and of nitrogen oxides, both ingredients in smog. The new fuel will help older diesel engines run cleaner; but the new diesel engines running with the new fuel (the only fuel they will run on) will produce 88 percent fewer particulates, 77% less nitrogen oxides, and 3000 percent less sulfur! That means diesels can meet the same emission standards as gasoline-powered cars.

**3. Convert to other fuels.**
Many diesel trucks and buses are being converted to natural gas engines. Cleaner-burning natural gas has become particularly popular for buses that stay within a local area. Because they return to a central spot, they do not need to worry about finding places to fuel up. Also, a locomotive engine called the Green Goat uses more than 300 batteries along with its small diesel engine to improve fuel economy and reduce pollution.

Slowly but surely, dirty diesel is becoming a thing of the past.

## SOURCES OF EMISSIONS THAT CAUSE SMOG




## EMISSIONS: WHERE DO THEY COME FROM? WHAT HARM DO THEY DO?

| Emissions | Sources | Effects |
|---|---|---|
| Hydrocarbons (HxCy) or Volatile Organic Compounds (VOCs) — HxCy | • Vehicle exhaust<br>• Evaporation of chemicals and fuels<br>• Natural sources (fires, volcanoes, decomposition) | • forms **OZONE**, which irritates eyes, noses, throats and impairs breathing |
| Nitrogen Dioxide ($NO_2$) — $NO_2$ | • Vehicle exhaust<br>• Factories and power plants that burn fossil fuels | • forms **OZONE**<br>• turns air brown<br>• causes acid rain<br>• increases possibility of getting sick<br>• makes breathing difficult |
| Carbon Monoxide (CO) — CO | • Primarily vehicle exhaust<br>• Burning wood or charcoal | • decreases oxygen in blood<br>• reduces mental alertness<br>• causes drowsiness<br>• causes headaches<br>• slows reflexes<br>• worsens and may cause heart disease |
| Sulfur Dioxide ($SO_2$) — $SO_2$ | • Primarily from coal-burning power plants<br>• Vehicle exhaust | • causes acid rain<br>• makes breathing difficult |
| Particulate Matter ($PM_{10}$) ($PM_{2.5}$) — PM | • Vehicle exhaust (especially diesel)<br>• Road dust<br>• Construction<br>• Rubber from tire wear<br>• Soot from fires | • invades deep into lungs, which makes breathing difficult and damages lungs<br>• irritates eyes<br>• causes cancer<br>• reduces visibility<br>• discolors buildings |
| Carbon Dioxide ($CO_2$) — $CO_2$ | • Vehicle exhaust<br>• Factories and power plants that burn fossil fuels<br>• Burning or decaying trees and plants | • causes global warming |

# Battling Smog

WHAT'S BEING DONE

## NEWSFLASH!

**....Los Angeles, July 1943** – *Los Angeles residents are under a "gas attack"– from their own air! Fumes fill lungs. Eyes are severely irritated. Visibility is reduced to 3 blocks*

**....Donora, Pennsylvania, October 1948** – *A heavy smog has settled into the area and visibility is so poor that even residents can't find their way. Doctors are flooded with calls as almost half the population falls ill. Twenty people have died.*

**....London, December 1952** – *A "killer" smog is blamed for 4,000 deaths. The pollution is so thick that people can see no more than 3 feet in front of them.*

Thus, the war began...

To fight back against the smog, many actions were taken – from banning backyard incinerators to controlling smoke from factories. Visibility improved a little, but still eyes watered and air sometimes smelled like bleach. Then in the early 1950s, a California scientist linked emissions from automobiles with the formation of ozone – the primary ingredient in smog. Now that we knew the enemy, we could figure out how to battle it.

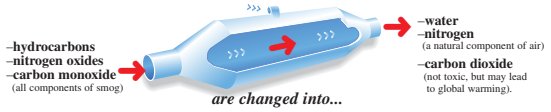
## THE BATTLES SO FAR...

In 1970, the Clean Air Act (CAA) was passed. This federal law and its amendments in 1977 and 1990 established many requirements for states, industries, businesses, automakers, and others to reduce air pollution throughout the United States. Since motor vehicles are a major source of smog in the U.S., the Clean Air Act has many regulations that affect cars. Violators of CAA requirements can be fined or penalized in other ways.

The CAA and the development of new technologies are helping us defeat smog.

### 1970s: The Catalytic Converter

Catalytic converters first appeared in new cars in 1975. According to many people, it was the most important device invented in the war against smog. Installed in the exhaust system of vehicles, the catalytic converter reduces carbon monoxide, hydrocarbon, and nitrogen oxide emissions. The catalytic converter is one of the biggest reasons today's cars produce less than 5% of the emissions produced by cars of the 1960s. The catalytic converter is also greatly responsible for eliminating lead emissions, which are toxic to humans. Catalytic converters required unleaded gasoline, resulting in the rapid decline of the use of lead in gasoline.




### 1980s: Reformulated Gasolines

Since burning gasoline in cars causes harmful emissions, it makes sense to try to change the gasoline so that it produces fewer emissions. The Clean Air Act has required just such changes in gasoline sold in smoggy areas. In the 1980s, detergents were added to gasoline to keep engine deposits from building up, which helps fuel burn cleanly. Also, gasoline was produced with higher oxygen content, allowing the gas to burn more completely so that carbon monoxide emissions were reduced. These "reformulated gasolines" helped reduce smog-forming emissions as much as 25%.

### 1980s: Required Smog Checks

In the 1980s, many states began to require vehicle checks to identify and fix vehicles emitting excessive pollution. These checks – either once a year or once every two years – have helped remove many of the older "polluter" vehicles from the roads.

### 1980-2000: Smaller, Lighter Cars

Every 100 pounds less a car weighs means about one more mile per gallon. In 1970, the average car (not including SUVs and trucks) weighed 4,000 pounds; in 2000, it weighed only 3000 pounds. Lighter cars mean higher gas mileage and fewer emissions.

### 1980-Present: Cleaner, More Efficient Gasoline Engines

To meet emission standards mandated by the Clean Air Act and other legislation, car makers began producing better engines. Computerized fuel-injection systems were developed to mix just the right amount of fuel and oxygen for more complete combustion.

### 1980s-Present: Stationary Sources of Air Pollution

Though most air pollution usually comes from mobile sources like cars, trucks, trains, boats, and airplanes, pollution also comes from stationary sources, such as factories, stores, and our own homes. Whenever we use products containing chemicals made from fossil fuels (such as paint and cleaning solvents) and whenever we burn fossil fuels directly (such as to heat buildings and to generate electricity at power plants), air pollutants are released into the air. But new products – such as water-based paints – now contain fewer or none of these fossil fuel chemicals. Also, many industries – such as printing and metal manufacturing – have developed new processes that produce fewer pollutants and new technologies that can capture more emissions before they are released into the air.

### 2000-Present: Alternate Sources of Energy

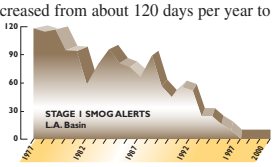
New technologies to power vehicles have started to appear. Hybrid engines – running on gasoline and electricity – improve gas mileage and thus reduce emissions. Fuel cells – long used in spacecraft – are being tested in cars and buses. Fuel cells use hydrogen, not fossil fuel, to power an electric motor, resulting in *no* polluting emissions.

***Chino, California, hydrogen refueling station on the state's "Hydrogen Highway."***

## THE WAR CONTINUES...

We have made progress in the war against smog. Smog has retreated. For example, in California, ozone levels today are about half of what they were in 1980, and the number of "Health Advisories" has decreased from about 120 days per year to only about 20 days per year in the 2000s.

But despite all of the improvement, the war isn't over. Smoggy cities, such as Los Angeles and Houston, must continue to work hard to meet Federal and State standards for ozone, particulate matter, and other air pollutants.




It has been estimated that 160 million Americans live in areas in which at least one air pollutant is over the standard established by the Environmental Protection Agency. And, unfortunately, the decreases in pollutant levels seem to be leveling off since 2000. Air pollution from motor vehicles is still a major problem. With all that's been done to reduce emissions, how can this be?

### More People

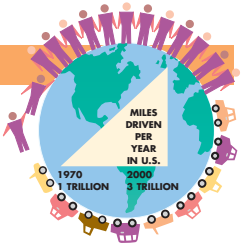
First, there are simply a lot more people today, and the population keeps increasing. Not only are there more people, but also the people own more cars. Whereas a family of four in the 1960s might have owned one car, many now own two or three. There are 600 million passenger cars in the world today; by the year 2030, twice as many cars are expected – 1.2 billion.

### More Miles

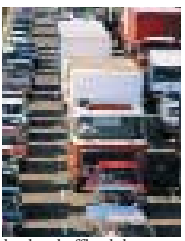
All these people are also driving more miles, which means they are burning more gasoline. Between 1970 and 2000, the total annual number of miles driven in the United States tripled – from 1 trillion to 3 trillion miles per year.

The number of miles per year is increasing so rapidly because:

- many people commute long distances to work
- three-fourths of the people drive to and from work alone
- little mass transit is available in many cities.




### More Vans, Trucks, SUVs



Mini-vans, small trucks, and especially sport utility vehicles have been very popular. And that's been a problem because in the past, gas-mileage and emission requirements for these vehicles were not as tough as for cars. But this is changing. By 2009, cars of all sizes in California will have the same minimum standards for gas mileage and emissions.

### More Products and Product Movement

As our population increases, so does business. For example, more products are manufactured, more ships bring products into ports, more equipment is used to load and offload the cargo, and more trucks and trains move the products all over the country. And all this activity increases air pollution.

All of our efforts at fighting smog have worked well, but they won't be enough for the future. We must continue to reduce the emissions from motor vehicles and other sources if we're going to win the war against air pollution.

# Cool Cars

What kind of cars did your grandparents drive when they were young? No matter what kind, they were most likely powered by an internal combustion engine – basically the same kind of engine that powers most cars today. The internal combustion engine (ICE) has been around for more than 100 years.

But now, finally, car companies are developing other ways to power cars – ways that produce less pollution. Most of the new cars being developed are a form of the original electric vehicle (EV), which has been around since the early 1900s. Cars powered by electric motors have no tailpipe emissions – in fact, they have no tailpipes – so they are much less polluting than those powered by ICEs.

Some of these cars are available now; others are on the way. Before long, you may be driving one of these cool cars.

## BETTER ICE

***How has the internal combustion engine (ICE) been improved?***

Through the years, technology has tweaked and toyed with the engine to save gasoline, improve performance, and reduce emissions. Some improvements include:

- **Catalytic Converter** to change polluting emissions into non-polluting emissions.
- **Fuel-Injection** to mix just the right amount of fuel and air for more complete combustion.
- **Variable Valve Timing** to precisely control when the valves open and close in each cylinder, resulting in more complete combustion.
- **Lean Burn Engines** to run on a "lean" mixture of fuel – more air, less gasoline; instead of the usual air to fuel ratio of 14.5 to 1, in the lean burn engine, it is about 22 to 1.
- **Direct Injection** to deliver the fuel right into the combustion chamber, which allows for "ultra-lean" mixtures – up to 50 to 1.

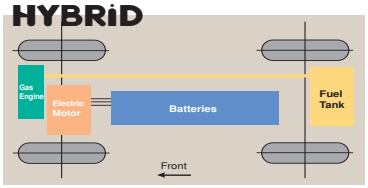
Each of these technologies cuts down on the amount of fuel used and the amount of emissions going into the air.

**TECHNOLOGY: CAN IT SAVE THE DAY?**

## HYBRID VEHICLES

"Hybrid" means "of mixed origins" and a "hybrid vehicle" is a mixture of power sources – both an internal combustion engine and an electric motor.

Hybrid vehicles aren't "zero" emission vehicles, since they do have an engine that uses gasoline. But their emissions are extremely low. Hybrids get good gas mileage because they run on both gasoline and electricity at the same time. And their electric batteries never need to be recharged! As the car runs, the gas engine turns a generator that charges the battery.




What's it like to drive a hybrid vehicle? The electric motor starts the car running. As speed increases, the internal combustion engine automatcally turns on and assists in powering the car. In most hybrids, both the internal combustion engine and the electric motor are powering the car together most of the time. When the driver takes his/her foot off the accelerator to slow down, both the engine and the motor shut off.

There are a number of hybrid vehicles available today, such as the Toyota Prius shown here. In 2000, the year that hybrids were first introduced in America, only 9,000 were sold. By 2005, more than 205,000 were sold, and the number is increasing each year.

## PLUG-IN HYBRID VEHICLES

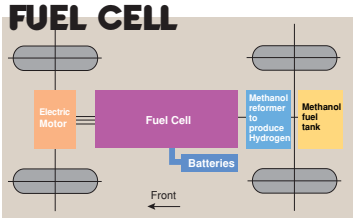
Plug-in hybrids, like regular hybrids, have both a gasoline engine and an electric motor. But the plug-in hybrid has additional batteries installed, which allows the car to function as just an electric vehicle. The driver can turn off the gasoline engine and drive 30 to 40 miles on electric power only. That's far enough for the daily commute of many drivers. But if you need to go farther, you can turn the gas engine on to help power and charge the car. Back at home, just plug the car into the wall to fully recharge the electric batteries overnight.

With a plug-in hybrid, your gas mileage can approach 100 mpg. And emissions can be very low. When only the electric motor is used, there are zero tailpipe emissions. The only air pollutants come from the power plant where the electricity needed to charge the battery is generated.

*The Toyota Prius is available in both hybrid and plug-in hybrid models.*

## FUEL CELL VEHICLES

*Toyota's Fine N fuel cell concept car.*




With a fuel cell, a vehicle can make its own electricity to power the electric motor – no need to plug in for a recharge.

Fuel cells have been around for more than 100 years, and they have been used to provide power in spacecraft. But they were always thought to be too expensive, too big, and too heavy to use in vehicles. Now, with new technology, that has changed. Fuel cell cars and buses are beginning to appear.

The fuel cell combines hydrogen (in the fuel tank) with oxygen (from the air) to produce electricity to power the vehicle's electric motor. And the only emissions are heat and pure water vapor. No pollutants.

Some fuel-cell vehicles can put compressed natural gas or even gasoline in their fuel tanks and then "reform" these fuels to produce the hydrogen needed to power the fuel cell. Some pollutants are produced with reformed fuels but up to 90 percent fewer emissions than with gasoline in an internal combustion engine.

So what's the problem? The hydrogen fuel presents challenges. Hydrogen must be stored under pressure at an extremely low temperature, which is difficult to do. Also, there aren't many fueling stations for hydrogen though some are being built.

These challenges, as well as others, currently make fuel cell vehicles very expensive. Costs will need to come down before we see many fuel cell vehicles on the road.

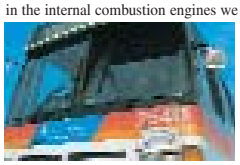
# Not So Future Fuels

You're driving across the state, even the country, and your car or truck is running low on fuel. What do you do? Easy. You pull into a filling station where you pump gasoline or diesel fuel into your vehicle. And you're back on the road. That's the way it's been for years.


Gasoline isn't the only fuel, however, that can run your car. Several others are powering cars, trucks, and buses, and others are being developed. Unlike gasoline, some of these fuels are *renewable*, which means we'll never run out of them. And all of them *burn cleaner* than gasoline, which means they produce fewer emissions. Though we don't see many yet, new types of filling stations are appearing along our roads.

### Natural Gas

Natural gas – the same natural gas used for cooking and heating – is often a popular alternative to gasoline. Besides burning much cleaner than gasoline, it can be used in the internal combustion engines we already have, with a few changes to the engine.



Natural gas has other advantages. First, we already have a whole network of underground pipelines that bring natural gas to our homes and businesses. Also, in the U.S., we have a lot of natural gas, so we don't have to depend on importing it from other countries.

To use natural gas for vehicles, it must be either compressed or liquefied. Compressed natural gas (**CNG**) must be stored under great pressure in big, heavy cylinders. These cylinders can be a problem because:

1) they are expensive;
2) only a few can be put in a vehicle due to their size and weight, so you can't drive as far as with gasoline.

Liquefied natural gas (**LNG**) is made by refrigerating natural gas to minus 260° Fahrenheit to condense it into a liquid. LNG must be kept at this extremely cold temperature, but it takes up less space than CNG, which means more energy can be stored in the same amount of space. Thus, you can drive further with LNG.

Because the number of fueling stations is limited, the main use of both CNG and LNG is for vehicles that return to a central place each night for refueling. CNG is used mainly in fleet vehicles – "company cars." And LNG, with its added power and driving range, is good for heavy-duty vehicles, such as trash trucks, delivery trucks, and buses.

### Liquefied Petroleum Gas

Propane, or liquefied petroleum gas (**LPG**), is a low-emission fuel that has been in use for many years. Worldwide, approximately 9 million propane vehicles are now on the road. Many cities power taxis, police cars, buses, trolleys, and fleet vehicles with propane. But propane is not widely available, so it is used mainly only when private fueling facilities are available.

### Ethanol

Ethanol is primarily made from the same corn that's grown to feed livestock. Thus, it is a renewable fuel. Ethanol also burns cleaner than gasoline, so it is currently mixed into gasoline in a ratio of 10 percent ethanol to 90 percent gasoline and sold particularly in areas with air pollution problems.

Ethanol is now also being used to make E85 – a fuel than contains 85 percent ethanol and 15 percent gasoline. E85 can be used only in "flex-fuel vehicles" – vehicles that are designed to run on either 100 percent gasoline or on a mix of gasoline with up to 85 percent ethanol. Currently about 24 models run on E85 – mostly SUVs and trucks.

E85 does reduce the overall pollution to the environment, but since there's less energy in ethanol than in gasoline, the typical car gets about 20 percent fewer miles per gallon of ethanol.

We couldn't plant enough corn in the whole country to make enough ethanol to run our vehicles. However a new form of ethanol is in the works. It allows ethanol to be made from bio-waste – such as waste from industries that produce food products. So perhaps in the next few years, more E85 will be produced and more flex-fuel vehicles will be developed.

### Biodiesel

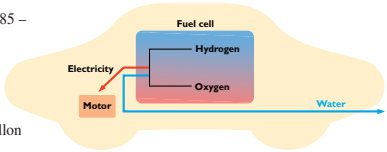
Want to run your car on left-over french-fry oil? It might be possible...if you have a diesel vehicle. Biodiesel fuel can be made from vegetable oils, animal fats, or recycled restaurant greases. It's 10 or 20 percent vegetable oil and 80 or 90 percent conventional diesel fuel. Any regular diesel vehicle can run on these fuels.

Diesel vehicles will actually run on 100 percent vegetable oil – or waste vegetable oil from restaurants (like used french-fry oil from fast food restaurants!) – but not without significant modifications to the vehicle and perhaps some unknown effects to the vehicle!

Compared to regular diesel fuel, biodiesel does reduce tailpipe emissions, especially carbon dioxide, which contributes to global warming.

### Hydrogen

Hydrogen may be the perfect automotive fuel. Hydrogen, either compressed as a gas or in liquid form, can be used in internal combustion engines. It not only gets good mileage but also burns very cleanly. And hydrogen is used in fuel cell vehicles, where the only emissions produced are heat and pure water vapor. Perfect!




Unfortunately, hydrogen isn't produced in nature. Usually, we create it by chemically reforming either natural gas or methanol. But hydrogen can also be created using only water and the sun! Solar cells can be used to transform sunlight into electricity. Then this electricity is used to separate water ($H_20$) – the Earth's most abundant resource – into its hydrogen and oxygen elements. The result: "solar hydrogen" – the perfect zero-emission fuel.

So why haven't we switched from gasoline to hydrogen? There are some safety concerns and some problems with storing hydrogen. Also the process of creating hydrogen is presently still more expensive than producing gasoline, diesel, or natural gas. But hydrogen is so abundant and so clean that it could be the "fuel of the future."

These alternatives to gasoline provide environmental advantages, and their use is growing. Perhaps one will fuel your car of the future.

**TECHNOLOGY: CAN IT SAVE THE DAY?**

# Hot Highway Trends

You wait in a line of cars, trucks, mini-vans, and SUVs to finally merge onto a packed highway. You spend the next hour inching your way along, never going more than 20 miles an hour, even though the speed limit signs say 65 mph.

This gloomy picture exists today in many cities and could exist tomorrow in many more if the number of cars on the road continues to multiply.

Besides eating away at our time and our nerves, this traffic congestion is also bad for air pollution. The longer our cars are running and the more time we spend in stop-and-go traffic, the more emissions come out the tailpipes.

We can't just build more and more roads, and we can't just keep cramming more vehicles onto the roads we have. So traffic engineers (yes, there are people who engineer traffic!) are combining computer simulations with actual traffic data to try to combat this invasion of cars. Here are some of their ideas that are being used right now.

**Intelligent Traffic Control:** Putting sensors in the pavement to adjust traffic signals causes cars to flow more continuously. This reduces the time spent idling at a red light, and thus reduces emissions.

**High Occupancy Vehicle (HOV) Lanes:** These are also known as "carpool lanes." Usually on major freeways, one or more lanes are reserved for cars carrying two or more people. These lanes are meant to encourage people to ride together, so that there are fewer cars on the road. In some states, these lanes may also be used by low-emission vehicles carrying only one person – such as hybrid or natural gas cars.

**Automated Toll Roads:** With a specially purchased device that you place on your windshield, your car can gain access to a special lane or road. As you pass a check-point with-out stopping, the device is read automatically and your credit card is charged. The cost may change depending on how crowded the highway is. These toll roads reduce congestion in the non-toll lanes, and they generate income for the communities.

**Transit Centers:** In a special lot near their homes, people can park their cars and then take public transportation or join a carpool or vanpool to work. Pedestrian trails and bike lanes might also leave from this central area. Some transit centers are now even including conveniences such as day-care sites and grocery stores.

## THE ROAD AHEAD

Traffic engineers and city planners have had lots of ideas about how to relieve traffic congestion. A few that are being tested and gaining some attention are:

**High-Occupancy Toll (HOT) Lanes:** These are really carpool lanes that you are charged to drive in. But how much you pay varies according to how many people are in your car. With two occupants, you pay one fee, with three a lower fee, and maybe with four you can use the lane for free.

**Personal Rapid Transit:** Unlike a *mass* transit system, in which many people share a bus or a train, *personal* rapid transit has individual cars. The fare is per car, so you can ride alone if you choose, or share the cost with a few other people. At the station, you buy a ticket to a particular destination, get into a computer-controlled car that moves along a guideway above ground, and press a "go" button. The car takes you non-stop to another station in the system while you sit back and do whatever you want to do! It's convenient and quick for the rider since there is no stopping to pick up other passengers, and it's good for the air since it runs on electric power.

**Livable Communities:** A good deal of traffic congestion is blamed on "sprawl" – the spreading of houses further and further from the areas where people work. In a "livable community," work areas and living areas would not be in different places. The community would mix homes of all different prices and styles with stores, schools, offices, and other worksites. Goods (such as food and clothes) and services (such as laundromats and libraries) would all be within walking distance. Bike paths would connect to areas outside the community. And a public transportation center would easily provide travel to all other communities or "downtown" areas. The goal is to create a community built for people, not for cars.

# What is the World Coming To?

"Wake up! Wake up! It's 7 a.m., April 5, 2057. Time to get up!"

You groan. "All right, Zytel," you say, waving away the personal robot you received for your 16th birthday. "I'm up. Now whip up my breakfast, make my bed, and program the car to pick up Tanta and Kekko and then to head for school."


On your way to the kitchen, you see your father already at work in his office – right down the hall. He is a telecommuter, working via e-mail and internet conferencing for a company thousands of miles away. But he rarely works alone since holograms of his co-workers from all over the country seem to always be floating around his office, having discussions with him. Your mother does commute to work, but on the electric-powered people mover, which leaves from the transit center a block away and drops her and other employees off right at their offices.

"Screen on," you announce as you walk into the kitchen, and the back wall lights up. "Weather news," you request, though the day's temperature really won't change what you wear since all your clothes are made from lightweight fabrics that automatically heat up or cool down to keep you at the perfect temperature. As the 3-D image of the newsperson reports the weather, you open the refrigerator and see that once again it is fully stocked. As soon as the supply of milk, juice, eggs, or other staples gets low, the refrigerator automatically notifies the grocery store for a delivery.

Outside, it's a bright, sunny day, which means that the solar roof tiles on your house will be generating enough electricity to power your house. On cloudy days, your electricity comes from the generating plant at your housing development, which is powered by hydrogen fuel cells.

You hop into your electric vehicle, which is also powered by a hydrogen fuel cell. Today being sunny, your car's photovoltaic outer "skin" will generate additional electrical current to charge the battery. The clear bubble roof closes and instantly adjusts its tint to allow in just the right amount of light. For a moment, you stare at the center of the steering wheel; a tiny camera reads the unique shape of your retinas and commands the engine to start. As the car backs itself into the street, the built-in speaker phone automatically calls Tanta to tell her you are on your way.

Tanta waves as you pull up to her house, and then points up to the sky. "Look," she says. Looking up, you see many police and rescue "cars" flying in the air. Further down the street, you watch another police car on the road stop, unfold its wings, and take off vertically to join the others. "I think there's been an accident," Tanta exclaims as she jumps into your car. "I hope this doesn't make us late for school!"

"Not to worry," you reply, tapping your global positioning system screen. "The Smartway is wide open!" You've noticed that ever since the Maglev Rail Line was built from the port to carry cargo containers inland, very few trucks now crowd the Smartway. And those magnetically levitated, electrically powered trains are quiet and clean.

You drive up to Kekko's house, but he is no where to be seen. "I'll find him!" Tanta states as she spreads her thumb from her forefinger, popping up a transparent screen from her finger glove. "His ID is programmed into my PCD *(personal communication device)*, so I always know where he is, and right now, he's just around the corner."

What's up?" you holler to Kekko as you pull up alongside him while he is walking down the street, his head bobbing to the music playing in his ear.

"Hey," Kekko answers. "I was just trying out my new shoes!" Kekko is, indeed, sporting the newest model of nanogenerator shoes, which with each step produce electricity to power the wireless electronic devices built into his clothes, such as his PCD and music player.

With Kekko finally in the car, you head toward the Smartway, where as soon as you merge into traffic, your car locks onto a magnetic strip buried in the roadway. You take your hands off the wheel and command the car to roll back the bubble top and to turn up the music. As the car moves swiftly down the road, you look up at the clear blue skies.

Within minutes, you are pulling into your school's parking lot. The three of you hop out and your car rolls away to park itself. As you walk onto campus, you see the school's massive digital monitor announcing that everyone is to go to the Assembly Hall for a computer-mind interface upgrade. "All you'll have to do now," the image on the monitor proclaims, "is *think* to pull up your computer screen, send messages...."

"Oh my," Tanta murmurs. "What is the world coming to?!"

Okay, the future may not be exactly like this; perhaps you won't have your own personal robot to make your breakfast and clean up after you, and maybe police cars won't be spreading wings to fly. But many of the technologies described in the story are in use or are being tested and could be in common use before long.

One futuristic technology being tested is the automatic vehicle control system – hands-free driving! A promising model uses magnetic sensors on the car that detect magnetic markers embedded in the roadway to keep the car in the proper position in its lane. But there's more. The system will also detect vehicles, debris, or other obstacles in the road ahead so your car can automatically change lanes to avoid trouble and continue smoothly down the road – all while you read a book or watch a movie or work on your computer. Reducing stop and go driving would truly help reduce air emissions, as well as increase safety and decrease stress!

The dreams of today can be the reality of tomorrow. What is the world coming to?

## WHAT DO YOU THINK?

### SUVs

People continue to argue about SUVs, those oh-so-popular sport utility vehicles. This sort "in" mode of transportation, along with pick-up trucks and vans, now make up half of all the new vehicles sold in the United States. That's right, *half.*

Why does anyone care, you ask? Mainly because of the environment. First, the larger SUVs get only about 13 to 18 miles per gallon of gasoline. And SUVs have been permitted to emit more smog-producing pollutants than cars. That will change, but until then SUVs produce more emissions. Some of the giant models produce twice as much pollution as a small car.

But clearly lots of people love SUVs. Here's what both sides have to say:

#### LOVE SUVs

- SUVs have a lot of passenger and cargo space, which means that they can carry a lot of people and a lot of stuff.
- Because they are big and heavy, SUVs provide a lot of safety for the passengers in case of crashes.
- With an SUV, you can go anywhere, do anything – tow a boat, drive in the snow, go off-road.
- In an SUV, you can see better because you are sitting up so high.

#### HATE SUVs

- All that passenger and cargo space in an SUV is usually wasted. People are burning up gallons and gallons of gasoline and polluting our air to carry only 2 or 3 people most of the time.
- SUVs *are* safe for the people in the SUV, but in a crash, an SUV will crush a regular car, which means people in other vehicles are less safe.
- SUVs are good for recreation, but 87% are used in cities and towns only for work, shopping, errands, and vacations; only 13% are used for off-road activities.
- Visibility is great for those people in SUVs, but if you're in a car stuck behind an SUV, then your visibility is practically zero.

### CARPOOL LANES

Gridlock – bumper to bumper cars – thousands of vehicles trying to move with no place to go. This is the situation on more and more freeways and highways in urban areas. You might ask, "Why don't we just add more lanes or build more freeways?" We don't because usually we can't. In some places, there is simply no more room. Tearing down homes and businesses to add more pavement is not favored by most people. And besides, building roads is expensive.

So how do we bust up that congestion? Several ideas have been proposed, and the idea that has received the most attention is carpool lanes, sometimes called high-occupancy vehicle (HOV) lanes. But not everyone agrees that these lanes are the answer. Some people want to eliminate the carpool lanes that already exist and turn them into lanes for all cars to use. Here's what people say:

#### MORE CARPOOL LANES

- Uncongested carpool lanes save people time, providing an incentive to ride-share. More ridesharing means fewer cars on the road and fewer emissions going into the air.
- Adding more lanes for solo drivers will not help because more lanes will simply attract more solo drivers who were taking other routes.
- If carpool lanes are underused, solo commuters could be charged a fee to drive in them, turning them into toll lanes.

#### MORE LANES FOR ALL DRIVERS

- In Southern California, one of the nation's most congested areas, it is estimated that only 15% of motorists share rides; therefore, carpool lanes are not significantly reducing the number of cars on the road.
- Carpool lanes are underused. If these lanes were opened to everyone, more vehicles could move faster, resulting in shorter travel times, less congestion, and less pollution.
- Turning carpool lanes into toll lanes wouldn't be fair because well-to-do people could cruise to work while others were stuck in traffic.

# Pay More Now: Breathe Better Later

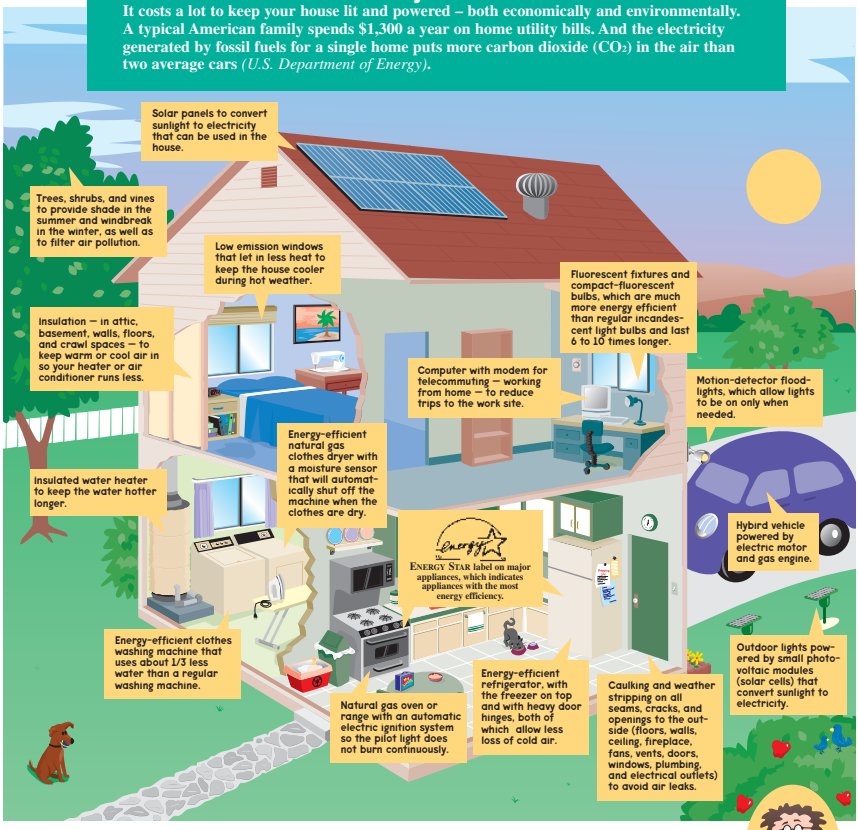
You know that driving less will reduce air pollution. But you're thinking, "Hey, I'm a kid. I don't even have a driver's license! What can I do?" A lot!

You are a very powerful force. But the source of your power isn't due to physical strength, famous friends, or supernatural abilities. Nope, you have power because you're a consumer. When you buy things, you make crucial choices about what products you spend your money on. A new cell phone, athletic shoes, a computer game, or a skateboard can become a major success or a major failure depending on what you choose to buy. That's some power!

What's this got to do with reducing air pollution? Think about it. You can use your consumer influence in an environmentally-friendly way, purchasing products that are energy-efficient, products that emit fewer pollutants into the air. And even though you personally may not buy many of these products now, you can influence your parents. (You probably already help determine how your parents spend their money!) What sort of environmentally-friendly products, you ask? Take a "virtual" tour through this house and find out.

Some of these energy-efficient appliances and products may initially cost more, but in the long run they can save money on utility bills and reduce air emissions, which, of course, will allow you, and people in the future, to breathe easier.

**Did you know?**
**It costs a lot to keep your house lit and powered – both economically and environmentally. A typical American family spends $1,300 a year on home utility bills. And the electricity generated by fossil fuels for a single home puts more carbon dioxide ($CO_2$) in the air than two average cars** *(U.S. Department of Energy)*.




## Air Care Actions

Technology is exciting. But it won't clean up the air tomorrow. New cars, fuels, and roads take time and money. In the meantime, it's up to you to reduce air pollution.

What can you do? Plenty!

Each and every one of us can help clean up the air *every day*, simply by the choices we make – the things we do or don't do – without spending any or much money.

Look at the chart below and check off the behaviors practiced by you or your family. Also, on the Think Earth website – www.thinkearth.org – you'll find two environmental surveys, one to use at home and one to use at school. Once you complete the surveys and enter your answers on the Think Earth website, you'll be able to print a list of recommendations indicating what your family and your school can do to support the environment even more.

**MAKING A DIFFERENCE**

Remember... the only real solution to air pollution is for everyone to take care of the air!

### Use Your Car Less
- ❑ Take public transportation when possible.
- ❑ Carpool.
- ❑ Combine several errands into one trip.
- ❑ Walk or ride a bicycle when possible.
- ❑ Shop by phone, mail, and online.

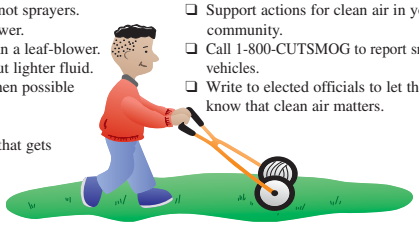
### Drive Smart
- ❑ Accelerate gradually.
- ❑ Drive at a steady speed.
- ❑ Use the car's air conditioner only when needed.
- ❑ Don't allow your car to idle for long periods.

### Keep Your Car "Clean"
- ❑ Keep the car's engine properly tuned.
- ❑ Keep the car's tires properly inflated.
- ❑ Use a clean-air formula gasoline.
- ❑ Avoid gas spillage and escaping fumes by not overfilling your tank.

### Use Air-Friendly Products
- ❑ Choose water-based paints labeled "Zero-VOC" when painting, and use brushes not sprayers.
- ❑ Mow with a push or electric mower.
- ❑ Use a rake or a broom rather than a leaf-blower.
- ❑ Light barbecue briquettes without lighter fluid.
- ❑ Choose non-aerosol products when possible (e.g., hairspray, deodorant).
- ❑ Choose recycled products.
- ❑ When buying a car, choose one that gets high mileage and pollutes less.

### Save Energy at Home
- ❑ Turn off lights, TVs, radios, appliances when you leave a room.
- ❑ Use toaster oven or microwave oven to cook small meals.
- ❑ Use light timers to automatically turn off lights.
- ❑ Keep the heater thermostat low – 68° or lower for day, 60° or lower at night.
- ❑ Keep the air-conditioner thermostat high – 78° or higher.
- ❑ Close vents in unused rooms.
- ❑ Recycle and reuse paper, plastics, and metals.
- ❑ When replacing household appliances, choose ones that use less energy.

### Promote Clean Air
- ❑ Use and support mass transit systems.
- ❑ Use and support bike lanes and pedestrian pathways in your community.
- ❑ Respond to newspaper articles and television shows about air-related issues.
- ❑ Support actions for clean air in your community.
- ❑ Call 1-800-CUTSMOG to report smoking vehicles.
- ❑ Write to elected officials to let them know that clean air matters.



## DEAR AIRHEAD

**Dear Airhead:**
It's not fair. Why is the smog worse in Southern California, where I live, than in other places?
*Gray*

**Dear Gray:**
I can answer that question in two words: population and geography (well, three words, but forget the "and.") In Southern California, there are millions of people – a huge population – driving day and night. The ocean breezes push into the valleys not only the emissions from cars, trucks, trains, and ships, but also pollutants from power plants, factories, homes, etc. Now here comes the geography part. The dirty air is trapped by the mountains on the sides and by a layer of warm air on top. This "smog bowl" stews in the sunshine and produces even more pollutants, specifically ozone, which is the main ingredient in smog.

No, it's not "fair" – it's more like smoggy!

**Dear Airhead:**
Smog is not as bad as it used to be. So what's the big deal about air pollution?
*Skye*

**Dear Skye:**
Boom! Did you hear that? That was the population exploding! While toll roads, carpool lanes, and futuristic "smart highways" that drive your car for you can help, there are still more people driving more cars – every day! New fuels? Yep, they will cut emissions – but they are not cheap, and you can't just get them at your local gas station yet. As for new cars . . . Hybrid vehicles are much better but still use gasoline, and fuel cell cars are not yet ready.

We can't just wait for technology to solve our problems. We all have to be concerned about air pollution NOW. And the single most important thing we all can do to improve the air NOW is to cut down on how much fuel we use – that means drive less and buy cars and trucks that get good gas mileage. Did you hear that? Someone else just started driving a car!

**Think Earth Environmental Education Foundation**
**5318 E. Second Street, #512**
**Long Beach, CA 90803** **www.ThinkEarth.org**