FREQUENT FLYERS: How Pollutants Move Through the Air

OBJECTIVES

Students will be able to do the following:

1. Describe how air pollution can travel from its source to other areas.
2. Describe how wind can disperse air pollution.
3. Explain how temperature inversions occur and how they can affect air quality.
4. Describe how poor air quality during certain types of weather can adversely affect health.
5. Explain the usefulness of air quality indices.

SUBJECTS: Science, language arts, art, social studies

TIME: 2-3 class periods

MATERIALS:

Paper

Student sheets

World map or globe

Two empty 2-liter soft drink bottles

Confetti

Cheesecloth

Blow dryer

Water

A shallow pan (baking pan)

Red (or other color) food coloring

Fan or straw

Two onions (same size and kind)

Knife

Cutting board

Small fan

Stopwatch (or clock with second hand)

BACKGROUND INFORMATION

When a source or a group of sources emits pollutants into the ambient air, the pollutants don't just stay at the point where they were emitted. If they did, the region between ground level and the height of the highest smoke stack would be a very thick "pea soup" of pollution all the time—and it would become worse day by day. Areas where there are sources would have a lot of pollution, and areas where there are no sources would have none. We know that is not the case. Air pollutants are found everywhere—not just near their sources. Air pollutants produced in Ohio can end up affecting lakes and forest in Maine. A volcano in Hawaii can affect farmers in France.

Air quality depends a great deal on weather patterns. When pollutants are released into the atmosphere, they usually dissipate or "disperse." They can be carried by winds to other areas of the country or world, and they can rise higher into the atmosphere. They can also fall from the air and settle on the ground or on water, or they can be "washed" from the air by precipitation, in

the form of rain, snow, sleet, and hail. Stagnant air (air that isn't moving very much) can promote the buildup of pollutants, possibly to dangerous levels.

~~The transport and dispersion of air pollutants are affected by weather patterns and topographical features.~~ The air in our atmosphere moves both horizontally and vertically. The horizontal movement of the air is what we refer to as wind. Wind speed affects how quickly pollutants travel from one area to another, thereby determining in part the concentration of pollutants in an area. Wind direction affects where a pollutant ends up. This also helps determine the concentration of pollutants in an area.

WEATHER PATTERNS

The air movement in our troposphere has it origin in the uneven heating of the earth by the sun. This non-uniform heating of the earth and its atmosphere creates horizontal air pressure differences that are the basis of all winds. Air tends to move from areas of high pressure to areas of low pressure.

Generally, regions around the equator get more direct sunlight and, therefore, become warmer than the regions near the poles. As the warm equatorial air rises and the cold polar air sinks, a cycle develops in which each air mass moves to take the place of the other. This exchange fuels the general horizontal movements of air higher in the atmosphere. Near the earth's surface, general movement is from east to west near the equator and poles and from west to east in the mid-latitudes. Other factors influencing the force and direction of air movement are land forms and the rotation of the earth.

The movement of large masses of air is responsible for much of the world's weather. In fact, meteorologists trace the movements of large warm and cold air masses to develop short- and long-range forecasts of local weather conditions.

Masses of air with similar moisture content and temperature and with other characteristics in common tend to pass over the earth in big chunks that cover thousands of square miles. In North America these weather systems generally move from west to east, but their exact path is influenced by several factors. The jet streams, fast-moving "rivers" of air that snake through the upper troposphere, tend to pull air masses along in their general direction. Topographic features, such as the Rocky Mountains or Appalachian Mountains also have an effect on the direction that air masses take. When air masses collide with one another, their courses are altered also.

High pressure usually brings fair weather, although the associated temperatures vary with the seasons.

Low-pressure systems fill the gaps between high pressure systems and are characterized by storminess and precipitation. All forms of precipitation—rain, snow, sleet, and hail—begin when water vapor in the atmosphere condenses on tiny particles called condensation nuclei. In this way, precipitation helps improve air quality by carrying airborne particulate matter back to earth.

MIXING

We have been talking about wind—the horizontal movement of air in our atmosphere. Vertical movements in the atmosphere also affect the transport and dispersion of air pollutants. The term

that meteorologists use to discuss this vertical motion is "atmospheric stability." Unstable conditions result in vertical mixing, and stable conditions can result in inversions.
Under normal conditions, air temperature decreases with increasing altitude in the troposphere. In other words, the warmest air is normally at the earth's surface. This creates a natural vertical circulation cycle in which the warm surface air rises, continually being replaced by cooler air that falls from higher in the atmosphere. Once it is near the earth's surface, this cooler air heats up and rises—and so on, and so on. This natural circulation serves to clean the surface atmosphere, lifting pollutants away from their sources and away from the air that we breathe.

A temperature inversion is exactly what the term indicates—an upside-down temperature situation. When the air at the earth's surface is cooler than the air above it, the natural vertical circulation stops. This condition occurs in winter and in summer and is most intense in valleys or basins or along coasts. People in the affected area experience both increased duration of exposure to pollutants and higher-than-normal pollutant concentrations—a dangerous, potentially lethal combination.

Even when there is no inversion, pollutant concentrations in the ambient air can cause health problems. For that reason, many newspapers and radio stations now report daily "air quality indices" to alert people at risk that ambient pollution levels are high. These air quality indices are usually measures of the levels of ozone and carbon monoxide

PROCEDURE

I. SETTING THE STAGE

A. Use the master provided & in some of the Resources to make an presentation on the How Wind Is Created

B. Lead a class discussion on the origins of wind.

II. ACTIVITY 1: THE TRAVELLING POLLUTANTS

A. Demonstrate how odors (pollutants) can travel through the air.

You will need the following materials:

- Two onions (same size and kind)
- Knife
- Cutting board
- Small fan
- Stopwatch (or clock with second hand)
- Data Sheet

1. Ask three students to come up front and be "scientists." Appoint one scientist to be the timer, another to be the observer, and the third to be the recorder.

2. Tell the other students that they will be "pollutant monitors."

3. Draw a floorplan of the room on the chalkboard. At the front of the room, cut up an onion. Have the timer check the time as you start.

4. Each monitor is to raise his/her hand the instant that he or she detects the onion odor. The observer, timer, and recorder should work together to record the results. Be sure that they record the amount of time between the first and last hand raised and how long it takes for the odor to disappear. They should also note the number of people who smelled the onion and whose eyes watered.

5. After the odor has dissipated, repeat the experiment with another onion and a fan. Cut up the onion and turn on the fan right-away. Record the same information.

6. Compare and discuss the results.

III. ACTIVITY 2: WHERE DO POLLUTANTS GO?

A. Continue the class discussion on the transport, trapping, and removal by precipitation of air pollutants, using some or all of the following questions .

1. Where do pollutants go when they come out of cars, smokestacks, and chimneys? (Into the air.)

2. Do they stay right around where they come out? (No, they "spread out" into the ambient air or they fall and land on the ground and on objects. If they stayed around the emission points we'd be walking around in a thick "soup" of pollution here at ground level.)

3. Where do you think the pollutants that are emitted here in our town end up? (If they are carried by the wind, they might end up halfway across the country or across the world, depending on prevailing winds, etc. If it rains, sleets, or snows, they might end up on the ground or in lakes, etc.)

4. If we didn't have any factories, cars, fireplaces, woodstoves, or other sources of outdoor pollution in this town, does that mean we wouldn't have any outdoor air pollution? (No. Pollution from other towns or cities nearby or far away could be carried here by wind. So could ash from far-away volcanoes, etc.)

5. Suppose we had a period in which there wasn't much air movement—if cool air were trapped under a layer of warm air. What do you suppose would happen to the pollutants emitted in this town? (They would stay here and build up to high concentrations.)

6. How would that affect us? (It might make some people sick. It would make it unpleasant to be outside. etc.)

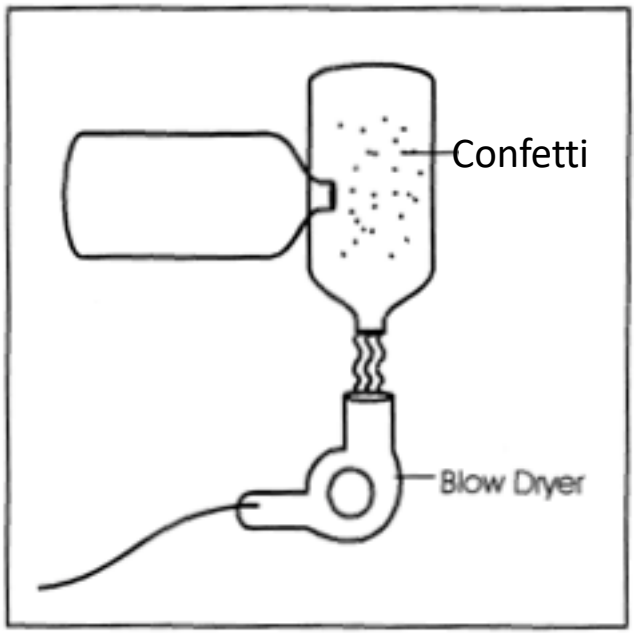
7. Other than by seeing it, smelling it, or experiencing its effects, how might we know that there was a high concentration of air pollution? (In some towns and cities, newspapers, radio stations, and television stations report air quality indices, which tell the public about the quality of the outdoor air that day. Ask students to look or listen for such reports and then share them with the class the next day.) Add Info on Air NOW

IV. ACTIVITY 3: MIXING UP POLLUTANTS

A. Demonstrate the transport of pollutants by air.

You will need the following materials:

- Two empty 2-liter soft drink bottles
- Confetti
- Cheesecloth
- Blow dryer



1. Fill one of the 2-liter bottles with confetti. This will be your "polluted air." Cover the neck of the bottle with a bit of cheesecloth.

2. Cut a hole the size of the mouth of the other bottle in the side of the "polluted air" bottle. Insert the mouth of the other bottle into the hole.

3. Use a blow dryer to blow air into the "polluted air" bottle

4. Ask students the following questions:
   a. How much "pollution" goes into the other bottle?
   b. How did it get there?

c. Is there any way that we could keep it from getting into the bottle? (A screen, cheesecloth, a fan blowing air back the other way, etc.)

V. ACTIVITY 4: AIR IS A FLUID

A. Because air is fluid, you can use another fluid (water) to show how something (pollution) can travel in a fluid.

You will need the following materials:

- A shallow pan (baking pan)
- Red (or other color) food coloring
- Fan or straw
- Water

1. Place two drops of food coloring in a shallow pan of water.

2. Place the pan in front of a small fan (or blow through a straw) to demonstrate how the food coloring is dispersed in much the same way that air pollutants are carried in ambient air.

VI. EXTENSION

You will need the following materials:

- World map or globe

A. Divide the class into small groups. Provide each group with one scenario about air pollution. Have students suggest possible locations where the pollutants might appear because of transport by wind. (Accept any reasonable answers.)

1. Possible scenarios: REPLACE WITH MORE RECENT EXAMPLES SUCH AS THE 2010 ICELAND VOLCANIC ERUPTION THAT KEPT PLANES FROM CROSSING THE ATLANTIC, OR THE WESTERN WILDFIRES
   a. The smog in Los Angeles, California, was at its highest level in the summer of 1990. What other cities might have been affected by L.A.'s smog?

   b. Seattle, Washington, which is located about 95 miles north of Mount Saint Helens, experienced the effects of the eruption of the Mount Saint Helens volcano in 1984. What other cities might have felt the effects of the volcanic ash and debris?

   c. Industries in Pittsburgh, Pennsylvania, used to emit high levels of sulfur dioxide. Would this pollution have had more effect on cities in Virginia, New York, or Texas? Explain your answer.

d. Could air pollutants in Minnesota have an impact on cities in another country? Explain your answer.

B. Have the students role play citizens of various cities or countries and their responses to pollution from other cities or countries.

RESOURCES ***Need to be reviewed and best resources selected***

National Geographic. Air Pollution.
http://education.nationalgeographic.com/education/encyclopedia/air-pollution/?ar_a=1

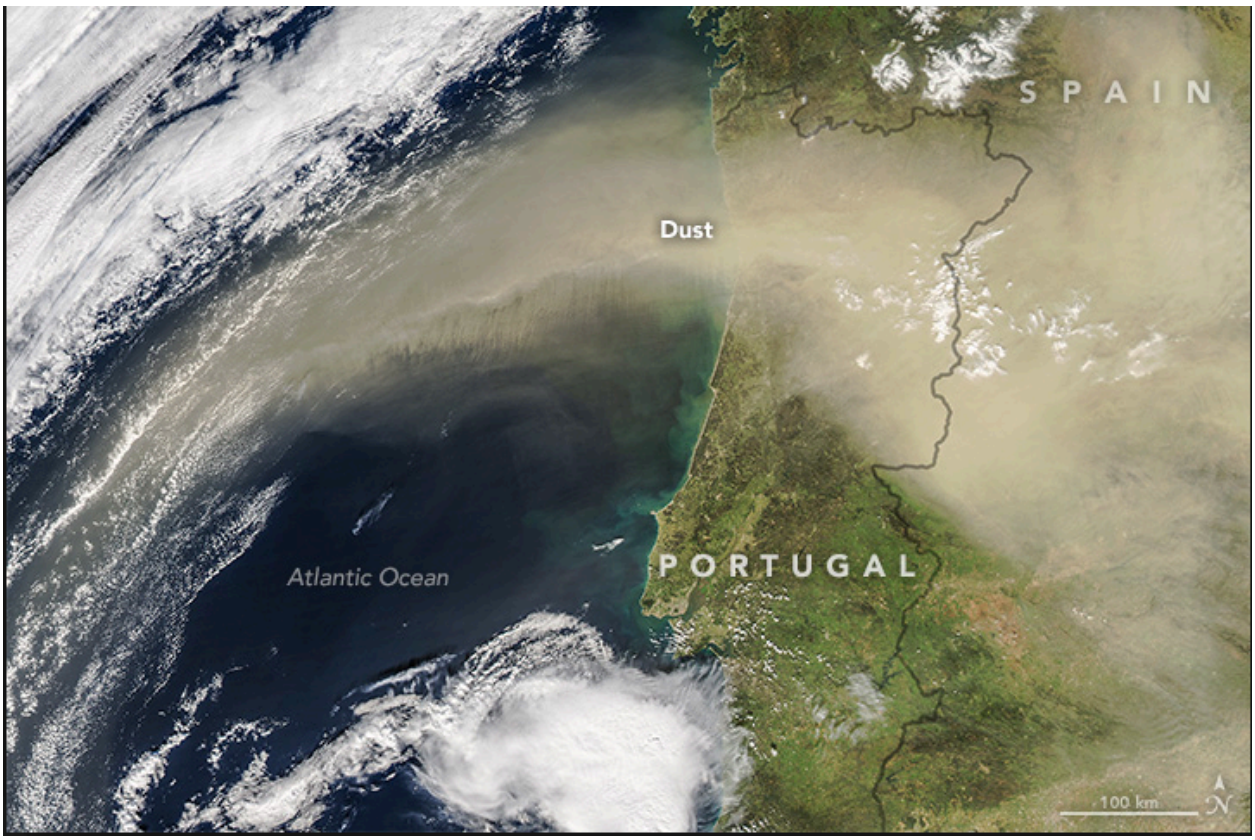
National Weather Service:
https://www.weather.gov/owlie/
https://www.weather.gov/owlie/science_kt
http://eo.ucar.edu/kids/

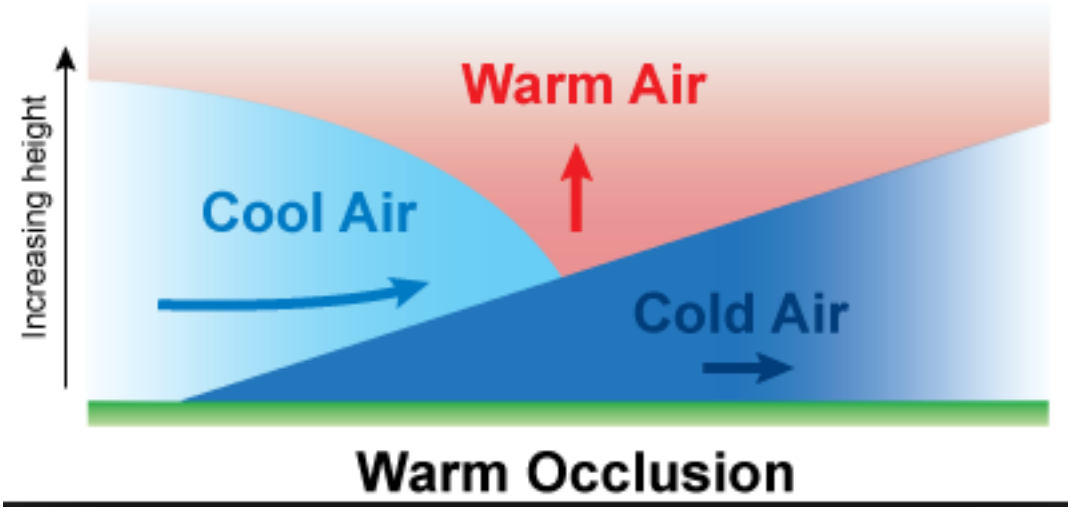
UCAR
Web Weather for Kids: https://scied.ucar.edu/webweather/weather-ingredients
Wind Fact Sheet: https://scied.ucar.edu/shortcontent/wind

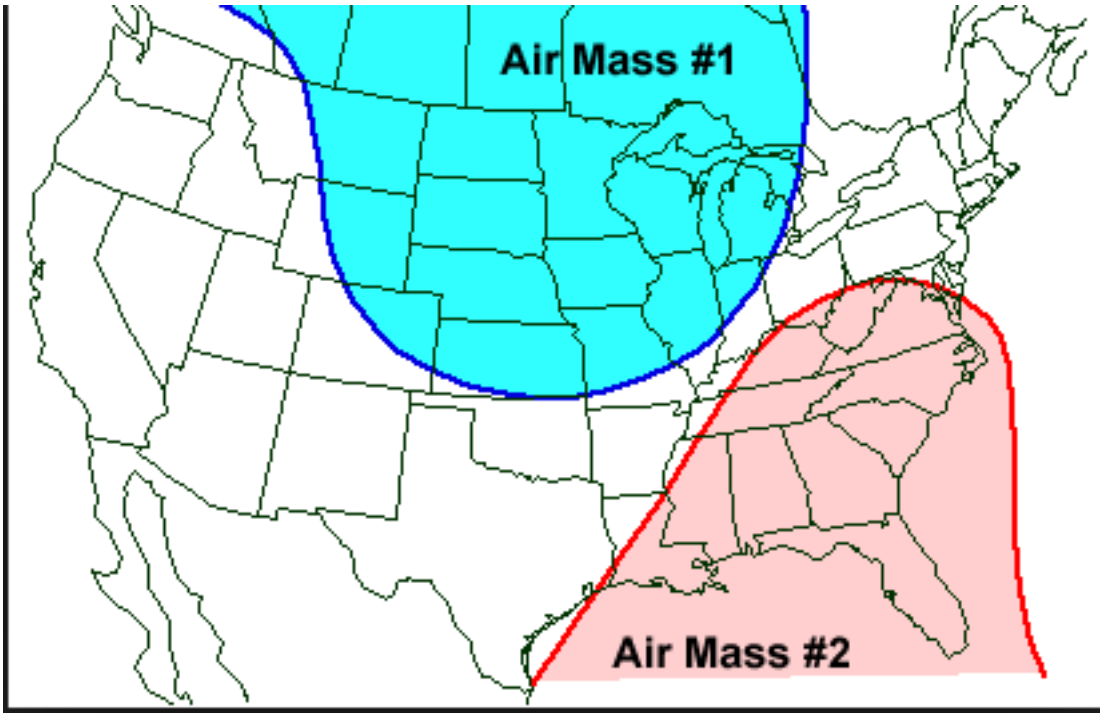
NOAA: https://scijinks.gov/classroom-activities/

NASA video simulation of pollution from a volcanic eruption:
https://www.nasa.gov/feature/goddard/2016/satellite-data-could-help-reduce-flights-sidelined-by-volcanic-ash
NASA Saharan Dust Sweeps over the Iberian Peninsula:
https://images.google.com/imgres?imgurl=https%3A%2F%2Feoimages.gsfc.nasa.gov%2Fimages%2Fimagerecords%2F87000%2F87566%2Fiberianpeninsula_amo_2016052.jpg&imgrefurl=https%3A%2F%2Fearthobservatory.nasa.gov%2FNaturalHazards%2Fview.php%3Fid%3D87566&docid=FscNkFps6TKpCM&tbnid=0Jc94GxDjmUOUM%3A&vet=1&w=720&h=480&source=sh%2Fx%2Fim

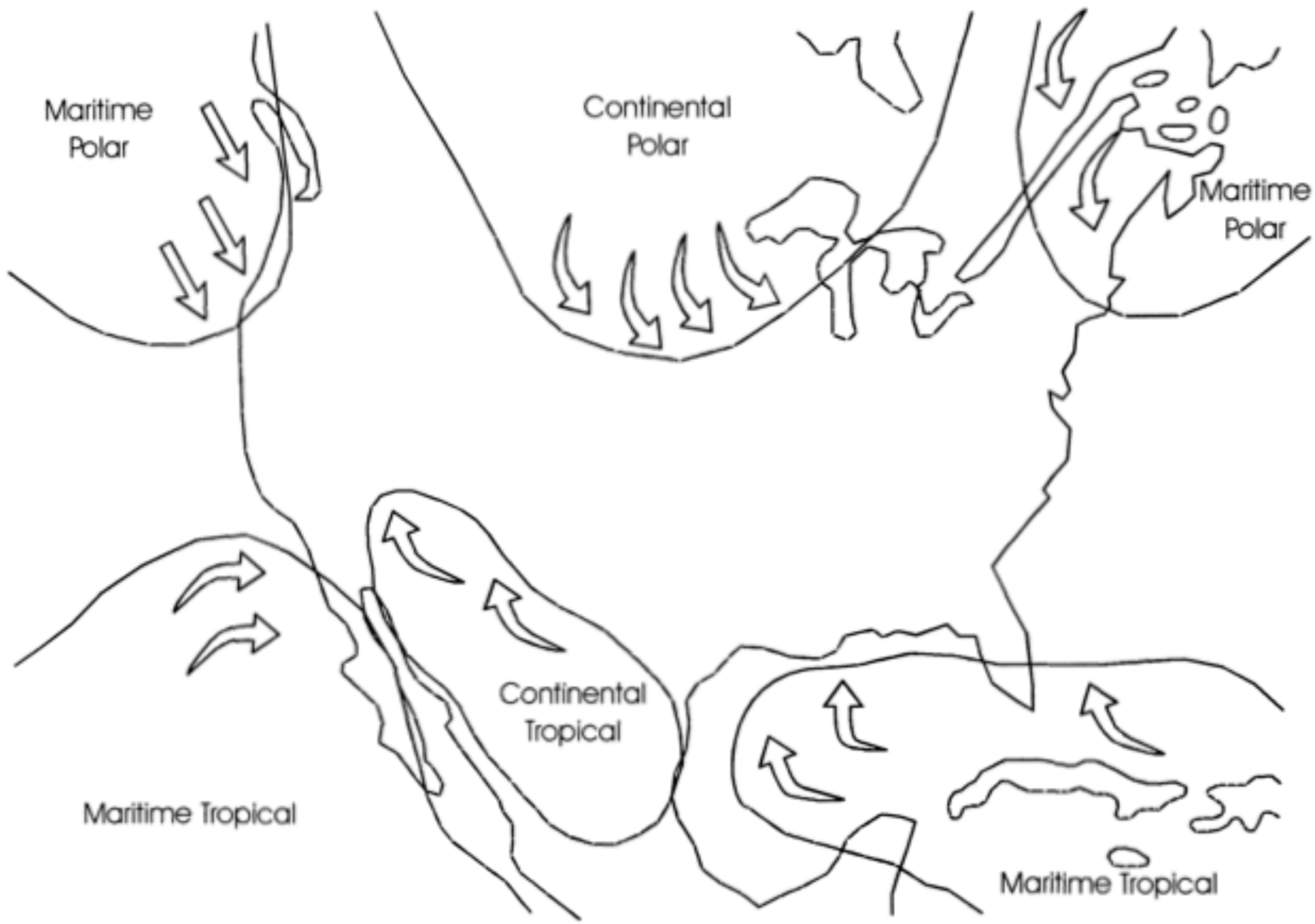
NOTE: Pages 10-14 are the original graphics provided to help teachers demonstrate movement of pollutants in the air. The images on pages 9 & 10 are possible updates


SPAIN
Dust
Atlantic Ocean
PORTUGAL
100 km
N


Warm Air
Cool Air
Cold Air
Increasing height
Warm Occlusion

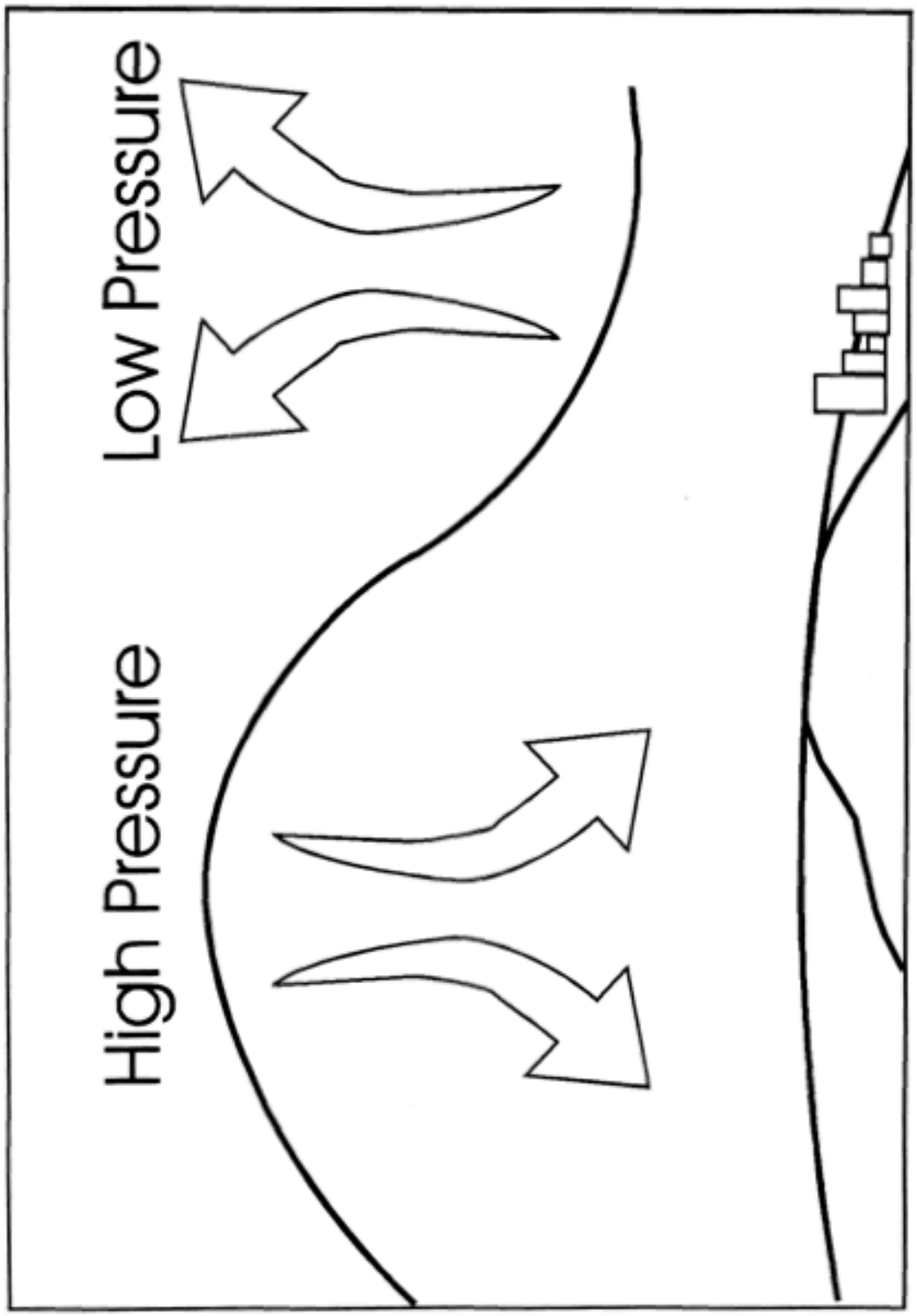

Air Mass #1
Air Mass #2

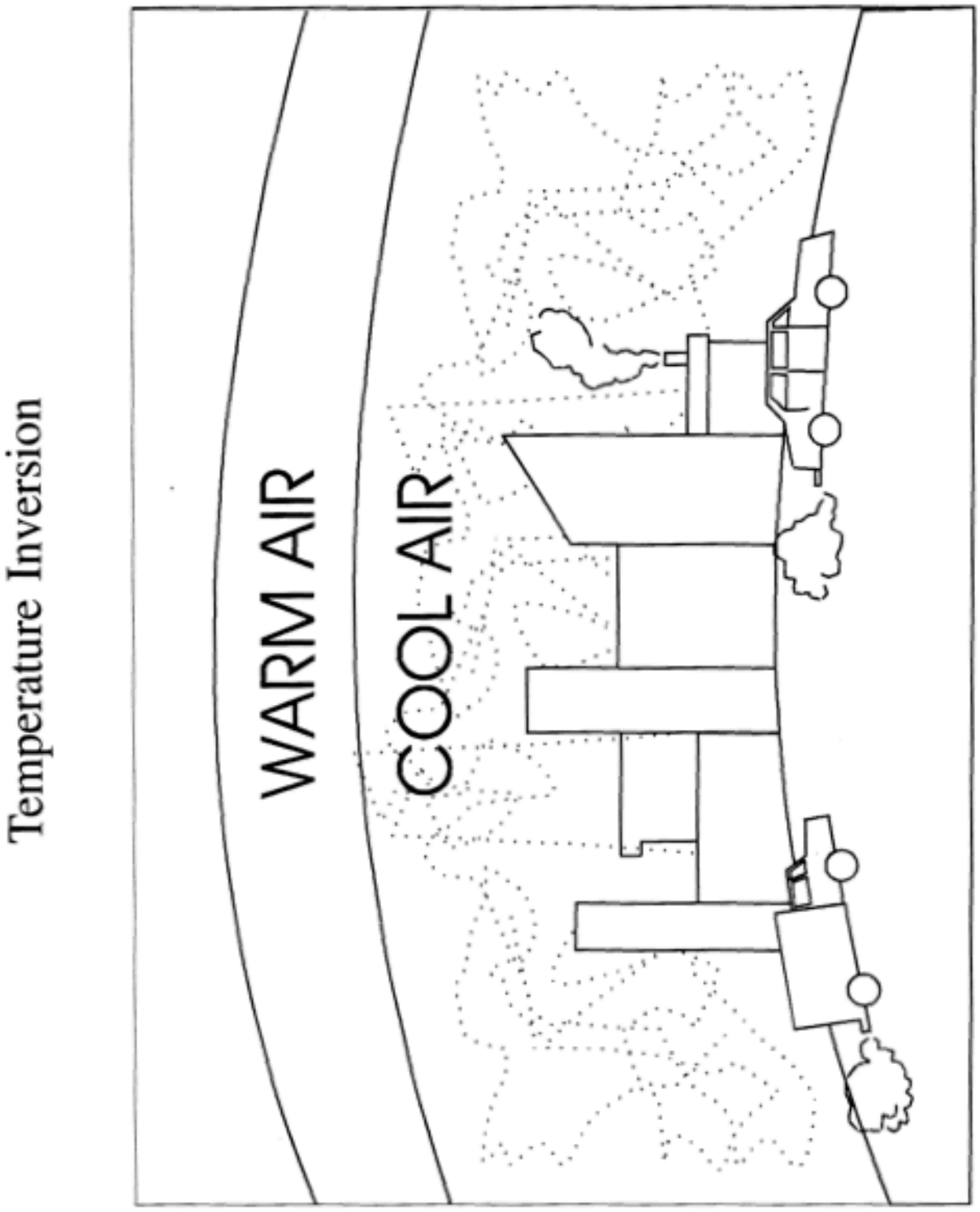
Air Masses



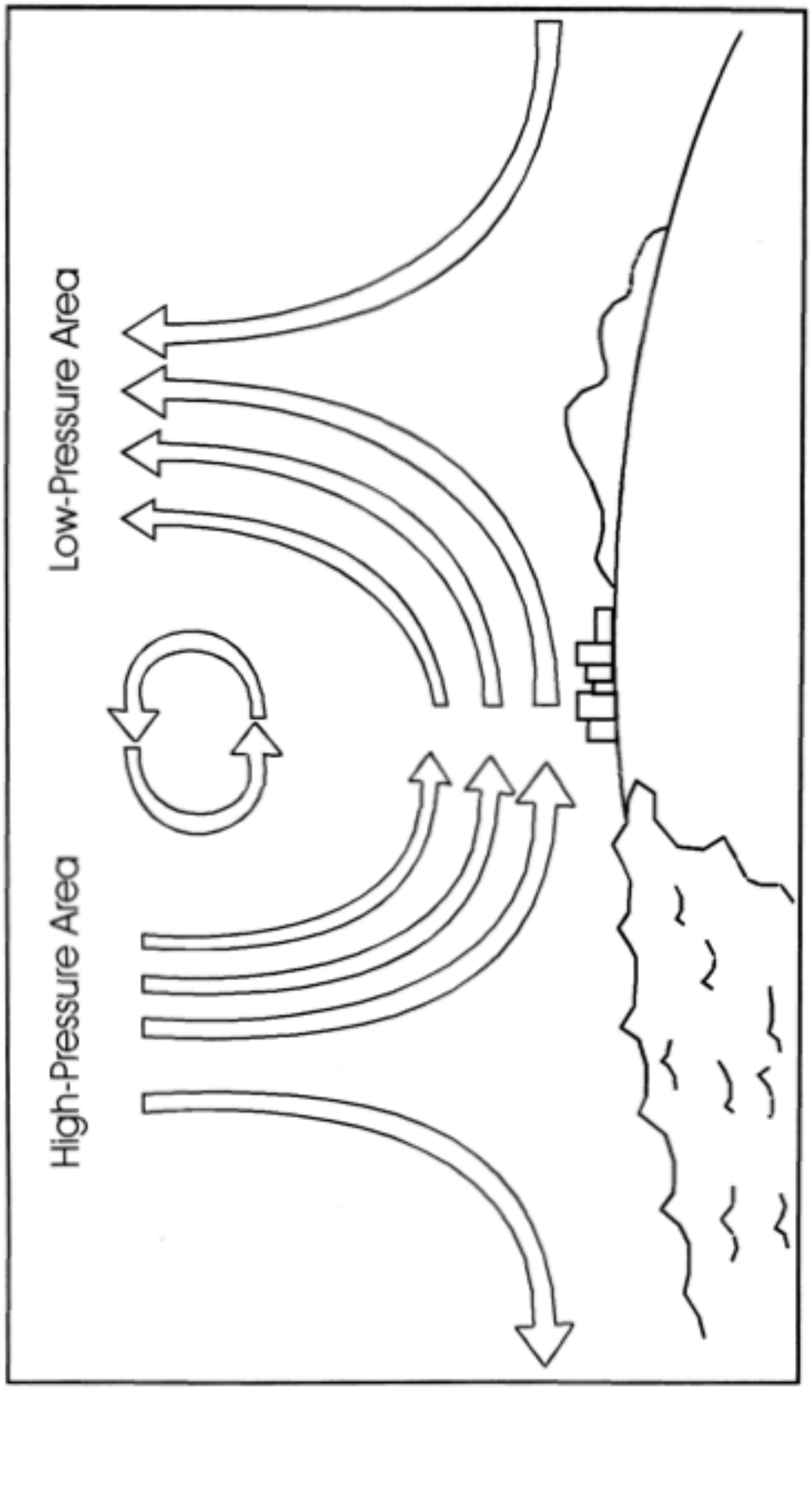
"Continental" refers to an air mass that developed over a continent. "Maritime" air masses developed over the ocean. Air masses may also be named according to whether they developed over the poles or over the tropics.

Pressure Systems



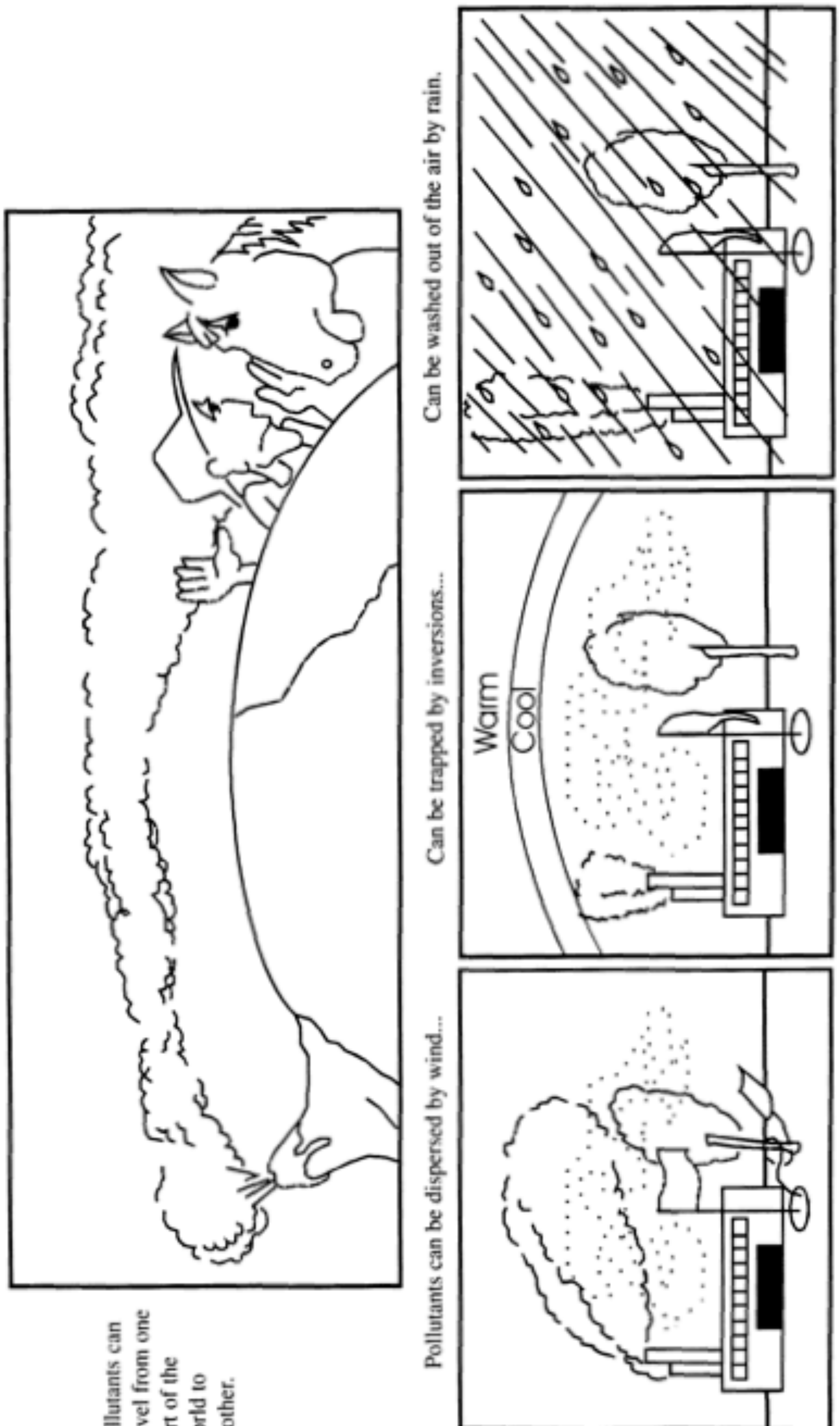

Temperature Inversion
WARM AIR
COOL AIR

How Wind Is Created



Air flows from high-pressure areas to low-pressure areas. As the air flows into a low-pressure area, the air that was there is pushed up, creating wind.

The Traveling Pollutants



Pollutants can travel from one part of the world to another.

Pollutants can be dispersed by wind...

Can be trapped by inversions...

Can be washed out of the air by rain.