Neo/SCI
Student's
Guide

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New ideas for teaching science

Air Quality

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Objectives

- ***Identify*** **potential sources of air pollution**
- ***Observe*** **and** ***identify*** **microorganisms present in the air**
- ***Collect*** **and** ***observe*** **airborne particulate matter**
- ***Describe*** **the effects of air pollution on plant and animal life**

Background

How clean is the air that we breathe? This is an important question to ask since we as humans, along with other life forms, depend on air to live. Our air quality has become an increasingly important issue in recent decades. Environmental specialists are able to perform tests to determine the levels of various pollutants, such as chemicals and particulate matter, in the air that we breathe. Air pollution can be either man-made or naturally-occurring, and it can also occur both indoors and outdoors.

There are numerous types of air pollutants. The most common are carbon monoxide, ozone, nitrogen oxides, and sulfur oxides. Here are some sources of air pollution and the possible health effects that each may cause:

- **Forest fires and volcanic eruptions:** These natural occurrences can produce smoke and gases, and they can also release a large amount of particulate matter into the air. Effects of such an event can cause a variety of respiratory problems in humans and animals. Low visibility and climate changes may also occur because of the particulates in the air.

- **Radon:** Radon is a by-product of the radioactive decay of uranium found within the earth. It seeps up through the ground and into homes, especially those with poor insulation or construction. Radon is known as the silent killer because there are no immediate signs of exposure. Exposure to radon increases the risk of lung cancer in humans.

- **Release of chlorofluorocarbons:** Chlorofluorocarbons, or CFCs, have been banned in the US since the mid-1990s, but they may still be in use by older equipment. In the past, they were used in refrigerators, air conditioners, and in the production of styrofoam. When released into the environment, the CFCs attack the ozone layer in the atmosphere. The ozone layer is responsible in protecting the Earth's surface from approximately 95% of harmful ultraviolet (UV) rays from the sun. Overexposure to UV rays can cause cataracts, skin problems, and cancer in humans. Plants can also be severely damaged by UV rays.

- **Poor indoor ventilation:** Pollutants such as chemical fumes, tobacco smoke, and insulation can be trapped in the air within a building if the ventilation is poor. This can lead to headaches, respiratory problems, and eye irritation in humans.

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- **Combustion:** Combustion, or burning, of fossil fuels is the most common source of air pollution. Common fossil fuels include the gasoline, oil, and coal used in our automobiles, planes, factories and homes. Sulfur dioxide and nitrogen oxides are released when fossil fuel is burned. They can combine with water vapor present in the air, resulting in acid rain. When this rain falls, it may kill fish and change the pH in bodies of water. It may also damage forests and soil. Buildings and other structures may also be attacked by acid rain. Nitrogen dioxide and hydrocarbons are also released when fossil fuels are burned. They combine with sunlight to form smog, which is the most common type of air pollution. Smog causes eye irritation, headaches, and lung problems in humans. It also damages plants.

- **Biological contaminants:** Biological contaminants, such as bacteria and fungi, can also affect air quality, both indoors and outdoors. Bacteria can be found in heating and cooling systems, on house pets, within garbage, and in bathrooms. They can cause colds, flu, respiratory infections, and eye infections. Fungal contaminants, such as mold spores, can be found in damp clothing, heating and cooling systems, walls, carpets and curtains. Mold spores can cause allergies, sinus headaches, and depression. Refer to page 3 and page 4 for charts of common types of bacteria and fungi that may be present in air.

What can be done to reduce air pollution? Many power plants and factories are required to use devices called scrubbers, which remove sulfur dioxide and other air pollutants before the by-products are released into the air. As mentioned earlier, the US, along with many countries, has banned the use of chlorofluorocarbons. The fast food industry responded to this legislation by discontinuing the use of styrofoam containers to serve food. Many governments require automobiles to have catalytic converters, which reduce the amount of pollution from automobile engines. Car-pooling or car-sharing can help to cut down on the number of automobiles on the road, thus reducing air pollution.

Activity Overview

In this experiment, you and your classmates will assume the role of environmental specialists. You will investigate the air quality of various local sources by performing two different types of tests.

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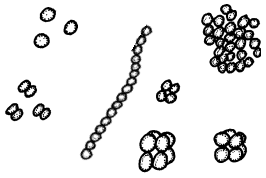
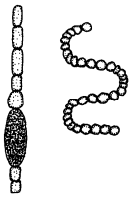
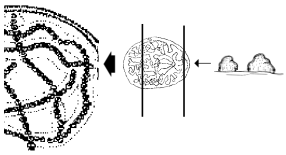
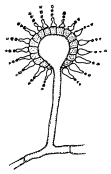
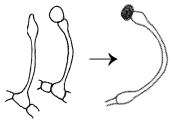
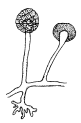
Common Bacteria Types

Name	Illustration	Where to look	What to look for
Cocci		Various surfaces, soils and in polluted water	Cocci are spheres 0.5 to 2.2 µm in diameter. After dividing, they usually adhere to each other and form clusters. Type of clusters include: Diplococcus (e.g. pairs), Tetracoccus (e.g. groups of four), Streptococcus (e.g. chains), Sarcina (e.g. cubes of eight), and Staphylococcus (e.g. irregular clusters).
Cyanobacteria-*Anabaena*		On submerged aquatic plants, other submerged surfaces or shoreline muds	Anabaena are macroscopic. Their blue-green color is evenly distributed throughout the cell. Their hair-like filaments are composed of beadlike or barrel-shaped cells (8 to 10 µm in diameter).
Cyanobacteria-*Nostoc*		Stagnant waters, ponds, lakes, ditches or on rocks or other submerged objects in stream riffles	Nostoc colonies are up to 2 cm in diameter and are usually globular with a firm mucilage matrix.
Rods-*Bacillus thuringensis*		Ornamental shrubs, trees and vegetables that are infested with caterpillars	Rods are 0.5 to 0.9 µm wide by 1.2 to 3.0 µm long. They exist as rods and produce a protein crystal.
Spirilla		Various surfaces, soils, and in polluted water	Spirilla appear as short rods, 0.5 µm to 0.8 µm wide by 5 to 60 µm long. They appear slightly bent or as rigid spirals.

Common Molds and Fungi

Name	Illustration	Where to look	What to look for
Aspergillus		Moldy breads; also appear on peanuts, especially after spring showers	Aspergillus are macroscopic. They have fuzzy appearance with dark spore cases. Fruiting bodies are either black (Aspergillus niger) or yellow-green (Aspergillus flavus). They resemble a fan with spherical-shaped spores (2 to 5 mm in diameter) located in chains that radiate from a central point. The hyphae are either transparent (Aspergillus flavus) or yellowish (Aspergillus niger) and have a cross wall. The mycelia are either white or yellow with small black spore cases.
Mucor		Moldy breads and fruits, such as oranges, coconuts, as well as other foods	The macroscopic mycelia are beige or white with black fruiting bodies. The microscopic fruiting bodies resemble a lollipop on a branched stick. Hyphae, which are also microscopic, are transparent and have no cross walls.
Penicillium		Moldy breads or fruits	Mycelia are macroscopic and green to bluish gray. The hyphae are microscopic, transparent and have cross walls. The fruiting bodies are also green to bluish gray. They resemble a brush or broomstick with spherical spores (2 to 5 mm) situated in chains on each hyphal branch.
Pilobolus		Barns or pastures housing horses or cows	Macroscopic. The fruiting bodies are transparent, bulblike structures with a black cap that sits on top of a long slender stalk. The hyphae have no cross walls.
Rhizopus		Moldy breads, bananas, potatoes and other plant materials	Mycelia are macroscopic. They are gray to white, fuzzy-looking, and have black spore cases. The microscopic fruiting bodies are black and resemble a lollipop on a long stick. Microscopic hyphae have no cross walls.
Rhytisma		Maple trees	Appear as black spots on maple trees

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Activity 1

Observation of the Air Around Us

What to do...

Step 1

First, your lab group will visually inspect a variety of environments for air quality. Your teacher may allow you to take a walk around the school, both inside and outside, just to observe the air around you. Make a mental note of any particulate matter, smoke, smells, etc. that you observe.

Step 2

After observing the characteristics of the air, answer the following questions:

1. Are there any characteristics that distinguish the air in one environment from another?

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2. Even though the air may look clean and pure, is this enough evidence to prove that it does not contain pollutants? Why or why not?

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Activity 2

Testing Air for Microorganisms

What you need

Per group

1 Nutrient agar plate (for growing bacteria)

1 Starch agar plate (for growing fungi)

Shared

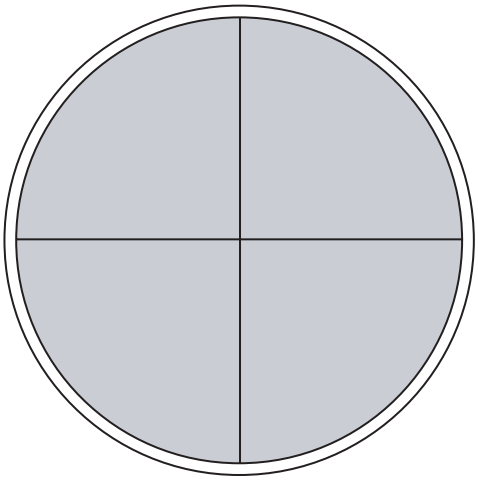
Masking tape

Wax pencil(s)

What to do...

Step 1

Obtain two agar plates, one nutrient and one starch from your teacher. With the lids still on the agar plates, turn them over and place them on your desk. Using a wax pencil, carefully split the bottom of your plates into four quadrants. Refer to the following illustration.



Step 2

Your teacher will assign your lab group a group number and an environment to test. Write these on the bottom of your agar plates and in Table 1. There will be control plates that your teacher will set up. Be sure to make a note of them in Table 1 as well.

Note: *Various kinds of bacteria grow on nutrient agar. Keep the plates covered until the actual time of use.*

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Step 3

Take your agar plates to your assigned environment with the lids still on the plates. Find a level spot where you would like to place them. Make sure that it is a spot that will not be disturbed. Remove the lids and place them underneath the plates. Place them together on the level surface. Allow the plates to sit there undisturbed for approximately 24 hours.

Step 4

After 24 hours, retrieve your plates and immediately cover them with their lids. Seal the plates with masking tape. Next, invert the plates, with the lids on the bottom, and incubate them at 37°C for 24 hours.

Note: *If you do not have an incubator, find a warm place in the lab to place your plates. This may increase the incubation time to 2-3 days. Be sure to check your plates daily.*

The plates must be inverted so that any condensation does not drop back on the surface of the bacterial colonies and inhibit their growth.

Safety: *Do not open the sealed plates. Some of the bacteria grown on these plates may be potentially pathogenic.*

Step 5

Predict the types of microorganisms that may grow on the plates in each environment.

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Step 6

Disinfect your work area after finishing with the lab. The work area should also be decontaminated by wiping it with either a bleach solution or 95% ethanol. You should also thoroughly wash your hands before leaving the laboratory.

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Activity 3

Observation of Microorganisms

What you need

Per group

Your nutrient agar plate

Your starch agar plate

Shared

Stereomicroscope or hand lens

What to do...

Step 1

Your agar plates can be observed after 24 hours for any growth. Observe the growth pattern of any colonies. Count the number of colonies in each quadrant on each plate.

Suggestion: *Share the counting with your lab partners. For example, have a different lab partner count each quadrant while one partner records the data.*

Add the number of colonies in each of the four quadrants on each plate to get the total number of colonies for your environment. Record your results in Table 1.

Step 2

Fill in the counts from the rest of the lab groups and from the control plates in Table 1. Once this is complete, analyze Table 1 with your class.

Based on the colony counts, which environment is most abundant with microorganisms?

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Step 3

Using a stereomicroscope or hand lens, study the morphology (physical characteristics such as color, shape, texture and overall appearance) of each type colony on your agar plates.

Note: *You should be able to perform this step with the lids on the plates. However, if you need to remove them, ask your teacher for assistance. If you happen to have a plate with no growth, find a lab group that has a plate with growth that you can study. In this case, just make sure to note which environment you are studying.*

As a group, choose two or three colonies that you would like to study further and make a drawing of them in Table 2. Next to each drawing, describe the morphology of the colony.

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Table 1

Group #	Environment	Type of Agar	# of Colonies per Quadrant				Total # of Colonies
Control							

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Activity 4

Making and Staining Bacterial and Fungal Smears

What you need

Per group

Slides that your teacher will prepare

Shared

Methylene blue

Compound microscopes

What to do...

Step 1

From your list in Table 2, choose a colony. Your teacher will smear and fix a small sample of the colony onto a microscope slide.

Safety Note: *For safety reasons, your teacher will demonstrate and perform this technique for you.*

Step 2

Obtain the slide and flood the slide with methylene blue stain for 1-2 minutes over a sink or tub.

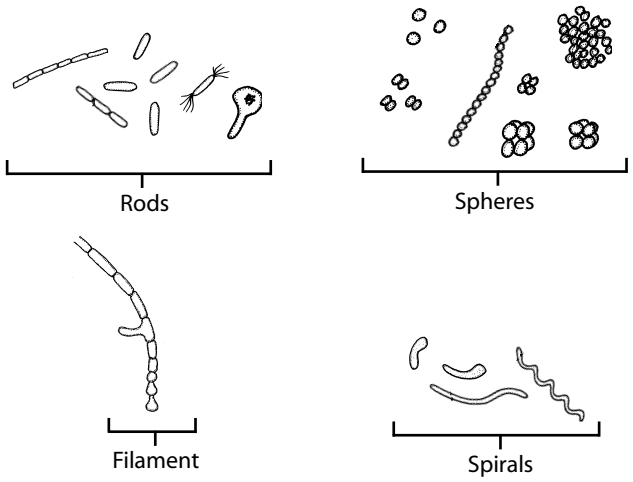
Step 3

Rinse the slide by dipping it into water and blotting it dry with a piece of filter paper or paper towel. Add 1-2 drops of mounting medium to the microscope slide in the area where the coverslip should be mounted. Place the cover slip onto the mounting medium, then apply gentle pressure to the coverslip to evenly distribute the mounting medium between the coverslip and the slide. Gently tap the coverslip with a soft eraser to eliminate air bubbles. Allow the mounting medium to dry.

Note : *Avoid getting the mounting medium on the top of the coverslip.*

Step 4

Examine the slide under high power and oil immersion (if available), and then make a drawing of what you see in Table 2. Describe the shape and detail of the microorganism in Table 2. Here are some common shapes of bacteria to look for:



Refer to the included Common Bacteria Types and Common Molds and Fungi charts (or any other reference material that your teacher recommends) to assist with the identification of the microorganism. Be sure to note your findings in Table 2.

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Step 5

Repeat Steps 1-4 for each of the colonies that you would like to study.

Step 6

Dispose of all materials after completing your final observations. These should go in a biohazard bag or other receptacle that your teacher designates. Wash your hands before leaving the laboratory.

Table 2

Drawing of Colony	Morphology	Drawing of Microorganism	Description	Type of Bacteria or Fungi Identified

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Activity 5

Testing Air for Particulates

What you need

Per group

1 Microscope grid

1 Toothpick

Shared

Petroleum jelly

Compound microscopes

What to do...

Step 1

Your teacher will assign your lab group a number and an environment. Obtain a microscope grid. Label the back side of your microscope grid and Table 3 with this information. A control will also be designated by your teacher so make sure to note this in Table 3 as well.

Step 2

Obtain a toothpick. Use the toothpick to cover the top of your microscope grid with a thin layer of petroleum jelly. Discard the toothpick into the designated receptacle.

Step 3

Gently place the microscope grid (jelly side up) into the palm of your hand with the other hand cupped over the slide. Alternatively, you may also place your slide into an appropriately sized box or container. This will allow you to transport your microscope grid to and from your designated environment with a minimal risk of contamination.

Note: *Make sure that you do not touch the jelly with your hands or with the container as it is being transported. Be sure to keep the microscope grid level as you transport it from place to place.*

Step 4

Carefully take your microscope grid to your designated environment. Find a safe, level spot to place your grid where it will not be disturbed.

Step 5

Gently set your grid on the level spot (jelly side up). Allow the grid to remain undisturbed for approximately 24 hours.

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Activity 6

Observation of Air Particulates

What to do...

Step 1

After 24 hours, retrieve your grid and carefully transport it to the lab in the same manner that you transported it to your environment.

Step 2

Using a microscope on low power, count the number of particles in 10 random squares on the grid. Just make sure that you do not count the same square twice. Record your data in Table 3.

Step 3

Once you have counted all 10 squares, take the average to determine the average number of particulates per square. Record this average in Table 3.

Step 4

Create a drawing, in the circles below, of any interesting particulate matter that you see on your grid.

Step 5

As a class, fill in the rest of Table 3 with information from each of the lab groups. Once this is complete, analyze the data table as a class.

Particulate Matter Drawings

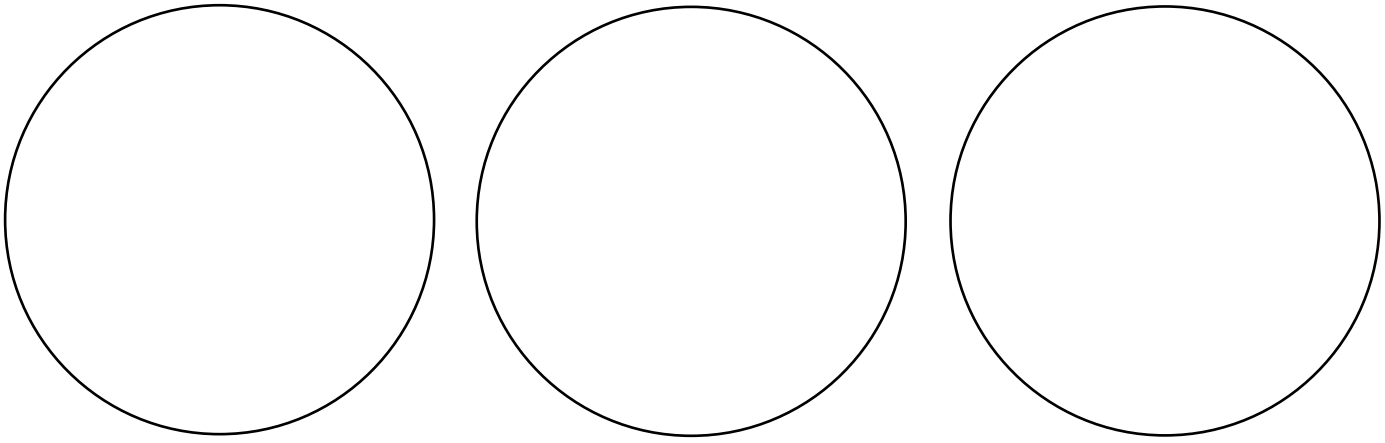

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Table 3

Group #	Environment	Number of Particulates per Square										Average # of Particulates per Square
Control												

Questions

1. In Table 1, which environment contained the most number of colonies?

2. Why do you think there is so much growth in this environment as compared to the others? Give some possible explanations.

3. Was there a control in this experiment? What was it? What does the growth on the control plate tell us about the control? Why are controls important when performing scientific experiments?

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4. What was the purpose of using the agar and the petroleum jelly in this experiment?

5. According to Table 3, which environment had the greatest amount of particulates? Which location had the least amount of particulates?

6. Suggest possible sources of particles that were observed in Activity 3.

7. Explain how the following factors might influence an experiment just like the one you just performed: the day, the time of day, the weather, the season.

8. Prepare a list of possible air pollutants and air pollution sources in your community.

9. What are some ways that you could reduce air pollution in your community?

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10. What are some of the effects on human health from air pollutants?

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11. What different aspects of your life could be affected by air pollution?

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Going Further

After identifying several types of microorganisms in this experiment, choose one to research. Find out if this microorganism affects humans in any way.

Design an experiment to test tailpipe emissions from automobiles. Then, research various ways that we could reduce automobile emissions in order to improve our air quality.

Research different types of air filters and air purifiers in order to create a consumer report based on your findings.

Learn and Read More About It

Allaby, Michael and Richard Garratt. *Fog, Smog, and Poisoned Rain (Dangerous Weather)*. Facts on File, Inc. 2003.

Billac, Pete. *The Silent Killer: Indoor Air Pollution.* Swan Books. 2000.

Kidd, J.S. and Renee A. Kidd. *Into Thin Air: The Problem of Air Pollution (Science and Society).* Facts on File, Inc. 1998.

Thompson, Colin. *The Tower of the Sun.* Knopf Books for Young Readers. 1997.

Neat Websites

http://www.epa.gov/airnow/

http://www.lungusa.org/air

http://www.nrdc.org/air/pollution/default.asp