

# INTRODUCTION TO LESSON CLUSTER 3

## THE AIR AROUND US

### A. Lesson Cluster Goals and Lesson Objectives

#### Goals

-Students should be able to describe air in terms of both its macroscopic properties and its microscopic composition.

#### Lesson Objectives

Students should be able to:

3.1 Describe air as a substance that takes up space.

3.2 Describe air as a mixture of molecules: nitrogen (N<sub>2</sub>), oxygen (O<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), water vapor (H<sub>2</sub>O), and other gases.

Explain how a variety of other substances may be mixed in air. Also, explain how we are able to smell some substances.

3.3 Describe how breathing changes the composition of air by increasing or decreasing the amount of O<sub>2</sub>, CO<sub>2</sub>, and H<sub>2</sub>O.

### B. Key Elements of a Good Description

At the macroscopic level, students should describe air as a substance that takes up space. Air is a **mixture** of gases. The component gases vary in proportion from place to place and time to time.

At the molecular level, air is a mixture of different kinds of molecules, mostly N<sub>2</sub> and O<sub>2</sub> with small and sometimes variable amounts of other gases, such as CO<sub>2</sub>, water vapor (H<sub>2</sub>O), etc. Other substances may also be mixed in air, for instance, dust, germs, smell of substances, etc., but they are not a part of what we call air.

Also at the molecular level, students should explain that breathing changes the composition of air by increasing or decreasing the amount of CO<sub>2</sub>, O<sub>2</sub>, and H<sub>2</sub>O.

### C. Students' Conceptual Learning

This lesson cluster provides opportunities for students to apply several ideas from previous lesson clusters, such as:

-- gas is a state of matter

- like all matter, air is made of molecules, so tiny that they are invisible, and constantly in motion
- air contains a mixture of different kinds of molecules
- there is always water vapor present in air

There are other ways in which the contents of this lesson cluster are new and potentially difficult, however. Some of these problems have to do with ideas about air that are common student thinking and in our language, but are not scientifically accurate. We speak of air as light, "airy," insubstantial, or even as nothing. Students must learn to see air and other gases as forms of matter like liquids and solids, with all the characteristics of matter in general:

- air is made of molecules
- air takes up space

The topic of air also causes difficulties for students because air is a complex mixture of gases that are generally colorless, odorless, and thus undetectable except by indirect means. Furthermore, the exact composition of air varies from time to time and from place to place. Many important phenomena, including respiration, photosynthesis, humidity, smells, pollution, and the water cycle, are associated with variations in the mixture of molecules in air. We cannot discuss all of these phenomena in this lesson cluster, or even in this unit. But a good understanding of the nature of air will prepare students for future learning about these phenomena.

### Lesson 3.1

The question "Is air something or nothing?" may sound trivial, but some students think that air is nothing. Others who think that air is something still may have ideas that are not scientifically accurate. For instance, some may use air as a generic term for gases. Some may think that air has color or odor. This problem is caused by the fact that pure air is colorless and odorless, and thus not easily detected. Students should realize that air is "something," that it is a form of matter, and that it takes up space.

Matter is often defined as anything that occupies space and has weight. The definition is fine. We have emphasized the former and neglected the latter, because the concept of weight is often difficult for students to understand.

### Lesson 3.2

A common student misconception about the composition of air is that molecules of air are substances that can be seen in the air. Some common examples of these misconceptions are as follows:

1. Air is made of dust particles, germs, bacteria, pollution, etc.
2. Dust particles or germs are comparable in size to that of molecules of air.
3. Air is made of some kind of "wavy" lines.

The teacher should take care to dispel these misconceptions by stressing that air is made of molecules. The teacher should also stress the size of a dust particle or other substances compared to the invisible size of molecules.

Another common student misconception about the composition of air is that air is a continuous medium that serves to hold things such as dust, dirt, and smells. The teacher should emphasize that air itself is composed of molecules and that particles of other substances such as dust and dirt can be mixed in air.

Students may also think that air is a single type of gas and thus that "pure air" contains only one type of molecule. The teacher should emphasize that even "pure" air is a mixture, consisting of different kinds of molecules of gases. (The relative amounts of these different kinds of molecules of gases vary from time to time or from place to place.)

Among the different kinds of molecules that make up air, the one students have most difficulty in understanding is the presence of water vapor in the air. The teacher should emphasize that air contains invisible water vapor ( $\text{H}_2\text{O}$ ) as well as other kinds of gases, including oxygen ( $\text{O}_2$ ), nitrogen ( $\text{N}_2$ ), carbon dioxide ( $\text{CO}_2$ ), and a few other gases.

The teacher should also help students understand that other substances may be mixed in the air, such as dust, dirt, germs, smells, etc. These substances are not part of the composition of pure or clean air. The gases that make up pure air are colorless and odorless, so what we see or smell is other substances mixed in air. You also should emphasize that air consists of only molecules and that there is nothing (that is, just empty space) between molecules of air.

Some students may be confused between observable movement of air and invisible molecular motion. For instance, students may think that molecules move in air because air is moving, and molecules stop moving when air is still. The teacher should stress that molecules of air always move and never stop. Since air is in the gaseous state, molecules are far apart and move freely.

Students may have difficulty in understanding the properties of smells of substances:

- smell is matter
- smell is gas
- smell is made of molecules

Smells are substances mixed in air. We smell because the molecules move to our nose. Some common misconceptions are that (1) air carries smell, (2) smell travels through air, and (3) air molecules pick up smell.

### Lesson 3.3

You should emphasize how breathing can change the composition of air by increasing the amount of  $\text{CO}_2$  and  $\text{H}_2\text{O}$  and decreasing the amount of  $\text{O}_2$ . A common student misconception is that we breathe in oxygen and breathe out carbon dioxide. The teacher should help students understand by stressing that we breathe in and out air but the mixture of different kinds of molecules are different. That is, the air we breathe in and out contains the same kinds of molecules: nitrogen, oxygen, water, carbon dioxide, and a few others. The amounts of these substances, though, are different. The air that we breathe out has less oxygen, because some of it has been used by our body. It has more carbon dioxide and water vapor, because these are produced by our body.

#### D. Conceptual Contrasts

The chart below contrasts common patterns in student thinking with scientific thinking about some of the important issues for this lesson cluster.

<u>Issue</u>	<u>Goal Conceptions</u>	<u>Students' Conceptions</u>
Matter vs. non-matter	Solids, liquids, and gases are matter, other things are not.	Gases often incorrectly classified as non-matter. Air is nothing.
	Matter takes up space; non-matter does not.	Classification based on other properties (e.g., something you can see or feel).
Smell	Smells are gases and made of molecules.	Smells considered ephemeral, not really matter. Air carries smell or smell travels through air. Air molecules pick up smell.
Water vapor	Air contains invisible water vapor (humidity).	There is no gaseous state of water.
Molecular constitution of matter	All matter is made of molecules.	Substances not describes as as molecular.
Size of molecules	Molecules are too small to see, even with a microscope.	Molecules may be comparable in size to cells, dust specks, etc. Molecules can be seen with a microscope.
Motion of molecules	Molecules are constantly moving.	Molecules may sometimes be still (e.g., still air).
Visibility of molecular motion	Molecular motion continues independently of observable movement.	Molecules simply share in observable movements of substances (e.g., molecules move in air because air is moving.)
Pure substance vs. mixture	Pure substances are made of one kind of molecules; mixtures two or more kinds of molecules.	Distinction based on observable properties, such as taste, color, odor, etc.

# LESSON 3.1

## IS AIR NOTHING OR SOMETHING?

### PURPOSE:

To help students describe air as a form of matter that has certain definite properties, such as taking up space.

### ADVANCE PREPARATION:

This activity will require several large containers of water, preferably ones which are clear to better permit students to see the air levels in tumblers inverted in the water. Large beakers would work well.

### MATERIALS LIST:

For each student group:  
small plastic bag  
plastic cup or small jar  
large container of water  
2 ft. length of plastic or rubber tubing  
grease pencil for marking water levels on cup

### TEACHING SUGGESTIONS:

This lesson is designed to show students that air really is "something," that it is a form of matter, and that it does take up space, as shown by the activities. Often students think that air is nothing, or not matter.

The major thrust of this lesson is Activity 3.1: Is the air in a cup a real substance?

## LESSON 3.2

### WHAT IS AIR MADE OF?

#### PURPOSES:

To help students describe air as a mixture of molecules: mostly nitrogen ( $N_2$ ), and oxygen ( $O_2$ ), but also including carbon dioxide ( $CO_2$ ), water ( $H_2O$ ), and other gases. To help students describe air as having other materials mixed in it, such as dust, dirt, and smells.

#### MATERIALS LIST:

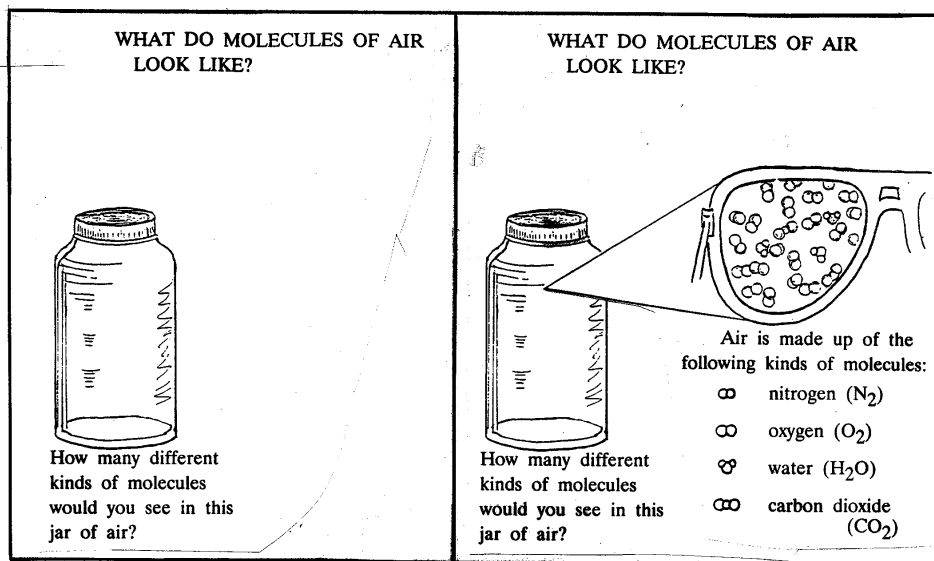
1. Transparencies: "What does the air look like?", "How big is a speck of dust compared to a molecule?", and "What is the smell of baking cookies?"
2. Perfume to be released in the classroom.

#### TEACHING SUGGESTIONS:

Resulting from the preceding lesson the students should be starting to think about air as matter. This lesson will reinforce that concept. Remember: A common student misconception is that molecules of air are substances that can be seen in air, such as dust or pollution. Continue to talk about having magic glasses so that students remember how tiny molecules are.

Have the students read the Science Book out loud or silently, and discuss any problems they might have.

Discuss the questions and the pictures thoroughly. Use Transparency 5 here:



#### TRANSPARENCY 5: WHAT DO MOLECULES OF AIR LOOK LIKE?

##### **BOTTOM LAYER:**

Students have a number of different conceptions about air. Some believe that air is nothing, or that there would be no molecules of air in the jar. Others believe that there is a generic kind of "air molecule." Some think that oxygen is the only thing of which air is made. Others believe that air is made up of pollution, germs, bacteria, smoke, dust, and other substances which can sometimes mix with air.

##### **OVERLAY:**

It is extremely important to contrast these naive ideas with the scientific conceptions. Students should learn that air is not only something, but a number of different "somethings," namely, nitrogen, oxygen, water, carbon dioxide, and small amounts of other gases. You should also point out that, although oxygen is a part of the air, it is not the only thing air is made of, or even the most plentiful. Show them that there is much more nitrogen in the air--almost four times more.

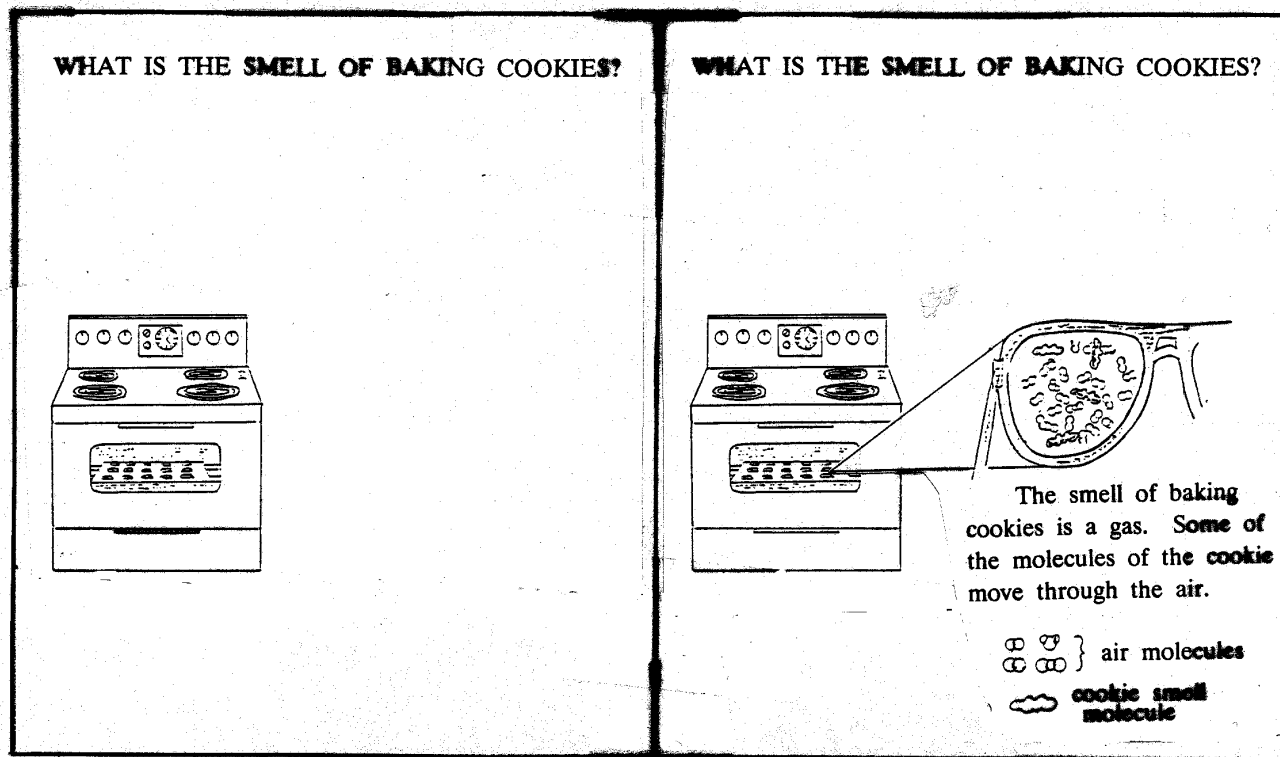
Use Transparency 1 here:

#### TRANSPARENCY 1: HOW BIG IS A SPECK OF DUST AS COMPARED TO A MOLECULE?

Look for illustration and explanation of student misconceptions in Lesson 1.3.

Before doing the perfume activity, close the classroom windows and doors to avoid drafts.

Use Transparency 6 here:



TRANSPARENCY 6: WHAT IS THE SMELL OF BAKING COOKIES?

**BOTTOM LAYER:**

Many students do not fully understand smells. These students will say that the smell of baking cookies is "a fume" or "an odor" or "a scent." They usually cannot use what they know about molecules to explain smells.

**OVERLAY:**

You should help students to see the scientific notion of smells, that all smells are gases and are made of molecules. Some of the molecules of the cookies break away from the cookie and then mix with and move through the air until the smell reaches your nose because of the constant motion of the air and smell molecules.



# LESSON 3.3

## AIR AND BREATHING

### PURPOSES:

To help the students explain that air breathed out contains more water vapor and carbon dioxide than normal air.

### BACKGROUND INFORMATION:

Bromthymol Blue (BTB) is an indicator that is blue in the presence of bases and yellow in the presence of acids. BTB turns yellow in this experiment because the interaction of carbon dioxide and water produces a weak acid, carbonic acid ( $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$ ).

### ADVANCE PREPARATION:

Prepare a BTB solution by adding about 35 drops of BTB to 3.5 liters (one gallon) of water. You may find it convenient to prepare more BTB solution to keep for later activities. Use approximately 10 drops of BTB per liter (quart) of water. The solution can be stored in plastic milk containers.

If the BTB solution is yellow when you prepare it, add a very small amount of household ammonia until the solution turns blue. Variations in the mineral content of the water can affect the color of the solution. Often the minerals will cause the BTB solution to turn green instead of yellow. However, this color change will still indicate the presence of carbon dioxide. Distilled or deionized water (available at grocery stores) have very low mineral contents.

### MATERIALS LIST:

For each student group:  
plastic cup  
soda straw  
BTB solution

### TEACHING SUGGESTIONS:

1. Use the Science Book to introduce Activity 3.3: Breathing Out and Breathing In.
2. After you completed the activity use the Science Book to help students explain what happens to the air when they breathe.

The observation that breath breathed out change the color of the BTB solutions shows more  $\text{CO}_2$  than in normal air, as you saw in the activity. Water vapor from breath condensing on a cool glass shows more  $\text{H}_2\text{O}$  than in normal air. These observations suggest these two components ( $\text{CO}_2$  and  $\text{H}_2\text{O}$ ) have variable composition in air. The relative amounts of  $\text{N}_2$  and  $\text{O}_2$  is quite constant throughout the world (78%  $\text{N}_2$ , 21%  $\text{O}_2$ , and about 1% other gases). The relative amounts of other gases are approximately:  $\text{CO}$ , 0.03%;  $\text{H}_2\text{O}$ , 0.3%.

Breath at high altitudes is discussed in lesson Cluster 5.3.

You might want to use [Question Set 3.3; Cluster Review](#) during the next class period. It can be used, if you wish, as an evaluatory tool.

# MATERIALS LIST

## CLUSTER 3, LESSONS 3.1-3.3

### Lesson 3.1:

For each group:  
small plastic bag  
plastic cup or small jar  
large container of water  
2 ft. length of plastic or rubber tubing  
grease pencil for marking water levels of cup

### Lesson 3.2:

Transparencies 5 and 6  
perfume to be released in the classroom

### Lesson 3.3:

For each group:  
a plastic cup  
a soda straw  
BTB solution