MATTER AND MOLECULES
Unit Introduction

For the next several weeks you will be studying matter and molecules. You will learn to explain what matter is made of and how it changes. Before you do that, though, let's talk about a basic question: What is matter anyway?

Matter is all the "stuff" that the world around us is made of. All solids, liquids, and gases are forms of matter. Your body, trees, the oceans, air, and clouds are examples of matter. You will learn in this unit about many different substances. All are kinds of matter.

As you learn about the substances in the world around you, you will discover that this unit is different from most other science books. You will learn some new and interesting facts, but more importantly, you will use those facts to explain things in the world around you. This unit is designed to help you explain things, not just learn facts.

Sometimes we will ask you to explain things that you haven't studied yet. We do this because sometimes your own ideas are important, even if they are not scientifically correct. Many of you will have different answers to these questions because you have different ideas. To learn science well, it is important for you to think about how your answers to questions are the same or different from other students' answers and your teacher's ideas. Whenever this book asks you to write your ideas about something before you talk about it in class, write the best answer you can, then think about your answer and other people's ideas.

So let's begin now. We will start by looking at one of the most common (and one of the most important) of all the substances around us – WATER.

LESSON CLUSTER 1
States of Water

Lesson 1.1: Solid Water and Liquid Water

You certainly know about liquid water. That's what you drink and take showers in. But have you seen any solid water around recently? Of course you have, only you probably called it ice.

How do you know that ice is really solid water? Can you show it? You probably can, but there isn't much time, so you'll have to hurry!

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Do Activity 1.1 in your Activity Book

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Ice and liquid water look and feel different, but they are still the same substance: ice can change to water and water can change to ice. Scientists call these different forms of water STATES. The solid state of water is ice. The liquid state of water is water. Water also exists in a third state a gas called water vapor. We will discuss water vapor in the next lesson. Since solid water (ice), liquid water, and gaseous water (water vapor) can be changed into each other by heating or cooling, that is a good reason to believe that they must be different states of the same substance.

Lesson 1.2: Solid. Liquid. and Gas

In the last lesson you learned about solid water and liquid water. In this lesson you will learn about the other state of water, the gas called water vapor. Have you ever seen water vapor? The answer is no. You have never seen water vapor, even though it is all around us and you have felt its effects. In order to learn more about water vapor, watch your teacher do Demonstration 1.2.

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Do Question Set 1.2 in your Activity Book

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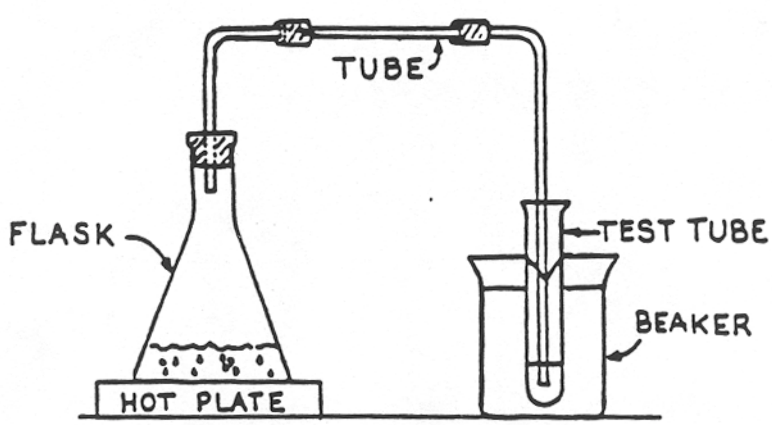
As you can see from the demonstration, water vapor is an invisible gas. Liquid water changes to water vapor when it evaporates or boils. The gas inside the bubbles of boiling water is water vapor. Water vapor can change back into liquid water when it cools down.

Water vapor is always invisible. You might think that the "steam" you see rising from boiling water is water vapor, but it is not. The "steam" you see is really tiny drops of liquid water that form when the water vapor cools.



Water changes from liquid to gas in the flask, then back to liquid in the test tube.

Because we cannot see it, we are not always aware of the water vapor around us, but it is always there. There is always water vapor in the air around us, and on humid days, the amount is especially high. Dew, and fog, and rain are all made of drops that formed when water vapor in the air changed back into liquid water.

Ice, liquid water, and water vapor are three different states of the same substance. They are water in its solid, liquid, and gas states. They are the same because they are all made of the same "stuff". In the next lesson, you will learn more about the makeup of the three states of water.

Lesson 1.3: Molecules, the Smallest Pieces of Water

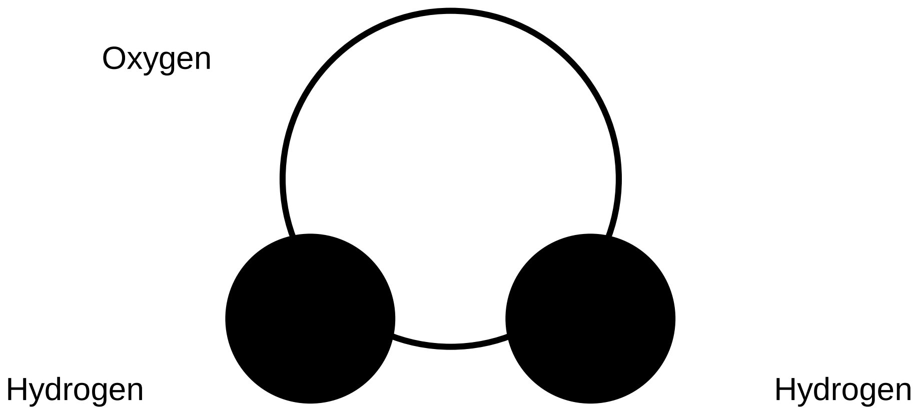
In Lesson 1.1 and 1.2 we decided that liquid water, ice and water vapor are all the same substance. What reasons did we give for that? They are all the same substance since they can change from one state to another by simply heating or cooling. Scientists have another reason for saying that they are the same substance. They are all made of the same tiny pieces or molecules.

What do we mean by that? Well, let's try to answer by thinking of the following question: If you had a pair of magic eyeglasses that showed the tiniest parts of water, what would the water look like?

This question may seem strange to you. After all, water doesn't look like it is made of anything except little drops of water. You know that water can be in little droplets, so maybe you said that water is made of little water droplets. Well, what is a water droplet made of?

We cannot tell what water is made of just by looking at it. But scientists say that water is made of water molecules. That is, if you divide a water droplet into smaller pieces until you can not divide it any more, then we have the tiniest pieces of water. We call these tiniest pieces, water molecules.

Some of you might have heard that water is called H_20. We call water H_20 because one water molecule is made of even tinier parts, called atoms. A single water molecule contains two hydrogen (H) atoms and one oxygen (0) atom. The oxygen atom is larger, and the hydrogen atoms are stuck to it in kind of a V-shape. All water molecules are the same. Each water molecule is H_20.



A molecule of water (H_20)

Every drop of liquid water--and every sliver of ice--is made of trillions of water molecules, and every water molecule contains three atoms (two hydrogen atoms and one oxygen atom).

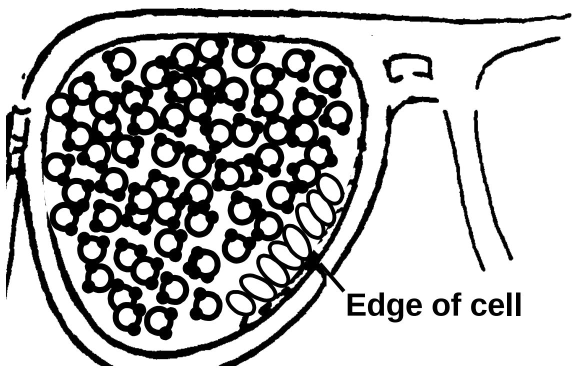
Since we already said that water molecules are the tiniest pieces that make up water, you know that they are very small. But how small are they?

Let’s compare them with some other small things. There are some small things that you can barely see, like specks of dust. Water molecules are much, much smaller than that.

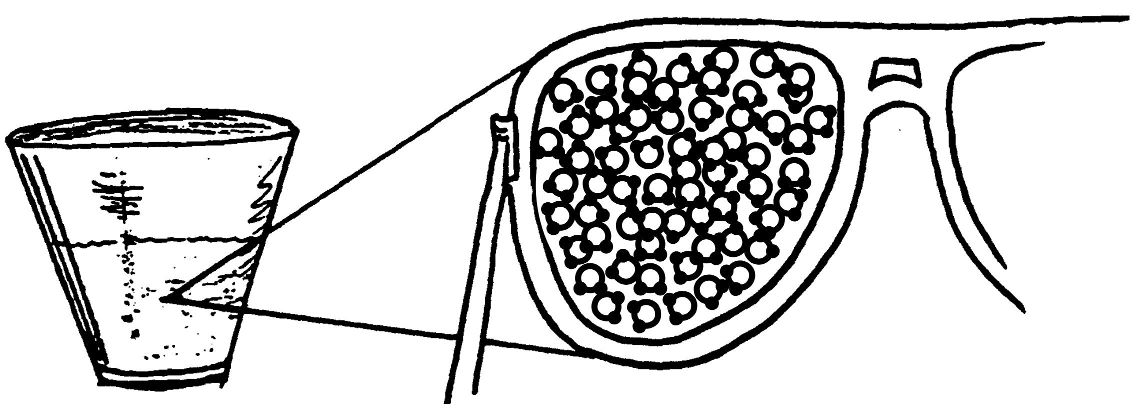
There are other small things that we can see only with a microscope, like germs or the cells our body is made of. Are water molecules smaller than cells or germs?

Yes, much smaller! In fact, a typical cell in your body might be made of 100 trillion (100,000,000,000,000) molecules. (More than half of these are water molecules, but a cell contains many other kinds of molecules, too.)

Suppose our magic eyeglasses could show us a single cell floating in a drop of water. What would it look like? Something like the picture below. (The picture can't show the whole cell because a cell is so much bigger than the water molecules.)



The molecules of liquid water are always moving. They are constantly sliding past and bumping into each other. They never stop. They are moving in all different directions. This movement goes on all the time, even when the water is just sitting in the cup.



The two important points we have talked about in this lesson are: liquid water is made of very tiny, tiny pieces called water molecules, and water molecules are always moving. In Lessons 1 and 2, we said that ice (solid water), liquid water, and water vapor (gaseous water) are the same substance.

Then in this lesson, you learned how all three states of water are the same. They are made of water molecules which are constantly moving. Now, can you guess what is different about the molecules in the three states of water? In Lesson 1.4, you will learn about how ice, liquid water, and water vapor are different. You will also learn how ice, liquid water, and water vapor are alike. First, though, try answering some questions about what you learned in this lesson.

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Do Question Set 1.3 in your Activity Book

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Lesson 1.4: Molecules and the Three States of Water

You have learned how ice, liquid water, and water vapor are the same. They are all made of water molecules, and those water molecules are always moving. Then, how are ice, liquid water, and water vapor different? Why do they look different? Why do they act differently? How can we explain the differences in terms of molecules? You will learn about these topics in this lesson.

The differences among the three states of water are not in the molecules themselves. Water molecules are all the same. The differences are in the way the molecules are arranged and the way they move. Can you think of ways that water molecules might be arranged differently in the three states of water? If you can, discuss your ideas with your classmates.

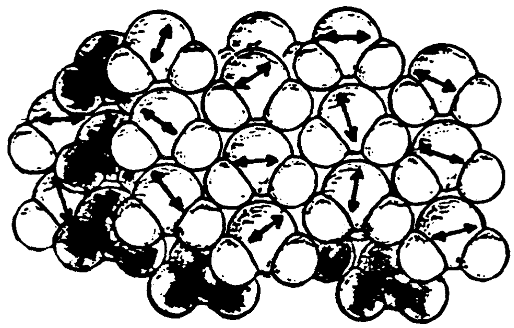
Here is how scientists explain the differences among the three states of water. In solid water (ice), water molecules are close together, locked in a rigid pattern, and thus they are not moving past each other. They vibrate, but they stay in place. Remember, molecules are constantly moving and never stop, even in a solid.

In liquid water, water molecules are moving faster. They are still close together, but they are no longer stuck in a rigid pattern as they are in ice. Water molecules in liquid water are constantly sliding past and bumping into each other; they keep moving from one place to another.

The molecules of water in water vapor are far apart and moving freely. They have lots of empty space between them. They move rapidly through this empty space, hitting and bouncing off each other.

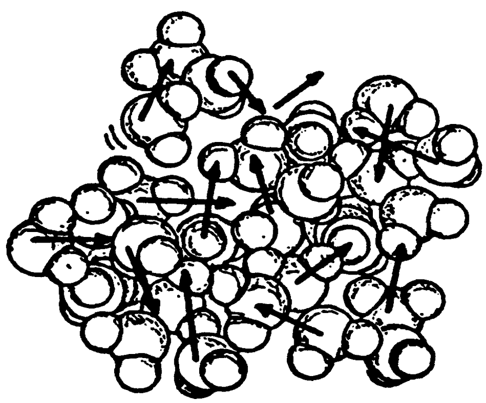
The pictures on the next page give a rough idea of how water molecules look in ice, liquid water, and water vapor. (Though you could never really see them--they're much too small!)

Ice:



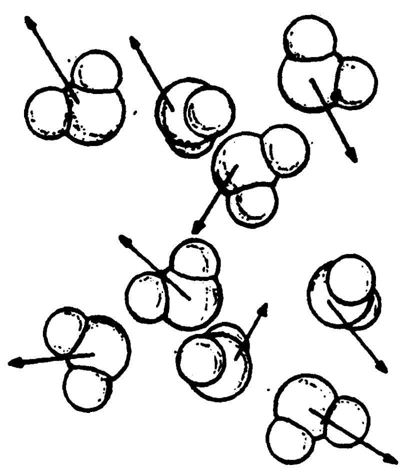
Water molecules are locked in a rigid pattern, vibrate in their places

Liquid water:



Water molecules slide and bump past each other

Water Vapor:



Water molecules bounce around freely in space

For the last four lessons you have been learning about a single important substance, water. You have learned that water exists in three states: ice, liquid water, and invisible water vapor. You have learned that the three states are the same in that they are all made of <u>very</u> tiny water molecules that are always moving.

Finally, you have learned how the arrangement and motion of water molecules are different in the three states. In ice the molecules are stuck rigidly together and vibrate in place. In liquid water they slide and bump past one another. In water vapor they are much farther apart and they bounce around freely.

Water is not the only substance in the world, though. We can see thousands of other substances all around us. In Lesson Cluster 2 you will learn about some of those other substances and the molecules that they are made of. Now we have some questions for you. Let's see if you can use these ideas to answer them.

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Do Review Question Set 1.4 Now

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Supplemental Reading: The Miracle of Water

Water is the most abundant liquid on earth and is needed by all living things. Rivers, oceans and lakes cover about three fourths of the surface of the earth. Besides this, there are large amounts of underground water. In many places, you can tap into this underground water by drilling wells. A water well is a hole in the ground from which you can pump water. Many people get their drinking water from these wells. Your body is about 71% water. Fruits and vegetables contain about 90-95% water.

Water, this very common liquid that you use every day, has many uncommon properties. Many of these uncommon properties are essential to life on earth. One of water's properties is that it dissolves more solids, liquids, and gases than any other liquid. This uncommon property of water allows your blood to carry oxygen and food to every cell of your body and to carry carbon dioxide and waste materials from each cell of your body. This property also allows you to wash your face, wash your clothing, cook your food, and to stay alive. It is for these reasons that water is called the universal solvent. (A solvent is a liquid that dissolves other solids, liquids, and gases.)

Another uncommon property of water is that it takes a lot of heat to increase its temperature, and it gives off a lot of heat when it cools down. If it were not for this uncommon property, life as we know it would only exist near the equator. The sun heats the earth, including the water, near the equator and as the water moves north and south from the equator it keeps the earth warm enough to support the living things that you are aware of. This uncommon property also helps you maintain your body temperature. In other words, this helps you stay warm in the winter and cooler in the summer.

One of the most surprising uncommon properties of water is that it expands when it freezes. Almost all other liquids contract when they solidify or freeze and expand when they melt. When you cool down water, it contracts just like any other liquid until it is 4 degrees Celsius. From 4^0C to 0^0C, the temperature at which water freezes, it expands. Ice, then, acts like any other solid and expands when heated and contracts when cooled.

This special property of water is truly a miracle because it makes possible life on earth. Because water expands when it freezes, ice is light enough to float on top of liquid water. Scientists predict that if water contracted instead of expanding when it freezes, the ice would build up from the bottom of the lakes until eventually the lakes were made of solid ice. This would mean that states like Michigan, Wisconsin, Indiana, Ohio, Pennsylvania and New York would be much colder in the summer time than they are now.

Because water expands when it freezes, it also helps to loosen the soil and break up rocks to make soil. Over thousands and thousands of years, this process has helped to make some of the richest farmlands in the world.

Another uncommon property of water is that it changes from one state to another within a relatively narrow temperature range. This enables us to have solid water in the freezer, liquid water to drink, and boiling water to cook our food.

The title of this section is “The Miracle of Water” because these uncommon properties of water make life possible on earth, make most portions of the earth warm enough for people to live, provide water in the form of rain far from lakes and rivers to help provide more food for people and help us have an abundance of a convenient liquid to wash our clothes, cook our food, and cool our drinks. As you study more about water, you will see that the combination of unique properties of water is truly a miracle

LESSON CLUSTER 2
Other Solids, Liquids, and Gases

Lesson 2.1: Are Other Substances Made Of Molecules?

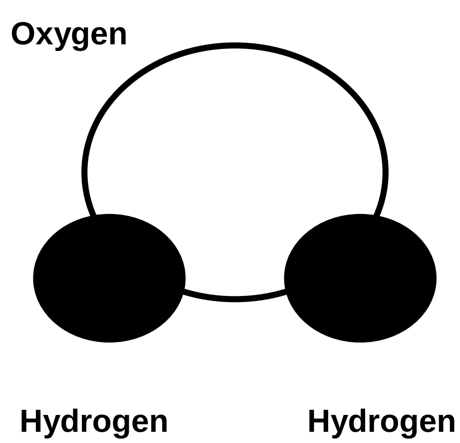
In Lesson Cluster 1 you studied ice, water, and water vapor. All three states of water are made of the same kind of molecules--H_20. Each state has molecules arranged differently, but the molecules are the same. Water molecules are the building blocks for ice, water and water vapor.

If you look around, most of the substances you see are solids, liquids, or gases. Most substances can also change from one state to another. For example, lead is usually a solid, but if you heat it hot enough, it becomes a liquid. If you heat liquid lead very hot it becomes a gas. You can change the solid form of a substance into a liquid, or a liquid into a gas. It is possible to do this because all the states of a substance are made of the same kind of molecules.

You could never change ice into glass, though, or water into alcohol, or water vapor into oxygen gas. Even though these substances look similar and are in the same state, one cannot be changed into another? Do you know why?

The answer is that their molecules are different. Each substance is different from every other substance because each is made of its own kind of molecules. In the same way, we can classify all substances as either solid liquid, or gas, but that doesn't mean that all liquids are exactly alike. Each substance is made of its own kind of molecules, with a certain size, shape, and weight.

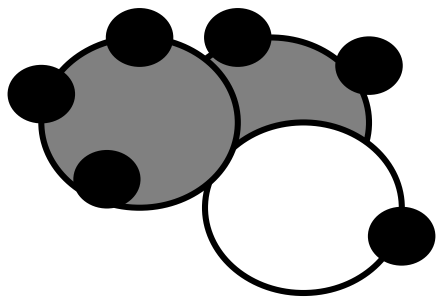
Let's look at some examples of different kinds of substances and their molecules. You have already studied one substance, water, and you have seen drawings of what a water molecule looks like. You learned that a water molecule can be drawn like the picture below.



A molecule of water (H_2O)

If we were able to see the molecules in a drop of pure water, (that is, water that is not dirty, or polluted) we would notice that all of the molecules of water would look exactly the same. They would all have the same structure.

If we could see the molecules of another substance, for example, alcohol, would these molecules look the same as the water molecules we just studied? No, the alcohol molecules are different from the water molecules. That's because each substance has its own kind of molecule, with a certain size, shape, and weight. The molecule of alcohol would look like this:

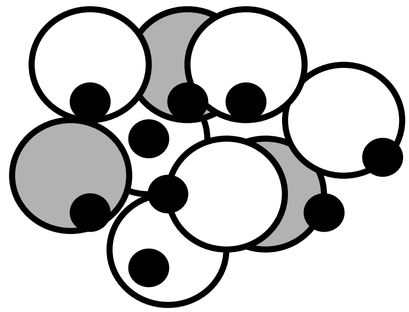


A molecule of ALCOHOL: CH_3 CH_2 OH

As you can see, an alcohol molecule looks very different from the molecules of water because it is made of different atoms. If we could use our magic eyeglasses to see the molecules in a drop of alcohol, we would see that all of the alcohol molecules have exactly the same shape, size, and weight.

The world is made of millions of different substances, and every substance is made of its own kinds of molecules! Some molecules, like water molecules, contain only a few atoms. Other molecules have hundreds or thousands of atoms. Even the largest molecules, though, are far too small to see.

Sugar is another substance you probably know. A sugar molecule is made of many atoms. (The formula is $C_{12}H_{22}0_{11}$). This is too complex to draw here. So in this unit, we will make-up a shape for a sugar molecule like this:



A molecule of SUGAR: $C._{12}H_{22}O_{11}$

All substances are made of molecules, but that doesn't mean that <u>everything</u> is made of molecules. Some things are not substances at all. Light, heat, and sound are not substances; they are forms of energy. Thoughts, love, and space are not substances either. Things that are not substances cannot be solids, liquids, or gases, and they are not made of molecules. There are no light molecules, or heat molecules, or sound molecules. There are no temperature molecules, or space molecules, or love molecules. Only matter exists as solids, liquids, and gases. Only matter is made of molecules.

Now try answering some questions about different substances and their molecules.

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Do Question Set 2.1 in your Activity Book

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Lesson 2.2: Pure Substances and Mixtures

You learned in the last lesson that different substances are made of different kinds of molecules. Molecules of each substance have their own size, shape, and weight, and they are different from the molecules of all other substances. We can use this idea to help us study the difference between a pure substance and a mixture. We can tell a pure substance from a mixture by thinking about molecules.

A pure substance has only one kind of molecule. Pure substances can be solids, liquids, or gases. Pure sugar is an example of a pure substance. It is made only of sugar molecules. Lead, water, and alcohol are also pure substances. They each have only one kind of molecule.

A mixture has two or more different kinds of molecules mixed together. Mixtures can also be solids, liquids, or gases. The Kool-Aid that you drink is an example of a mixture: It contains water molecules and other molecules mixed together. Sometimes you can tell that something is a mixture by looking at it, but not always! Try making some mixtures and see!

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Do Activity 2.2 in your Activity Book

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It is easy to tell that some things are mixtures because you can see the separate particles: salt and pepper, for example. Sometimes, though, the substances when mixed together break up into individual molecules: sugar and water, for example. You can no longer see the different substances, but their molecules are still there, just all mixed together!

Most of the materials around us are mixtures, made of two or more different kinds of molecules. Very few substances are pure substances. Even substances that look pure may actually be mixtures.

For example, you might think that glass is a pure substance because it is clear, and you can see through it. But glass is actually a mixture of many different kinds of molecules. Milk is a mixture, and ocean water, too. Your body is a mixture containing thousands of different kinds of molecules.

What about air and water? Are they pure substances or mixtures? Water is a pure substance, made of only water molecules. Air, on the other hand, is a mixture, made of many different kinds of molecules mixed together. You will study more about air in Lesson Cluster 3, but for now the important point to remember is that it is very hard to tell whether a substance is a pure substance or a mixture just by looking at it, tasting it, or smelling it.

All pure substances are solids, liquids, or gases. But some mixtures such as muddy water are not easily classified as a solid, a liquid, or a gas. This is because mud contains solid particles of dirt mixed with liquid water. So mud is partly solid <u>and</u> partly liquid. Mud and many other mixtures contain two different states of matter.

Lesson 2.3: Molecules and States of Matter

In Lesson Cluster 1 you studied the three states of a single substance--water. In this lesson cluster you have studied several other substances: sugar, alcohol, oxygen, and so forth. Try using what you know about these substances to think about these questions:

How are all substances alike?
How are substances different from each other?

You might want to think about these questions for a minute before you read on.

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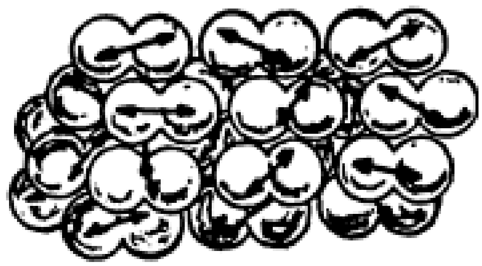
There are many possible answers to the above questions. Substances are alike and different in many ways. Here are three correct answers that are very important:

I. All substances are alike in that they are all made of molecules.
2. Substances are alike in that they are found in three basic states: Solid, liquid, and gas.
3. Different substances are made of different molecules. (Pure substances like water and sugar are made of only one kind of molecule. Mixtures like air and wood contain different kinds of molecules mixed together.)

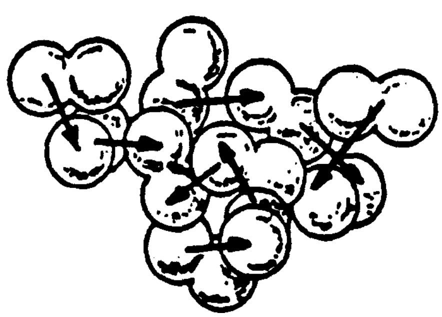
In this lesson you will be thinking about the molecules of solids, liquids, and gases. In what way are the molecules of all solids alike? In what ways are the molecules of different solids different? What about liquids and gases? You can think about these questions by discussing some substances that you are already familiar with.

Let's start with solids. Solids of different substances, like salt, steel, and sugar, are made of different kinds of molecules, but all solids are alike in the arrangement and motion of their molecules. All solids are made of molecules that are close together and locked into a rigid pattern. They move by vibrating in place and bumping into each other.



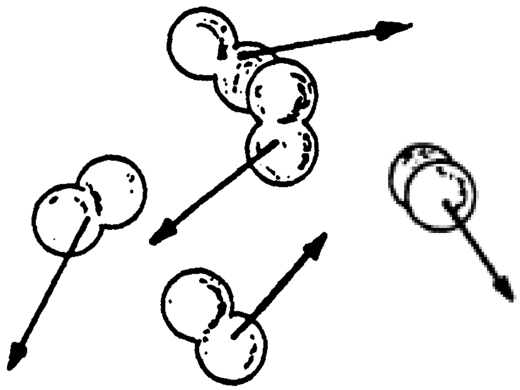
The molecules of all solids are locked in a rigid pattern and vibrate in place

Similarly, different liquids such as water, alcohol, and gasoline are made of different kinds of molecules, but all liquids are alike in the motion and arrangement of their molecules. All liquids are made of molecules that move around freely but stay close together. The molecules of liquids slide past each other and are constantly bumping into other molecules.



The molecules of all liquids slide and bump past each other

Different gases such as water vapor, oxygen, and carbon dioxide are made of different kinds of molecules, but all gases are also alike in the motion and arrangement of their molecules. All gases are made of molecules that are far apart from each other and moving freely through space. Sometimes gas molecules collide with other molecules or with objects.



The molecules of all gases are far apart and bounce around freely

Now you have learned a lot about solids, liquids, and gases of different substances. You have learned that all solids, liquids, and gases are made of molecules. Different substances are made of different kinds of molecules, but the motion and arrangement of molecules is about the same in all solids. All liquids also have molecules that move and are arranged in similar ways. So do all gases.

You also know that some substances are pure substances; all their molecules are the same. Most substances, though, are mixtures, of different kinds of molecules. In the next lesson cluster you will study a gas that is a mixture of several different kinds of molecules. We can't see this gas, but it is very important to us. The gas is air.

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Do Review Question Set 2.3 Now

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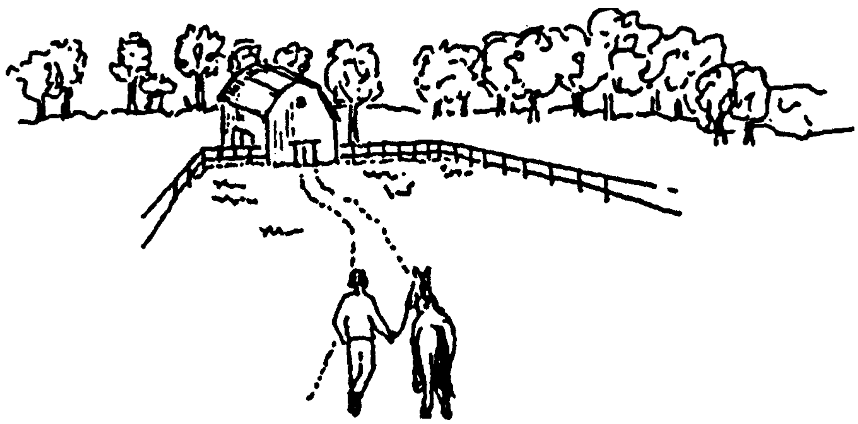
LESSON CLUSTER 3
The Air Around Us

Lesson 3.1: Is Air Nothing or Something

Air is all around us and all around the earth, but you can't see it. What is air?



Air is all around us

I asked one of my friends what would be left if you took all the furniture and rugs out of a room. She said "nothing." What about the air? Is air nothing? You can't see it, but there is something there. Try some activities where you work with the "something" that is air.

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Do Activity 3.1 in your Activity Book Now

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When you hold a cup upside down under water, the cup does not fill up with water because air is really something. It is a gas that takes up space. Otherwise, we could easily fill up the cup with water.

When you sucked air out of the cup, did you notice that the level of water inside the cup went up? What happened when you blew air back in? You might have noticed that, this time, the water level went down. Air must be something, because it makes the water move up and down inside the cup.

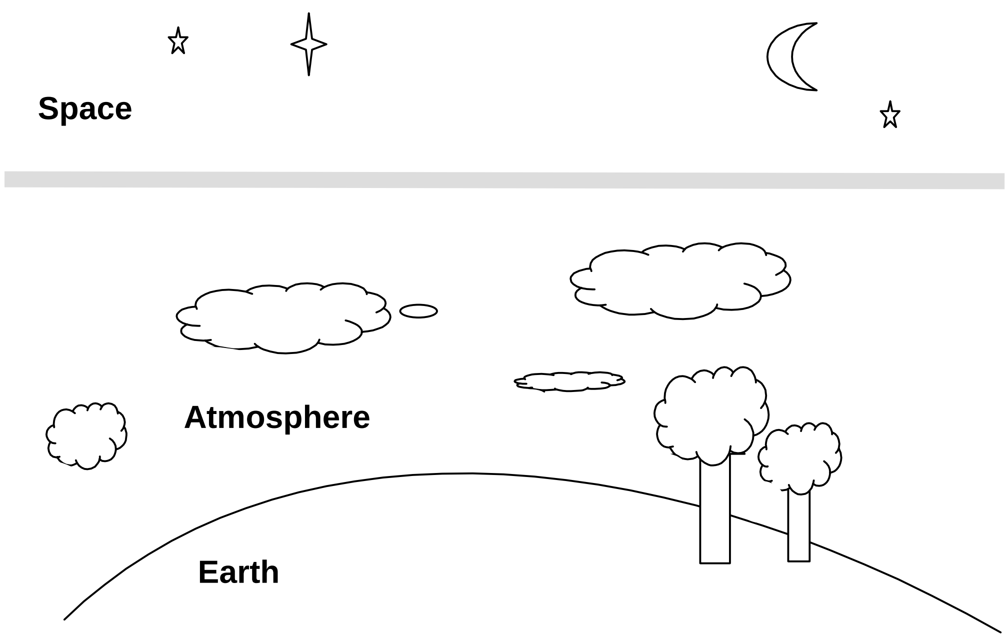
In this lesson you learned that air is something that takes up space. The next lesson will help you find out what that "something" is.

Lesson 3.2: What is Air Made of?

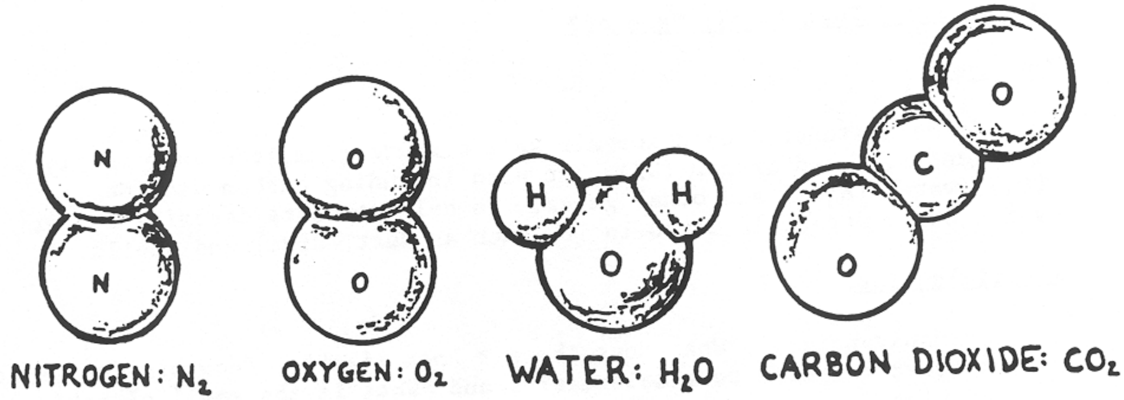
Air is not a liquid or a solid. Air is a gas. Like all gases, air is made of molecules that are far apart. That is why you cannot see air.

All the molecules of air are moving all the time, even when there is no breeze. The molecules never stop moving. They are far apart so they move freely, but they bump into each other and into other things, bouncing back and forth. Air is all around us, all the time. Even though you can't feel them, molecules of air are always hitting you. You breathe in molecules of air and breathe them back out.

The air that is all around the earth is called the atmosphere. The atmosphere goes up past the clouds, higher than mountains. As you go higher in the air, the molecules of air get farther and farther apart, and the air gets thinner and harder to breathe. If you keep going up, you finally get to space, where there are no air molecules at all.



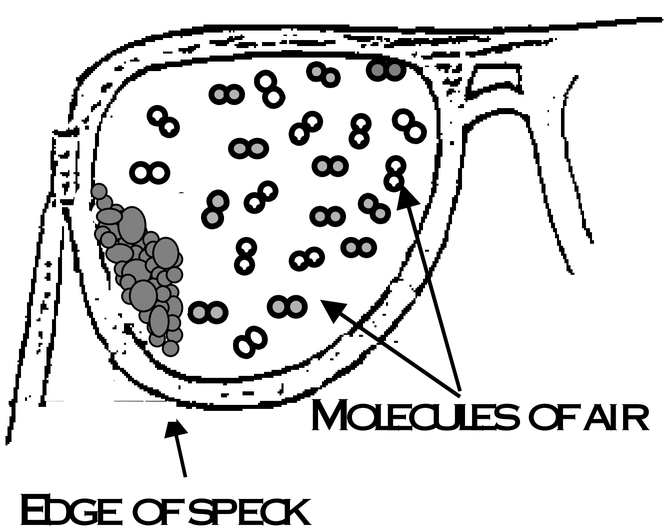
What are molecules of air like? First of all, let's imagine clean air without any germs, bacteria, dirt, dust, smoke, or pollution in it. Clean air is a mixture of different kinds of molecules, including nitrogen molecules (N_2), oxygen molecules (O_2), carbon dioxide molecules (CO_2), and water molecules (H_2O). These molecules "look" something like the pictures on the next page, though they are really too small to see.



Air is made mostly of nitrogen, oxygen, water, and carbon dioxide

How are these molecules alike and how are they different? All the nitrogen molecules are alike, but they are different from the oxygen molecules. All the oxygen molecules are alike, but they are different from water molecules. These molecules move freely and mix together to make air. AIR IS MADE OF THESE MOLECULES.

How big or small do you think these molecules of air are? Different molecules have different sizes. Oxygen molecules are slightly bigger than nitrogen molecules. Nitrogen molecules are slightly bigger than water molecules. But how does the size of any kind of a molecule compare with a very, very small object you can see with your eyes, like a speck of dust? Which is bigger, a molecule or a speck of dust? How much bigger? If we compare the size of a molecule and that of a speck of dust, it would look like the picture below:



As you see in the picture, a speck of dust that you can barely see with your eyes is much, much, bigger than a molecule (trillions of times bigger!). The speck of dust is made of trillions of molecules itself; it is a solid while air is a gas.

If you look at the air molecules in the picture, you will see that they are mostly nitrogen and oxygen molecules. Air is about 4/5 nitrogen and 1/5 oxygen. Water, carbon dioxide, and other gases make up only two or three percent of the molecules in the air. Can you think of any substances other than dust that mix in air? There are many, including dirt, germs, bacteria, smoke, and many other substances. Most substances that you can see in the air, like dust or smoke, are made of solid particles that contain trillions of molecules each. But sometimes substances that you can't see also mix with air.

What else is sometimes in the air? Did you think of smell?

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Do Question Set 3.2 in your Activity Book

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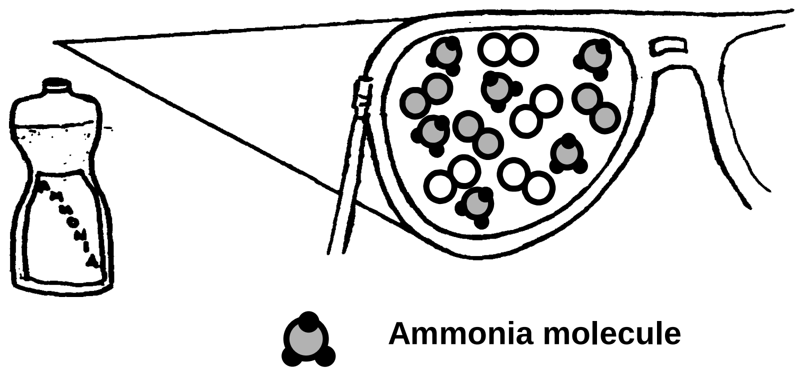
What is the smell of perfume? First of all, smell is a gas and made of molecules. When a bottle of perfume is opened, some molecules of the perfume leave the bottle, go into the air, and mix in the air. These molecules of perfume in the air are constantly moving, so they spread out. They spread out until the perfume molecules reach and affect your nose. Then you can smell them.



You smell ammonia when you breathe air with ammonia molecules in it.

The same thing happens when you open a bottle of ammonia or you cut into a lemon. Molecules of the ammonia or lemon spread out in the air until they reach your nose. Ammonia, lemon, and perfume molecules are smelly because they affect your nose.

In this lesson you answered questions such as “What is air made of?”, “What are smells?”, and “How do smells travel?” In Lesson 3.3 you will study more about air and breathing.

Lesson 3.3 Air and Breathing

Has anyone ever told you that you breathe in oxygen and breathe out carbon dioxide? Well, that isn't really quite true. You breathe in air, which has oxygen molecules mixed in with molecules of nitrogen and other gases. What you breathe out is air, too, but the mixture of molecules is different! This lesson is about the changes that take place in air when you breathe it in and breathe it back out.

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Do Activity 3.3 in your Activity Book

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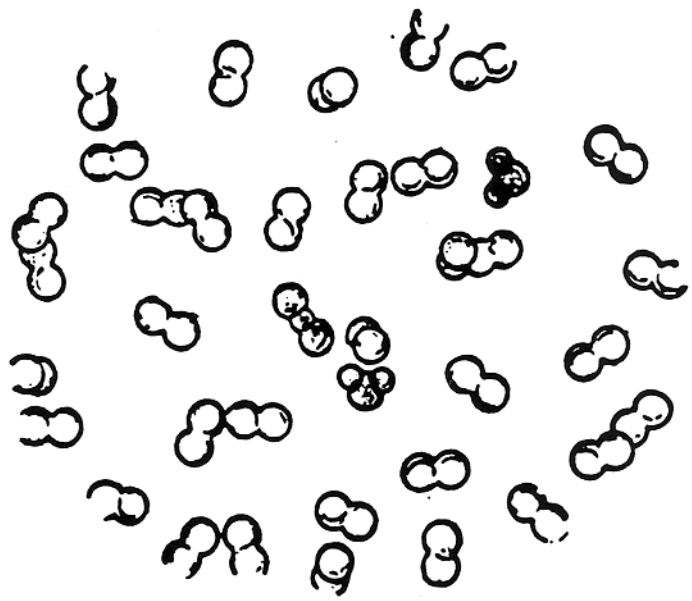
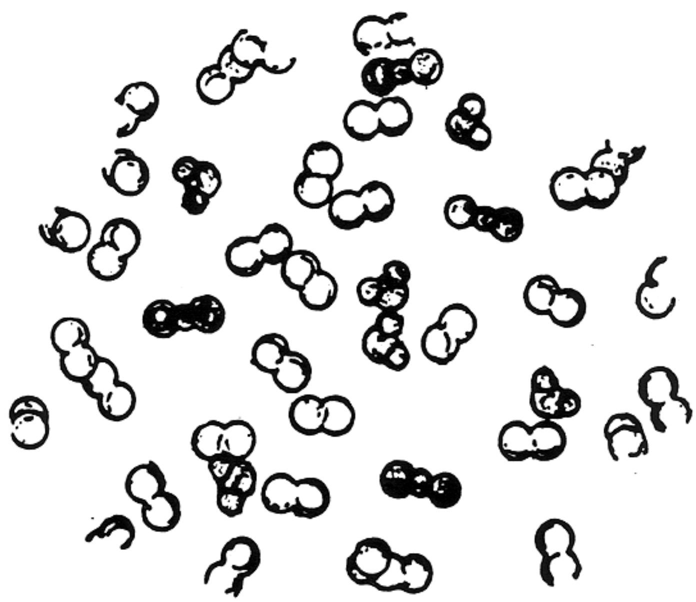
The air you breathe in is made mostly of nitrogen molecules, but your body has no use for them. You breathe them right back out. What your body needs from the air is the oxygen molecules that it contains. Oxygen molecules are used by your body; you get your energy by combining food and oxygen.

When your body uses food and oxygen, it produces two other substances, carbon dioxide and water vapor. How do you get rid of them? By putting them into the air that you breathe out!

The air that you breathe out, then, still contains the same kinds of molecules: nitrogen, oxygen, water, carbon dioxide, and a few others. The amounts of those substances, though, are different. The air that you breathe out has less oxygen, because some of it has been used by your body. It has more carbon dioxide and more water vapor, because these are produced by your body. The pictures on the next page illustrate these differences



Air breathed in



Air breathed out

In this lesson cluster you studied what air is made of and how breathing effects the make-up of air. In the next lesson cluster you will learn how to compress and expand air.

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Do Review Question Set 3.3 Now

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LESSON CLUSTER 4
Compressing and Expanding Air

<u>Lesson 4.1: Explaining Things with Molecules</u>

In the lessons that you have already studied, you have been learning quite a bit about molecules; what they are, how small they are, how they move, how they are arranged, and so on. These lessons have been helping you explain things in terms of molecules, not just in terms of what you see, hear, or feel.

In science, we often explain how things happen by giving molecular explanations. By using what we know about molecules in our explanations, we can better understand why something happens in a certain way.

For example, we have already learned that molecules are constantly moving. Because air molecules are constantly moving, they are always hitting objects in the air. This helps to explain why certain things happen. See if you can use the idea of air molecules hitting things to help you explain the demonstrations that your teacher will now do. Watch and discuss the demonstrations, then answer questions about these events in your activity book.

1. Hair dryer and ping pong ball.
2. Sitting on inflated ball, basketball or football.
3. Blowing on wind chimes (optional).

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Do Question Set 4.1 in your Activity Book

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In talking about the demonstrations you just watched, you might give explanations that mention the air but not air molecules. But a much better scientific explanation would also talk about what the <u>molecules</u> are doing and how they are involved in what is happening. Talking about molecules gives a better, more complete explanation of how things happen.

Look at the explanations that you wrote in your activity book. Did the explanations mention how the molecules of air were hitting the objects? If you did not, then see if you can change your explanations so that they talk about molecules.

Lesson 4.2: Compressing Air

Can you push air closer together to get more air in a smaller space? This activity will help us answer that question.

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Do Activity 4.2 in your Activity Book

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A good explanation of why you can push the plunger partway in with air in the syringe, but not all the way, would go like this: Molecules of gases are far apart and have empty spaces between them. The molecules of air in the syringe are scattered all through the syringe. When the plunger is pushed in, the molecules of air are pushed closer together. When air molecules are pushed closer together, we say that the air is compressed.

Air and other gases can be easily compressed because their molecules are far apart. The molecules of solids and liquids, though, are already close together. This makes it almost impossible to compress solids or liquids such as water.

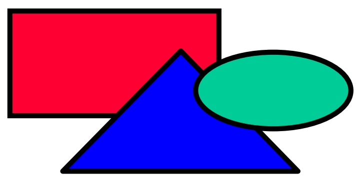
When you pushed the plunger in and then let it go, you should have seen the plunger move back out again. The plunger moves back out because air molecules are hitting it all the time, pushing on it, just like air molecules in the wind were pushing on the ping pong ball to hold it up. When you push in on the plunger, the air molecules are pushed closer together, and more of them hit the plunger. When you let go of the plunger, the air molecules push it back out.

The molecules that make up air and the molecules that make up water are always moving. Molecules of water are sliding past each other, moving all around. Molecules of air move quickly around inside the syringe, hitting each other and hitting off the inside of the syringe and plunger. This constant motion keeps the molecules spread evenly through the inside of the syringe.

Lesson 4.3: Breathing Thick Air and Thin Air

You have just learned about how air can be compressed in a syringe when its molecules are pushed closer together. Now we'll look at other examples of air that are more or less compressed, we'll call them thin air and thick air.

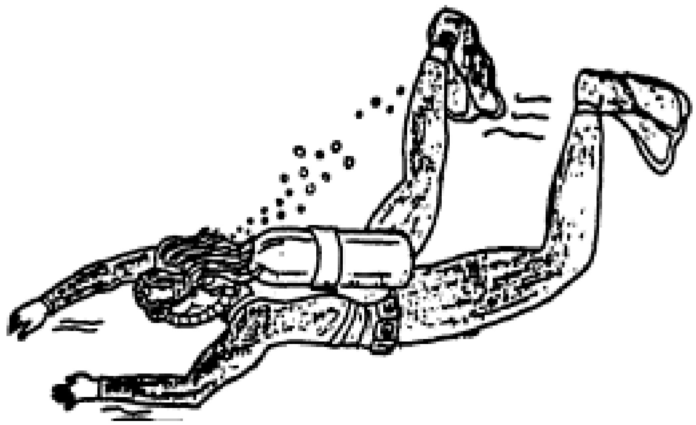
Thin air. One example of thin air is the air that is found in parts of the world where there are very high mountains. The air becomes much thinner high up in the atmosphere. When people climb really high mountains, they need to take extra oxygen with them in tanks. There is not enough air in every breath they take to let them climb the mountain without fainting.



The air is thin up high in the mountains

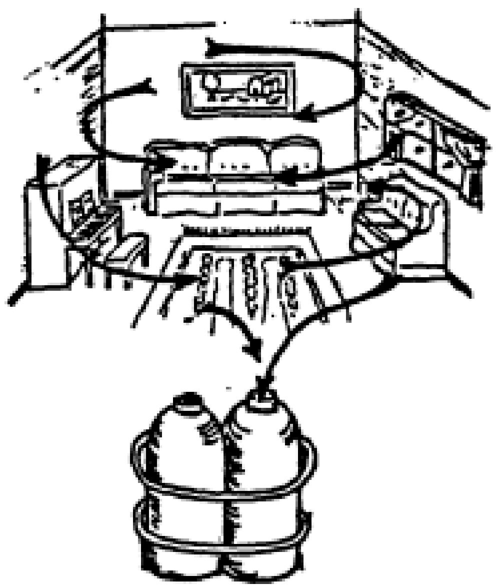
A similar thing happened to runners in the 1968 Olympic Games in Mexico City. Mexico City is very high up in the mountains. Runners had to breathe very hard because they took in less air with each breath. In order to prepare their bodies for this, many runners did their training in mountain areas all over the world so that they could get used to the "thin air.

Thick air. An example of thick air is the air found in a scuba tank. A scuba tank is a tank of air that a person can use to breathe underwater for about an hour.



A scuba tank contains compressed air

All of the air molecules in the room are forced into the tank



The tank itself is not that big. In order to breathe from it for an hour, a lot of air has to be pushed into it. In fact a whole room full of air is compressed into the tank.

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Do Question Set 4.3 in your Activity Book

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Why is it harder to breathe up in the mountains than down in the valleys? We have already said that mountain climbers and runners in the mountains take in less air with each breath they take. How can we use what we know about molecules to help us understand that?

Air is made of molecules. These molecules are always moving, and they are very far apart. Up in the mountains, air molecules are farther apart than down in the valleys.

Each breath we take in the mountains has fewer molecules in it because the molecules are farther apart. Our bodies need the same amount of air, so we have to breathe harder, or else we will not get enough oxygen. That is why mountain climbers need to take the oxygen tanks with them.

What happens when we release air from a scuba tank? The air molecules have been pushed very close together in a full tank. When the tank valve is opened, the air rushes out -- you can hear it making a rushing noise. Because the molecules inside the tank are pressed close together, they escape from the tank very quickly. As they escape, they move farther apart from each other. The air from the tank expands or spreads out, as it escapes into the room.

Lesson 4.4: Bicycle Tires

Up to this point in this cluster, you have seen that air can be compressed. We explained air compression by saying that air molecules are normally very far apart, with lots of empty space between them, and they can be pushed closer together.

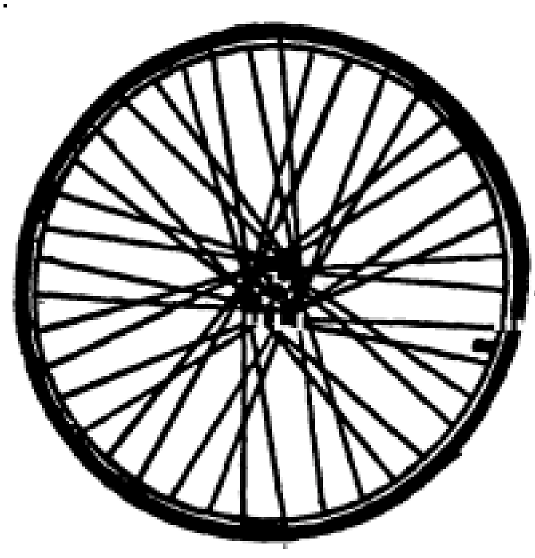
You have also learned something about scientific explanations. To make a good explanation, you often need to talk about molecules. You need to talk about the way molecules move and the way they are arranged in solids, liquids, and gases. You also need to know what kind of molecules you are talking about. You need to identify the substance that is changing and tell how it is changing.

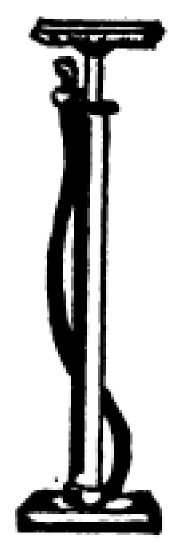
In other words, a good explanation answers at least two questions:

1. A question about substances: What substance is changing and how is it changing?
2. A question about molecules: What is happening to the molecules of the substance?

Let's think about the explanation of air escaping from an air tank and see if it answers those questions. We said that air (substance) comes out of the tank and expands into the room because the molecules of air inside the tank are pressed very close together, and they move farther apart. That explanation answers both the question about substances and the question about molecules.

Now let's try to explain something else: What happens when you fill a bicycle tire with air? This is a little more complicated than the scuba tank or the syringe, but it will help you learn more about air molecules and how to make good explanations.





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Do Question Set 4.4 in your Activity Book

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Here is one explanation that answers both the question about substances and the question about molecules: As the tire is pumped up, air (substance) in the tire is being pushed into the tire and compressed. The molecules of the air are being pushed closer and closer together.

Notice that the air is the substance that is making the important changes, not the bicycle tire. The tire is getting a little bit bigger, but not a lot bigger. For a lot of air to fit into a bike tire, the molecules have to move closer together. The air has to be compressed.

The air in a bike tire will be evenly distributed inside the tire. As the molecules of air are pumped into the tire, the molecules spread out evenly, so there will not be more molecules near the valve.

If you let the air out of a tire, the molecules that were pressed very close together will now spread far apart. When this happens, the spaces between the molecules get bigger, and the air expands.

In this lesson cluster, you have learned many things about air molecules. You have learned that air molecules are constantly moving and hitting things. You have learned that air molecules can be pushed closer together; that is, air can be compressed. Air molecules can also spread farther apart. When this happens, we say that the air expands. You have also learned that air molecules are evenly distributed--this means that they spread out evenly and that they don't bunch up together in one place more than another place.

Finally, you learned what the two parts are to a good explanation. To make good explanations, you need to answer two questions:

1. A question about substances: What substance is changing and how is it changing?
2. A question about molecules: What is happening to the molecules of the substance?

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Do Review Question Set 4.4 Now

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LESSON CLUSTER 5
Explaining Dissolving

Lesson *5.1:* How Did the Sugar Get Out?

A long time ago, in Lesson Cluster 2, you studied pure substances and mixtures. Do you remember the difference? Pure substances, like pure water and pure oxygen, are made of only one kind of molecule. Mixtures, like salt water and air, contain several different kinds of molecules.

This is a lesson cluster about mixtures. One kind of mixture is formed by dissolving a solid in a liquid. When a solid dissolves in a liquid, the molecules of the liquid hit the solid, breaking apart the solid into invisibly small molecules. These molecules spread evenly throughout the liquid.

In this lesson cluster you will dissolve several solids in water, you will find out how to make solids dissolve faster or slower, and you will learn to explain what happens to the molecules of both the liquid and solid in dissolving. The first step, though, is to watch something dissolve and describe what you see. So let's get started!

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Do Activity 5.1 in your Activity Book
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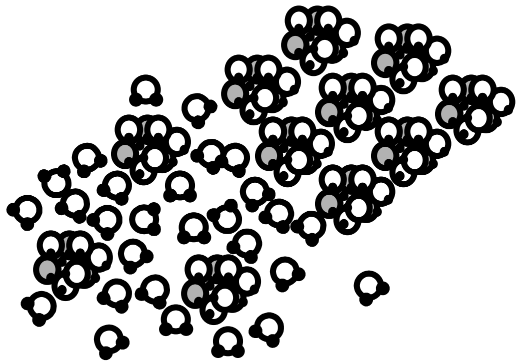
Did you say that you could see wavy lines under the tea bag and taste the sugar in the water? That is true. We cannot see the tiny molecules of sugar or the tiny molecules of water; but we can taste the sugar in the water. The sugar did not disappear, but the sugar grains broke into separate, tiny molecules, so that we could no longer see the sugar. Just because we cannot see the sugar does not mean it is not there. The water tastes sweet, so it must still be there.

How did the sugar get out the tea bag? You can answer this question if you think about the size of sugar molecules. The holes in the tea bag are much smaller than a grain of sugar, but much larger than a molecule of sugar or water. As the water molecules enter the tea bag and hit the solid sugar, the molecules of sugar break away rapidly and mix with the water molecules. The tiny molecules of sugar and water easily pass through the holes in the tea bag. The wavy lines under the tea bag were caused by trillions of sugar molecules streaming from the solid sugar and mixing with the water molecules. As the sugar mixes more completely and spreads throughout the water, the wavy lines disappear.



Sugar molecules break out of their rigid pattern and mix with water molecules

Now let's try to organize these ideas into an explanation. Remember the parts of an explanation you were introduced to in Lesson Cluster 4? We'll use those to organize our explanation.

- <u>Question:</u> How did the sugar get out of the tea bag?

- <u>Substance:</u> The water went into the tea bag and dissolved the sugar. Sugar-water came out of the tea bag and mixed with the rest of the water. (The wavy lines were made by the sugar-water coming out of the tea bag.)

- <u>Molecules:</u> The water molecules went through the holes in the tea bag, hit the grains of sugar, and broke off sugar molecules. The mixture of sugar molecules and water molecules went back out through the holes in the tea bag.

Lesson 5.2: Dissolving Fast and Slow

In the first lesson, you dissolved sugar in water. The sweet mixture of water molecules and sugar molecules is called a solution. Many different substances dissolve in water (or other liquids), so you can make many different solutions. Can you make substances dissolve faster or slower? How? Activity 5.2 will help you answer those questions.

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Do Activity 5.2 in your Activity Book

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My friend found a way of making the salt dissolve faster. She stirred one cup. The salt dissolved much faster in the cup that she stirred than in the other one.

Let's try explaining why her method worked, using our guide for explanations.

- Question: Why did stirring cause the salt to dissolve faster?

- Substances: She stirred the mixture and water rushed around the grains of salt.

- Molecules: Stirring caused more molecules of water to hit the salt grains, so the molecules of salt were broken off from the grains faster.

How did my friend's method compare with your method? Look at the explanation above and compare it with the explanation you wrote in your activity book. Do you see any ways that you could make your explanation better?

Lesson 5.3: Complex Solutions

In Activity 5.2 you made a solution by dissolving both salt and sugar in water. We call solutions like that complex solutions: they contain more than one dissolved substance.

There are many complex solutions. For example, grape Kool-Aid drink has sugar, purple color, and grape flavoring all dissolved in water. Ocean water is another example. It contains not only salt, but many other substances dissolved in it. If you took ocean water, filtered out all the dirt, placed it in a pan, and let the water evaporate, you would get many salt crystals, but you would also get a variety of other kinds of crystals. Each kind of crystal indicates a different kind of substance.

You have also seen many other complex solutions, though you might not have known what they were. Honey is a complex solution. It consists mostly of water molecules and sugar molecules. That's why it is sweet. But the special flavor of honey comes from many other kinds of molecules that are mixed with the water and sugar. Syrup and ginger ale are also complex solutions. They both have water and sugar, plus other substances that give them their special flavors.

A grocery store is full of complex solutions. Sometimes the labels even tell you what substances have been mixed together to make them. You might try looking at the labels on bottles of mouthwash, or soda, or shampoo. They tell you what substances have been dissolved in water to make them.

Even our drinking water has a number of substances dissolved in it. If your city gets drinking water from a well, the water has come into contact with a variety of rocks containing various minerals. Most of these minerals dissolve in water to some extent. If your drinking water comes from a spring, a lake, or a river, the same is true. Most of the water that you see, therefore, has a number of solids dissolved in it. So the water we get from a faucet is not really pure; it is really a complex solution.

Now try answering some questions about complex solutions--and the other things you have studied in this lesson cluster.

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Do Review Question Set 5.3 Now

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This lesson cluster is just about over. Let's end it with a summary of some of the most important ideas. See how much of this summary is like the one you wrote in your answer to the last question.

Lesson 1 was about dissolving sugar. You learned that when sugar dissolves it breaks up into individual molecules. You also learned how dissolving takes place. The water molecules break molecules of sugar off the grains. The water molecules and the sugar molecules intermingle until the sugar molecules are spread evenly through the water.

In Lesson 2 you learned that you can make things dissolve faster by stirring, and you learned that stirring speeds up dissolving because it makes more molecules of water hit the sugar grains and break off sugar molecules faster.

In Lesson 3 you learned that many of the liquids around you are solutions, usually complex solutions that have several different substances in them.

Can you think of a way to make a solid dissolve faster in water <u>without</u> stirring? Without even touching the cup? That is one thing you will learn about in Lesson Cluster 6.

LESSON CLUSTER 6
Heating and Cooling, Expansion and Contraction

Lesson 6.1: Another Way to Make Something Dissolve Faster

In the last lesson you learned one way to make things dissolve faster: you can stir the water. There is another way to make something dissolve faster, though. This way involves no stirring and no moving the cup. Do you know what it is? You can try this way in Activity 6.1.

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Do Activity 6.1 in your Activity Book

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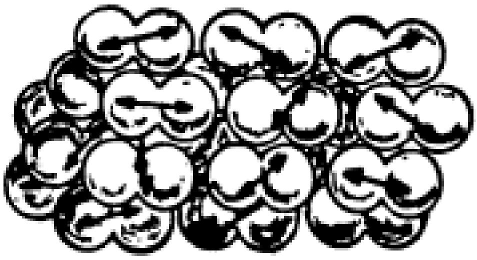
Did you know that when you say that something is “hot” or “cold,” you are actually saying something about the molecules of that substance? Words like “hot” and “cold” describe how fast or slow the molecules of a substance are moving. Hot substances have fast-moving molecules. Cold substances have slower-moving molecules.

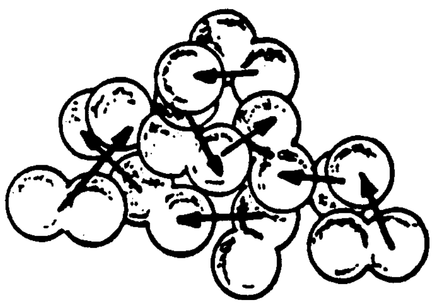
Heating any substance makes the molecules of that substance move raster. In hot solids, the molecules vibrate faster in their places. In hot liquids, the molecules move faster as they slide and bump past each other. In hot gases, the molecules move faster through space.

Cooling any substance makes the molecules of that substance move slower. In cold solids, the molecules vibrate more slowly in their places. In cold liquids, the molecules move more slowly as they slide and bump past each other. In cold gases, the molecules move more slowly through space. These differences between hot and cold substances are illustrated on the following page.

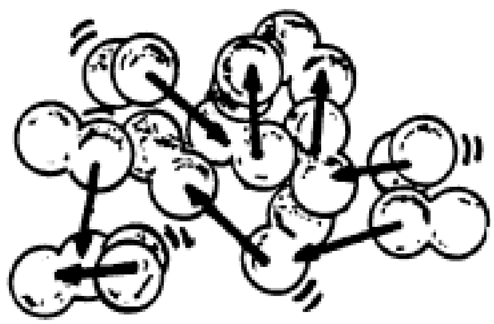


1. Cold solids: Molecules vibrate slowly in place.

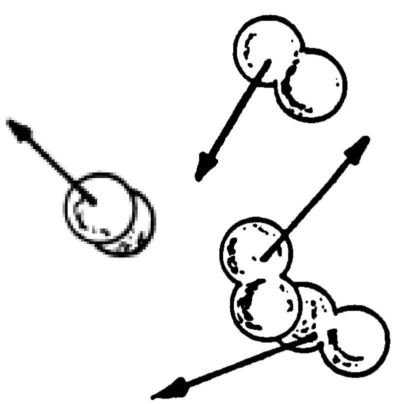
2. *Hot solids: Molecules vibrate quickly in place.*



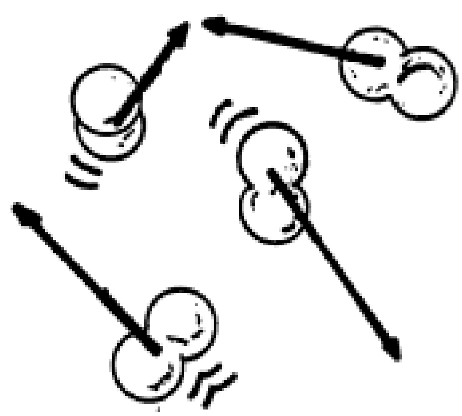
3. Cold liquids: Molecules slide and bump slowly past each other.



4. Hot liquids: Molecules move fast as they slide and bump past each other.



5. Cold gases: Molecules move slowly through space.



6. Hot gases: Molecules move fast through space.

Now let's try using these ideas to explain why the candy dissolved faster in hot water. We will talk about the cold water, then the hot water. We will answer the question about substances and the question about molecules for each temperature of water.

In the <u>cold water</u> the <u>candy</u> (substance) dissolved slowly because the <u>water molecules</u> were moving slowly as they knocked off molecules from the pieces of candy.

In the hot water the candy dissolved faster because the water molecules were moving faster and hit the candy more often. That made them knock the molecules off the pieces of candy more quickly.

Did the explanation about hot water answer both the question about substances and the question about molecules? Find the parts of the explanation that answer each question.

When molecules are moving faster they make substances dissolve faster. Fast-moving molecules cause other effects, too. You will learn about one of those other effects in the next three lessons.

Lesson 6.2: Heating Solids

Heating a solid, such as a metal ball, makes the molecules vibrate faster. This fast vibration makes the ball feel hot when you touch it. The fast vibration of the molecules has another effect, too, one that is harder to see or feel. When the molecules vibrate faster they actually push each other a little farther apart.

So what happens when all the molecules of a solid push each other a little farther apart? The solid gets a little bigger, or expands. So heating solid objects makes the objects expand. This process is called thermal expansion ("thermal" means "with heat").

Let's try using these ideas to explain why a metal ball that barely fits through a ring won't go through the ring after it is heated. In this explanation we will talk about molecules first, then substances. As long as an explanation answers both questions, though, it is still a good explanation.

Heating the ball made the molecules of the metal vibrate faster, so they pushed each other farther apart. This made the metal ball expand (substance), so it would no longer fit through the ring.

Metal balls are not the only things that expand when heated. All solids expand when they are heated (unless heating causes some of the molecules to break up or makes the solid lose molecules). Concrete, rocks, metal objects, glass, and other solids all expand when they are heated. They all expand for the same reason, too. Their molecules move faster and push each other farther apart.

When solids cool, the molecules slow down. This allows the molecules to move closer together, so the solids contract. Solids expand when they are heated. They also contract when they are cooled; this process is called thermal contraction.

It is hard to see solids expand and contract because the molecules move only slightly farther apart or closer together. We have to measure the solids very carefully to tell that their size has changed.

Now try using what you know about thermal expansion and contraction to answer some questions about other situations where solids are heated or cooled.

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Do Question Set 6.2 in your Activity Book

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Lesson 6.3: The Thermometer

In the last two lessons you have learned that the molecules of all substances move faster when the substances are heated, and that solids expand when they are heated and contract when they are cooled. What about liquids? Do you think that they expand and contract the way solids do? Try Activity 6.3 and find out!

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Do Activity 6.3 in your Activity Book

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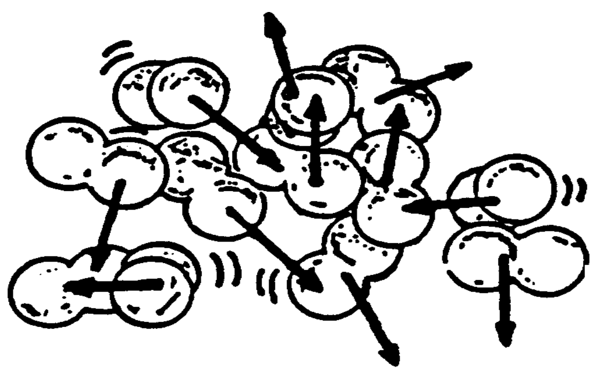
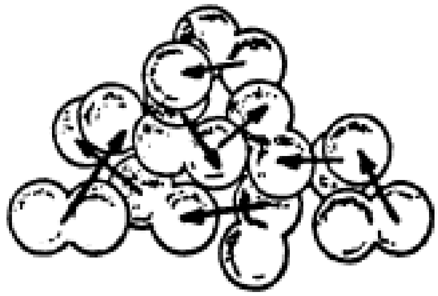
Could you explain why the column of the liquid in the thermometer rose and then fell? You know from Lesson 6.1 that the molecules of liquids move faster when the liquid is heated. That is one way that liquids and solids are alike.

Liquids and solids are also alike in another way. When the molecules move faster, they bump into each other harder and push each other farther apart. So just like solids, liquids expand when they are heated.

Liquids also contract when they are cooled. When the molecules of a liquid slow down, they move closer together. So liquids go through thermal expansion and thermal contraction just as solids do.



Heating makes the molecules of a liquid move faster and push each other farther apart

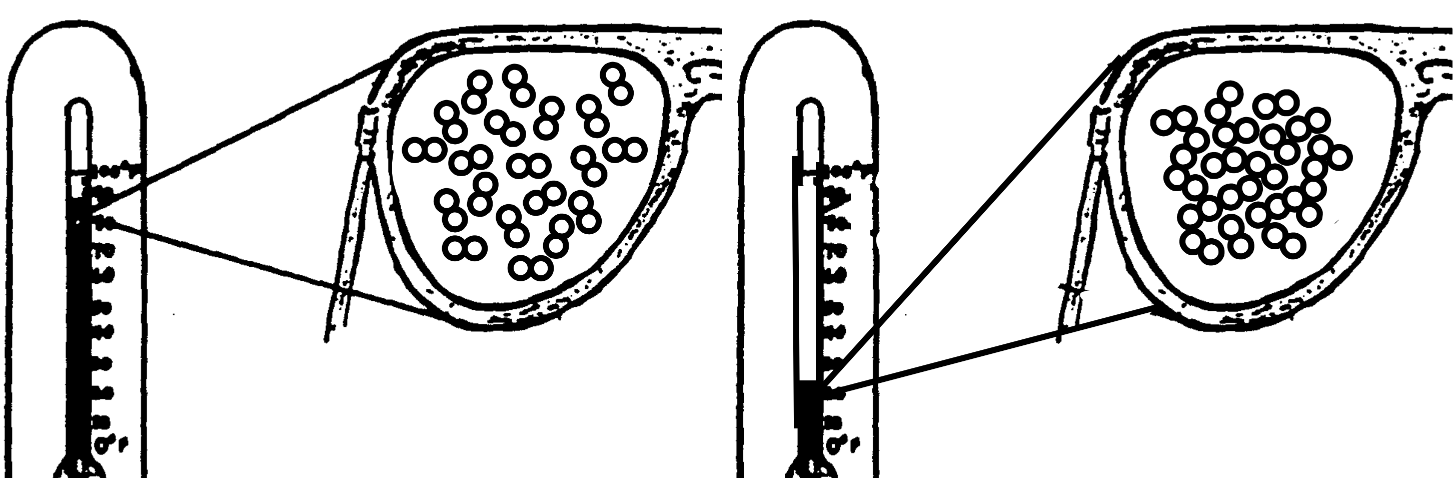


Cooling slows down the molecules of a liquid and they move closer together

Now we can explain how the thermometer works. Compare the explanations below to the ones you wrote in your Activity Book. Did you answer the questions about substances and the questions about molecules in the same way as the explanations below?

When you place the bulb of the thermometer in hot water, the molecules of the colored liquid move faster and push each other farther apart. This causes the colored liquid to get larger or expand. The colored liquid expands up through the thermometer tube which gives a higher temperature reading.

When you place the bulb of the thermometer in cold water, the molecules of the colored liquid move slower and come closer together. This causes the colored liquid to get smaller or contract. The contraction makes the column of colored liquid move down toward the bulb. This gives a lower temperature reading.

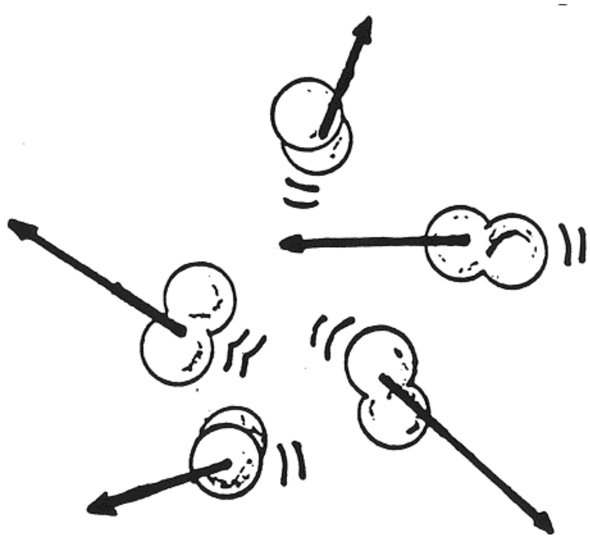


Lesson 6.4: Gases and the Dancing Dime

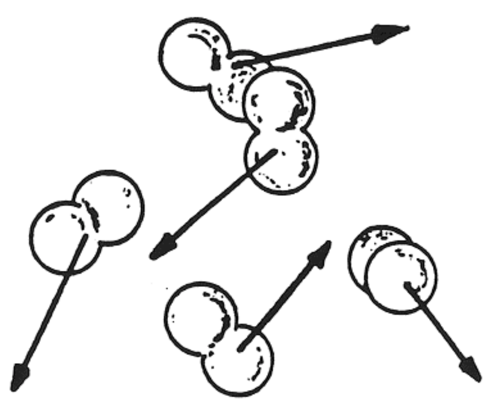
Solids expand when they are heated and contract when they are cooled. So do liquids. It probably won't surprise you that gases act the same way. Gases also expand when they are heated and contract when they are cooled.

The molecules of a hot gas move faster than the molecules of a cold gas, so they hit each other harder and bounce harder off the sides of a container. This makes the molecules move farther apart and push the sides of a container outward.

Cooling is just the opposite. The molecules slow down, so they don't hit each other or the walls of a container as hard, and they move closer together.



Hot gases have fast-moving molecules that bounce farther apart



Cold gases have slow-moving molecules that stay closer together

Do you remember when you studied expansion and compression of gases in Lesson Cluster 4? Now you know two ways of moving the molecules of a gas closer together or farther apart!

In Lesson Cluster 4 you moved the molecules of gases closer together by pushing them together with pressure from something like a syringe or a bicycle pump. Another way to move the molecules closer together is to cool off the gas. Then the molecules slow down and move closer together even without an extra "push."

In Lesson Cluster 4 you moved the molecules of gases farther apart by releasing pressure, like when you released the plunger of the syringe or let the air out of the bicycle tire. Another way to move the molecules farther apart is to heat the gas. Then the molecules move faster and push each other farther apart.

Let's try that other way of getting gases to expand. The dancing dime will help you see it happen!

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Do Activity 6.4 in your Activity Book

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This lesson cluster is almost over. You knew before this lesson cluster that all substances are made of tiny particles called molecules. You knew that molecules are always moving.

In this lesson cluster you learned another important idea. The temperature of a substance tells you something about how fast the molecules are moving. Heating a substance makes the molecules move faster. Cooling a substance makes molecules move slower.

The motion of the molecules explains why solids dissolve faster in hot water, as well as thermal expansion and contraction. In Lesson Cluster 7 you will use these ideas about molecular motion to explain melting and freezing.

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Do Review Question Set 6.4 Now

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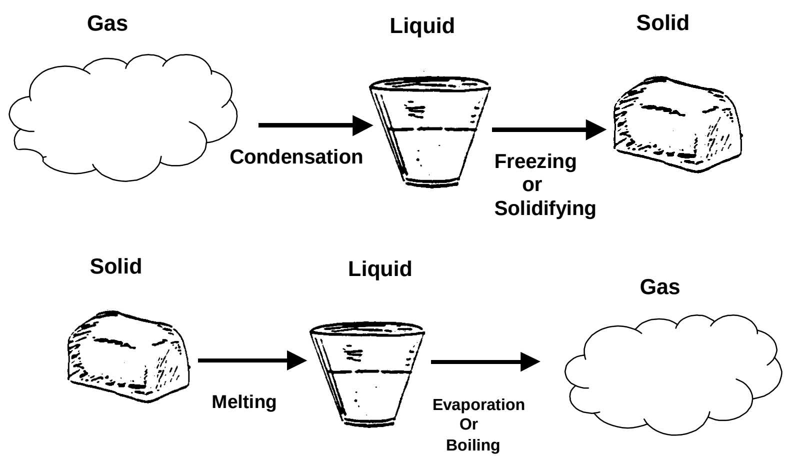
LESSON CLUSTER 7

Explaining Melting and Solidifying

Lesson 7.1: Melting Ice and Freezing Water

Do you remember the first experiment you did in this unit? It was an ice melting race. You learned then about the states of water: ice, liquid water, and water vapor. You also learned how water molecules are arranged and how they move in each state. What you did not learn in the first lesson cluster was how or why water changes from one state to another.

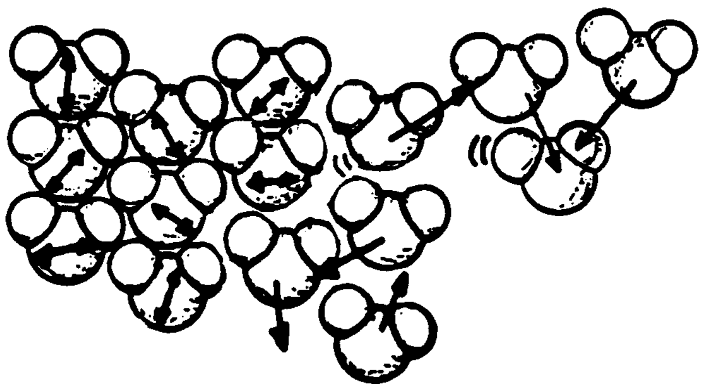
This lesson cluster, as well as Lesson Clusters 8 and 9, is about changes of state in water and other substances. You have seen changes of state many times, and you probably know most of the words that we use to describe them. When a solid changes into a liquid, we call it melting. When a liquid changes into a solid we call it freezing or solidifying. Changes from the liquid state to the gas state are called evaporation or boiling. Changes from the gas state to the liquid state are called condensation. This drawing summarizes all the different changes of state:



Now let’s go back to melting ice. When ice melts, one substance (water) is going through a change of state (melting). Can you explain how and why it happened? You already know how molecules are arranged and how they move in solids and liquids. You also know something else important: Molecules move faster when a substance is heated. Let’s try putting these ideas together in an explanation of how ice melts.

When ice is warmed it melts into liquid water. The water molecules in ice are locked into a rigid pattern, but as they vibrate faster they break out of that rigid pattern and begin sliding and bumping past each other. Solid ice has melted into liquid water!

(Did the explanation above answer both the question about substances and the question about molecules? Check it and see!)



Ice melts when the water molecules vibrate fast enough to break out of their rigid pattern

Water freezes when it is cooled down and the water molecules move slower. To completely explain how water freezes there is one other thing you need to know about molecules. Water molecules are attracted to each other. This attraction makes the molecules stick together in a rigid pattern if nothing breaks them apart.

But the attraction between molecules keeps them stuck in a rigid pattern only if the molecules are moving slowly. When water molecules are moving fast, their motion keeps them from sticking together. They jiggle apart rather than settling into a rigid pattern. When water gets cold, though, the molecules slow down. Then the attraction between them makes them stick together in a pattern. Liquid water has changed into ice!

Water is not the only substance that melts and solidifies. You will learn about some other substances in the next lesson. First, though, try answering some questions about what you have learned.

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Do Question Set 7.1 in your Activity BooK

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Lesson 7.2: Melting and Solidifying of Other Substances

If you can explain how water melts and freezes, then you can also explain how other substances melt and solidify. Different substances are made of different molecules, so they melt at different temperatures. But the processes of melting and solidifying are about the same for all substances.

Whenever any substance melts, its molecules are moving fast enough to break out of their rigid pattern. Whenever any substance solidifies, its molecules have slowed down enough so that they start sticking together in a rigid pattern.

Can you explain how melting is different from dissolving? In some ways melting and dissolving are alike. Both involve the molecules of a solid breaking out of their rigid array. But the causes of melting and dissolving are very different. Melting is caused by heat: When the molecules of a solid move fast enough, they break out of their rigid pattern. Dissolving, on the other hand, occurs when the molecules of a liquid knock the molecules of a solid apart and carry them away.

Melting is also different from thermal expansion. Both are caused by heat, but in the case of thermal expansion the motion of the molecules just moves them farther apart. Their pattern stays the same. Melting occurs when the motion of the molecules makes them break out of their rigid pattern.

(There are some materials that do not melt and solidify because their molecules break apart when they are heated. This is especially true of substances made from living things, like wood or cloth or paper or meat. When wood is heated, for example, its molecules break apart into smaller molecules. The wood burns if there is oxygen around it. If there is no oxygen, the wood is changed into new substances made of smaller molecules, including charcoal, water, and other liquids.)

One place where you often see materials melt and solidify is in your kitchen. Have you ever melted butter? What about cheese? Chocolate? Caramel? Sugar? Try some activities with kitchen materials that you can melt and solidify.

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Do Activity 7.2 in your Activity Book

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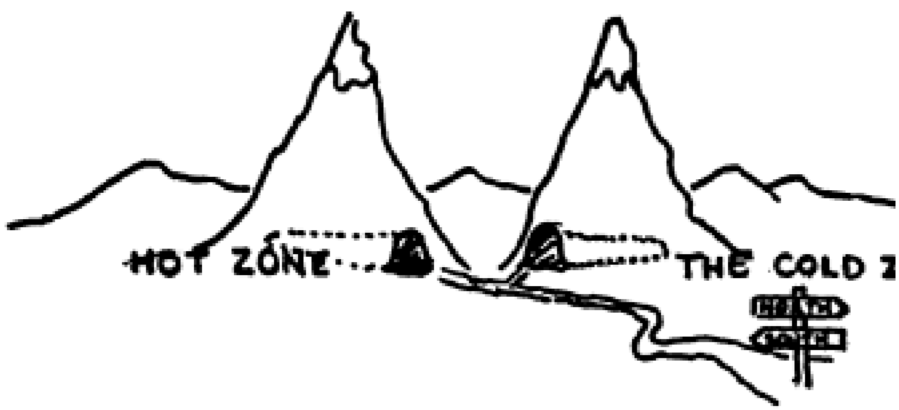
Lesson 7.3: Adventure into the Hot Zone and the Cold Zone

You can see some substances going through changes of state, like water and other things in the kitchen. Other substances, though, always seem to be the same state. Oxygen and nitrogen, for example, always seem to be gases. Steel and rocks always seem to be solids. Can those substances melt and solidify? In order to find out you will have to venture into the hot zone and the cold zone. Get ready!

As you explore the valleys between the highest Himalayan mountains you stumble across two large caves. One is in the north side of the valley, the other in the south. Each cave is marked by a rock column and a message in Hanzi. After conferring with your guide you understand that the column to the north says "The Cold Zone" and the column to the south "The Hot Zone." The guide further explains that the deeper you go into the tunnel on the north side the colder it gets



and the further you go into the tunnel on the south side the hotter it gets.

You decide to go into the south tunnel first. As you step inside the tunnel there are two rock columns with weird looking clothing suspended between them. After the guide reads the message in Hanzi on the stone pillars, he informs you that unless you wear the special clothing you cannot survive in the tunnel.

After carefully dressing in the special clothing you proceed into the tunnel. You proceed slowly because you can tell that it is quite hot at the end of the tunnel, but just beyond the pillars you recognize a large rock of ice slowly dripping water on your clothing. A little distance beyond the ice rock there is a rock of sugar that is also melting. Beyond that there are a number of familiar metals. First is solder (similar to what plumbers or electricians use). Beyond that is a huge chunk of aluminum that is melting. It glistens like silver, but it is not quite the same as silver. You can tell

because just beyond the aluminum is silver and then pure gold. The silver and gold have melted and resolidified so that there are beautiful configurations on the walls and on the bottom of the cave. Beyond this you can see sandstone and a variety of rocks melting.

As you keep going, more and more substances melt. There aren't any solids left! By the time you reach 2700 degrees Celsius, all metals are liquids, and so are all rocks. You are swimming now in your magic suit! You put on your magic eyeglasses and see that the molecules are really moving fast. No wonder they won't stay in a pattern! You look forward and the cave back goes on and on into higher and higher temperatures. Some of the liquids are turning into gases and forming bubbles, boiling up out of sight. But it is time to turn back before your suit loses its magic and you become a bunch of liquids and gases!

You come out of that cave and look across the valley toward the north. The cold zone seems very inviting because you are still very hot. As you step inside the cold zone cave, you again see two pillars with very different clothing than you had in the hot zone. It takes you a long time to put this clothing on and it is so heavy that it is difficult to walk. There is also a special light that you will need in the cold zone.

After you make sure that your clothing is adjusted properly and you figure out how to operate the special light, you proceed into the cold zone. And immediately you find a very familiar rock--ice. But just beyond this ice rock, there is something that you hardly believe. It is solid antifreeze. You had thought that antifreeze would not freeze. But it does, and it makes up a beautiful rock. When you get beyond the antifreeze you see another rock that looks like silver. It is hard like silver, too, but it is mercury. Now, mercury is normally a liquid at room temperature, but it is a solid in the cold zone. Deeper in the cave you find solid carbon dioxide or dry ice. You've seen this before, but not nearly as much as in the cold zone.

By the time you reach –219^{o}C, there is no more air to breathe. You look around you and see why: Oxygen and nitrogen have turned into liquids, and now they are solids. The last gas, helium, becomes a liquid at –272^{o}C. It is the only liquid left. Every other substance has solidified!

You look up and see that the cave stops at –273^{o}C. It doesn't go on and on like the hot zone. Your magic eyeglasses show you why. The molecules have almost stopped moving. You have reached absolute zero, the point at which molecules can go no slower. It is time to turn around and go back. You slowly make your way to the two stone columns again. You take off the clothing from the cold zone, hang it on the two pillars, and are eager to get out into the warm sun light between the two Himalayan mountains.

While resting with your guide you express surprise that gases like nitrogen, oxygen, and hydrogen could be solids. He assures you that all substances can be solid if they are cold enough. As you breathe the fresh mountain air, you have more appreciation for the nitrogen, oxygen, and carbon dioxide in the air, because for the first time in your life, you have seen them. You have seen them as solids. The hot zone was not nearly as surprising as the cold zone, because you had seen pictures of volcanoes spewing out liquid rock on television. But the trip to the cold zone was something you will never forget.

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Do Review Question Set 7.3 Now

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LESSON CLUSTER 8

Explaining Evaporation and Boiling

Lesson 8.1: Where Did the Water Go?

You see things drying out around you all the time; puddles dry up; clothes dry on a clothesline or in a dryer; your hair dries out after a shower; towels dry when they are hung up. Have you ever wondered what happens to the water when something dries up? It takes trillions of water molecules to make something wet. Where do they go when something dries out?

You probably already know the answer to this question. The water does not just disappear; things dry out when water changes from liquid water to water vapor. This is called evaporation. The liquid water changes to water vapor that mixes with the air.

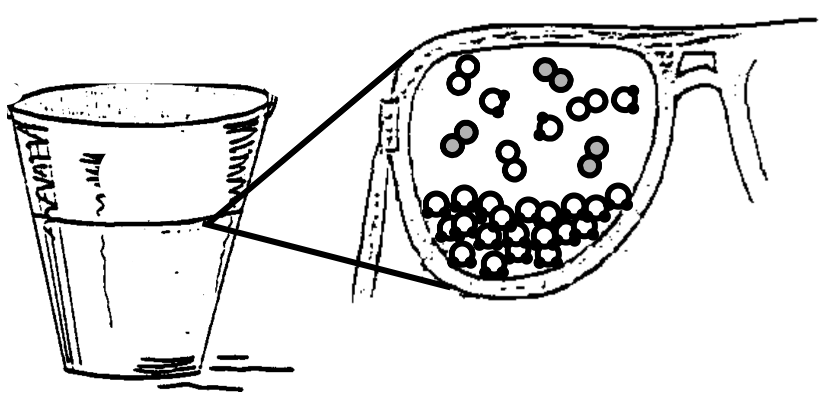
You probably also know that clothes and towels dry out more slowly when the air is humid. Sometimes you feel sticky because sweat evaporates from your skin more slowly. What do we mean when we say that the air is humid?

The air is humid when there is a lot of water vapor in the air. You may remember from Lesson Cluster 3 that there is always some water vapor in the air. After a summer rain, you may say that it is hot and humid. That means that the temperature is high and the amount of water vapor in the air is also high. Sometimes, there is so much water vapor in the air that our homes become uncomfortable. We may use a device called a dehumidifier, which takes some of the water vapor out of the air.

In the wintertime, there is usually less water vapor in the air, and we may become uncomfortable because water is evaporating too fast from our skin, causing our skin to feel dry. To become more comfortable, we may add water vapor to the air. That is why many furnaces have a humidifier, which adds water vapor to the air when the air is very dry. This makes us feel more comfortable.

How does evaporation happen? Let's try explaining it in terms of molecules. You know that the molecules in liquid water are constantly moving. In a liquid, though, the attractive forces between molecules keep them close together. What you might not know is that the molecules in a liquid move at different speeds. Some molecules are moving very fast, while other molecules are moving more slowly.

What do you think would happen if a fast-moving molecule reached the surface of a drop of water? Yes, it would escape! It would break away from the strong attraction of the other water molecules and become a molecule of water vapor in the air. If all the water molecules escape in this way, we say that something has "dried out." The liquid water has turned into water vapor in the air, and the water vapor makes the air more humid.



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Do Question Set 8.1 in your Activity Book

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Lesson 8.2 Where Does the Water in the Air Come From?

You learned in the last lesson that when things dry out, the water goes into the air. When you dry your hair, when clothes dry, or when puddles of water dry up all the water eventually goes into the air.

Sometimes the air is humid, though, even if there is no liquid water nearby. In fact, there is some water vapor in all air, even air in a desert that is far away from any liquid water. Where does all that water vapor come from?

To answer this question you have to think of the entire earth, not just of what you see around you. There is lots of liquid water on the earth. In fact, most of the world is covered with liquid water. Three-fourths of the earth is covered with oceans, rivers, and lakes and only one-fourth with land.

Think of the hardest rain you can remember. Sometimes it rains for several days, and rains very hard. Millions of gallons of water are falling around you, and most of them evaporated from the oceans, rivers, and lakes far away. Moving air, or wind, moves the water vapor from one place to another. For example, water molecules are constantly escaping from the surface of the ocean and moving into the air. The moving air sometimes carries these water molecules high into the atmosphere, where they may be carried thousands of miles. In this way the water vapor can move from oceans over the land. Some of this water vapor is always in the air.

Water is always evaporating from the land, too, from trees and other plants. Plants, like all living things, are mainly water. Some of the water molecules from the plants are moving fast enough to escape the surface of the leaves and other parts of the plant. If you've ever been in the middle of a deep forest or in a cornfield where the corn plants are higher than your head, you might have noticed that the air was unusually humid. In other words, the air has a lot of water vapor in it. Most of this water vapor comes from the evaporation of water from plants.

Even you are a source of water vapor in the air. When you sweat, the liquid water on your skin evaporates and becomes water vapor in the air.
You add water vapor to the air in another way, too. Every breath that you breathe out contains water vapor from your lungs. A little bit of the liquid water from your lungs evaporates and leaves your body with each breath.

So there are always water molecules in the air, molecules that have escaped from liquid water in the oceans, in lakes and rivers, in plants, and even from liquid water in your blood. After you have answered some questions about the many ways that water can evaporate, you will get to try making another liquid evaporate: alcohol.

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Do Activity 8.2 in your Activity Book
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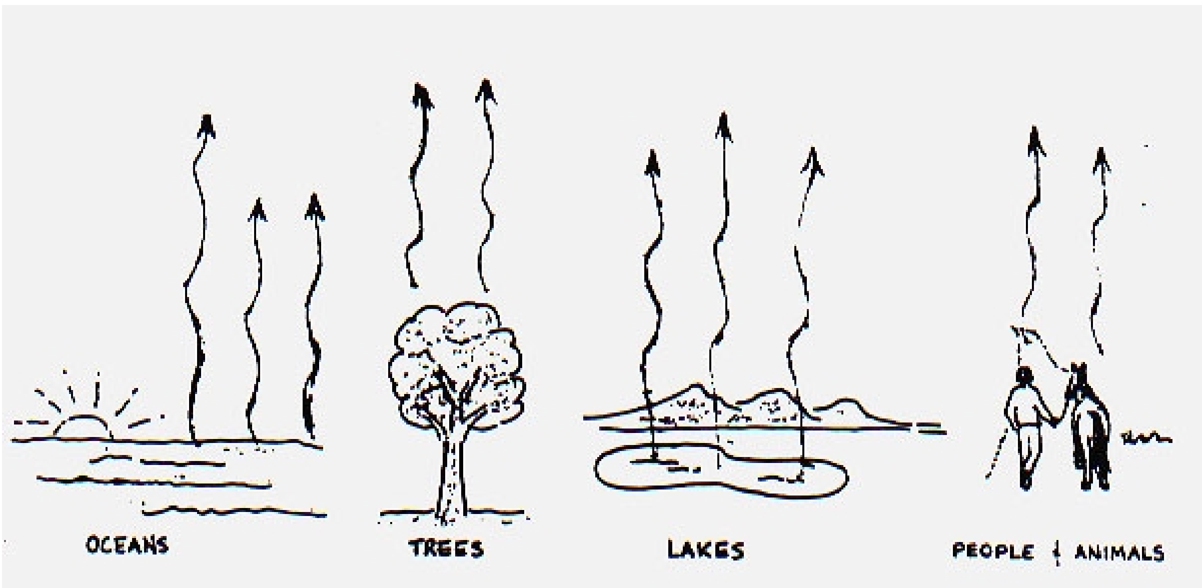

Lesson 8.3: Fast Evaporation and Boiling

Suppose you want to make water--or some other liquid--evaporate faster. How could you do it? You discussed one way in Lesson 8.1: water evaporates faster in dry air than in humid air. There are other ways, though. See if you can figure some of them out.

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Do Activity 8.3 in your Activity Book

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You probably thought of a lot of different ways to make the alcohol evaporate faster. Some of these ways help more air move by the alcohol. You might blow on the alcohol, for example, or swirl it around, or pour it out and spread it around.

Another thing you might have done is to figure out ways of warming the alcohol. You might have used your hands to make it warmer, for example. Can you explain why heating a liquid makes it evaporate faster?

It makes sense if you think about it. When you heat a liquid, there are more fast-moving molecules, so more molecules can break away from the attractive forces and escape.

Some appliances, like clothes dryers and hair dryers, use both heat and blowing to speed up evaporation. For example, a clothes dryer heats up the clothes so that more molecules are moving fast enough to escape from the surface of the clothes. The large drum inside the dryer tumbles the clothes through the air so that the hot air comes in contact with all the pieces of clothing. If the clothes were not tumbled, only the ones on the top would dry. The water molecules could not escape from the clothes on the bottom.

Now let's think about what happens if the molecules of a liquid start moving really fast. If you continue to heat a beaker of alcohol (or any other liquid), the molecules at the bottom move faster and faster until the attractive forces can no longer hold them together and they fly apart. The alcohol changes to alcohol vapor down at the bottom of the beaker! This alcohol vapor forms bubbles that rise to the surface of the alcohol. This process is called boiling.

So evaporation and boiling are both changes of state from liquid to gas, but they don't work in quite the same way. Let's compare the two processes.

1. When molecules escape from a liquid's surface and mix with the molecules of air, it is called evaporation. In evaporation, individual molecules escape from the liquid.

2. When molecules of a liquid move faster and faster at the bottom of a heated container, they eventually move fast enough to overcome the attractive forces between them and fly apart. The liquid changes to a gas at the bottom. The gas forms bubbles that rise to the top of the liquid. This is boiling.

The gas inside the bubbles of a boiling liquid is invisible. It looks like air, but it is not air. Air is a mixture of different kinds of molecules: nitrogen, oxygen, and so forth. The bubbles in boiling water contain only water molecules; the bubbles in boiling alcohol contain only alcohol molecules.

Lesson 8.4: Evaporation and Smells

You know a lot, now, about evaporation and boiling. Let's try using what you know to explain something else that is all around you: smells. Do you remember studying smells in Lesson Cluster 3? We said that you smell something when your nose detects molecules that are mixed in with the other molecules in the air.

That explains how you smell gases, but lots of the things we smell are solids like cookies or liquids like perfume. How do you smell them? For an example, let's think about something really smelly. How about a skunk?

Skunks make their scent by spraying out a liquid that contains many different kinds of molecules. The liquid that skunks spray out begins to evaporate. Some of its molecules escape from the liquid and mix with the air, then they move around with the breeze. Our noses are very sensitive to these molecules so we can smell a skunk even if there are only a few of it's smell molecules mixed with the air. It takes a long time for all the liquid to evaporate, so if you are sprayed by a skunk, people will know it for a long time!

Many other substances are made of molecules that our noses can detect. What did the room smell like during the alcohol evaporation race? Can you explain why?

Many of the things we smell are actually complex mixtures that only allow some of their molecules to escape. Cookies, for example, contain many different kinds of molecules. When cookies are baked, some of the substances in them remain solids, but other substances melt and start to evaporate. Then the molecules of those substances reach our noses. Aaaah!

When molecules of a substance mix with air, they bounce around and move through space just like air molecules. One way to see how much the molecules are moving, even in "still" air, is to see how smells spread through a room. Perhaps you can try it.

So when you smell a solid or a liquid, it isn’t really the solid or liquid that you smell. You smell molecules that escape from the solid or liquid and come to your nose by bouncing through space like the other gas molecules in the air. Our noses wouldn’t have much to smell if it weren’t for evaporation!

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Do Review Question Set 8.4 Now

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LESSON CLUSTER 9

Explaining Condensation and the Water Cycle

Lesson 9.1: Boiling and Condensation

You have been studying changes of state for quite a while now. You have studied melting, freezing or solidifying, evaporation, and boiling. That means there is only one change of state left to study: condensation.

You know that if a liquid is heated enough, it turns into a gas. The molecules of the liquid move fast enough to escape from the attractive forces that hold them together and begin moving freely through space.

What do you suppose happens if we slow down the molecules of a gas by cooling the gas? The slow-moving molecules begin to stick to each other and form clumps. Clumps with lots of molecules make up drops of liquid. This process, where a gas turns back into a liquid, is called condensation.

Sometimes it is possible to use boiling and condensation to purify dirty liquids. Your teacher will show you how.

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Do Demonstration 9.1 in your Activity Book

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Let's explain what happened.

When you heat the flask, the liquid water changes to water vapor at the bottom of the flask and rises to the surface as bubbles. This, of course, is called boiling. The hot water vapor goes through the tube into the bottom of the cold test tube. When the water vapor hits the cold test tube, the molecules slow down and move closer together. When the molecules slow down enough, the attraction among them makes them stay close together. They cluster together to form a liquid.

The dye and other substances in the flasks are made of molecules that do not boil as easily as water. When the water boils and goes through the glass tubing, the dye and other substances stay behind in the flask.

The process of boiling or evaporating a liquid and then condensing it again is called distillation. It is possible to separate very complex mixtures by this process. For example, we can get pure water from salt water by distillation. To do this, we would boil off the pure water, leaving the salt and other materials behind in the flask. In a similar way, we distill gasoline and many other useful substances from petroleum. Petroleum is a very black, complex mixture containing thousands of different substances. By distillation we can separate out those substances that make up gasoline.

You don't need a test tube to see water boil and then condense. You can actually see water condense whenever you boil water, or soup, or any other liquid. The water vapor produced by boiling is invisible. But when the water vapor cools off it condenses to form the tiny droplets of water that we see and call steam. As these droplets rise a little higher, they evaporate and change into invisible water vapor once again!

Lesson 9.2: Purifying Water Without Boiling

In the last lesson your teacher demonstrated one way of purifying water. When water boils, the liquid water turns to vapor, but other substances are left behind. Then the water vapor can condense into pure water.

There are other ways of purifying water that do not involve boiling. Your teacher will show you one now.

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Do Demonstration 9.2 in your Activity Book
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Did you figure out how the demonstration worked? It worked by a three-stage process:

1. Evaporation. The water in the tumbler evaporated. Molecules were escaping from its surface. The heat from the overhead projector made the water evaporate faster by making its molecules move faster. When the water evaporated, the salt and food coloring were left behind.
2. Spreading of water vapor. The evaporation made the air inside the aquarium very humid; it contained lots of water molecules. This humid air spread throughout the container.
3. Cooling and condensation. This humid air cooled down when it came near the cool plastic wrap at the top of the aquarium. When the air cooled down, the water molecules in the air moved more slowly, and the attraction between them made them clump together to form drops of water. The tiny drops of water collected into larger drops that fell into the cup.

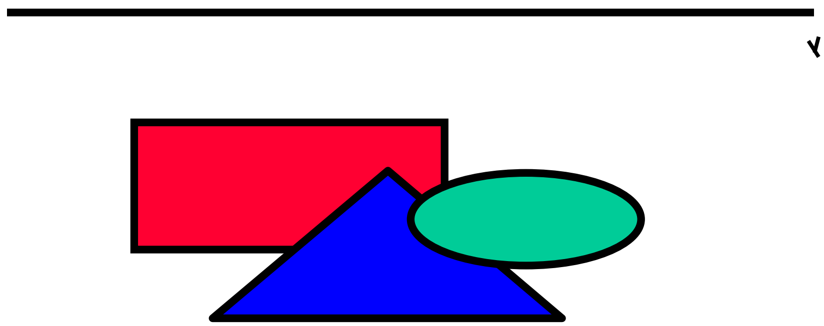
There are many ways that this demonstration and the distillation of boiling water (Demonstration 9.1) are alike. In both demonstrations, the water changed from a liquid to a gas, then condensed back into a liquid again. In both cases, the water was purified because the salt and food coloring did not change into gases.

In one way, though, the two demonstrations were different. In Demonstration 9.1, the water was changed from a liquid to a gas by boiling. In Demonstration 9.2, the water changed to a gas by evaporation. Boiling is not the only way to produce water vapor that can later condense. Evaporation works more slowly but just as well. By using evaporation it is possible to distill liquids without boiling them.

Lesson 9.3: A Solar Still

In Lessons 9.1 and 9.2 you saw examples of stills. Stills are devices that purify liquids by boiling or evaporating them, then condensing the gases back into liquids. Stills can be very useful. Suppose, for example, you were trapped on an island with no pure water to drink. You will die if you drink a large amount of ocean water; it has too much salt in it. What could you do?

The crew of the Mimi found themselves with a problem like this. They were shipwrecked, and they could find no fresh water. They solved their problem by constructing solar stills.



Let's try explaining how the solar still works. It is a three-stage process:

1. Evaporation. The water down at the bottom, which is dirty or salty, is heated by the sun. Its water molecules move faster and more of them escape from the surface. The water evaporates, leaving salt and dirt behind.
2. Spreading of water vapor. The water molecules mix with the other gases in the air and move all through the container. The air becomes very humid.
3. Cooling and condensation. The plastic at the top is cooler than the air inside the still. The molecules slow down when they come close to it. The attraction between the water molecules pulls them together, and they form drops. Pure water—without any salt--condenses on the plastic.

This three-stage process -- evaporation, spreading, condensation--occurs whenever there is water inside a closed room or container. Try answering some questions about other situations where it occurs.

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Do Question Set 9.3 in your Activity Book

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Lesson 9.4: Condensing in the Open Air

It is easy to see where the water vapor that condenses in a solar still comes from. It evaporated from the water at the bottom of the still. What if there is no liquid water in a room, though? Can water vapor still condense?

The answer, of course, is yes. There is always water vapor in the air. This water vapor comes from oceans, lakes, rivers, and from you. If the air is cooled, the water molecules slow down, and the attraction between them causes them to cling together. The water vapor condenses.

The water molecules that slow down and stick together on a cold glass probably evaporated at many different times and places. Some molecules escaped from the ocean, others from lakes or rivers. Some molecules escaped from the leaves of trees or other plants. Some came from your breath. The motion of those water molecules mixed them with the other molecules of the air and brought them into the room. Water condenses on a cold glass because the glass cools the humid air around it and causes water vapor in the air to condense.

A little bit of water condenses on cold drinks but there is lots of water vapor in the air. Enough to make billions of gallons of water. Most of the water in the air condenses to form various kinds of precipitation: rain, snow, fog, sleet, hail, or dew.

All precipitation occurs when humid air cools off, the water vapor in the air condenses. Rain, for example, starts when humid air rises high up, where the air is cold. The water molecules in this cooling air slow down and clump together to form ……raindrops!

Every day the sun shines on the oceans and billions of gallons of water evaporate. Those water molecules travel all over the world, then condense and come down as rain (and other forms of precipitation). The salty oceans produce salt-free rain; the whole world is like a giant solar still!

Rain water collects into lakes and rivers, the rivers run into the oceans, and the whole process can start over again. This is how all the precipitation on Earth originates. The same water goes through the process over and over again, evaporating, spreading, condensing, and evaporating again. The whole process is called the water cycle.

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Do Question Set 9.4 in your Activity Book

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Lesson 9.5: Condensation and Precipitation

We said in the last lesson that all forms of precipitation (rain, fog, dew, snow, sleet, hail) are caused by condensing water vapor. In this lesson we will discuss in more detail how different kinds of precipitation are formed. As you read, remember that all kinds of precipitation form in the same basic steps; the differences are only in the details. The steps you already know about:

1. Evaporation: Water evaporates from oceans, lakes and rivers, plants and animals.
2. Spreading: Water vapor is carried around by winds.
3. Cooling and condensation: The air cools off, and the water molecules clump together to form drops (or, if it is cold enough, crystals of ice).

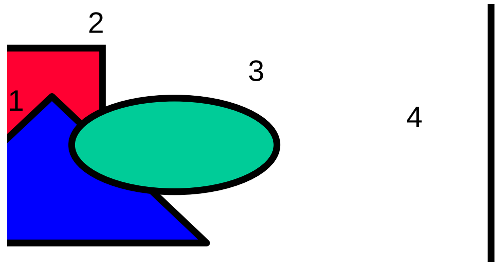
When we see those drops or ice crystals high up in the air above us, we call them clouds. When they come close to the Earth, we call them precipitation: rain, fog, snow, sleet, or whatever. Now let's talk about how some specific types of precipitation are formed.

Clouds and rain. You should have some idea how rain is formed from the previous lesson. The first step is evaporation. As air moves over bodies of water or plants and animals, some of the molecules of water are moving fast enough to escape and move freely in the air. As more and more molecules move from the liquid to the air, the air becomes humid. That means that the air has a lot of water vapor in it.

Next comes spreading. Sometimes this humid air travels high above the Earth.

Then comes cooling and condensation. As this warm, moist air moves higher in the atmosphere, it becomes colder and colder. The water molecules slow down, move less freely, attract each other, clump together, and form visible water droplets. If there are lots of water droplets we can see them from the ground; we call them clouds. If the air continues to get colder, these droplets of water get larger and larger until they fall to the Earth as rain.

1. Evaporation: water evaporates from lakes, plants, etc.
2. Spreading: warm humid air rises.
3. Condensation: Air cools off and water vapor condenses into drops: CLOUDS.
4. Precipitation: Drops fall from clouds to the ground: RAIN

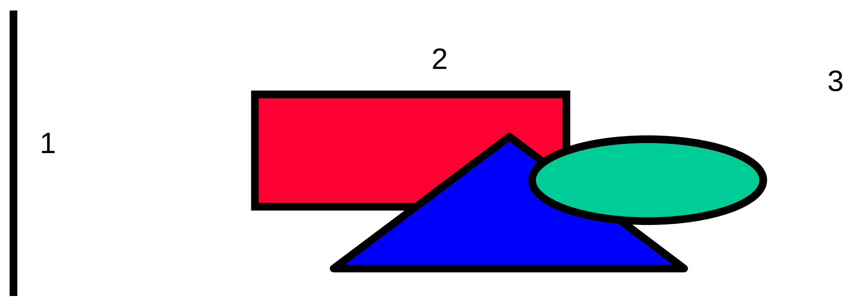


Sequence of events leading to forms of precipitation: CLOUDS and RAIN

Fog. Have you ever wondered what the inside of a cloud looks like? You actually know what it is like inside clouds because you have been inside clouds that are close to the ground. Only you didn't call them clouds. When clouds form at ground level we call them fog.

Fog forms in about the same way as clouds do high up in the sky. First the water evaporates, then the water vapor is carried around by the wind, then the air cools off and drops of water form. Fog often forms at night, when the air is cooler. If you have ever been in a thick fog, you know that the tiny droplets of water collect on your hands, face, and clothing, making you moist.

1. Evaporation: Water evaporates and air becomes warm and humid in sunshine.
2. Spreading: warm humid air spreads around.
3. Condensation: Air cools off at night and water vapor condenses into droplets: FOG

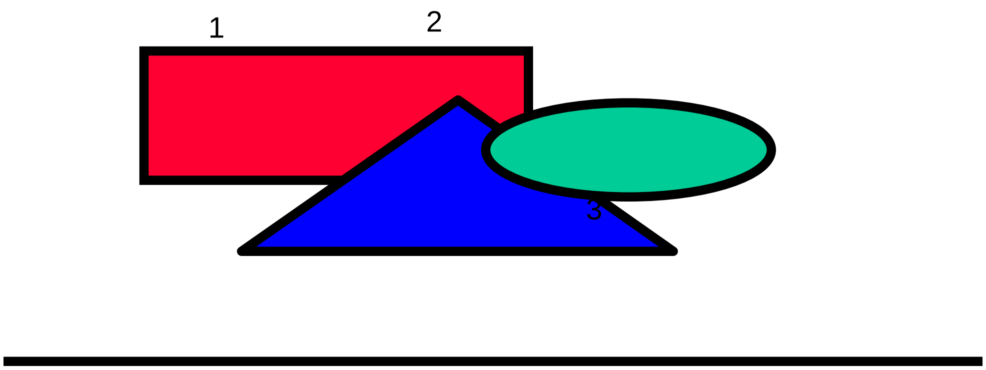


Sequence of events leading to forms of precipitation: FOG

Dew. Have you ever walked through grass in the early morning hours when the grass was wet or had water droplets on it? This is called dew. How do you think dew is formed? First comes evaporation. During the day, when the sun is shining, the ground and the plants in the ground become warm. Water evaporates from the lakes, rivers, and streams, as well as the plants and the air and becomes humid. This humid air spreads all around. What do you think will happen after the sun goes down and the ground and plants become cool?

You probably know the next step. It is cooling and condensation. As the air next to the ground becomes cool, the water molecules in the air move slower, hit each other less often, attract each other more, and move closer together, forming clusters of trillions of molecules of water that we call droplets. Drops of water clinging to plants and other materials on the surface of the Earth are call dew.

1. Evaporation: Water evaporates and air becomes warm and humid in sunshine.
2. Spreading: Warm humid air spreads around.
3. Condensation: Grass cools off at night and water vapor condenses on it: DEW



Sequence of events leading to forms of precipitation: DEW

Snow, sleet, frost and hail. Sometimes water vapor condense in places where it is really cold, so cold that liquid water freezes into ice. When the happens, instead of water droplets you get – crystals of ice! Many of the clouds that you see are actually made of ice crystals rather than drops of water. When those pieces of ice come down to the ground, we call them other forms of precipitation: snow, sleet, frost or hail. Whether it comes in the form of ice or liquid water, though, all precipitation is formed by the same basic steps. First water evaporates, then the water vapor spreads around with the wind, the it cools off and condenses (and sometimes freezes, too).

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Do Questions Set 9.5 in your Activity Book

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Lesson 9.6 You Drank the Water that George Washington Used to Wash His Boots

The rain that falls to Earth today is not new water, but water that has been on Earth for centuries. You know that molecules are very, very small. In fact, a gallon of water has about 120,000,000,000,000,000,000,000,000 molecules in it. The chances are, therefore, that some of the water you drank today had at least one molecule of water that George Washington used to wash his boots with in 1776.

Imagine that in 1776, George Washington stood under a cherry tree and washed his boots. Some of this water was soaked into the ground, was taken up by the roots of the cherry tree, and evaporated from the leaves of the cherry tree. The wind carried these molecules far across the Atlantic Ocean and they rained down on the ocean in a thunderstorm.

In the ocean, they were constantly moving like all the other molecules of water in the ocean, and they were constantly being hit by all the other molecules. Eventually, some of the molecules from George Washington's boots moved fast enough to escape again into the air, where they moved freely.

The air currents moved them northward and eastward until they were again part of a big, beautiful cloud that was cooled by air coming from the north. They lost some of their speed and became part of rain droplets that fell over the lush vineyards of France. The roots of the grapevines took the molecules in, and again they evaporated from the leaves and became part of the free-moving air. This continued until the molecules moved through three or four more water cycles all the way to the Pacific Ocean. They were carried across the United States from the West to the East Coast. In the Central plains, a cold Canadian mass of air pushed the molecules high in the air where they slowed down, became part of a cloud, and eventually fell as rain.

They made their way deep in the soil and continued down until they reached the ground water. Many cities pump their water from this ground water. It became part of the drinking water and this morning you drank some of the very same molecules George Washington used to wash his boots in 1776.

The purpose of this story was to show you that the amount of water that is on the Earth remains about the same, and is only recycled over and over again through evaporation, spreading, and condensation. This repeated evaporation, spreading, and condensation is called the water cycle.

Most of the water molecules on Earth are very, very old; they have been around since the Earth began. During that time they have been through many, many water cycles, evaporating, spreading, and condensing, and evaporating, spreading, and condensing again. They have been carried all over the Earth by wind and rivers and ocean currents. Through all the changes and movements, though, the molecules themselves have stayed the same. The water molecules and the water cycle go on and on.

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Do Review Question Set 9.6 Now

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THE LAST PAGE

Yes, this is the last page of the unit. Your long study of molecules is over. We hope you have learned a lot about molecules and about how they can help you explain many different things. Can you think back to how molecules can explain the way things dissolve? What about thermal expansion? Compression of gases? Changes of state?

Even if you have learned a lot about molecules, there is still much more to learn. We can use ideas about molecules to explain what happens inside our bodies when we breathe, for examples, or how we grow or what happens when things burn or decay. We cannot explain those things in this unit, but we hope that this unit will prepare you to learn and understand much more in the future. There is always more to learn; we hope you find it interesting!