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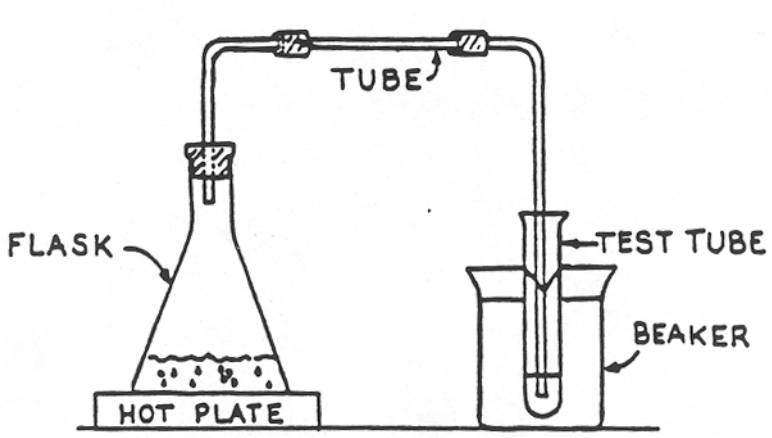
As you can see from the demonstration, water vapor is an invisible gas. Liquid water changes to water vapor when it evaporates or boils. The gas inside the bubbles of boiling water is water vapor. Water vapor can change back into liquid water when it cools down.

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.

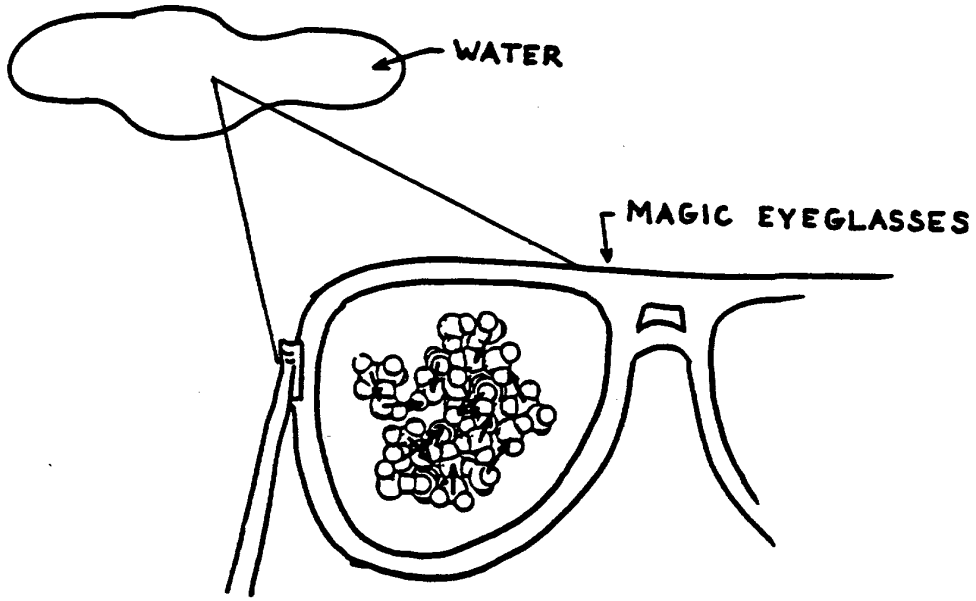
Lesson 1.3: Molecules, the Smallest Pieces of Water

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?

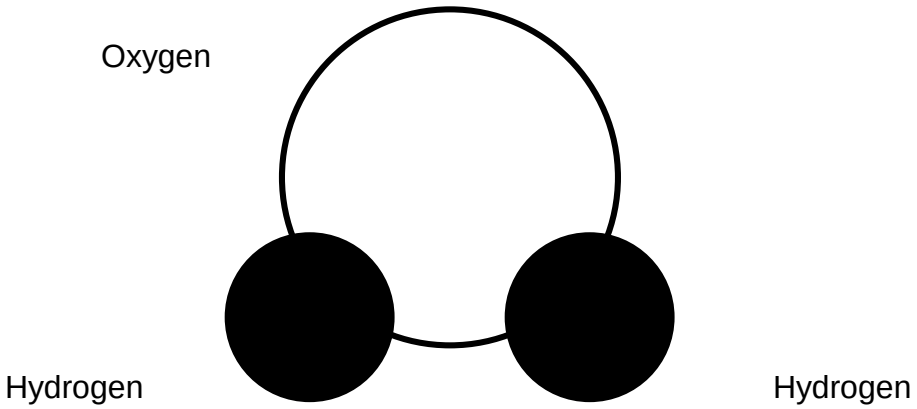
We cannot tell what water is made of just by looking at it. But scientists say that water is made of water molecules. That is, if you divide a water droplet into smaller pieces until you can not divide it any more, then we have the tiniest pieces of water. We call these tiniest pieces, water molecules.




*Magic eyeglasses show molecules of water*

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).

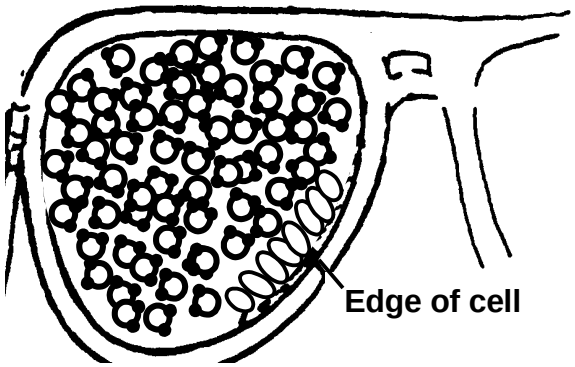
Since we already said that water molecules are the tiniest pieces that make up water, you know that they are very small. But how small are they?

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.

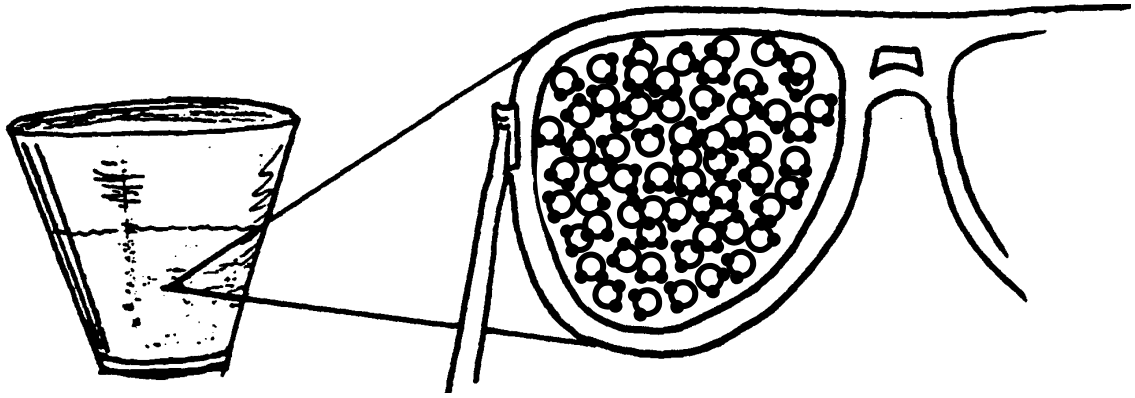
There are other small things that we can see only with a microscope, like germs or the cells our body is made of. Are water molecules smaller than cells or germs?

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.

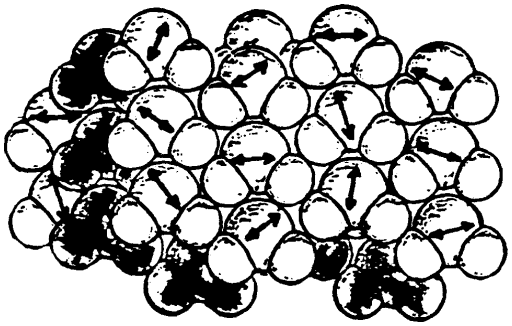
Here is how scientists explain the differences among the three states of water. In solid water (ice), water molecules are close together, locked in a rigid pattern, and thus they are not moving past each other. They vibrate, but they stay in place. Remember, molecules are constantly moving and never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

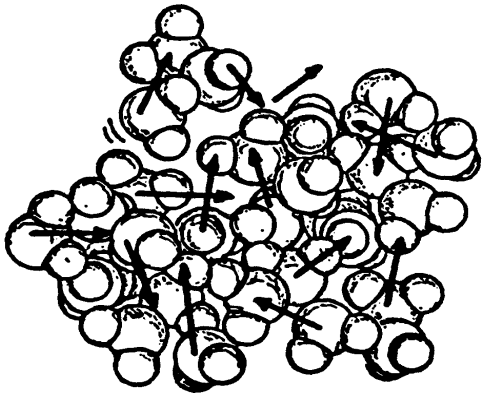
The pictures on the next page give a rough idea of how water molecules look in ice, liquid water, and water vapor. (Though you could never really see them--they're much too small!)

Ice:



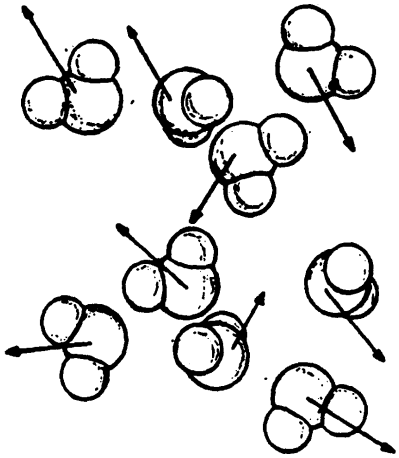
*Water molecules are locked in a rigid pattern, vibrate in their places*

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 very 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 $4^0$C to $0^0$C, 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.