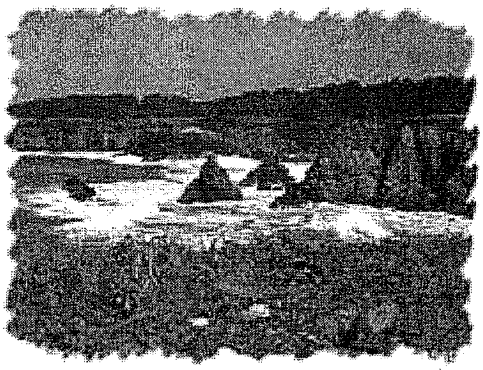
Matter is the Stuff Around You

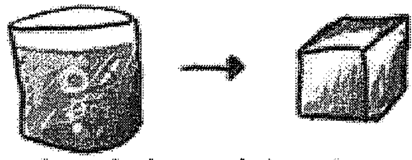
Matter is everything around you. **Matter** is anything made of atoms and molecules. Matter is anything that has a **mass**. Matter is also related to light and electromagnetic radiation. Even though matter can be found all over the universe, you usually find it in just a few forms. As of 1995, scientists have identified five **states of matter**. They may discover one more by the time you get old.



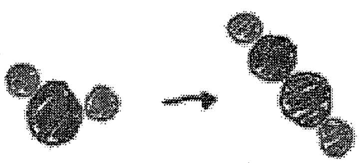
THE EARTH IS ONE LARGE MIXTURE OF MOLECULES IN GASES, LIQUIDS AND SOLIDS.

You should know about solids, liquids, gases, plasmas, and a new one called Bose-Einstein condensates. The first four have been around a long time. The scientists who worked with the Bose-Einstein condensate received a Nobel Prize for their work in 1995. But what makes a state of matter? It's about the physical state of molecules and atoms.

Changing States of Matter



PHYSICAL CHANGE OF WATER INTO ICE



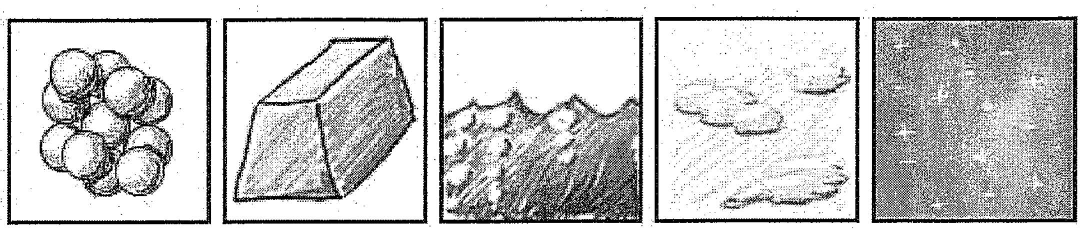
CHEMICAL CHANGE OF WATER INTO HYDROGEN PEROXIDE

Elements and compounds can move from one physical state to another and not change. Oxygen (O_2) as a gas still has the same properties as liquid oxygen. The liquid state is colder and denser but the molecules are still the same. Water is another example. The **compound** water is made up of two hydrogen (H) atoms and one oxygen (O) atom. It has the same molecular structure whether it is a gas, liquid, or solid. Although its physical state may change, its chemical state remains the same.

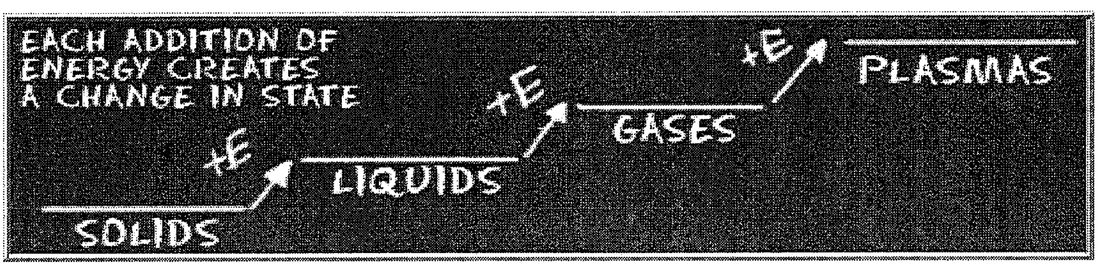
So you ask, "What is a chemical state?" If the formula of water were to change, that would be a **chemical change**. If you added another oxygen atom, you would make hydrogen peroxide (H_2O_2). Its molecules would not be water anymore. Changing states of matter is about changing densities, pressures, temperatures, and other physical properties. The basic chemical structure does not change.

States of Matter

There are four states of matter. Solids, liquids, gases, and plasmas are all different states of matter. Each of these states is also known as a phase. Elements and compounds can move from one phase to another phase when special **physical forces** are present. One example of those forces is temperature. The phase or state of matter can change when the temperature changes. Generally, as the temperature rises, matter moves to a more active state.

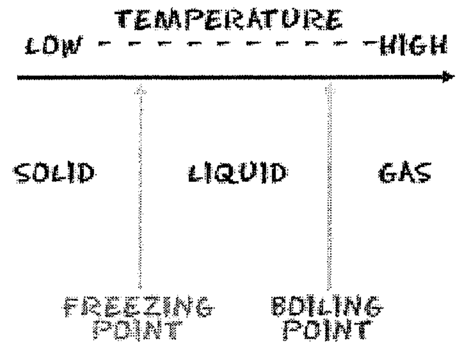


Phase describes a physical state of matter. The key word to notice is physical. Things only move from one phase to another by physical means. If energy is added (like increasing the temperature or increasing pressure) or if energy is taken away (like freezing something or decreasing pressure) you have created a physical change.

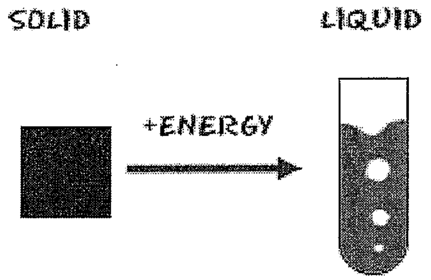


One compound or element can move from phase to phase, but still be the same substance. You can see water **vapor** over a boiling pot of water. That vapor (or gas) can **condense** and become a drop of water. If you put that drop in the freezer, it would become a solid. No matter what phase it was in, it was always water. It always had the same chemical properties. On the other hand, a chemical change would change the way the water acted, eventually making it not water, but something completely new.

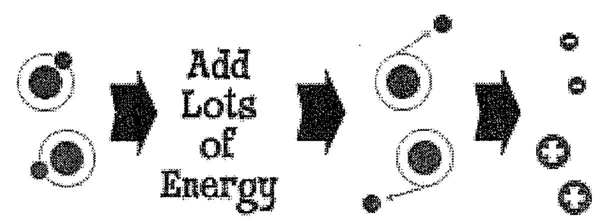
Changing States of Matter



All matter can move from one state to another. It may require very low temperatures or very high pressures, but it can be done. Phase changes happen when certain points are reached. Sometimes a liquid wants to become a solid. Scientists use something called a **freezing point** to measure when that liquid turns into a solid. There are physical effects that can change the freezing point. Pressure is one of those effects. When the pressure surrounding a substance goes up, the freezing point also goes up. That means it's easier to freeze the substance at higher pressures. When it gets colder, most solids shrink in size. There are a few which expand but most shrink.



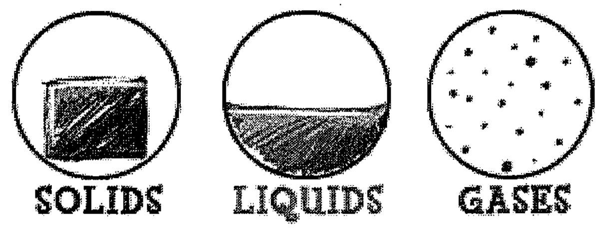
Now you're a solid. You're a cube of ice sitting on a counter. You dream of becoming liquid water. You need some **energy**. Atoms in a liquid have more energy than the atoms in a solid. The easiest energy around is probably heat. There is a magic temperature for every substance called the melting point. When a solid reaches the temperature of its melting point it can become a liquid. For water the temperature has to be a little over zero degrees Celsius. If you were salt, sugar, or wood your melting point would be higher than water.



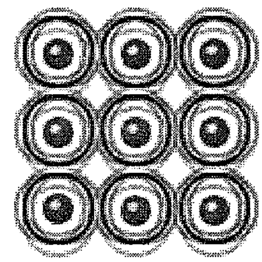
The reverse is true if you are a gas. You need to lose some energy from your very excited gas atoms. The easy answer is to lower the surrounding temperature. When the temperature drops, energy will be sucked out of your gas atoms. When you reach the temperature of the condensation point, you become a liquid. If you were the steam of a boiling pot of water and you hit the wall, the wall would be so cool that you would quickly become a liquid.

Finally, you're a gas. You say, "Hmmmm. I'd like to become a plasma. They are too cool!" You're already halfway there being a gas. You still need to tear off a bunch of electrons from your atoms. Eventually you'll have bunches of positively and negatively charged particles in almost equal concentrations. When the ions are in equal amounts, the charge of the entire plasma is close to **neutral**. (A whole bunch of positive particles will cancel out the charge of an equal bunch of negatively charged particles.) A plasma can be made from a gas if a lot of energy is pushed inside. All of this extra energy makes the neutral atoms break apart into positively and negatively charged ions and free electrons. They wind up in a big gaseous ball.

Solid Basics



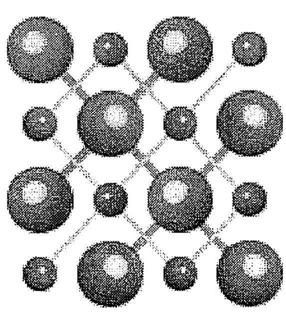
So what is a solid? Solids are usually hard because their molecules have been packed together. The closer your molecules are, the harder you are. Solids also can hold their own shape. A rock will always look like a rock unless something happens to it. The same goes for a diamond. Even when you grind up a solid into a powder, you will see little tiny pieces of that solid under a microscope. Liquids will move and fill up any container. Solids like their shape.



In the same way that a solid holds its shape, the atoms inside of a solid are not allowed to move around too much. This is one of the **physical** characteristics of solids. Atoms and molecules in liquids and gases are bouncing and floating around, free to move where they want. The molecules in a solid are stuck. The atoms still spin and the electrons fly around, but the entire atom will not change position.

Solids can be made up of many things. They can have pure elements or a variety of compounds inside. When you get more than one type of compound in a solid it is called a **mixture**. Most rocks are mixtures of many different compounds. Concrete is a good example of a manmade mixture.

Crystals



On the other end of the spectrum from a mixture is something called a crystal. When a solid is made up of a pure substance and forms slowly, it can become a crystal. Not all pure substances form crystals because it is a delicate process. The atoms are arranged in a regular repeating pattern called a cystal lattice. A crystal lattice is a very exact organization of atoms. A good example is carbon. A diamond is a perfect crystal lattice while the graphite arrangement is more random.

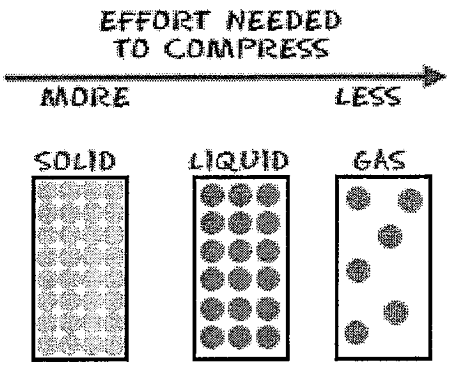
Liquid Basics


THE OCEANS OF THE WORLD ARE ALL SOLUTIONS.

The second state of matter we will discuss is a liquid. Solids are hard things you can hold. Gases are floating around you and in bubbles. What is a liquid? Water is a liquid. Your blood is a liquid. Liquids are an in-between

state of matter. They can be found in between the solid and gas states. They don't have to be made up of the same compounds. If you have a variety of materials in a liquid, it is called a solution.

One characteristic of a liquid is that it will fill up the shape of a container. If you pour some water in a cup, it will fill up the bottom of the cup first and then fill the rest. The water will also take the shape of the cup. It fills the bottom first because of **gravity**. The top part of a liquid will usually have a flat surface. That flat surface is because of gravity too. Putting an ice cube (solid) into a cup will leave you with a cube in the middle of the cup; the shape won't change until the ice becomes a liquid.

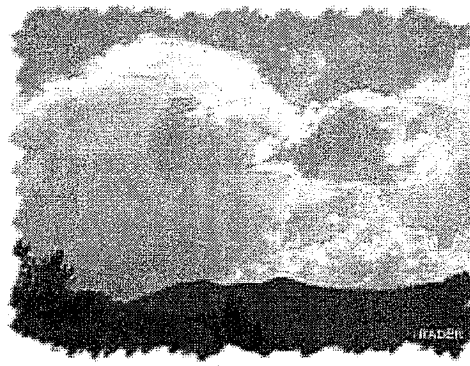


Another trait of liquids is that they are difficult to compress. When you compress something, you take a certain amount and force it into a smaller space. Solids are very difficult to compress and gases are very easy. Liquids are in the middle but tend to be difficult. When you compress something, you force the atoms closer together. When pressure go up, substances are compressed. Liquids already have their atoms close together, so they are hard to compress. Many shock absorbers in cars compress liquids in tubes.

A special force keeps liquids together. Solids are stuck together and you have to force them apart. Gases bounce everywhere and they try to spread themselves out. Liquids actually want to stick together. There will always be the occasional evaporation where extra energy gets a molecule excited and the molecule leaves the system. Overall, liquids have **cohesive** (sticky) forces at work that hold the molecules together.

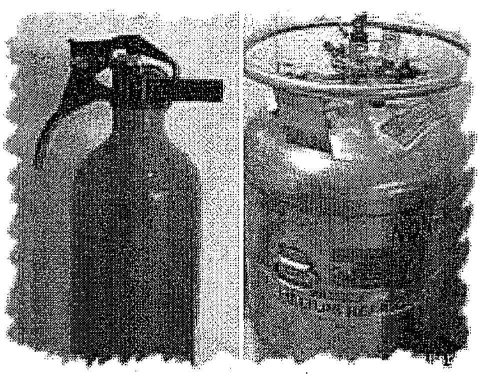
Looking for a Gas

Gas is everywhere. There is something called the atmosphere. That's a big layer of gas that surrounds the Earth. Gases are **random** groups of atoms. In solids, atoms and molecules are compact and close together. Liquids have atoms a little more spread out. However, gases are really spread out and the atoms and molecules are full of energy. They are bouncing around constantly.



CLOUDS ARE ACTUALLY LARGE AMOUNTS OF TINY WATER DROPLETS.

Gases can fill a container of any size or shape. That is one of their physical characteristics. Think about a balloon. No matter what shape you make the balloon it will be evenly filled with the gas atoms. The atoms and molecules are spread equally throughout the entire balloon. Liquids can only fill the bottom of the container while gases can fill it entirely.



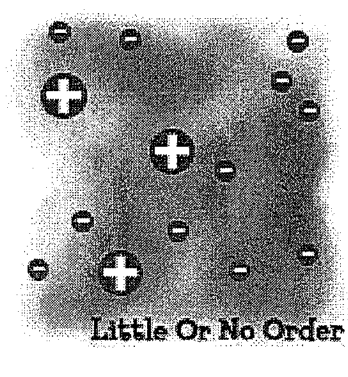
PRESSURIZED GASES ARE ALL AROUND YOU.

You might hear the term **vapor**. Vapor and gas mean the same thing. The word vapor is used to describe gases that are usually found as liquids. Good examples are water or mercury (Hg). Compounds like carbon dioxide are usually gases at room temperature so scientists will rarely talk about carbon dioxide vapor. Water and mercury are liquids at room temperature so they get the vapor title.

Gases hold huge amounts of energy, and their molecules are spread out as much as possible. With very little pressure, when compared to liquids and solids, those molecules can be **compressed**. It happens all of the time. Combinations of pressure and decreasing temperature force gases into tubes that we use every day. You might see compressed air in a spray bottle or feel the carbon dioxide rush out of a can of soda. Those are both examples of gas forced into a space smaller than it would want, and the gas escapes the first chance it gets.

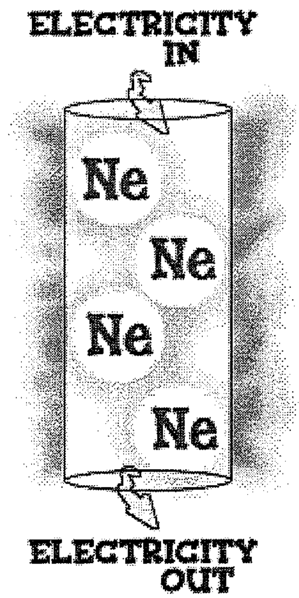
Plasma Basics

Plasmas are a lot like gases, but the atoms are different because they are made up of free electrons and ions of the element. You don't find plasmas too often when you walk around. They aren't things that happen regularly on Earth. If you have ever heard of the Northern Lights or ball lightning, you might know that those are types of plasmas. It takes a very special environment to keep plasmas going. They are different and unique from the other states of matter.



Finding A Plasma

You won't find plasmas just anywhere. However, there may be some in front of you. Think about a fluorescent light bulb. They are not like regular light bulbs. Inside the long tube is a gas. Electricity flows through the tube when the light is turned on. The electricity acts as that special energy and charges up the gas. This charging and exciting of the atoms creates glowing plasma inside the bulb.



Another example of plasma is a neon sign. Just like a fluorescent light, neon signs are glass tubes filled with gas. When the light is turned on, the electricity flows through the tube. The electricity charges the gas, possibly neon, and creates plasma inside of the tube. The plasma glows a special color depending on what kind of gas is inside.

You also see plasma when you look at stars. **Stars** are big balls of gases at really high temperatures. The high temperatures charge up the atoms and create plasma. Stars are another good example of how the temperature of plasmas can be very different. Fluorescent lights are cold compared to really hot stars. They are still both forms of plasma, even with different physical characteristics.

The Mass of Matter

Matter may change from a solid to a liquid. Elements may react together to form compounds. What happens to the mass of matter in a bowl of water when it is left to stand in the hot sun? What happens to the mass of matter in a piece of paper when it is burned? Sometimes in situations like this it seems as if matter is disappearing. But the disappearance of matter is an illusion.

Matter may change from one form into another. For example, when the water in the bowl absorbs energy from the sun and evaporates, it becomes water vapor in the atmo-sphere. The piece of paper gives off heat and light energy as it burns, and the matter in it is converted into carbon dioxide, water vapor, and other gases that escape into the atmo-sphere. Some of the mass will remain behind as ash. In both cases, the matter changes its form, but its total mass stays the same. The same mass of each element is present before and after the change. Matter is neither created nor destroyed during these changes.