



MATTER

What is matter?

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.

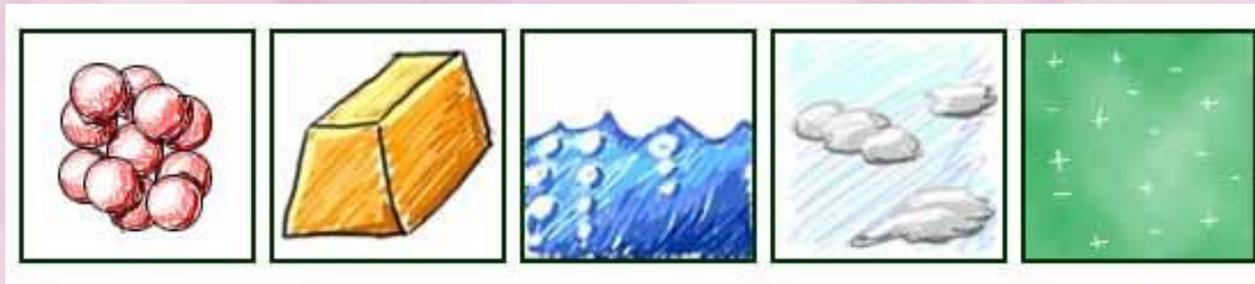
Even though matter can be found all over the universe, you usually find it in just a few forms.

Matter has states.

- As of 1995, scientists have identified five **states of matter**. They may discover one more by the time you get old.

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.

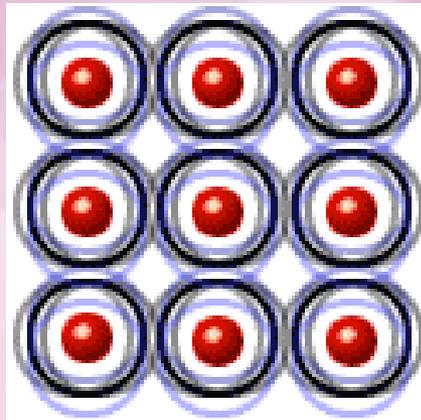
The scientists who worked with the Bose-Einstein condensate received a Nobel Prize for their work in 1995. But what makes a state of matter? It's about the physical state of molecules and atoms.



Solids

- 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. 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.



Liquids

- 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.
- 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.



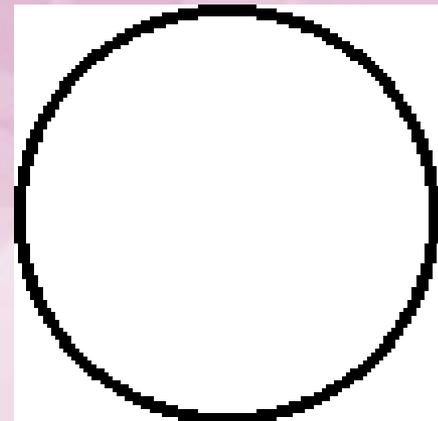
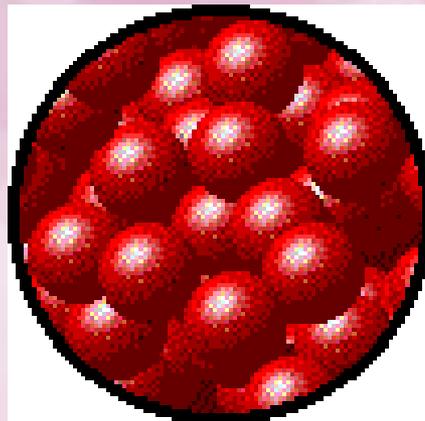
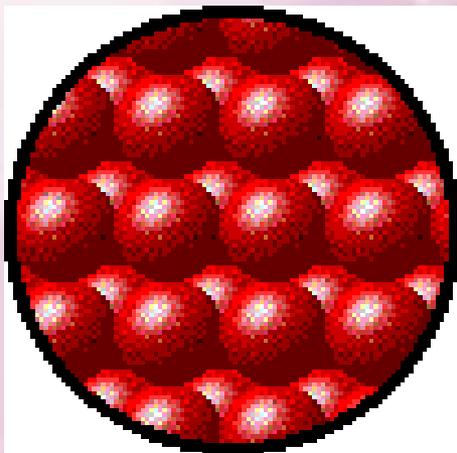
Gases

- 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.
- 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.

Gases, liquids and **solids** are all made up of microscopic particles, but the behaviors of these particles differ in the three phases. The following figure illustrates the microscopic differences.



Note that:

Particles in a:

- gas are well separated with no regular arrangement.
 - liquid are close together with no regular arrangement.
 - solid are tightly packed, usually in a regular pattern.
- gas vibrate and move freely at high speeds.
 - liquid vibrate, move about, and slide past each other.
 - solid vibrate (jiggle) but generally do not move from place to place.

Liquids and solids are often referred to as condensed phases because the particles are very close together

Some Characteristics of Gases, Liquids and Solids and the Microscopic Explanation for the Behavior

<i>Gas</i>	<i>Liquid</i>	<i>Solid</i>
assumes the shape and volume of its container particles can move past one another	assumes the shape of the part of the container which it occupies particles can move/slide past one another	retains a fixed volume and shape rigid - particles locked into place
compressible lots of free space between particles	not easily compressible little free space between particles	not easily compressible little free space between particles
flows easily particles can move past one another	flows easily particles can move/slide past one another	does not flow easily rigid - particles cannot move/slide past one another

Plasmas

- Plasmas are a lot like gases, but the atoms are different because, they are **super hot and super excited**, and also, Plasmas are made up of free electrons and ions of the element

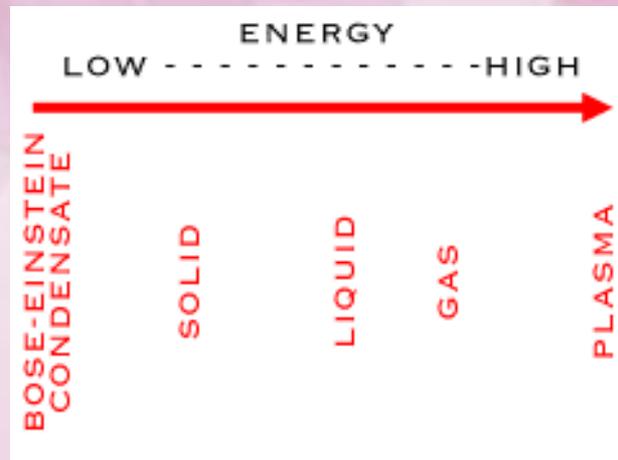
You don't find plasmas too often when you walk around. They aren't things that happen regularly on Earth. If you have ever heard of the Northern Lights or ball lightning, you might know that those are types of plasmas, other examples of plasmas are fluorescent light bulb, a neon sign and stars. **Stars** are big balls of gases at really high temperatures.

It takes a very special environment to keep plasmas going. They are different and unique from the other states of matter.



Bose-Einstein Basics

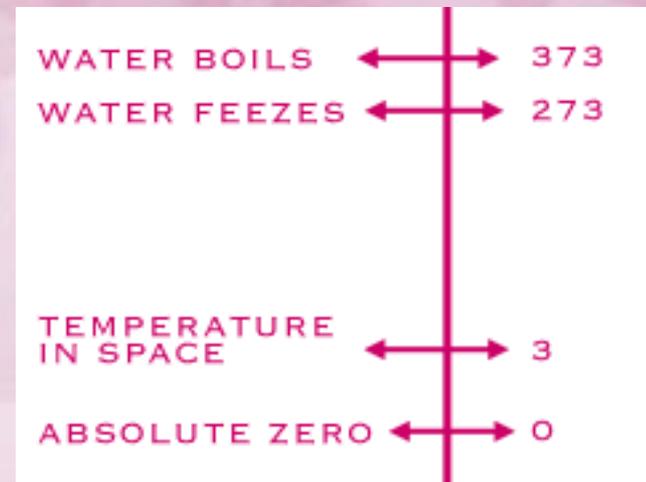
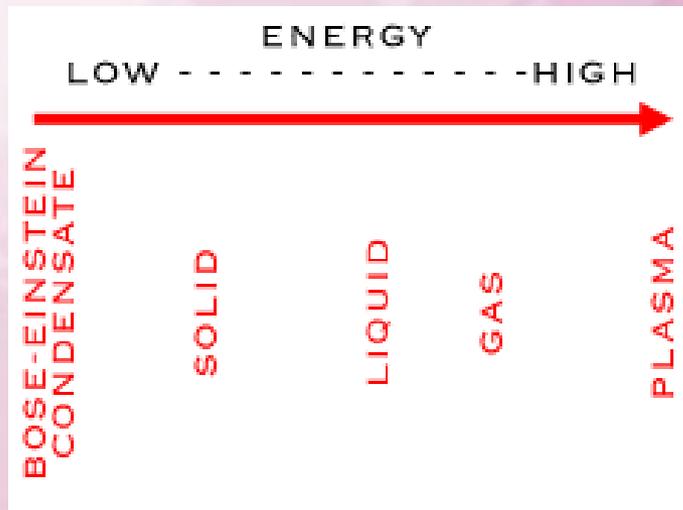
This state of matter was the only one created while you were alive. In 1995, two scientists, Cornell and Weiman, finally created this new state of matter. Two other scientists, Satyendra **Bose** and Albert **Einstein**, had predicted it in the 1920s. They didn't have the equipment and facilities to make it happen in the 20s. Now we do. If plasmas are super hot and super excited atoms, the atoms in a Bose-Einstein condensate (BEC) are total opposites. They are **super-unexcited and super-cold atoms**.



Bose-Einstein Basics

About Condensation

Let's explain condensation. Condensation happens when several gas molecules come together and form a liquid. It all happens because of a **loss of energy**. Gases are really excited atoms. When they lose energy, they slow down and begin to collect. They can collect into one drop. Water (H_2O) vapor in the form of steam condenses on the lid of your pot when you boil water. It cools on the metal and becomes a liquid again. You would then have a **condensate**.



Bose-Einstein Basics

- The BEC happens at super low temperatures. We have talked about temperature scales and **Kelvin**. At zero Kelvin (**absolute zero**) all molecular motion stops. Scientists have figured out a way to get a temperature only a few billionths of a degree above absolute zero. When temperatures get that low, you can create a BEC with a few special elements. Cornell and Weiman did it with rubidium (Rb).

Let the Clumping Begin

- So, it's cold. A cold ice cube is still a solid. When you get to a temperature near absolute zero, something special happens. Atoms begin to **clump**. The whole process happens at temperatures within a few billionths of a degree, so you won't see this at home. When the temperature becomes that low, the atomic parts can't move at all. They lose almost all of their energy. Since there is no more energy to transfer (as in solids or liquids), all of the atoms have exactly the same levels, like twins. The result of this clumping is the BEC.

ACTIVITY

1. As of the 1990s, scientists have proved the existence of how many states of matter?
 - a. Two
 - b. Three
 - c. Four
 - d. Five
2. what is the densest state of matter between gases, liquids, and solids,?
 - a. Solids
 - b. Liquids
 - c. Gases
 - d. Plasmas

3. Because electrons have been stripped away from atoms in plasma, plasmas have a negative charge.

a. True

b. False

4. The molecules in a gas are in constant motion.

a. True

b. False

5. Atoms in a liquid are farther apart than the atoms in a gas.

a. True

b. False

Check your answers

1. (d) Scientists have now proven that there are five states of matter.
Solids, Liquids, Gases, Plasmas, Bose-Einstein Condensate.
2. (a) Of those three choices, solids are the densest state of matter. The molecules in solids are more tightly packed than either liquids or gases.
3. (b) Plasmas have a neutral charge. Even though the electrons have been stripped from the atoms, the positively charged nuclei remain. The positive charges cancel out the negative charges.

4. (a) The molecules in a gas are in constant motion. Actually, all molecules in solids, liquids, and gases are in constant motion at any temperature above absolute zero. The molecules in a gas are just more active than the molecules found in solids and liquids.
5. (b) Atoms in a gas are actually farther apart than the atoms in a liquid. Solids are the densest state of matter (of solids liquids, and gases). Gases are the least dense and have atoms that are the most spread out.

Taken from:

- [http://www.chem4kids.com/files/matter intro.html](http://www.chem4kids.com/files/matter_intro.html)