

## What is matter?

**Matter** is everything around you. Atoms and molecules are all composed of matter. Matter is defined as **anything that has mass and takes up space**.

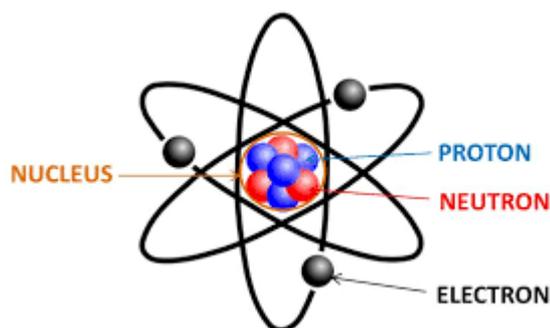
Even though matter can be found all over the Universe, you will only find it in a few forms on Earth !! We will examine five states of matter . Each of those states is sometimes called a **phase**. There are many other states of matter that exist in extreme environments. Scientists will probably discover more states as we continue to explore the Universe.

You should know about:

1. solids,
2. liquids,
3. gases,
4. plasmas, and
5. BEC - one state called the Bose-Einstein condensate (BEC).

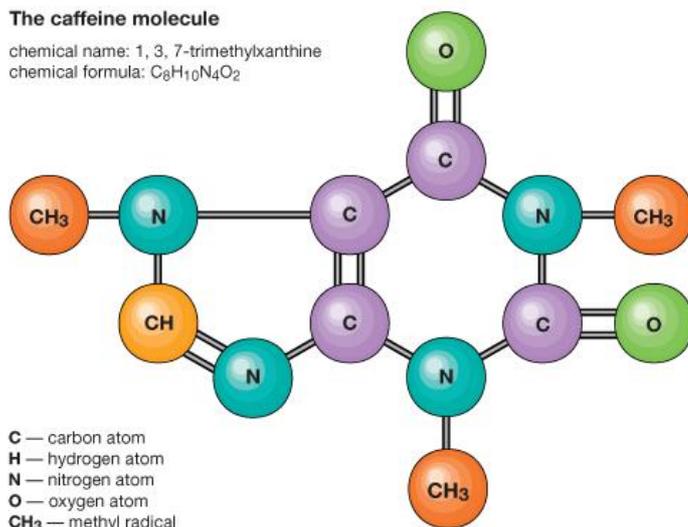
Scientists have always known about solids, liquids, and gases. Plasma was a new idea when it was identified by William Crookes in 1879. The scientists who worked with the Bose-Einstein condensate received a Nobel Prize for their work in 1995.

The atoms make up molecules:



### The caffeine molecule

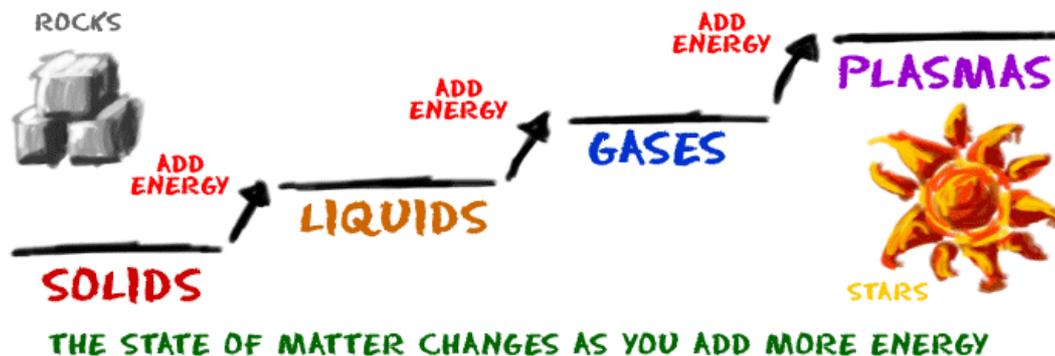
chemical name: 1, 3, 7-trimethylxanthine  
chemical formula:  $C_8H_{10}N_4O_2$



## What makes a state of matter?

It's about the **physical state** of the molecules and atoms.

- Think about solids. They are often hard and brittle.
- Liquids are fluidy, can move around a little, and fill up containers.
- Gases are always around you, but the molecules of a gas are much farther apart than the molecules in a liquid. If a gas has an odor, you'll be able to smell it before you can see it.
- **The BEC is all about atoms that are even closer and less energetic than atoms in a solid !!**
- Plasmas are **highly energized gases that have lost their electrons !!** Stars, including the Sun, are covered in plasma. Hydrogen (H) and helium (He) ions float around the Sun with their electrons moving freely.



*When the temperature of a system goes up, the matter in the system becomes more excited and active.  
If enough **energy** is placed in a system, a phase change may occur  
as the matter moves to a more **active state**.*

Molecules can move from one physical state to another (phase change) and not change their basic **structure**. Oxygen (O<sub>2</sub>) as a gas has the same chemical properties as liquid oxygen. The liquid state is colder and denser, but the **molecules** (the basic parts) are still the same. Water (H<sub>2</sub>O) is another example. A water molecule 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!!**

## What is a chemical change?

Let's start with a glass of pure water. If the formula of water were to change, that would be a chemical change. If you could add a second oxygen atom to a water molecule, you would have hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>). The molecules would not be water anymore. The reality of creating hydrogen peroxide is more difficult.

**Chemical changes occur when the bonds between atoms in a molecule are created or destroyed.** Changes in the physical state are related to changes in the immediate **environment** such as temperature, pressure, and other physical forces. Generally, the basic chemical structure does not change when there is a physical change. **Of course, in extreme environments such as the Sun, no molecule is safe from destruction. !!**