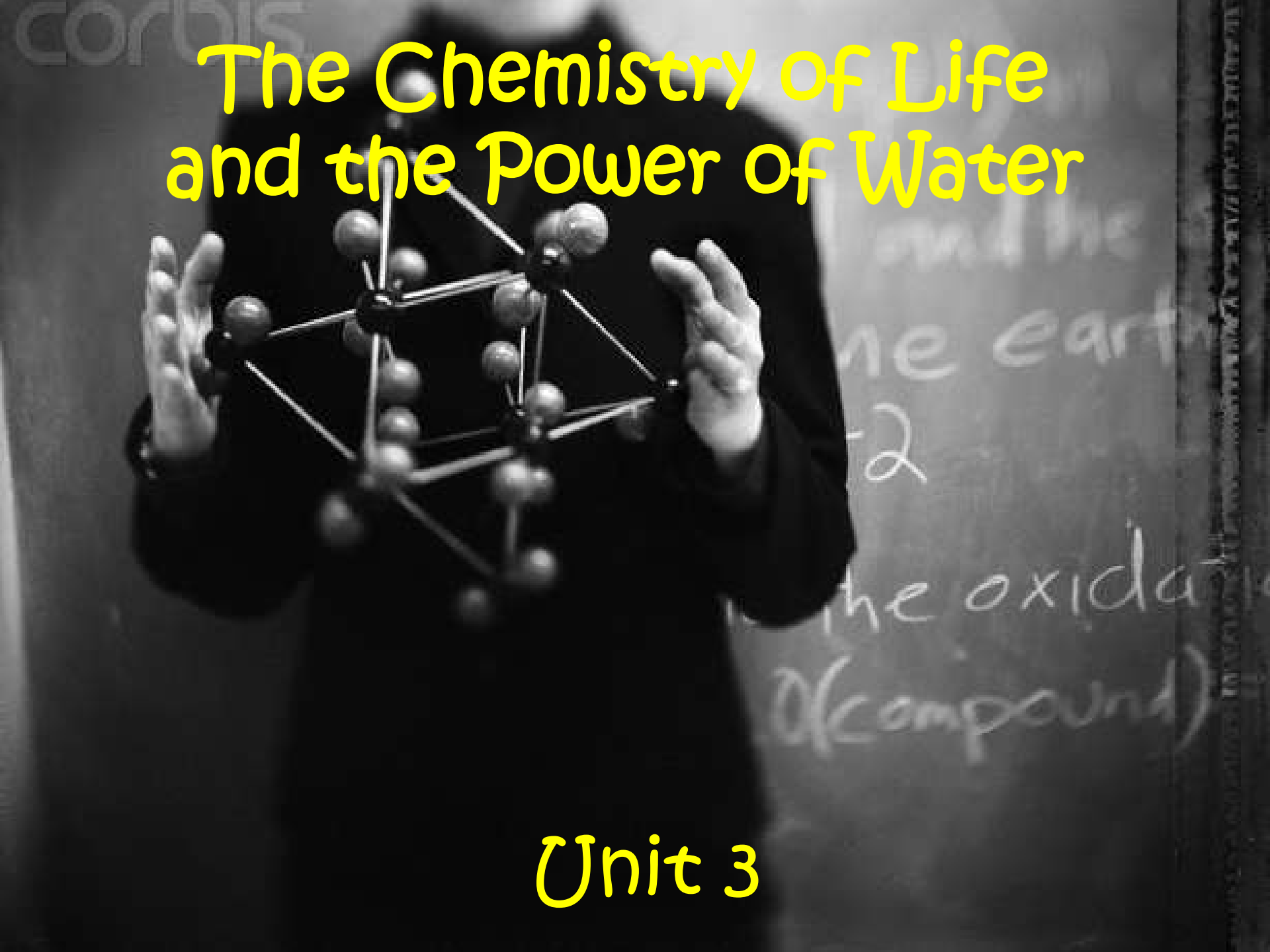


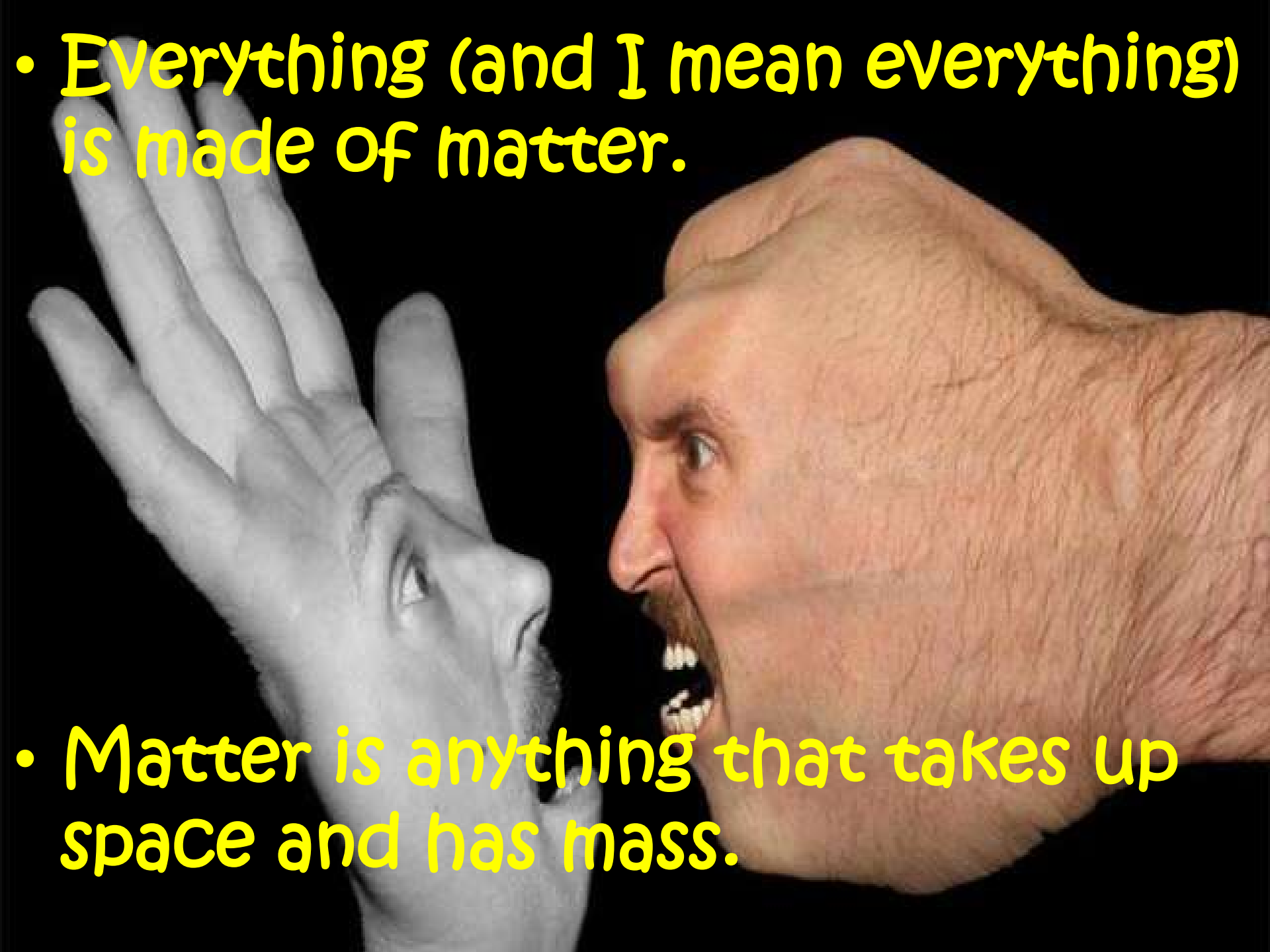
The Chemistry of Life and the Power of Water

Unit 3

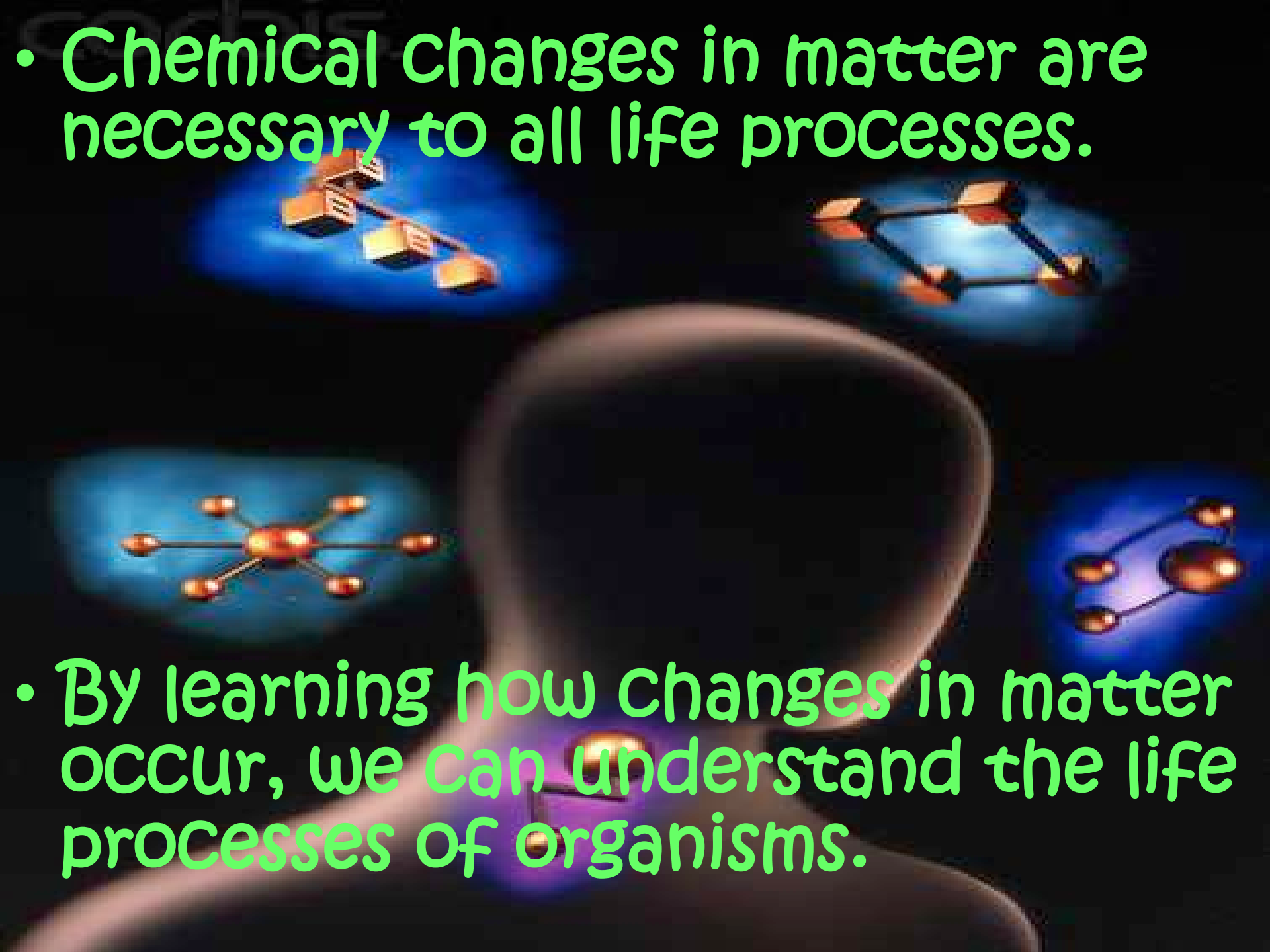
Chemistry ??? REALLY?

I thought this was Biology! Why are we talking about Chemistry??

- Understanding basic chemistry will help us understand living things and how they work.

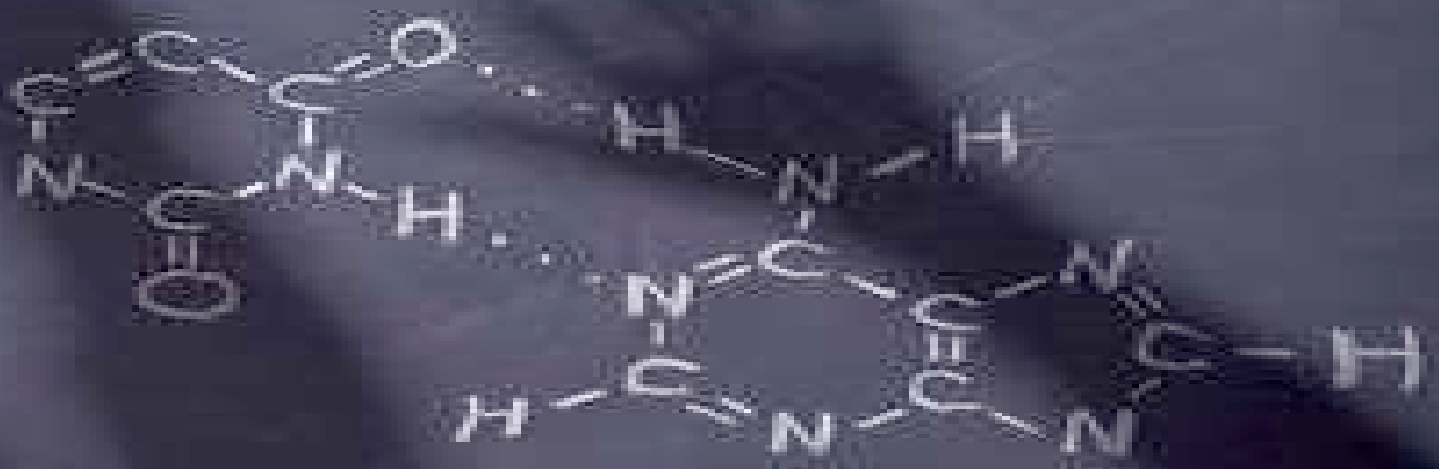

• Everything (and I mean everything) is made of matter.
• Matter is anything that takes up space and has mass.

- Chemical changes in matter are necessary to all life processes.

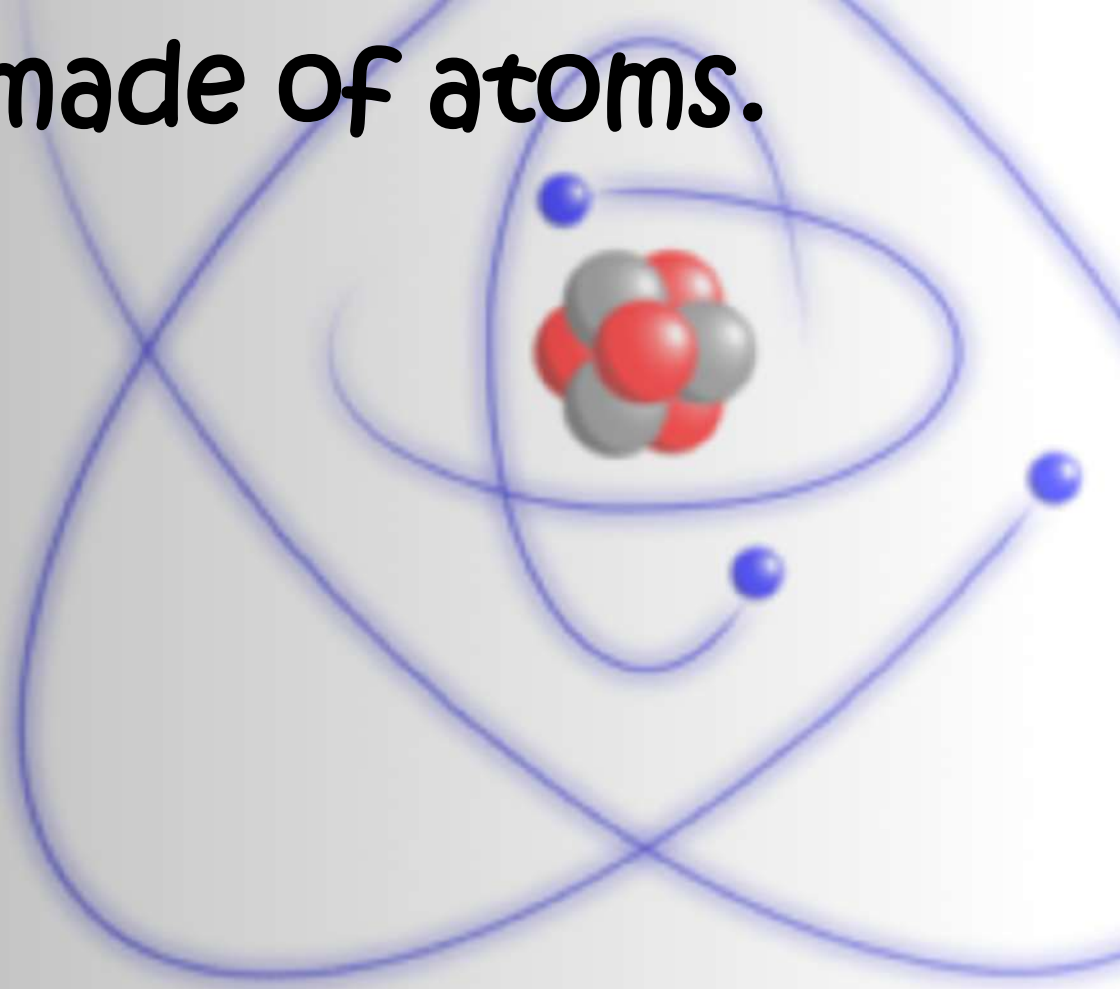


- By learning how changes in matter occur, we can understand the life processes of organisms.

- First we need to start with some basic chemistry facts...

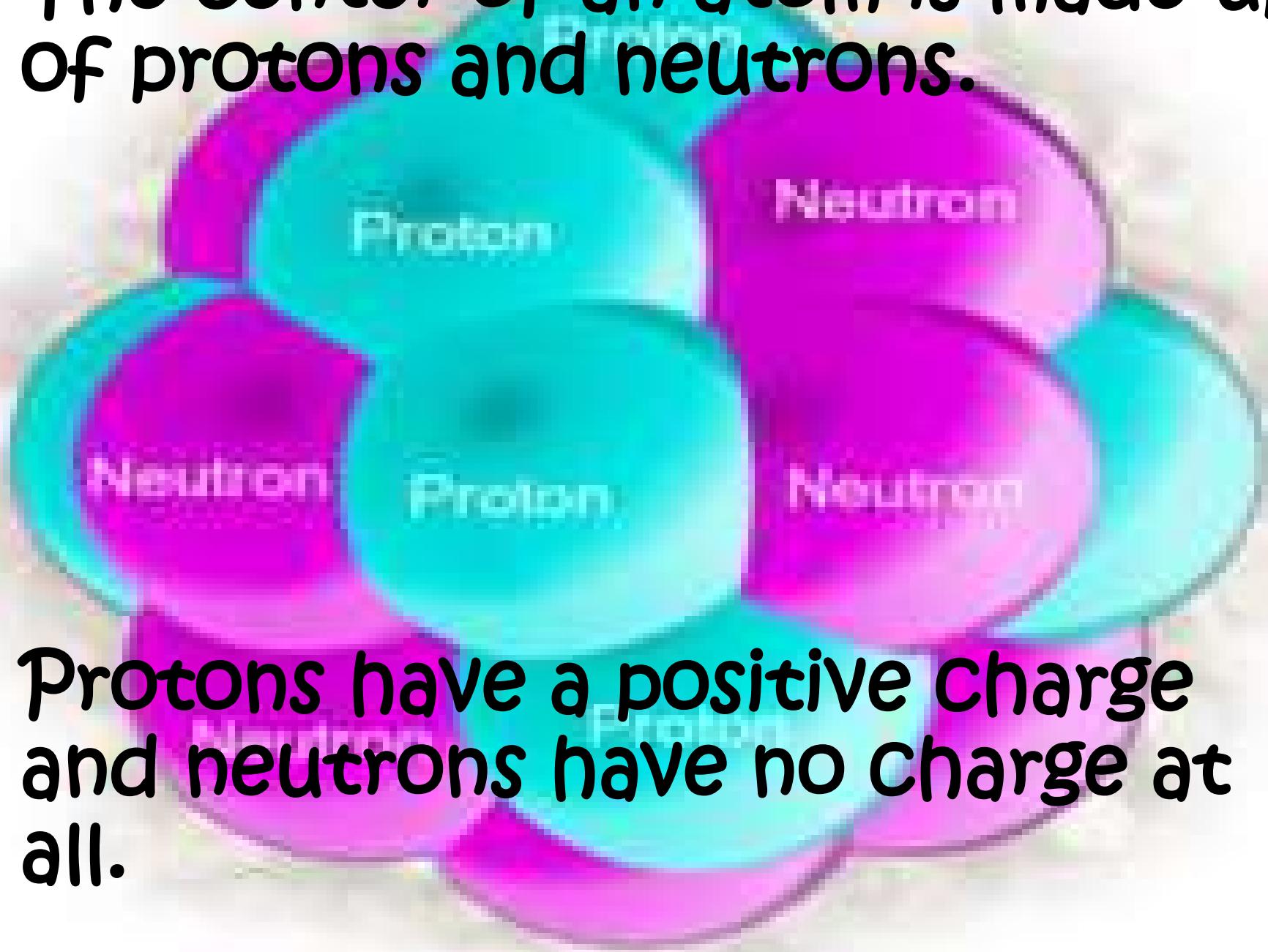


- All matter is made of atoms.



- Atoms are extremely small! Each atom is made up of 3 subatomic particles.

- The center of an atom is made up of protons and neutrons.

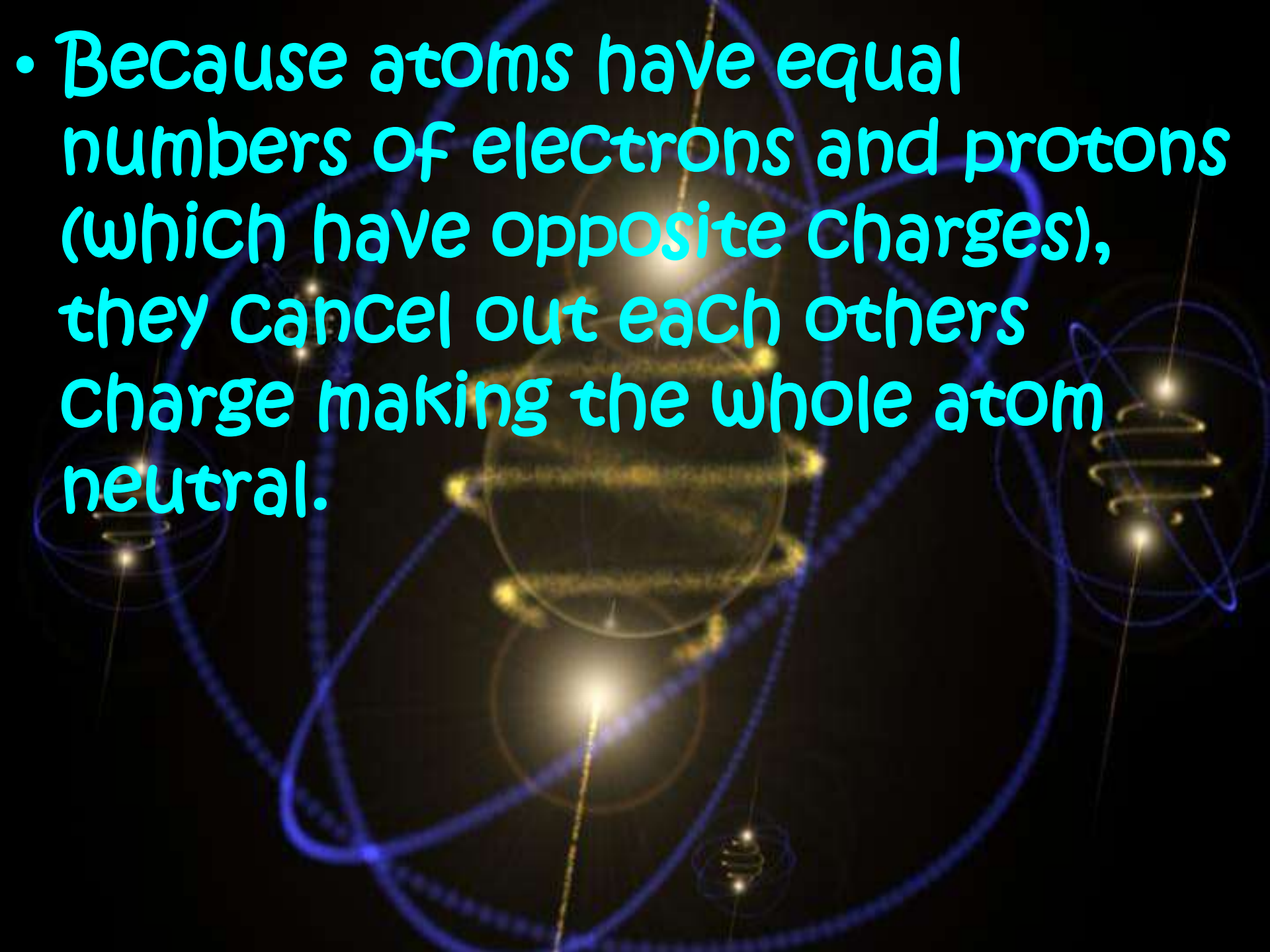


- Protons have a positive charge and neutrons have no charge at all.

Strong forces hold protons and neutrons together in the atom to form the nucleus.

- The third subatomic particle in an atom is electrons.

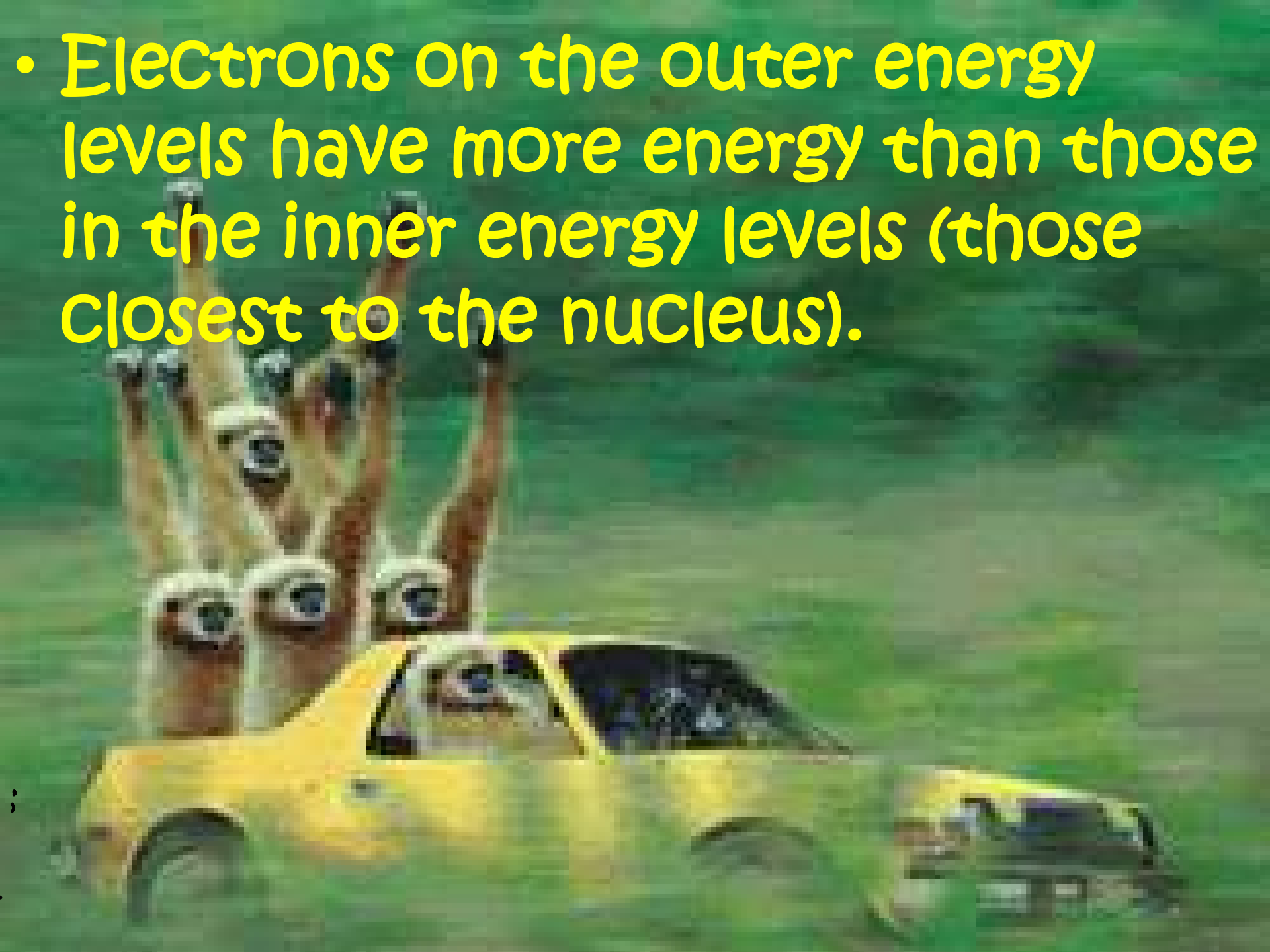
- Electrons have a negative charge. Electrons are in constant motion and circle around the nucleus.

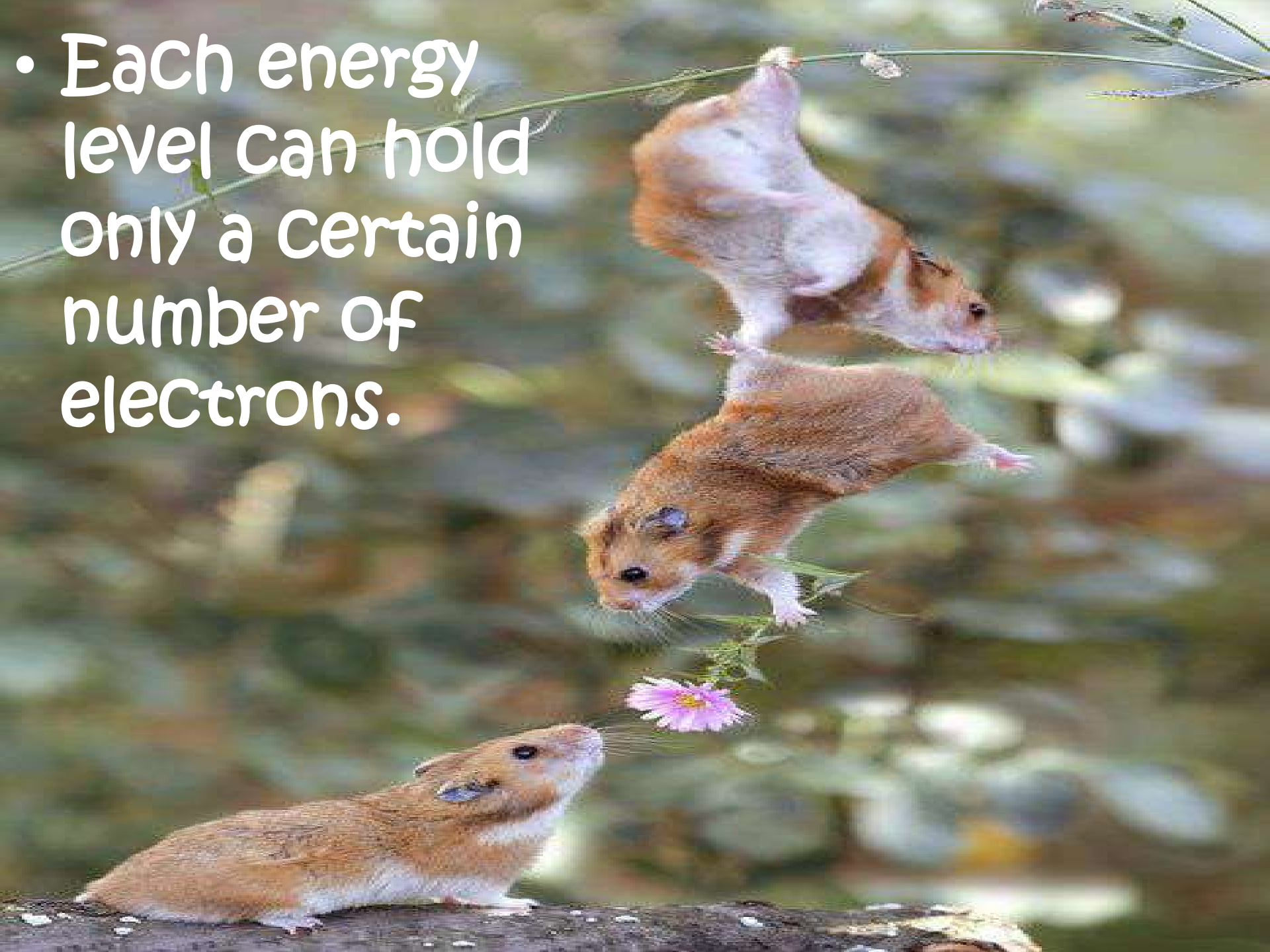


- Because atoms have equal numbers of electrons and protons (which have opposite charges), they cancel out each others charge making the whole atom neutral.

- Electrons move about the nucleus at very high speeds in several different energy levels.

- Electrons on the outer energy levels have more energy than those in the inner energy levels (those closest to the nucleus).





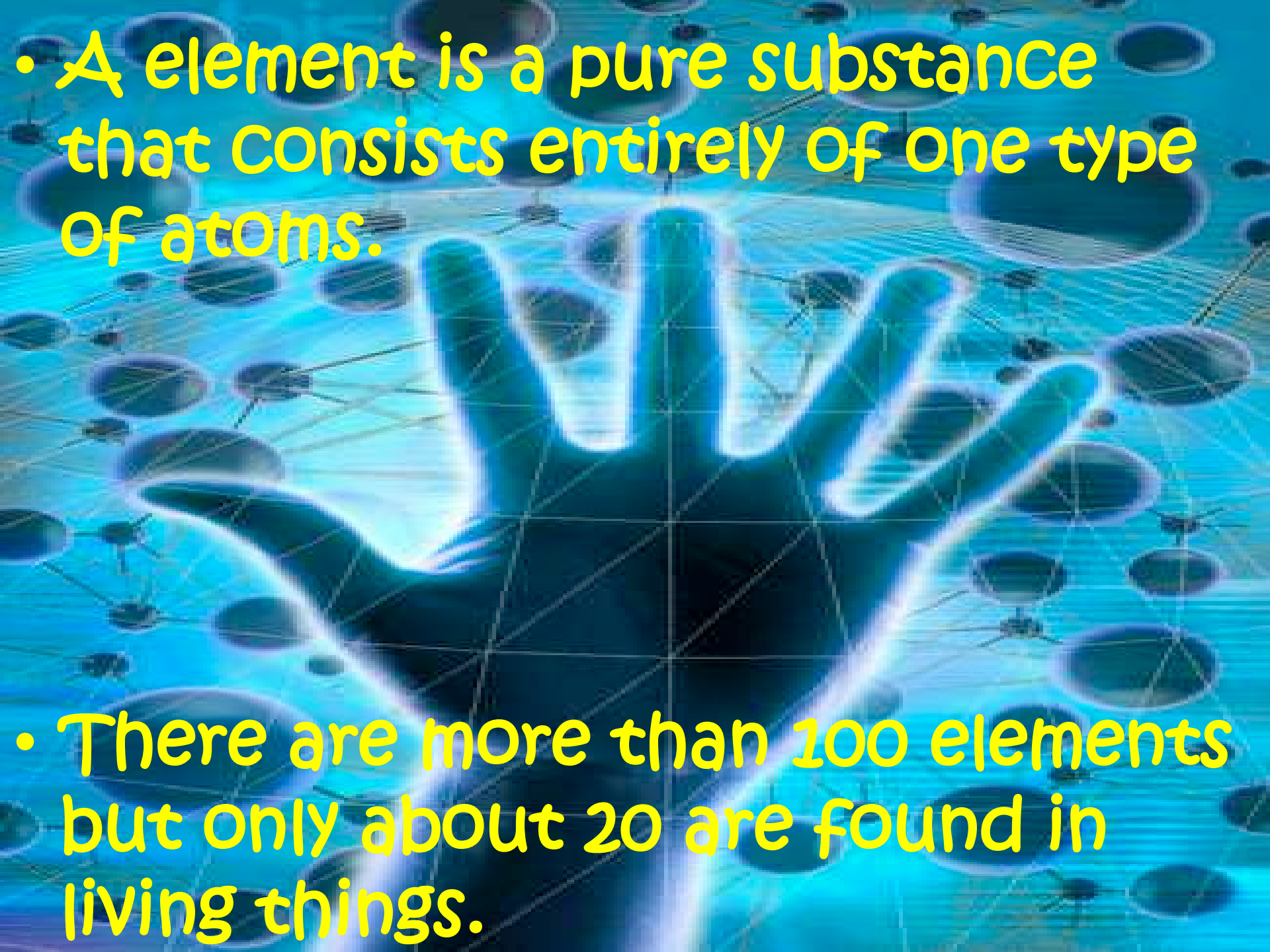
- Each energy level can hold only a certain number of electrons.

- The first energy level can hold up to 2 electrons.

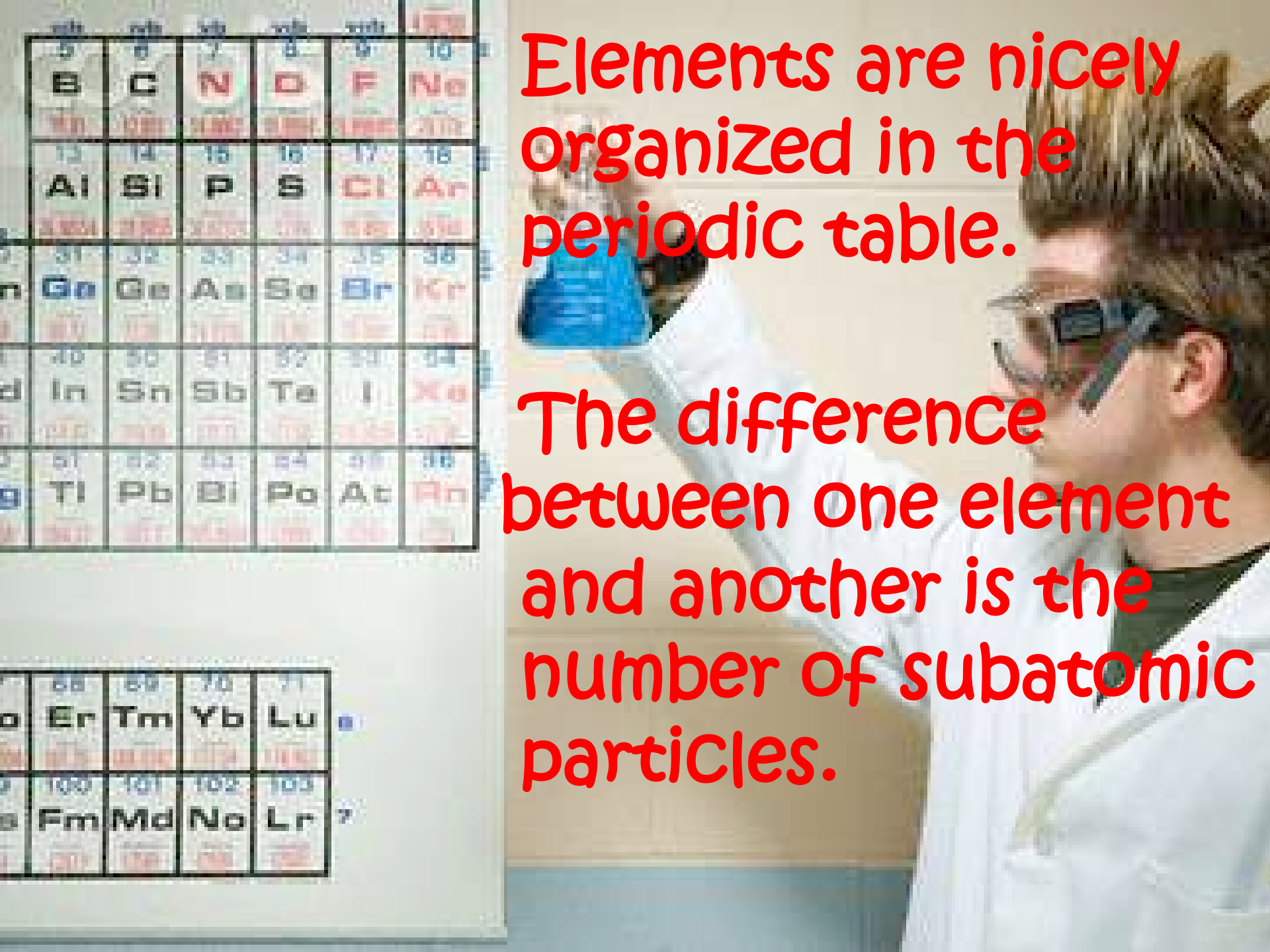
  The second and third energy level can hold up to 8 electrons.

  Most atoms do not have their outer energy levels full.

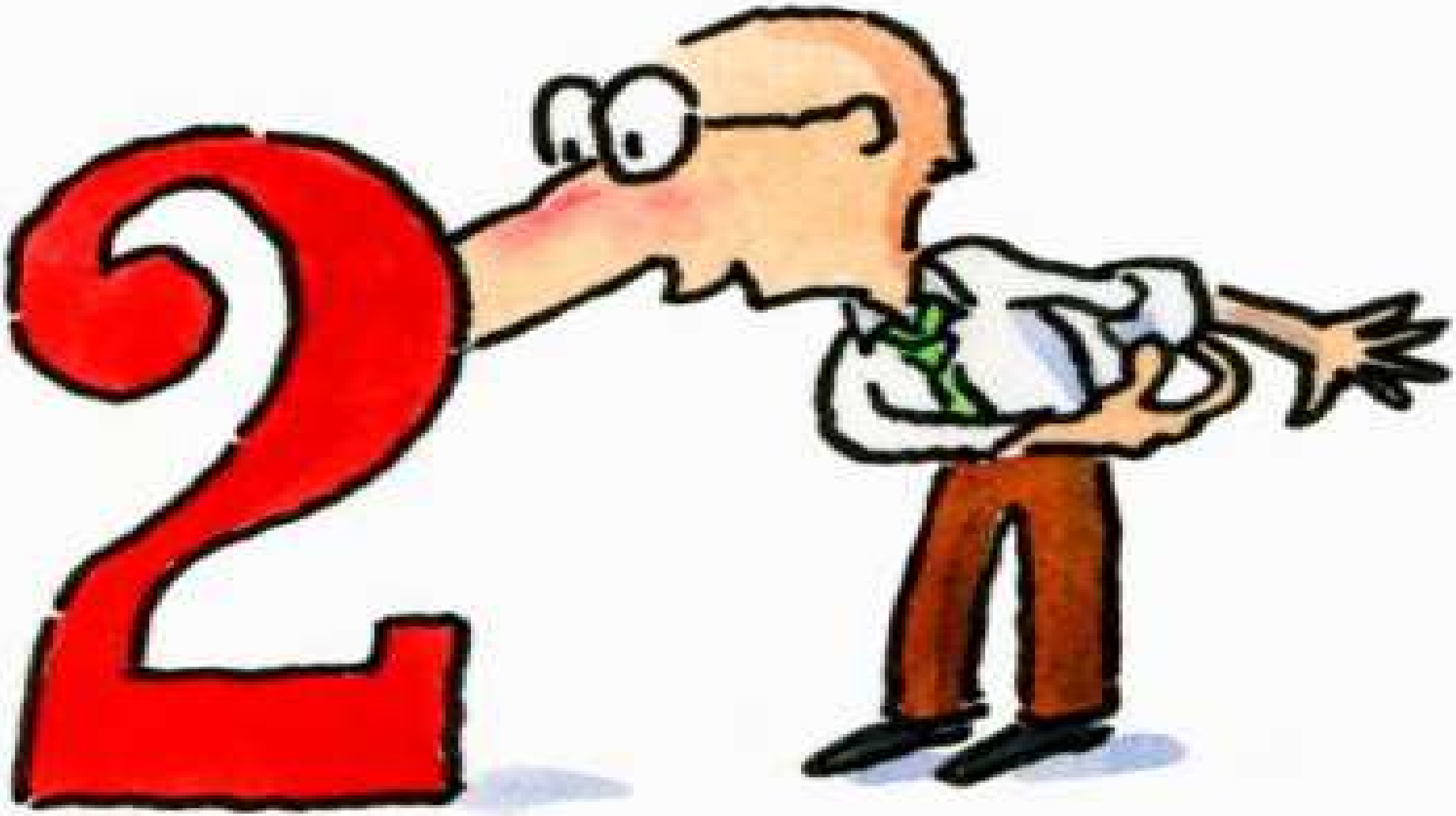
- The Amazing Nano Brothers Juggling Show - Atomic Structure - YouTube



- A element is a pure substance that consists entirely of one type of atoms.
- There are more than 100 elements but only about 20 are found in living things.

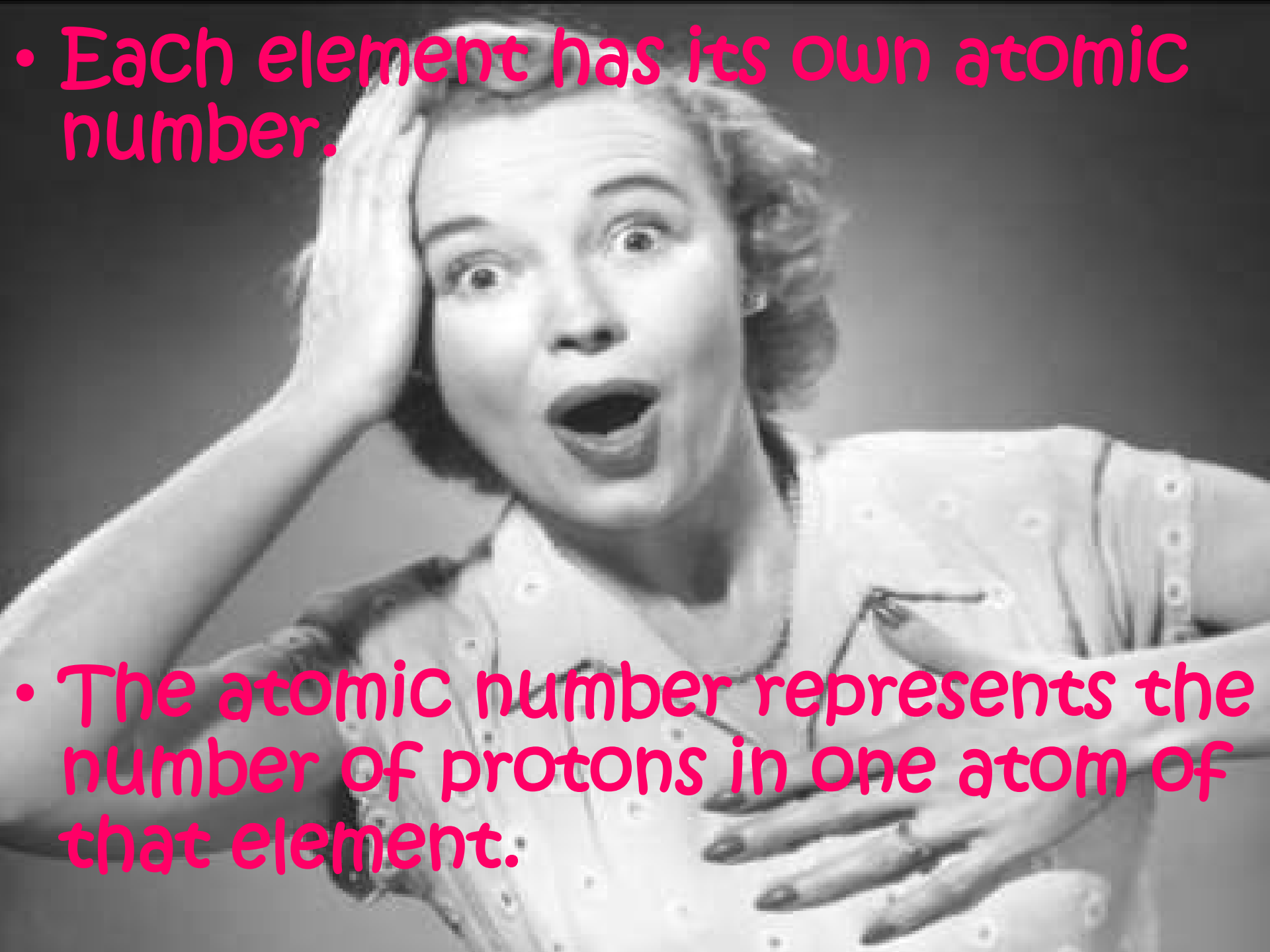

Elements are nicely organized in the periodic table.
The difference between one element and another is the number of subatomic particles.

- Elements are represented by one or two letters.



- Using the periodic table, find the symbols for the elements listed in your lecture notes.

- Go ahead… I'll wait!



- Each element has its own atomic number.
- The atomic number represents the number of protons in one atom of that element.

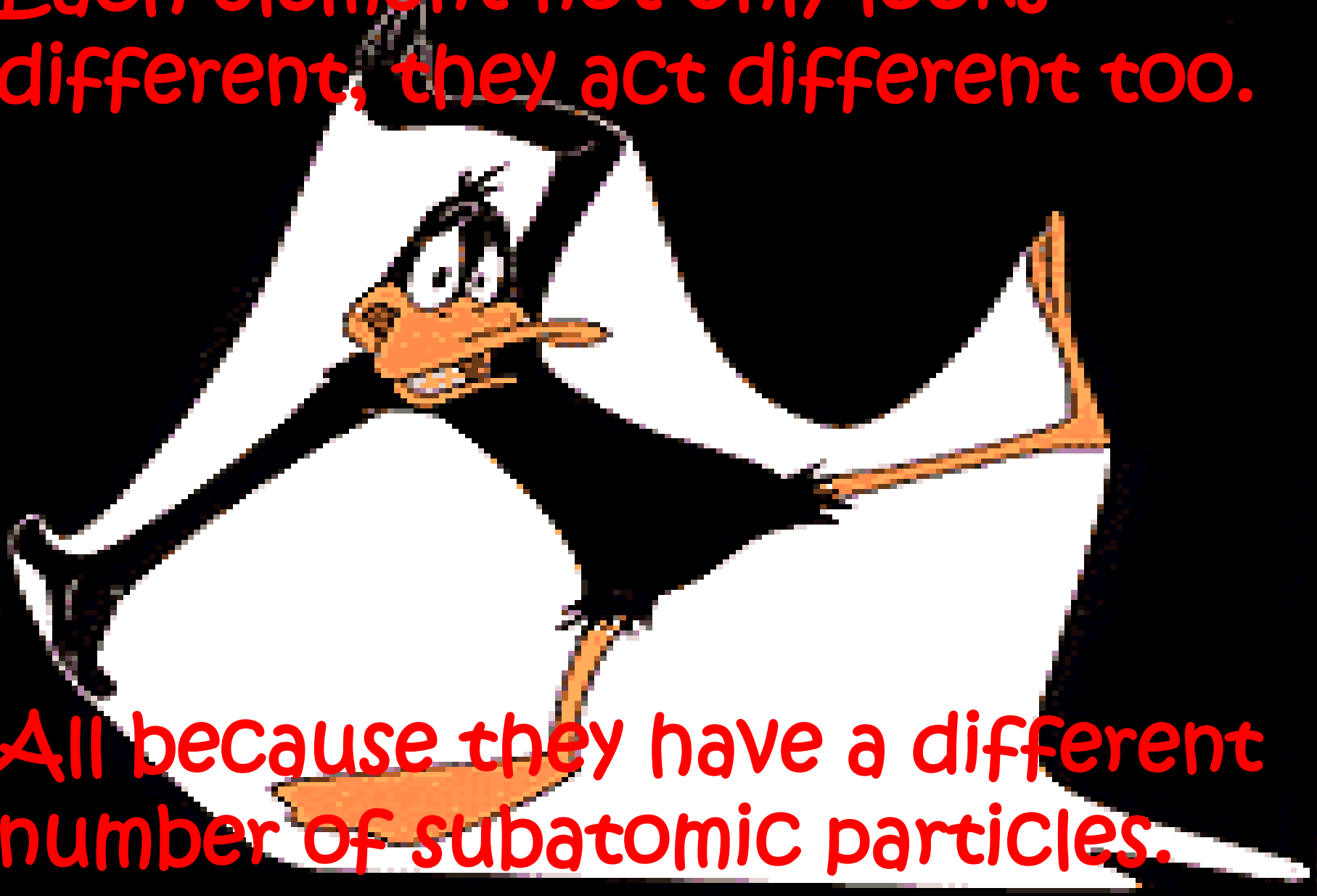
- Let's hunt for the atomic numbers of some elements:

- Also on the periodic table is the atomic mass for each element.

To calculate the mass of an atom of a particular element, add the number of protons and neutrons.

- (The number of electrons are not counted because they are too small!)

- Each element not only looks different, they act different too.



- All because they have a different number of subatomic particles.

- Let's build some atoms…

- Build Carbon
  - How many p^+?
  - How many e^-?
  - How many n_o?
  - How many energy levels?
  - How many electrons on each level?

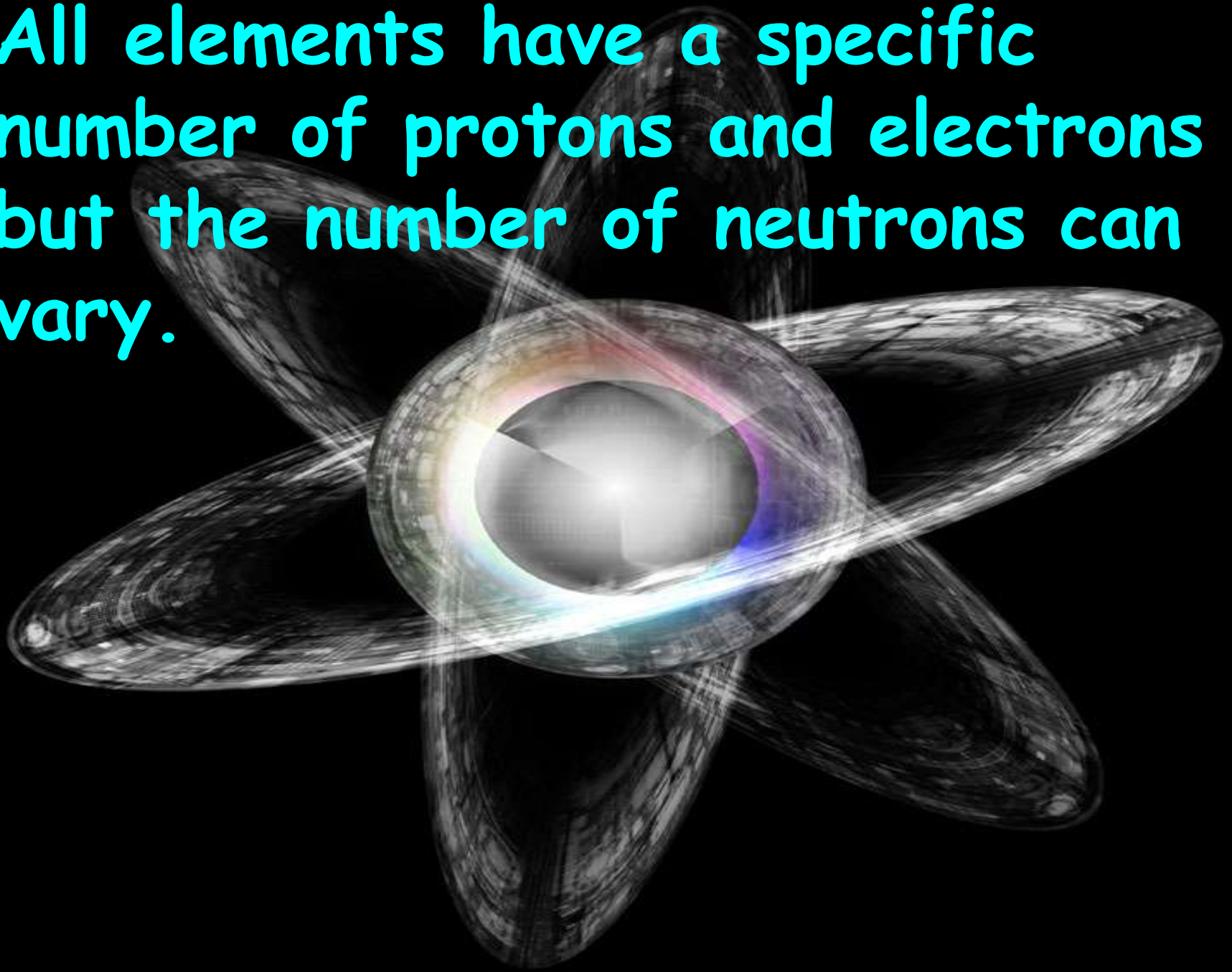
- Build Oxygen
  - How many p+?
  - How many e-?
  - How many n_0?
  - How many energy levels?
  - How many electrons on each level?

- Build Lithium
  - How many p^+?
  - How many e^-?
  - How many n_o?
  - How many energy levels?
  - How many electrons on the each level?

- Build Neon.
  - How many p+?
  - How many e-?
  - How many n_o?
  - How many energy levels?
  - How many electrons on each level?


• Video time!!!

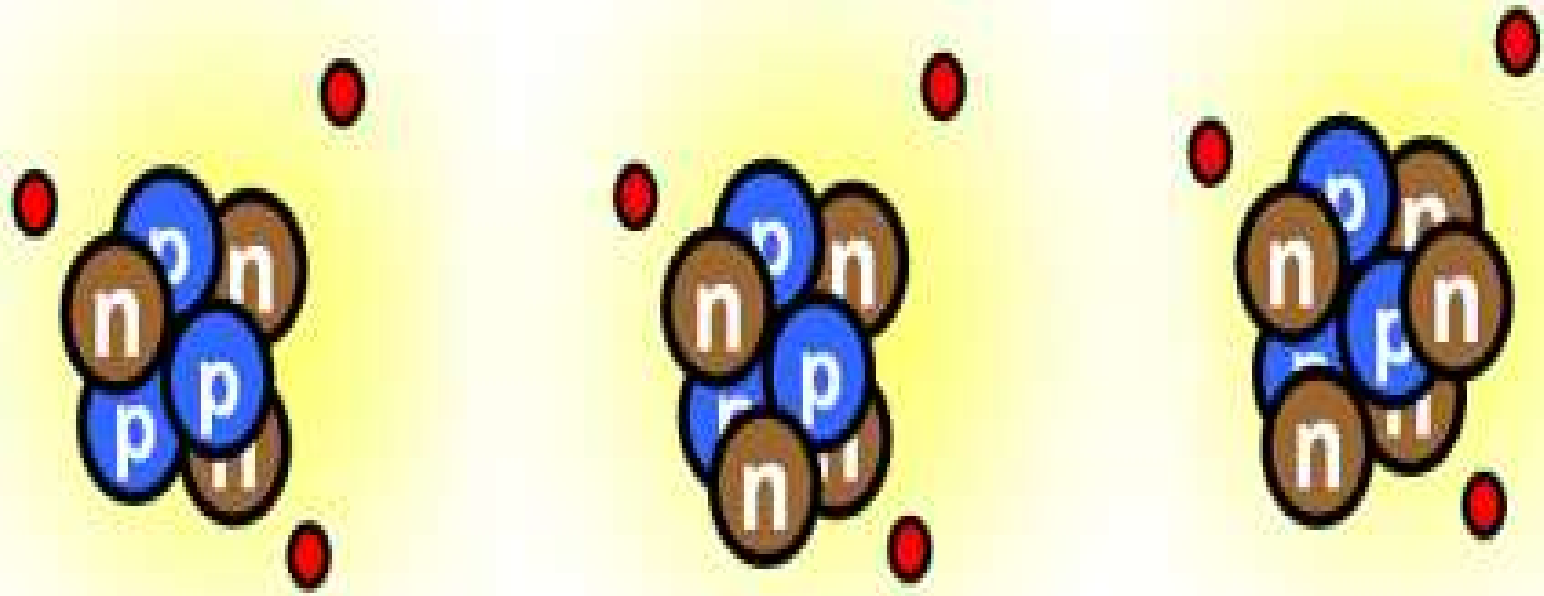
- All elements have a specific number of protons and electrons but the number of neutrons can vary.



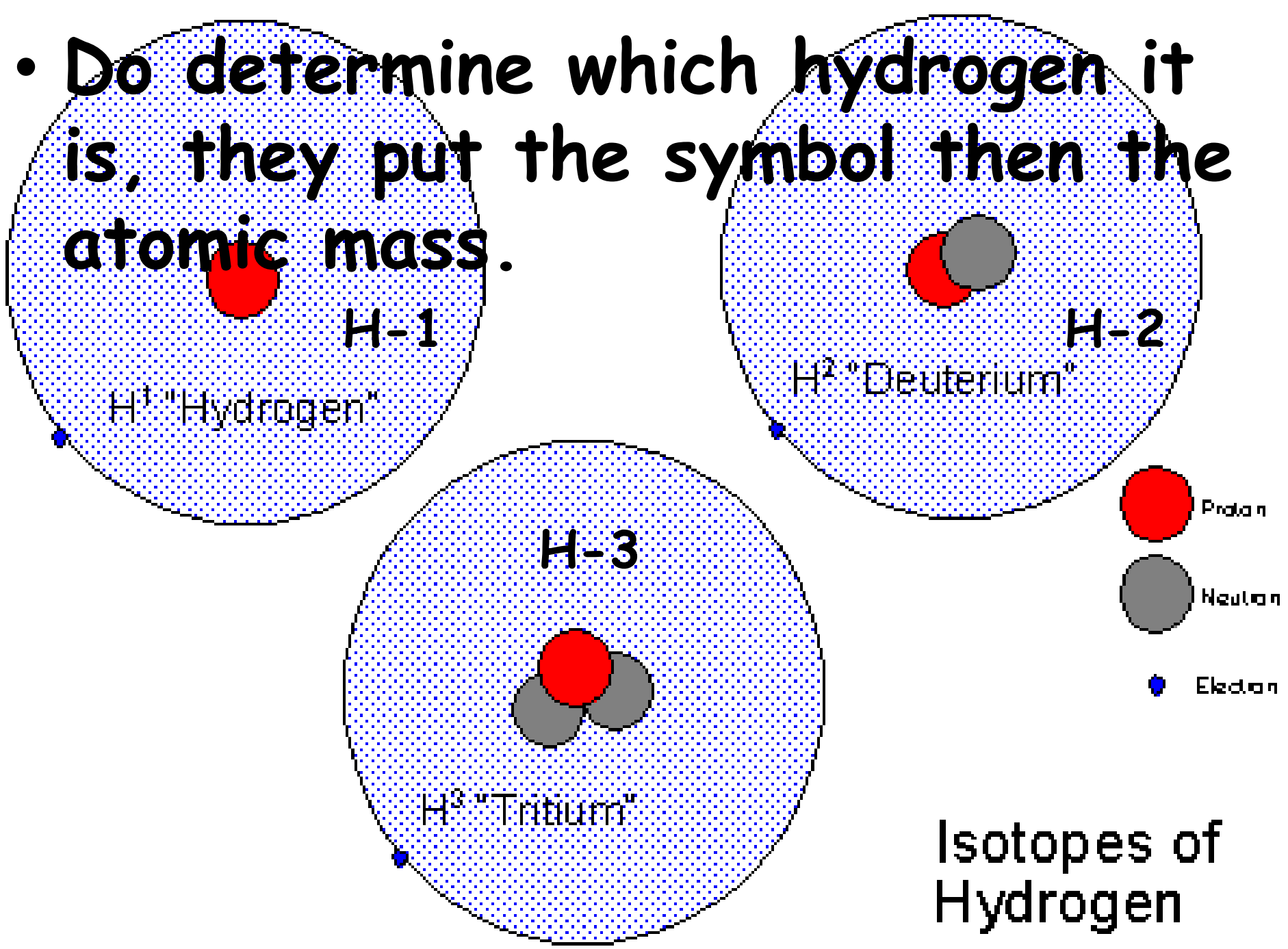
- Atoms of the same element that differ in the number of neutrons they contain are known as isotopes.

- Example of an isotope is lithium.

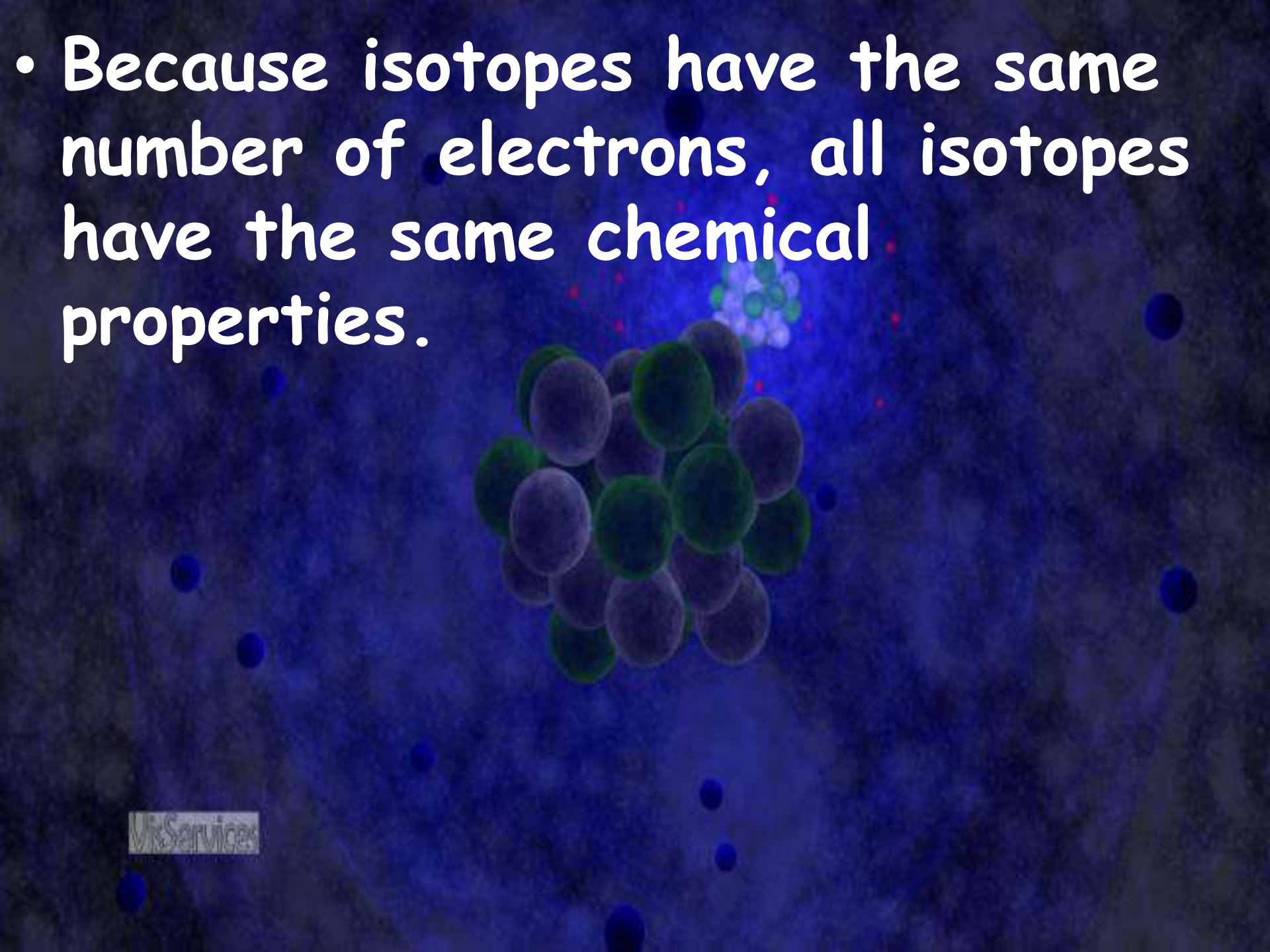
$^{6}_{3}Li$ $^{7}_{3}Li$ $^{8}_{3}Li$

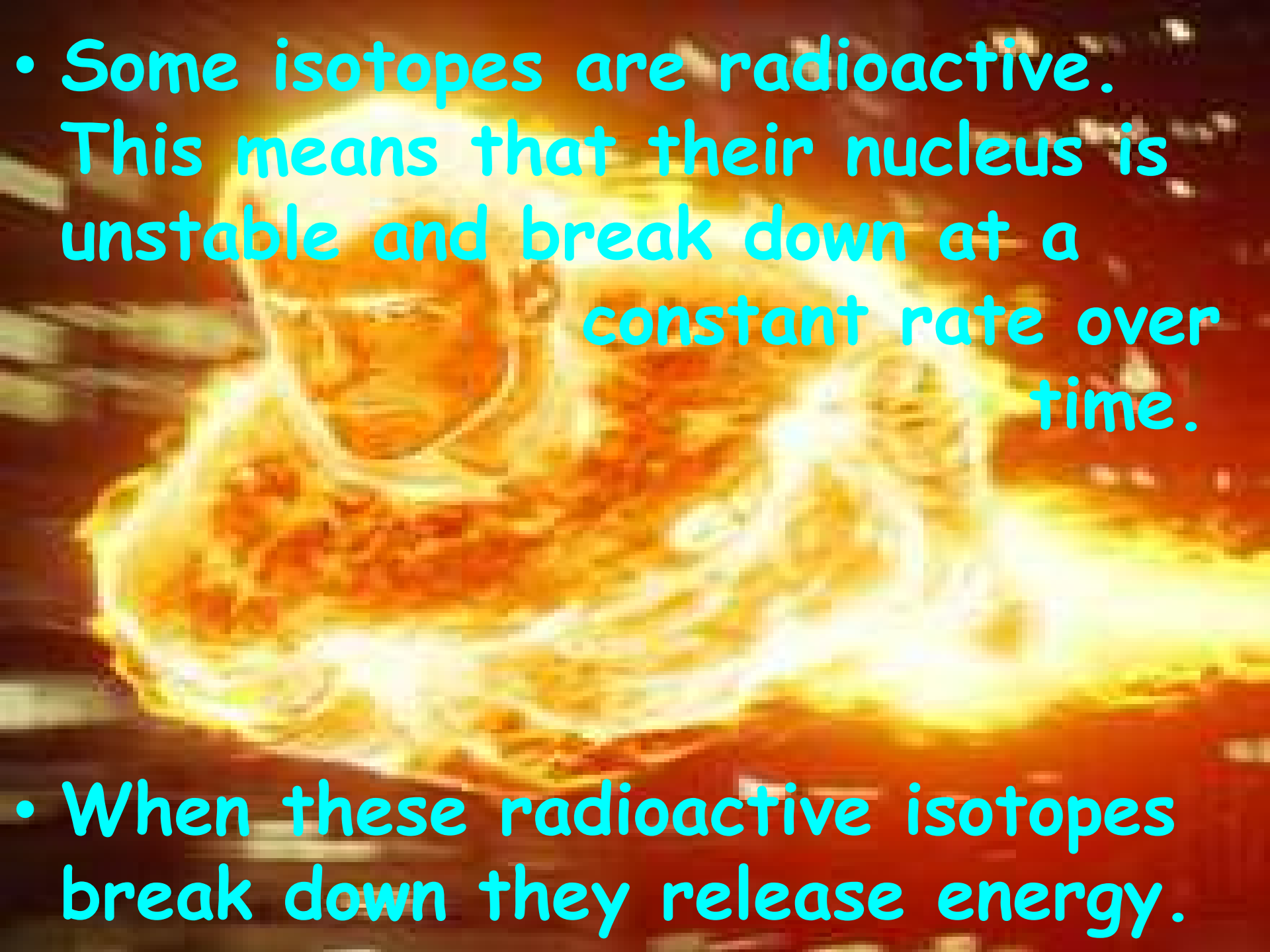


- Do determine which hydrogen it is, they put the symbol then the atomic mass.

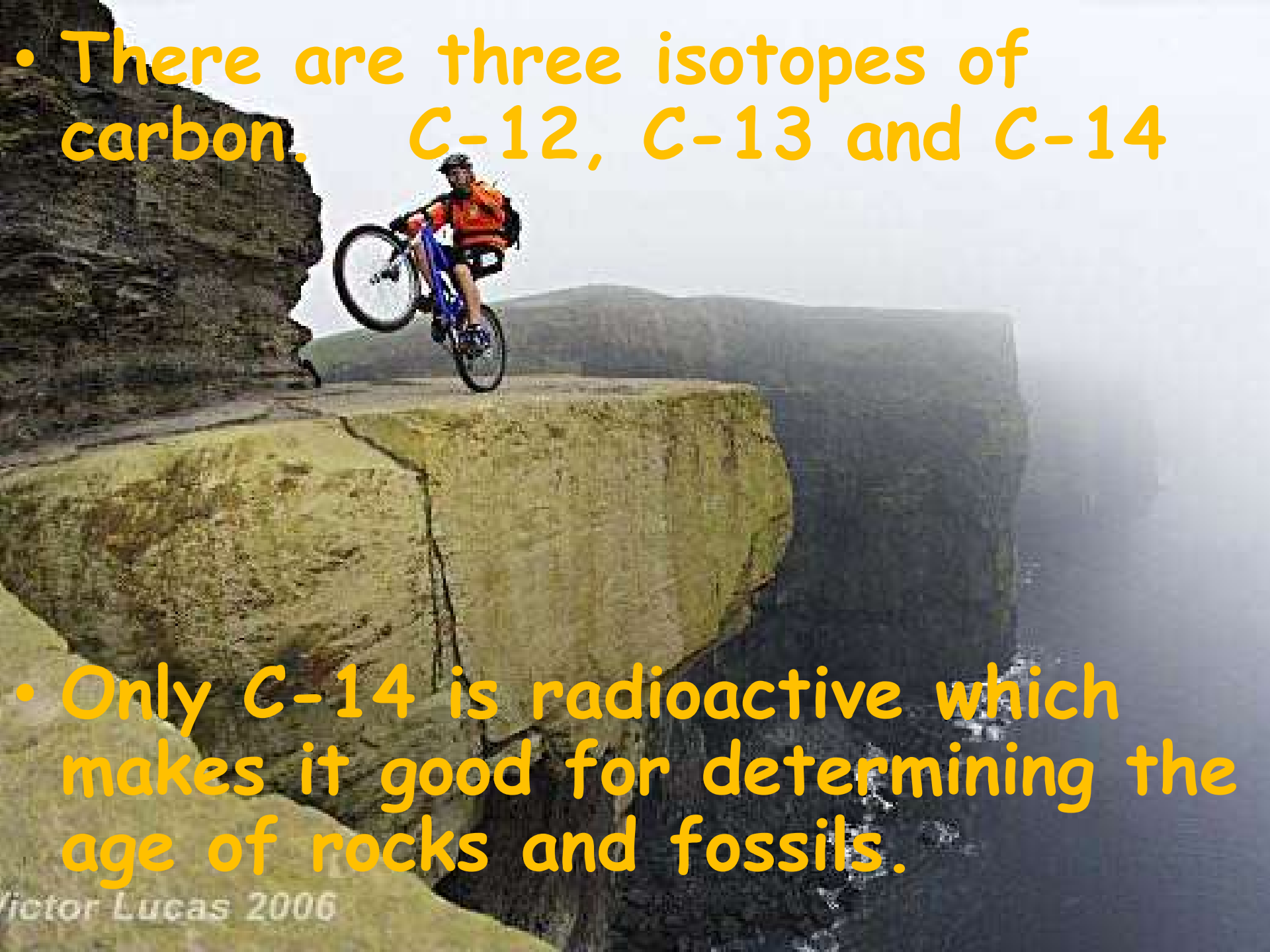


- Because isotopes have the same number of electrons, all isotopes have the same chemical properties.





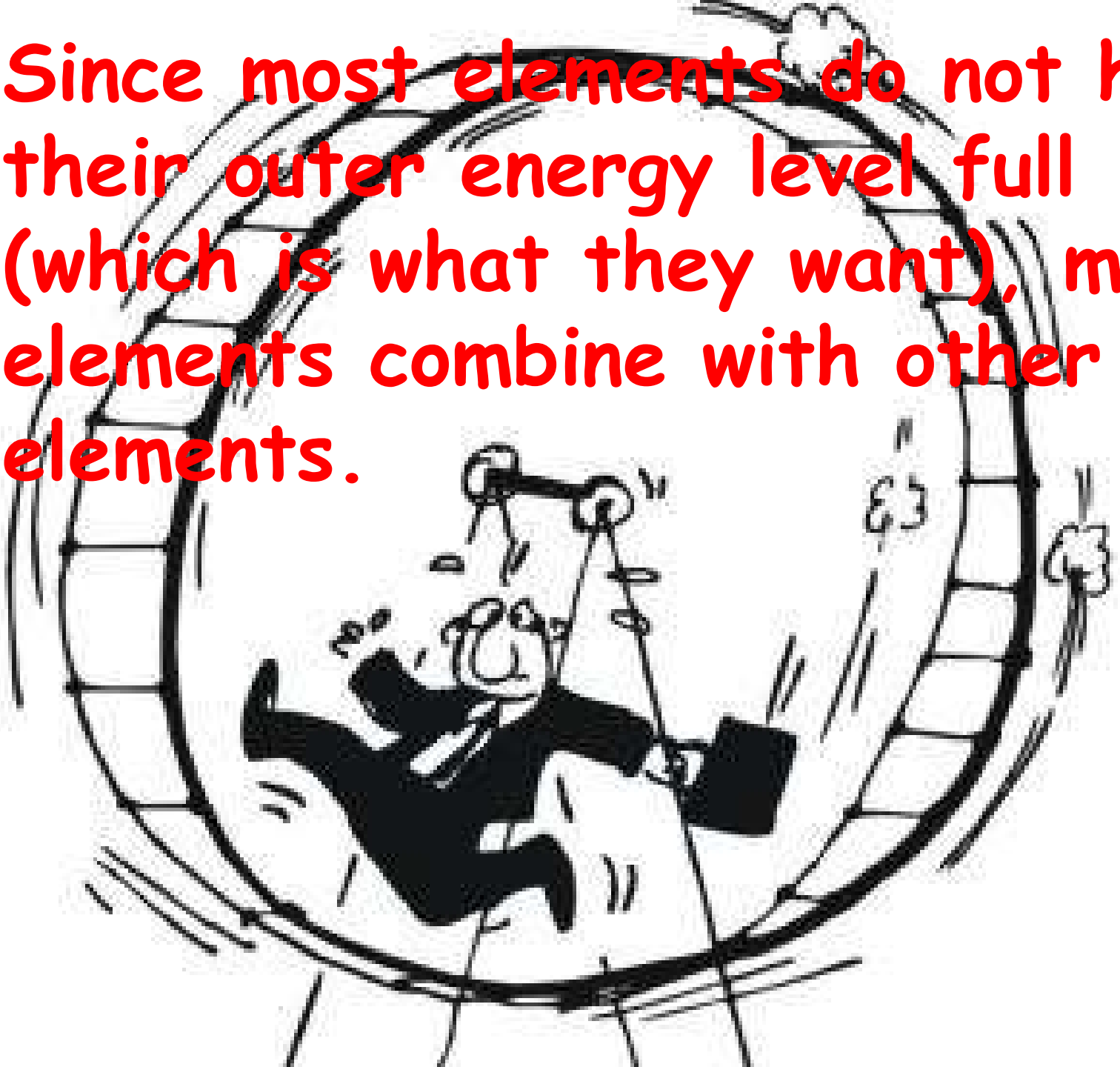
- Some isotopes are radioactive. This means that their nucleus is unstable and break down at a constant rate over time.
- When these radioactive isotopes break down they release energy.



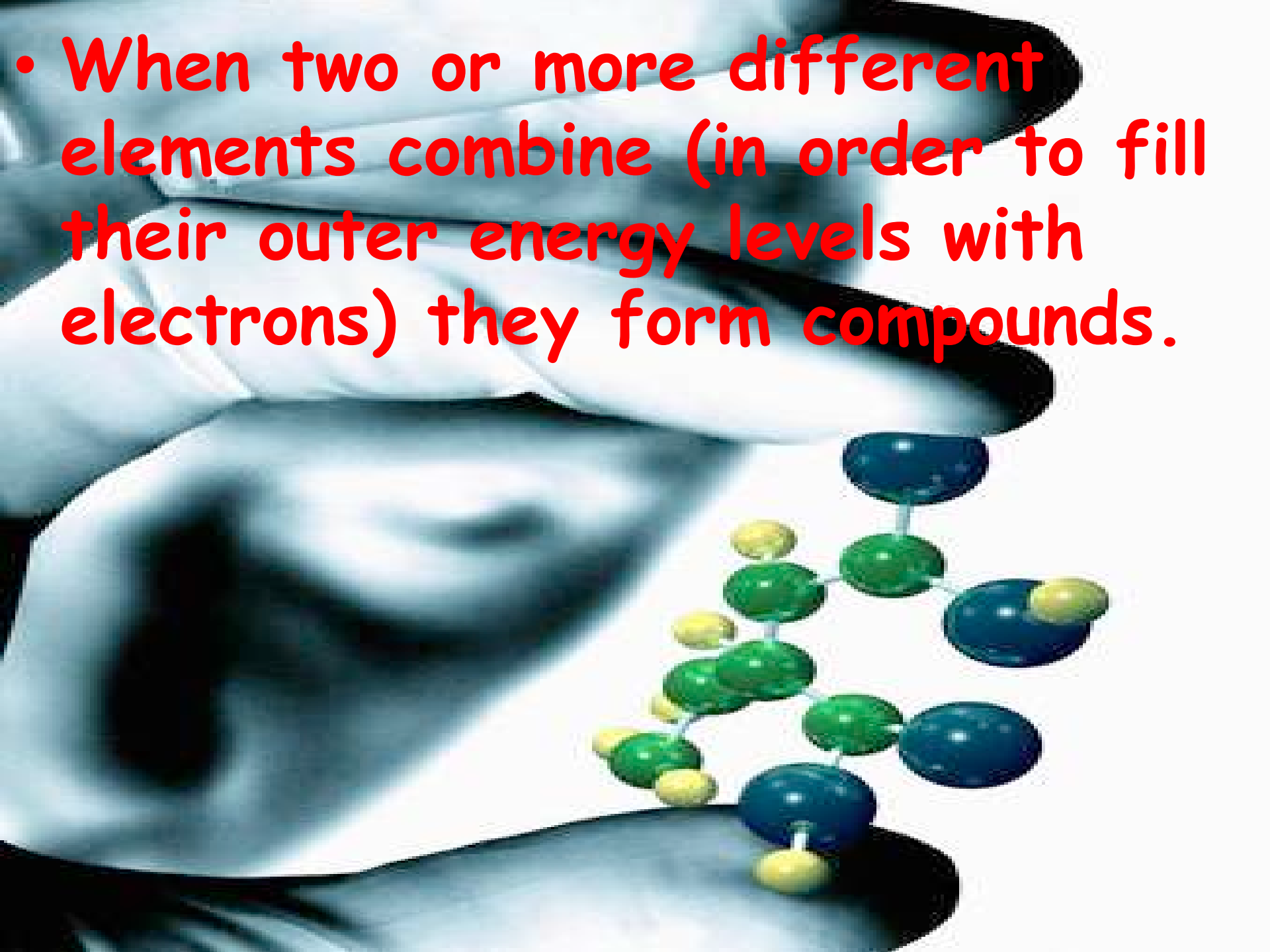
- There are three isotopes of carbon. C-12, C-13 and C-14
- Only C-14 is radioactive which makes it good for determining the age of rocks and fossils.

- Radiation from some isotopes can be used to treat cancer.

- Since most elements do not have their outer energy level full (which is what they want), most elements combine with other elements.

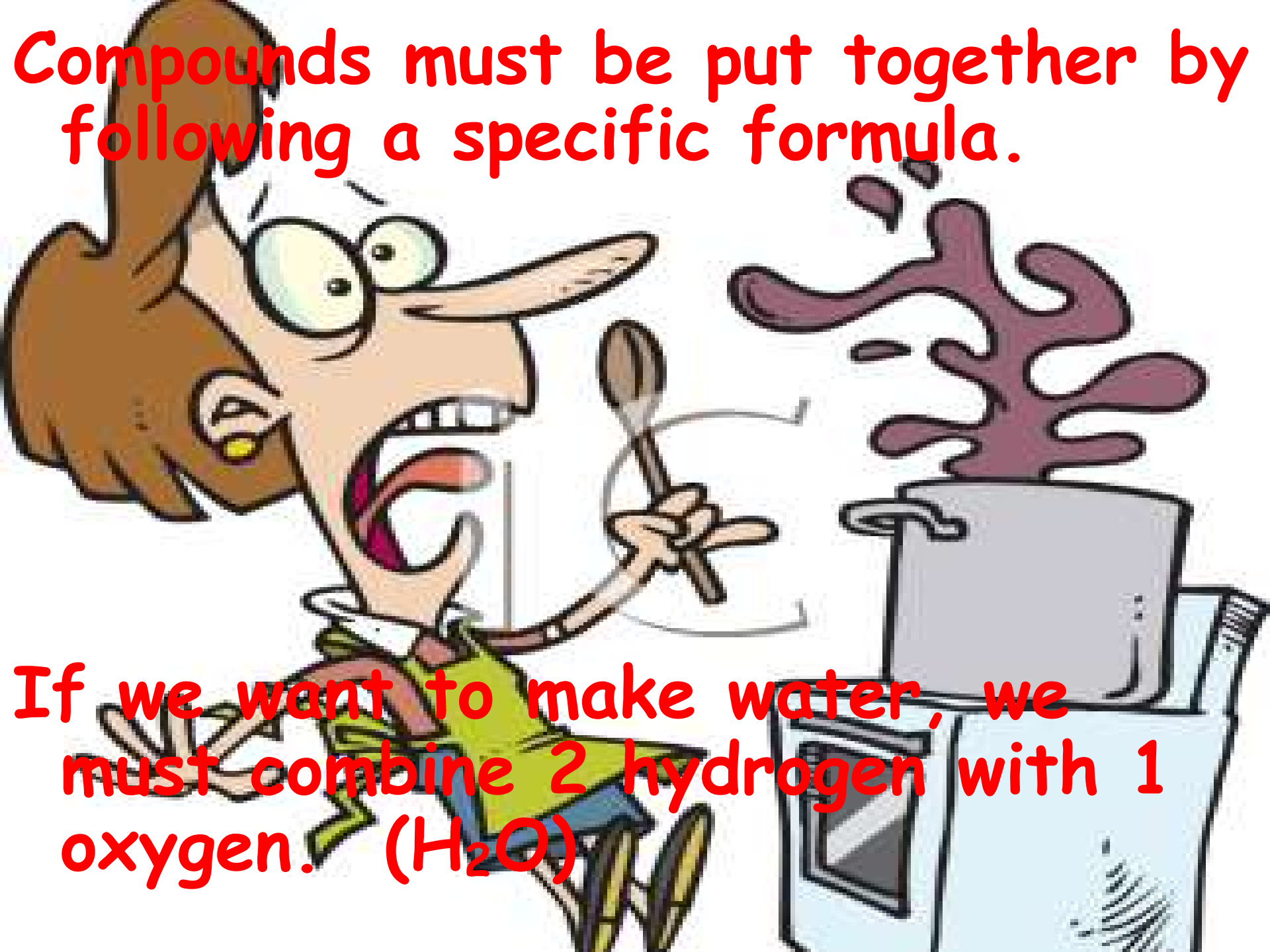


- When two or more different elements combine (in order to fill their outer energy levels with electrons) they form compounds.

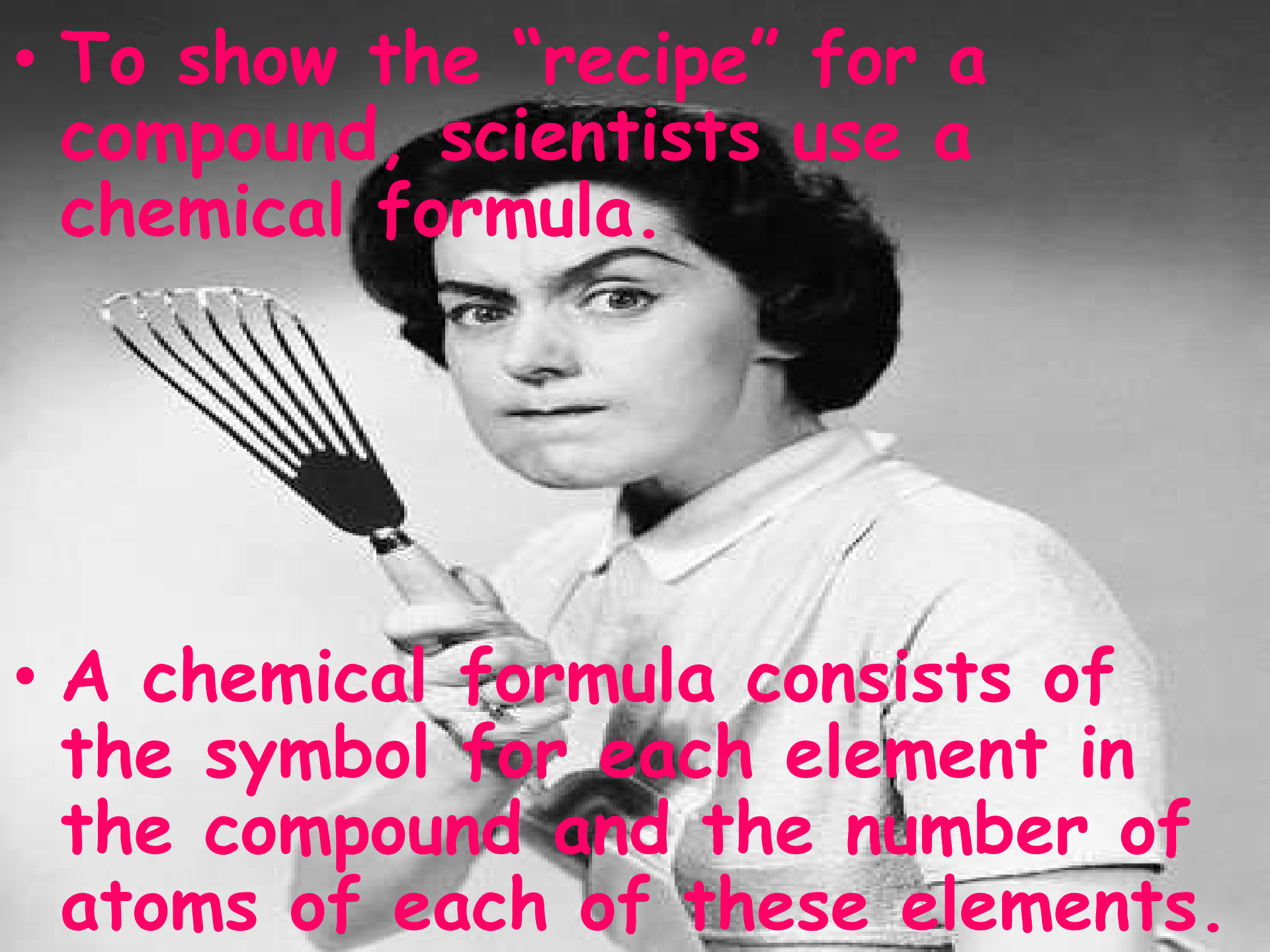


- The physical and chemical properties of compound are different from the physical and chemical properties of the individual elements that make it up.

Compounds must be put together by following a specific formula.



If we want to make water, we must combine 2 hydrogen with 1 oxygen. (H_2O)



- To show the "recipe" for a compound, scientists use a chemical formula.

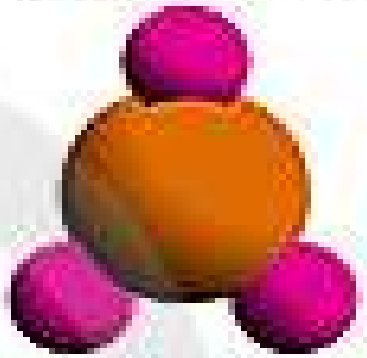
- A chemical formula consists of the symbol for each element in the compound and the number of atoms of each of these elements.

Common Chemical Compounds

Water

H_2O

Ammonia

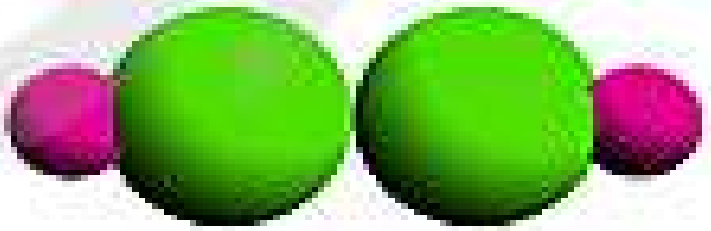


NH_3

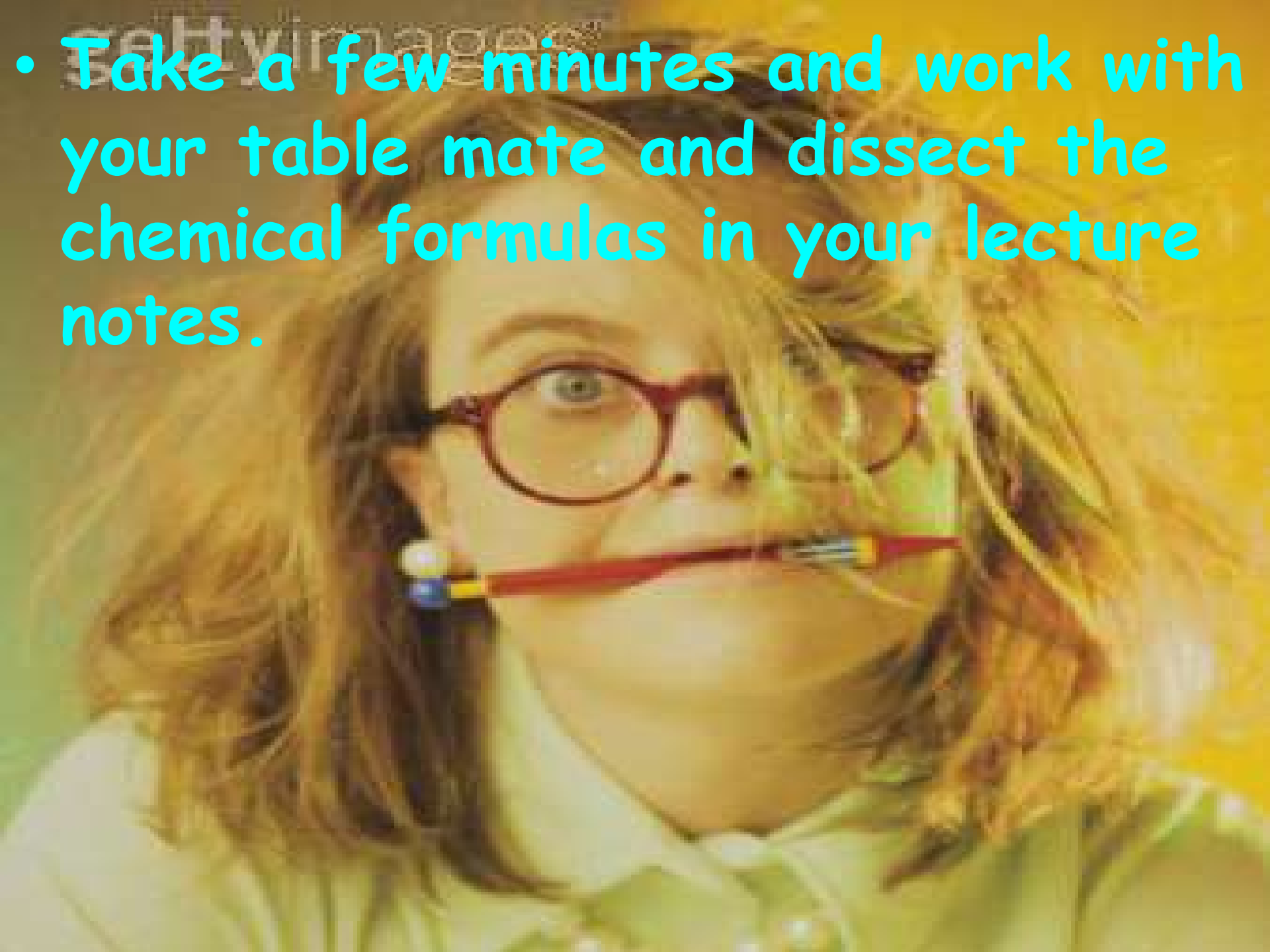
Carbon Dioxide

CO_2

Hydrogen Peroxide

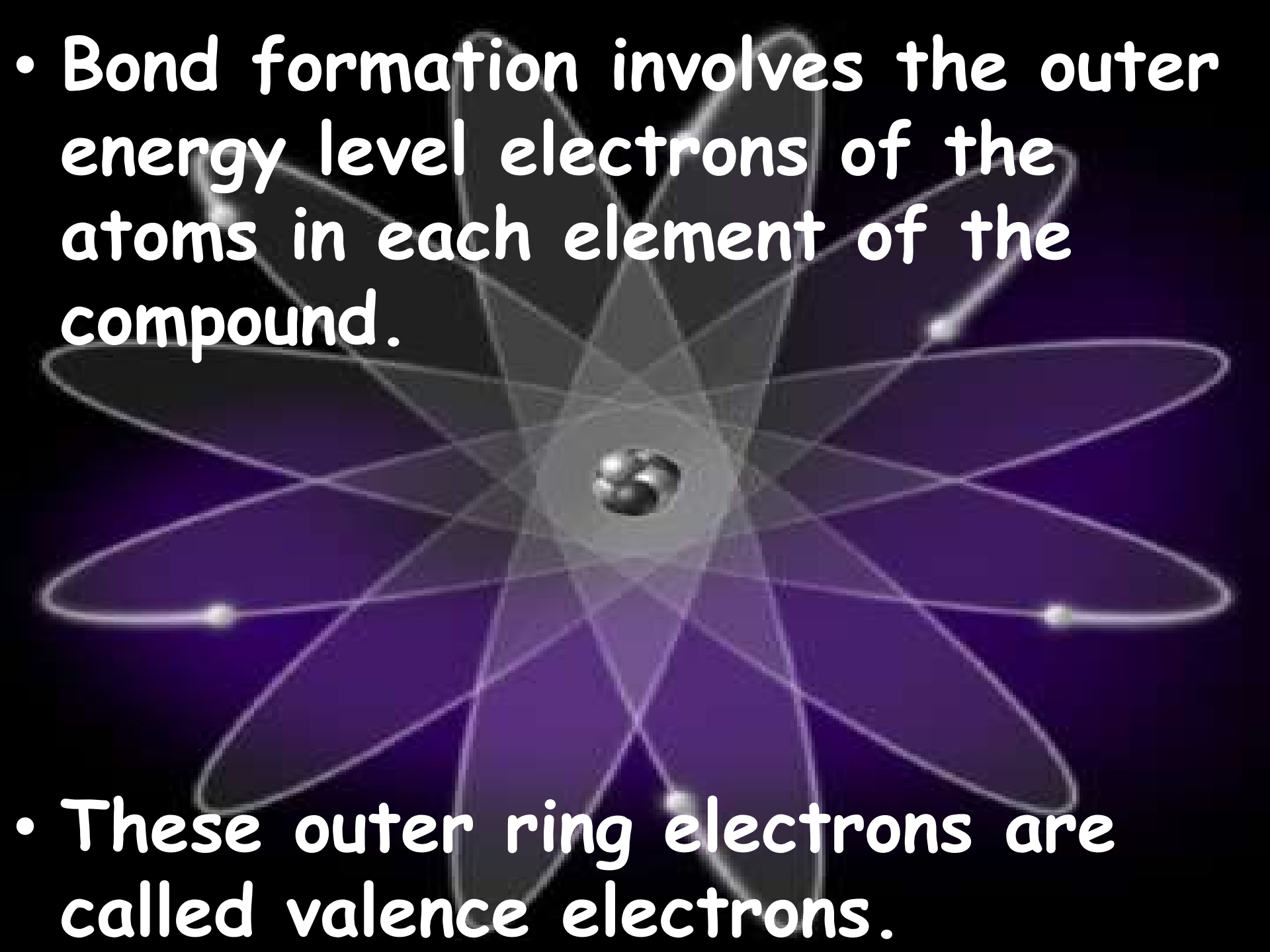


H_2O_2



- Take a few minutes and work with your table mate and dissect the chemical formulas in your lecture notes.


The atoms in compounds are held together by chemical bonds.



- Bond formation involves the outer energy level electrons of the atoms in each element of the compound.

- These outer ring electrons are called valence electrons.

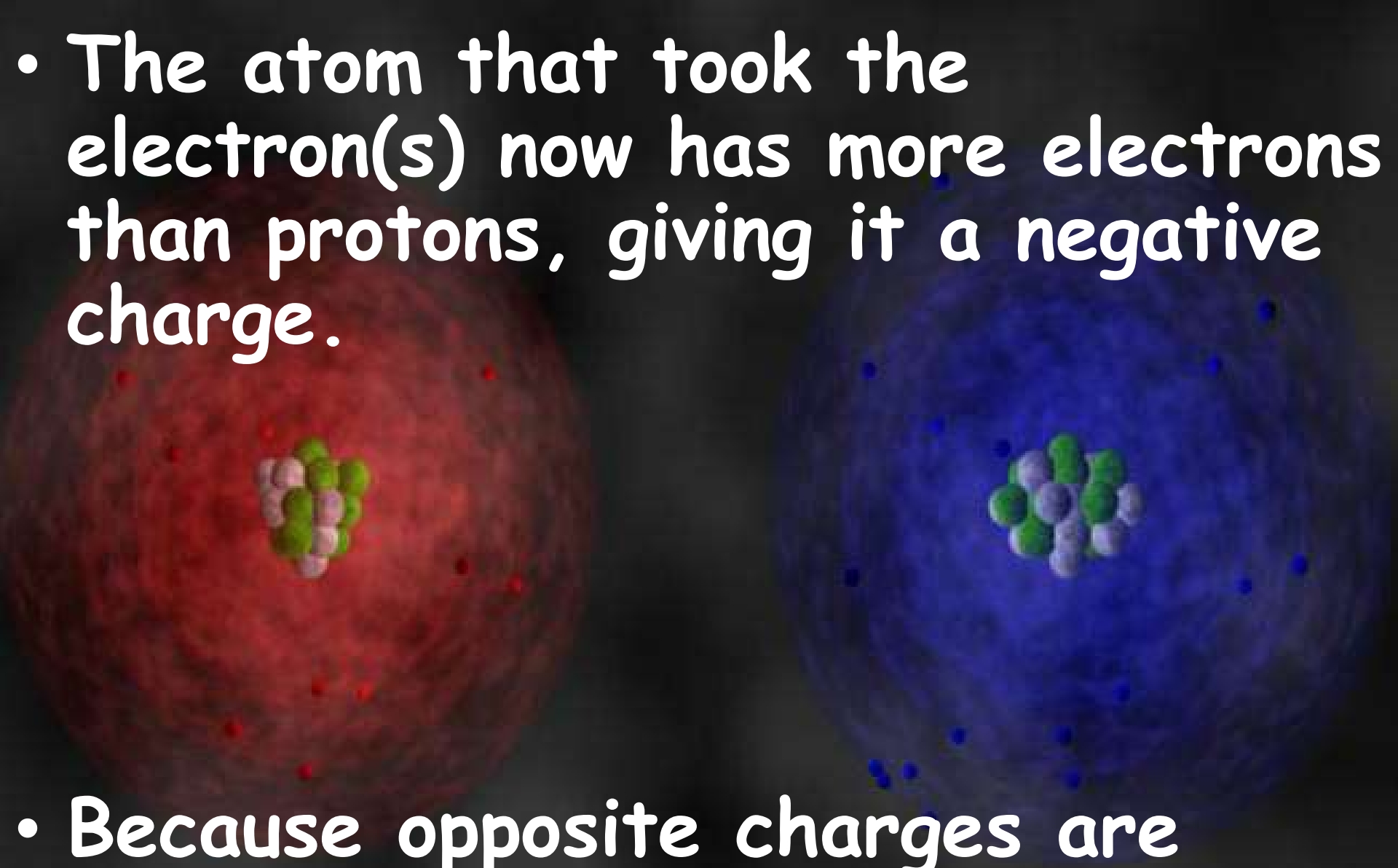
- The main types of chemical bonds are ionic bonds and covalent bonds.

- Both of these type of bonds are strong…they just go about "sticking" together in a different way.

An ionic bond is formed when one or more electrons are transferred from one atom to another.

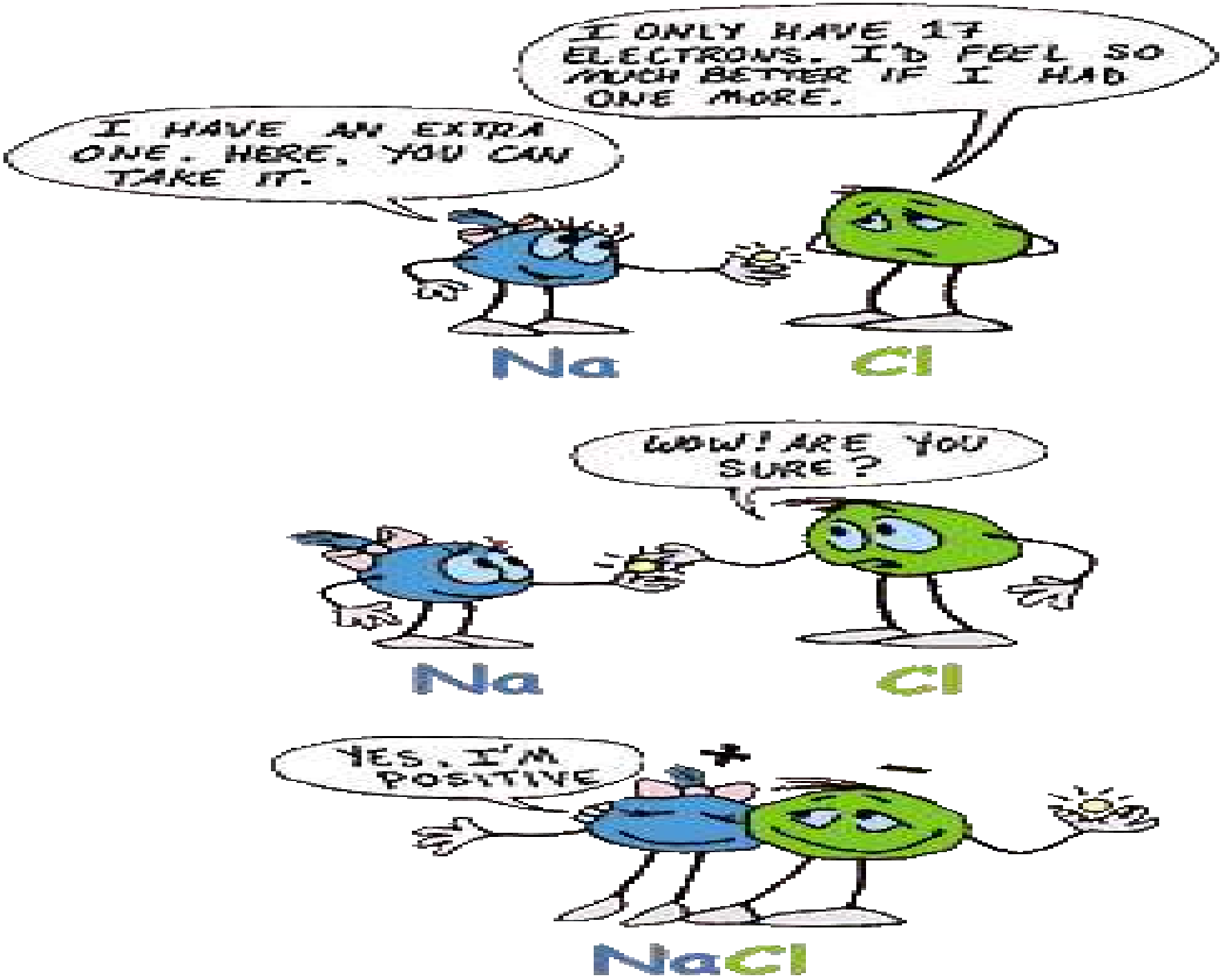
When one of the atoms loses (or gives up) its outer ring electron(s), it now has more protons than electrons, giving the atom a positive charge.

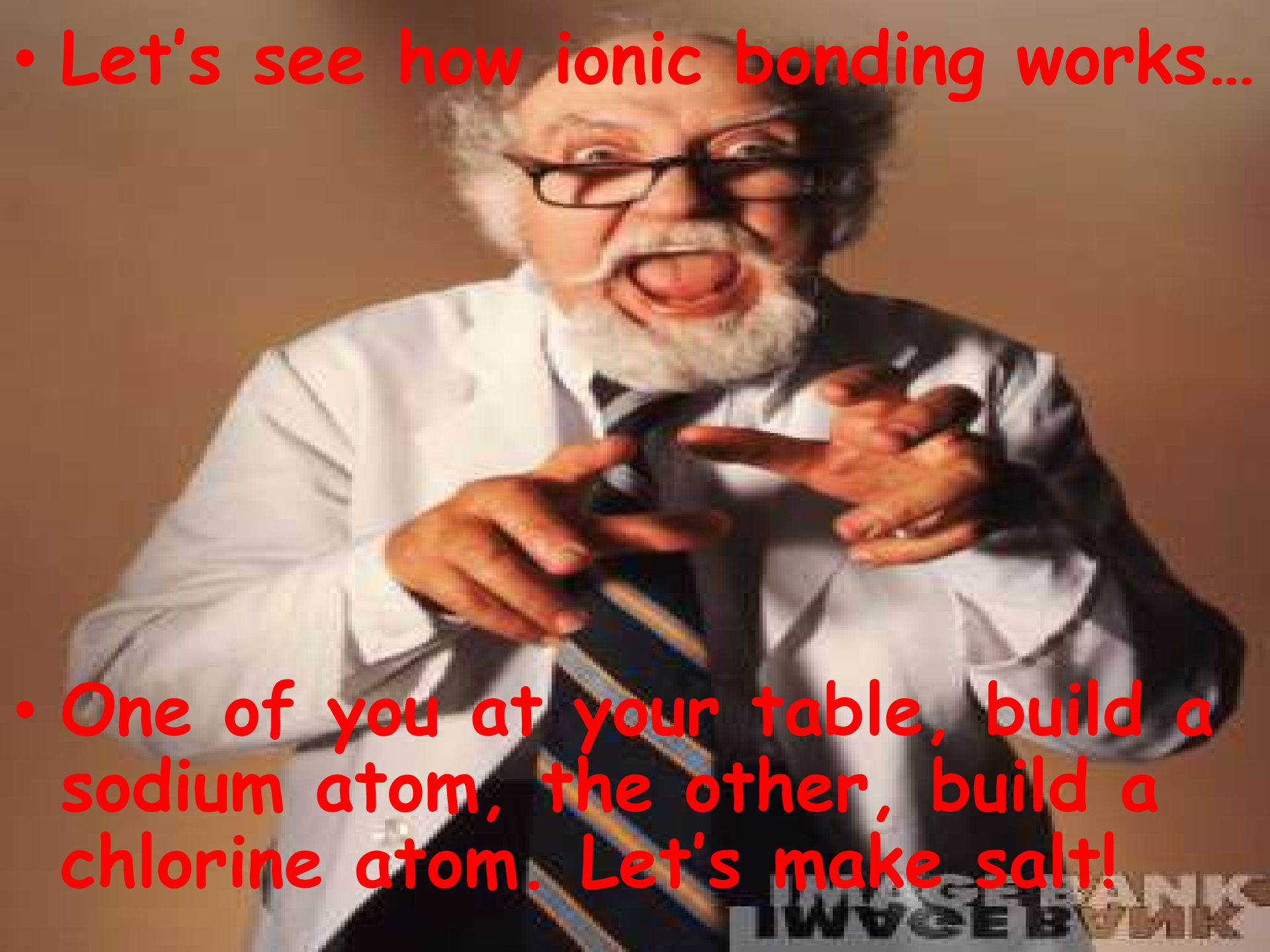
- The atom that took the electron(s) now has more electrons than protons, giving it a negative charge.



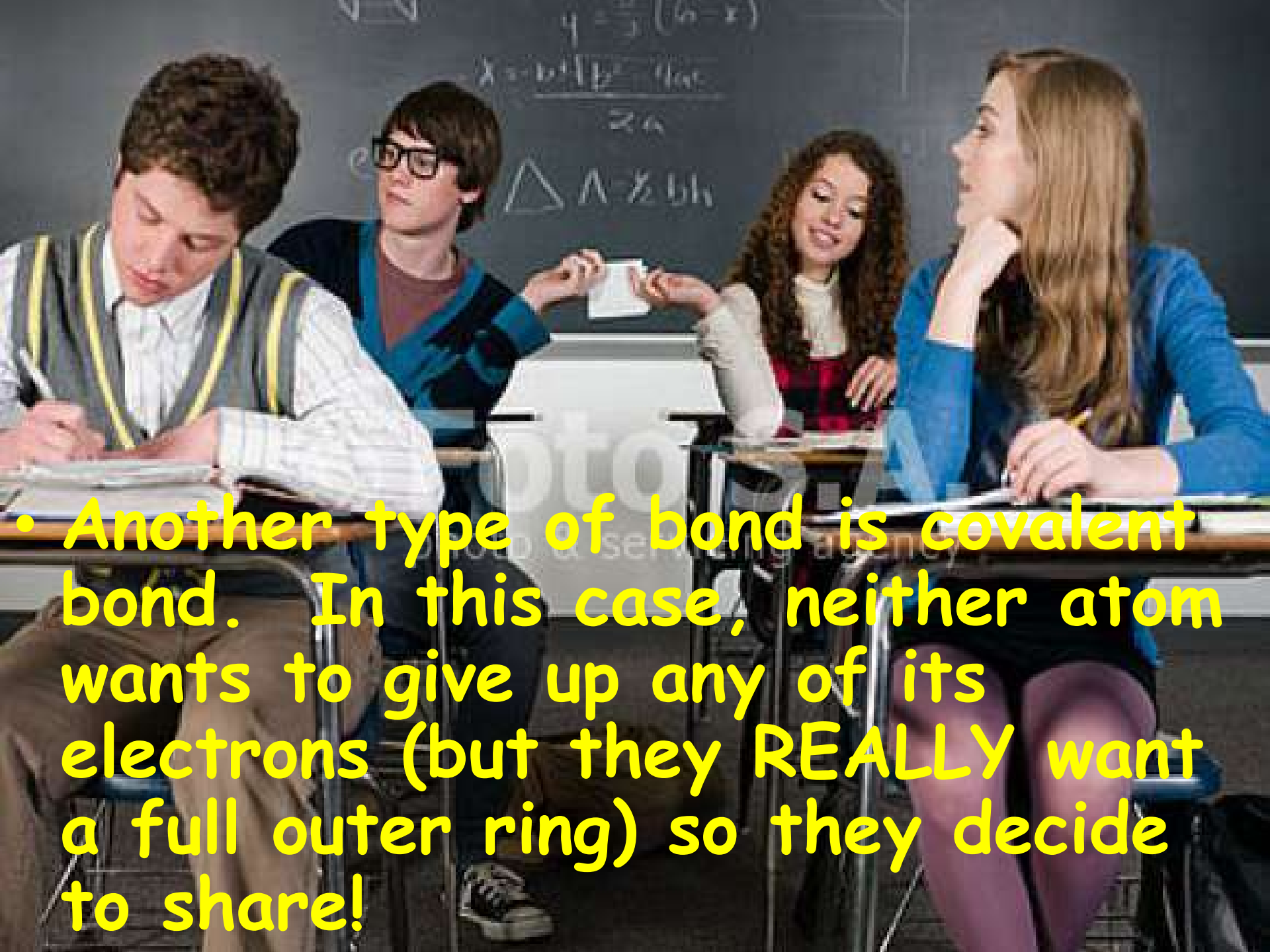
- Because opposite charges are attracted to each other, they "stick" together!

- The reason they call this type of bond "ionic" is because any atom or molecule that has a negative or positive charge is called an ion.

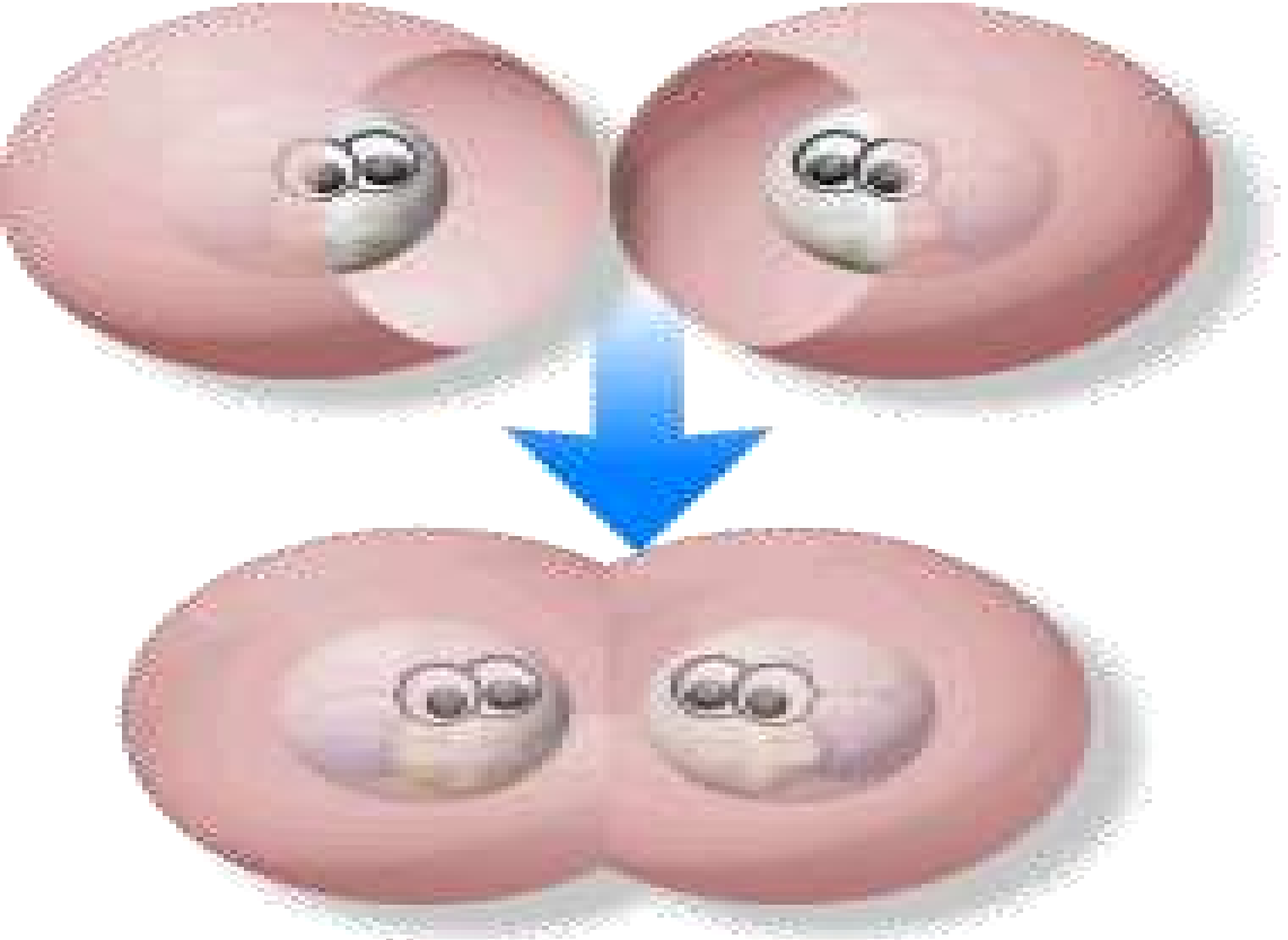

I ONLY HAVE 17 ELECTRONS. I'D FEEL SO MUCH BETTER IF I HAD ONE MORE.
I HAVE AN EXTRA ONE. HERE, YOU CAN TAKE IT.
Na
Cl
WOW! ARE YOU SURE?
Na
Cl
YES, I'M POSITIVE
NaCl



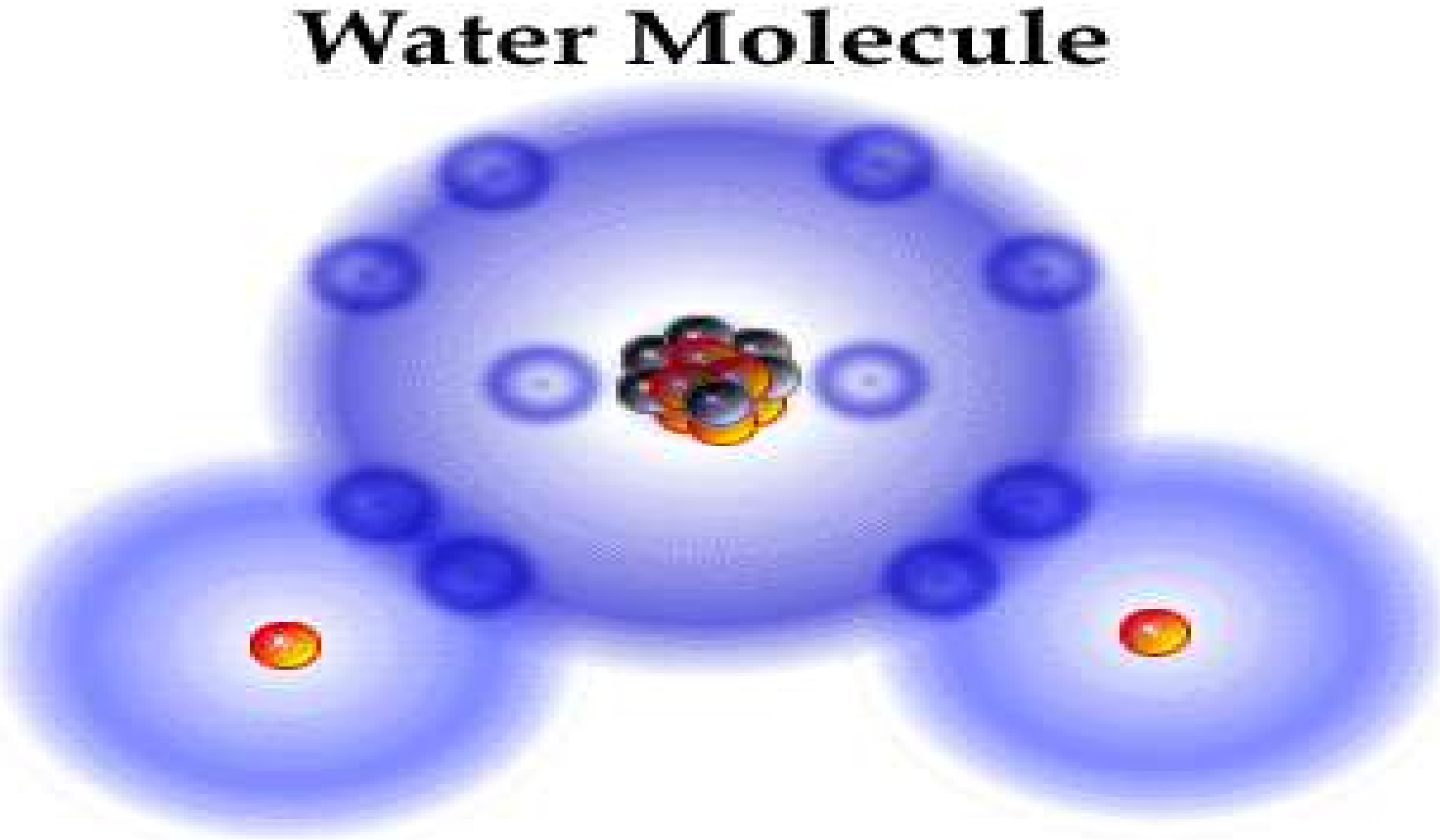
- Let's see how ionic bonding works…
- One of you at your table, build a sodium atom, the other, build a chlorine atom. Let's make salt!



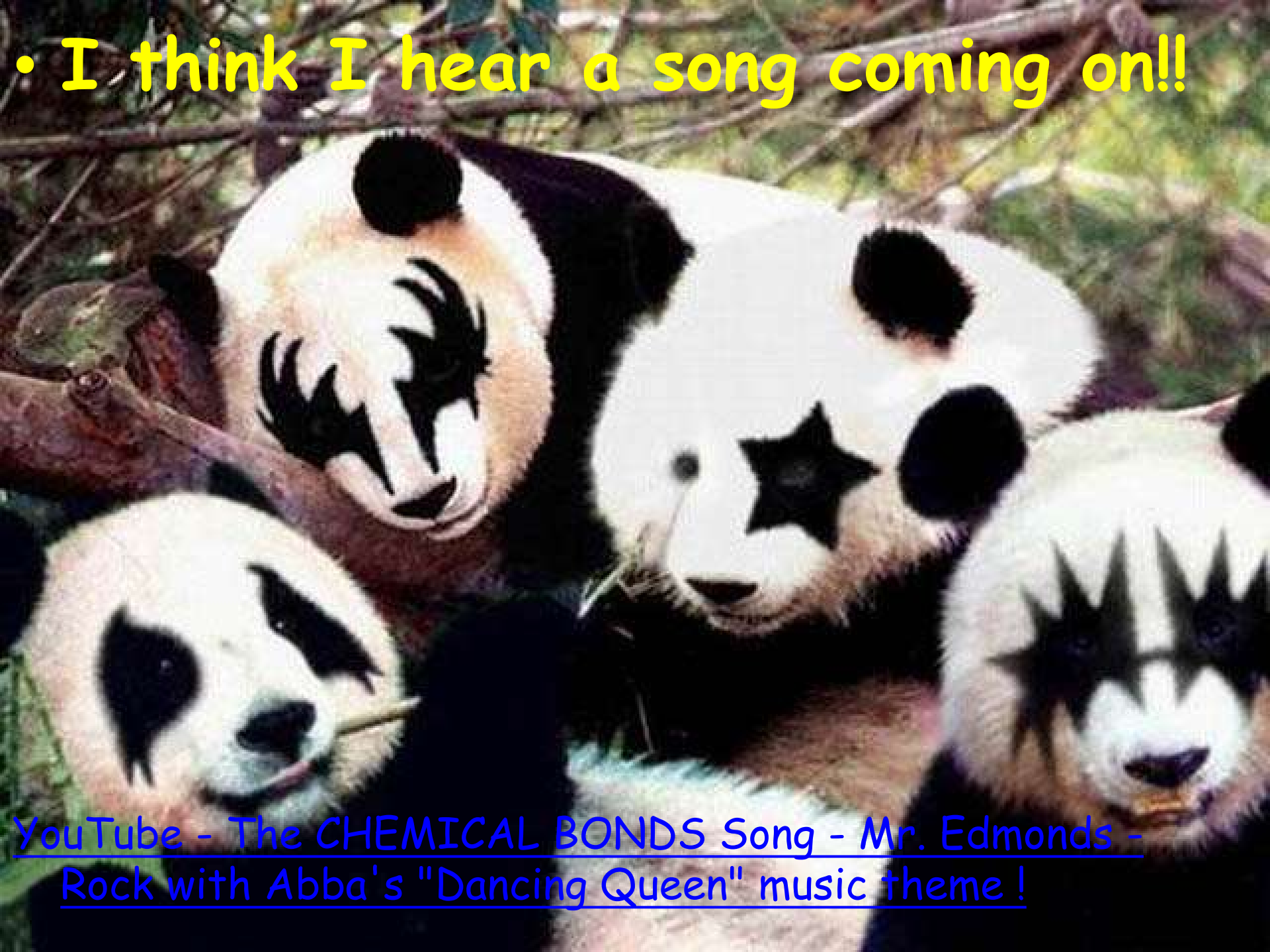
- Another type of bond is covalent bond. In this case, neither atom wants to give up any of its electrons (but they REALLY want a full outer ring) so they decide to share!



- The two hydrogen and one oxygen in water share electrons forming a covalent bond.

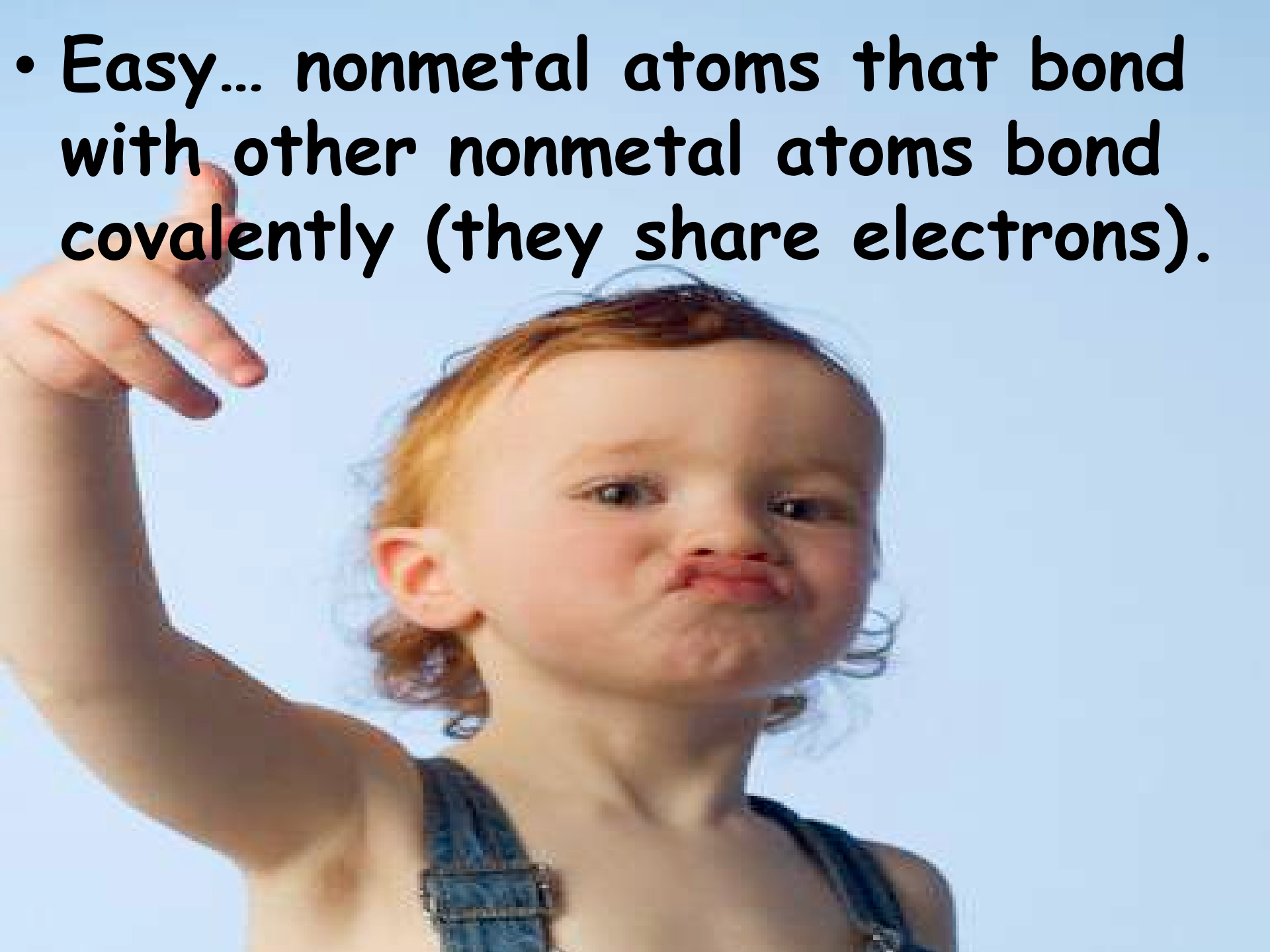


- Show me the bond!!!
- YouTube - Ionic and covalent bonding animation

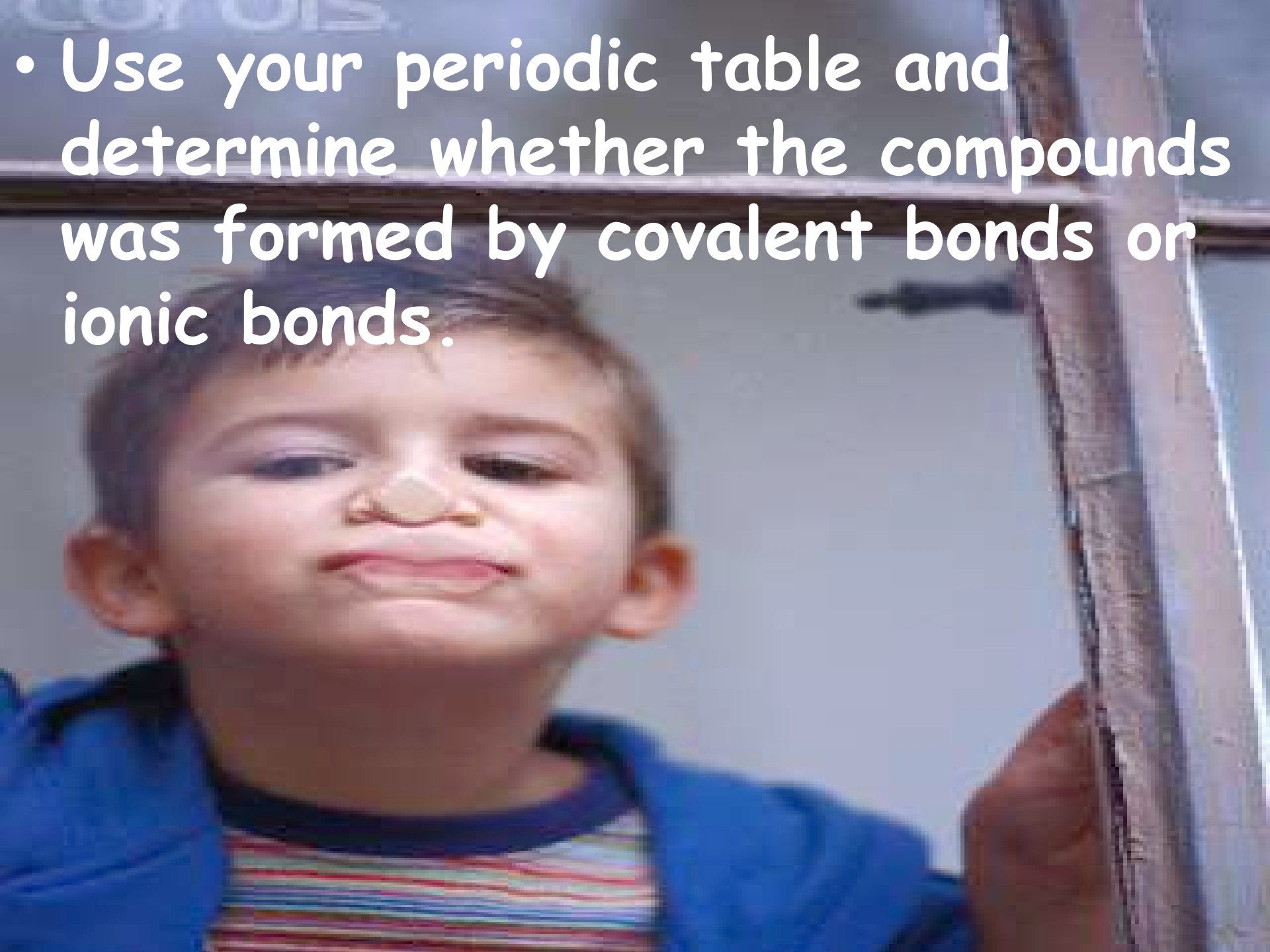

• I think I hear a song coming on!!
YouTube - The CHEMICAL BONDS Song - Mr. Edmonds - Rock with Abba's "Dancing Queen" music theme !

- So how do elements who bond with other elements decide if they are going to bond covalently or ionicly????

- Easy… nonmetal atoms that bond with other nonmetal atoms bond covalently (they share electrons).



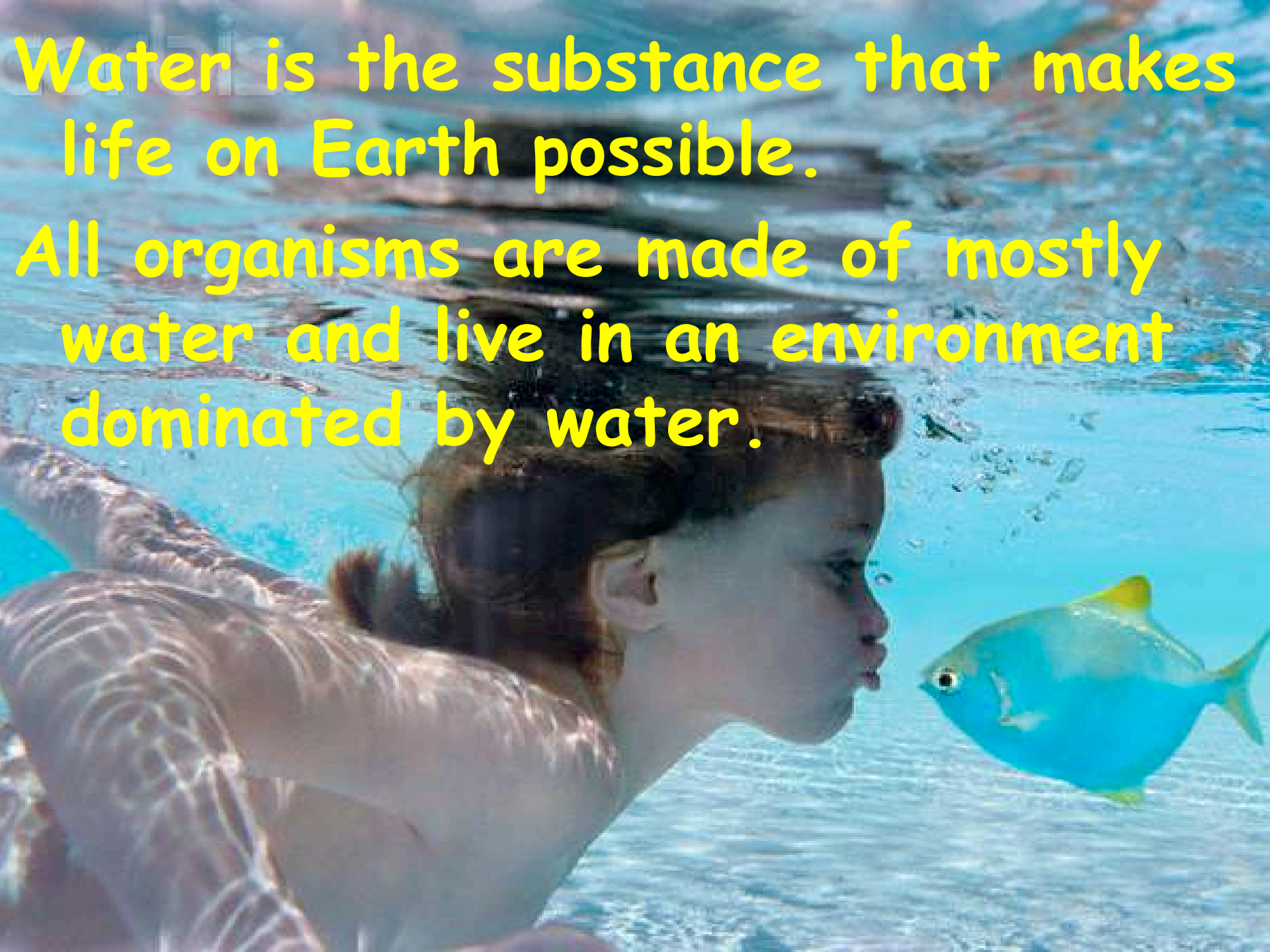
- Nonmetal atoms bond with metal atoms forming ionic bonds.

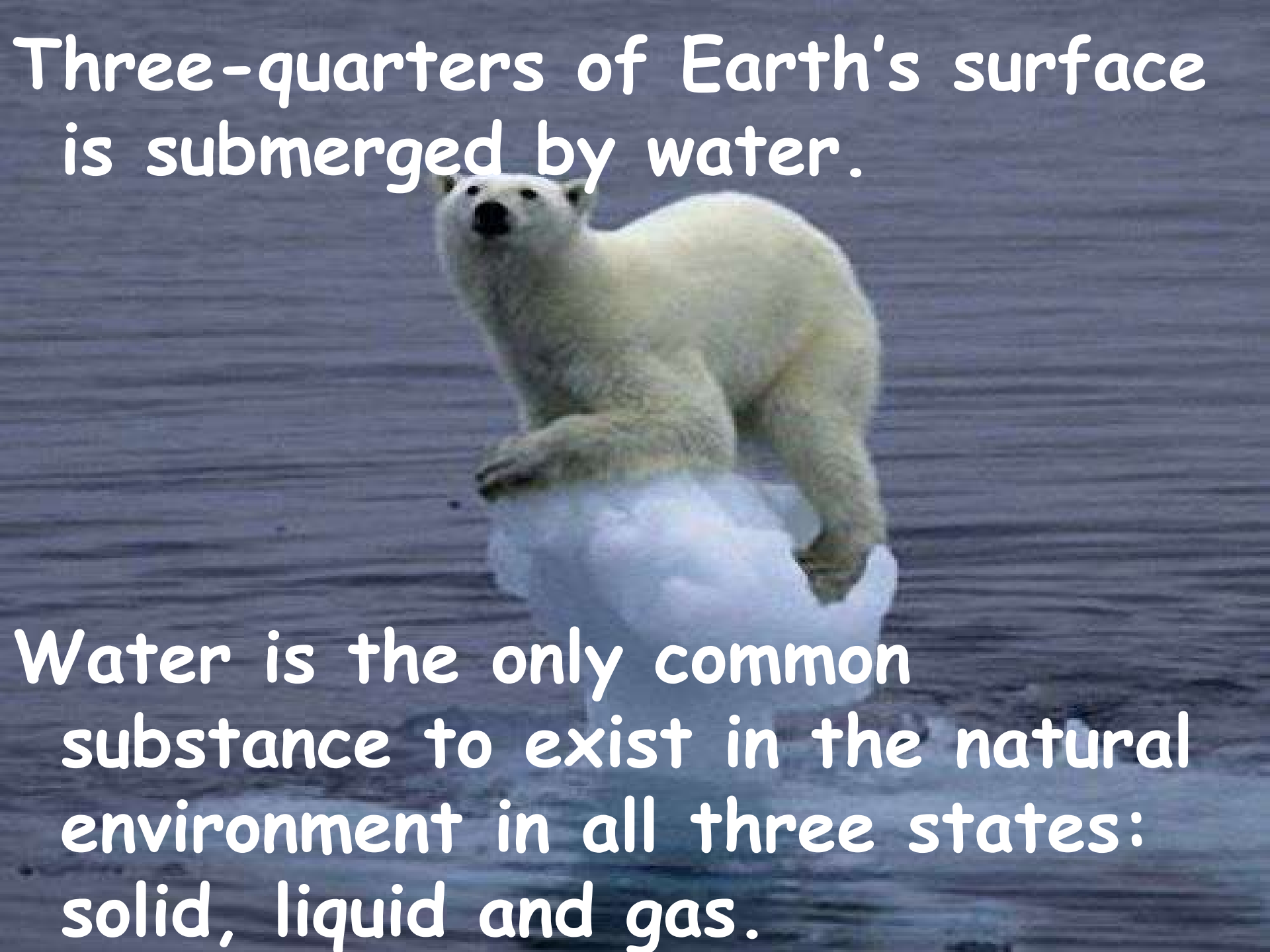


- Use your periodic table and determine whether the compounds was formed by covalent bonds or ionic bonds.

2-2 The Properties of Water

Brad Paisley - Water - YouTube


Water is the substance that makes life on Earth possible.
All organisms are made of mostly water and live in an environment dominated by water.



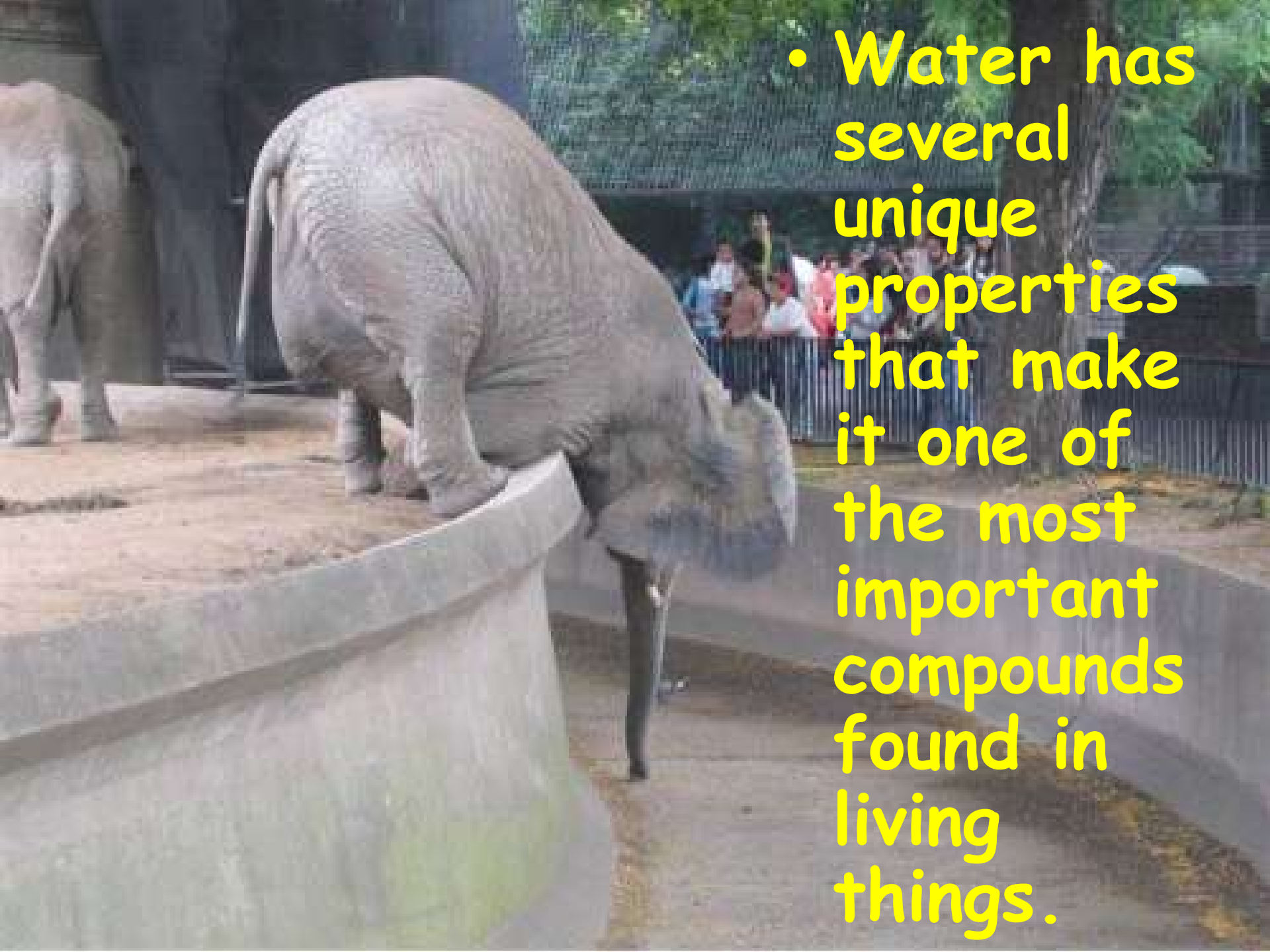
Three-quarters of Earth's surface is submerged by water.

Water is the only common substance to exist in the natural environment in all three states: solid, liquid and gas.

- Most cells are surrounded by water, and cells themselves are about 70-95% water.

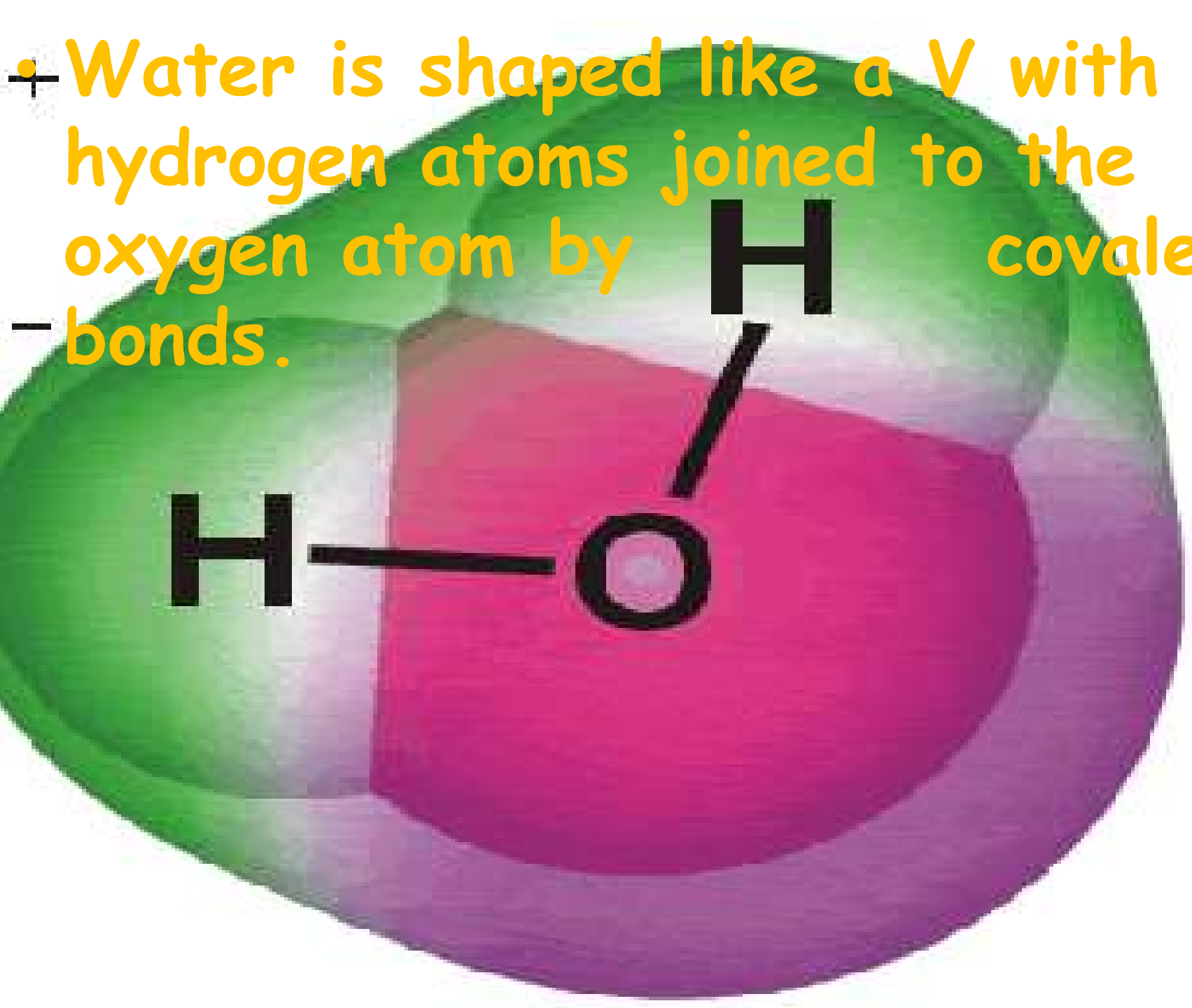
- Molecules of water participate in many chemical reactions necessary to sustain life.

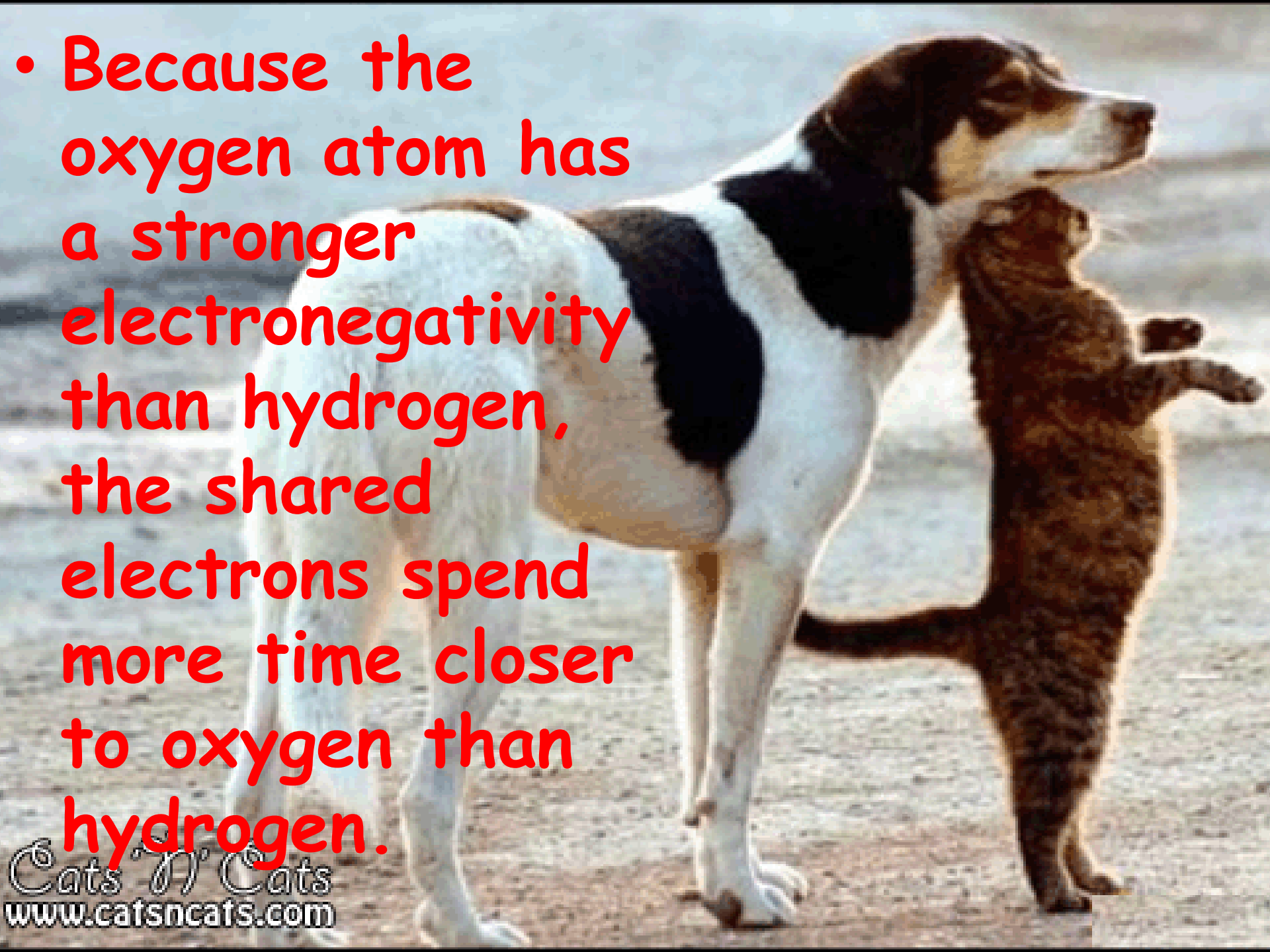
We can trace water's unique behavior to its structure and interactions of its molecules.



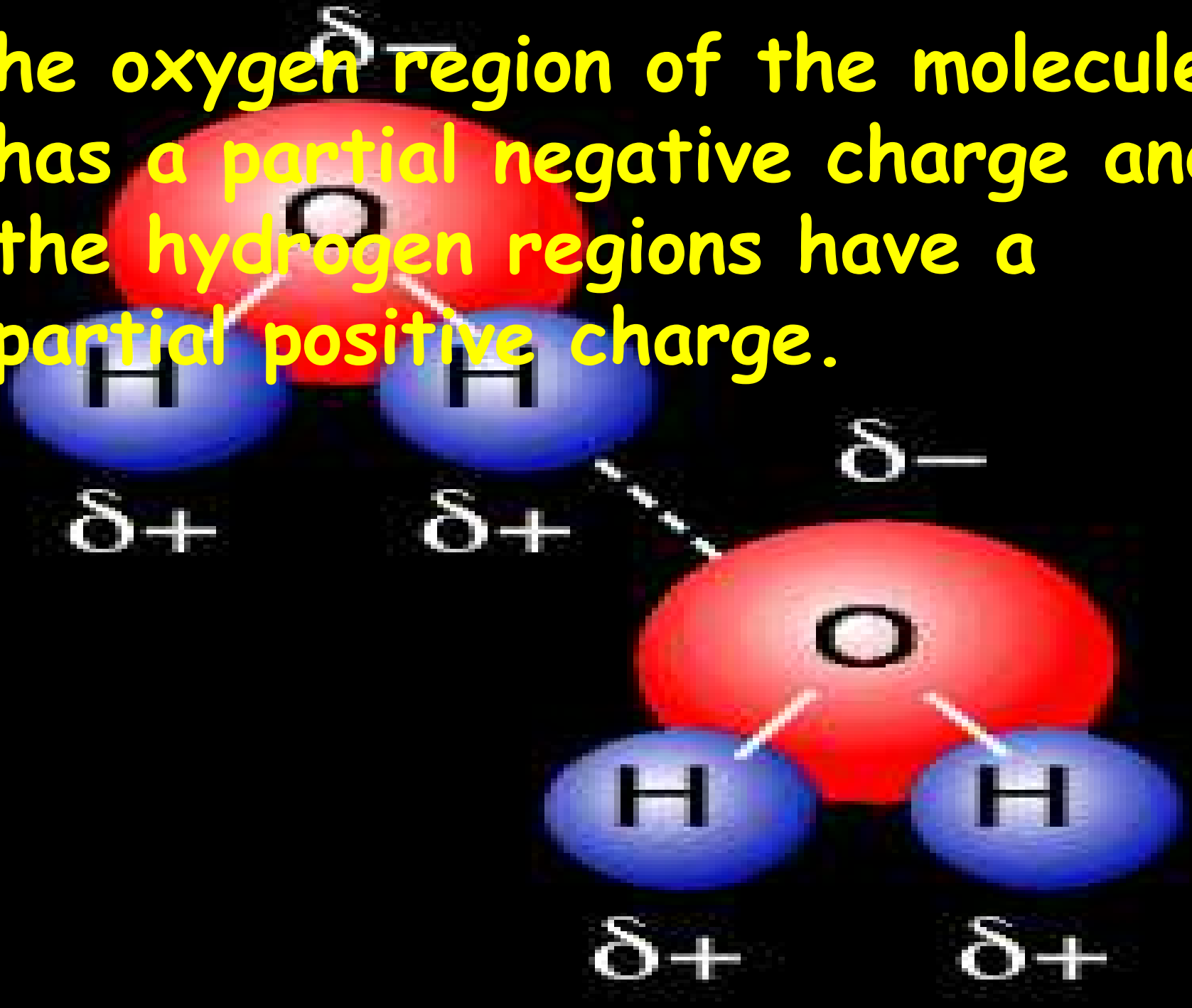
- Water has several unique properties that make it one of the most important compounds found in living things.

- Water is shaped like a V with two hydrogen atoms joined to the oxygen atom by covalent bonds.

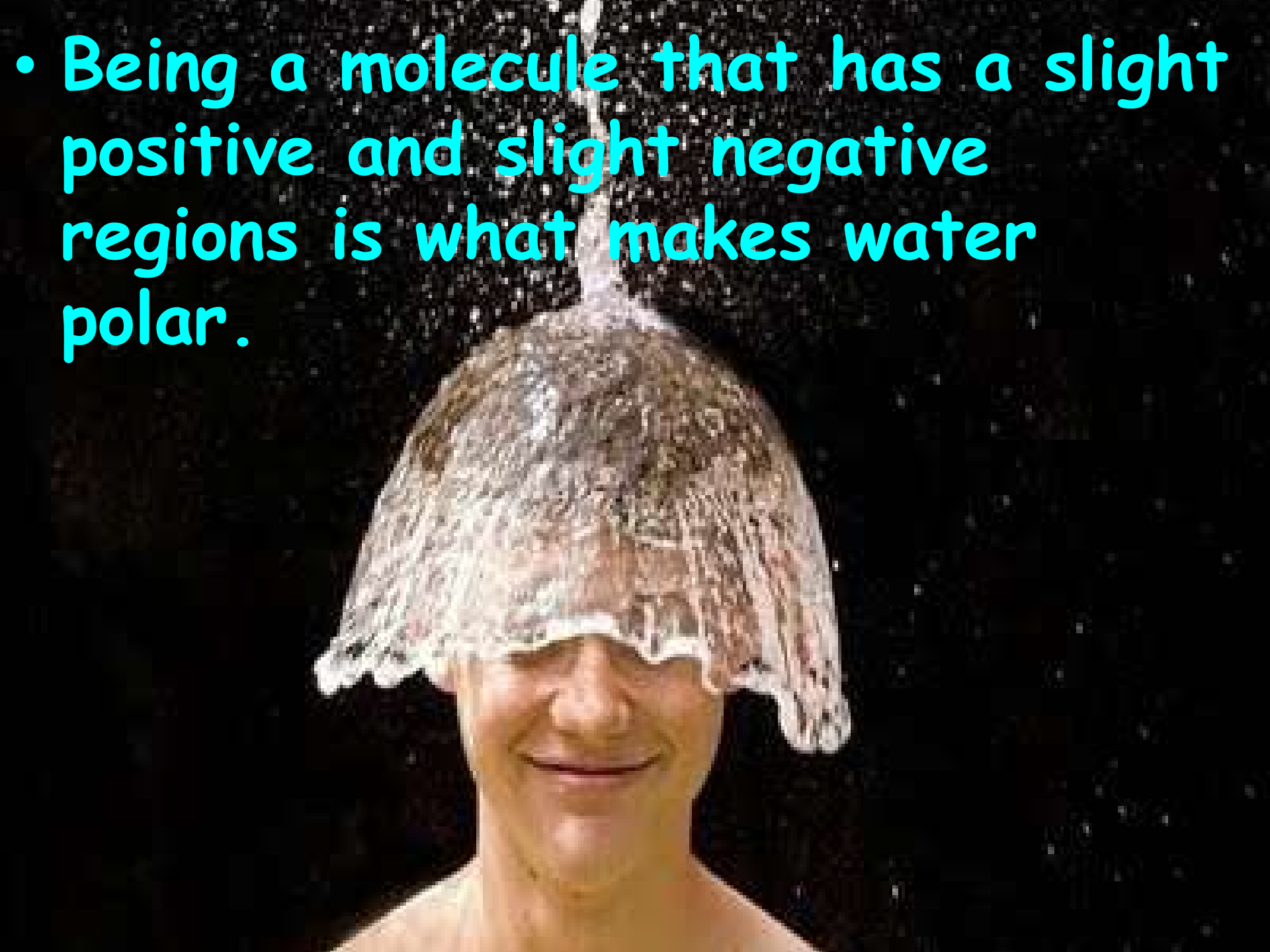



• Because the oxygen atom has a stronger electronegativity than hydrogen, the shared electrons spend more time closer to oxygen than hydrogen.
Cats 'N' Cats
www.catsncats.com

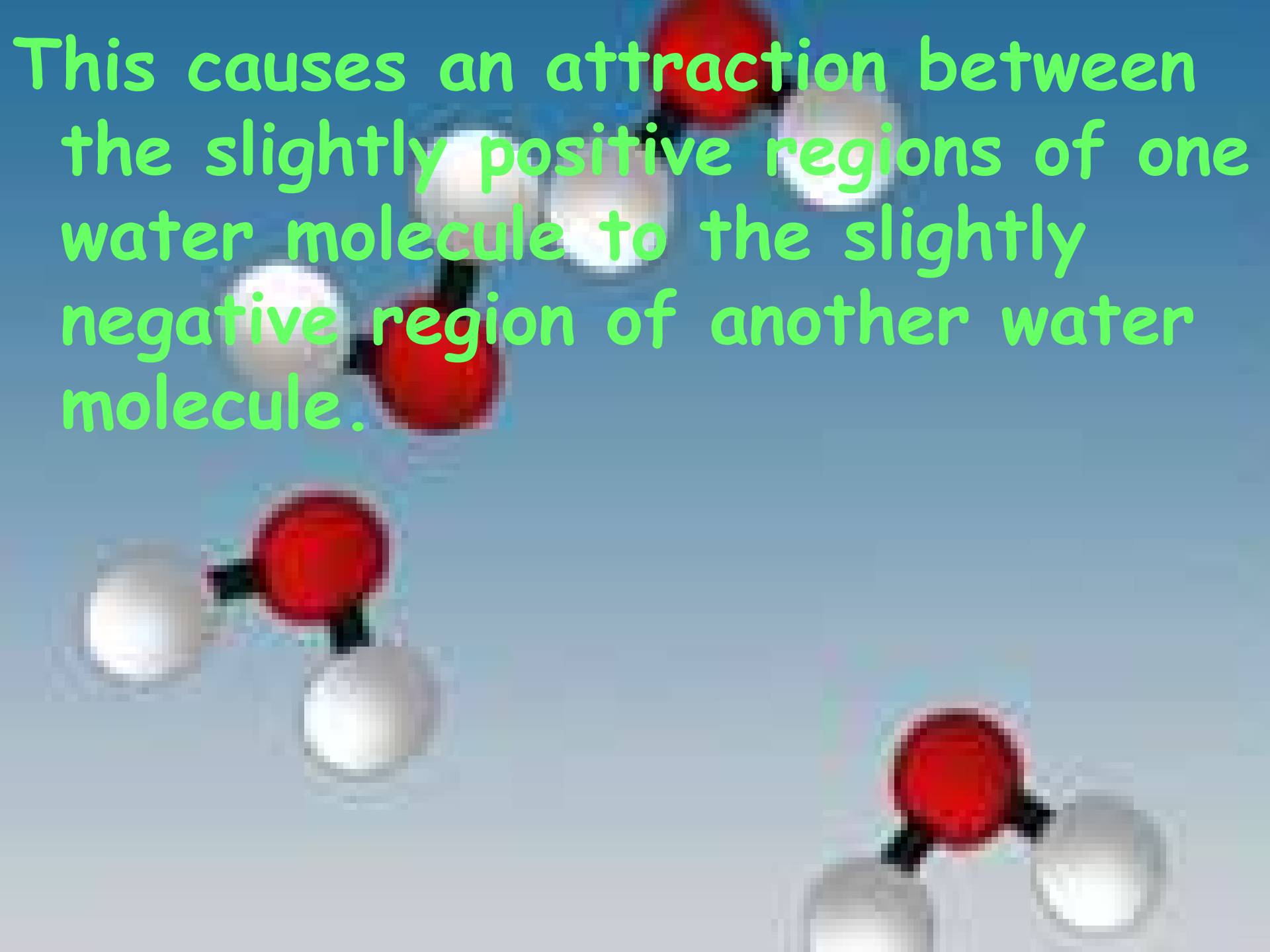
The oxygen region of the molecule has a partial negative charge and the hydrogen regions have a partial positive charge.

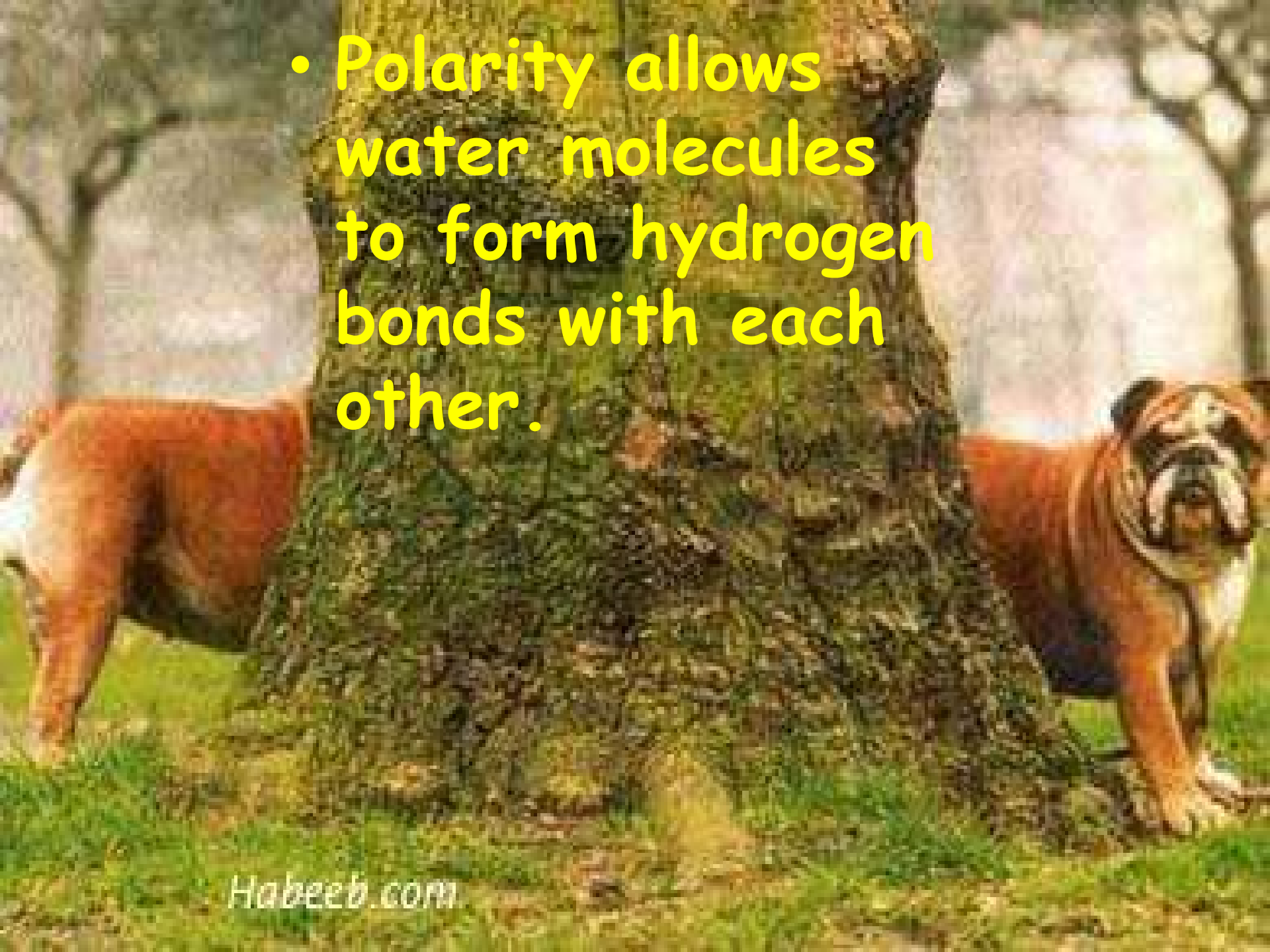


- Being a molecule that has a slight positive and slight negative regions is what makes water polar.



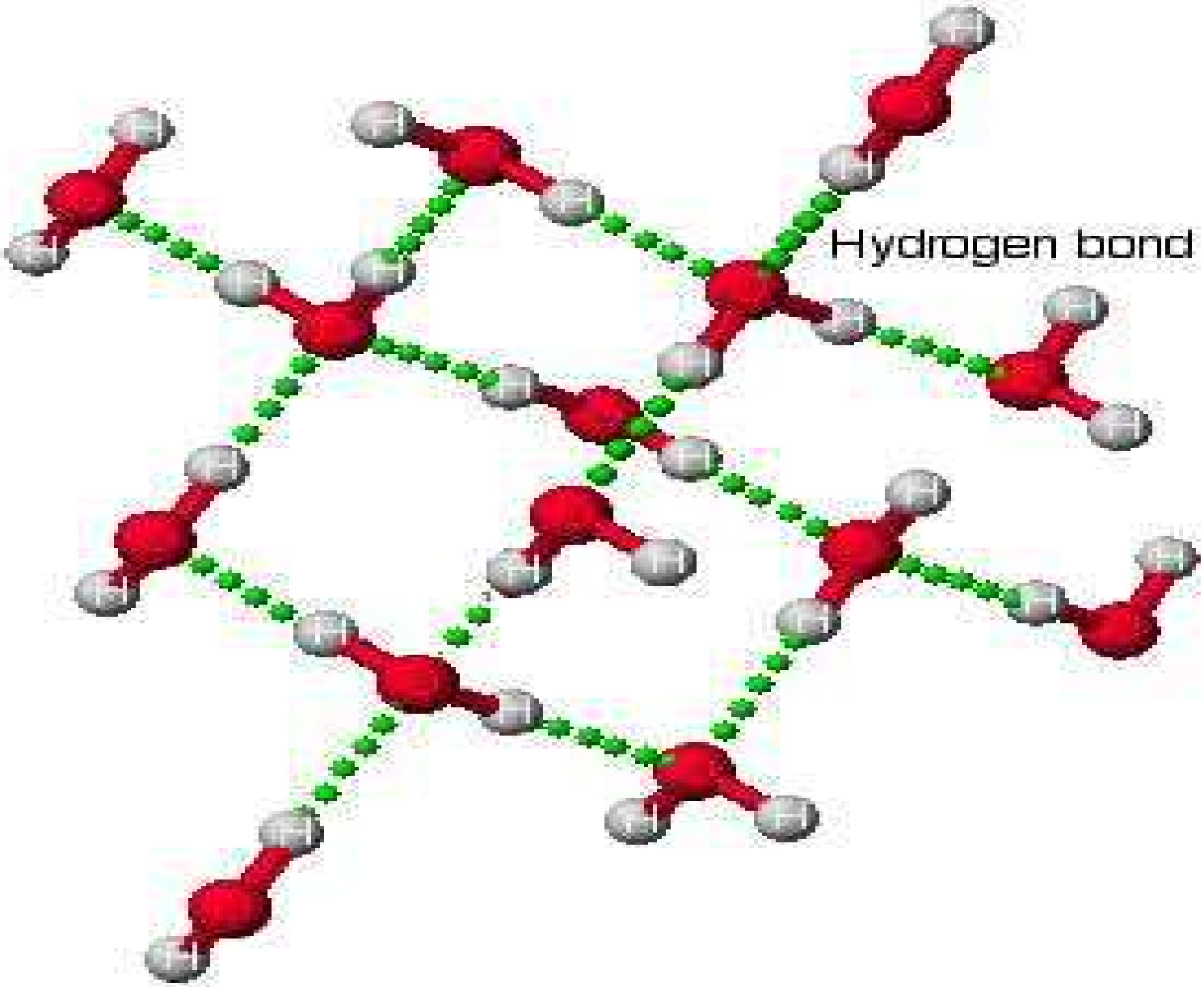
This causes an attraction between the slightly positive regions of one water molecule to the slightly negative region of another water molecule.



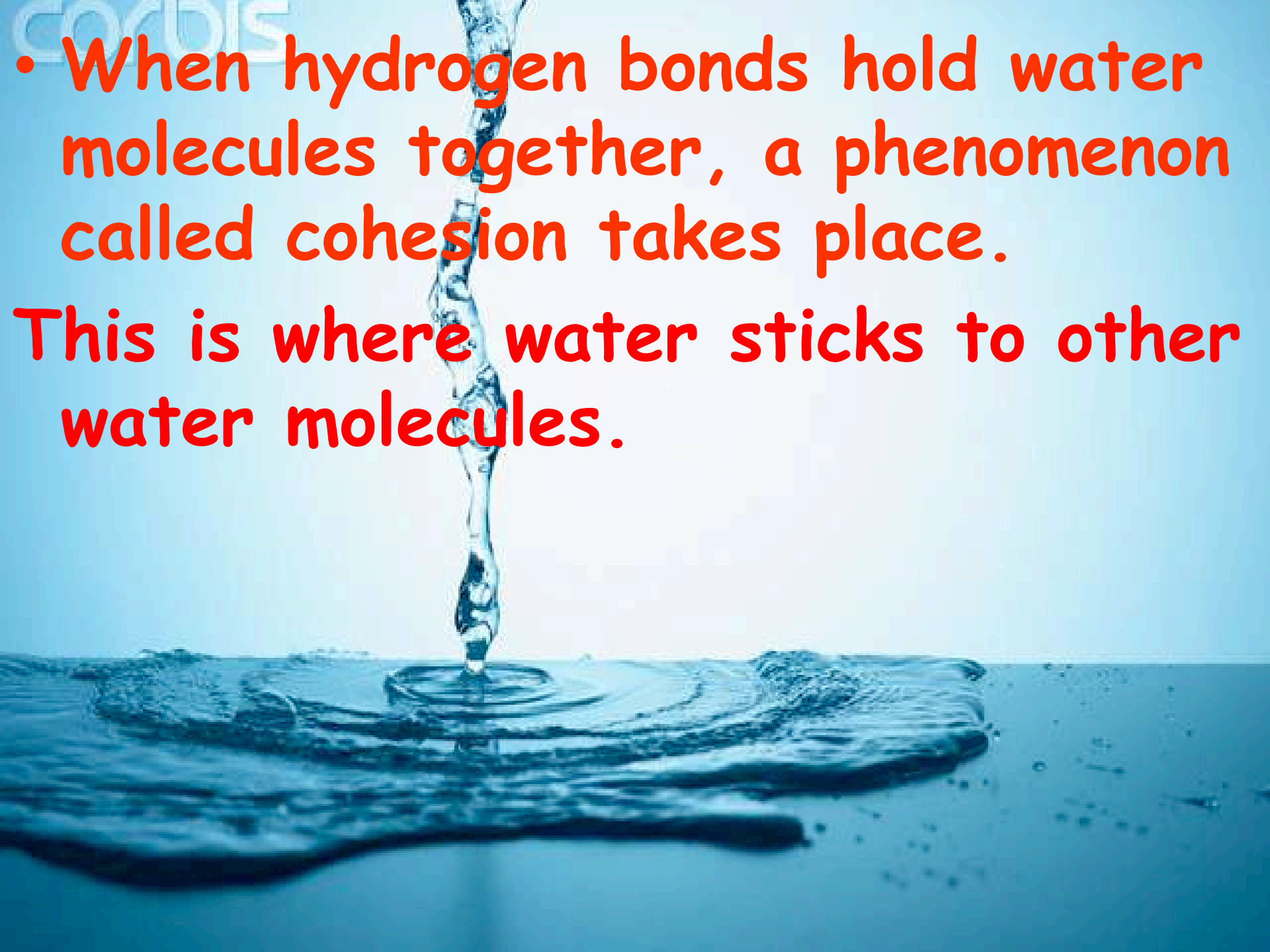


- Polarity allows water molecules to form hydrogen bonds with each other.

Hydrogen Bonding in Water



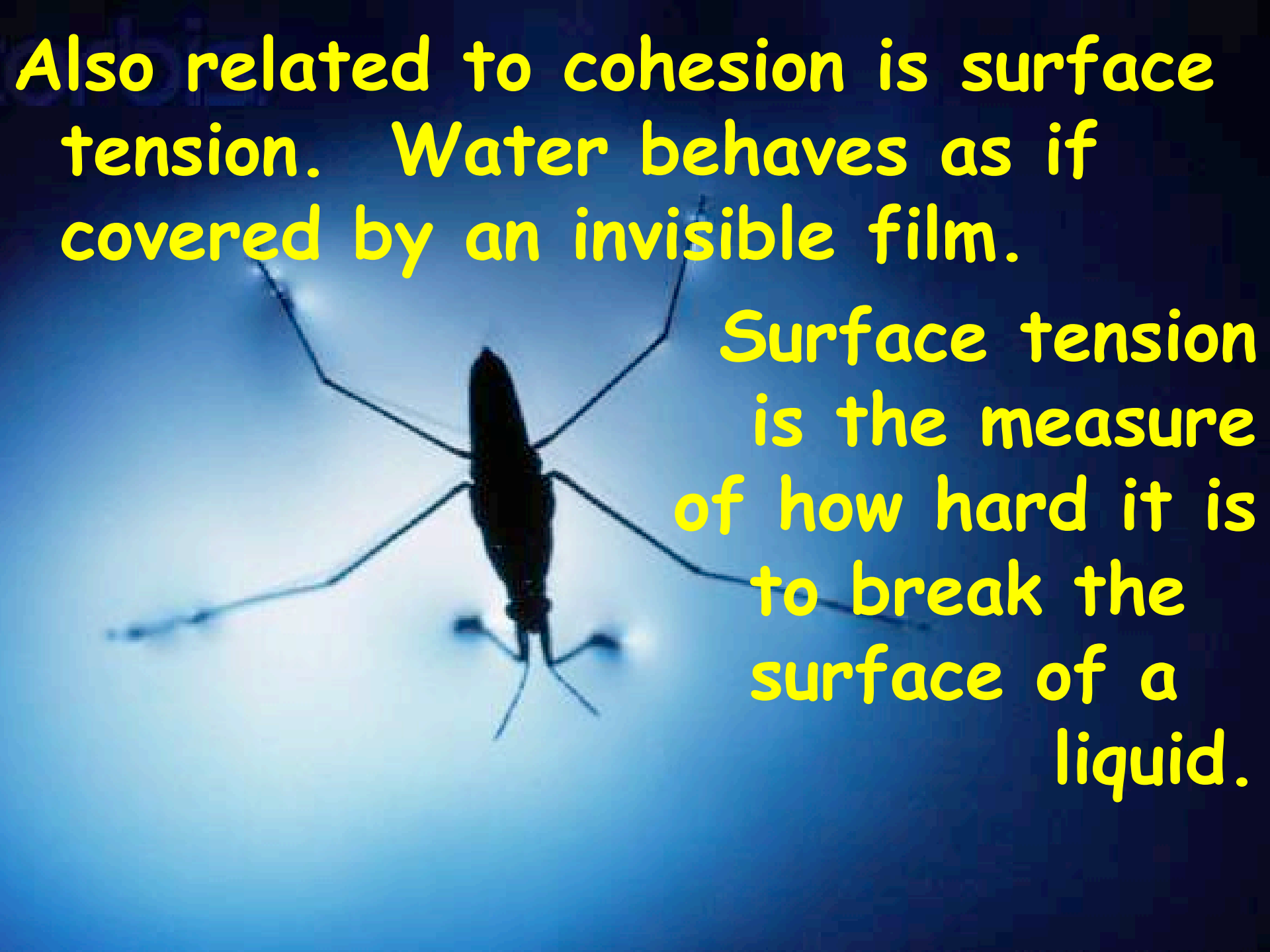
- Hydrogen bonds are not as strong as covalent or ionic bonds but water's ability to form multiple hydrogen bonds is responsible for many of its special properties.



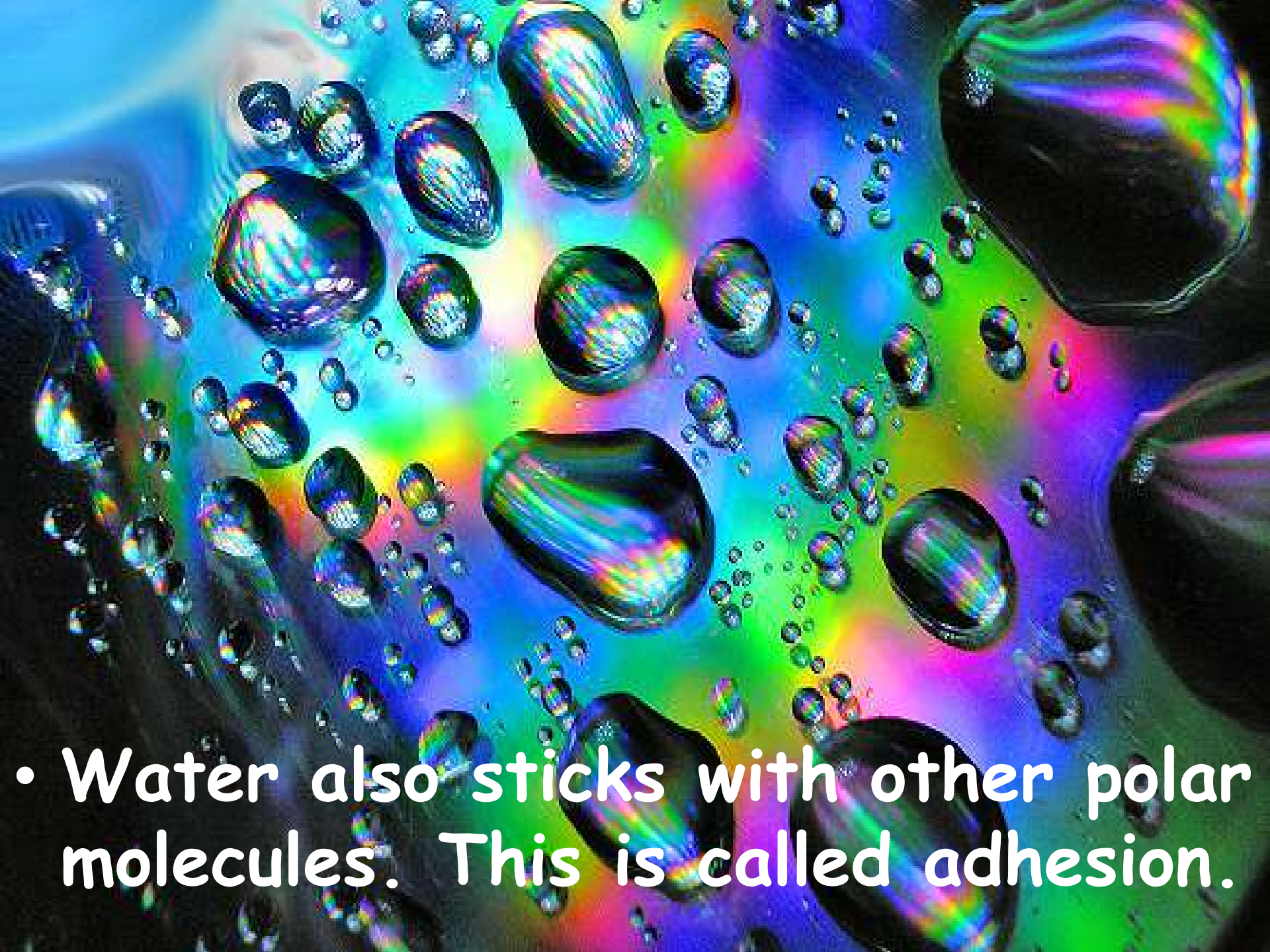
- When hydrogen bonds hold water molecules together, a phenomenon called cohesion takes place.

This is where water sticks to other water molecules.

Also related to cohesion is surface tension. Water behaves as if covered by an invisible film.

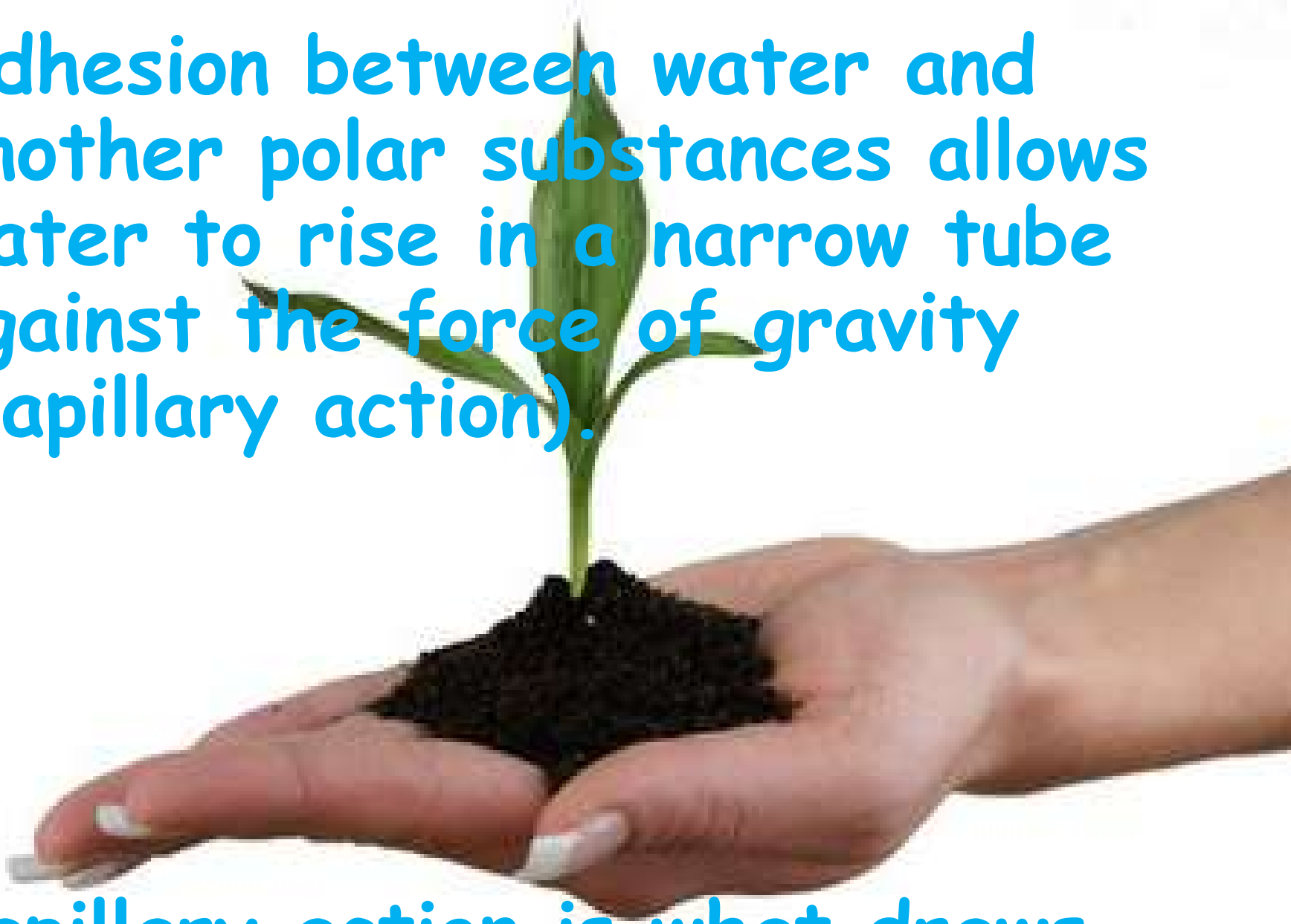


Surface tension is the measure of how hard it is to break the surface of a liquid.



- Water also sticks with other polar molecules. This is called adhesion.

- Adhesion between water and another polar substances allows water to rise in a narrow tube against the force of gravity (capillary action).



- Capillary action is what draws water out of the roots up a plant.

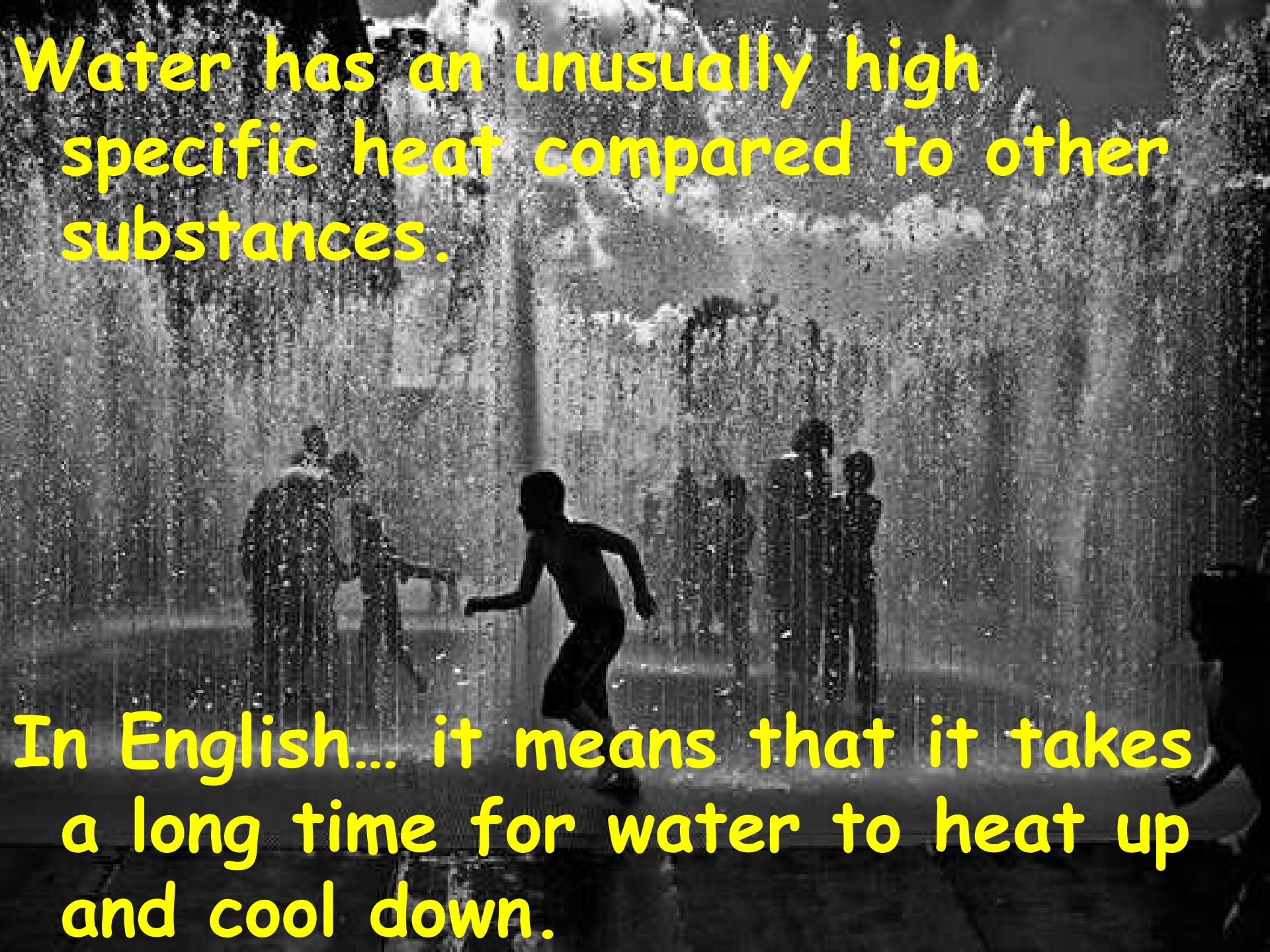
- Let's take a minute and build some water!!!


• I feel the need for a lab!!
• Let's investigate surface tension.

- But before we begin, let's watch this!
- Jesus Christ Lizard - YouTube

- More unique properties of water:

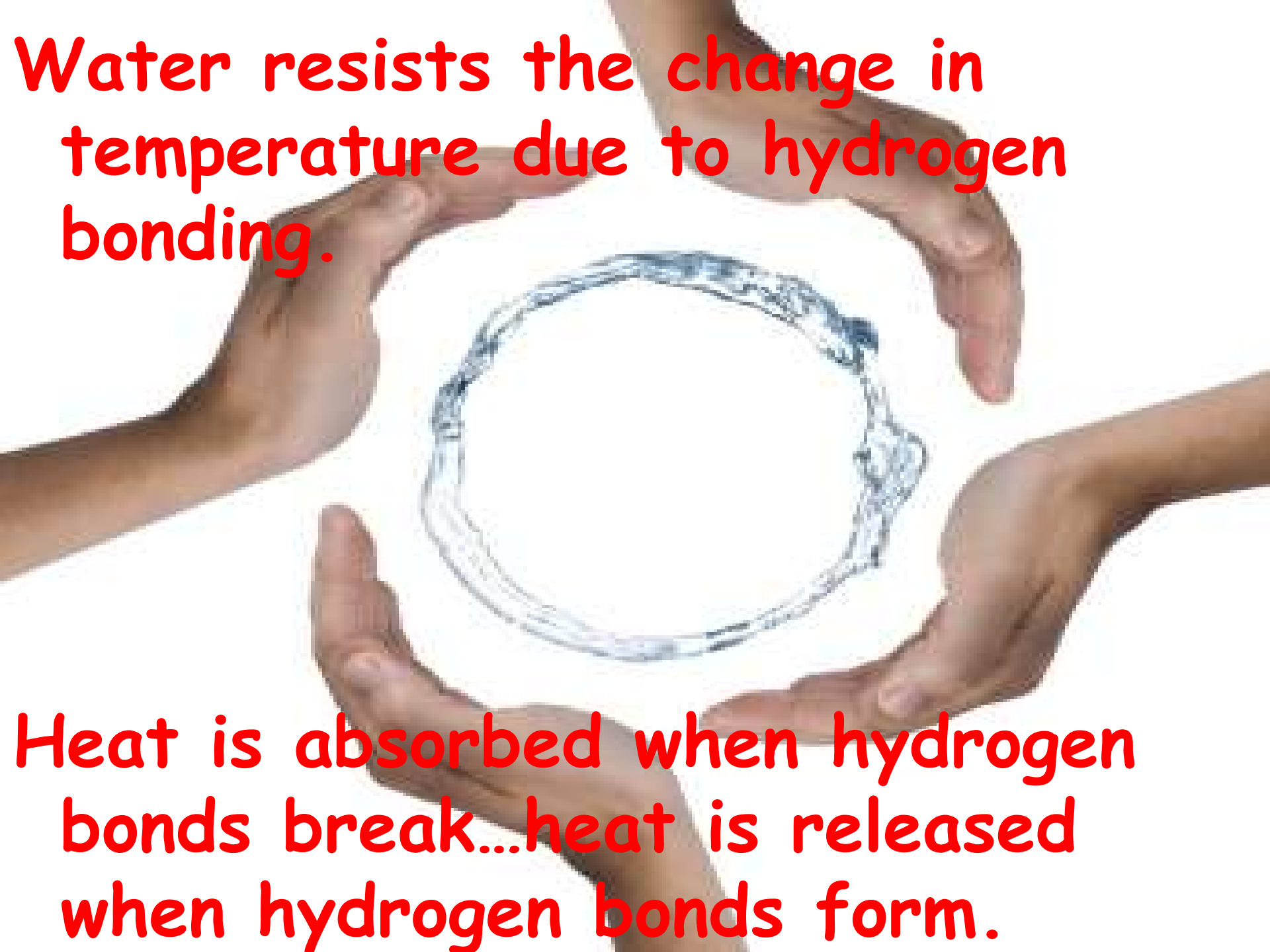
Water can absorb or release a large amount of heat with only a slight change in its own temperature.



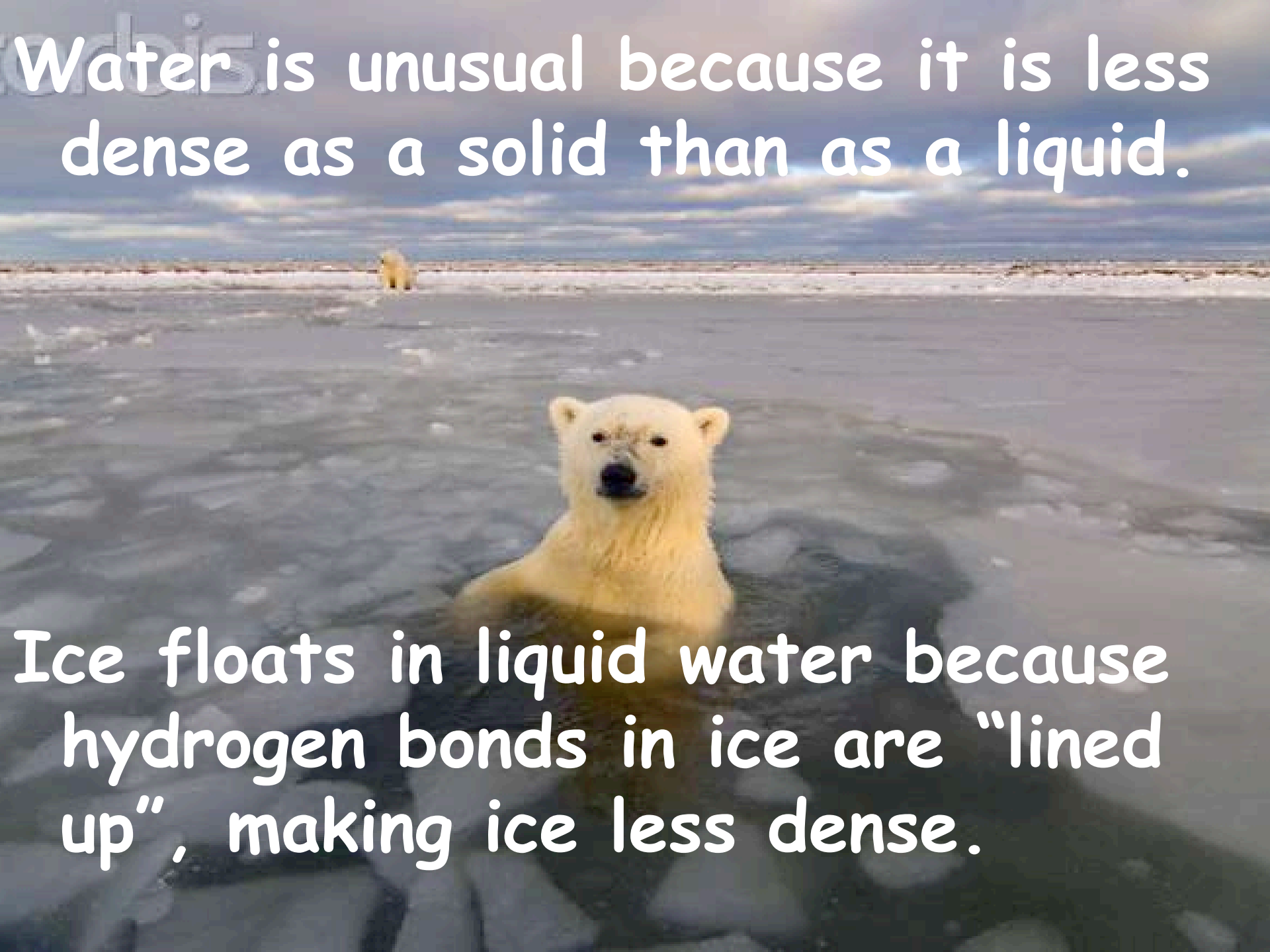
Water has an unusually high specific heat compared to other substances.

In English… it means that it takes a long time for water to heat up and cool down.

Water resists the change in temperature due to hydrogen bonding.



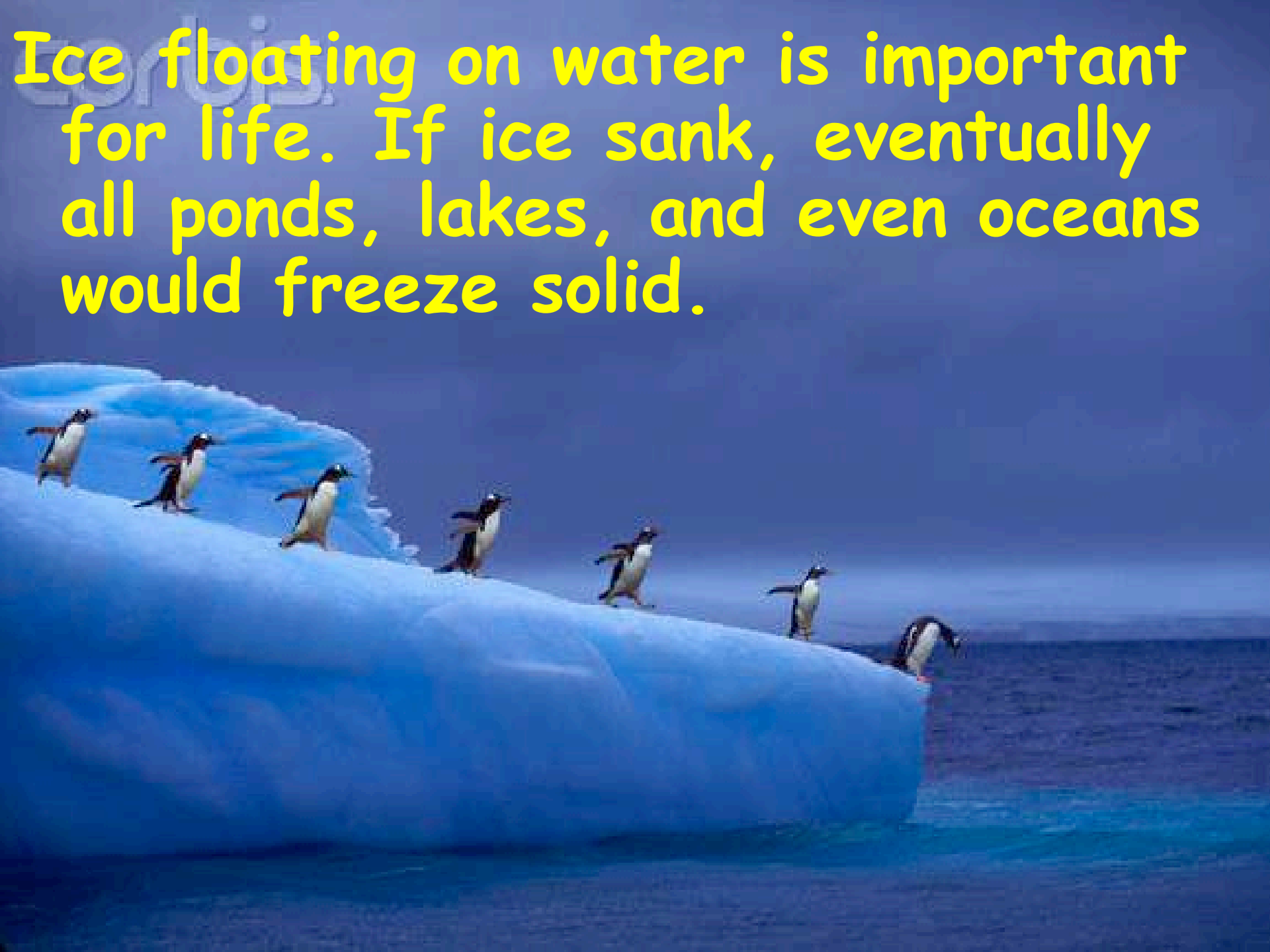
Heat is absorbed when hydrogen bonds break…heat is released when hydrogen bonds form.

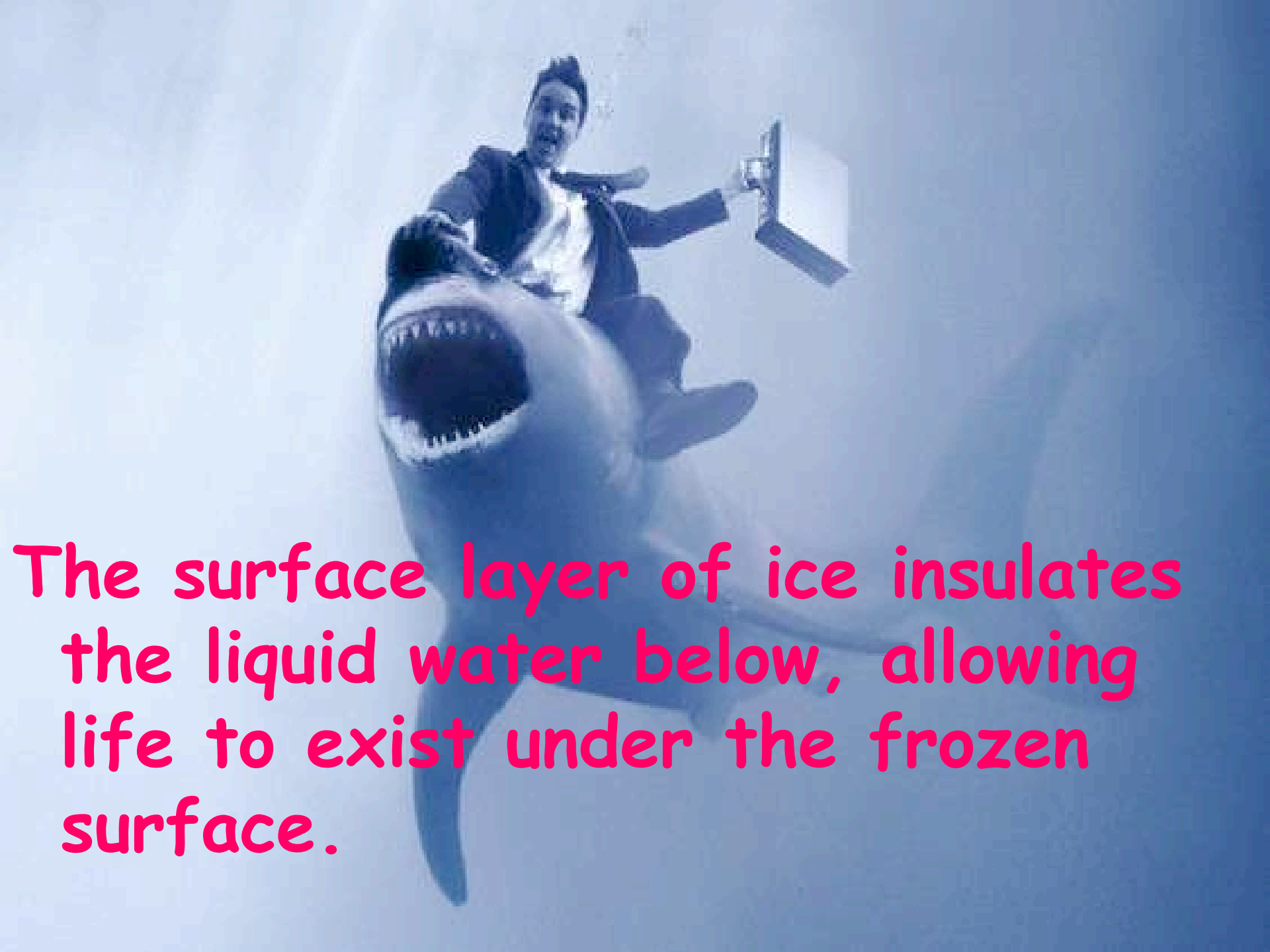


Water is unusual because it is less dense as a solid than as a liquid.

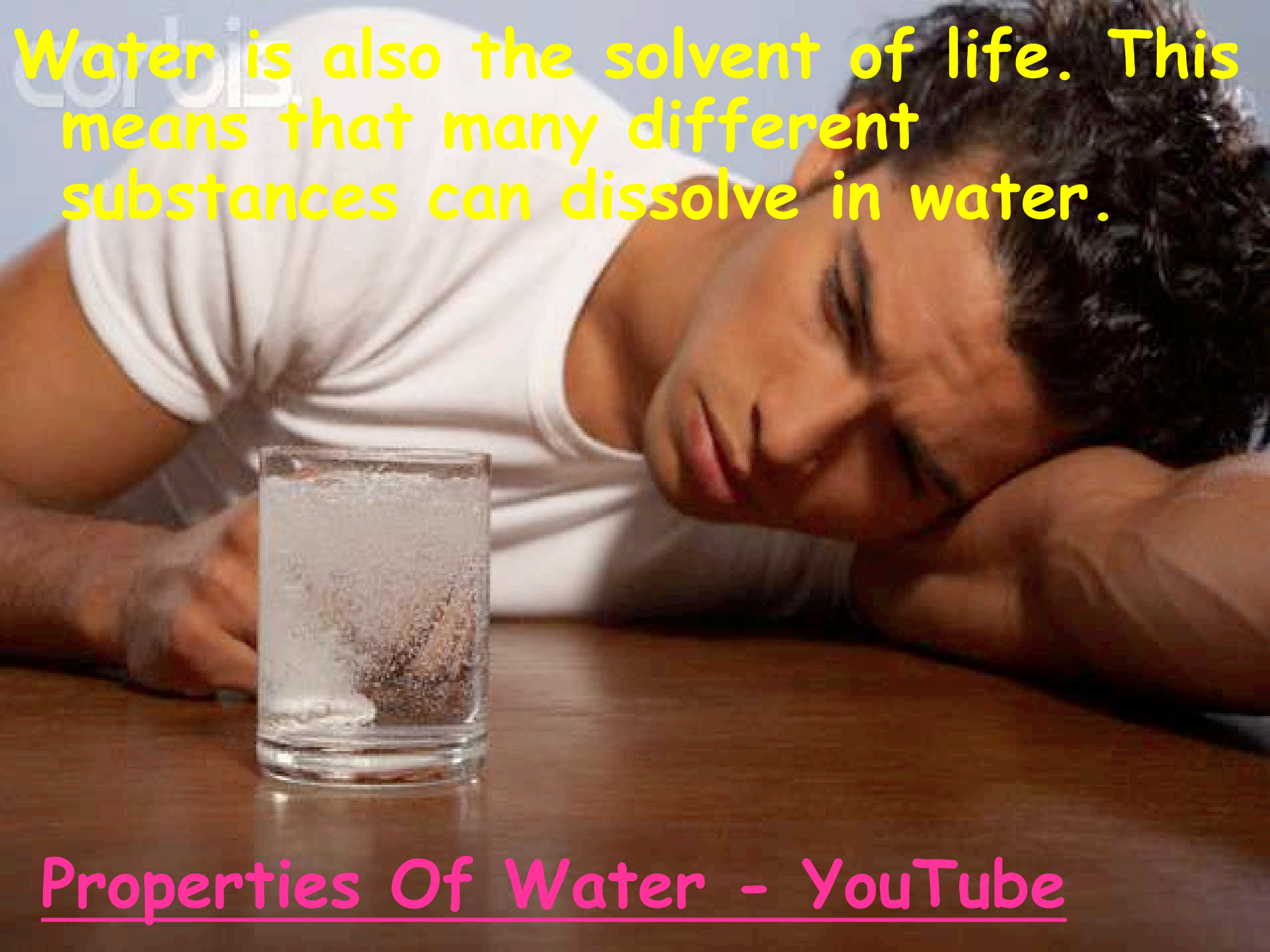
Ice floats in liquid water because hydrogen bonds in ice are "lined up", making ice less dense.

Ice floating on water is important for life. If ice sank, eventually all ponds, lakes, and even oceans would freeze solid.



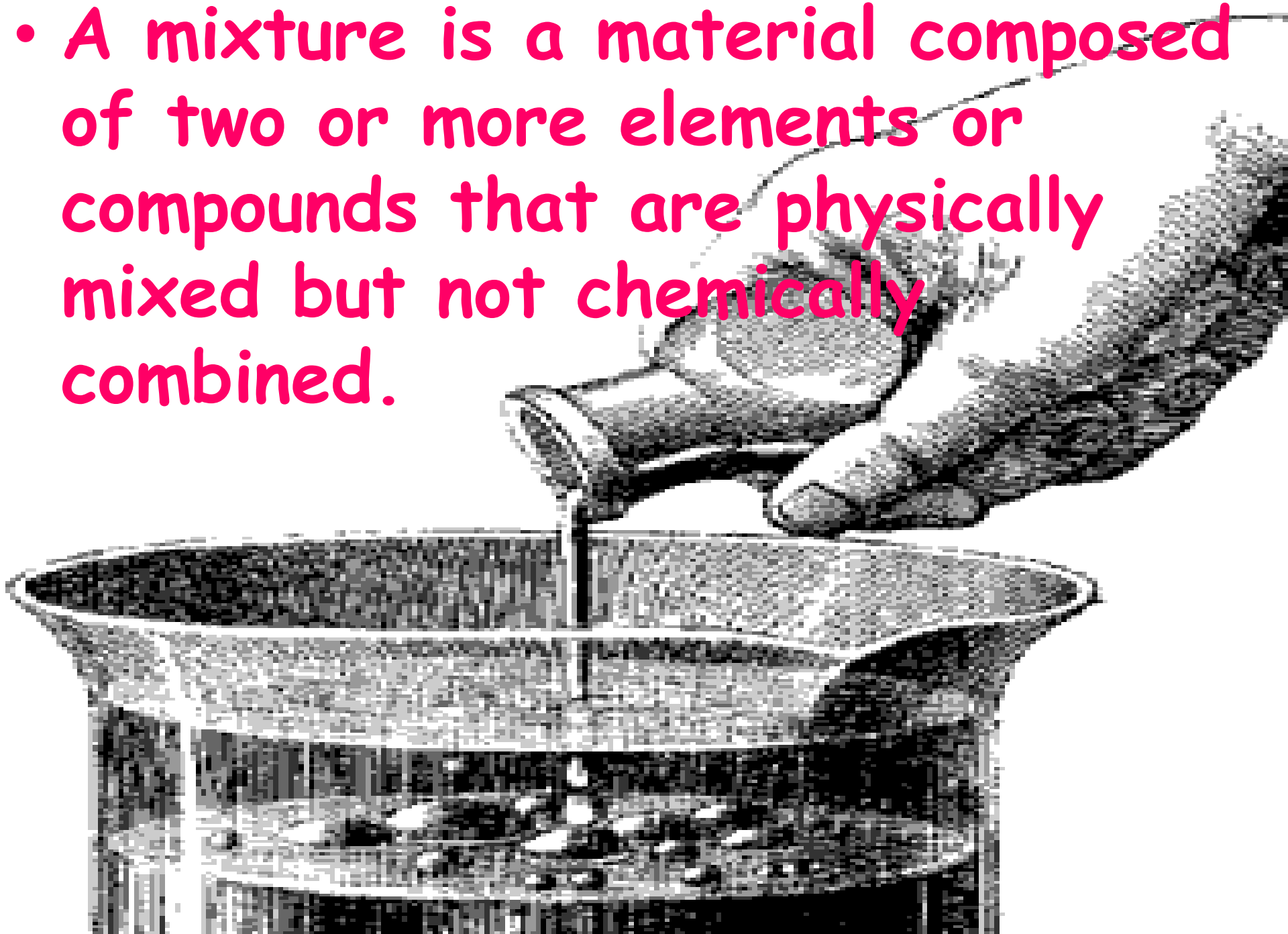


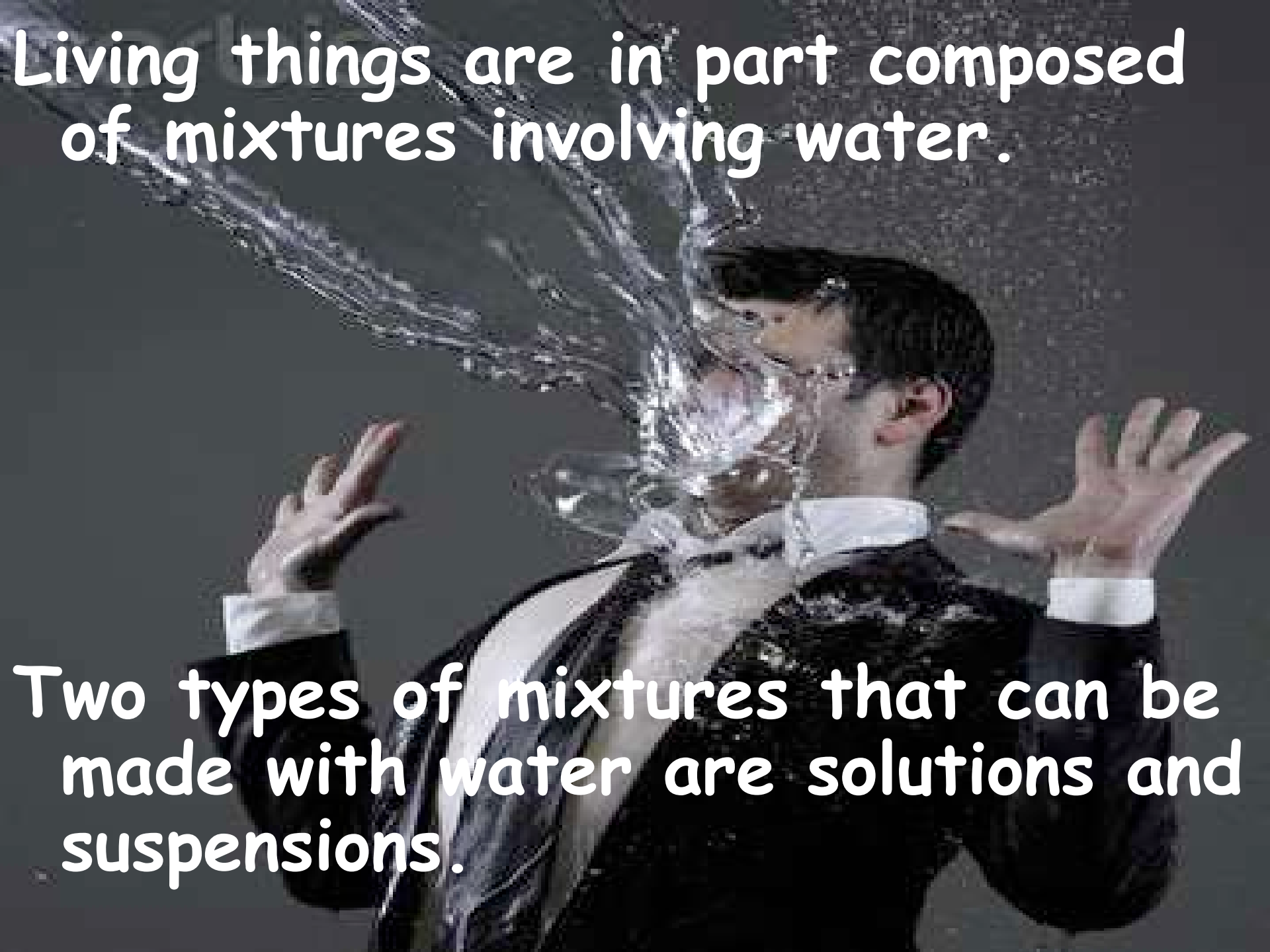
The surface layer of ice insulates the liquid water below, allowing life to exist under the frozen surface.


Water is also the solvent of life. This means that many different substances can dissolve in water.
Properties Of Water - YouTube

- Water is usually part of a mixture.

- A mixture is a material composed of two or more elements or compounds that are physically mixed but not chemically combined.

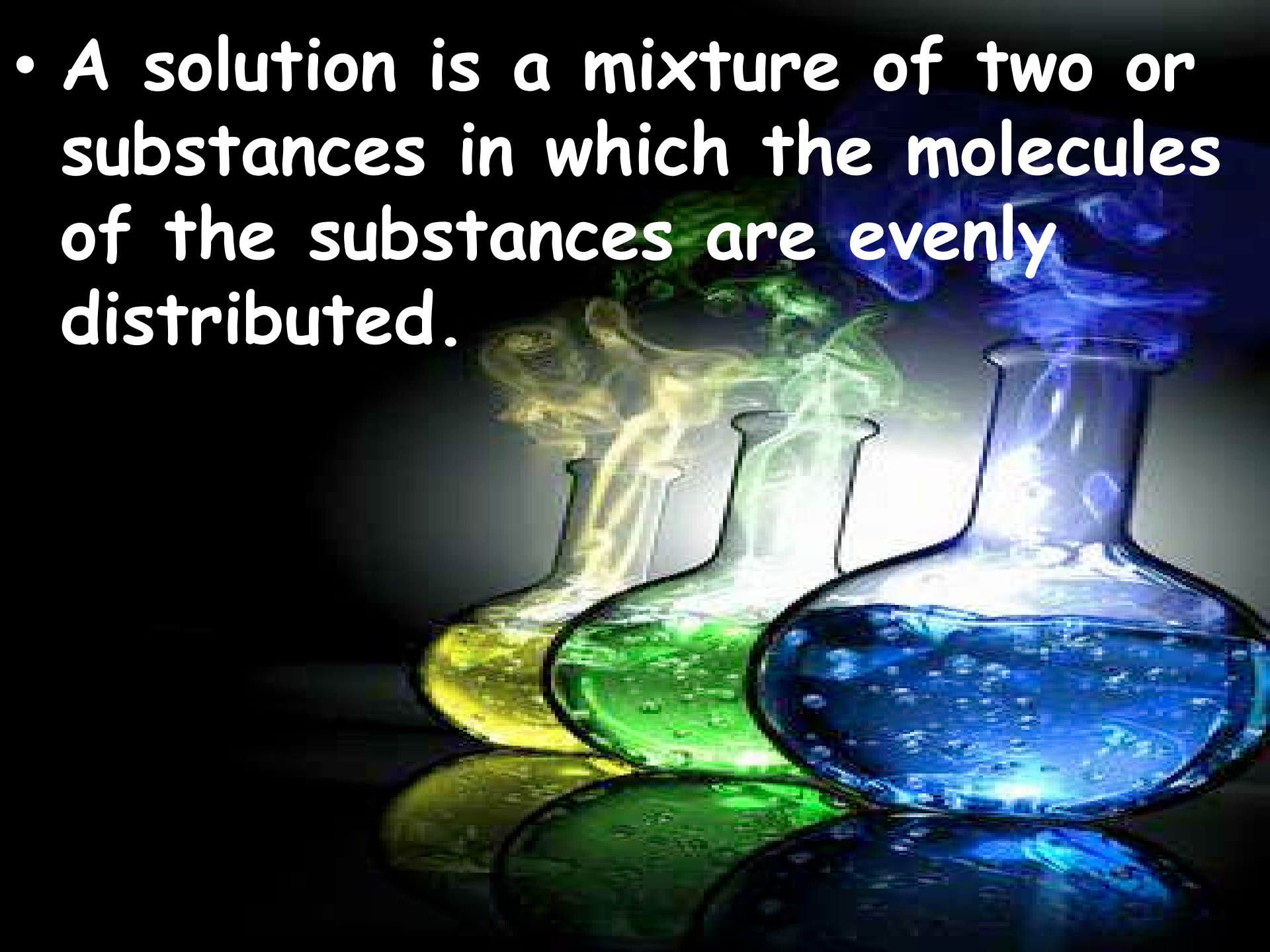




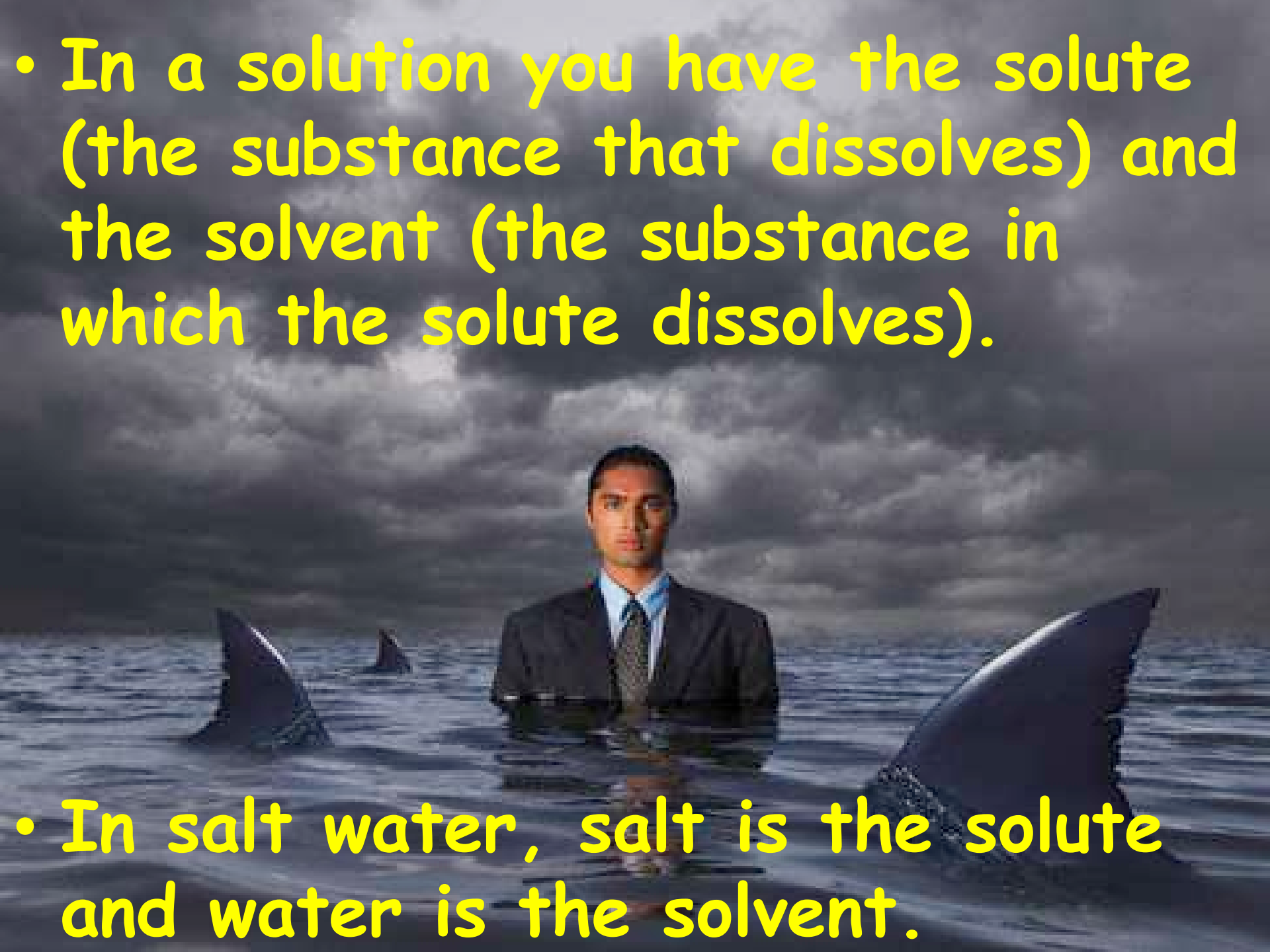
Living things are in part composed of mixtures involving water.

Two types of mixtures that can be made with water are solutions and suspensions.

- A solution is a mixture of two or substances in which the molecules of the substances are evenly distributed.



- In a solution you have the solute (the substance that dissolves) and the solvent (the substance in which the solute dissolves).



- In salt water, salt is the solute and water is the solvent.

- Water's polarity gives it the ability to dissolve both ionic compounds and other polar compounds.

Water is the greatest solvent on Earth.

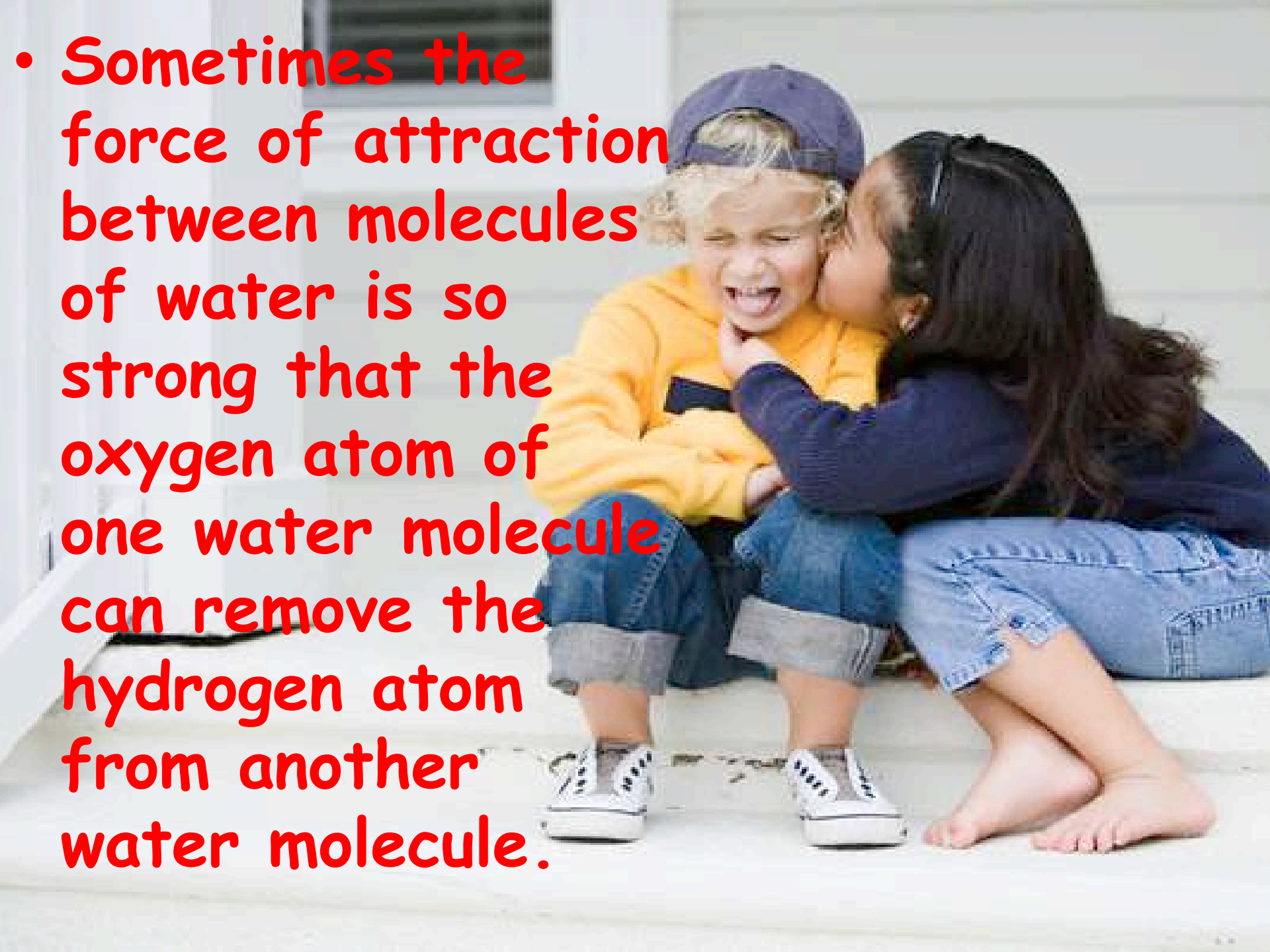
- Some materials do not dissolve when placed in water. Instead they separate into pieces so small that they do not settle to the bottom.

- The movement of water molecules keeps the small particles suspended.
- Mixtures of water and nondissolved materials are called suspensions.

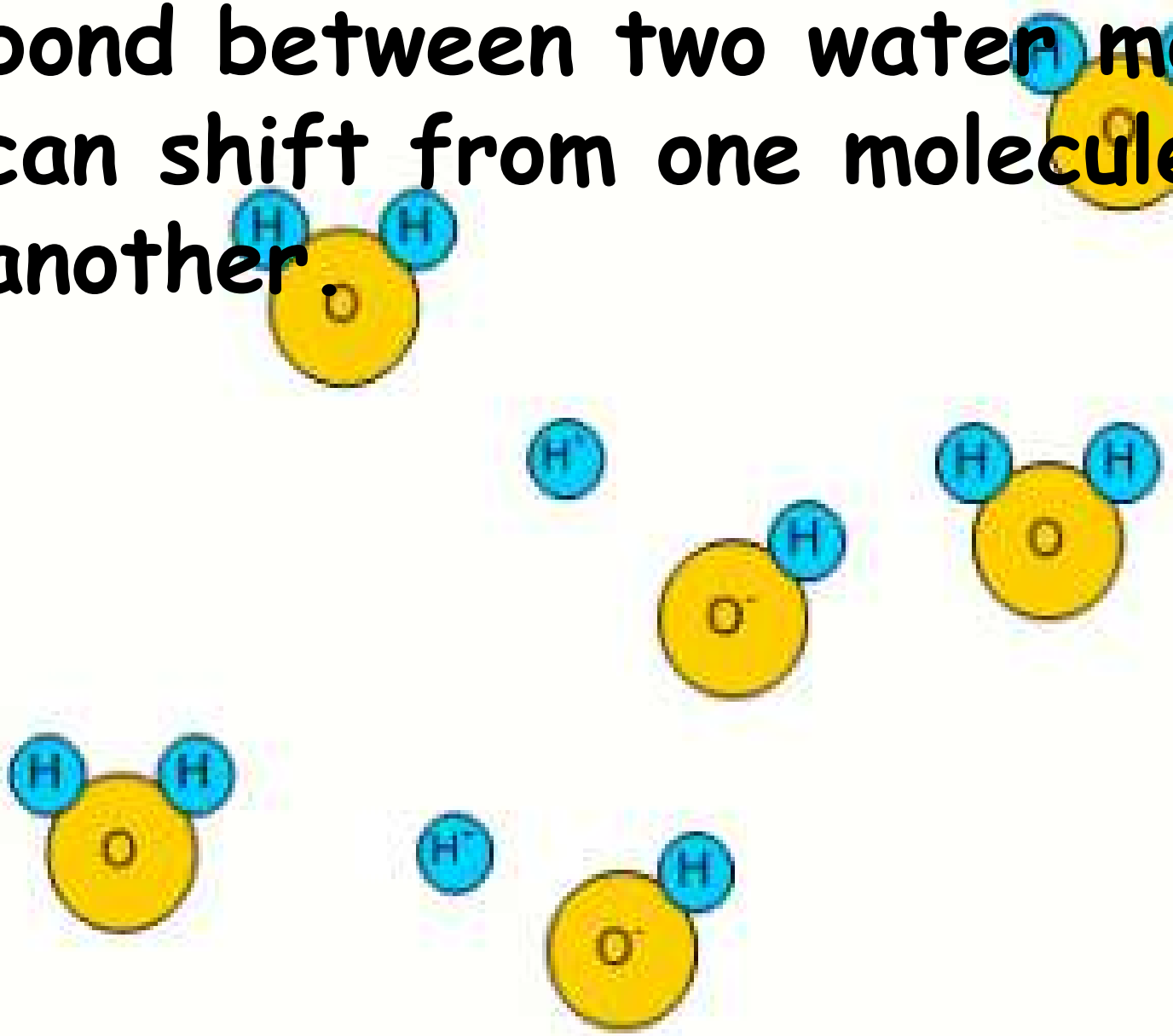
- Some of the most important biological fluid are both solutions and suspensions.

- Blood is mostly water which contains many dissolved particles (making it a solution); however, it also contains cells and other undissolved particles that remain suspended because blood circulates.

- Sometimes the force of attraction between molecules of water is so strong that the oxygen atom of one water molecule can remove the hydrogen atom from another water molecule.

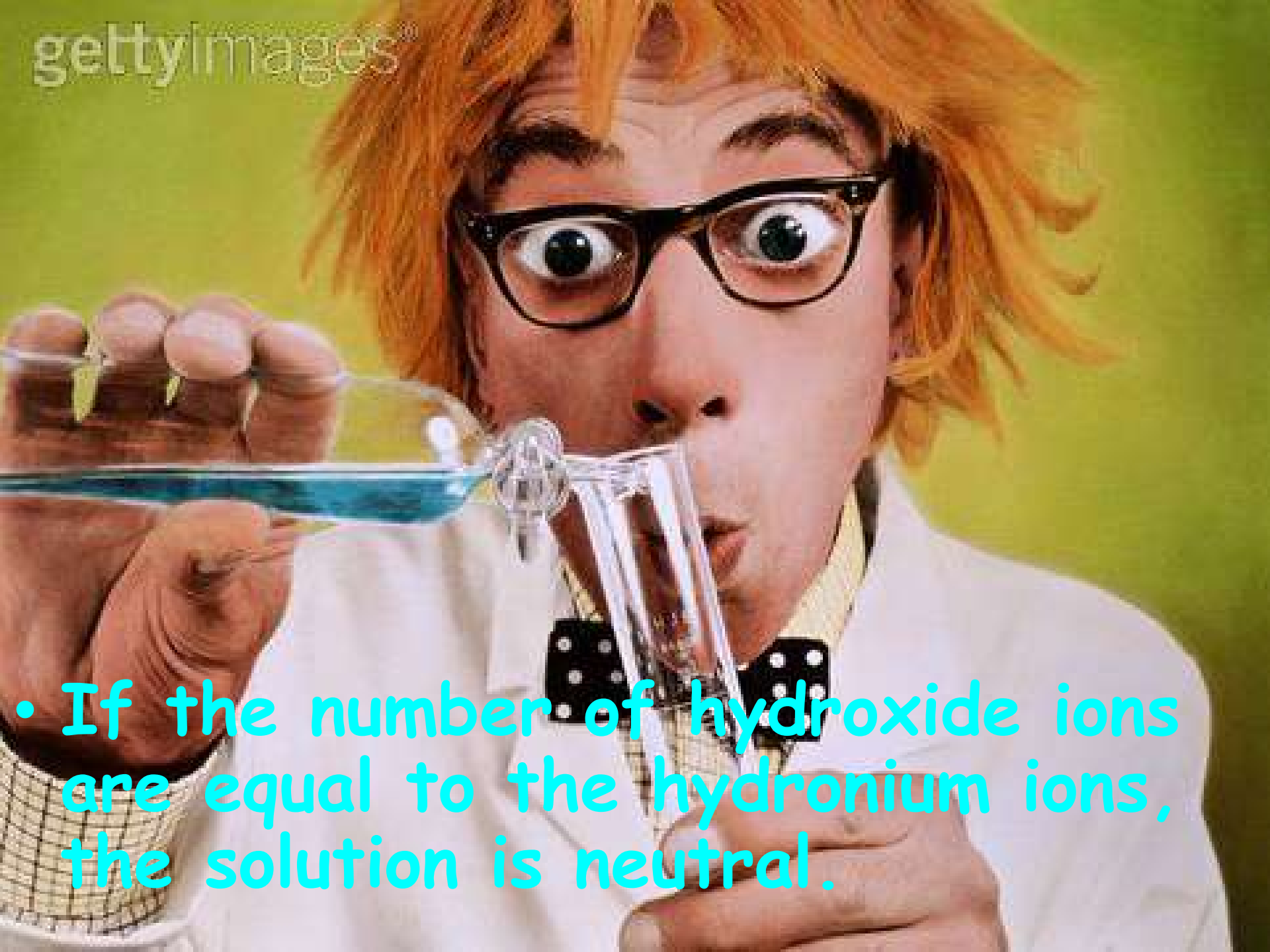


- A hydrogen atom in a hydrogen bond between two water molecules can shift from one molecule to another.

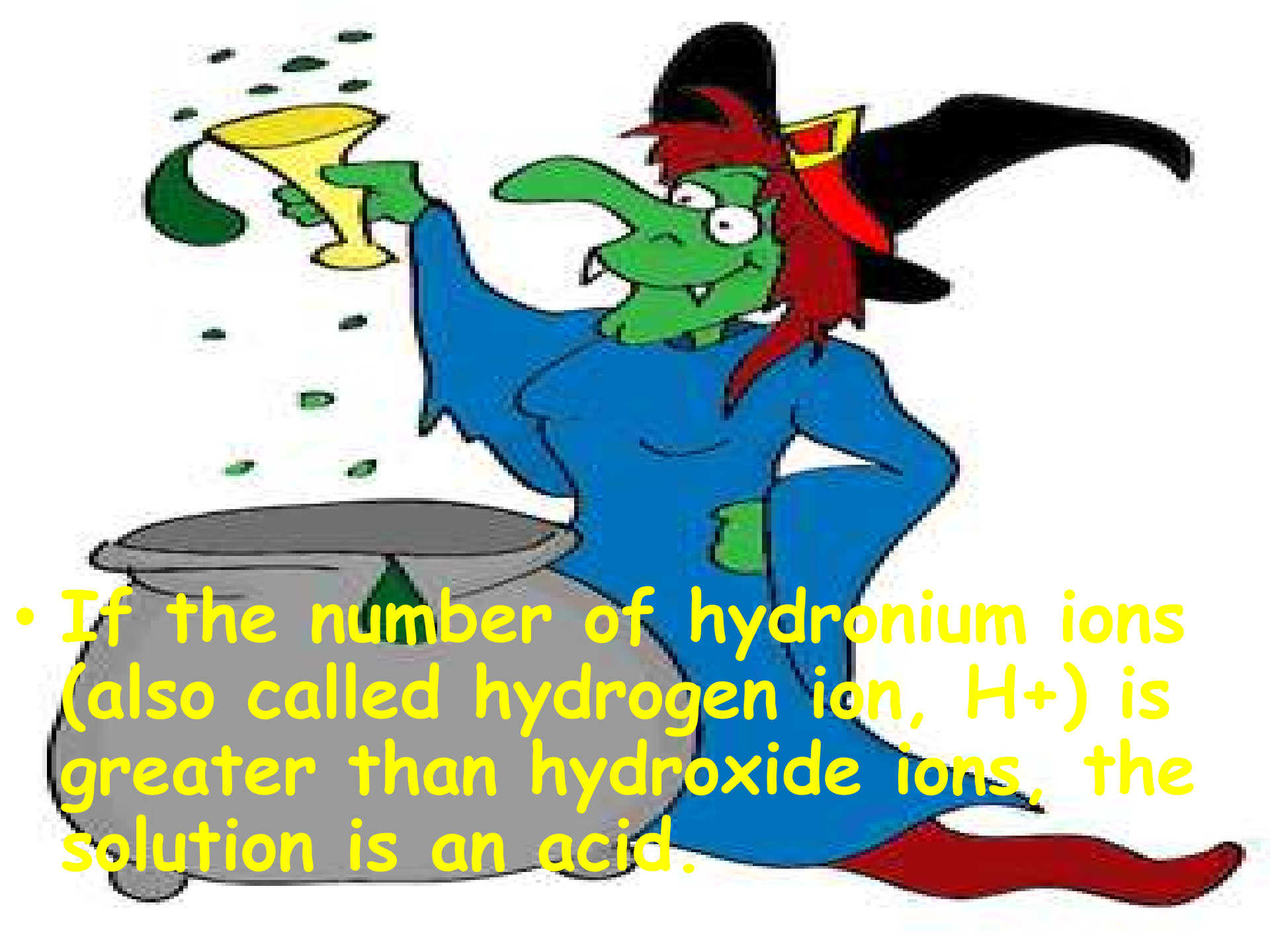


- The breaking apart of a water molecule into two ions is called dissociation.

$H_2O \rightarrow H^+ + OH^-$

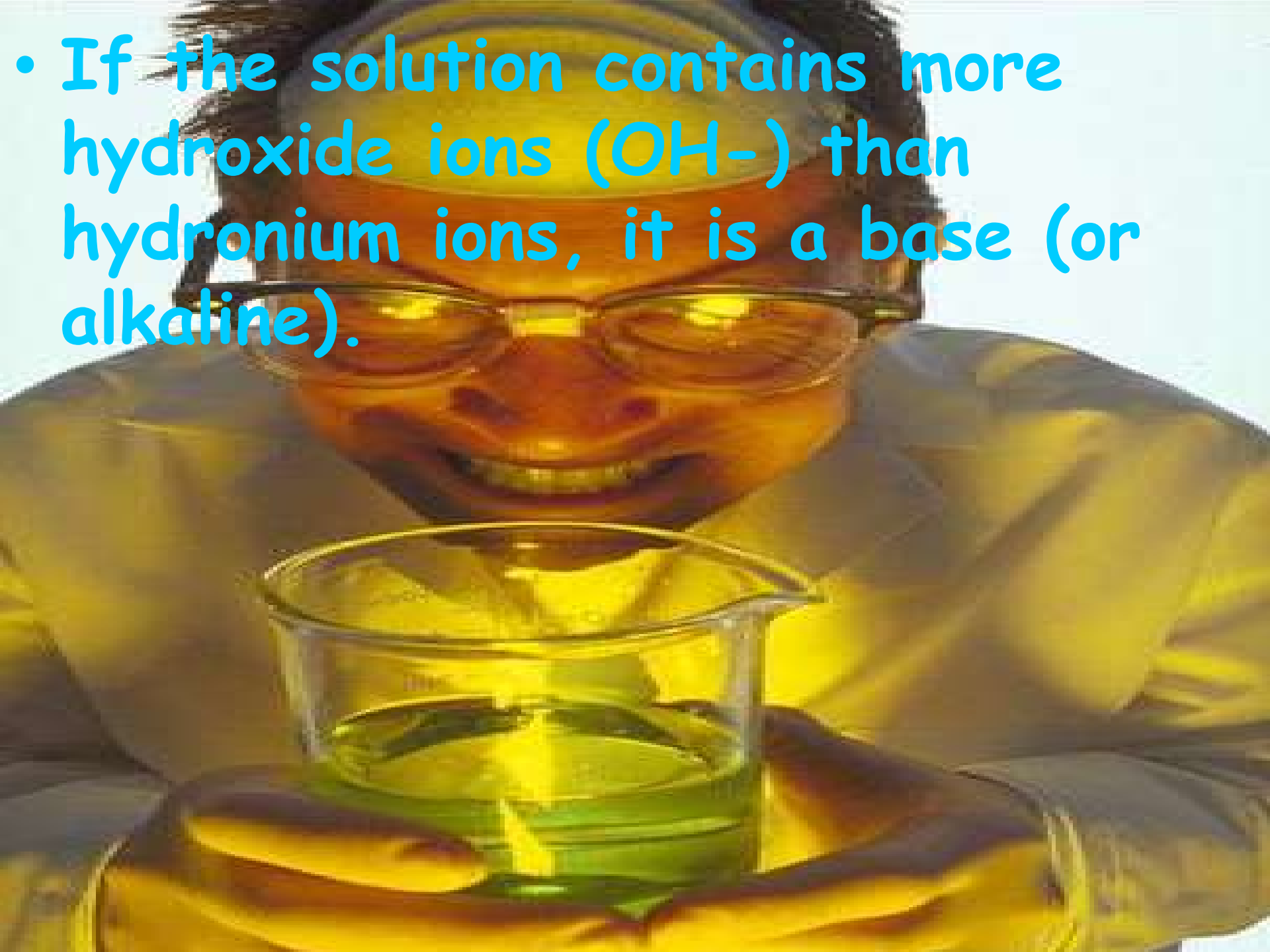


- If the number of hydroxide ions are equal to the hydronium ions, the solution is neutral.



- If the number of hydronium ions (also called hydrogen ion, H+) is greater than hydroxide ions, the solution is an acid.

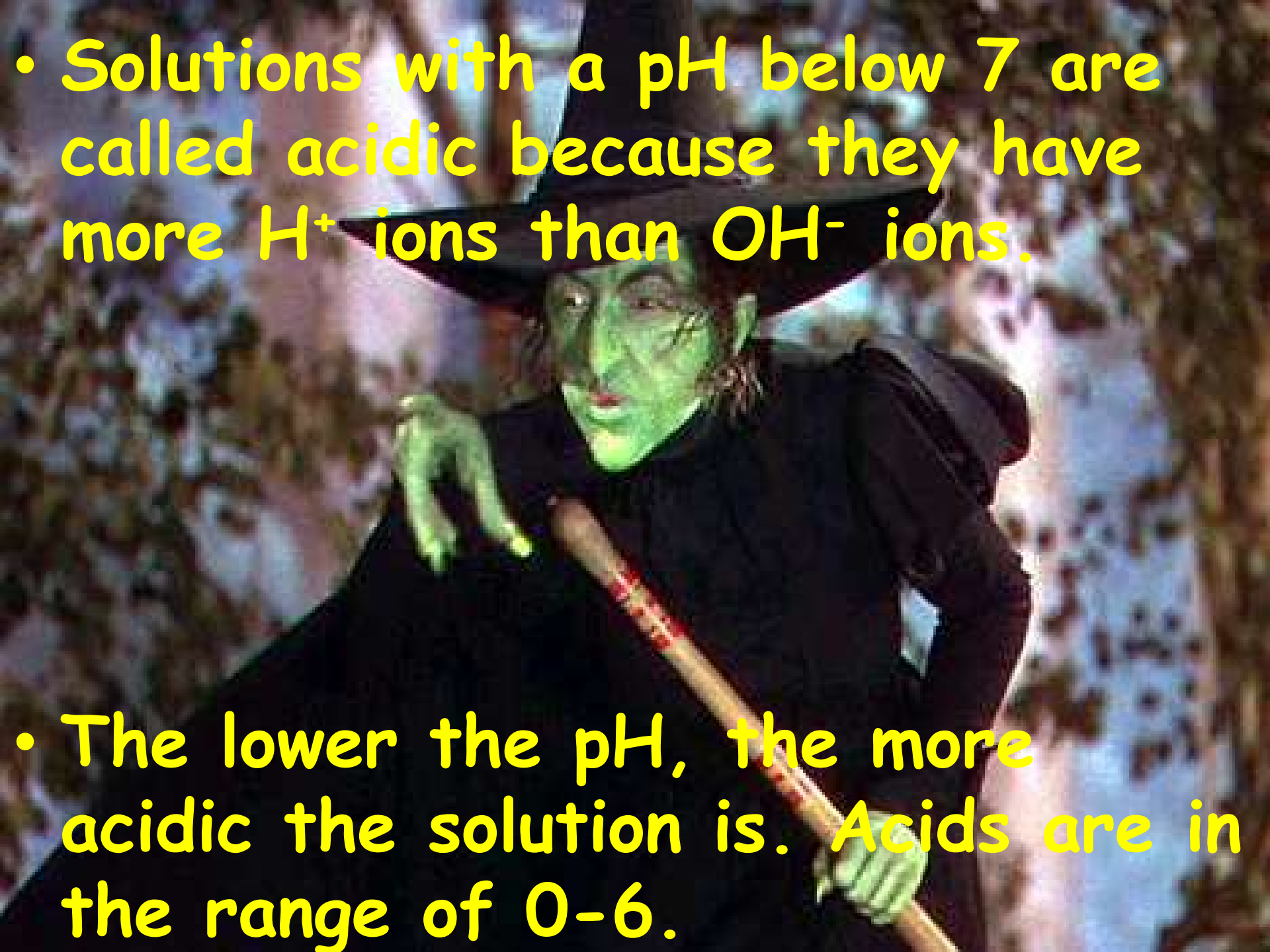
- If the solution contains more hydroxide ions (OH-) than hydronium ions, it is a base (or alkaline).



- Chemists devised a measurement system called a pH scale to indicate the concentration of H^+ ions in solutions.

- The pH scale ranges from 0-14. At a pH of 7, the concentration of H^+ ions and OH^- ions is equal.

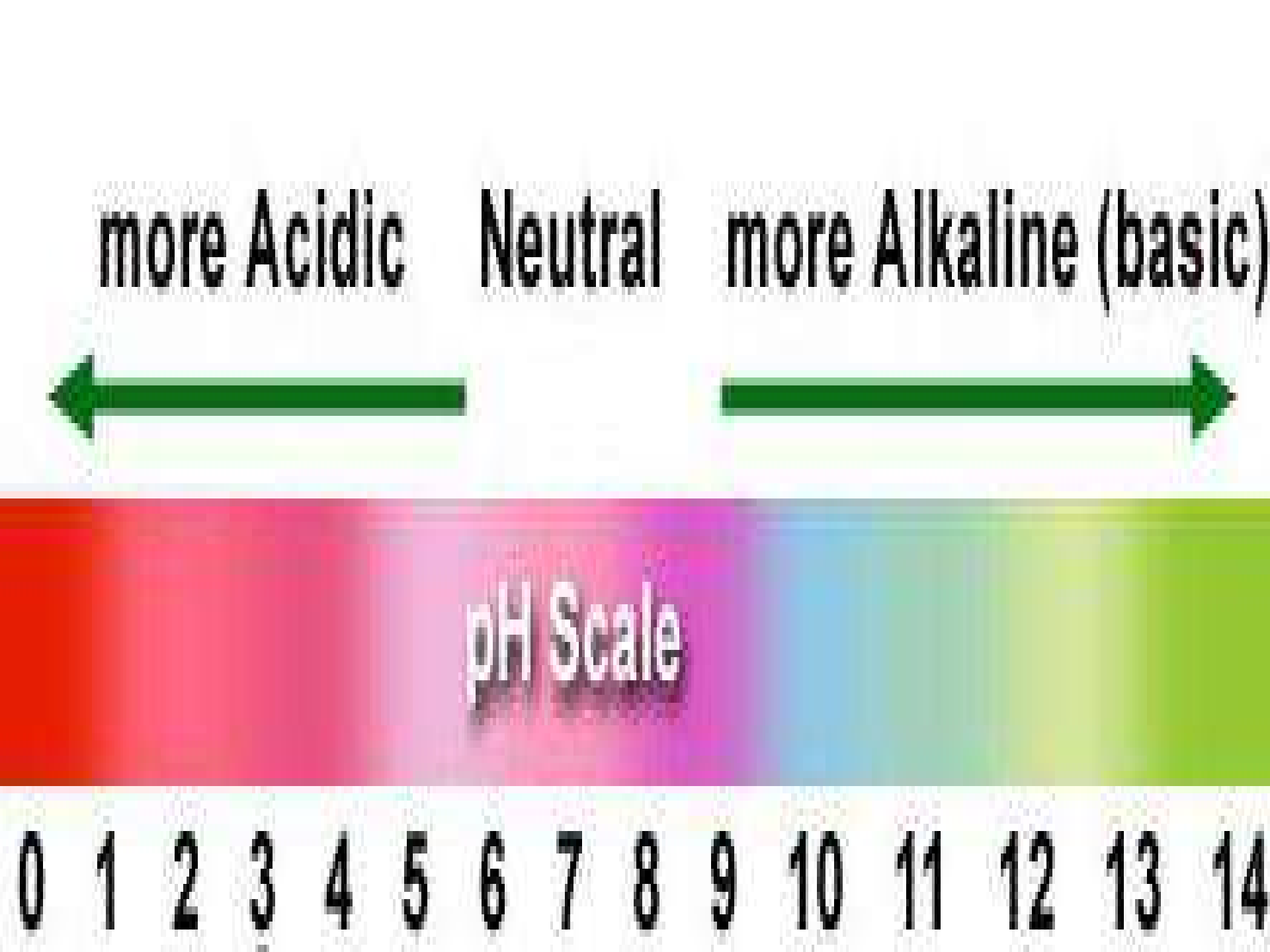
- Pure water has a pH of 7.

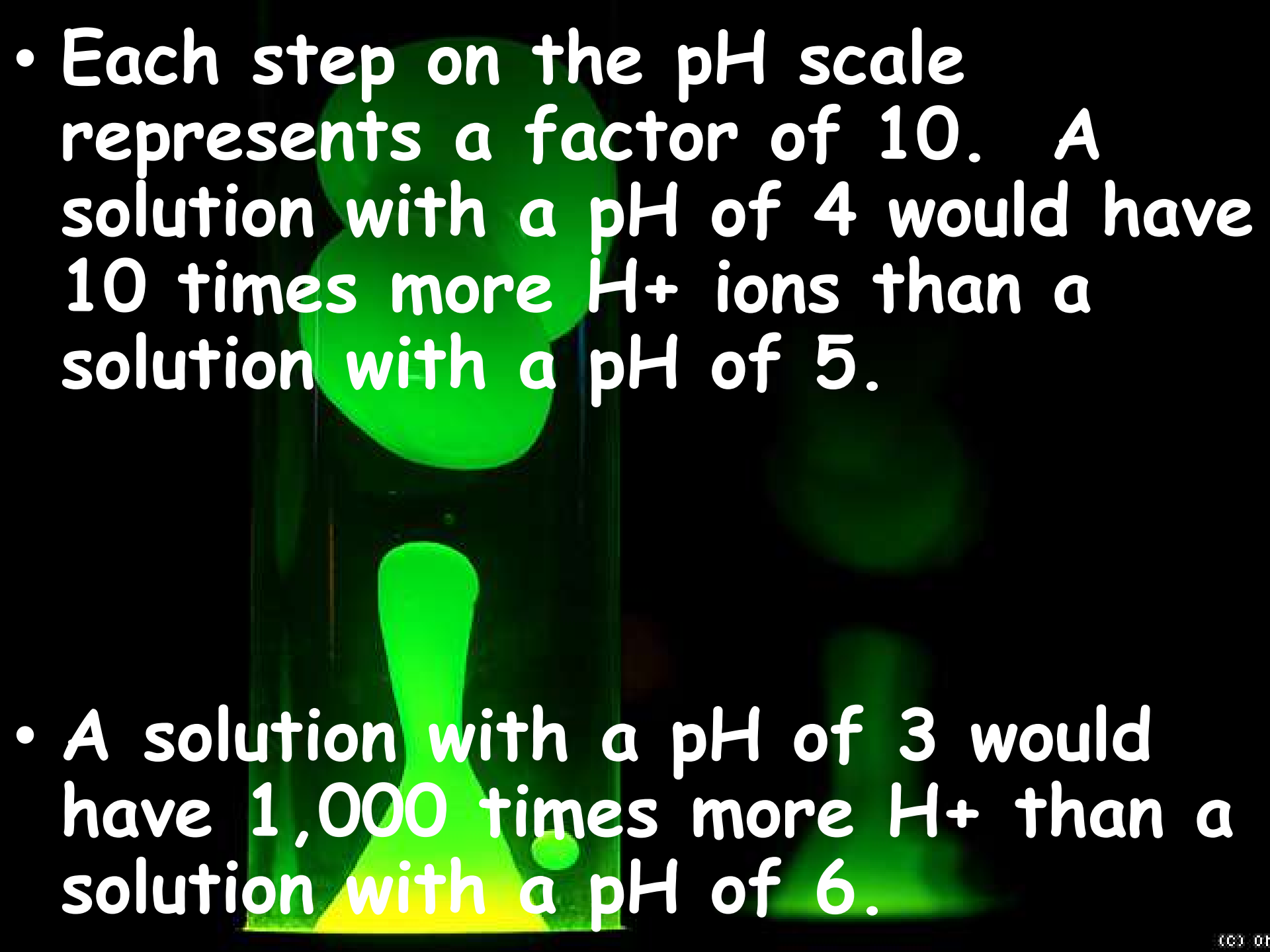


- Solutions with a pH below 7 are called acidic because they have more H^+ ions than OH^- ions.
- The lower the pH, the more acidic the solution is. Acids are in the range of 0-6.

- Solutions with a pH above 7 are called basic because they have more OH^- ions than H^+ ions.

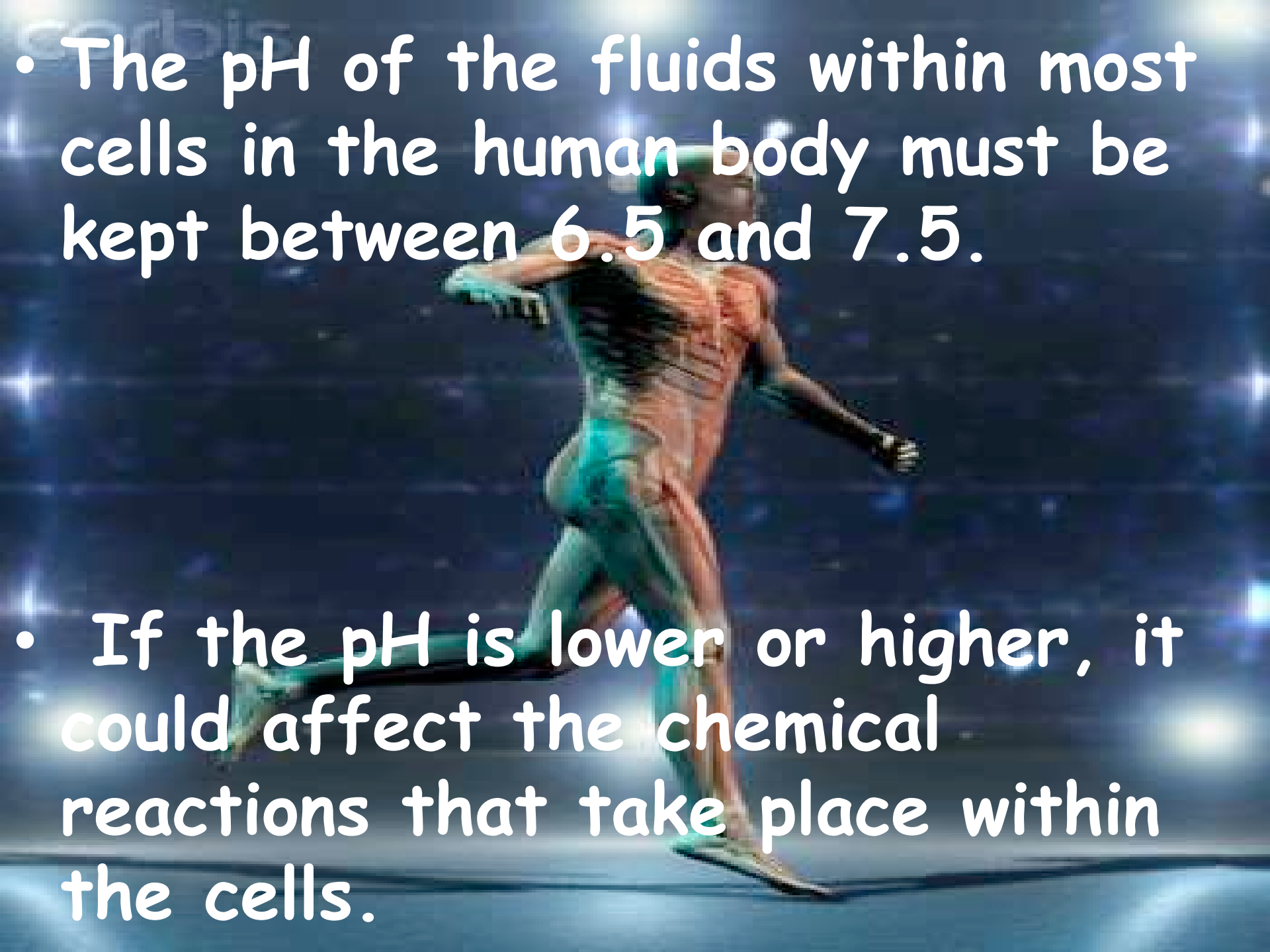
- The higher the pH, the stronger the base. Bases range from 8-14.


more Acidic
Neutral
more Alkaline (basic)
pH Scale
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14



- Each step on the pH scale represents a factor of 10. A solution with a pH of 4 would have 10 times more H+ ions than a solution with a pH of 5.

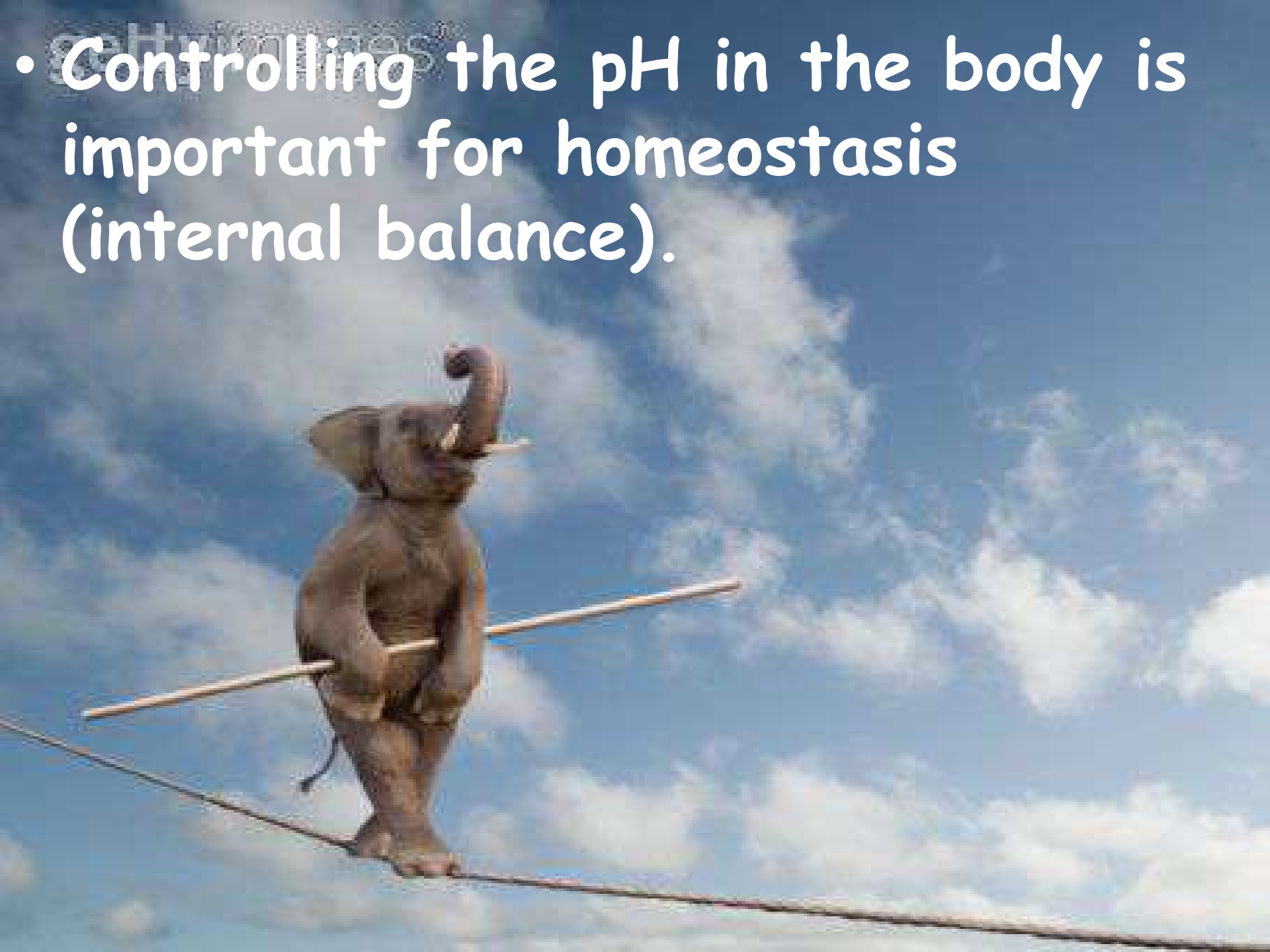
- A solution with a pH of 3 would have 1,000 times more H+ than a solution with a pH of 6.

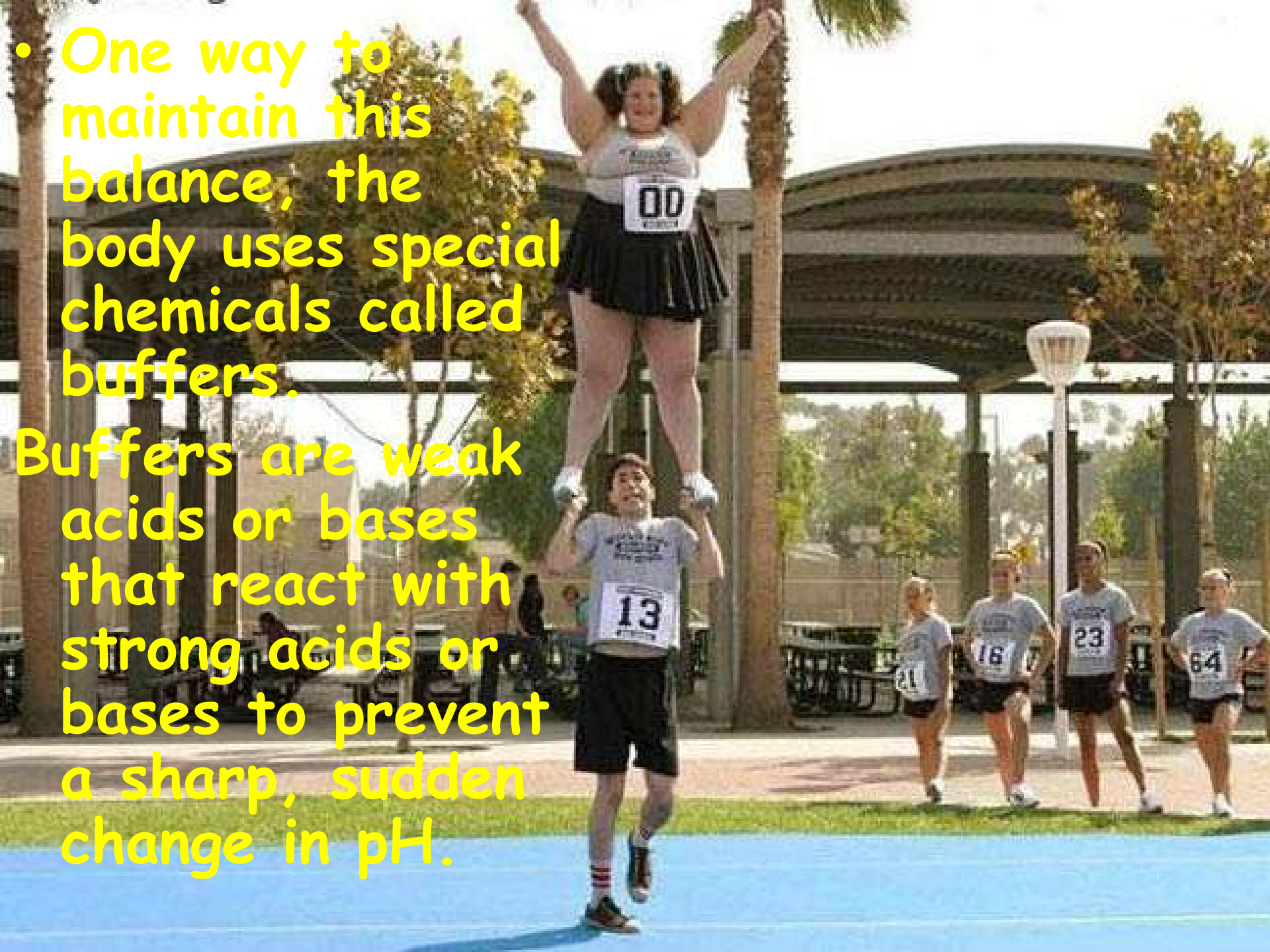


- The pH of the fluids within most cells in the human body must be kept between 6.5 and 7.5.

- If the pH is lower or higher, it could affect the chemical reactions that take place within the cells.

- Controlling the pH in the body is important for homeostasis (internal balance).





- One way to maintain this balance, the body uses special chemicals called buffers.

Buffers are weak acids or bases that react with strong acids or bases to prevent a sharp, sudden change in pH.

- BART mixes acids and bases – YouTube
- Acids and Bases Champions Science Adventures - YouTube