The six main elements found in living things:

C O H N S P

Living things are composed of only about 26 elements; 6 of these 26 make up practically all of the weight of most living matter. The other 20 elements essential for life are present in very small amounts, some in such tiny amounts that they are simply called "trace elements" [Spurenstoffe]. Nevertheless they are very important for the functioning of an organism; some examples are: iron (in red blood cells), iodine (in thyroxine, a hormone), cobalt (in vitamin B12), zinc and copper (in enzymes). Na, K and Ca ions are important for nerve signalling, Ca is also in bones.

☞ Find the six elements (C, O, H, N, S and P) in the given periodic table. To what group do they belong (metals, nonmetals, etc.)?
The six elements are introduced below in their elementary form and their common natural occurence including living matter. Their abundance in a human body:
http://www2.open.ac.uk/openlearn/periodictablephase2/body-chemistry.html

Carbon (Kohlenstoff) is the key component of all living matter on Earth! Our bodies are ca 20% C. We say that life on Earth is “carbon-based“.
https://www.seilnacht.com/Lexikon/6Kohlen.htm

Carbon molecules can form long chains and complex molecules with other elements, such as oxygen, hydrogen and nitrogen, to form the basic molecules of living things such as sugars and starch (called carbohydrates [Kohlenhydrate]), energy-rich fats and structural proteins of organisms including muscles, nails and hair, and special messenger substances such as hormones. Plants’ cell walls are made of C-based “cellulose“ [Zellulose] (paper tissue fibers!). Carbon is also found in graphite pencils, in fossil fuels such as coal and petroleum oil and in petroleum products such as synthetic plastics.

This diversity is possible because of carbon’s chemical properties, based especially on the four electrons in its outer shell, enabling it to form *covalent bonds* with oxygen and hydrogen atoms in such compounds. Having 4 electrons means that it can accept 4 more to complete its outer shell of 8.

Small molecules such as the compounds CO_2 (carbon dioxide) and methane [Methan, Erdgas] (CH_4) are gases and are not considered organic molecules.

wyomingmining.org https://i.ytimg.com/vi/SQpGEIZAaas/hqdefault.jpg

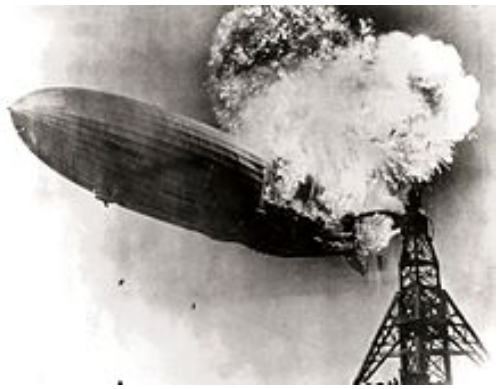
Above: Coal (soft and flammable) resulted from plant remains 100s of millions of years
Diamonds (the hardest substance on Earth) are also made of elemental carbon.

Some people want to have the remains of a beloved pet [Haustier] turned into a diamond!

http://www.dna2diamonds.com/pet-diamonds

Hydrogen (Wasserstoff) is the "first" and most basic element in the universe, i.e. the element with the smallest and lightest atoms (with only 1 proton and 1 electron). It is also the most common element in the universe (≈ 75%) and is the material of stars! In stars hydrogen exists in an extremely hot state of matter called "plasma" where the H-atoms get converted into He-Atoms in a process called fusion. It is an important part of all living matter and exists as a gas (H_2) in our atmosphere.

Because hydrogen is the lightest element, lighter than air, it was used for filling "Zeppelins", a type of airship with propeller engines (with propane gas as fuel) and a cabin carrying passengers. As *hydrogen reacts violently with oxygen* (it burns explosively) to form water if a spark sets off the reaction, its use in such "airships" was extremely dangerous. The famous Zeppelin disaster of 1937 resulted in the deaths of 36 of the 97 people onboard. Today's ballons are filled with the noble gas helium.



http://www.corbisimages.com/Search#mlt=BE027464&mla=10352424 Betmann/CORBIS

Hydrogen in the water molecule

As you learned in the tutorial, the hydrogen atom in the water molecule cannot be easily dislocated, the water molecule is a very stable particle.

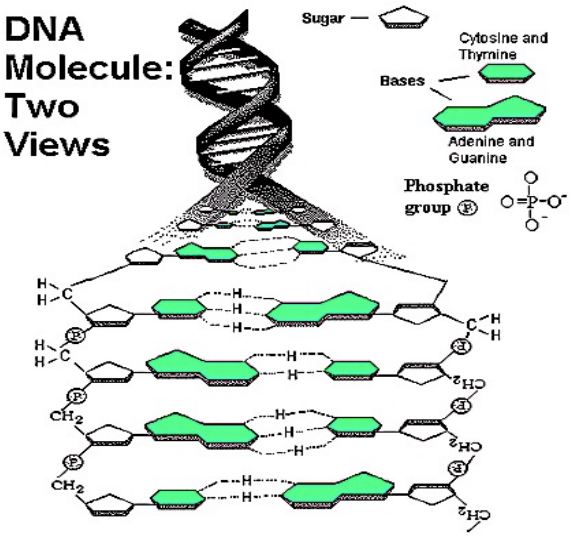
In the watery inner milieu of living things the hydrogen atom in molecules can form weak bonds (connections) between some organic molecules and between water and organic molecules. These "*hydrogen bonds*" are held together by the attraction between the positive and the negative sides of some molecules with shared electrons (you may want to check the picture of the "polar" water molecule model in your tutorial). The positive and negative sides attract eachother liketwo magnetic poles.

See also: https://www.youtube.com/watch?v=UukRgqzk-KE

http://www.livestrong.com/article/184056-the-major-importance-of-hydrogen-in-living-organisms/

"Hydrogen bonds" between molecules can easily be disconnected when necessary.

Example DNA: Hydrogen bonds enable the two strands of DNA to stay together until they need to be separated when the information in the DNA needs to be accessed.

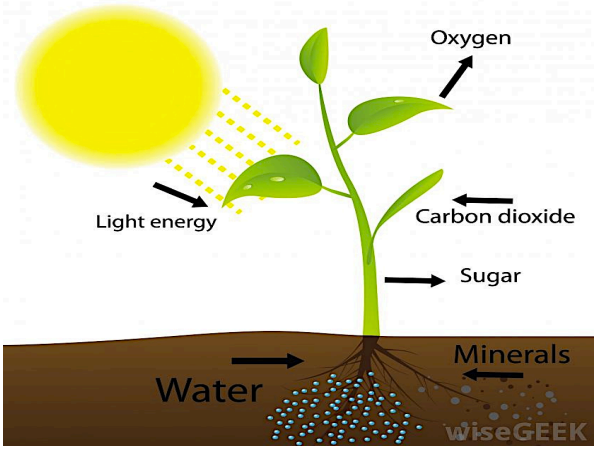


Oxygen (Sauerstoff) is the *most common element* in the earth's crust [Erdkruste, Erdoberfläche] and in organisms.

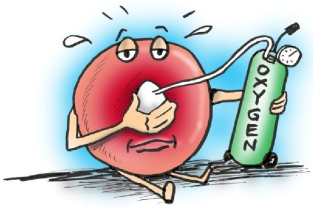
Our air is 21% oxygen. Oxygen is an odourless and invisible gas (O_2) in our atmosphere and is a part of the water molecule.

When plants make their own food in *photosynthesis* with the help of sunlight they produce oxygen.

Oxygen is the gas that most living things, including plants, need for *respiration* in order to free the energy in the glucose (sugar) molecule. This energy is needed by an organism to carry out the life processes – sensitivity, movement, reproduction, growth, feeding, excretion, etc.



Photosynthesis in a plant images.wisegeek.com/photosynthesis.jpg



industrialoxygengasplant.wordpress.com

Oxygen is a very *reactive gas*, it "burns" fuels (substances that contain energy) when it is ignited with a spark or flame, and also forms "oxides" with almost all other elements such as iron [Eisen] (example). This reactive property [Eigenschaft] explains its toxicity for some organisms (for example for some harmful pathogenic bacteria). Pure oxygen itself does not burn!

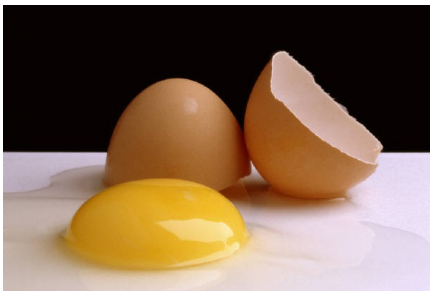
https://i.ytimg.com/vi/iz7wtTO7roQ/hqdefault.jpg

http://yourpetsneedthis.com/wp-content/uploads/2014/03/rusty-nails.jpg

Example: iron combines with oxygen to form rust [Rost].

Sulfur (Schwefel) is an important part of proteins (Eiweisse), for example in eggs.

In nature sulfur can be found as a solid made of bright yellow crystals (in different forms).



https://upload.wikimedia.org/wikipedia/commons/2/2e/Sulfur.jpg

Organic sulfur compounds are the cause of unpleasant smells when organic matter decays [sich zersetzt], such as the smell of rotten eggs. Other organic sulfur compounds add interesting flavours to foods such as cheeses, garlic, chocolate and some tropical fruits!

The downside of organic sulfur

Because *fossil fuels* are formed from the remains of organisms, they also contain sulfur compounds. When these fuels burn in the air using oxygen, sulfur is released into the atmosphere as sulfur dioxide gas. This compound is very aggressive and can pollute the air, combining with rain water to form “acid rain“ [saurer Regen] which is a threat to aquatic organisms [Wasserlebewesen] with calcareous shells [Kalkschalen] and is destroying many old limestone [Kalkstein] monuments.

Nitrogen (Stickstoff) is the most common element in the atmosphere; 78% of it is nitrogen gas N_2.

Nitrogen is an important part of the complex molecules of living things, in proteins, hormones and DNA. Animals can get nitrogen when they eat plants (or eat eachother!) but plants need to take up nitrogen from the soil [Erde] as salts dissolved in water with their roots.

When humans take wheat, rice, potatoes and other plants out of the soil for food, they also remove the nitrogen which the plants got from the soil. This nitrogen has to be replaced, usually as fertilizer [Dünger], either as inorganic (mineral) fertilizer (such as nitrate) or as organic compost fertilizer or even as animal excretions sprayed on farmland – like liquid manure [Jauche, “Gülle“].

Muensterlandzeitung.de

Phosphorus (Phosphor) does not exist in a pure elementary form because it is so extremely reactive: in air it would "self-ignite" and burn! (Pure P_4 must be stored in water.) For this reason it can only be found as *phosphate* in mineral deposits.

As it ignites [entflammt] easily in air it is used in match striking surfaces – and in deadly bombs!
https://www.youtube.com/watch?v=1CrEZKe1x_k

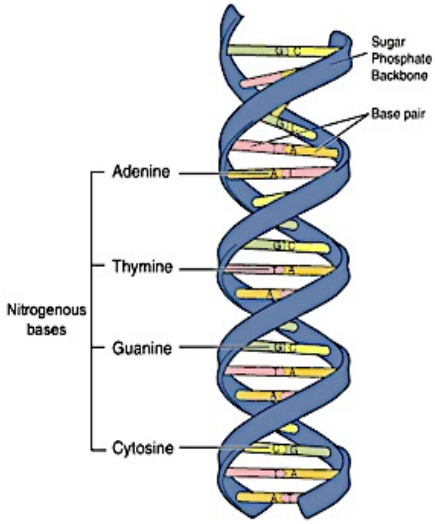


Image adapted from: National Human Genome Research Institute.

Bones and DNA contain phosphorus

Phosphorus is an important part of proteins and genetic material (DNA). It gives bones their strength.

As phosphorus limits plant growth (like nitrogen), phosphate salts are also commonly used in fertilizers [Dünger] because it is always being removed from the soil together with the crops.

Phosphorus used in fertilizer is also originally produced by living things, for example as animal excretions such as "guano", the droppings of sea birds:

A "fertilized" lake Bioclearwater.com

Dissolved phosphorus and nitrogen fertilizer salts are often washed from farmlands and carried down into lakes and rivers, acting as "fertilizer" on aquatic plants [Wasserpflanzen]. The result is often a massive growth of algae in the warm season, becoming a green slimy mass together with bacteria rotting in the sun on the water surface. This can become a problem when the bacteria on the decaying algae use up too much oxygen which fish and other animals need.

Body chemistry This interactive site is full of interesting facts about the elements of life!

http://www2.open.ac.uk/openlearn/periodictablephase2/body-chemistry.html

The three basic nutrients (Nährstoffe)

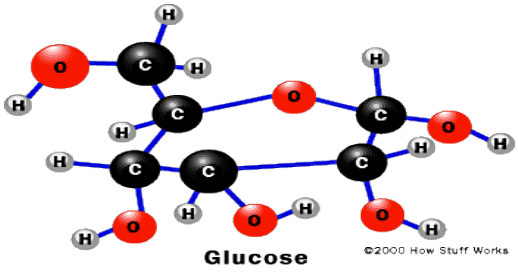
The three basic organic nutrients – carbohydrates, fats (& oils) and proteins are a part of all living organisms. All contain the nonmetal elements carbon, oxygen and hydrogen.

Carbohydrates are compounds made of carbon, hydrogen and oxygen and are the most important *source of energy* which organisms (plants) produce and all organisms utilize.

They include sugars and starches [Stärke] (in potatoes, rice & pasta).

Carbohydrates are also used by organisms for making mucus [Schleim].

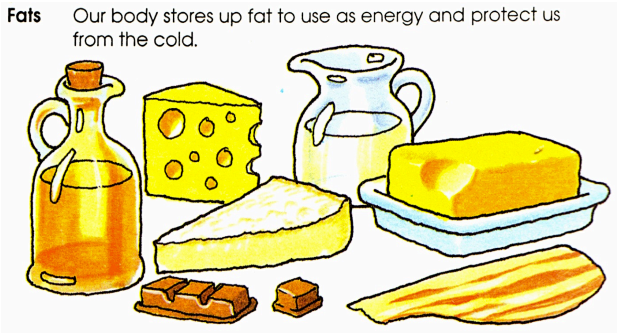
The molecules exist in the form of chains and rings (sugars) or long spirals (Starch).



Glucose = Traubenzucker

Fats (solid) and oils (liquid) also consist of carbon, hydrogen and oxygen like the carbohydrates, but the atoms in the molecules are organized differently than in carbohydrates so that they are water-repellent [wasserabstossend]. Oil and water do not mix.

They are *high-energy molecules*, often stored in the body or in the seeds of plants (sunflower seeds and nuts) as reserves. In addition they are a key component of cell membranes and brain tissue.



mariannegutierrez.com

expertrain.com

Proteins consist of large molecules made of many “amino acids“ [Aminosäuren], often showing a final complex 3-D structure. Apart from H, C and O atoms they typically contain N and sometimes also S.

Proteins are a basic building block of especially animal bodies, of muscles, organs and and eggs. They are in every cell. Thus meat (muscle), fish and eggs are primary sources of protein.

The “legumes“ [Hülsenfrüchte] such as soya, chick peas [Kichererbsen] and beans are an important source of plant proteins (especially for vegetarians).

“Enzymes“, which help the body to efficiently carry out chemical reactions, are also proteins with special structured “sites“ for “working“ on molecules.

Below is a model of the complex enzyme “catalase“ which breaks down a toxic product appearing in the cell during metabolism [Stoffwechsel]. The red parts indicate the sites where it temporarily attaches to the substance it has to break down.