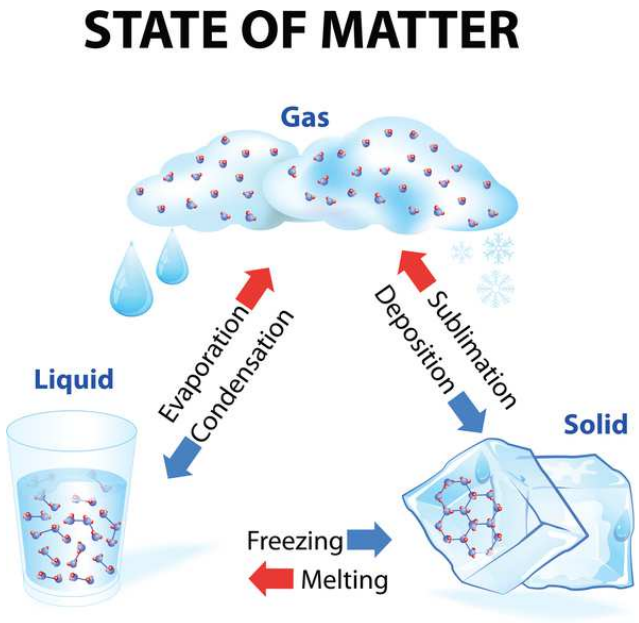
The forms of water

Drinking a glass of water is the most simplest act in the world. Or rather, in this world. Very special and very rare conditions must occur in order for water to be liquid: our planet is a marvellous exception.

Water is an extraordinary molecule. It is minute, made up of only three atoms, two of which are hydrogen, which are also the tiniest of all. The third is an oxygen atom, large enough to attract the electrons of the two hydrogen atoms towards it. The well-known chemical formula H_2O means precisely one atom of oxygen (O) plus two hydrogen atoms (H). Due to the uneven distribution of the electrons, that is of the negative charges, a water molecule behaves like a sort of minute magnet: oxygen is the negative pole, the two hydrogen atoms form the positive one; water is therefore a polar compound. Just like magnets, water molecules attract one another and bond together in a fluid and dynamic lattice in which the bonds from and dissolve at a rate that depends on the temperature: faster if the water is hot, more slowly if it is cold. At 0°C, the bonds become stable and water solidifies into ice; at 100°C, the bonds become too fragile and water turns into a gas: steam.



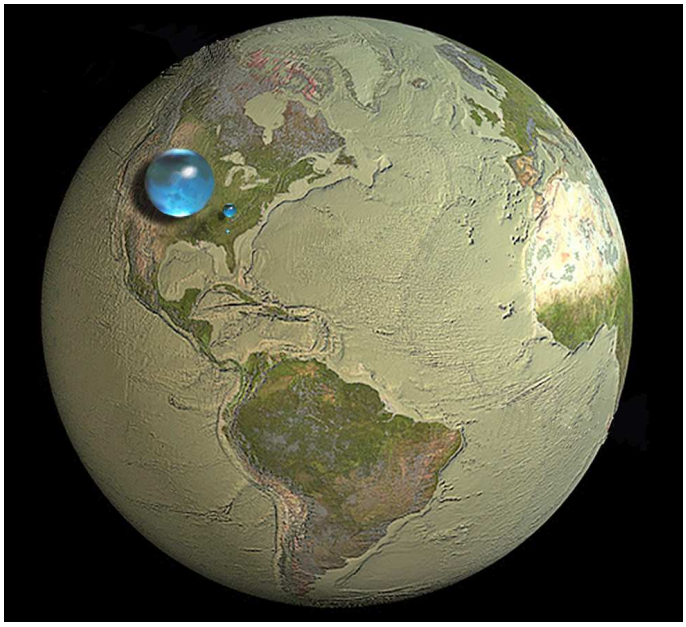
Changes in the state of water

Like tiny magnets, water molecules attach themselves to substances, they slip into crystals, break the bonds and dissolve the matter. Water is an extraordinary solvent, it dissolves all manner of substances, but only those that, like it, have a polar nature: salt, sugar, lime, bicarbonate. Neutral molecules, that is those without surface electric charges, are also known as non-polar and do not dissolve in water. Water rejects them and they, if immersed in liquid, aggregate in large drops, as oil does on the surface of a glass of water. Interactions between the water solvent, solutes and non-polar molecules are the chemical basis of life.

Water covers 71% of Earth's surface, but occupies only a thousandth of the total volume of the planet. If all the water on Earth were collected in a sphere, it would be a sphere sixteen times smaller than the moon. Water is a vital daily presence, so familiar that it makes us lose sight of its mysterious origin. Where does the water in our glass, that of the

Con il patrocinio del Ministero dell' Istruzione, dell' Università e della Ricerca
e Ministero dell'Ambiente e della Tutela del Territorio e del Mare

seas, or the water that makes up 70% of our bodies come from? The debate on the origin of the water on our planet has not yet been solved. According to some theories, water has an extra-terrestrial origin, according to others it was formed at the same time as Earth.



How much water is there on Earth? The large blue sphere represents all the water available on Earth; the second represents the fresh water on Earth; the smallest sphere represents the quantity of fresh water in rivers and lakes. Credits: USGS

Comets are solid blocks of rock fragments held together by abundant frozen water and gas in the solid state, such as carbon dioxide present in the form of dry ice. Theories that sustain the “space” origin explain that water-rich celestial bodies, like comets and particular asteroids (carbonaceous chondrites), bombarded the planet that had just formed and freed the precious substance on its surface. More recent theories hold that it is more probable that water was already present in the cloud of gas and detritus surrounding the sun from which the planets originated. Therefore, Earth is thought to originate from that ancient wet dust. It is fascinating to think that the water we are drinking is a mouthful of space.

Recently a group of Italian researchers discovered liquid water on Mars by analysing the radar data collected by the Mars Express probe in orbit around the red planet. Under the surface, at a depth of approximately 1500 metres, there is a lake that stretches for twenty square kilometres and therefore as large as Lake Orta in Piedmont. It is very likely that it contains salt water because it is liquid even though the temperature measured is lower than zero and we know that salt, on Earth too, lowers water's freezing point. Together with the icecaps that make Mars’ poles white, the salt lake is what remains of the plentiful water that once flowed on the surface of the planet. We are sure of this because traces remain on Mars of the ancient seas, rivers and lakes dried by the solar wind, the flow of charged particles issued by the star, that swept the surface of the planet, cancelling the water and perhaps simple lifeforms. The underground lake, on the contrary, may still contain the descendants of what remains of life on Mars: in any case, nothing more complex than a bacterial cell. Earth, too, is constantly swept by solar wind, but fortunately the powerful magnetic field that moves compasses deflects the flow of radiation into space. At the poles of our planet, the auroras make this constant battle between solar particles, the magnetic field and the atmosphere splendidly clear.

There is also water on the Moon. It is ice accumulated at the bottom of the craters that are always in the shade in the polar regions of our satellite. It can also be found on the moons of other planets in the solar system. For example: under the frozen surface of Enceladus, one of Saturn's small moons, there is an immense salt ocean. This has been revealed by the Cassini probe that orbited around Saturn and its satellites for thirteen years before crashing onto the surface of the planet in September. Cassini took Huygens with it, a small probe that in December 2004 detached from it to fly by part of Titan and then land on it. Titan is something different. On Saturn's largest moon, the seas, lakes, rivers and even the rain are formed by methane. A hostile environment for life as we know it. On this world.

by Andrea Bellati