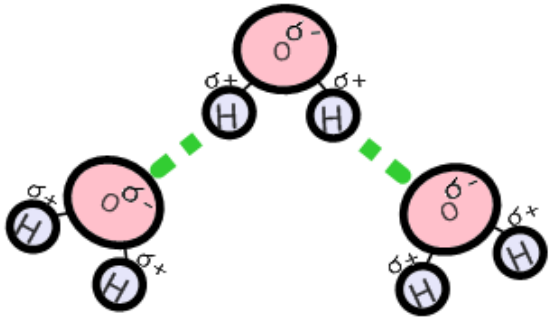


Chemical Elements and Water

Many elements occur frequently in living organisms or are of use in metabolic processes:

	I	II
1	1 **H** hydrogen	
2	3 **Li**	4 **Be**
3	11 **Na** sodium	12 **Mg** magnesium
4	19 **K** calcium	20 **Ca** potassium
5	37 **Rb**	38 **Sr**
6	55 **Cs**	56 **Ba**
7	73 **Fr**	74 **Ra**

The most commonly occuring elements in living organisms are:

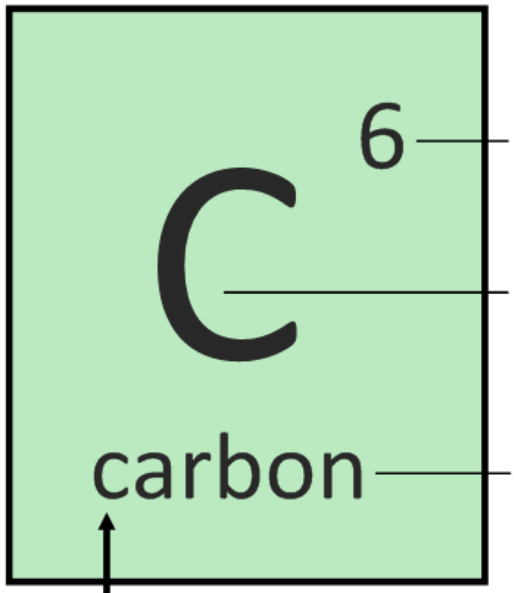
6 **C** carbon	1 **H** hydrogen	8 **O** oxygen	7 **N** nitrogen

Other common elements are shaded in green.

21 **Sc**	22 **Ti**	23 **V**	24 **Cr**	25 **Mn** manganese	26 **Fe** iron	27 **Co** cobalt	28 **Ni** nickel	29 **Cu** copper	30 **Zn** zinc
39 **Y**	40 **Zr**	41 **Nb**	42 **Mo**	43 **Tc**	44 **Ru**	45 **Rh**	46 **Pd**	47 **Ag**	48 **Cd**
57 **La**	58 **Hf**	59 **Ta**	60 **W**	61 **Re**	62 **Os**	63 **Ir**	64 **Pt**	65 **Au**	66 **Hg**
75 **Ac**	76 **Ku**	77 **Ha**							

III	IV	V	VI	VII	VIII
					2 **He**
5 **B**	6 **C** carbon	7 **N** nitrogen	8 **O** oxygen	9 **F**	10 **Ne**
113 **Al**	14 **Si**	15 **P** phosphorous	16 **S** sulphur	17 **Cl** chlorine	18 **Ar**
31 **Ga**	32 **Ge**	33 **As**	34 **Se**	35 **Br**	36 **Kr**
49 **In**	50 **Sn**	51 **Sb**	52 **Te**	53 **I** iodine	54 **Xe**
67 **Tl**	68 **Pb**	69 **Bi**	70 **Po**	71 **At**	72 **Rn**

Elements in the Periodic Table:



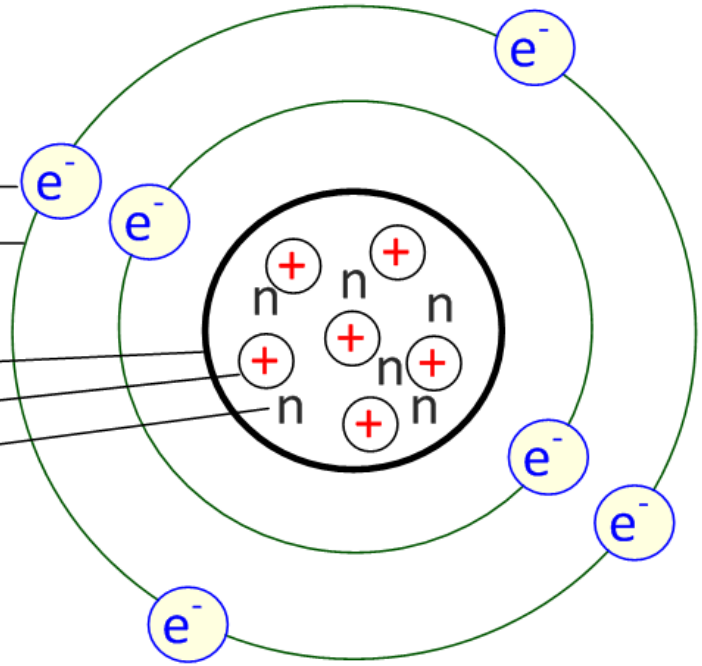
atomic number (number of protons) (+)
(same as electron number - if it is not an ion) (e^-)

element symbol

element name

do not capitalise

An Atom:



electrons:
can move in their shells
can be gained or lost

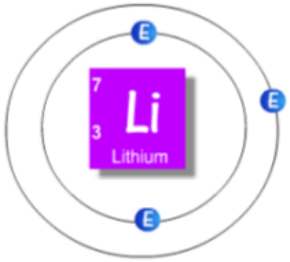
nucleus:
protons
neutrons
(locked in place)

Ions

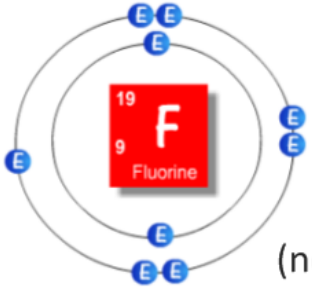
An unreactive (stable) atom has a full outer electron shell.
The inner shell is 'full' with two electrons.
Subsequent shells are 'full' with eight electrons.

inner shell = 2
(full)

outer shell = 1
(not full - lose one!)



Lithium



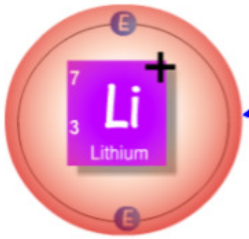
Fluorine

inner shell = 2
(full)

outer shell = 7
(not full - gain one!)

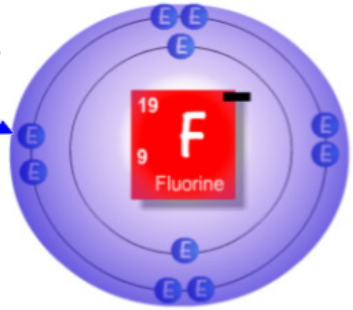
As electrons can be gained or lost, they may move from one atom to another, in order to complete the outer shell of both:

Now:
more protons
than electrons
so
postive CATION



Lithium ion

moves
e^-

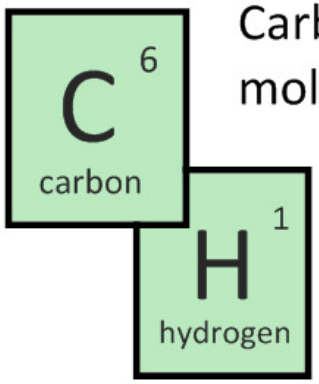


Fluoride ion

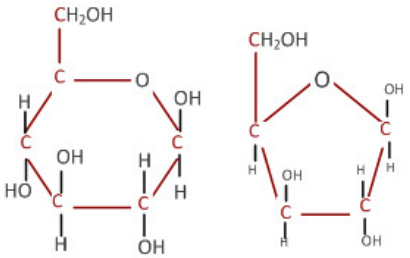
Now:
more electrons
than protons
so
negative ANION
"a negative ion"

images from http://www.footprints-science.co.uk/ionic.htm

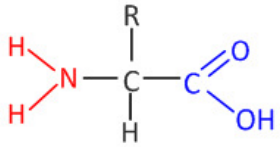
- http://www.footprints-science.co.uk/ionic.htm



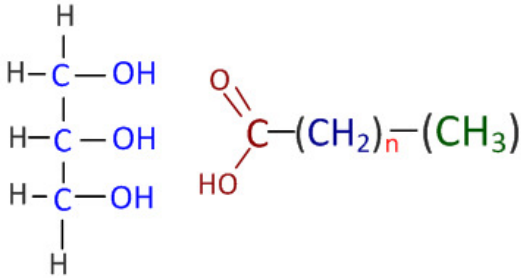
Carbon and hydrogen are the foundation of organic molecules: molecules found in living things:



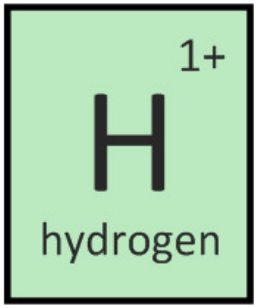
sugars & carbohydrates



amino acids & proteins

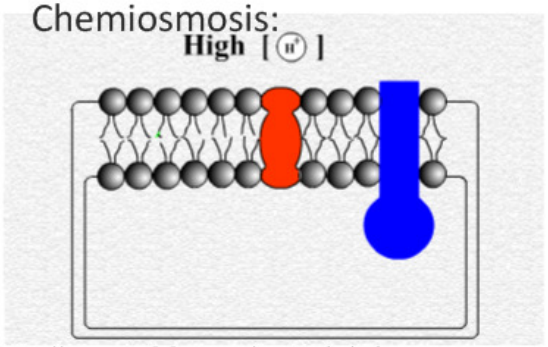


lipids: fats & oils

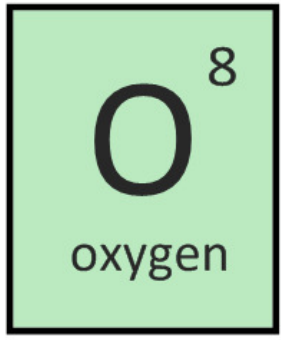


Hydrogen ions are used in active transport, photosynthesis, cell respiration (through chemiosmosis).

The pH of a solution is a measure of the activity of dissolved H^+ ions.
A low pH (1-6) signifies a high concentration of H^+ ions (high $[H^+]$).
A high pH (8-14) signifies low $[H^+]$.



http://www.tvdsb.on.ca/westmin/science/sbioac/plants/chemios.htm

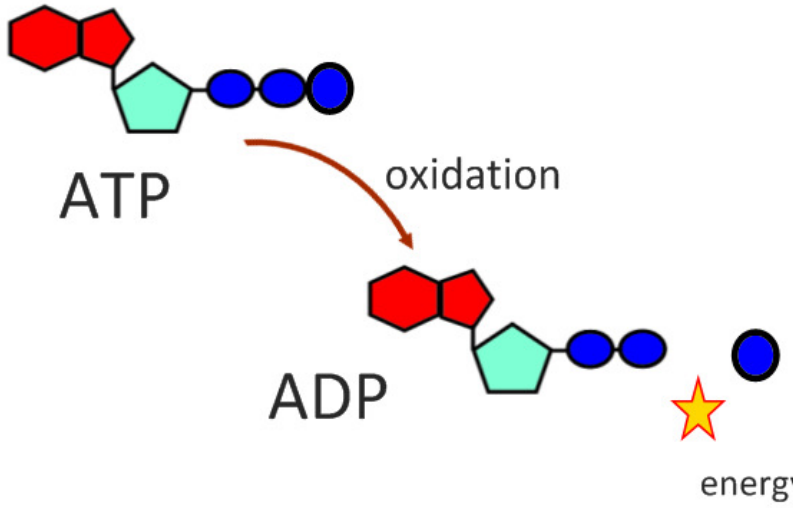


The main role of oxygen is in aerobic respiration.

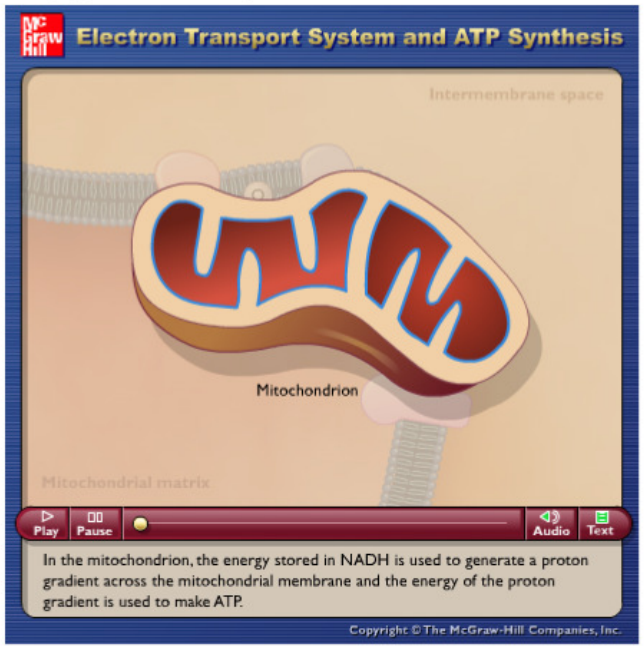
This is in the last stage of cell respiration in the miochondrion: oxidative phosporylation. Oxygen is used to accept electrons following the production of ATP - keeping the whole system flowing.

Oxygen is also used in oxidation reactions: oxygen is put in.

e.g. breaking phosphate from ATP to release energy in tissues.



Oxygen in respiration:



http://highered.mcgraw-hill.com/olc/dl/120071/bio11.swf

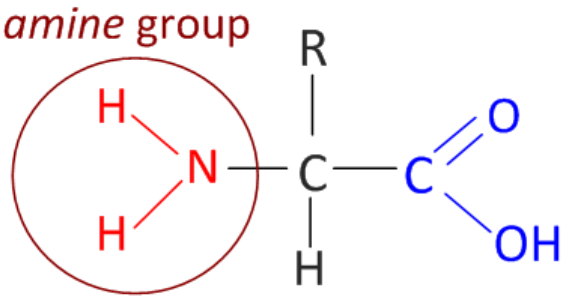
- http://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter25/animation__electron_transport_system_and_atp_synthesis__quiz_1_.html

7
N
nitrogen

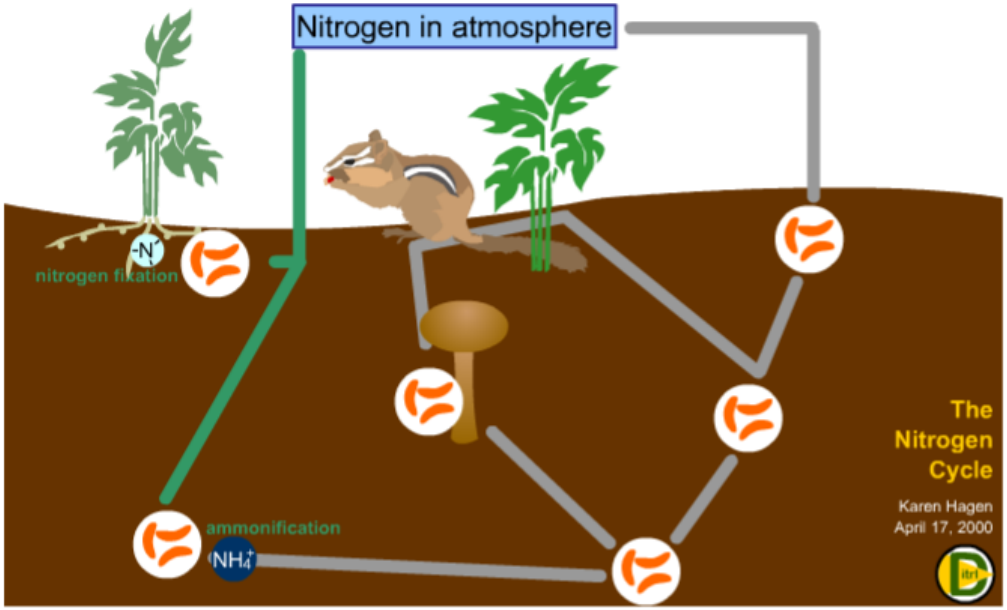
The main use of nitrogen is in the production of amino acids.

Amino acids are polymerised into proteins.

Nitrogen is also used in chlorophyll.



Nitrogen takes many forms in nature:



http://www.biology.ualberta.ca/facilities/multimedia/uploads/ecology/ncycle.swf

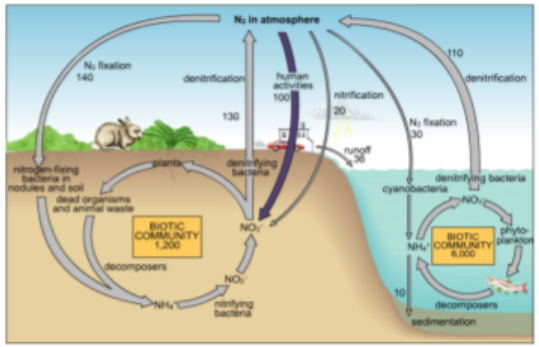
Nitrogen N_2

Ammonium NH_4^+

Nitrates NO_3^-

Nitrites NO_2^-

urea $(NH_2)_2CO$



http://www.mhhe.com/biosci/genbio/tlw3/eBridge/Chp29/animations/ch29/1_nitrogen_cycle.swf

26

Fe

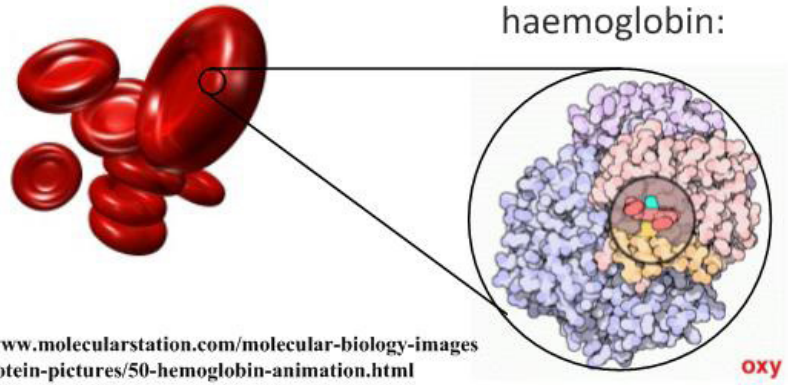
iron

Iron is an important micronutrient in living things.

In animals, it is the oxygen-binding component of haemoglobin.
In plants, it is used to make chlorophyll and takes part in photosynthesis (as ferredoxin).

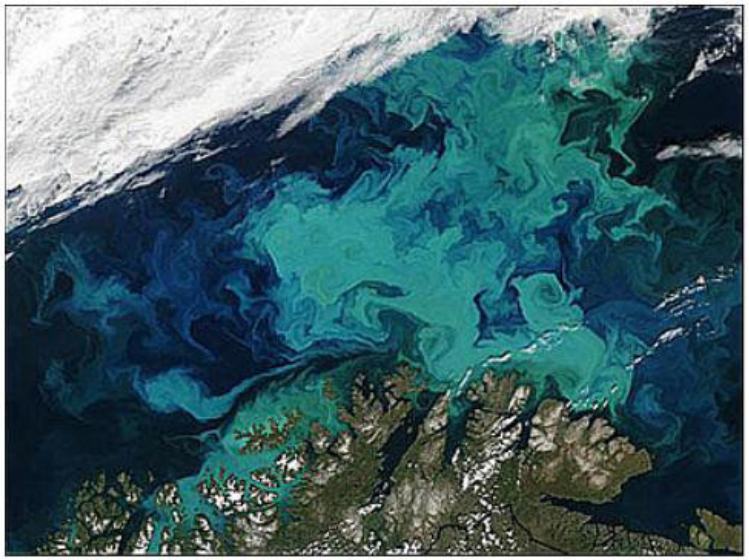
Iron binds well with oxygen for transport. It also faciltates the movement of electrons in cells, including bacteria.

haemoglobin:



http://www.molecularstation.com/molecular-biology-images/505-protein-pictures/50-hemoglobin-animation.html

Iron is often a limiting factor in plant productivity. Experiments of iron seeding can have dramatic effects, such as this phytoplankton bloom:



http://www.fas.org/irp/imint/docs/rst/Sect14/Norway.jpg

20

Ca

calcium

Calcium is an essential mineral in many species.

It is used in the structure of bones and teeth in animals, as well as in blood clotting.

Calcium carbonate ($CaCO_3$)is used in the production of exoskeletons in animals and unicellular organisms.

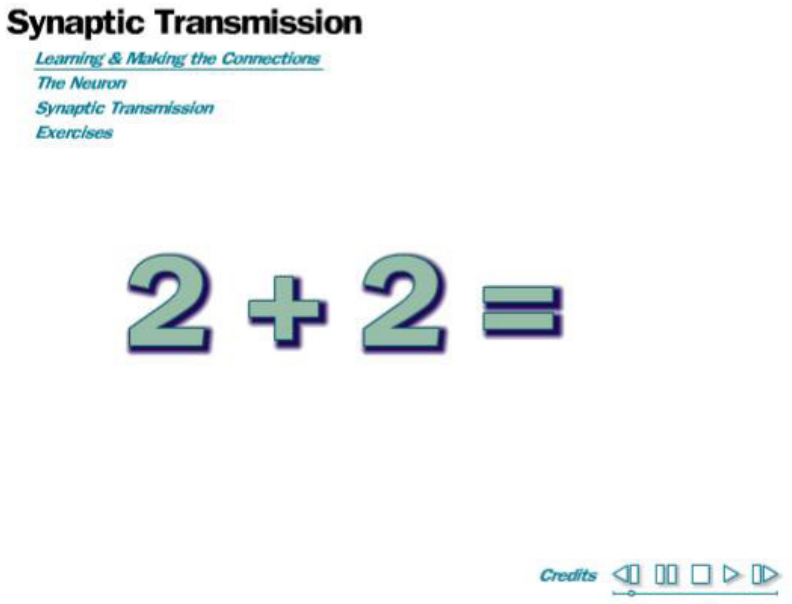
Calcium ions (Ca^{2+}) are essential in synaptic transmission - the propagation of an electrical signal along nerves (nerve impulses) and muscle contraction.

E. huxleyi makes a calcium carbonate shell

http://www.cascadecreativeservices.com/GH/Ehux.htm

Calcium forms the extra-cellular matrix of bone

http://www.usm.maine.edu/bio/courses/bio205/bio205_17_terrestrial_loco.html



http://outreach.mcb.harvard.edu/animations/synaptic.swf

- http://outreach.mcb.harvard.edu/animations/synaptic.swf

15

P

phosphorous

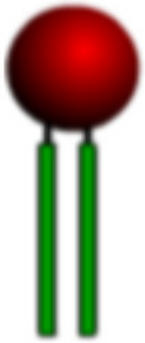
Phosphorous is essential in the formation of the phospholipid bilayer:

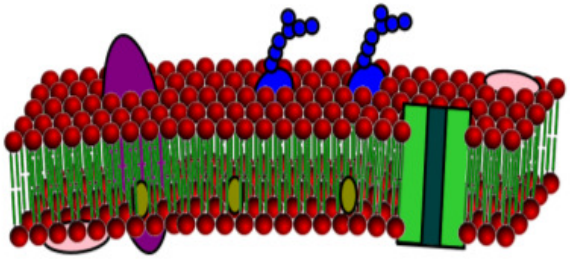
hydrophilic phosphate heads

water attracted

hydrophobic hydrocarbon tails

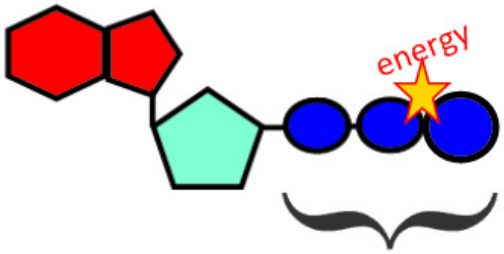
water repelled





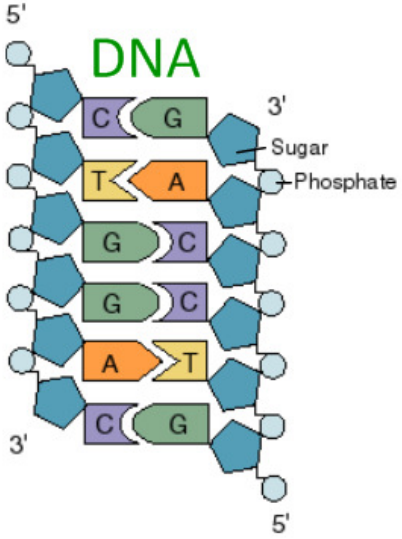
Phosphates are also the active component in ATP molecules and make up part of the 'backbone' of DNA:

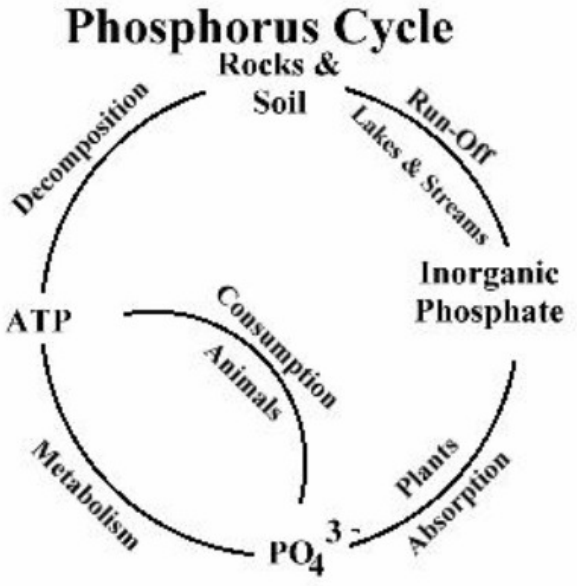
ATP



phosphates

DNA





http://www.starsandseas.com/SAS%20Ecology/SAS%20chemcycles/cycle_phosphorus.htm

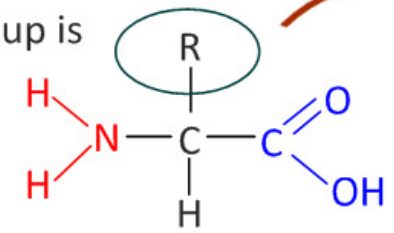
16

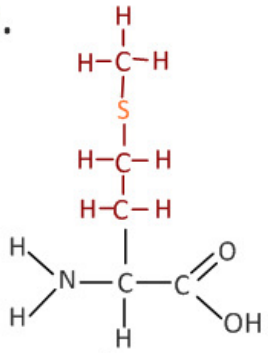
S

sulphur

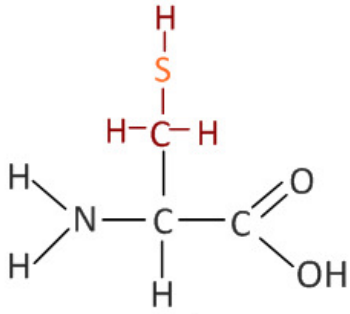
Sulphur is found in some amino acids.

The 'R' group is variable.



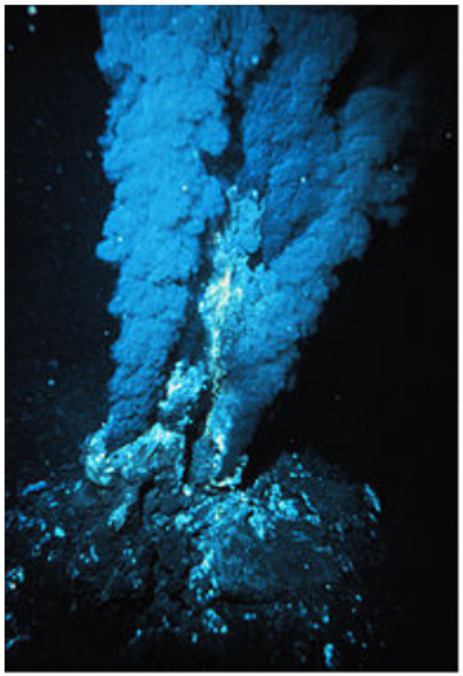


methionine



cysteine

black smoker hydrothermal vent



http://en.wikipedia.org/wiki/Hydrothermal_vent

It is also a reactant for chemosynthetic bacteria (chemoautotrophs) - found in deep-sea vents.

Chemosynthetic bacteria produce organic molecules from hydrogen sulphide, carbon dioxide and oxygen:

$$4H_2S + CO_2 + O_2 \longrightarrow CH_2O + 4S + 3H_2O$$

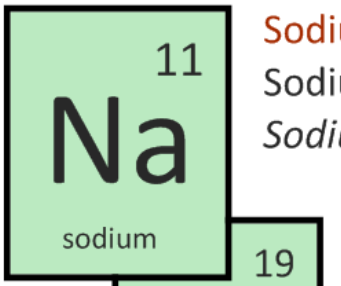
hydrogen sulphide

formaldehyde

Where do the CO_2 and O_2 come from?

Even though light is not directly part of the process, does chemosynthesis still rely on sunlight to an extent?

http://www.newscientist.com/article/mg17423405.700-life-needs-light.html



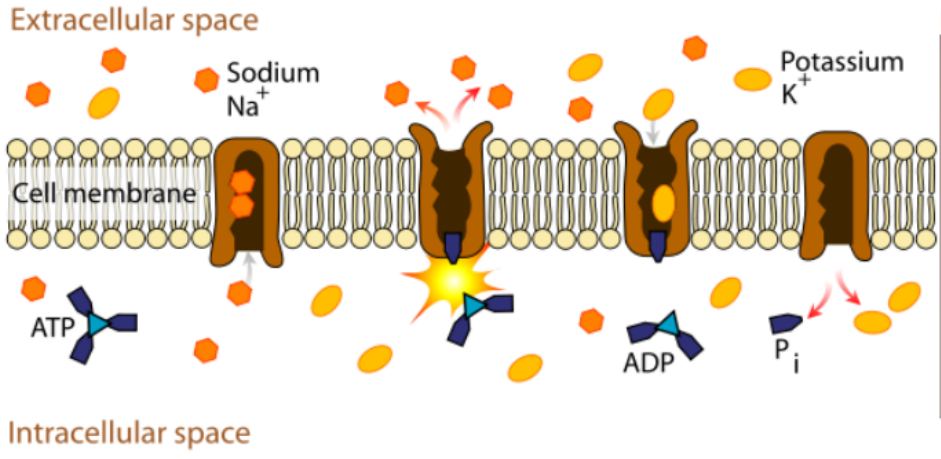
Sodium (Na^+)is essential in generating an action potential for nerve impulses. Sodium chloride (NaCl), or salt, is a main source of these ions. *Sodium is main cation in blood plasma.*

Potassium also plays a role in nerve impulses and has a strong influence in osmosis. *Potassium is the main cation in cell cytoplasm.*

Potassium ions are larger than sodium ions.

The sodium-potassium pump:

This is an example of active transport.



blood plasma

It is responsible for resetting nerve impulses and maintains the volume of cells through its influence on omosis.

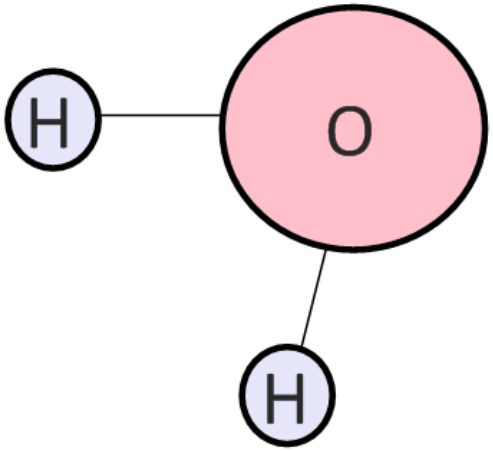
cell cytoplasm

http://chaitanya1.wordpress.com/2007/11/15/listening-to-the-body/sp-pump/

- http://chaitanya1.wordpress.com/2007/11/15/listening-to-the-body/sp-pump/

Water

Begin with this tutorial:



Properties of Water

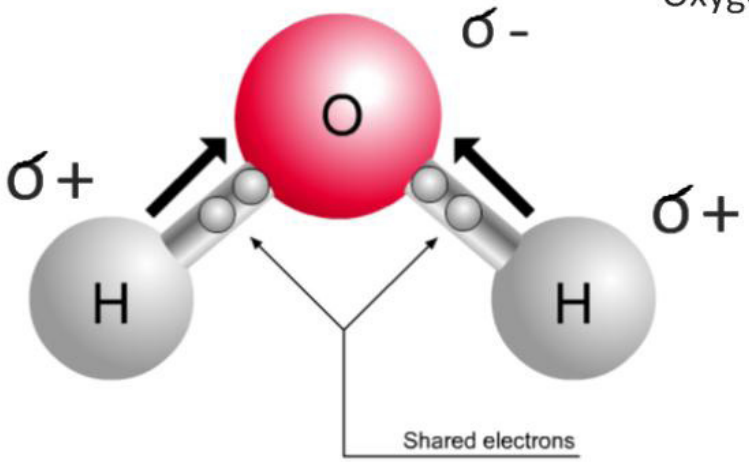
From *Biological Science*, Second Edition, © 2006 Pearson Prentice Hall, Inc.
Storyboard and animation by Sumanas, Inc.
Sample version. Not for distribution.

Go to animation

http://www.sumanasinc.com/webcontent/animations/content/propertiesofwater/water.swf

- http://www.sumanasinc.com/webcontent/animations/content/propertiesofwater/water.swf

Water is a polar molecule:



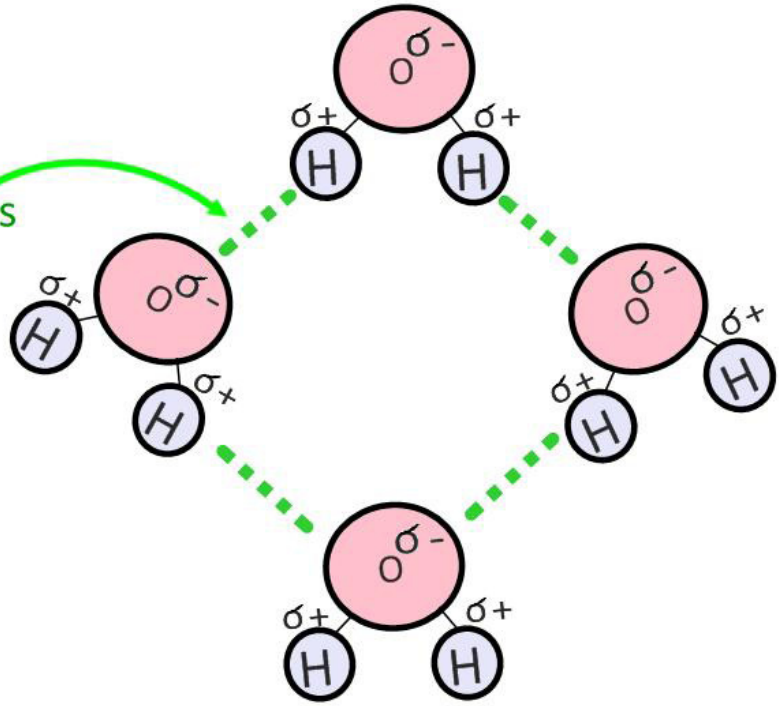
Oxygen exerts a greater pull over the shared electrons. They move a little closer to the oxygen.

That means the 'oxygen end' is overall *slightly negative*: σ - .

The 'hydrogen end' is overall *slightly positive*: σ+.

http://www.sumanasinc.com/webcontent/animations/content/propertiesofwater/water.swf

Hydrogen bonds are the attractions between polar molecules.



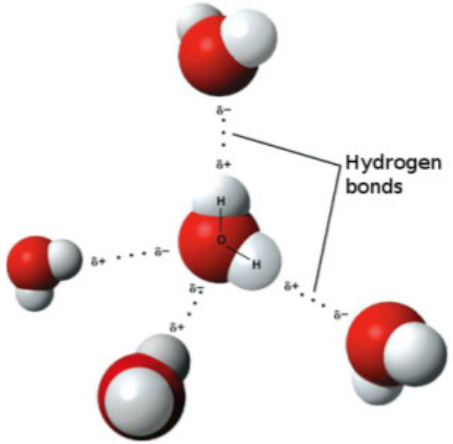
Try this:

http://www.colorado.edu/physics/2000/applets/h2ob.html

- http://www.colorado.edu/physics/2000/index.pl

Cohesive properties of water

A single hydrogen bond is not very strong. A large number of hydrogen bonds is very strong. Each water molecule bonds with four others in a tetrahedral arrangement:



http://en.wikipedia.org/wiki/Water

Because of these hydrogen bonds, water is cohesive: molecules of water stick to each other.
Water is also adhesive - it will stick to other surfaces.

These properties lead to:

Capillary Action - water will move up xylem against gravity

Surface tension - the surface of water is strong enough to support insects and causes drops to form

pondskaters walk on water:

http://focusonnature.be/keywords/insects?page=6

cohesion forms droplets
surface tension keeps them spherical
adhesion sticks them to the leaf

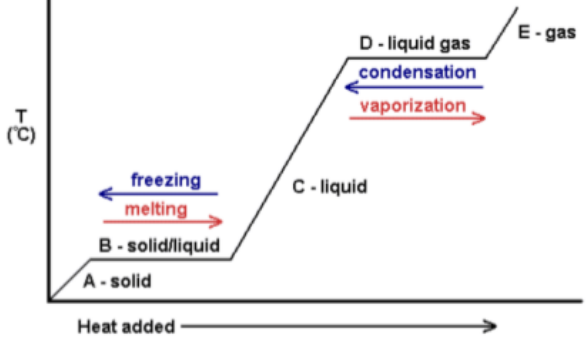
http://en.wikipedia.org/wiki/Adhesion

Thermal properties of water

Water has a high specific heat capacity.
This means it takes a lot of energy for the temperature of water to change.
This is because there are so many H-bonds.

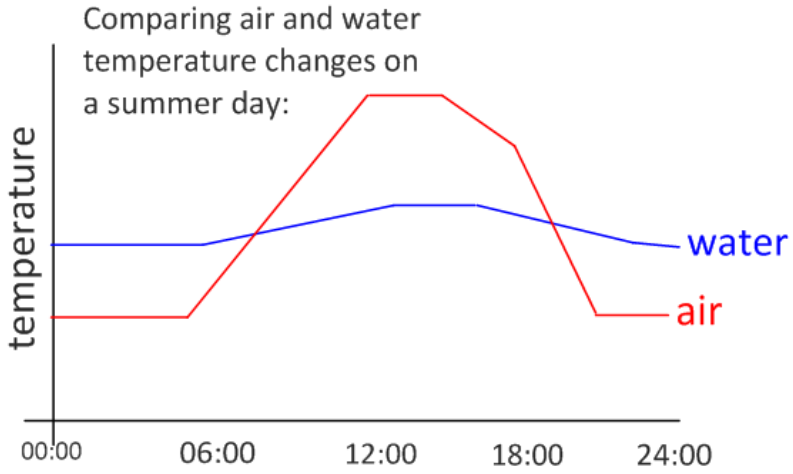
This all means that the temperature of water remains relatively stable

A lot of energy needs to be put in to change state:



http://www.kentchemistry.com/images/links/matter/HeatCool.gif

Most organisms are adapted to a narrow range of conditions. The slow heating and cooling of water are ideal for these organisms - there is less risk of extreme changes.



Because it takes a lot of energy to make water evaporate, it is a good coolant - evaporating water removes a lot of heat energy from the organism.

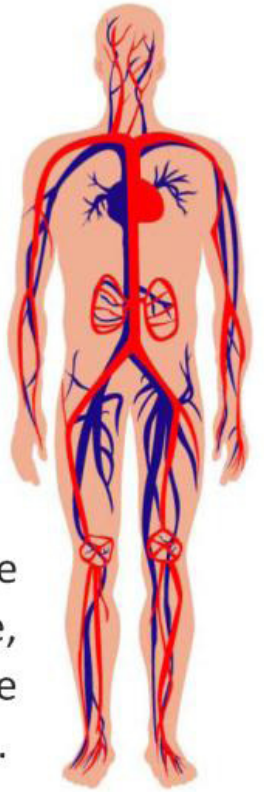
Water as a coolant:

High temperatures damage tissues and denature proteins - causing enzymes to cease to work.

It takes a lot of energy for water to change temperature.
This means that it will heat and cool more slowly than air or land.
This is useful to animals in hot climates - who can use water or mud to cool off in the hot day.

http://image03.webshots.com/3/5/28/47/752847_ph.jpg

When water evaporates, it removes a lot of energy from the system.
This is felt as a cooling sensation - excess heat energy is removed from the body (latent heat of evaporation). The skin and their blood vessels are cooled.
This also helps aquatic habitats remain at fairly constant temperatures in hot summers.

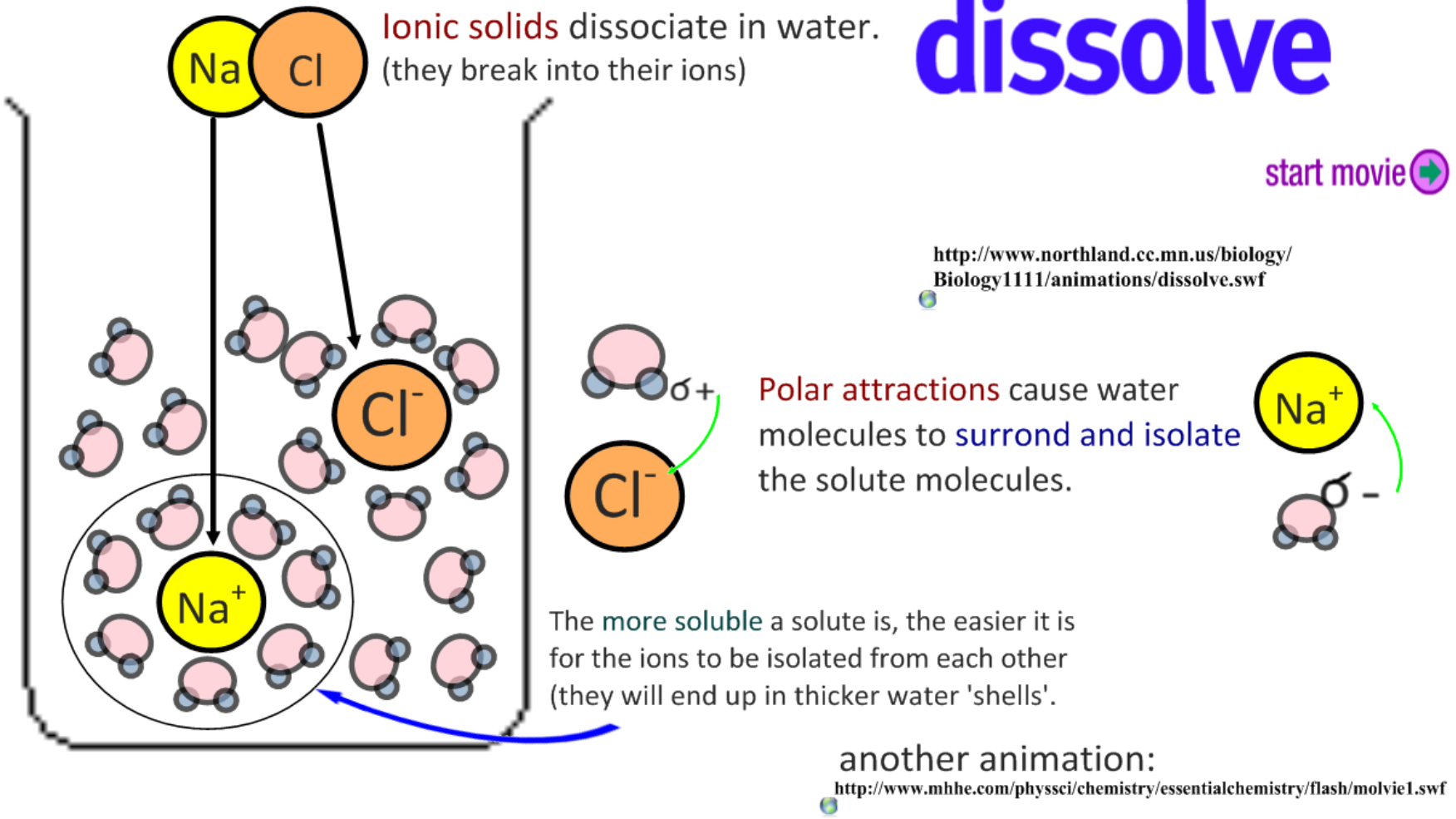


http://www.telemediamagazine.com/circulation.htm

Water makes up 70% of the body, including the blood. Because it is resistant to temperature change, cooler blood from some parts of the body can be circulated to other parts, cooling them down.

Solvent properties of water

Water is a good solvent because it is a polar molecule.
It will dissolve polar solutes easily.

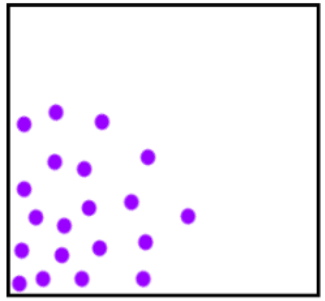


- http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/molvie1.swf

Water as a medium for metabolic reactions:

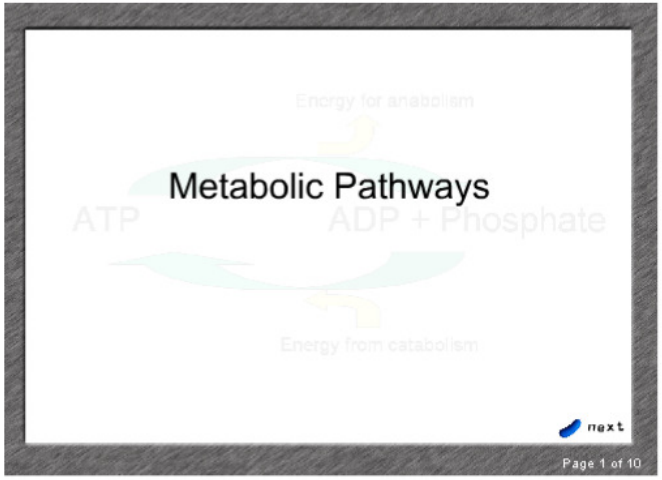
Water is a good solvent.
Dissolved particles are able to move around - and diffuse.
Moving particles are likely to collide with one another, leading to a reaction.

All metabolic reactions (reactions in living things) occur in solution - the reactants are dissolved.



http://iweb.tntech.edu/mcaprio/diffusion-animated.gif

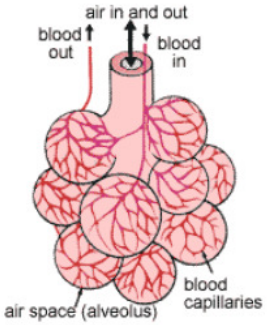
What is a metabolic reaction?



http://www.wisc-online.com/objects/MBY2604/MBY2604.swf

Membranes and biological surfaces are wet.
This allows molecules to dissolve, including gases, so they can diffuse through more easily.

e.g. in the alveoli, oxygen is dissolved on the membrane and can then diffuse into the the blood.



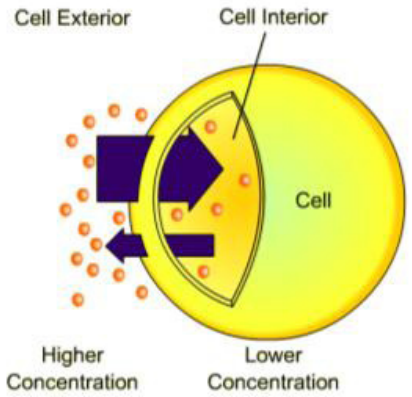
http://resources.schoolscience.co.uk/abpi/asthma/images/5c2AlvBrjpg.gif

- http://www.wisc-online.com/objects/MBY2604/MBY2604.swf

Water as a transport medium:

Water is a good solvent: it dissolves nutrients, gases and waste products. These can be carried in the circulatory system of animals, through xylem and phloem in vascular plants or through the water in soil or aquatic habitats.

Water can transport molecules across membranes in diffusion, as well as within the cell or interstitial (between-cell) fluid.



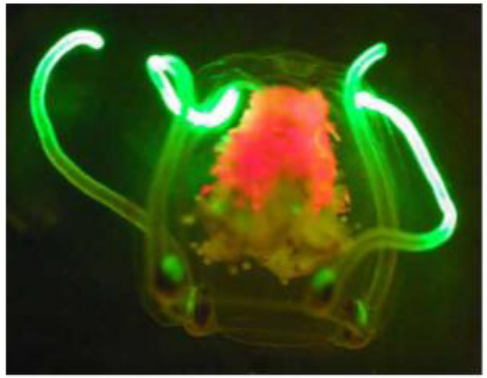
http://www.wiley.com/legacy/college/boyer/0470003790/animations/membrane_transport/membrane_transport.swf

http://ocean-spirits.blogspot.com/2007/10/sighting-of-rare-whale.html

Water is dense.
This means it can support the mass of large and small organisms - they can float or swim in water.

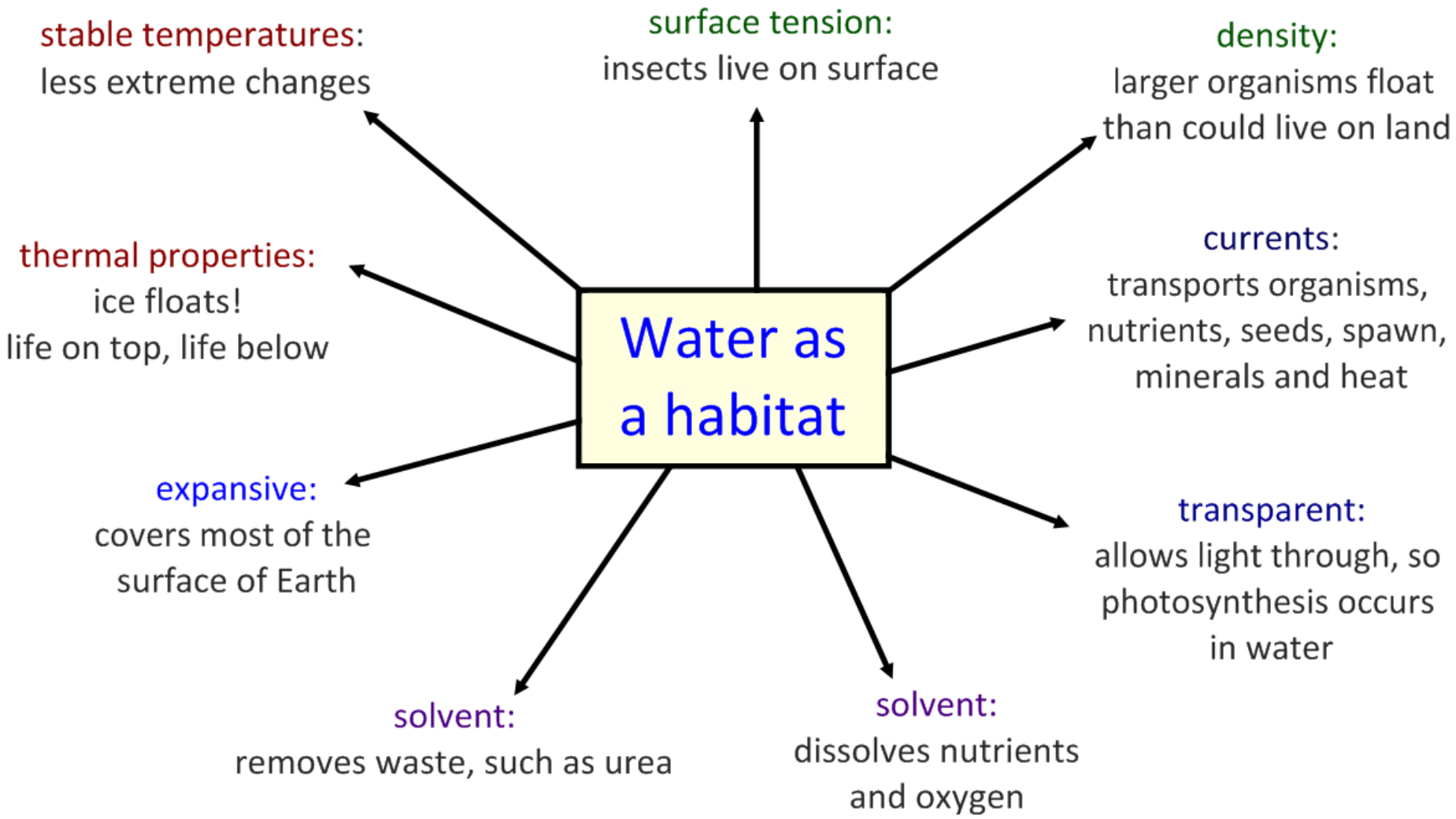
Aquatic systems are rarely still:
they have flows and currents that can carry planktonic organisms, spores, seedsand nutrients over a large area.

Planktonic organisms rely on water movement for their own transport:
Small fluorescent jellyfish



http://oceanexplorer.noaa.gov/explorations/05deepscope/background/fluorescence/media/jellyfish.html

Can you add any more advantages of water as a habitat?



Oxygizer Water: read the article and answer the questions below the text.

http://www.guardian.co.uk/education/2004/jan/22/research.badscience

What is PSEUDOSCIENCE?

http://www.youtube.com/watch?v=Z6G4s8-upGk

- http://www.youtube.com/watch?v=Z6G4s8-upGk
- http://www.guardian.co.uk/education/2004/jan/22/research.badscience