Hydropath Technology in power stations applications
By Dr. D Stefanini November 2003

Modern power stations employ various heat exchangers in the process of power generation. The larger of witch are the steam condensers in power stations that use steam turbines for the power generation.

The cooling media used in most condenser application is water. If large rivers with constant water flow are available, then fresh water is used. The water has to be treated to remove suspended solids and chemically treated to prevent corrosion and to reduce hardness, to prevent the formation of deposits in the condensers and oil heat exchangers.

When river water is not available power stations are designed to use seawater as cooling media. I such cases condensers and heat exchangers are affected by bio fouling.

Water treatment in power stations

Water is softened on a large scale by the addition of just enough lime to precipitate the calcium as carbonate and the magnesium as hydroxide, whereupon sodium carbonate is added to remove the remaining calcium salts. This operation is costly and produces large volume of calcium carbonate that has to be trucked away. A power station situated near hard water river can produce as much volume of calcium carbonate to fill 12 trucks a day. Cooling water produced in this way has to be treated again before returning to the river to comply with the regulation.

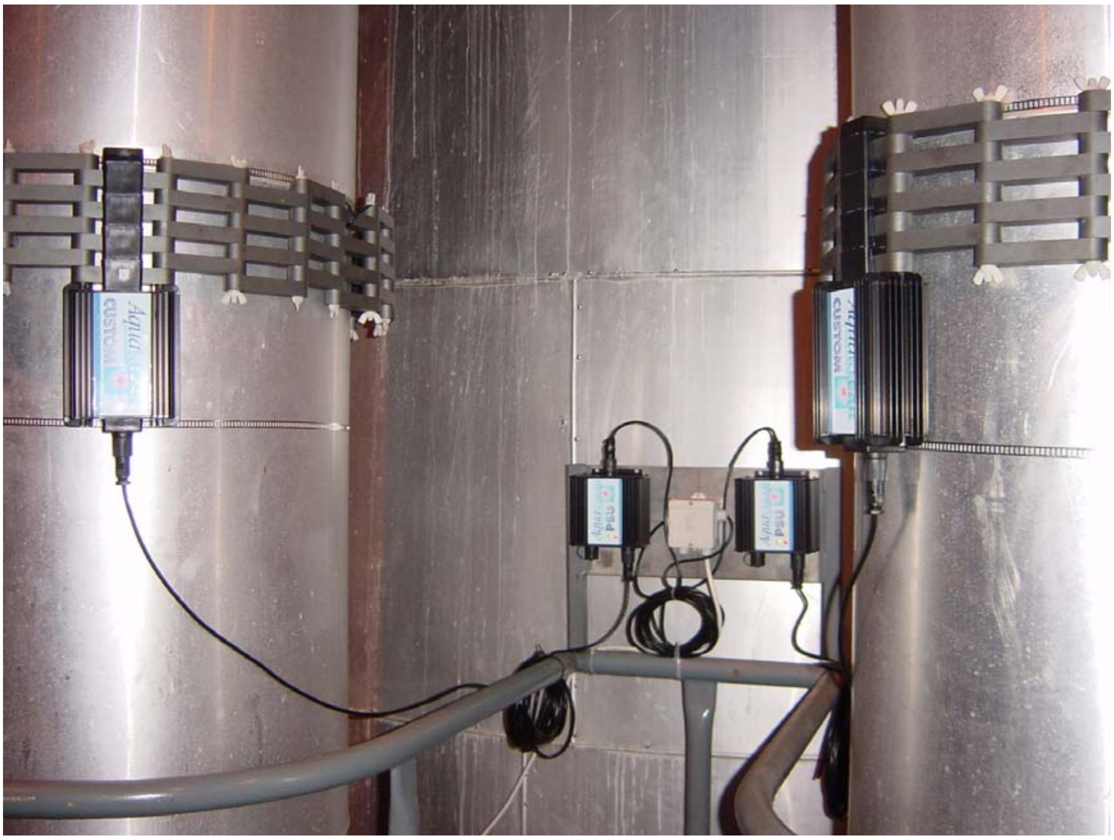
Water treatment can be minimized with the use of Custom ***Hydropath*** technology.

1. Water treatment by softening is never perfect; as a result Heat exchangers and towers experience scaling and anti-scaling chemicals are required.
2. Softened water is aggressive and requires anti-corrosion chemicals to be introduced to prevent corrosion damage to the Heat exchanger.
3. Soft water cannot dissolve carbonate deposits; as a result acid cleaning of the Heat exchanger is regularly required.
4. If **hard feed water** is used; ***Hydropath*** technology will produce precipitation of all the calcium salts in solution, converting the bicarbonates to suspended carbonate crystals (see following text).
   $Ca\,(HCO_3)_2$ ------> $CaCO_3$ $+ H_2O + CO_2$
   Calcium bicarbonate Calcium carbonate deposits.
5. CO_2 under pressure in the steam boilers and Heat exchanger is converted to carbonic acid.
6. Carbonic acid will combine with existing carbonate deposits to form bicarbonates that are soluble and will dissolve in the water
   $CaCO_3 + H_2O + CO_2$ ------> $Ca\,(HCO_3)_2$.
7. ***Hydropath*** technology precipitates the bicarbonates from solution to suspension by introducing clusters of ions in the water to act as seed for suspended crystallisation (see following text).
   $Ca\,(HCO_3)_2$ ------> $CaCO_3$ $+ H_2O + CO_2$
   Calcium bicarbonate Calcium carbonate suspended crystals.

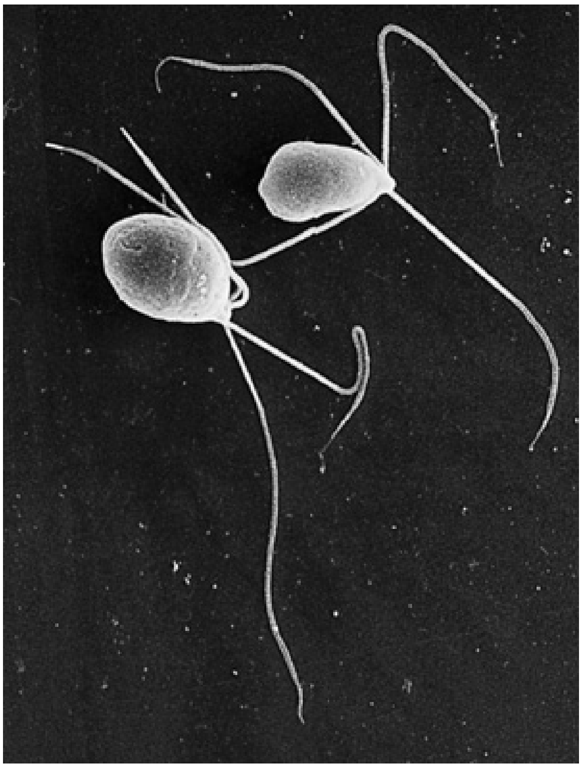
8. The suspended crystals are removed from the heat exchangers and Cooling tower in the blow-down.

9. The existing carbonates deposits are gradually dissolved; improving heat transfer and efficiency of the Heat exchanger.

The introduction of *Hydropath* technology will only be completely effective if soft feed-water is replaced with hard feed-water.



Seawater cooling.



If the cooling media is seawater the operators are faced with different problems.
Bio fouling is the main problems facing power stations situated near the coast.

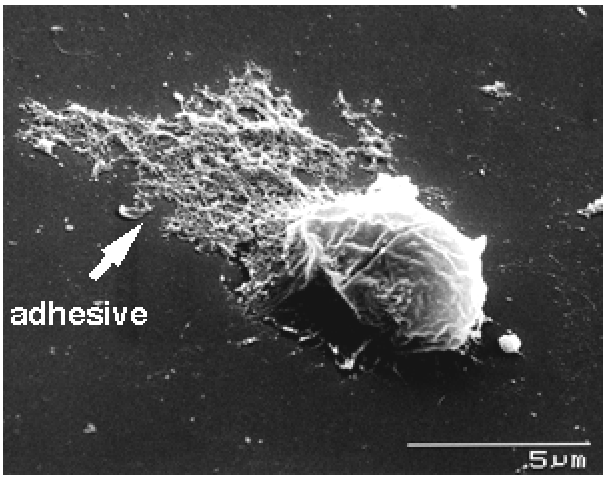
Like ships and boats; power station condensers and other heat exchanger efficiency is reduce by the effect of bio fouling.

Organisms that cause bio fouling can be subdivided into minute microfoulers and larger macrofoulers.

Microfoulers (e.g. sticky bio films of bacteria initiate the process by colonising new surfaces. These then allow the larger macrofoulers (e.g. barnacles, limpets and seaweeds) to gain a foothold

The effect begins with the formation of a bacteria film; a transparent gel that can grow to several centimeters thick. This reduces the heat transfer efficiency and facilitates the attachment of macrofoulers.

The larva of mussels, barnacles, limpet, and seaweed; uses the bacteria film to attach themselves to the pipe and condensers surfaces they then metamorphosize to the adherent species.



Without the presents of the bacteria film the larva fragile tentacles (see photo above) will not be able to get a foothold and will be swept away by the flow of water.

In an attempt to prevent this; seawater is treated with chlorine, this can damage sea fauna in the power station vicinity and the quantities of such treatment is strictly regulated.

Power stations have been plagued with Tiger mussel. This mussel is large enough to block the condenser tube when it become detached and is carried to the condenser; this requires costly manual cleaning reducing the power station output.

The introduction of Custom ***Hydropath*** technology will prevent the formation of the bio film and kill the larva by osmosis (see following text) thus braking the larva cycle.

Hydropath technology is an electronic water treatment device that generates an electric field that is applied to all suspended particles flowing through the ferrite ring. The electric field is applied longitudinally and its effect on dissolved ions is over the all the plumbing system.

Hydropath technology has been working successfully in bio fouling applications and commercial swimming pools internationally for over 3 years.

Osmosis

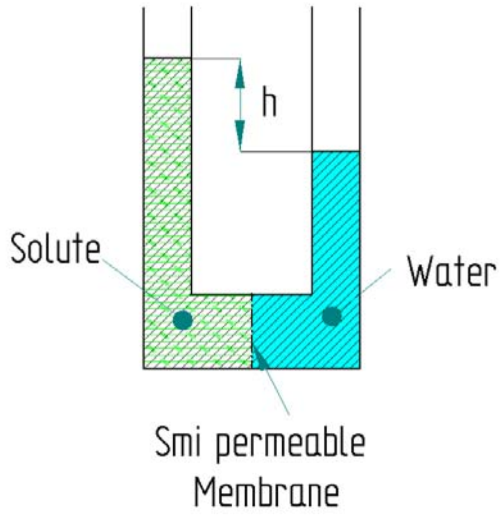
What is osmosis? It is the phenomenon of water flow through a semi permeable membrane that blocks the transport of salts or other solutes through it. Osmosis is a fundamental effect in all-biological systems. It is applied to water purification and desalination, waste material treatment, and many other chemical and biochemical laboratory and industrial processes.

When two water (or other solvent) volumes, are separated by a semi permeable membrane, water will flow from the side of low solute concentration, to the side of high solute concentration. The flow may be stopped, or even reversed by applying

external pressure on the side of higher concentration. In such a case the phenomenon is called reverse osmosis.
If there are solute molecules only in one side of the system, then the pressure that stops the flow is called the osmotic pressure.
The solvent molecules that surround it over damp the movement of a solute molecule within a solvent. In fact, the solute movement is wholly determined by fluctuations of the collisions with nearby solvent molecules. However, the average thermal velocity of the molecule is the same as if it were free in a gas phase.
Whenever a wall blocks a solute movement it will transfer momentum to it and, therefore, generate pressure on it. Since the velocity is the same as that of a free molecule, the pressure will be the same as the pressure of an ideal gas of the same molecular concentration. Hence, the osmotic pressure π, is given by van't Hoff formula

$$\pi = cRT$$

Where c is the molar solute concentration, R is the gas constant, and T is the absolute temperature. This formula is the same as the pressure formula of an ideal gas.

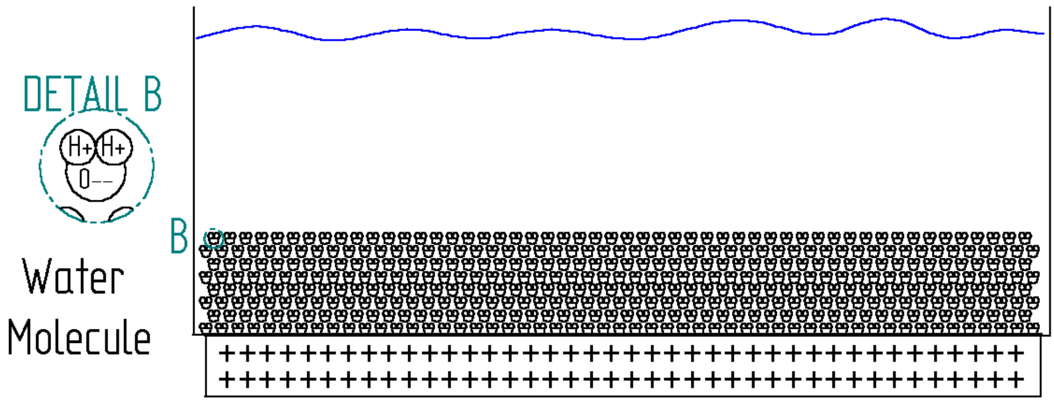


The Figure above shows connected vessels separated by a semi permeable membrane. If there is only water in the device, the level will be the same at both sides. When solute molecules are added to one side, water will start to flow into it, so that its level will go up at this side, and down at the other side. The system will stabilize when the hydrostatic pressure generated by the difference in the water levels balances the osmotic pressure.

$$cRT = \rho h$$

Where ρ is the water specific gravity

Charged surfaces and water

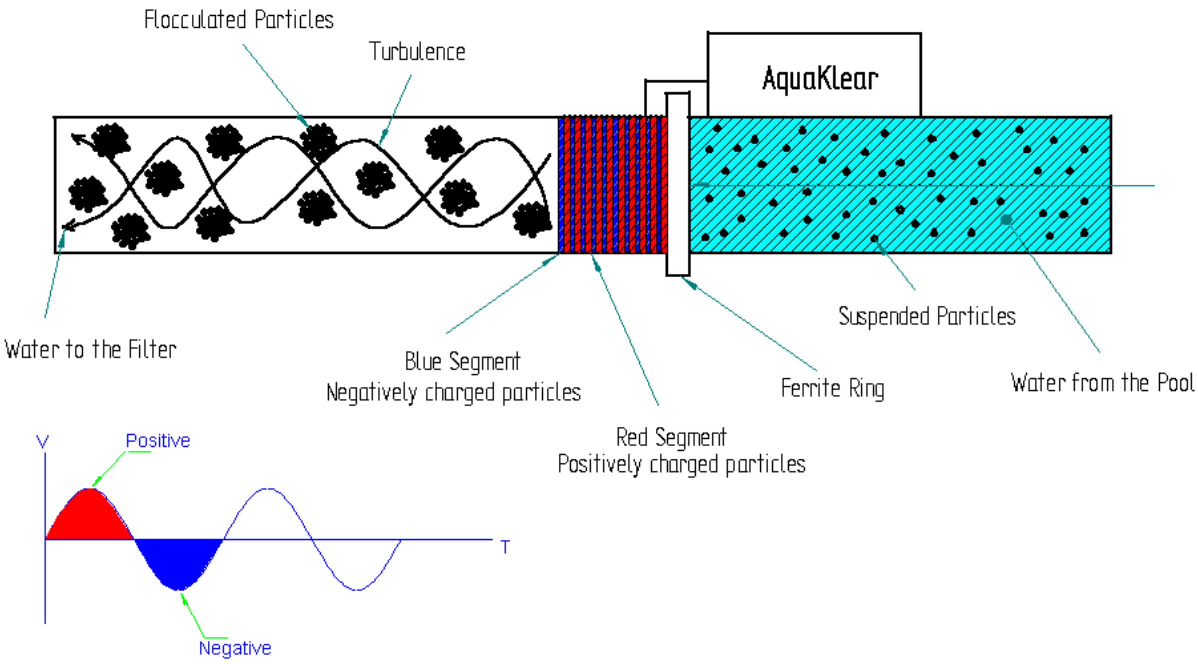


The Figure above illustrates the way the water molecules arrange over a positively charged surface. Water molecules as illustrated above, are bi-polar. The Hydrogen atoms have lost their electrons to the Oxygen atom thus becoming positively charged, the Oxygen has gained electrons thus becoming negatively charged. With the bond angle of $104.31^{0,}$ the radius of the molecule is 1.38 Angstroms (Angstrom=10^{-8} cm.), and the O-H distance is 0.99 Angstroms. The H atoms are so deeply embedded in the Oxygen as to make the molecule almost spherical.

A number of stable array layers are formed due to the attraction of water molecules to the charged surface. This in turn attracts more lyres due to the fact that all the molecules are facing the same way. The number of layers depends on the charge strength of the charged surface and the concentration of the solute. The osmotic force will be reducing the number of layers and a balance will be reached between the osmotic force and the charge voltage. The water molecules are arranged in a regular array. Excluding any other molecule. The water in the layers is pure water!

Flocculants such as Alum are used to flocculate solids. Flocculation makes the filters more effective as it is easier for larger particles to be stopped than it is for tiny ones. Flocculants are expensive.

With *Hydropath Technology* there is no need for flocculants, *Hydropath Technology*

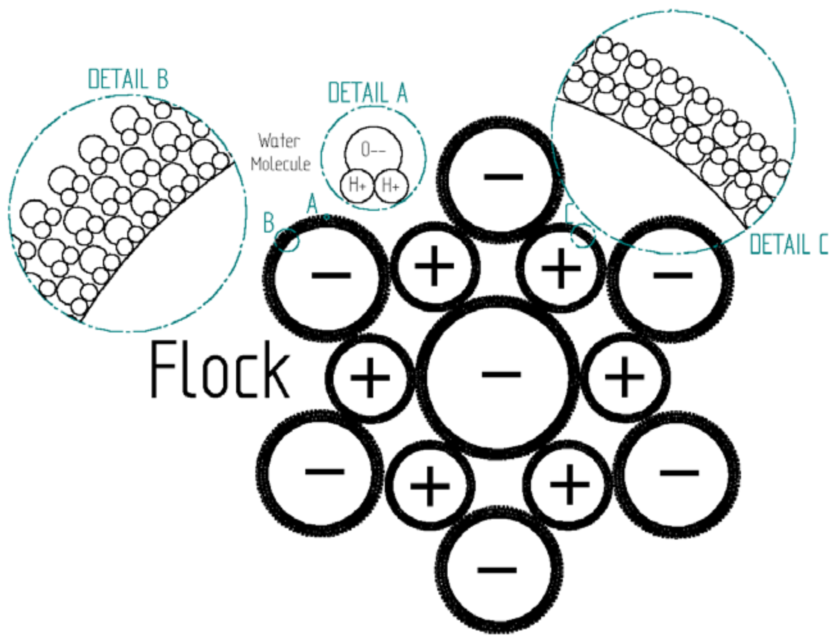


is able to produce continues flocculation effect as illustrated. The signal applied to the water by *Hydropath Technology* is sinusoidal and will charge any suspended particle with a charge according to the state of voltage at the time. Assuming a frequency of 100 KHz and a speed of water of 10m/s.

Time = [1/ Frequency]/ 2 (1/100,000)/2 = 0.000005 second

Distance = Speed of water * Time 10 * 0.000005 = 0.00005m = 0.05mm

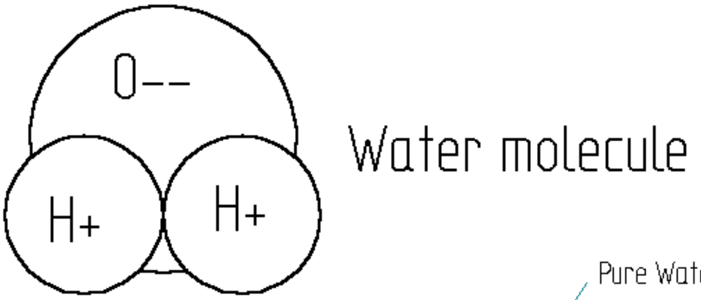
Segments of water of .05mm are generated inside the ferrite ring, and are charged alternatively.

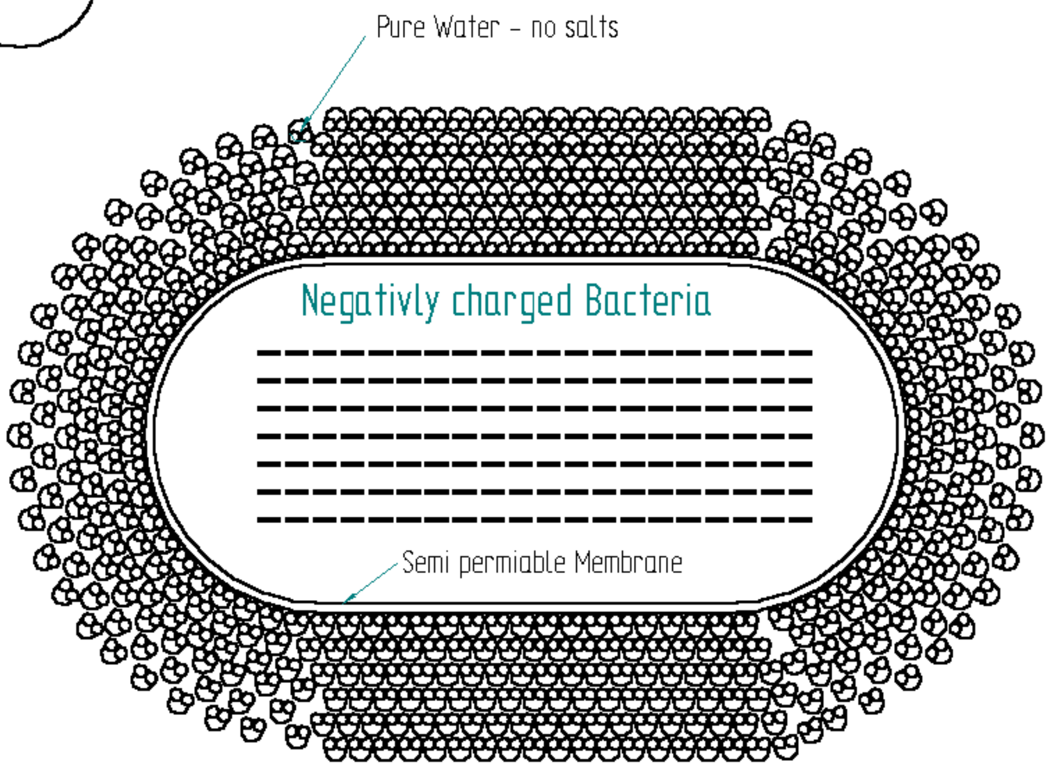


Water molecules as illustrated above are bi-polar. All charged suspended particles that are in the rage of >1000Angstroms will be surrounded by water molecules as illustrated above (this process is called hydration). The charge of the suspended particle is reflected out and will attract other particles of the inverse charge. Water molecules; as arranged are pure water, the conductivity is very low (38 billionths mho/cm at 0^0 C.), this prevent the inverse charges of the particles from being equalised.

Large long lasting and stable flock can thus be maintained.

Hydropath Technology **Effect on Bacteria and larva**





The Figure above illustrates the way the water molecules arrange around a negatively charged bacterium. A bacterium that has passed in the ***Hydropath*** technology ferrite ring will obtain a charge that is negative or positive according to the voltage induced in the water at the time. The illustration above is for a negative charge. If a positive charge is obtained the process is the same, the only difference is that the water molecules will be reversed.

The result of this water molecules arrangement is that, a layer of pure water is surrounding the bacterium. The bacterium will subjected to an instant change of environment, the same as being plunged into distilled water.

Protozoa Include the Most Complex Single Cells Known

The complexity that can be achieved by a single eucaryotic cell is nowhere better illustrated than in the free-living, single-celled eucaryotes known as *protists* (Figure 1). These are evolutionarily diverse and exhibit a bewildering variety of different forms and behaviours: they can be photosynthetic or carnivorous, motile or sedentary. Their anatomy is often complex and includes such structures as sensory bristles, photoreceptors, flagella, leg like appendages, mouth parts, stinging darts, and muscle like contractile bundles. Although they are single cells, protists, especially the larger and more active types known as **protozoa**, can be as intricate and versatile as many multicellular organisms. This is particularly well illustrated by the group known as **ciliates.**

Didinium is a carnivorous ciliate. It has a globular body, about 150µm in diameter, encircled by two fringes of cilia; its front end is flattened except for a single protrusion rather like a snout (Figure 1-28). *Didinium* swims around in the water at high speed by means of the synchronous beating of its cilia. When it encounters a suitable prey, usually another type of protozoan, such as a *Paramecium,* it releases numerous small paralyzing darts from its snout region. Then the *Didinium* attaches to and devours the *Paramecium*, inverting like a hollow ball to engulf the other cell, which is as large as itself. Most of this complex behaviour – swimming, and paralyzing and capturing its prey – is generated by the cytoskeletal structures lying just beneath the plasma membrane. Included in this *cell cortex*, for example, are the parallel bundles of microtubules that form the core of each cilium and enable it to beat.

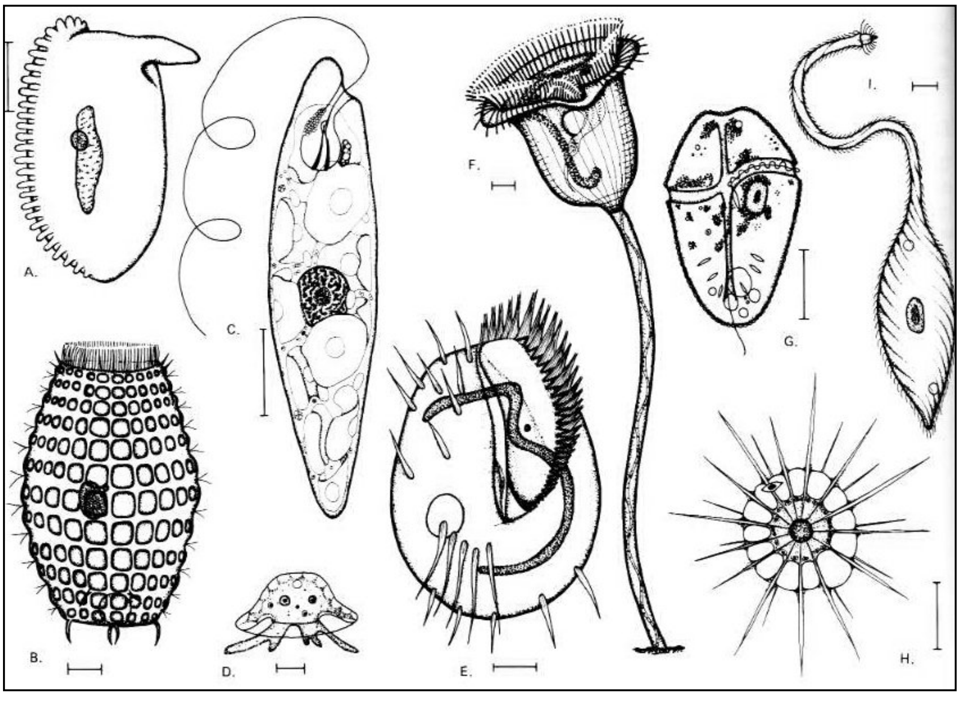


Figure1 An assortment of protists, illustrating some of the enormous variety to be found among this class of single-celled organisms. These drawings are done to different scales, but in each case the bar denotes 10µm. The organisms in (A), (B), (E), (F), and (I) are ciliates; (C) is an euglenoid; (D) is an amoeba;

(G) is a dinoflagellate; (H) is a heliozoan. (From M.A. Sleigh, The Biology of

Protozoa. London: Figure 1
Edward Arnold, 1973.)

Cryptosporidium parvum is a parasitic protozoa. Due to its complex internal structure, the concentration of its Cytoplasm fluids is higher. Exposure to *Hydropath Technology* technology it will be affected by osmotic force.

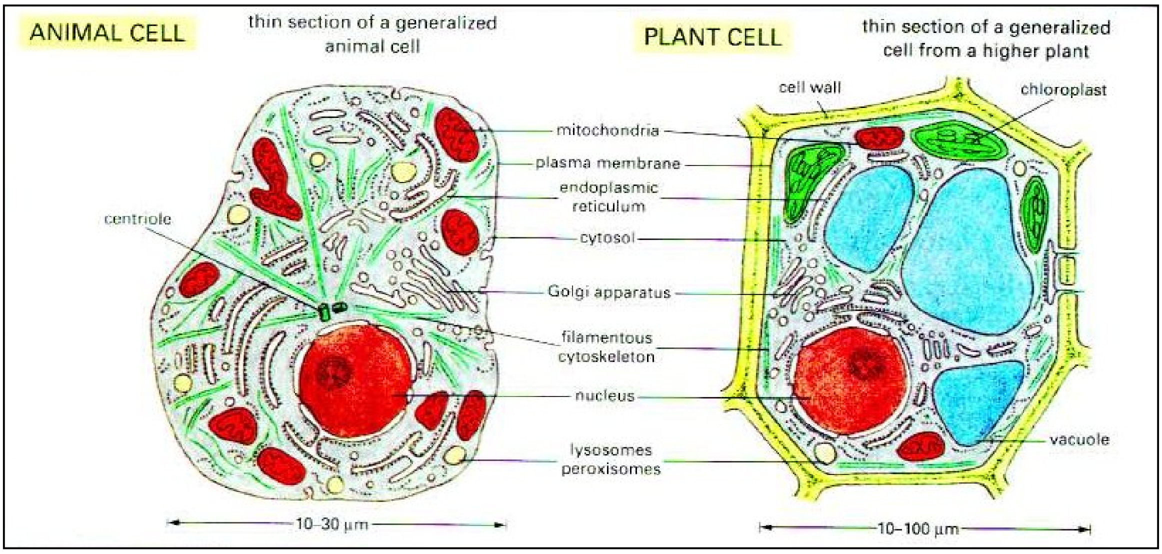
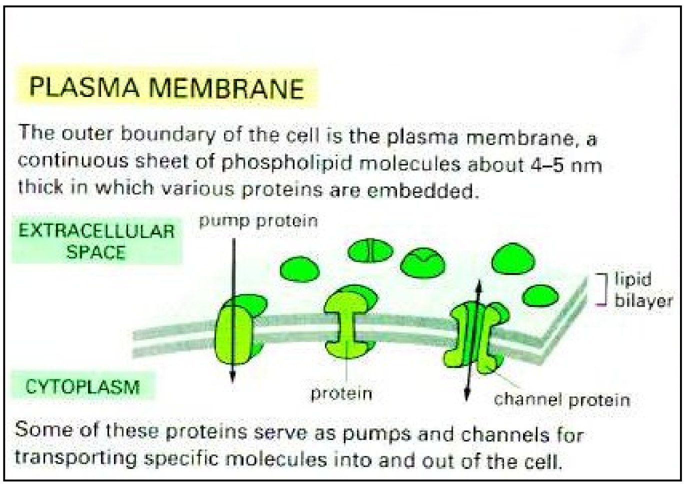


Figure 2

The lipid bilayer of the cell membrane is semi-permeable and cannot resist the osmotic force. Water molecules will be forced past the membrane. The cell will be exposed to the osmotic pressure. The higher the Cytoplasm concentration the higher will be the osmotic pressure. In seawater bacteria the concentration of the cytoplasm is adjusted to the seawater concentration, the osmotic force is considerable. At low osmotic pressure, this will prevent the ingress of food to the cell and will disrupt the normal metabolism. At higher pressure the osmotic force will be strong enough to rapture the membrane.



A bacterium to be able to function has to adjust the internal concentration according to the concentration of its environment, The internal Cytoplasm concentration is always higher than the extracellular space, as a result the cell has to expel water continuously trough the channel proteins that are imbedded in the membrane, to overcome the osmotic force. This process helps the cell to expel byproducts of metabolism. These processes are inhibited while the ***Hydropath*** technology unit has charges the cell. A bacterium growing in concentrated solution will have adjusted the internal solution to suit. The sudden change in concentration that the cell is exposed to as a result of the charge gained within the ferrite ring will result a rapid increase of internal pressure causing membrane rupture and death of the cell.

A bacterium adapted to a low concentration solution will be effected by dilution of the Cytoplasm due to the electrical attraction of the water molecules towards the charged Cytoplasm, as the channel proteins opens, water molecules will flood in. The dilution of the Cytoplasm will disrupt the metabolic processes. The effect on the bacteria will be as if it was dropped in distilled water.