Lecture Series on Biochemistry (Part 2)

Discussion so far...

- What is cell?
- Cells of cellular organism.
  - Prokaryotic cell
  - Eukaryotic cell
  - Differences between prokaryotic and eukaryotic cell.
- Cytoplasmic matrix.
- Chemical composition of the cell.
  - Elements
  - Ions
  - Electrolytes and non-electrolytes

Types of compounds of cytosol

- Chemical compounds of the cytosol are conventionally divided into 2 groups viz. organic and inorganic.
- Organic compounds form 30% of a typical cell and the rest are inorganic substances such as water and other substances.

Inorganic compounds

- The inorganic compounds are those which are normally found in the bulk of the physical, non-living universe, such as elements, metals, non-metals and their compounds such as water and variety of electrolytes and non-electrolytes.

Water

- Most abundant inorganic component of the cytosol is water (notable exceptions are seeds, bone and enamel).
- Water constitutes about 65 to 80% of the matrix.
- In the matrix, water occurs in 2 forms viz. free water and bound water
  - 95% of the total cellular water used by the matrix as solvent for various inorganic substances and organic compounds is known as free water.
  - Remaining 5% of the total cellular water remains loosely linked protein molecules by hydrogen bonds and is known as bound water.

- Water contents of the cellular matrix of an organism depend directly on age, habitat
- For e.g.
  - Embryonic cells have 90 to95% water which decreases progressively in the cells of the adult organism.
  - Cells of lower aquatic animals contain comparatively high percentage of water than the cells of higher terrestrial animals.
- Percentage of water in the matrix also varies from cell to cell according to the rate of metabolism.

Molecular structure of water

- The special physical properties of water are found in its molecular structure.
- Water is found by the combination of hydrogen and oxygen through formation of covalent bonds.

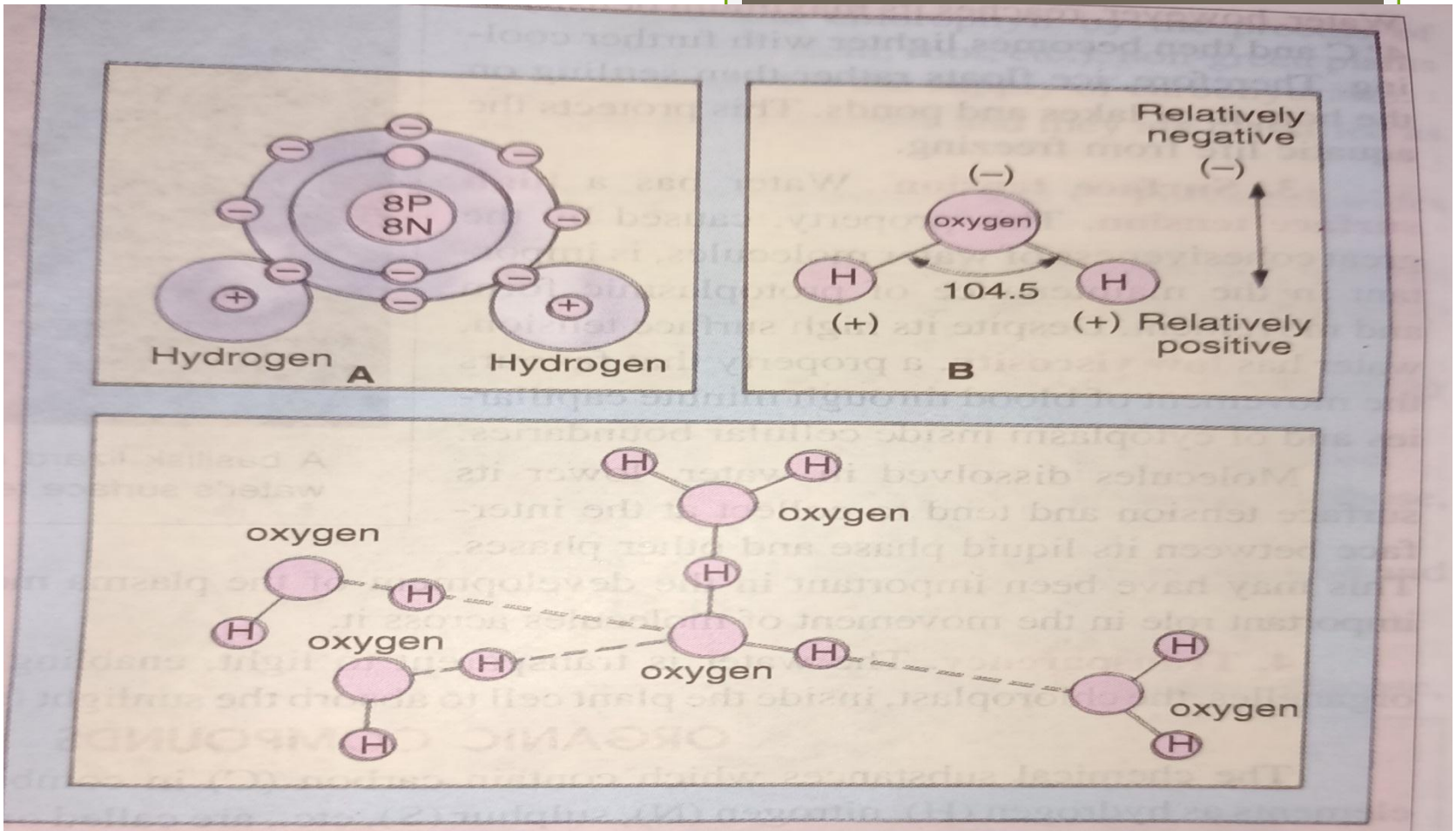


Fig. 4.4. Structure of a water molecule : A— How two hydrogen atoms share their single electrons with oxygen atom; B— The hydrogen atoms position themselves to one side of the oxygen, leaving a relatively negative cloud of electrons exposed on other side. The electrons of the hydrogen are maintained close to the oxygen, leaving the hydrogen relatively positive since its proton is exposed; C— A tetrahedron is formed due to formation of hydrogen bonds between four water molecules.

Unique physical properties of water and their biological utility

- Water as a solvent
- Thermal properties of water
- Surface tension
- Transparency

Water as a solvent

- Water's properties as a solvent for inorganic substances such as mineral ions, solids etc. and organic substances such as carbohydrates and proteins depends on water's dipole nature.
- Due to this polarity, water can bind electrostatically to both positively and negatively charged groups in the protein..
- This solvency is of great biological significance because all the chemical reactions that take place in the cells do so in aqueous medium.
- Water also forms good dispersion medium for colloidal system of the matrix.

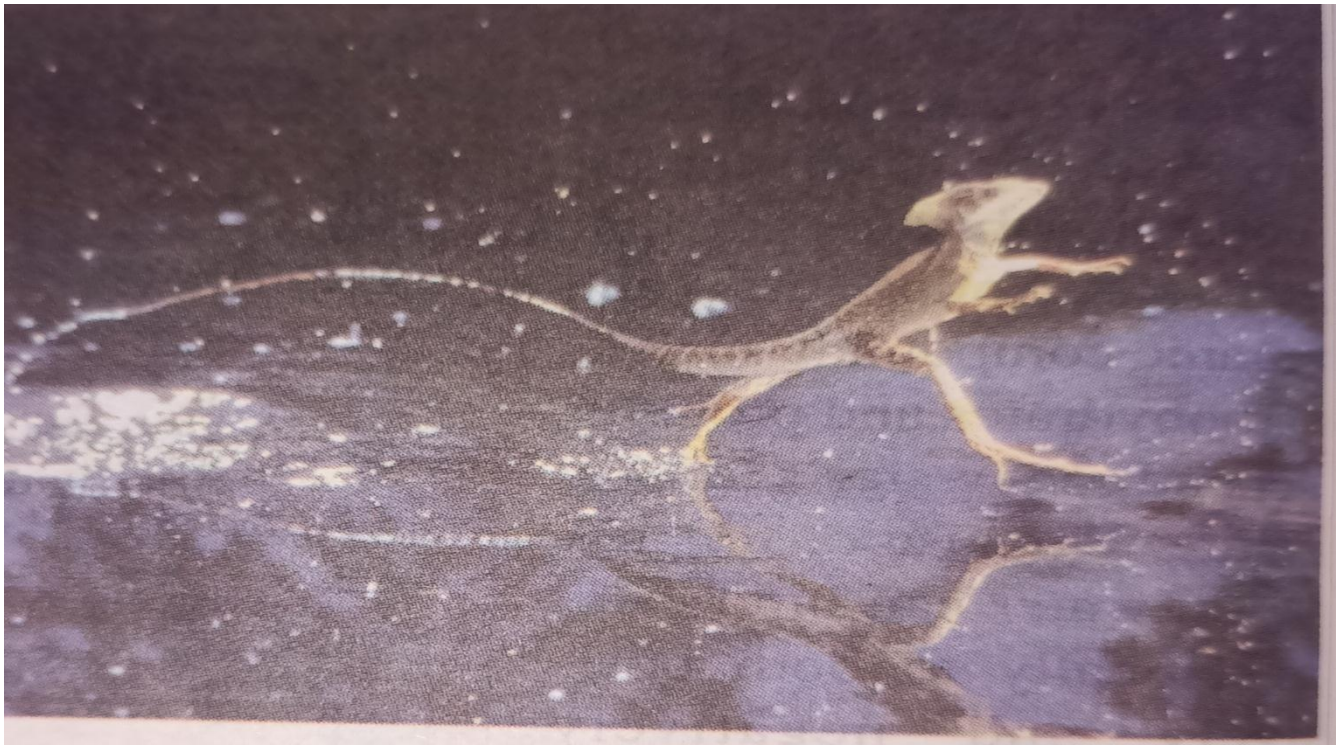
Thermal properties of water

- Water has a high specific heat requiring 1 calorie to elevate the temperature of 1 gm of water by 1^0C.
- Such high thermal capacity of water has great moderating effect on environmental temperature changes and is a great protective agent for life.
- Water also has high heat of vaporisation. It requires more than 540 calories to change 1gm of water into water vapour.
- Thus, water tends to have a remarkably high boiling point (100^0C) for a substance of such low relative molecular mass.
- For terrestrial plants and animals, cooling produced by the evaporation of water is an important means of getting rid of excess heat.

- An important property of water from biological standpoint is its unique density behaviour during change of temperature.
- Most liquids become continually more dense with cooling. Water, however, reaches its maximum density at 4^0C and then becomes lighter with further cooling.
- This protects the aquatic life from freezing.

Surface tension

- Water has high surface tension.
- This property, is important in the maintenance of protoplasmic form and movement.
- Despite its high surface tension, water has low viscosity, a property that favours the movement of blood through minute capillaries and of cytoplasm inside cellular boundaries.
- Molecules dissolved in water lower its surface tension and tend to collect at the interphase between its liquid phase and other phases.
- This may have been important in the development of the plasma membrane certainly plays an important role in the movement of molecules across it.



A basilisk lizard runs across a pond, putting the water's surface tension to good use.

Transparency

- Water is transparent to light, enabling the specialized photosynthetic organelles, the chloroplast, inside the plant cell to absorb sunlight for the process of photosynthesis.

Organic Compounds

- The chemical substances which contain C in combination with one or more elements as H, N, S etc. are called organic compounds.
- Organic compounds usually contain large molecules which are formed by similar or dissimilar unit structure known as monomers.

The main organic compounds of the matrix are:

- Carbohydrates
- Lipids
- Proteins
- Vitamins
- Hormones
- Nucleotides.