SECTION 3-1, WATER

Compare the body of the jellyfish with your own body. The jellyfish will die if it is removed for its water environment. You can live in the driest parts of Earth. Jellyfish and humans seem utterly unlike each other, yet the bodies of both are made of cells filled with water. The chemical reactions of all living things take place in an Aqueous environment. Water has several properties that make it one of the most important compounds found in living things.

OBJECTIVES: Describe the structure of a water molecule. Explain how water's polar nature affects its ability to dissolve substances. List Two of water's properties that result from hydrogen bonding.

POLARITY

1. Many of Water's Biological Functions stem from its Chemical Structure.

2. In the Water Molecule, H₂O, the Hydrogen and Oxygen Atoms SHARE Electrons to form a Covalent Bond, but these atoms DO NOT Share the electrons Equally.

3. The Oxygen Atom, because of its 8 Protons versus Hydrogen's 1 Proton, PULLS the Shared Electrons towards its Nucleus and AWAY from the Hydrogen Atom. As a result, the Electrical Charge is UNEVENLY Distributed in the Water molecule. (Figure 3-1)

4. Although the TOTAL Electrical Charge on a Water Molecule is NEUTRAL, the region of the molecule where the Oxygen Atom is located has a Slightly NEGATIVE Charge, while the regions of the molecule where each of the Two Hydrogen Atoms are located have a Slightly POSITIVE Charge.

5. Because of this UNEVEN PATTERN of CHARGE, Water is called a POLAR MOLECULE.

6. It is this Polar Nature that makes Water VERY EFFECTIVE in Dissolving many other substances.

7. Water Dissolves Other Polar Substances including, Sugars, some Proteins, and Ionic Compounds such as Sodium Chloride, NaCl.

8. An Ionic Compound mixed in water trends to DISSOCIATE (Break Apart) into Ions. This breaking up of an Ionic Compound FREES Ions to participate in many Biological Reactions. (Figure 3-2)

HYDROGEN BONDING
CHAPTER 3: BIOCHEMISTRY NOTES

HYDROGEN BONDING

1. The Polar Nature of Water also causes Water Molecules to be attracted to one another or stick together. That Holds TWO Water Molecules Together is called HYDROGEN BONDING. ONE MOLECULE IS ATRACTED TO THE NEGATIVE REGION OF A BOND that can be easily broken.

2. The Type of ATTRACTION that Holds TWO Water Molecules Together is called HYDROGEN BONDING. (Figure 3-3)

3. A POSITIVE REGION OF ONE MOLECULE IS ATRACTED TO THE NEGATIVE REGION OF ANOTHER MOLECULE.

4. A Hydrogen Bond is a WEAK Bond that can be easily broken.

5. The Hydrogen Bonds in Water exert a significant Attractive Force, causing Water to Cling to other Surfaces (Adhesion).

6. An Attractive Force BETWEEN PARTICLES OF THE SAME KIND is known as COHESION. This causes Water to look like it is Climbing up the side of a Glass.

7. ADHESION is the Attractive Force BETWEEN UNLIKE SUBSTANCES.

8. Together, Adhesion and Cohesion enable Water Molecules to MOVE UPWARD through narrow tubes Against the PULL OF GRAVITY. This Property of Water is known as CAPILLARITY. This is what allows Plants to move Water from their Roots to their Leaves.

9. Water MUST GAIN or LOSE a LARGE Amount of ENERGY for its Temperature to Change. This makes Water a VERY STABLE Molecule.

10. Water's ability to Absorb Large amounts of Energy HELPS keep cells at an EVEN Temperature despite Temperature changes in the Environment.

SECTION 3-2, CARBON COMPOUNDS

All of the many compounds discovered can be classified in TWO Broad Categories: ORGANIC COMPOUNDS AND INORGANIC COMPOUNDS. ORGANIC COMPOUNDS contain CARBON ATOMS that are Covalently Bonded to other Carbon Atoms and to other Elements as well - typically Hydrogen, Oxygen, and Nitrogen. The Chemistry of Carbon is the Chemistry of Life.

OBJECTIVES: Define organic compound and name Three Elements often found in organic compounds. Explain why carbon forms so many different compounds. Define Functional Group and explain its significance. Compare a condensation reaction with hydrolysis.

CARBON BONDING

1. A Carbon Atom has FOUR Electrons in its outermost Energy Level, to be stable a Carbon Atom needs EIGHT Electrons in its outermost level, a Carbon Atom therefore READILY forms FOUR COVALENT BONDS with other Elements.
CHAPTER 3: BIOCHEMISTRY NOTES

2. Carbon also readily bonds with other Carbon Atoms, forming Straight Chains, Branched Chains, or Rings. (Figure 3-5)

3. This tendency of Carbon to bond with itself results in an enormous Variety of Organic compounds.

4. Carbon can share two or even three pairs of electrons with another atom: (Figure 3-5)

A. Single bond - a bond formed when two atoms share one pair of electrons.

B. Double bond - Atoms share two pairs of electrons.

C. Triple bond - Atoms sharing three pairs of electrons.

FUNCTIONAL GROUPS

1. In most Organic Compounds, Cluster of Atoms, called Functional Groups, Influence the properties of the molecule they compose.

2. The Functional Group IS THE STRUCTURAL BUILDING BLOCK THAT DETERMINES THE CHARACTERISTICS OF THE COMPOUND.

3. One functional group important to living things is the Hydroxyl Group, represented by OH. (Figure 3-6)

4. An Alcohol is an Organic Compound with a Hydroxyl Group attached to one of its Carbon Atoms.

5. The Hydroxyl Group makes Alcohol a Polar molecule that has some Properties similar to Water, including the Ability to Form Hydrogen Bonds.

LARGE CARBON MOLECULES

1. Large Carbon Compounds are built up from smaller simpler molecules called Monomers (Mono = One).

2. Monomers can bind to one another to form complex molecules known as Polymers.
3. A Polymer consist of repeated, linked units, forming Large Polymers called **MACROMOLECULES**. (MACRO = LARGE)

4. Monomers link to form Polymers through a Chemical Reaction called **CONDENSATION REACTION**. During the formation of Polymers, Water, H₂O, is Released or is By Product of the Reaction.

5. Example (Figure 3-8) During the Formation of the Sugar SUCROSE, which is Table Sugar, GLUCOSE and FRUCTOSE Combine.

6. In the Chemical Reaction the Glucose Molecule Releases a Hydroxide Ion, OH-, and the Fructose Molecule Releases a Hydrogen Ion, H+. The OH- and H+ Ions that are Released Combine to Produce a Water Molecule = CONDENSATION REACTION.

7. The BREAKDOWN of some Complex Molecules, such as Polymers, occurs through a process known as **HYDROLYSIS**.

8. Hydrolysis is the Reversal of a Condensation Reaction. The ADDITION of Water, to some Polymers can Break the Bonds that hold them together.

9. **ENERGY CURRENCY - ATP**

   1. Life Processes require a constant supply of ENERGY. This Energy is available to Cells in the form of Compounds that contain a Large amount of Energy in their overall Structure.

   2. The Most common Energy Compound used by Cells is **ADENOSINE TRIPHOSPHATE OR ATP**. (TRI = 3)

   3. An ATP Molecule is made of a Sugar (RIBOSE, A FIVE-CARBON SUGAR), and Adenine Molecule, and a Chain of THREE Phosphates groups (TRIPHOSPHATE GROUP). When the Bonds between the outermost Two Phosphate Groups of ATP is broken, ATP becomes ADP (ADENOSINE DIPHOSPHATE). (DI = 2)

   4. The term diphosphate means TWO Phosphate Groups.

   5. The Reaction that Forms ADP from ATP Releases a sizable amount of energy.

   \[ \text{EQUATION: } \text{ATP} \rightarrow \text{ADP} + \text{P} + \text{ENERGY} \]

7. The Transfer of this Energy Fuels most BIOCHEMICAL REACTIONS. This Conversion of Energy is USED by the Cell to drive the Chemical Reactions that enable an Organisms to Function.

**SECTION 3-3, MOLECULES OF LIFE**

Four main classes of Organic Compounds are essential to the life processes of All Living Things: **CARBOHYDRATES, LIPIDS (FAT), PROTEINS, and NUCLEIC ACIDS (DNA, RNA)**.
CARBOHYDRATES, LIPIDS (FAT), PROTEINS, and NUCLEIC ACIDS (DNA, RNA). These compounds are built from Carbon, Hydrogen, and Oxygen, the atoms occur in different ratios in each class of compound. Despite their similarities, the different classes of compounds have different properties.

OBJECTIVES: Define monosaccharide, disaccharide, and polysaccharide, and discuss their significance to organisms. Compare the structure of the various types of proteins. Relate the structure of lipids to their function. List Two essential functions of nucleic acids.

CARBOHYDRATES

1. The cells of the human body obtain MOST of their ENERGY from CARBOHYDRATES.

2. CARBOHYDRATES ARE COMPOUNDS MADE OF CARBON, HYDROGEN, AND OXYGEN IN A RATIO OF ABOUT TWO HYDROGENS TO ONE OXYGEN ATOM. THE NUMBER OF CARBON ATOMS VARIES.

3. Sugars, Starches and Cellulose are Carbohydrates.

4. There are THREE TYPES of Carbohydrates, grouped according to complexity: MONOSACCHARIDES, DISACCHARIDES, AND POLYSACCHARIDES. (Figure 3-10)

5. MONOSACCHARIDES ARE SINGLE SUGARS (Simple Sugar) SUCH AS GLUCOSE, GALACTOSE, A SUGAR FOUND IN MILK, AND FRUCTOSE, A SUGAR FOUND IN FRUITS. (C6 H12 O6).

6. Glucose, Fructose, and Galactose have the same Molecular Formula, C6 H12 O6, but their differing structures determine the different properties. Compounds like these sugars, with a single chemical formula but different forms, are called ISOMERS.

7. DISACCHARIDES, OR DOUBLE SUGARS, CONSIST OF TWO SINGLE SUGARS (Monosaccharides) LINKED TOGETHER. Common disaccharides include SUCROSE, OR TABLE SUGAR; LACTOSE, OR MILK SUGAR; AND MALTOSE; A SUGAR CONTAINED IN CEREAL GRAINS.

8. POLYSACCHARIDE IS A CARBOHYDRATE MADE OF LONG CHAINS OF SUGARS ("Many Sugars", Three or More Monosaccharides). The prefix POLY means "Many". Starches, such as those in BREAD, PASTA, AND POTATOES, ARE POLYSACCHARIDES.

9. Animals store Glucose in the form of Polysaccharide Glycogen in the Liver and Muscles to be used as Quick Energy. Glycogen consists of hundreds of Glucose Molecules strung together in a highly branched chain.

10. Plants convert excess sugars into Starches for long-term storage. Cellulose is a Polysaccharide contained in the cell walls of plants. Cellulose gives Strength and Rigidity to plant cells and makes up about 50 percent of wood.

PROTEINS
CHAPTER 3: BIOCHEMISTRY NOTES

1. Proteins are Organic Compounds Composed mainly of Carbon, Hydrogen, and Nitrogen. They are the construction materials for the body parts such as muscles, skin, and blood.

2. Proteins are made up of smaller units called **AMINO ACIDS**, the monomer building blocks of protein.

3. Our cells need proteins to make other proteins, such as enzymes.

4. Proteins are made of amino acids. The Monomer Building Blocks of Protein.

5. Our bodies contain thousands of different proteins. All these proteins are made from about 20 Different Amino Acids.

6. Amino Acids Differ ONLY in the type of R Group they Carry. The difference among the Amino Acid R Groups gives different Proteins Very Different Shapes. (Figure 3-11)

7. The different shapes allow Proteins to perform many different roles in the Chemistry of Living Things.

8. Two Amino Acids bond to form a **DIPEPTIDE**, during a condensation reaction, Two Amino Acids form a covalent bond, called a **PEPTIDE BOND**. (Figure 3-12)

9. Amino Acids can Bond to Each Other one at a time, forming a long chain called a **POLYPEPTIDE**.

10. Proteins are composed of one or more polypeptides. Some proteins are very large molecules, containing hundreds of amino acids.

11. One group of proteins - **ENZYMES** - help control chemical reactions by acting as **CATALYSTS**, they are essential for the functioning of cells. Catalysts can speed up some reactions by more than a billion fold.

12. Enzymes work by a physical fit (lock and key) between the Enzyme Molecule and its **SUBSTRATE**, the reactant being catalyzed. (Figure 3-13)

13. The fit of Enzymes on a Substrate Weakens some chemical bonds, which reduces the activation energy for the chemical reaction to occur.

14. After the reaction, the enzyme is released and is unchanged, so it can be used many times.
LIPIDS OR FATS

1. Lipids are Large, nonpolar Organic Molecules that DO NOT Dissolve in Water.
2. They have a HIGHER Ratio of Carbon and Hydrogen Atoms To Oxygen Atoms than Carbohydrates have.

FATTY ACIDS

1. FATTY ACIDS are Unbalanced Carbon Chains that make up most Lipids. (Figure 3-14)

(a) Hydrophilic “head”
(b) Hydrophobic “tail”

The two ends (HEAD AND TAIL) of a Fatty Acid molecule have different properties:

- (HEAD) of the Fatty Acid Molecule is POLAR, and Attracted to Water. It is said to be HYDROPHILIC, WHICH MEANS "WATER LOVING".
- (TAIL) of the Fatty Acid Molecule is Nonpolar, and tends Not To Interact with Water. It is said to be HYDROPHOBIC, OR "WATER FEARING".

- Fatty Acids are Classified as either SATURATED OR UNSATURATED. The classification depends on the proportion of Hydrogen Atoms to Carbon - Carbon Bonds in the molecule.

- The FEWER the Hydrogen Atoms the MORE Double Bonds there will be connecting the Carbons. Double bonds can be broken and more Hydrogen's Added.

6. FATS WITH DOUBLE BONDS ARE CALLED UNSATURATED FAT. MOST UNSATURATED FATS ARE A LIQUID AT ROOM TEMPERATURE, AND ARE USUALLY REFERRED TO AS OILS.

7. SATURATED FATS HAVE NO DOUBLE BONDS (THEY ARE FULL) BETWEEN THE CARBONS AND CONTAIN THE MAXIMUM NUMBER OF HYDROGEN ATOMS.

8. SATURATED FATS ARE USUALLY SOLID AT ROOM TEMPERATURE, AND MOST COME FROM ANIMAL PRODUCTS.
10. **THREE Classes of Lipids important to Living Things contain Fatty Acids: TRIGLYCERIDES, PHOSPHOLIPIDS, AND WAXES.**

   A. **TRIGLYCERIDES** - Composed of Three Molecules of Fatty Acids joined to One Molecule of Alcohol Glycerol.

   VO Fatty Acids joined by a Molecule of Glycerol. The Cells of Phospholipids called a **LIPID BILAYER** and forms a side of the Cell. (Figure 3-15)

   B. **PHOSPHOLIPIDS** - Have TWO Fatty Acids joined by a Molecule of Glycerol. The Cell Membrane is composed of Two Layers of Phospholipids called a **LIPID BILAYER** and forms a Barrier between the inside and outside of the Cell. (Figure 3-15)

   C. **WAX** - Consists of a Long Fatty Acid Chain Joined to a Long Alcohol Chain. Waxes are highly Waterproof, in Plants and Animals they provide Protective Coatings. Earwax prevents middle ear.

   **STEROIDS**, Molecules that are composed of Four Fused Groups attached to them.

   Hormones, Testosterone in Males. One of the most Familiar **ROL**, which is needed by the body for nerve cells and other

**NUCLEIC ACIDS - DNA AND RNA**

**NUCLEIC ACIDS** are very Large and Complex Organic Molecules that STORE Important Information in the Cell. (Genetic or Heredity Information)

**NUCLEIC ACIDS** use a System of FOUR Compounds to store Heredity Information. A Sequence of compounds arranged in a certain order acts as a Code for Genetic Instructions of the adenine, guanine, cytosine, thymine - they make up the nitrogen-containing bases found in (chap. 10-1)

3. **DEOXYRIBONUCLEIC ACID, OR DNA**, contains information that is essential for almost all Cell Activities, Including Cell Division.

4. **RIBONUCLEIC ACID, OR RNA**, Stores and Transfers Information essential for the Manufacturing of Proteins.
Both DNA and RNA are polymers, composed of thousands of linked monomers called **NUCLEOTIDES**.

Each nucleotide is made of **THREE MAIN COMPONENTS**: a **PHOSPHATE GROUP**, a **FIVE-CARBON SUGAR**, and a **RING SHAPED NITROGEN BASE**. (Figure 3-16)