Matter, Elements, and Compounds

MATTER: anything that takes up space and has mass.

molecules are the smallest units of a substance that still possess the fundamental chemical and physical properties of the substance

molecules can be chemically broken down into simpler constituents called atoms

ELEMENT: a substance that cannot be broken down by ordinary means. The material making up matter.

- There are 92 naturally occurring elements, of these 25 are essential to life. 4 of these make up 96% of living matter (Carbon, Hydrogen, Oxygen, and Nitrogen).
- The rest are called trace elements. These are required in minute amounts(zinc, cobalt, iron, magnesium).

Small units of matter are called atoms. Protons(+), neutrons(0), and electrons(-), are the subunits of atoms. Their mass is measured in units called Daltons.

ATOMIC NUMBER: THE TOTAL NUMBER OF PROTONS IN AN ATOM.

ATOMIC MASS: THE TOTAL NUMBER OF NEUTRONS AND PROTONS IN AN ATOM.

ISOTOPES: Different atomic forms caused by varying the number of neutrons.

Example: Normal carbon is 12, carbon isotope is 14.

Some isotopes are radioactive; they undergo a transformation to gain a stable condition. This transformation is called the half-life of the isotope. Ex: Let's say the half-life of carbon is 5730 years, if we have 100g of carbon 14 now, in 2865 years we'll have 50g. In 1432.5 years we'll have 25g etc.

Two useful applications of radioisotopes are:

1. radiometric dating

when the ratio of carbon-12 to carbon-14 in a dead or fossilized organism is measured, scientists can predict the amount of time that has elapsed since the organism's death

2. radioactive tracers

when radioactive elements exist in living tissue, they emit radiation

this radiation can be detected using various kinds of equipment – which means that any radioactive element can be followed or traced chemical reactions

this is how scientists learn about reaction mechanisms and biochemical processes such as respiration and photosynthesis

carbon-14 and hydrogen-3 (tritium) are commonly used tracers in biological research

Homework: Practice 1-7, p. 10

BONDING

- using statistics, scientists can determine the most probable location of electrons in regions of space called orbitals
- these fixed, 3-dimensional, regions of space around the nucleus are called orbitals (Figure 4, p. 11)
- orbitals can only accommodate 2 electrons
- each energy level that surrounds a nucleus of an atom possesses subshells that contain these orbitals
- for example, energy level one possesses one subshell, (the s subshell), which in turn, is the first orbital, energy level two possesses two subshells, (the s and the p subshell), therefore 4 orbitals, the s, and the three p orbitals, energy level three possesses three subshells, (the s, the p, and the d subshell), therefore nine orbitals, the one s, the three ps, and the five ds, etc.
- the 1st orbital of every energy level has the same shape, the 2nd orbital has another distinct shape (see Figure 4, p. 11)
- the maximum number of electrons that each energy level can hold can be calculated using 2n2, where n is the energy level
- for example, energy level 3, alone, can hold a maximum of 2(3)2 = 18 electrons
- an atom that has three energy levels can hold a maximum of 2(1)2 + 2(2)2 + 2(3)2 = 28 electrons
- the arrangement of electrons in the orbitals is called an atom's electron configuration (Table 3, p. 12)
- the outermost orbitals contain the electrons furthest away from the nucleus of an atom
- the orbitals that exist on the outer-most level contain the electrons that are responsible for bonding to form molecules
- electrons found in these outer-most orbitals are called valence electrons
- they are the ones involved in the chemical reactions of that atom
- the chemical stability of an atom is determined by the arrangement of an atom's valence electrons
- atoms that have completely filled orbitals are more stable, and less reactive than atoms with half-filled, or incomplete orbitals ex: Noble gases (Ne) of group 18
- all other elements in the universe have incomplete outer orbitals, therefore are reactive
- Figure 5, p. 12 shows the number of valence electrons that the first 20 elements of the periodic table each possess
- elements can become chemically stable by either taking, losing, or sharing valence electrons
- the elements on the left of the periodic table will lose electrons to become stable
- The elements on the right will gain electrons to become stable
- for example, if a sodium atom were in contact with a chlorine atom, the sodium would lose one electron to the chlorine, resulting in a stable number of 10 electrons (just like neon)

· as a result, sodium becomes a cation with a positive one in charge, and chlorine becomes an anion with a negative one charge

· positive sodium is attracted to negative chloride, resulting in a force of attraction that keeps them together called an ionic bond; sodium chloride is an ionic compound

· molecular forces of attraction are forces that result from sharing of electrons between two atoms

· for example, if a carbon atom were in contact with two oxygen atoms, neither would lose nor gain electrons

· instead, the carbon would share two electrons with one oxygen, and two with the other

· the covalent bonds within the molecule are referred to as intramolecular forces.

· groups of atoms held together by covalent bonds are called true molecules -- Table 4, p. 13, shows examples of different compounds

Homework: Practice 8-9, p. 16

POLARITY DUE TO ELECTRONEGATIVITY

· all the atoms of the periodic table have a certain ability to attract electrons of other atoms – this ability is called electronegativity

· atoms on the right upper hand corner of the periodic table are the smallest, and as a result, their positive proton can get close to electrons of other atoms to attract them away from the other atom and bring them over to themselves – this means that these atoms have a high electronegativity

· atoms on the lower left hand corner of the periodic table are the largest, therefore have a low electronegativity

· when two or more atoms combine, the greater their difference in electronegativity, the greater the polarity of that substance

· in all cases of ionic bonding, and in some cases of covalent bonding where sharing of the electron pair is not equal, the molecule results in being polar - it has a positive end and a negative end

· this is because the electrons spend more time around one species (the more electronegative one), and less time around another (the less electronegative one)

· this means that each end of the molecule is oppositely charged – one end is slightly positive, the other, slightly negative

· to determine the amount of polarity in a molecule, the electronegativity values of the atoms involved are subtracted from one another

· if the difference is less than 1.7, the molecule is said to be a polar covalent substance

· if the difference in electronegativity greater than 1.7, the molecule is said to be ionic in character (see Figure 8, p. 14)

· for example, hydrogen chloride is more polar than chlorine gas because the difference in electronegativity between hydrogen and chlorine is 2.9 – 2.1 = 0.8, and the difference between the two atoms of chlorine in chlorine gas is 2.9 – 2.9 = 0.0.

· hydrogen chloride is slightly polar, and chlorine gas is completely non-polar (the truest molecule you can get)

INTERMOLECULAR BONDS

· the polarity of an entire molecule is dependent on two things – the bond polarity and the molecular shape

· symmetrical molecules (like Figure 10 (a)) are non-polar, while asymmetrical molecules are polar in nature

· all molecules attract other molecules – these forces of attraction are called intermolecular bonds

· these are the bonds that are broken in a substance when it changes state from solid to liquid to gas

· there are three types of intermolecular bonds, or van der Waals Forces: (Figure 12, p. 17)

1. London forces – weakest of the three; exist between all atoms and molecules; occur between non-polar substances

2. dipole-dipole forces – hold polar molecules together; positive side of one molecule with the negative end of another

3. hydrogen bonds – strongest of the three; occur between a hydrogen of one molecule and a very electronegative atom of another neighboring molecule, such as nitrogen (N), oxygen (O), or fluorine (F)

· Figure 13 and 14, p. 18 shows a diagram of H-bonding

THE PROPERTIES OF WATER

Hydrogen bonding of Water molecules: Due to the polar covalent bonds that hold a water molecule together, Hydrogen bonds form where the negative Oxygens and the positive Hydrogens are located.

Drawing of Hydrogen bonded water molecules:

The results of these bonds are as follows:

1. COHESION: is the sticking together of similar molecules. Water is very cohesive.

2. SURFACE TENSION: cohesion allows water to pull together and form droplets or form an interface between it and other surfaces. The measure of how hard it is to break this interface is its surface tension.

3. ADHESION: The sticking of one substance to another. Water is a good adhesive. It will cling on to many objects and act as a glue. Capillary Action is an example of cohesion and adhesion working together to move water up a thin tube.

4. HIGH SPECIFIC HEAT:

· Specific heat of a substance is the heat needed (gained or lost) to change the temperature of 1g of a substance 1degree Celsius. It takes 1,000 calories to raise 1,000g of water 1 degree C.

· This high specific heat allows water to act as a heat sink. Water will retain its temperature after absorbing large amounts of heat, and retain its temperature after losing equally large amounts of heat.

· The reason for this is that Hydrogen bonds must absorb heat to break.

· They must release heat when they form. The Ocean acts as a tremendous heat sink to moderate the earth's temperature.

5. HIGH HEAT OF VAPORIZATION:

· Water must absorb a certain amount of additional heat to change from a liquid into a gas. This extra heat is called heat of vaporization. In humans, this value is 2407 joules/ml.

· This results in evaporative cooling of the surface. Alcohol has a value of 991joules/ml. and chloroform 247 joules/ml.

· As one can see water removes much more heat from a surface upon evaporation than does either alcohol or chloroform.

6. Freezing and Expansion of Water: Water is most dense at 4 degrees C. At 0 degrees C it is 10% less dense. Ice floats because maximum Hydrogen bonding occurs at 0 degrees C.

7. VERSATILE SOLVENT:

· Water is a major solvent in nature. When water and another substance is mixed the resulting solution is called an aqueous solution.

· Any solution contains the following parts: Solute (what's being dissolved) + Solvent (what is doing the dissolving) = Solution.

· Solute Concentration: The concentration of the dissolved materials in relation to the solvent. This is always measured in moles.

· 1 mole = 6.02 x 10 23 atoms, molecules, or formula units of a substance

· One must first find the atomic weights of the substance involved and add them together for the representative molecule and change the value to grams.

· Molarity occurs when the mole (gram atomic weight of the substance) is placed in a container and dissolved in one Liter of water.

· pH: Refers to the dissociation of water molecules.

The pH constant is Kw = 1.0 x 10-14 (mol/L)2

· We have an even split of H+ and OH- ions.

· If 1.0 x 10-14 = H+ and OH- Then the conc. of the H ion is 1 x 10-7 and the conc. of the OH ion is also 1x10-7

· The true definition of pH is the negative log of the hydrogen ion concentration. (pH = -log[H+])

Problems:

1. H+ conc = 1 x 10-10 mol / L. Determine the pH.

2. OH- conc = 1 x 10-2 mol / L. Determine the pH.

Therefore, pH represents a 10 fold difference in the concentrations of each ion. A pH of 1 is 10 X smaller that a pH of 2 and 100 X smaller that a pH of 3, etc.

Buffers: Abrupt changes in pH is harmful to the cell and any living organism. In order to minimize this harm cells contain buffering systems. In order to change the pH of a solution H ions must be added or taken from it. Buffers do just that.

Carbon and Molecular Diversity

Carbon has a valence of 4 which, makes it capable of entering into 4 covalent bonds.

The following are variations in which carbon may form different chemical compounds:

1). Length of the carbon skeleton may differ (C-C, C-C-C, C-C-C-C-C, etc..).

2). Branching of the carbon skeleton (C-C-C-C- C-C-C-C-C)

3). The number of double bonds may differ (C=C-C-C, C=C=C-C).

4). The molecular structure may be in ring form.

Chemical compounds with the same molecular formula but different structural formulas are called isomers.

THERE ARE 3 TYPES OF ISOMERS:

a). Structural: These isomers differ from others due to the differing covalent arrangements of the atoms.

b). Geometric: These isomers contain the same covalent arrangement but different spatial arrangements. The double bonds make the molecule rigid, which prevents atomic rotation.

c). Optical: These isomers are mirror images of one another. There are right and left handed versions of these compounds.

FUNCTIONAL GROUPS: These are certain groups of atoms attached to the carbon skeleton. This area is usually on the end of the molecule.

1. HYDROXYL: R- OH makes molecule polar and produces an alcohol.

2. CARBONYL: R=O produces compounds known as ketones and aldehydes

3. CARBOXYL: R=O and OH forms organic acids (carboxylic acids: formic, acetic, etc).

4. AMINO: R- N + 1 charge, usually basic, acts as a good buffer.

5. SULFHYDRAL: R- S-H thiols, stabilizes protein molecular structures.

6. PHOSPHATE: R- O- P- O plus 2 more Oxygens attached to the P. energy storage that can be passed on from one molecule to another by the transfer of the group.

(See functional group handout)

Structure and Function of Macromolecules

Organic molecules that weigh more than 100,000 atomic mass units are referred to as macromolecules.

These macromolecules are constructed of smaller units called polymers. These polymers are subdivided into their basic units called monomers.

Making and breaking of polymers:

Dehydration synthesis: is an anabolic(putting together small molecules to make larger molecules) process by which two molecules are chemically bonded through the use of enzymes and a loss of water. Example: glucose + glucose = maltose + water.

Hydrolysis: is a catabolic (taking apart larger molecules to make smaller molecules) process by which the bond between monomers are broken by the enzyme and the addition of water. Example: Sucrose + water = glucose + fructose.

The four major Organic Compounds found in Living Things

1.Carbohydrates: include sugars and their polymers. They include monosaccharides, disaccharides, and polysaccharides. The monosaccharide is a monomer, the disaccharide is a polymer, and the polysaccharides are macromolecules.

Monosaccharides: The basic formula (CH2O)

Examples: glyceraldehyde, dihydroxyacetone, ribose, deoxyribose, ribulose, glucose, galactose, and fructose.

Disaccharides: These are double sugars with the formula C12H22O11. Notice that one molecule of water is missing from the formula. Examples: sucrose = glucose + fructose.

maltose=glucose + glucose, and lactose = glucose + galactose.

Polysaccharides: The basic formula is (C6H10O5)n . These are macromolecules capable of acting as structural or storage molecules.

A. Storage Polysaccharides: Starch is a plant storage polysaccharide that is composed entirely of glucose joined by a 1-4-glycoside linkages. Amylose is the simplest form of starch. Amylopectin is more complex and is branched. Glycogen is an animal starch stored in the liver and muscles of vertebrates.
B. Structural Polysaccharides: Cellulose and chitin are examples of structural polysaccharides. Cellulose is the most abundant organic compound on earth. It is made of glucose, like starch, but they differ in the type of 1-4 linkage. Instead of an a linkage as in starch cellulose contains a β 1-4 linkage. Enzymes find it difficult to break the β 1-4 linkage.

2. LIPIDS: A group of polymers that have one characteristic in common, they do not mix with water. They are hydrophobic. Some important groups are fats, phospholipids, and steroids.

FATS: are large molecules composed of 2 types of monomers, glycerol (an alcohol containing 3 carbons) and 3 fatty acid molecules.

The bond connecting the glycerol and fatty acids in the fat molecule is called an ester bond.

There are two types of fatty acids: saturated and unsaturated.

The saturated fatty acids do not contain any double bonds between the carbons, while the unsaturated fatty acids contain one or more double bonds between the carbons.

These double bonds cut down on the number of hydrogen atoms that can be attached to the carbon in the molecule. This causes the molecule to bend or kink at each of the double bond sites.

Saturated vs. unsaturated diagram

Fat diagram 1 glycerol + 3 fatty acids

Characteristics of Fats:

Saturated	Unsaturated
1. solid at room temperature	1. liquid at room temperature
2. found mostly in animals	2. found mostly in plants
3. no double bonds between carbons	3. double bonds found between carbons

Function of fats: acts as insulation in higher vertebrates, serves as an energy storage source 1g = 37.7 kJ of energy, and shock absorber for internal organs.

PHOSPHOLIPIDS: structurally related to fats but contain 2 fatty acids and one molecule of phosphate.

These molecules are found making up the plasma membrane of cells. They exhibit a polar and nonpolar quality.

The phosphate group is hydrophilic while the fatty acid area is hydrophobic.

STEROIDS: Lipids characterized by a carbon skeleton of 4 fused rings.

Cholesterol is an important steroid found in all animal tissue. Plants do not contain cholesterol.

Cholesterol functions in many ways: it is a precursor from which many of the bodies steroids are constructed from. It also adds strength to the plasma membrane in animal cells.

3. PROTEINS: macromolecules that make up 50% of the dry weight of most cells. Their monomers are called peptides. Most amino acids consist of a carbon bonded to an amino group, hydrogen, an R group,and a carboxyl group. When dissolved in water the carboxyl group donates a H+ ion to amino groups. Therefore the carboxyl group becomes negative and the amino group becomes positive. a.a. may be polar (hydrophilic or non polar (hydrophobic), or charged (acidic or basic) depending on its side chains.

There are 20 different amino acids. The bond formed between amino acids is called a peptide bond. This is a dehydration synthesis.

Types of proteins:

1. Structural functions in support, examples: elastin, collagen, and keratin
2. Storage food source, examples: ovalbumin and casein
3. Transport moves other substances, examples: hemoglobin and cell membrane proteins
4. Hormonal coordinates bodily activities, example insulin
5. Contractile movement, examples: actin and myosin
6. Antibodies defense, examples: Ig.E, IgA,and Ig.G
7. Enzymes aid in chemical reactions, examples: amylase and proteases

4. AMINO ACIDS: Most amino acids consist of an asymmetrical carbon bonded to an, amino group, hydrogen, an R group, and a carboxyl group.

8. There are 20 different amino acids. Each amino acid has an optical isomer. The left amino acid is the functional one. The D- amino acid only rarely function. Proteins are formed by bonding amino acids together. The bond formed is called a peptide bond.
9. Levels of Protein structure:
10. Primary: refers to the unique sequence of amino acids in the protein. All proteins have a special sequence of amino acids, this sequence is derived from the cell's DNA.
11. Secondary : the coiling or bending of the polypeptide into sheets is referred to the proteins secondary structure. alpha helix or a beta pleated sheet are the basic forms of this level. They can exist separately or jointly in a protein.

12. Tertiary: The folding back of a molecule upon itself and held together by disulfide bridges and hydrogen bonds. This adds to the proteins stability.
13. Quaternary: Complex structure formed by the interaction of 2 or more polypeptide chains.

NUCLEIC ACIDS: DNA and RNA.

Nucleotides: monomers that come together to form a nucleic acid.

They contain either a ribose or deoxyribose sugar (ribose has one more oxygen in its molecule), phosphate, and a nitrogenous base (purine = guanine or adenine, pyrimidine = cytosine, thymine ,or uracil).

Pyrimidines are constructed of a single ring while purines are characterized by a double ring.

The nucleotides are joined together by phosphodiester bonds.

Base pairing rule. A-T, A-U, C-G. DNA has a double helix shape, while RNA is single stranded.

Chemical Reactions: The combination of 2 or more elements forming a different product or products.

· Each reaction contains reactants and products. The reactants are written on the left side of the equation, while the products are written on the right side.

The reactants and products must contain the same number of atoms making the reaction balanced.

Introduction to Metabolism

Metabolism: the totality of an organisms chemical processes. It is divided into two parts: catabolic biological pathways used in the breaking down of substances(respiration, digestion, etc.) and anabolic biological pathways that build complex molecules (photosynthesis, protein synthesis).

Metabolism manages the material and energy resources of the cell.

Energy: the ability to do work. There are two types of energy: kinetic and potential. Kinetic is energy of movement (thermal and light) while potential Figure 2, p. 60 is energy of position or stored energy (chemical).

Energy is transformed (not cycled) from one form to another. The study of these transformations is called thermodynamics.

Laws of Thermodynamics:

First law states that energy of the universe is constant. It may change from one form to another but cannot be created or destroyed. This is sometimes called the Law of conservation of energy.

The second law states that “once energy has been used to do work, it becomes less available to do additional work” or every process increases the entropy (S) of the universe.

Entropy is the quantitative measure of disorder of a system. If we look at any organism as a system that needs and uses energy, we can see what would happen if the energy supply was cut off. The system would fail due to lack of the necessary energy to meet its needs. This type of system is considered a closed system. No new energy can enter, while the available energy is changed into useless heat, causing the system to fail.

Heat is a useless form of energy unless it is used to maintain temperature of a system, but it must move from a warm area to a cool one. The earth and its organisms are not closed systems. They are considered open, due to the fact that they can replenish their energy when needed. The sun and food are their means of replacement. If for some reason the energy supply stops they will become a closed system and fail. All open systems will eventually fail due to the process of energy turning into useless heat. The universe will eventually die due to a lack of useful energy and an abundance of heat. The universe is a closed system.

Chemical Energy: is stored in the bonds of the chemical they are holding together. Covalent bonds contain the most energy, while hydrogen bonds contain much less. During a chemical reaction 2 things must occur,

1). Energy must be absorbed to break the bonds of the reactants. 2). Energy is released when new bonds are formed. This is called bond energy.

$CH_4 + 2O_2$ --------------> $CO_2 + 2H_2O$

Each C-H bond contains 99 kcal / mol of stored energy. Since methane contains 4 of them its total bond energy is 396 kcal / mole. The double bonded oxygen contains 118 kcal / mole and there are 2, giving us 236 kcal / mol. Since these bonds must be broken the total energy absorbed is 633 kcal / mol.

On the products side (new molecules being formed), each C = O bond contains 174 kcal /mol since there are 2 each carbon dioxide contains 348 kcal / mol of energy. The O-H bond contains 111 kcal / mole, and there are 4 of them giving us a total of 444 kcal / mol. The total amount of energy released is 792 kcal / mol. 160 kcal / mol is the net energy released or the heat we feel from the reaction. This is the heat of the reaction or delta-H = - 160 kcal / mol. This refers to the stored energy being released. Always subtract the product answer from the reactant answer. If a reaction has a negative delta H, it is said to be exothermic.

Enthalpy : The total potential energy of a molecule. Enthalpy relates to the amount of heat energy released from a chemical reaction.

In an exothermic reaction the enthalpy of the products is less than the reactants, hence you feel the heat.

In an endothermic reaction the reverse is true, since the products have more enthalpy than the reactants. This occurs at the expense of its surroundings.

Spontaneous Reactions: is a reaction that will occur without any outside help. Specifically it can occur without the introduction of external energy. A nonspontaneous reaction cannot occur on its own; it will only happen if external energy is added.

Free Energy: The quantity that combines total energy (enthalpy) and entropy is free energy. Free energy is represented by the letter (G). Spontaneous reactions occur when the free energy of the system decreases. During nonspontaneous reactions the free energy of the system increases.

Based on free energy movement in a system the terms exergonic and endergonic are used to determine the direction of this free energy. An exergonic reaction will release energy from the reaction,

while an endergonic reaction will absorb free energy from its surroundings.

In order for an endergonic reaction to go to completion it needs an outside source of energy (activation energy).

In the cell this energy source comes from the chemical compound ATP. ATP helps the cell carry on 3 main types of work. Mechanical (cell movement), chemical (anabolism), and transport (pumping materials into and out of the cell). ATP (adenosine triphosphate) is constructed of a molecule of adenine attached to a molecule of ribose sugar which is attached to 3 phosphates.

ATP + H_2O ---------------> ADP + P + DG = -7.3 kcal / mol

This occurs in a test tube. In the human cell -10 / -12 kcal / mol are given off.

ATP transfers this energy to whatever it is reacting with. When the new chemical receives the P it is said to be phosphorylated. Phosphorylation has occurred.

ATP is renewable. ADP + P ------------------> ATP DG = + 7.3 kcal / mol (endergonic)

REDOX REACTIONS

When biochemical reactions involve the transferring of electrons from one molecule to another, it is called a reduction-oxidation or redox rx

The process of losing electrons is called oxidation, and the process of gaining electrons is called reduction (remember….LEO THE LION ROARSGER)

Example:

Na + Cl2 -----> 2NaCl

The Na starts out with an oxidation number of zero (0) and ends up having an oxidation number of 1+. It has been oxidized from a sodium atom to a positive sodium ion.

The Cl2 also starts out with an oxidation number of zero (0), but it ends up with an oxidation number of 1-. It, therefore, has been reduced from chlorine atoms to negative chloride ions.

The substance bringing about the oxidation of the sodium atoms is the chlorine, thus the chlorine is called an oxidizing agent. In other words, the oxidizing agent is being reduced (undergoing reduction).

The substance bringing about the reduction of the chlorine is the sodium, thus the sodium is called a reducing agent. Or in other words, the reducing agent is being oxidized (undergoing oxidation).

Figure 12, p. 67 shows this coupled redox process

Any burning or combustion is categorized as a redox rx this is because oxygen (a good oxidizing agent – thus the name), steals electrons from fuel that it burns the result is a decrease in potential energy of the transferred electrons, thus a release of free energy – heat, light

For example, Figure 13, p. 67 illustrates how oxygen removes methane's electrons, causing them to lose potential energy and release it as heat

Cellular respiration is a slow, controlled redox reaction

Homework: p. 68, 1-10.

ENZYMES

Enzymes: are catalysts that speed up a chemical reaction by lowering its activation energy. Enzymes are proteins that act on a substance called a substrate.

enzyme

substrate -------------> product

In the above reaction the enzyme's active site binds with the substrate. This active site is specific for each different type of substrate. Even the slightest change in the form of this site will alter the enzyme's function.

Factors affecting enzyme activity: Temperature, pH, and a particular chemical that specifically influences that enzyme. Enzymes work best at temperatures between 35o and 40oC in humans. pH range between 6 and 8 promotes optimum function. Salts inhibit enzyme action.

Coenzymes: are non protein chemicals that help enzymes act. Many of these coenzymes are vitamins.

Enzyme Inhibitors:

1. Competitive inhibitors: These chemicals mimic or resemble the normal substrate molecule.

2. Noncompetitive inhibitors: These chemicals attach themselves to the enzyme at another point and alters the enzyme's shape. This causes the enzyme's active site to become non receptive to the substrate.

3. Allosteric regulation: Most enzymes that are affected by this type of regulation are composed of 2 or more polypeptide chains. These enzymes fluctuate between an active and inactive substance.

The enzyme contains 2 sites the active site and the allosteric site, located away from the active site. The allosteric site must contain an activator substance that will allow the active site to remain open. If the activator is missing then an inhibitor occupies the space and inactivates the enzyme. Figure 7, p. 73

Feedback Inhibition: The most common form of metabolic control. The process involves the switching off of the metabolic pathway by its end product.

Homework: p. 77, 1-8.

Cellular Respiration

Energy Review:

Cells require a constant source of energy to carry out their life functions.

The main source of energy for most living systems is the sun.

Photosynthetic organisms capture sunlight and transform it into a useable source of energy via the chemical bonds in the organic compounds it produces.

Cells use some of this chemical bond energy to make ATP, the energy source for cellular work.

Much of this energy is released as unusable heat.

Catabolism: Chemical pathways that break down materials and release energy.

The catabolic process of respiration transfers the energy stored in food molecules to ATP.

Organisms use ATP molecules to capture and release small amounts of energy to fuel various bodily functions.

The molecule contains the nitrogenous base adenine connected to three molecules of phosphorous.

When ATP releases the terminal (end) phosphate, energy is released while forming a new compound ADP. ADP can be refitted with another phosphate to form ATP again.

In order for the most efficient production of ATP to occur the cell must transfer this energy from the chemical bonds of the organic compounds to the ATP molecule with minimal loss.

Homework: p. 93, 1-4.

Cellular respiration can be divided up into 3 stages:

1. Glycolysis
2. Krebs Cycle (Citric Acid Cycle)
3. Electron Transport Chain (ETC) and oxidative phosphorylation

Glycolysis:

Harvests chemical energy by oxidizing glucose to pyruvate.

Glycolysis is a catabolic pathway during which six-carbon glucose is split into 2 three- carbon sugars, which are then oxidized and rearranged to produce two pyruvate molecules

It occurs under aerobic or anaerobic conditions.

The process occurs in two phases: The energy investment phase and the energy yielding phase.

The Steps of Glycolysis:

The Krebs Cycle:

Completes the energy yielding oxidation of organic molecules.

The fate of pyruvate depends upon the presence or absence of oxygen. If oxygen is present, pyruvate enters the mitochondrion where it is completely oxidized by a series of enzyme-controlled reactions.

The junction between glycolysis and the Krebs Cycle is the formation of Acetyl-CoA. The Acetyl-CoA combines with oxaloacetate to begin the cycle. This process occurs in the mitochondrial matrix.

The Electron Transport Chain:

Is made of electron carrier molecules embedded in the inner mitochondrial membrane.

Each successive carrier in the chain has a higher electronegativity than the carrier before it, so the electrons are pulled down hill toward the oxygen.

Except for ubiquinone (Q), most of the carriers are protein containing a non -protein cofactor.

Fermentation: a cell process that can produce ATP without the presence of oxygen. Fermentation recycles NAD+ from NADH. The two most common forms of fermentation are: 1) alcoholic and 2). lactic acid fermentation.

Alcohol Fermentation (plants cells).

Pyruvate + NADH = Ethanol + NAD + CO2

- Ethanol is a toxic material to cells
- The Process allows the cell to rejuvenate its supply of NAD
- This also occurs without the presence of Oxygen

Lactic Acid Fermentation (animal cells).

Pyruvic Acid + NADH = Lactic Acid + NAD+

- Strenuous exercise causes the muscle cell to produce lactic acid.
- Lack of oxygen allows this process to occur.
- Lactic acid accumulation causes the muscle pH to decrease, causing fatigue and pain.
- Lactic acid is changed back to pyruvic acid in the liver.

Homework: p. 124 (1-13)

PHOTOSYNTHESIS

CHLOROPLAST STRUCTURE:

Double membrane enclosing stacks of green disc like structures called grana.

These grana make up what are called the thylakoids. These thylakoids are surrounded by a dense fluid called the stroma.

Nature of Sunlight and The electromagnetic spectrum:

GAMMA RAYS- X-RAYS - UV VISIBLE LIGHT INFRARED MICRO RADIO WAVES

VIOLET	INDIGO	BLUE	GREEN	YELLOW	ORANGE	RED
380 nm	450 nm	500 nm	550 nm	600 nm	650 nm	700 nm

1. Plants use light in the 450 and 700 nm range.

2. Various plant pigments help use light.

3. Carotenoids, chlorophyll a, b, and c. Chlorophyll a absorbs indigo and red lights,

4. b absorbs blue and orange -red,

5. c absorbs blue and orange in smaller amounts.

6. CHLOROPHYL is a molecule containing 2 main parts: a complex ring with a magnesium ion in the center and a nonpolar tail.

Homework: 1-9, pp. 145-146. Homework: pp. 154 – 155 (1-11)

OVERVIEW OF PHOTOSYNTHESIS:

The reactions of photosynthesis take place in two main stages:

1. those that capture energy (Light Reactions)
2. those that use energy to make carbohydrates (Calvin Cycle)

LIGHT REACTIONS:

These reactions take place in the thylakoid membranes. They involve 2 sets of light-absorbing reactions and 2 sets of electron transport chain reactions.

STEP 1. Light hits Photosystem II (P 680) causing electrons to be boosted to a higher energy level and pass into an electron transport chain. As a result some of the H+ from the stroma are carried through the thylakoid membrane and released into the space inside. ATP is produced here.

STEP 2: at the end of the chain a low energy electron enters Photosystem I (P- 700). Here it gets energized by more sunlight.

This energizes the electrons and moves them into the NADPH electron chain.

This chain passes electrons to NADP+ in the stroma. Each NADP+ accepts 2 electrons and reacts with a H+ in the stroma to form NADPH. The result is to move the electrons out of the thylakoid into the stroma.

These electrons are replaced by the splitting of water, that also produces H+ and O2.

The H+ stays in the thylakoid and becomes part of the H+ reservoir that will power the chemiosmotic synthesis of ATP.

The Calvin Cycle:

ATP and NADPH produced by the light reactions are used in the Calvin cycle to reduce carbon dioxide to sugar.

The Calvin cycle is similar to the Krebs cycle in that the starting material is regenerated by the end of the cycle.

Carbon enters the Calvin cycle and leaves as sugar.

ATP is the energy source, while NADPH is the reducing agent that adds high energy electrons to form sugar.

The Calvin cycle actually produces a 3 carbon sugar glyceraldehyde 3-phosphate.

The Calvin cycle may be divided into 3 steps.

Step 1. Carbon Fixation. This phase begins when a carbon dioxide molecule is attached to a 5 carbon sugar, ribulose biphosphate (RuBP).

This reaction is catalyzed by the enzyme RuBP carboxylase (rubisco) one of the most abundant proteins on earth.

The products of this reaction is an unstable 6 carbon compound that immediately splits into 2 molecules of 3-phosphoglycerate.

For every 3 molecules of carbon dioxide that enter the cycle via rubisco, 3 RuBP molecules are carboxylated forming 6 molecules of 3-phosphoglycerate.

Step 2: Reduction. This endergonic reduction phase is a 2 step process that couples ATP hydrolysis with the reduction of 3-phosphoglycerate to glyceraldehyde phosphate.

An enzyme phosphorylates (adds a phosphate) 3-phosphoglycerate by transfering a phosphate from the ATP. The product is 1-3-bisphosphoglycerate.

Electrons from the NADPH reduce the carboxyl group of the 1-3-bisphosphoglycerate to the aldehyde group of glyceraldehyde-3-phosphate.

For every three carbon dioxide molecules that enter the Calvin cycle,6 glyceraldehyde-3-phosphates are produced, only one can be counted as a net gain. The other 5 are used to regenerate 3 molecules of RuBP.

Step 3: Regeneration of RuBP. A complex series of reactions rearranges the carbon skeletons of 5 glyceraldehyde-3-phosphate molecules into 3 RuBP molecules.

These reactions require 3 ATP molecules.

RuBP is thus regenerated to begin the cycle again.

C4 Plants: Many plants begin the Calvin cycle with a 4 carbon compound instead of a 3 carbon compound. These are called the C4 plants.

They include the grasses (sugar cane and corn). These plants live in areas that are very hot and semi-arid.

The intermediate process is shown below and the product is then introduced to the bundle sheath cells where the Calvin cycle will take place. Homework: 1-13, p. 166 Homework: 1-9, p. 172

Photosynthesis and Cellular Respiration

Comparison	Respiration	Photosynthesis
1. Overall Reaction a. reactants b. products c. energy	• organic molecules (e.g. glucose) • CO_2 + H_2O • Released	• CO_2 + H_2O • organic molecules • stored
2. Electrons a. source b. carrier(s)	• organic molecules (e.g. glucose) • NAD+, FAD+	· Water · NADP+
3. Electron Transport System a. energy profile b. electron source c. electron sink d. products	Energy time • NADH and FADH2 • oxygen • ATP	Energy time • water • NADPH • ATP and NADPH
4. ATP Synthesis and Organelle Structure and Function a. location of ETC b. H+ ion reservoir and the pumping action of the ions by the ETC c. membrane embedded ATPase and the synthesis	• inter membrane (cristae) • pumped out of the matrix and into the inner membrane space • ATPase is oriented such that the H+ ions move from the outside in and ATP is made on the matrix side	• thylakoid membrane • pumped into the out of the stroma and into the thylakoid lumen • ATPase is oriented such that the H+ ions move from the inside out and ATP is made on the stroma side

pf ATP by chemiosmosis		

Homework: 1-5, p. 182

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