Biology 111 Review of Chapters 2, 3 and 4

Living organisms, plants, animals, bacteria monera and protists, all exist because they are organized (thus the name **organism.**) They are organized around the “laws” of nature. There are physical laws such as those of gravity, thermodynamics and there are chemical laws such as the laws of bonding and neutralization. We cannot understand organisms completely unless we have a basic understanding of some of the laws of physics and chemistry. Everything is related. No field of knowledge exists in insolation. We don’t learn a language just to know words and grammar. We use that language to express ourselves, acquire information and pass on that information. We don’t learn math just so we can solve isolated math problems we need the concepts of math to understand our money system, measure, tell time, and communicate information about quantity. It is sometimes not easy for students of biology to see the relevance of protons and electrons, bonding, neutralization and other chemical reactions to the study of living things. The purpose of these chapters is to help students see the relationship between the studies of chemistry and physics to the functioning of living things.

Scientists have determined that the universe is made up of 92 types of matter. These types of matter are called **elements**. The difference between each elements is the number of **protons** (positively charged subatomic particles) contained within the **nucleus** of the atoms of the elements. The smallest identifiable unit of each type of element is an **atom**. Atoms have 2 other subatomic particles that play an important in the function of the element. One of these particles is called the **electron** (negatively charged sub atomic particles) Electrons are about 1/2000 the weight of a proton. In a balanced atom the number of protons and the number of electrons is equal in number. However, this hardly ever happens under natural circumstances. (except for the elements called the noble gasses and these are found in the for right column of the Periodic Table of the Elements) The third important subatomic particle is called the **neutron**. This particle has the same weight as a proton. The number of neutrons is *about* the same as that of the protons. Atoms with a variable number of neutrons are called **isotopes**. (iso meaning the same) Combined together the protons and the neutrons make up the weight - called the **atomic weight** - of the atom. The number of protons an atom has is called the atomic number for that element. Among the 92 kinds of atoms there are only a very few that are used to form the bodies of organisms. The most used of these are C, H, O and N. Many others are used but in much smaller quantities.

One important property atoms have is the ability to **bond** together. This form a more or less stable union between each other. There are **bonding rules**. One if the important factors in the bonding rules is that atoms are most stable if the number of electrons on their outer surface have either 2 electrons (only in the case of hydrogen and helium) or 8 electrons in the case of most other atoms. (Remember there are usually exceptions to most rules in science. There atoms that don’t follow these rules of bonding but few if any are used in the bodies of living organisms) Depending upon which rule the bonding atoms are following they form **compounds** having many different properties. The smallest unit of a compound that retains all of the properties of that compound is called a **molecule**. Bonding is the result of the interaction of the electrons on the very outer edge (surfaces) or the atoms. There are three types of bonding that occurs between the atoms of elements that are most often found in living organisms. These are called **ionic** (formed by the give and take of electrons) **covalent** (formed by the sharing of pairs of electrons between the atoms) and **hydrogen** (which is the result of the unequal distribution of electrons within a molecule caused by one or more of the atoms within the molecule having more attraction for the electrons than the other atoms within that molecule. When H is used to build a molecule it has only one proton so has very little attraction for the electrons. The electrons are more attracted to the other atom or atoms with in the molecule so the hydrogen end develops a weak + charge and the other end of the molecule develops a weak – charge) Molecules with this electron arrangement and having a + and – end are called **polar compounds**. Examples of ionic compounds are **acids**, **bases** and **salts**. Examples of covalent compounds are **carbohydrates**, **lipids**, **proteins** and **nucleic acids.** Compounds used for building the bodies of organisms are of the covalent and hydrogen bonding type. Ionicly bonded compounds more often had an active function.

There are two broad branches of chemistry, inorganic and organic chemistry. One group of compounds in the inorganic group are acids, bases and salts. Acids are compounds that when placed in water release H^+ ions (otherwise knows as protons.) Bases are compounds that when placed in water produce an ion with a negative change that will attach to and remove H^+ ions from an acid solution. This group is extremely important in living things. They are very common types of compounds and they are part of the materials that makes up the cytosol or cytoplasm of all cells. The are also common in the fluid between cells in multicellular organisms and in the water of the environment of organisms. As is familiar to everyone, sea water contains a high concentration of salt...most of this is the common salt knows as table salt **NaCl** or sodium chloride. Salts play a vital role in maintaining a certain enrolment within and surrounding cells. They are important in nerve impulse transmissions and many other functions. HCl (hydrochloric acid) is necessary for the enzymes of the stomach to carry out their functions in digesting certain foods. A relationship exists between acids, bases and salts. The combining of an acid and a base results in a chemical reaction knows as **neutralization**. The products of this reaction are water and salt. Remember that acids release H^+ in water and bases release an ion that will combine with the H^+. This is often OH^-. So when H^+ and OH^- are present in the same solution HOH or H_2O results. The ions that were originally attached to the H^+ and OH^- then are free to combine and these for a salt. Remember, table salt NaCl is only one of many kinds of salts. Salt in chemistry is a general term.

One function of salts is to maintain water balance in cells. The protoplasm of cells has dissolved within it a certain concentration of salts. (mostly NaCl but others as well) There is a physical law that says molecules tend to move from areas where they are in high concentrations to areas where they are less concentrated. The illustration often used is that of opening a bottle of perfume in one corner of a room and given enough time the liquid will evaporate (leaving its area of most concentration) and be evenly distributed throughout all areas of the room. This process has the name diffusion. This process keeps water in the cell and maintains a certain pressure I the cell that causes the membrane of the cell to be expanded. If cells are in water with low salt concentration then water tends to move into the cell where IT is diluted by the water of the cell. The property of the membrane is to let water freely flow in and out but not the salt molecules. If the cell is flooded with water in which the salt concentration is higher than that of the cell (meaning also that the water concentration is lower than that of the cell) then the water from within the cell flows to an area of lower water concentration... out of the cell into the salt water. (the salts would move as well but the membrane keeps them trapped within the cell) One of the results of the water from within the cell moving out is to lower the pressure inside the cell. (the same as letting air out of a balloon) Since the cell membrane is stretchable it is no longer expanded and shrinks into a smaller structure. This process is called plasmolysis. You should have seen this when you put salt water on the elodea leaf and the contents of the cell, easily seen because of the presence of chloroplasts, should have appeared to ball up I the center of the cells. The process of water diffusing through a membrane is called osmosis.

Covalent bonding forms an enormous number of types of **organic compounds** (compounds containing carbon.) Of the millions or possible types of organic compounds that exist only those that fall into 4 groups (called **families** of organic compounds) are found in the bodies of living organisms. These are known as: **Carbohydrates**, **Lipids**, **Proteins** and **Nucleic Acids**. Each of these families have specific structures and functions that make them very useful to plants and animals. Some of their functions over lap. Knowing the general structure and function of each of these families is an important part of understanding how plants and animals are made and function.

In general **carbohydrates** are simplest of these 4 families of organic compounds. They are the easiest to make. The name is a clue to the chemical make up of the members of this family. Carbo = carbon and hydrate = water. The ratio of C to H_2O is just that. One C for every one water molecule. The basic general formula for a carbohydrate s CH_2O. (a hydrated carbon molecule.) They used in the making of compounds in the other families. They are made by **photosynthesis** in the **chloro*plasts*** found in the green parts of plants. Glucose ($C_6H_{12}O_6$) is the basic monomer of the carbohydrate family. It can be **polymerized** into **macromolecules** or **polymers** of greater complexity. The three most common and important of these is **amylose** (starch) **cellulose** and **glycogen**. The first two are found in plants and the last one is found in animals. Glucose, amylose and glycogen are all used as a source of energy and cellulose is an extremely important building material in plants. Many carbohydrates fall into the subfamily of sugars and their names can be recognized by the suffix **ose**. The only source of carbohydrates is the product of photosynthesis and the subsequent synthesis of the other various molecules of the family. The most common functions of the molecules of the carbohydrate family is that of an immediate supply of energy (sugars and amylose) or that of a very durable building material, cellulose. A principal to remember is that for most molecules found in organisms plants make them and animals must eat them. However, with the right combination of ingested molecules animals can synthesize many of the other compounds they need for proper functioning.

Lipids exist in many and varied forms. One of the most important for organisms is that of the **triglyceride** form. These molecules consist of a short 3 carbon chain known as glycerin with three molecules of **fatty acids** attached to the three carbons. Fatty acids differ from each other in the number of carbon atoms in the chain and the presence or absence of double bonds between the carbon atoms. For every double bound with in the carbon chan if a fatty acid there are 2 fewer hydrogen atoms. Fatty acids with double bonds and fewer hydrogen molecules are known as **unsaturated fats**. **Saturated fats** have all the hydrogens atoms they can hold. Molecules of the lipid family are manufactured by plants and must be eaten by animals. However, if animals ingest the correct balance of basic molecules the can manufacture many lipid molecules. Lips have 3 basic functions: providing immediate energy, energy storage, and building materials for a large number of components of plants and animals. (among these are the myelin sheath of the nerve cells of animals, cuticle, or waxy material on the surface of leaves and fruits which prevent dehydration) energy storage in the form of many types of lipid molecules and the structure of membrane material surrounding most cell **organelle**. Lipids also serve as energy storage compounds for both plants and animals. In many animals lipids serve as insulation against cold. Some members of the lipid family that are not triglycerides serve the function of hormones (testosterone, progesterone etc.) in animals.

Proteins are the most important building material in organisms. Proteins are polymers of **amino acid** monomers. Proteins also serve as the chemicals which drive or control the chemical reactions within cells. These chemicals are called **enzymes**. Proteins are polymers of **amino acid** monomers. There are 20 types of amino acid molecules that are used in the building of proteins found in organisms. Of these 20 humans must eat a very specific 10 (called the essential amino acids) every day to properly produce their proteins. If the 10 essential amino acids are ingested then the body can synthesize the other10. Amino acids have a common structural feature in that the have a basic structure of a nitrogen atom and 2 carbon atoms. Attached to the N atom are 2 H atoms and this is knows as the **amine** end of the molecule. To the carbon in the middle of the amino acid molecule is a group of atoms of various complexity called the **Radicle**. There are 20 different radicles. To the second C atom at the end opposite the amine end is attached the **-COOH** group of atoms knows as the carboxyl group and is a feature of all **organic acids**. Thus the COOH end is called the acid end. The names of these two ends give rise to the name of the compound amin-o acids.

Proteins being a polymer of amino acids are the result of the combination of any number of types of amino acids. Thus, the difference between any two proteins is the result of the number and sequence of its constituents amino acids. It has been determined that the "average" protein has some where between 300 up to 1,000 amino acids as its building blocks.

Proteins have another unique feature. They are basically long chains of amino acids (known as the primary structure) The finished molecule of a protein results from bending and twisting and cross bonding between certain amino acids in the chains. A protein of any one type has the same twists and bonding and as a result has the same shape. The shape is often referred to as the **nature** of the protein. Therefore, every type of protein has a different final shape. This shape is extremely important in the function of the protein. Building proteins such as those in hair bond a very specific way. Enzyme proteins do their jobs because of their shape. Enzymes most often have one of 2 functions. They cause molecules to join together or break apart. The molecules being worked on by enzymes are called the **substrate**. Substrate molecules are recognized by specific enzymes because of their **complimentary** shapes. Proteins that fall into the subcategory of enzymes often, but not always, have the ending -**ase**. Thus amylase is the is the enzyme that breaks down amylose (starch) in the mouth. There are a few enzymes such as pepsin and rennin that are common enzymes found in the stomach that digest proteins that do not follow the -ase rule.

There a few proteins that have functions other than building and enzymes. One such protein is insulin which is a hormone and another is the red protein, hemoglobin, found on the surface of red blood cells whose function is to attach to oxygen and carbon dioxide molecules and transport these molecule around the body.

Nucleic Acids (**RNA** and **DNA**) make up the final family of **biochemicals** most commonly found in living organisms. RNA and DNA are polymers of **nucleotide** monomers. The structure of nucleotides has been illustrated both in your text and in images projected by the instructor. Nucleotides are more complex molecules than are the monomers of the carbohydrates, lipids and proteins. A nucleotide is made of three smaller molecules. A phosphate, a sugar (**ribose** or **deoxyribose**) and a nitrogenous base (of which there are 5, **adenine**, **guanine**, **cytosine**, **thymine** and **uracil**.) A fact you just have to remember is that thymine is found in DNA and uracil is found in RNA. A nucleotide has the following 3 dimensional shape

phosphate
|
sugar -- base

(refer to you notes and the text book for the actual structural diagram)
The nucleotides polymerize to form the two nucleic acids. DNA and RNA have some interesting contrasts and comparisons. Because of its structure and shape DNA has the ability to do two things: 1. reproduce itself 2. be used as a pattern (template) for the production of RNA. The ability of DNA to replicate itself is extremely unique among molecules. This ability give life one of its unique characteristics and that is its ability to reproduce. DNA is a double stranded (see illustrations) molecule knows as a double helix. It consists of two complimentary polymers of nucleotides that attach and coil around each other. DNA in most organisms (**eukaryotes**) is confined to the nucleus and mitochondria) The DNA of each species of organism is ultimately unique to that organism. HOWEVER !!! related organisms have extremely similar DNA. The DNA of humans and gorillas for instance is 98% identical. All DNA in existence today came from DNA in the past. If two organisms have similar DNA they have a common ancestor organism in the past. DNA and RNA differ also in one of the nitrogenous bases, DNA contains thymine and RNA contains uracil. In the DNA structure and in the manufacture of RNA by DNA a pairing patters is always maintained. Adenine always pairs with Thymine (in DNA) and Uracil in RNA. Cytosine and Guanine whether in DNA or RNA always pair together. Here is an always! The reason why is that A and T (or in RNA A and U) bond together with 2 hydrogen bonds and C and G are held together –bonded– by 3 hydrogen bonds.

The basic function of DNA is to make RNA in its image. DNA remains extremely constant (but not 100% constant) from generation to generation. The slight changes in DNA from generation to generation are called mutation. These rare but important DNA changes may lead to organisms having slightly altered traits when compared with their parents and siblings and thus could possibly have traits that better adapt them to their environment. As these changes accumulate in certain lines of organisms over the millennia organisms not only continually adapt to inevitable changes in the environment and over time become different enough from their ancestral past to be considered a new and different species. (if the organism of today and its ancestor both lived side by side they could not breed and produce fertile offspring, thus the definition of species.) When you think about this it is an amazing property of living things.. both to be able to maintain enough stability from generation to generation to continue lines of organisms for literally millions of years and yet have the ability to adapt to an ever changing environment.

RNA has the basic function of transporting coded chemical information from the DNA out into the cell and at the ribosomes direct the production of proteins... those chemicals that build the structures of organisms and make the enzymes that direct the chemical activity of the cell.

You have the hair color you do because your DNA "told" the RNA to form in a certain sequence of nucleotides which when "read" at the ribosomes causes hair of a certain color to be synthesized. This is true for all of your inherited physical (hair color, location of organs etc.), chemical (blood type, ability to digest lactose etc.)and behavioral traits (your ability to play music, write a play or be athletic.)

Biological principal: All proteins are unique because of their shape which is the result of the number and sequence of their amino acids. That number and sequence structure was caused by the number and sequence of nitrogenous bases (A, U, C & G) in RNA which in turn is patterned on the sequence of nitrogenous bases (A, T, C & G) of the DNA.

...And then the enzymes which are proteins are responsible for organisms ability to preform photosynthesis, cellular respiration, for the eventual shape of the over all organisms. For the ability of the organism to be able to take in and digest food. For that food being converted to chemical energy in the mitochondria to be used by the brain or the muscles to preform their functions. For the ability of plants to manufactured a lipid called wax that covers leaves of desert plants allowing then to conserve what little water they produce and thus survive in deserts. The enzymes are responsible for the bright color of male birds and their ability to attract females for the purpose of mating and passing on to the next generation nearly unaltered DNA so that it can make RNA to make baby birds nearly identical to the parents but sometimes just enough different to withstand just slightly colder winters because their enzymes made by RNA which was made by their DNA they got from their parents gave them the ability to store just a little more fat to get then through a slightly longer colder winter so that they alone could be the parents of the next generation of birds that was just slightly different from their grandparents and..........so live changes and evolves and goes on as long as the earth is a place on which the conditions necessary for life exist!!!!