Unit 2: Biochemistry

Ms. Randall

Essential Questions:

- Where do living things get energy?
- How are chemical reactions controlled in the human body?
- What are the basic molecules that make up the human body? How do they work?
- Why is cancer a disease that can affect any living organism? Why is it so difficult to cure?
- What role does the cell membrane play in cell communication?

Unit Objectives:

- Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules.
- Define pH and the role of blood in maintaining pH balance
- Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions.
- Identify factors, such as pH and temperature and their effect on enzyme activity.
- Describe the structures of fatty acids, triglycerides, phospholipids, and steroids. Explain the functions of lipids in living organisms.
- Identify some reactions that fatty acids undergo. Relate the structure and function of cell membranes.
- Describe the structures of proteins and amino acids. Explain the functions of proteins in living organisms.
- Identify some reactions that amino acids undergo. Relate the structure and function of enzymes.
- Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.
- Explain the relationship between mutation, cell cycle, and uncontrolled cell growth potentially resulting in cancer
- Relate structure to function for the components of plant and animal cells.
- Explain the role of cell membranes as a highly selective barrier (passive & active).

Unit Vocabulary:

Enzyme
Catalyst
Carbohydrate
Lipid
Protein,
Nucleic acid
Mutation
Cancer
Diffusion
Osmosis

Lesson 1: What makes up Matter?

Objective:

- To relate the basic building blocks of matter to living things
- To relate chemical bonds in organic and inorganic molecules to the energy and structure of life.

The chemicals that make up living things are more complex than those in nonliving things. Learning the chemical basis of biology can help you understand how processes occur and how living things respond to the environment. Chemical reactions allow living things to grow, develop and reproduce

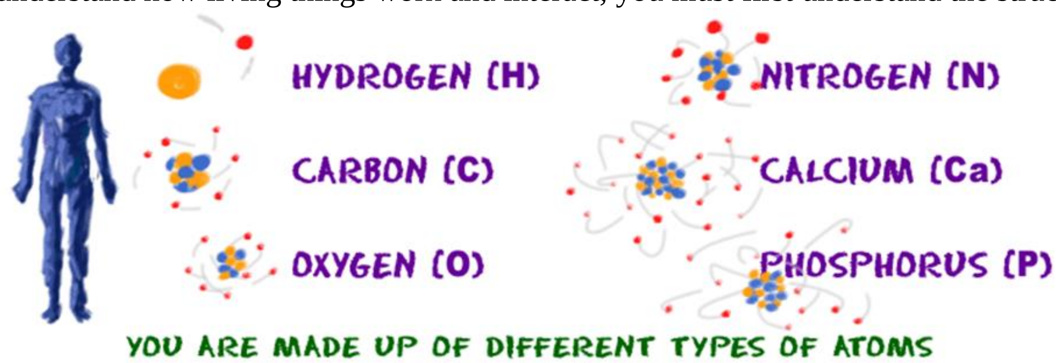
What makes up matter?

All matter is made up of atoms. An atom has a positively charged core surrounded by a negatively charged region.

What are some important interactions between substances in living things?

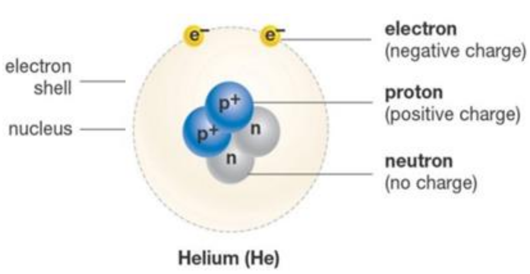
Hydrogen bonding plays an important role in many of the molecules that make up living things.

Every living and nonliving thing is made of matter. Matter is anything that has mass and takes up space. To understand how living things work and interact, you must first understand the structure of matter.



ATOMS

Structure of an atom:

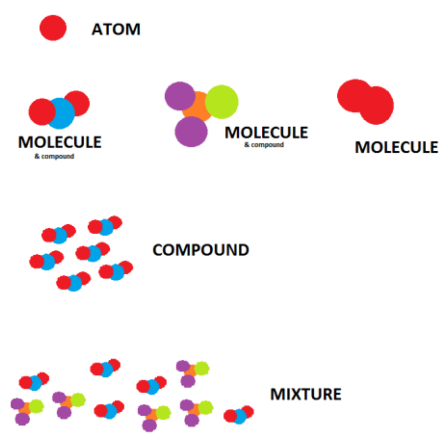


Nucleus - enter of an atom that contains protons and neutrons

- Neutron - particles with no charge that are located in the nucleus
- Proton - positively (+) charged particles that are located in the nucleus
- Electron - negatively (-) charged particles that are located outside the nucleus

Atoms are the building blocks of matter. Atoms are so small that you cannot even see them with a regular compound light microscope. Atoms are neutral; they contain the same number of protons as electrons. By definition, an ion is an electrically charged particle produced by either removing electrons from a neutral atom to give a positive ion or adding electrons to a neutral atom to give a negative ion. When an ion is formed, the number of protons does not change. Neutral atoms can be turned into positively charged ions called **cations** by removing one or more electrons. A neutral sodium atom, for example, contains 11 protons and 11 electrons. By removing an electron from this atom we get a positively charged Na+ ion that has a net charge of +1. Atoms that gain extra electrons become negatively charged. These are called **anions.** A neutral chlorine atom, for example, contains 17 protons and 17 electrons. By adding one more electron we get a negatively charged Cl ion with a net charge of -1. The gain or loss of electrons by an atom to form negative or positive ions has an enormous impact on the chemical and physical properties of the atom. Sodium metal, for example, which consists of neutral sodium atoms, bursts into flame when it comes in contact with water. Neutral chlorine atoms instantly combine to form Cl_2 molecules, which are so reactive that entire communities are evacuated when trains carrying chlorine gas derail. Positively charged Na+ and negatively charged Cl ions are so unreactive that we can safely take them into our bodies whenever we salt our food.

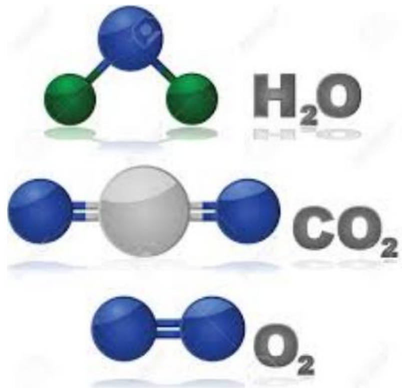
An element is a substance that can't be broken down into simpler chemical substances. The smallest particle of an element that has the characteristics of that element is called an atom. The nucleus is the positively charged center of an atom composed of neutrons and positively charged protons, and surrounded by negatively charged electrons.



A compound forms when two or more elements combine. The chemical bond that holds the elements together is a bond when electrons are shared. A substance with this kind of bond is called a molecule.

An atom that has lost or gained one or more electrons becomes **an ion**, which carries an electric charge.

Chemical Bonds are formed when atoms share electrons form **molecules**. The oxygen you breathe consists of molecules made up of <u>two</u> oxygen atoms <u>sharing</u> electrons.



Why are bonds important? Strong bonds provide energy for life processes! **Bonds store ENERGY!!!!**

The Importance of Water

Water is one of the most unique molecules known to man and also one of the most important to biological systems. Not only does water exist in nature in all three states of matter (solid, liquid, gas), it also covers 75 percent of the earth and composes roughly 78 percent of the human body.

The uniqueness of water comes from its molecular structure. It has a slight positive and slight negative charge on opposite ends and is a bent molecule.

Because water is a bent, it possesses biologically important characteristics. They are critical to the creation and support of life on Earth.

Hydrogen Bonding

When water molecules align with each other, a weak bond is established between the negatively charged oxygen atom of one water molecule and the positively charged hydrogen atoms of a neighboring water molecule. The weak bond that often forms between hydrogen atoms and neighboring atoms is the *hydrogen bond*. Hydrogen bonds are very common in living organisms; for example, hydrogen bonds form between the bases of DNA to help hold the DNA chain together. Hydrogen bonds give water molecules two additional characteristics: cohesion and surface tension.

PROPERTIES OF WATER

- All life occurs in water
- Neutral molecule
- Oxygen (-) and hydrogen (+) molecules are connected by hydrogen bonds (opposites attract)
- Great solvent
- High surface tension
- Can form hydrogen ions (H+) and hydroxide ions (OH-)

Organic vs. Inorganic

The primary difference between organic compounds and inorganic compounds is that **organic compounds** always contain **carbon** while most inorganic compounds do not contain carbon. Also, almost all organic compounds contain carbon-hydrogen or C-H bonds.

Molecules associated with living organisms are **organic**. These include nucleic acids, fats, sugars, proteins, enzymes and many fuels.

- DNA
- Glucose or sugar, $C_6H_{12}O_6$

Inorganics include salts, metals, substances made from single elements and any other compounds that don't contain carbon bonded to hydrogen.

- table salt or sodium chloride, NaCl
- carbon dioxide, CO_2
- oxygen, O_2
- water, H_2O

Why do we eat? We eat to take in more of these chemicals

1. Food for building materials
   - To make more of us (cells)
   - For growth
   - For repair
2. Food to make energy
   - Calories
   - To make ATP (Adenosine triphosphate, energy currency molecule)

Metabolism is a collection of chemical reactions that takes place in the body's cells. Metabolism converts the fuel in the food we eat into the energy needed to power everything we do, from moving to thinking to growing. Specific proteins in the body control the chemical reactions of metabolism, and each chemical reaction is coordinated with other body functions. In fact, thousands of metabolic reactions happen at the same time — all regulated by the body — to keep our cells healthy and working. Metabolism is a constant process that begins when we're conceived and ends when we die. It is a vital process for all life forms — not just humans. If metabolism stops, living things die.

What do we need to eat?

Foods to give you more building blocks & more energy for building & running bodies
Carbohydrates, proteins, fats, nucleic acids, vitamins, minerals, salts, water

Remember- 65% of your body is H_2O. Water is inorganic and doesn't contain carbon. Rest of you is made of carbon molecules!

Distribution of Elements in the Body

Table 2.1 Main Chemical Elements In the Body

Chemical Element (Symbol)	% of Total Body Mass	Significance
MAJOR ELEMENTS	**96%**	
Oxygen (O)	65.0	Part of water and many organic (carbon-containing) molecules; used to generate ATP, a molecule used by cells to temporarily store chemical energy.
Carbon (C)	18.5	Forms backbone chains and rings of all organic molecules: carbohydrates, lipids (fats), proteins, and nucleic acids (DNA and RNA).
Hydrogen (H)	9.5	Constituent of water and most organic molecules; ionized form (H^+) makes body fluids more acidic.
Nitrogen (N)	3.2	Component of all proteins and nucleic acids.
LESSER ELEMENTS	**3.8%**	
Calcium (Ca)	1.5	Contributes to hardness of bones and teeth; ionized form (Ca^{2+}) needed for blood clotting, release of hormones, contraction of muscle, and many other processes.
Phosphorus (P)	1.0	Component of nucleic acids and ATP; required for normal bone and tooth structure.
Potassium (K)	0.35	Ionized form (K^+) is the most plentiful cation (positively charged particle) in intracellular fluid; needed to generate action potentials.
Sulfur (S)	0.25	Component of some vitamins and many proteins.
Sodium (Na)	0.2	Ionized form (Na^+) is the most plentiful cation in extracellular fluid; essential for maintaining water balance; needed to generate action potentials.
Chlorine (Cl)	0.2	Ionized form (Cl^-) is the most plentiful anion (negatively charged particle) in extracellular fluid; essential for maintaining water balance.
Magnesium (Mg)	0.1	Ionized form (Mg^{2+}) needed for action of many enzymes, molecules that increase the rate of chemical reactions in organisms.
Iron (Fe)	0.005	Ionized forms (Fe^{2+} and Fe^{3+}) are part of hemoglobin (oxygen-carrying protein in red blood cells) and some enzymes (proteins that catalyze chemical reactions in living cells).
TRACE ELEMENTS	**0.2%**	
		Aluminum (Al), Boron (B), Chromium (Cr), Cobalt (Co), Copper (Cu), Fluorine (F), Iodine (I), Manganese (Mn), Molybdenum (Mo), Selenium (Se), Silicon (Si), Tin (Sn), Vanadium (V), and Zinc (Zn).

Lesson 2: Acids, Bases & Blood pH

***Objective*:**

- To compare and contrast properties and uses of acids and bases
- Describe the role of blood in maintaining pH balance

Every liquid you see will probably have either **acidic** or **basic** traits. Water (H_2O) can be both an acid and a base, depending on how you look at it. It can be considered an acid in some reactions and a base in others. Water can even react with itself to form acids and bases. It happens in really small amounts, so it won't change your experiments at all. It goes like this:

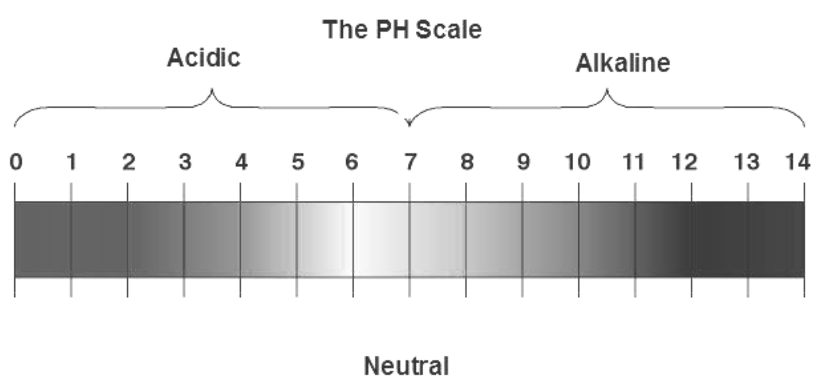
$2H_2O \rightarrow H_3O^+ + OH^-$

An **acid** is a substance that donates (gives up) hydrogen **ions** (ions are atoms with extra electrons or missing electrons). Because of this, when an acid is dissolved in water, the balance between hydrogen ions and hydroxyl ions is shifted. When a hydrogen ion is released, the solution becomes acidic.

A **base** is a substance that accepts (gains) hydrogen ions. When a base is dissolved in water, the balance between hydrogen ions and hydroxyl ions shifts the opposite way. When a hydroxide ion is released, the solution becomes basic. This kind of solution is alkaline.

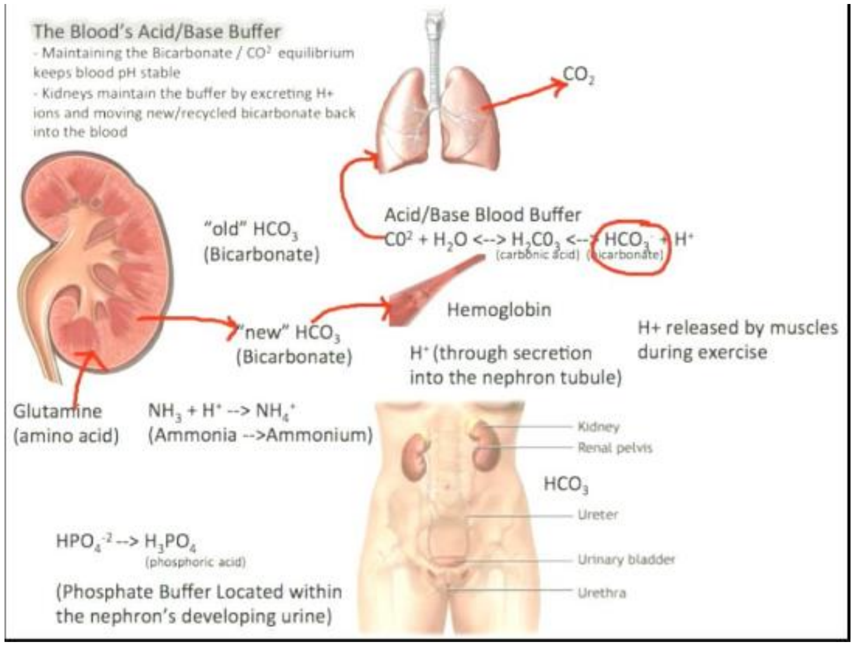
Acidity and alkalinity are measured with a logarithmic scale called **pH**. Here's why: a strongly acidic solution can have one hundred million million (100,000,000,000,000) times more hydrogen ions than a strongly basic solution! The flip side, of course, is that a strongly basic solution can have 100,000,000,000,000 times more hydroxide ions than a strongly acidic solution.

Scientists use something called the **pH scale** to measure how acidic or basic a liquid is. Although there may be many types of ions in a solution, pH focuses on concentrations of hydrogen ions (H+) and hydroxide ions (OH-). The scale measures values from 0 all the way up to 14. Distilled water is 7 (right in the middle). Acids are found between 0 and 7. Bases are from 7 to 14. Most of the liquids you find every day have a pH near 7 which is considered neutral.



pH scale - indicates the concentration of H+ ions in a solution

Buffer - weak acids or bases that react with strong acids or bases to prevent sharp, sudden changes in pH.



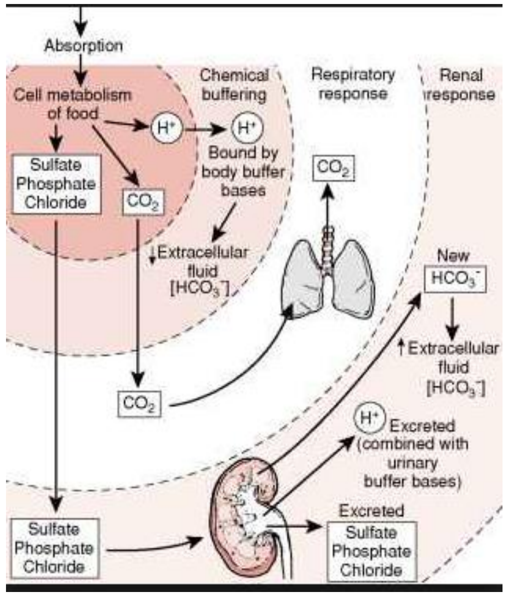
Blood pH:

The bloodstream is the most critically buffered system of the entire body, far more sensitive than any other. Arterial and venous blood must maintain a slightly alkaline pH: arterial blood pH = 7.41 and venous blood pH = 7.36. Because the normal pH of arterial blood is 7.41, a person is considered to have acidosis when the pH of blood falls below this value and to have alkalosis when the pH rises above 7.41.

Our bodies function optimally when the blood pH is in a very narrow range of 7.35 to 7.45. When your blood moves out of this range, your body attempts to correct the imbalance by tapping its stores of neutralizing nutrients. Unfortunately, those nutrients are often taken from sources where they're needed for other, equally important tasks.

Your bones, for example, are especially susceptible to drops in pH level because they are rich in calcium. In an acidic environment, bone tissue dissolves into some of its basic mineral constituents (alkaline salts), which are used as neutralizing agents. This process not only destroys the bone, but it inhibits any attempts by your body to rebuild it. Some experts consider acidosis to be the true cause of osteoporosis.

As the body becomes even more acidic, immunity and energy levels also suffer, and the production of adenosine triphosphate (ATP)—the body's basic cellular fuel—is impaired. Collectively, these effects make you more vulnerable to illness and age-related disorders.



Two Factors That Contribute to Blood pH Imbalance

The first is our intake, oxygen-carbon dioxide, and dietary habits.

When food is metabolized and broken down, it leaves certain chemical and metallic residues, a noncombustible "ash" which, when combined with our body fluids, yields either acid or alkali potentials of pH. Certain foods are "acid-forming" in nature, whereas others are known to be "alkali-forming."

The second is our production, elimination, and stress.

An overactive adrenal gland, can cause the release of cortisol and aldosterone, the buildup of glucose, lactic acid, and ketones. Sleep deprivation and inflammation can also adversely affect pH. An over active adrenal gland caused by high levels of stress can release a hormone called aldosterone into the blood stream causing large quantities of potassium to be excreted into the urine. Aldosterone also causes the excretion of magnesium into the urine. Stress and anxiety are the principal acid generators aside from the diet.

Acid-Base Disorders: Acidosis and Alkalosis

- **Acidosis**
    - Acidosis is excessive blood acidity caused by an overabundance of acid in the blood or a loss of bicarbonate from the blood (metabolic acidosis), or by a buildup of carbon dioxide in the blood that results from poor lung function or slow breathing (respiratory acidosis).
- **Alkalosis**
    - Alkalosis is excessive blood alkalinity caused by an overabundance of bicarbonate in the blood or a loss of acid from the blood (metabolic alkalosis), or by a low level of carbon dioxide in the blood that results from rapid or deep breathing (respiratory alkalosis).

Metabolic Acidosis and Alkalosis

- Metabolic Acidosis and Alkalosis are caused by an imbalance in the production of acids or bases and their excretion by the kidneys.

- Metabolic acidosis develops when the amount of acid in the body is increased through ingestion of a substance that is, or can be broken down (metabolized) to, an acid.

- Metabolic acidosis can also occur as a result of abnormal metabolism. Even the production of normal amounts of acid may lead to acidosis when the kidneys are not functioning normally and are therefore not able to excrete sufficient amounts of acid in the urine.

- Metabolic alkalosis can develop when excessive loss of sodium or potassium affects the kidneys' ability to control the blood's acid-base balance. For instance, loss of potassium sufficient to cause metabolic alkalosis may result from an overactive adrenal gland or the use of diuretics.

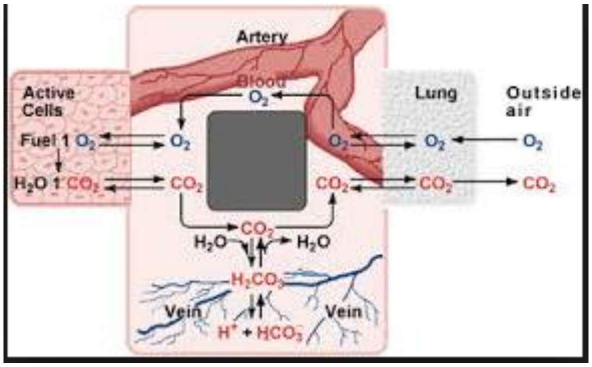
Major Causes of Metabolic Acidosis and Metabolic Alkalosis

Metabolic acidosis

- Diabetic ketoacidosis (buildup of ketones)
- Drugs and substances such as acetazolamide, alcohol, aspirin , iron
- Lactic acidosis (buildup of lactic acid as occurs in shock)
- Loss of bases, such as bicarbonate, through the digestive tract from diarrhea, an ileostomy, or a colostomy
- Kidney failure
- Poisons such as carbon monoxide, cyanide, ethylene glycol, methanol,
- Renal tubular acidosis (a form of kidney malfunction)

Metabolic alkalosis

- Loss of acid from vomiting or drainage of the stomach
- Overactive adrenal gland (Cushing's syndrome)
- Use of diuretics (thiazides, furosemide)



Respiratory Acidosis and Alkalosis

Respiratory Acidosis and Alkalosis are caused primarily by changes in carbon dioxide exhalation due to lung or breathing disorders.

- Respiratory acidosis develops when the lungs do not expel carbon dioxide adequately.
- Respiratory alkalosis develops when rapid, deep breathing (hyperventilation) causes too much carbon dioxide to be expelled from the bloodstream.

Major Causes of Respiratory Acidosis and Alkalosis

Respiratory acidosis

- Lung disorders, such as emphysema, chronic bronchitis, severe asthma, pneumonia, or pulmonary edema
- Sleep-disordered breathing
- Diseases of the nerves or muscles of the chest that impair breathing, such as Guillain-Barré syndrome or amyotrophic lateral sclerosis
- Overdose of drugs such as alcohol, opioids, and strong sedatives

Respiratory alkalosis

- Anxiety
- Aspirin overdose (early stages)
- Fever
- Low levels of oxygen in the blood
- Pain

<u>Lesson 3 Carbohydrates and Lipids</u>

Objective:

- To describe the structure and function of carbohydrates
- To describe the structure and function of lipids

<u>Watch this!</u> [You are what you eat!]

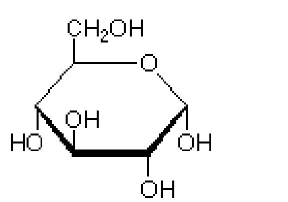
There are four main classes of Organic Compounds are essential to the life processes of all living things: **Carbohydrates, Lipids** (fats), **Proteins** and **Nucleic Acids**. These compounds are built mainly from Carbon, Hydrogen, and Oxygen, the atoms occur in different ratios in each class of compound. Despite their similarities, the different classes of compounds have different properties. The first of these compounds that we will learn about will be Carbohydrates.

Carbohydrate is a fancy way of saying "sugar." They are compounds made up of long chains of simple sugars made of carbon, oxygen and hydrogen. Carbohydrates can be very small or very large molecules, but they are still considered sugars. Organisms can create long chains of glucose molecules for food storage or structural reasons. These carbohydrates provide living things with energy and act as substances used for structure in plants.

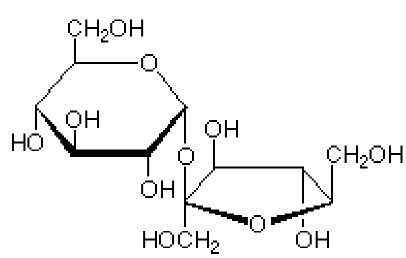
Scientists also use the word saccharide to describe sugars. If there is only one sugar molecule, it is called a **monosaccharide**. If there are two, it is a **disaccharide**. If there are three, it is a trisaccharide. When several carbohydrates combine, it is called a **polysaccharide** ("poly" means many). Hundreds of sugars can be combined in a branched chain. These long chains of glucose molecules are also known as **starches.** You can find starches in foods such as pasta, bread and potatoes. They are very good sources of quick energy for your body and are used to carry out cell processes.

An important structural polysaccharide (carbohydrate) is cellulose, which is found in plants. **Cellulose** is in wood and the cell walls of plants. You know that shirt you're wearing? If it is made of cotton, that's cellulose, too! There can be thousands of glucose subunits in one large molecule of cellulose. If we were like some herbivores or insects, such as termites, we could eat cellulose for food. Those animals don't actually digest the polysaccharides. They have small microorganisms in their bellies that break down the molecules and release smaller sugars.

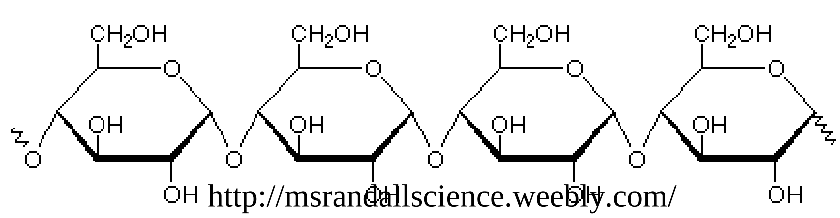
Animals store Glucose in the form of a polysaccharide called **glycogen** in the Liver and muscles. It is used for quick energy. Glycogen consists of hundreds of Glucose molecules strung together in a highly branched chain. Animals do not digest cellulose; it provides fiber/roughage in their diet.



monosaccharide (glucose)

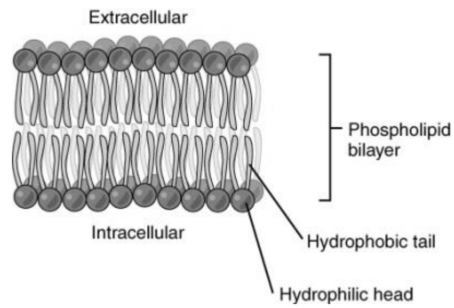


disaccharide (sucrose)

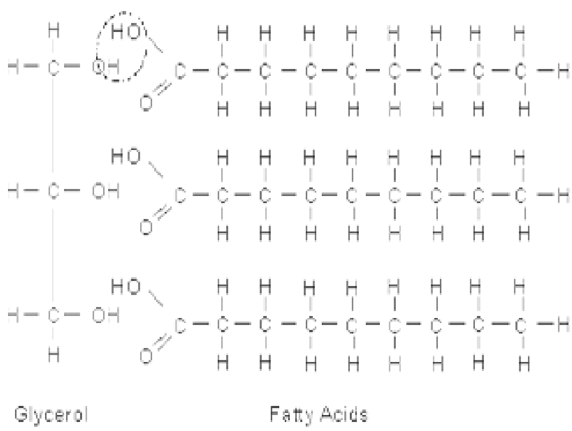


polysaccharide (amylose starch)

Lipids are another type of organic molecule essential to the life processes of all living things. Remember that organic means they contain carbon (C) and hydrogen (H) atoms. A lipid molecule consists of 1 glycerol molecule bonded to 3 fatty acids. These large molecules are repeated over and over to form very long chains. When you think of **fats**, you should know that they are lipids. **Lipids** are also used by organisms to make steroids and waxes. Cell membranes are made out of **phospholipids.**



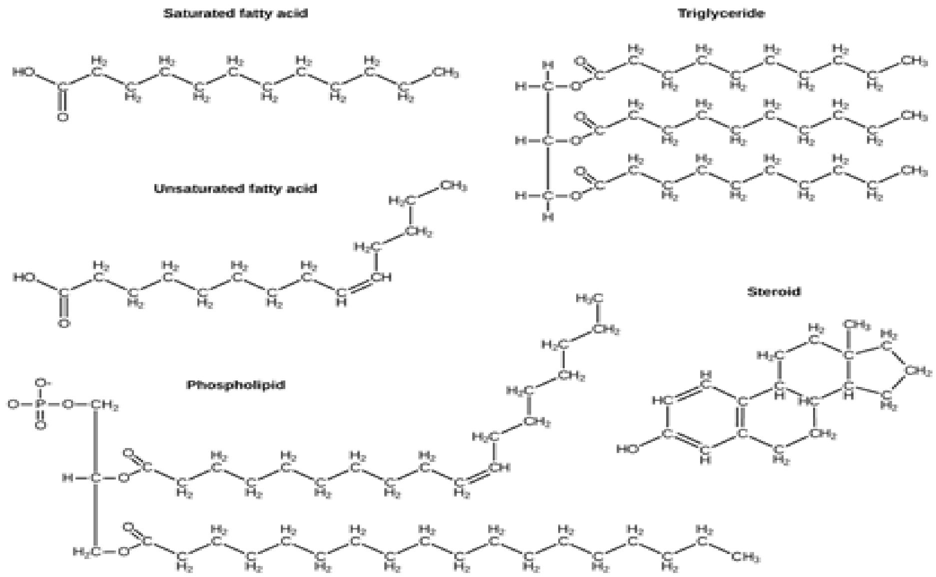
There are two kinds of fats (lipid), saturated and unsaturated. **Unsaturated fats** have at least one double bond in one of the fatty acids. They are much stronger than single bonds with only two electrons. Olive oil, nuts and avocado's contain unsaturated fats. **Saturated** fats have no double bonds and are solids at room temperature. Saturated fats are found mostly in animal products (meat cheese and milk) and foods fried in some plant oils. Saturated fats can raise blood cholesterol levels, and ultimately increase the risk of both heart disease and stroke.



Fats have a lot energy stored up in their molecular bonds. That's why the human body stores fat as an energy source. When you have extra sugars in your system, your body converts them into fats. When it needs extra fuel, your body breaks down the fat and uses the energy. Where one molecule of sugar only gives a small amount of energy, a fat molecule gives off many times more energy.

Steroids are found in animals within something called hormones. The basis of a steroid molecule is a lipid. You may have heard of steroids in the news. Many bodybuilders and athletes have used anabolic steroids to build muscle mass. Steroids are also used in necessary medicines. Some help people with acne, while others are used as muscle relaxers for injuries.

Waxes are used to coat and protect things in nature. Bees make wax. It can be used for structures, such as the bees' honeycombs. Your ears make wax. It is used to protect the inside of your ear. Plants use wax to stop evaporation of water from their leaves. There is a compound called **cutin** that you can find in the plant cuticle covering the surface of leaves. It helps to seal and protect plant structures.



Other Lipoid Substances in the Body

Fat Soluble Vitamins

Vitamin A, E, K
-A comes from orange pigmented vegetables (carrots) and fruits (oranges), part of photoreceptor rhodopsin needed for vision (night)
-E comes from wheat germ and green leafy vegetables, promotes wound healing, acts as a strong antioxidant by neutralizing free radicals that can cause biological problems
-K synthesized by intestinal bacteria, necessary for blood clotting

Prostaglandins-derivatives of fatty acids found in cell membranes, have various functions depending on the class. Stimulate uterine contractions, regulate blood pressure, control the movement of material through the digestive tract

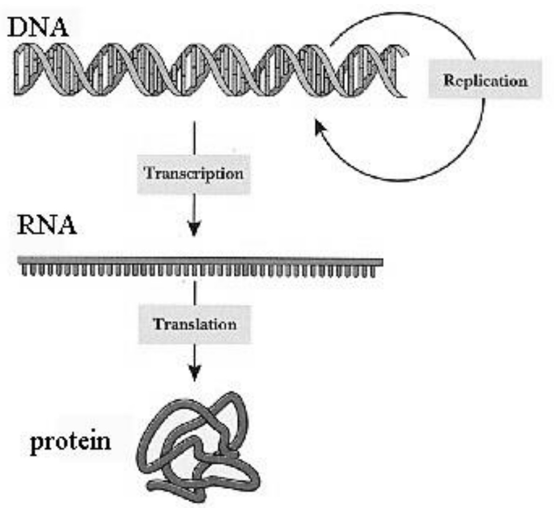
Lipoproteins- lipid and protein based structures that transport fatty acids and cholesterol in the blood stream. LDL (low density lipoprotein) carries fats and cholesterol to cells (bad cholesterol) and HDL (high density lipoprotein) carries fats and cholesterol away for removal (good cholesterol)

Lesson 4: Nucleic Acids and Proteins

Objective:

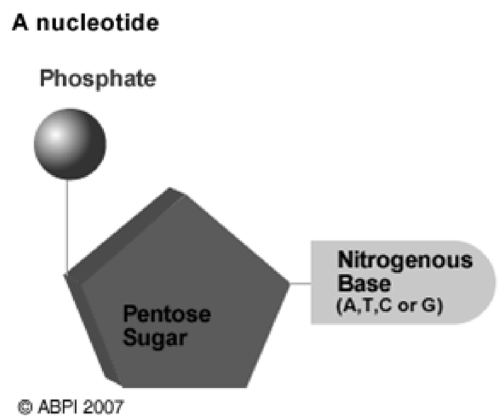
- **To describe the structure and function of DNA and RNA**
- **To describe the structure and function of Proteins**

Nucleic Acids



Living organisms are complex systems. Hundreds of thousands of proteins exist inside each one of us to help carry out our daily functions. These proteins are produced within cells and assembled piece-by-piece to exact specifications. The information detailing the specific structure of the proteins inside of our bodies is stored in a set of molecules called **nucleic acids.**

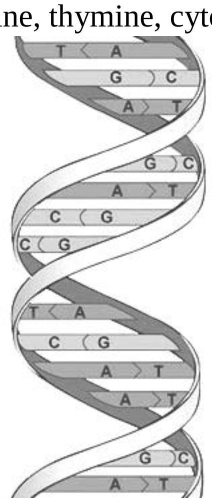
There are two types of nucleic acids, DNA and RNA. Both control protein synthesis and are stored in the nucleus of every cell. This diagram shows how DNA is used to make RNA which is then used to make protein.



Both DNA and RNA are composed of repeating units called nucleic acids or nucleotides. A **nucleotide** has three parts; a sugar molecule, a phosphate molecule and a nitrogenous base. Though the building block of DNA and RNA is the same, the sugar and bases of their nucleotides differ.

DNA is the "master copy" of instructions in a cell for protein synthesis. If the DNA in a cell were changed, protein synthesis in the cell would be affected. This is why DNA is stored in the nucleus and never leaves.

DNA is referred to as a "double helix" because it is a double stranded chain of nucleotides that is twisted like a spiral staircase. Each nucleotide contains the sugar deoxyribose, hence why DNA is named ***deoxyribonucleic acid***. Each DNA nucleotide contains one of four nitrogenous bases (adenine, thymine, cytosine or guanine).

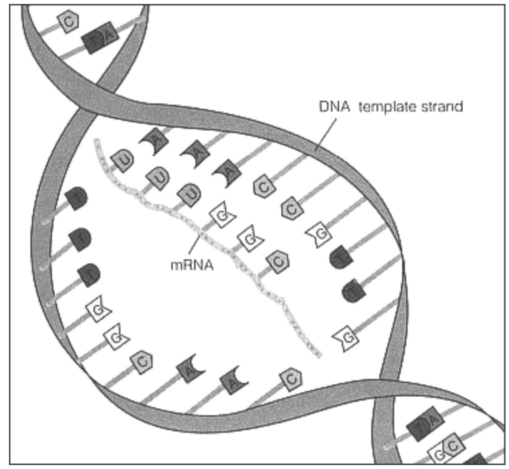


The shape of DNA resembles the shape of a ladder- two sides connected to each other by rungs. The side consists of alternating sugar and phosphate molecules. The rungs of the ladder consist of two bases bonded together. Adenine always bonds with thymine. Guanine always bonds with cytosine. This is called **the law of base pairing.**

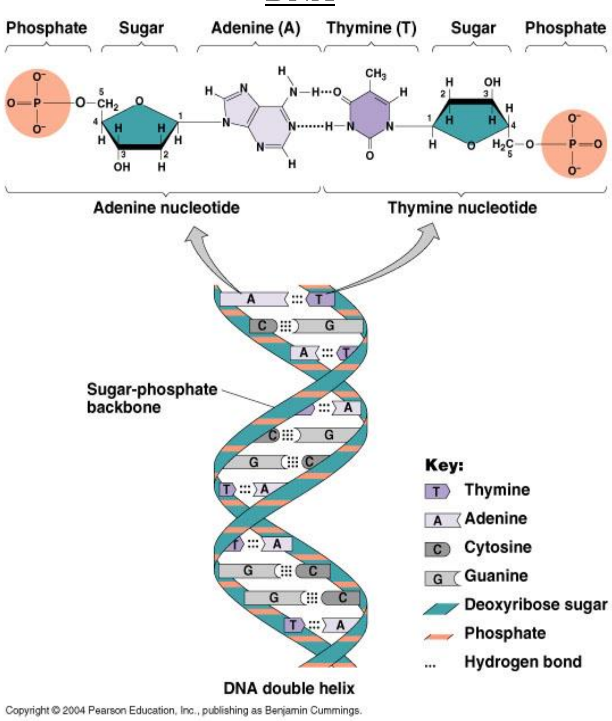
The structure of DNA was discovered **by James Watson and Francis Crick** in the 1950's. Interestingly, no two people have the same sequence of bases, except identical twins. Humans have 46 chromosomes in the nucleus of every cell in their body. Each chromosome is a tightly coiled strand of DNA. If the entire DNA in a cell were stretched out end to end, it would be about 4 centimeters long and billions of base pairs long.

RNA is a “blueprint” copy of DNA. It job is to leave the nucleus and take the instructions for protein synthesis to an organelle called the ribosome that manufacture the protein. This diagram shows how DNA untwists to make a type of RNA called mRNA.

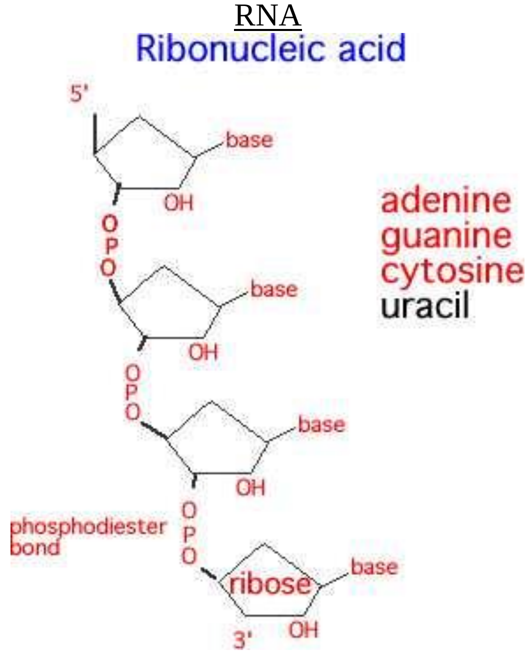
RNA is a single strand of nucleotides. Each nucleotide contains the sugar ribose, hence why is called *ribonucleic acid*. Each RNA nucleotide contains one of four nitrogenous bases (adenine, uracil, cytosine or guanine). There are two types of RNA; mRNA and tRNA. These molecules have the ability to bond together during protein synthesis following the law of base pairing. Since RNA does contain thymine, adenine bonds with uracil.



DNA



RNA



Proteins

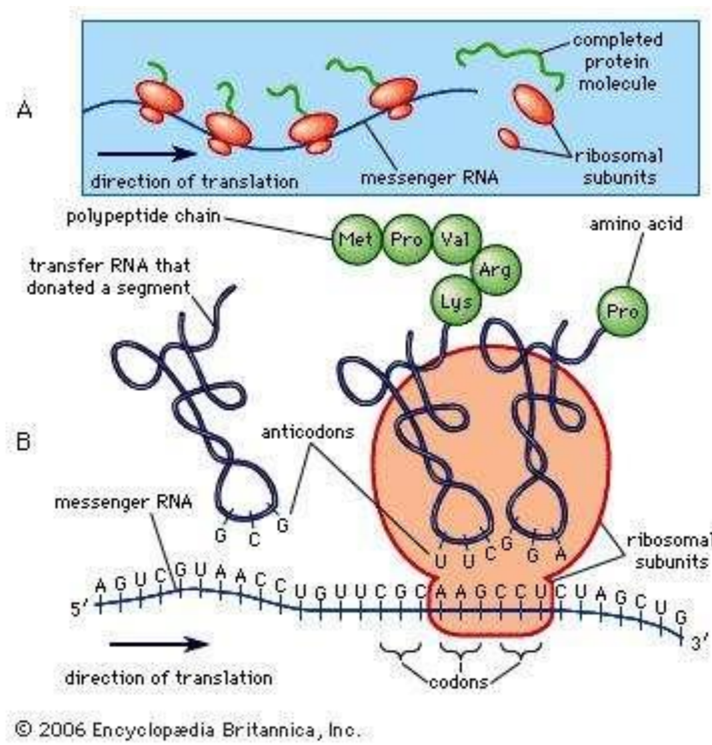
Amino acids are used in every cell of your body to build the proteins you need to survive. All organisms need some proteins, whether they are used in muscles or in simple structures in the cell membrane. Amino acids have a two-carbon bonds; one of the carbons is part of a group called the carboxyl group (COO-). A carboxyl group is made up of one carbon (C) and two oxygen (O) atoms. The second carbon is connected to the amino group or the R group. The main difference among the different amino acids is in their R groups. The difference among the amino acid R groups gives different proteins different shapes and function.

Even though scientists have discovered over 50 amino acids, only 20 are used to make proteins in your body. Of those twenty, nine are defined as essential amino acids. This means that your body cannot make them, you must ingest them. The other eleven can be synthesized by an adult body. Amino acids bond together to make long chains; these long chains of amino acids are also called proteins. Thousands of combinations of those twenty amino acids are used to make all of the proteins in your body.

Proteins are organic compounds composed mainly of carbon, hydrogen, oxygen, and nitrogen. They are formed from the bonding of amino acids into long chains. These chains then fold over and over again until they are a certain shape. The shape of a protein determines its function. Depending on their shape, proteins have many functions including making bones, cell repair and growth, regulating cell processes, cell structures, and movement. Enzymes are made out of protein and they regulate the bodies' life functions. Red blood cells, muscles, enzymes, skin and hair are all made out of protein.

There are two basic groups of proteins are either; hydrophobic, they repel water or hydrophilic meaning water loving. These characteristics play a role in protein folding. Even though a protein can be very complex, it is basically a long chain of amino acid subunits all twisted around like a knot or "folded" into shape. When a protein unfolds, it is called denaturing and the protein is no longer able to do its job. Denaturing of proteins occurs with changes in pH and temperature.

Protein, containing essential amino acids can be found in foods like meat, cheese, fish, nuts and soy products.



Synthesis of protein.*Encyclopædia Britannica, Inc.*

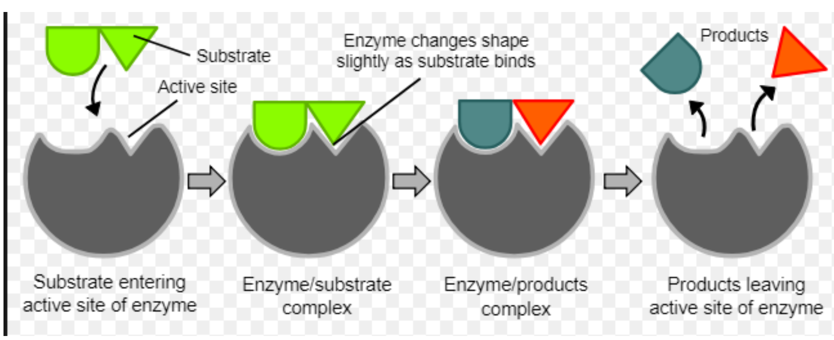
The protein content of animal organs is usually much higher than that of the blood **plasma**. Muscles, for example, contain about 30 percent protein, the liver 20 to 30 percent, and **red blood cells** 30 percent. Higher percentages of protein are found in hair, bones, and other organs and tissues with a low water content. The quantity of free amino acids and **peptides** in animals is much smaller than the amount of protein; protein molecules are produced in **cells** by the stepwise alignment of amino acids and are released into the body fluids only after synthesis is complete.

The high protein content of some organs does not mean that the importance of proteins is related to their amount in an organism or **tissue**; on the contrary, some of the most important proteins, such as **enzymes** and **hormones**, occur in extremely small amounts. The importance of proteins is related principally to their function.

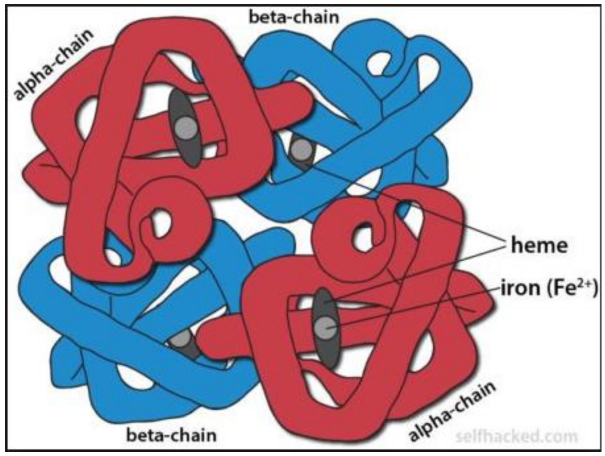
Classification of Some Proteins and their Functions

Class of Protein	Function in the Body	Examples
Structural	Provide structural components	*Collagen* is in tendons and cartilage. *Keratin* is in hair, skin, wool, and nails.
Contractile	Movement of muscles	*Myosin* and *actin* contract muscle fibers.
Transport	Carry essential substances throughout the body	*Hemoglobin* transports oxygen. *Lipoproteins* transport lipids.
Storage	Store nutrients	*Casein* stores protein in milk. *Ferritin* stores iron in the spleen and liver.
Hormone	Regulate body metabolism and nervous system	*Insulin* regulates blood glucose level. *Growth hormone* regulates body growth.
Enzyme	Catalyze biochemical reactions in the cells	*Sucrase* catalyzes the hydrolysis of sucrose. *Trypsin* catalyzes the hydrolysis of proteins.
Protection	Recognize and destroy foreign substances	*Immunoglobulins* stimulate immune responses.

All enzymes identified thus far are proteins. Enzymes, which are the **catalysts** of all metabolic reactions, enable an organism to build up the chemical substances necessary for life—proteins, **nucleic acids**, carbohydrates, and lipids—to convert them into other substances, and to degrade them. Life without enzymes is not possible.



There are several protein hormones with important regulatory functions. In all vertebrates, the respiratory protein **hemoglobin** acts as **oxygen** carrier in the **blood,** transporting oxygen from the lung to body organs and tissues. A large group of structural proteins maintains and protects the structure of the animal body.



<u>Unit Project:</u> Molecules of Life **Due Date: _______________**

Organic polymers must be broken down and reassembled as they are cycled through the food chain. As you are part of this dynamic, your task is to closely examine some of the polymers in your food.

1. Select two food items (not liquids/beverages) which have nutrition labels attached. You will need to turn in these labels along with your assessment of them, so be sure that you can cut them out and keep them.

2. <u>Design a table</u> which compares the values for the carbohydrates, lipids, and proteins contained within the food items. <u>Identify</u> which polymer has the most energy available and <u>describe</u> why it does. Be sure to <u>consider</u> molecular structure in your answer.

3. Use a textbook or other resources; <u>Describe</u> one enzymatic reaction that will happen when you eat one of the food items.

    - Be sure to <u>name</u> the enzyme, substrate, and products.

    - <u>Describe</u> what would happen if the enzyme was unavailable. In your description, be sure to consider the role of water in the digestion of polymers.

4. After digestion, your bloodstream will carry the monomers produced to your cells, where new carbohydrates, proteins, and lipids will be built.
    - <u>Describe</u> what will happen during these condensation reactions.

    - For each polymer, <u>describe</u> at least one function it will have within your body.

Turn in both nutrition labels as well as the answers to the above questions.

Scoring Guide:

4	• Student goes beyond the requirements of a “3” to make relevant connections to additional learning.
3	• Student accurately and appropriately uses relevant scientific vocabulary. • Student accurately explains concepts, providing original examples with added details to illustrate his/her understanding.
2	• Not all parts of the answer are present and/or accurate. Some vocabulary is incorrectly used. • Student does not show independent learning; all examples and descriptions are taken from the text or other resource **or** not enough detail is provided to show understanding.
1	• Little or no understanding of concepts demonstrated. Relevant scientific vocabulary is not used or is misused. • Multiple parts of the assessment are incomplete.