Bio Boot camp - Biochemistry

Bio A.2.2.1 Explain how carbon is uniquely suited to form biological macromolecules

- Carbon has lots of properties that make it essential to building lots of different molecules
- Due to the number of electrons in it's outer shell, carbon is most likely to make a *covalent bond*
- Covalent bonds are formed when an element shares electrons with another molecule. Carbon would need to share with four molecules to fill it's valence shell
- Carbon, however, can make special bonds where they share multiple electrons with the same molecule
    - These are called double or triple bonds
- In addition to these special bonds, carbon can bond in different arrangements
    - Carbon can make long straight chains, carbon can make long branched chains, and carbon can also make rings of molecules
- Because of this flexibility, carbon can act as a generic building block that can make many different types of *large* and *diverse* molecules.
- Carbon tends to make extremely large molecules which contain many carbon - carbon bonds. This is called an *organic molecule*

Bio A.2.2.2 Explain how biological macromolecules form from monomers

- Monomers are single molecules that can be constructed in lots of different ways to create many different, diverse molecules
- Monomers can be bonded together to create macromolecules, which literally means large molecule
- Monomers are constructed using a reaction called a condensation reaction (also called dehydration synthesis)
    - Condensation reactions bond molecules together by releasing water

Bio A.3.2.2 Compare the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms

- The four most important organic molecules to living things are carbohydrates, lipids, proteins, and nucleic acids

Carbohydrates

- Carbohydrates are molecules that provide quick energy for the cell, and can be used for structure in certain organisms
- Carbohydrates are made up of carbon, hydrogen and oxygen which are shaped in a ring

- Carbohydrates are made up of monomers called saccharides, that combine to make polysaccharides
- Saccaride rings can be formed into long straight or branched chains
- Carbohydrates can be considered simple or complex
- Simple carbohydrates are smaller molecules that are generally some type of sugar
- Complex carbohydrates are much larger and include starch and cellulose in plants and glycogen in animals

Lipids

- Lipids have several jobs, the most important of which is long term energy storage
- Lipids can also act as certain steroids, pigments, waxes and cholesterol in the body
- Lipids are made up of the elements carbon and hydrogen, with an extremely limited amount of oxygen
- Lipids are made up of monomers called fatty acids arranged in long chains
- Lipids also are the most prevalent component of the cell membrane

Proteins

- Proteins are molecules that act as structure in the body, along with their job as enzymes in the body
- Proteins are made up of carbon, hydrogen, oxygen, and nitrogen
- Proteins are made up of monomers called amino acids, which are arranged in long chains
- These chains will then fold, bend and link together to form large 3 dimensional structures
- Muscles, hair, fingernails, tendons, etc are made up of proteins

Nucleic acids

- Nucleic acids are compounds in the body that have all of the codes to make protein and run the body
- Nucleic acids are made up of a sugar, phosphate groups, and nitrogen bases
- The monomer of a nucleic acid is the nucleotide
- The 2 important nucleic acids found in the body are deoxyribonucleic acid and ribonucleic acid (DNA and RNA)
- DNA is linked together in a structure called a double helix
- RNA is made up of a single strand of a portion of DNA

Bio A.2.3.1 Describe the role of an enzyme as a catalyst in regulating a specific biochemical reaction

- Catalysts are molecules that speed up the rate of a chemical reaction
- There are important proteins in the body called enzymes, which act as a catalyst in the chemical reactions of the body
- Enzymes work by binding to a specific substrate (molecule) and either putting it together or taking it apart

- Each substrate has a specific enzyme that they work with like a lock and key
- Enzymes are unchained by the reaction

Bio A.2.3.2 Explain how factors such as pH, temperature, and concentration level can affect enzyme.

- Many factors can effect the productivity of an enzyme
- pH and temperature can both alter the shape of an enzyme, which prevents it from attaching correctly to the substrate
- Concentration level can effect the reaction by limiting the amount of enzyme available

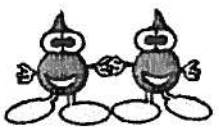
Bio B.2.2.2 Describe the role of ribosome, endoplasmic reticulum, Golgi apparatus, and the nucleus in the production of specific types of proteins.

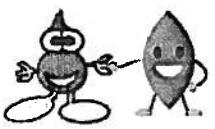
- Proteins are one of the most important organic molecules in an organism
- Almost all traits in the body are dependent upon the action of a protein either structurally, or when it is acting as an enzyme
- Specific parts of the cell are responsible for creating proteins:
    - The **nucleus** does 2 jobs - the nucleus receives messages from the cell that tell the nucleus what proteins are needed
    - The nucleus also contains the **nucleolus**, which makes the ribsome that are needed to make the protein
    - **Ribosome** are either free floating or attached to a structure called the endoplasmic reticulum
    - The **endoplasmic reticulum** is a series of tubes / passageways through which material is transported throughout the cell
    - Once a protein is made, it is shipped through the rough endoplasmic reticulum and sent out in a structure called a **vesicle**
    - These vesicles then travel to the **Golgi apparatus**, where they are accepted, repackaged or changed as needed, labeled and sent back out to where they are needed - either in the cell or another cell

Bio Bootcamp – Cellular Processes

BIO.A.2.1.1: Describe the unique properties of water and how these properties support life on Earth (e.g., freezing point, high specific heat, cohesion).

- Water is a **polar** molecule, made up of 1 oxygen and 2 hydrogen, where the oxygen end is slightly negative and the hydrogen end is slightly positive
- Because of the polarity, water makes hydrogen bonds between water molecules
- Water molecules are **cohesive**, meaning that they stick together (molecules that are the same stick together)
- These hydrogen bonds create a "sheet" of water molecules, called surface tension
    - Water molecules are also **adhesive**, meaning that they stick to other types of polar molecules
        - An important biological application of adhesion is capillarity, where water climbs the small tubes in plants
    - Because of the hydrogen bonds in water, it takes a lot of energy to break the bonds between the molecules
    - Water does not have great fluctuations in temperature, which gives organisms a chance to adapt to temperature changes. This is called **high specific heat**
- This applies to the freezing of water also
- It takes a long time for water to heat up and a long time for water to cool down
- Water is also unique in that it becomes less dense as it becomes solid, so it floats. This provides insulation and prevents organisms from being crushed or limiting the amount of space they have available


Cohesion


Adhesion

BIO.A.3.1.1: Describe the fundamental roles of plastids (e.g., chloroplasts) and mitochondria in energy transformations.

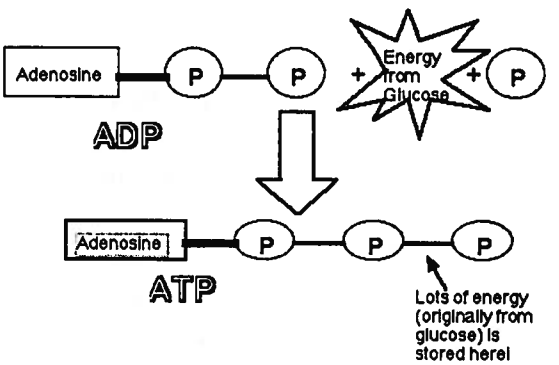
- The most important plastid is the **chloroplast.**
- The chloroplast contains chlorophyll, a green, light absorbing pigment
- The job of the chloroplast is to absorb light energy from the sun and turn it into chemical energy that can be used by the cell, through the process of photosynthesis
- Chloroplasts create chemical energy in the form of glucose, $C_6H_{12}O_6$
- Chloroplasts are found only in plants

- **Mitochondria** are found in all cells

- Mitochondria take the glucose that is formed in photosynthesis and break it down into a useable form of energy
- This useable form of energy is ATP
- This conversion of glucose into ATP occurs in the process of cellular respiration
- Cells which require a lot of energy, such as muscle and sperm cells, have a lot of mitochondria

BIO.A.3.2.2: Describe the role of ATP in biochemical reactions.

- ATP is adenosine triphosphate, a molecule that is used by the cell as energy currency
- This is a cyclical molecules whose only job is to act as energy storage and release - in fact **ANY** reaction that requires energy in the body will use ATP
- It stores energy in a bond between the 2nd and 3rd phosphate
- By removing the phosphate, energy is released
- By adding the phosphate, energy is stored.



BIO.A.3.2.1: Compare and contrast the basic transformation of energy during photosynthesis and cellular respiration.

- Photosynthesis is the process of changing light energy, from the sun, into chemical energy, in the form of glucose $C_6H_{12}O_6$
- Photosynthesis occurs in plants and other organisms that contain chloroplasts
- These organisms are called autotrophs
- These organisms are always green in color
- Photosynthesis requires the input of sunlight, carbon dioxide and water
- Photosynthesis create glucose and oxygen
- The most important product for the plant / the goal of photosynthesis is glucose - energy is stored in the bonds of the molecule
- Oxygen is a by product; however oxygen is important for us
- Energy in the form of light enters and is changed into and stored as chemical energy

- Glucose is a high energy molecule. In fact, if the body tried to directly use glucose, too much would be lost
- Cellular respiration is the process of breaking glucose into ATP, which is a more useable form
- Cellular respiration takes in glucose and oxygen and creates ATP, water, and carbon dioxide
- ATP is the main product of respiration
- All organisms undergo cellular respiration
- Energy in the form of glucose enters and is broken into smaller chunks and stored in the bonds of ATP

- Photosynthesis and cellular respiration are dependent cycles of each other.

- They both recycle oxygen and carbon dioxide
- Both are multistep processes that transform energy from one form into another
- Both use the same basic materials - what is the by product of one becomes the starting material for the other

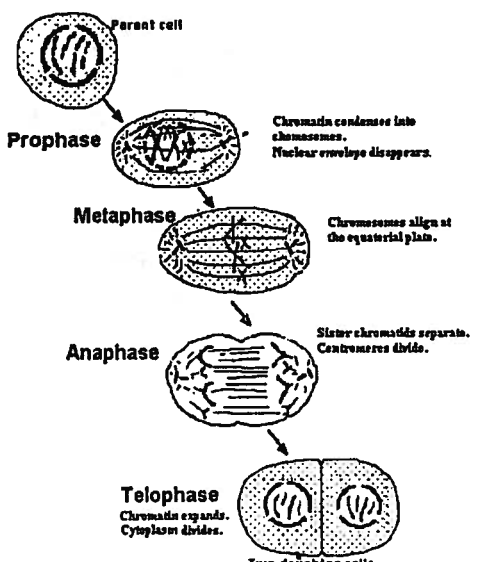
BIO.B.1.1.1: Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis.
BIO.B.1.1.2: Compare and contrast the processes and outcomes of mitotic and meiotic nuclear divisions.

- The cell cycle could also be called the cell's life cycle
- **Interphase** is the time of normal cell activities
- Interphase is the longest portion of the cell cycle (cell life)
- Interphase is also the time in which the cell prepares for cell division, including making copies of the DNA (replication)

- Nuclear division is divided into 2 types: mitosis and meiosis

- **Mitosis** is the process that makes copies of the cell that are identical to the original
- The purpose of mitosis is for growth of an organism and repair of existing damaged cells
- Mitosis is triggered when the cell becomes too big to work efficiently
- Mitosis is divided into 4 stages
  - Prophase is where the DNA condenses into chromosomes, the nuclear membrane disappears, and the centromeres move to opposite ends of the cell with the spindle between them
  - Metaphase is where the chromosomes line up in the middle
  - Anaphase is where the identical chromatids break apart and move to opposite ends
  - Telophase is where the steps of prophase reverse themselves

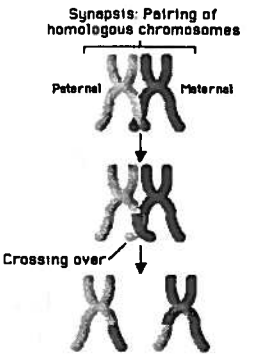
- The result of mitosis is 2 daughter cells that are smaller but **otherwise identical** to the original



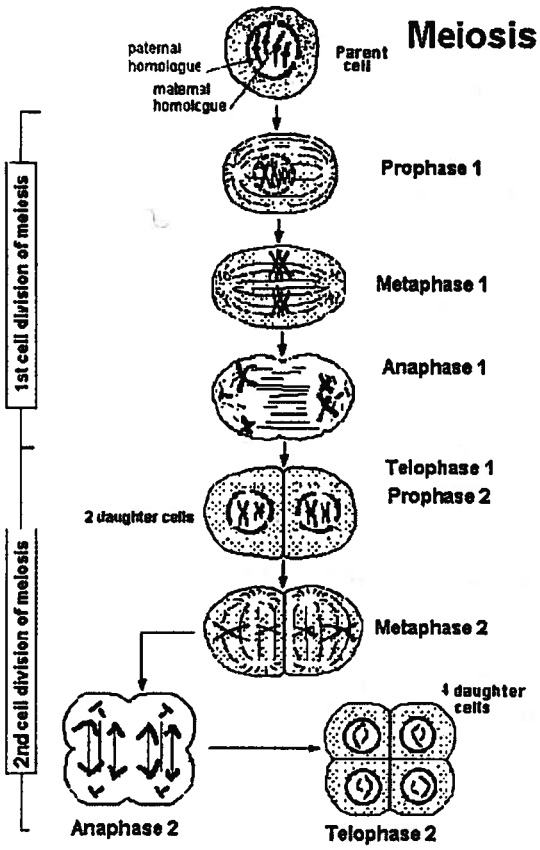
Mitosis

- **Meiosis** is a similar process to mitosis that creates reproductive cells, **gonads** (sperm or egg)
- Meiosis is divided into meiosis I and meiosis II.
  - The steps of meiosis are prophase I, metaphase I, anaphase I, and telophase I
  - The steps of meiosis II are prophase II, metaphase II, anaphase II, and telophase II
  - Prophase generally has the same look, metaphase is always in the middle, etc

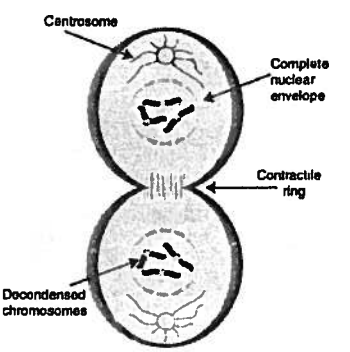
- The biggest difference between mitosis and meiosis is in prophase I where the process of **crossing over** occurs.
- Crossing over is when 2 homologous (same size and type) chromosomes join together in a structure called a **tetrad** and exchange genetic material;
- Crossing over allows for new combinations of genes in the offspring



- The result of meiosis is 4 daughter cells that have half the genetic material of the original. This genetic material is different from the genetic material that went in to the start of the process



- **Cytokinesis** is the process that follows both mitosis and meiosis, Cytokinesis is the division of the cytoplasm and cell organelles



- In animal cells, the cell pinches in to separate the new cells
- In plant cells, a wall is built between the cells

BioBoot Camp – Cells

BIO.A.1.1.1 Describe the characteristics of life shared by all prokaryotic and eukaryotic organisms

All living organisms have:

- **Organization and cells** – all organisms have cells. May be made of 1 cell (unicellular) or many cells (multicellular).
- **Response to stimuli** - the stimulus can be a physical or chemical change in the internal or external environment
- **Homeostasis** - organisms must maintain stable internal conditions even when the external environment changes examples are organisms regulating their temperature, water levels, oxygen levels and pH
- **Metabolism** - is the sum of all the chemical reactions that take in and transform energy and material from the environment.
    - Autotrophs – make their own food
    - Heterotrophs – consume other organisms for food
- **Growth and development** - growth is because of cell division and causes an increase in the amount of cells. Development is the process of an organism becoming a mature adult – involves cell differentiation and specialization
- **Reproduction** – essential for survival of species, not each individual.
    - Sexual reproduction– exchange of hereditary information between 2 "parents" - offspring will be different
    - Asexual reproduction– no exchange of hereditary information – offspring are identical to parent.
- **Change through time** - population of organisms evolve over time. Important for survival in changing world.

BIO.A.4.2.1 Explain how organisms maintain homeostasis (eg thermoregulation, water regulation, oxygen regulation)

- **Thermoregulation** is the ability of an organism to keep its body temperature within certain boundaries, even when the surrounding temperature is very different.
    - Vertebrates can regulate their body temperatures in 2 different ways
        - <u>Ectotherms</u> – reptiles, fish and amphibians – warm body by absorbing heat from its surrounding. Aquatic animals have body temperatures close to the water temp. Terrestrial (land dwelling) change location to get more sun/shade as needed. Can't live in very cold climates
        - <u>Endotherms</u> – mammals and birds – have rapid metabolism which generates heat needed to warm body. Also have insulation such as hair, feathers, fat
- **Water regulation (osmoregulation)** is the control of water concentrations in the bloodstream which controls theamount of water available for cells to absorb.
    - The primary organ of osmoregulation in mammals is the kidney which regulates the amount of water in urine depending on hydration level, exercise, salt levels etc.
- **Oxygen regulation** O_2 levels must be regulated according to activity level. The more active the body/cells then more oxygen needed. During periods of slower activity level less oxygen is needed. Rate is controlled by the brain/brain stem to make sure carbon dioxide and oxygen levels are suitable for life.
    - Structures include lungs, book lungs, gills, cell membranes, skin – depending on organism involved.

BIO.A.1.2.1 Compare cellular structures and their functions in prokaryotic and eukaryotic cells.

- **Prokaryotes**

Unicellular, lack true nucleus and membrane-bound organelles, have a single loop of DNA and ribosomes ex: bacteria

- **Eukaryotes**

Can be unicellar or multicellular, have a true membrane-bound nucleus with DNA in chromosomes, have a variety of membrane-bound organelles ex: fungi, protists, plants, animals

Organelle	Found In	Function
Cell Membrane	all cells	regulates entry/exit of substances
Cell Wall	bacteria, plants	rigid structure providing support for cell
Cytoplasm	all cells	jelly-like substance filling internal space of cell
Cytoskeleton	plants/animals	network of fine tubes and filaments throughout the cytoplasm, help to provide internal structural support
Nucleus	Plants/animals	membrane-bound structure containing DNA, control center of cell
Nucleolus	plants/animals	small structure within nucleus, site of rRNA production
Nuclear Membrane	plants/animals	boundary between nucleus and cytoplasm, regulates passage of materials between the two
Mitochondria	plants/animals	site of aerobic respiration
Chloroplasts	plants	contains chlorophyll, site of photosynthesis
Vacuole	plants (large) animals (small)	area filled with water, helps to maintain water balance of the cell
Ribosomes	all cells	where protein synthesis occurs, may be free floating or attached to ER
Rough Endoplasmic Reticulum	plants/animals	network of flattened membranes forming tunnels, have ribosomes embedded, produces proteins for exportation/transport
Smooth Endoplasmic Reticulum	plants/animals	network of flattened membranes forming tunnels, assists with making some lipids and finalizing some proteins
Golgi Apparatus	plants/animals	stacks of flat membranes, where export proteins are modified and stored prior to leaving cells
Lysosomes	animals	contain enzymes which break down toxins or unwanted cell materials
Centrioles	animals	help with division of chromosomes during mitosis
Plastids	plants	Used for storage – exs: starch, pigments
Vesicles	Plants/animals	packages for storage or transport of materials
Cilia/Flagella	Varies	Assist cells with movement, on outside of cells

BIO.A.1.2.2 Describe and interpret relationships between structures and function at various levels of biological organization (ie organelles, cells, tissues, organs, organ systems, and multicellular organisms)

- **Cell** – smallest unit that can perform all life's processes.
  - **Organelles** - inside of cells, tiny structures that carry out functions necessary for the cell to stay alive
- **Tissues** – groups of cells that have similar abilities/functions
- **Organs** – groups of tissues, structures that carry out specialized jobs.
- **Organ systems** – groups of specialized parts that carry out a certain function in the organism
- **Multicellular organisms** – complex organisms made up of many different structures that must work together to maintain homeostasis and allow the organisms to survive.

- **Structure and function are closely related!**

  Examples of cells:

  Red blood cells – shape allows for the ability to carry oxygen and fit through blood vessels
  Muscle cells – long and stretchy to expand and contract to move body parts
  Nerve cells – have long extensions reaching out in various directions to send/receive messages
  Plant cells- have cell wall to provide support to plant
  Skin cells – flat, plate-like help to cover and protect the surface of the body

  Examples of organs:

  Lungs contain many small air sacs (alveoli) to increase the surface area for gas exchange
  Small intestines have many small projections (microvilli) to increase the area available for nutrients absorption

BIO.A.4.1.1 Describe how the structure of the plasma membrane allows it to function as a regulatory structure and/or protective barrier for a cell.

Functions of the plasma membrane:

- Allows certain materials to enter or leave the cell – selectively permeable
- Separates internal metabolic reaction from external environment
- Allows the cell to excrete wastes and interact with the environment

Structure of plasma membrane – Fluid Mosaic Model

- **Phospholipids** – have a polar hydrophilic (water-loving) phosphate head and 2 nonpolar hydrophobic (water-fearing) fatty acid tails. They line up in a double layer (phospholipid bilayer) so that the heads face the outer and inner cell surfaces and the tails are sandwiched together in between.

- **Cholesterol** – small molecules inserted between the lipids, help to make the membrane more firm and prevent the membrane from freezing at low temperatures.

- **Membrane proteins** – have different types of proteins in the membrane to perform different functions such as the transport of materials, identification of the cell type, receptors for recognizing substances, and enzymes to regulate reactions.

BIO.A.4.1.2 Compare the mechanism that transport materials across the plasma membrane (ie passive transport – diffusion, osmosis, facilitated diffusion; and active transport – pumps, endocytosis and exocytosis)

PASSIVE TRANSPORT – the movement of substances across the cell membrane without any input of energy

1. Diffusion - Movement of molecules from areas of high concentration to areas of low concentration.
2. Osmosis – diffusion of water molecules across a cell membrane from areas of high concentration to areas of low concentration. Some organisms that live in aquatic environments have contractile vacuoles to pump out excess water that enters the cell due to osmosis
3. Faciliatated Diffusion – used when substances cannot easily pass across the membrane due to composition or size. In this type of transport a carrier protein helps to move the molecule across the membrane from areas of high concentration to areas of low concentration. Glucose is transported into cells using this method

ACTIVE TRANSPORT – movement of materials from areas of lower concentration to areas of higher concentration, "up" the concentration gradient. Requires a cell to expend energy

1. Cell membrane pumps – involves a specific carrier protein which changes shape to move the molecule across the membrane and release it on the other side. Energy required is supplied by ATP. Common example – sodium potassium pump
2. Endocytosis – process of cells ingesting larger particles such as fluids, macromolecules, or other cells. Materials are enclosed in a pouch (vesicle) and brought into the cell
3. Exocytosis – process of cells releasing substances from the cell. Materials placed in a vesicle and transported to cell membrane and then released. Used for proteins, wastes and toxins.

BIO.A.4.1.2 Describe how membrane-bound cellular organelles (eg endoplasmic reticulum, golgi apparatus) facilitate the transportation of material within a cell.

- Proteins are made by the ribosomes on the Rough ER
- Are placed in sacs called vesicles.
- The vesicles are then transported to the Golgi where they are moved along and modified.
- The vesicles then move to the cell membrane and release the contents or transport the vesicle to another part of the cell where the protein is needed for the cell to function properly.

BioBoot Camp – Genetics

BIO.B.1.2.1 Describe how the process of DNA replication results in the transmission and/or conservation of genetic information

- DNA Replication is the process of DNA being copied before cell division occurs
- During this process the double stranded helix will unwind and split apart
- Each half of the DNA strand will then serve as a template to make a new complementary strand The new nucleotides will bond with their complement on the original strand
- At the end of replication there are 2 identical DNA strands
- This method ensures that replication will be exact and each new cell will receive the proper DNA after division
- The process is extremely accurate – only 1 mistake per 1 billion nucleotides. The cell has proofreading enzymes that look for errors during the process. If a mistake is made it is called a "mutation". Mutations can be helpful, harmful or neutral

BIO.B.2.2.1 Describe how the processes of transcription, and translation are similar in all organisms.

Protein Synthesis – process of making a protein – involves the DNA located in the nucleus, RNA – messenger, transfer and ribosomal, and ribosomes located in the cytoplasm. Divided into 2 phases – transcription and translation.

- **Transcription** is the process of making a messenger RNA (mRNA) strand. This mRNA strand is a temporary copy of a gene needed to make a specific protein. The DNA must always stay inside the nucleus but the mRNA strand will be able to leave the nucleus and travel to the ribosome. The mRNA "writes" down the DNA code in the form of complementary nucleotides so that no information is lost.
- **Translation** is the process of the information from the mRNA being decoded on the ribosome. The tRNA and mRNA work together to ensure that the correct amino acids in the correct order are bonded together to make a complete protein.
    - The genetic code for all organisms is the same – meaning that in ALL organisms the same mRNA code will code for the same amino acids. An organism's proteins are different because the DNA specifies a different number, order and type of amino acids for each protein to be made.
    - There are 20 amino acids that combine in different numbers, orders and types to make proteins for all organisms on earth.

BIO.B.2.3.1 Describe how genetic mutations alter the DNA sequence and may or may not affect phenotype (silent, nonsense, frameshift)

Point mutations are places where the nucleotide sequence is altered in one spot. They can be:

- **Silent** – no visible effect on the protein due to the fact that it still specifies the same amino acid (ex: a one letter typo in a paper that does not change the meaning of the word – you are able to "figure it out")

- **Missense** – a mutation that changes which amino acid is coded for – may change the function of the protein (ex: you type the wrong word in your paper – it may change the meaning of the sentence. The dog ate the cat or The dog ate the car)

- **Nonsense** – when the mutation changes an amino acid sequence into a stop codon. The process will stop too soon and the protein won't be finished. This missing part of the protein will cause it to not function properly. (ex: you accidently cut off the last three words of the sentence so you don't know how it ends...the murderer is.)

Frameshift Mutations are caused by nucleotides being added or removed. They cause the entire code to shift. All the amino acids after the mutation will be incorrect. This causes a complete loss of the enzyme activity and could have a disastrous effect on the organism.

Examples: Original : The dog ate the cat

Insertion Frameshift: The ddo gat eth eca t

Deletion Frameshift: The oga tet hec at

BIO.B.1.2.2 Explain the functional relationships between DNA, genes, alleles, and chromosomes and their roles in inheritance.

- **DNA** – large nucleic acid, macromolecule made of nucleotides. Encodes the genetic information for living organisms. Located in the nucleus of a eukaryotic cell or the nucleoid region of a prokaryotic cell. The DNA has all of the genetic information for the organism to survive. Segments of the DNA will be copied during protein synthesis and used to make proteins to carry out cell functions or characteristics.

- **Chromosomes** – a single piece of coiled DNA and proteins. Found in a linear form in the nucleus of eukaryotes and in circular form in the cytoplasm of prokaryotes. Contains genes that code for traits. Each species has a characteristic number of chromosomes (ex: humans have 46 chromosomes in each cell). Chromosomes can be shown as a line or X in a diagram. The sex chromosomes (X and Y in humans) are also responsible for determining the sex of an individual. (females are XX and males are XY)

- **Genes** – a short sequence of nucleotides composing a segment of DNA. This "chunk" of DNA provides the information for a specific hereditary trait. (Ex: the gene for tongue rolling, gene for lactase enzyme, gene for earlobes etc.)

- **Alleles** – a variation of a gene's nucleotide sequence. An alternate form of a gene. Alleles are represented by letters (ex: A or a, B or b). They may be dominant or recessive when expressed in an organism.

BIO.B.2.1.1 Describe and/or predict observed patterns of inheritance (dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple allele)

Note: Genotype – using letters/alleles to describe the gene Ex: AA, Bb, cc

Phenotype – using words/traits to describe the effect of the genes Ex: red hair, purple flowers, long tail

- **Dominant** – trait where the phenotypic effect of one allele is completely expressed with in a homozygous or heterozygous genotype. When a dominant gene allele is present it will hide/mask the expression of other alleles and the organism will have the dominant characteristic.

- **Recessive** – trait where the phenotypic effect of the recessive allele is only expressed within a homozygous genotype. There must be 2 recessive alleles present for the recessive trait to be seen/expressed in the organism

- **Co-dominance** – trait where the phenotypic effect of 2 alleles in a heterozygous genotype are fully and equally expressed. Neither allele is able to dominate the other so they both show up in their individual form (do NOT blend) Example: White-hair rabbits, Black-fur rabbits, black and white fur rabbits)

- **Incomplete dominance** – trait where the 2 alleles are neither dominant nor recessive so the resulting phenotype is a blending of the two traits. Example: red roses, white roses, pink roses

- **Sex-linked** – a trait associated with a gene carried on either the male or female parent. The traits will be expressed differently in males and females due to the different sex chromosomes present. Examples in humans would include color blindness and hemophilia

- **Polygenic** – a trait in which the phenotype is controlled by 2 or more genes located at different locations on different chromosomes. Produces a range of possible phenotypes (ex: height in humans)

- **Multiple Allele** – a trait where there is more than 2 forms of the gene that can control the expression of the gene Example: Human blood typing – gene forms are A,B and i (O)

BIO.B.2.1.2 Describe processes that can alter composition or number of chromosomes (crossing over, nondisjunction, duplication, translocation, deletion, insertion, and inversion)

- **Crossing – over** - exchange of genetic information between homologous chromosomes during meiosis, contributes to the genetic diversity of organisms

Chromosomal mutations

- **Nondisjunction** - process in which chromatids fail to separate during and after mitosis or meiosis

- **Translocation** – the process in which a segment of a chromosome breaks off and attaches to another chromosome

- **Insertion** – one or more nucleotides are added to a gene

- **Deletion** – loss of a piece of chromosome due to breakage

- **Duplication** – an area of a chromosome is repeated

- **Inversion** – a chromosomal segment breaks off, flips backwards and reattaches in the same location

BIO.B.2.4.1 Explain how genetic engineering has impacted the fields of medicine, forensics, and agriculture (selective breeding, gene splicing, cloning, genetically modified organisms, gene therapy)

- **Genetic engineering** – the process of altering the genetic material of cells or organisms to allow them to make new substances or to change their traits.
- **Selective breeding** – when humans select which organisms to breed to get a desirable trait (example – breed cows to get them to produce the most milk) This method used trail/error and was time consuming. Using genetic engineering we can now accurately get the desired results every time.
- **Cloning** – making a genetically identical copy of an organism
- **Genetically modified organisms** – organisms that have DNA from a different organism in them.
- **Gene therapy** – attempting to treat a genetic defect in an organism by introducing a new gene for the missing/defective original gene

Uses for genetic engineering

Medicine:

- Create new medications (ex: human insulin made by bacteria, clotting factors for people with hemophilia)
- Figure out how genes function during development – look for ways things go wrong
- Look for cures for genetic diseases (cystic fibrosis – replace missing gene to help lessen symptoms)
- Continuing to research cures for cancer, AIDS, hemophilia etc
- Create new vaccines

Forensics:

- Identify criminals
- Identify human remains
- Identify the parents of an individual
- Trace human origins

Agriculture:

- increase food supply by making crops more tolerant to environmental conditions
- make plants resistant to herbicides, pests and certain diseases
- improve nutritional value

Ethical issues of genetic engineering – many people have different opinions on whether these things should be done with genetic engineering. Some of the common ideas/problems are

- ✓ are we "playing" or "messing" with genes
- ✓ are the end products safe
- ✓ how will the modified plants/animal affect the environment – will they have unwanted effects to normal organisms
- ✓ does it hurt humans, will we find out later that it has unintended consequences
- ✓ does it destroy embryos (difference of opinions on when life begins)
- ✓ will my personal genetic information be kept confidential

Keystone Biology Review Guide – Evolution

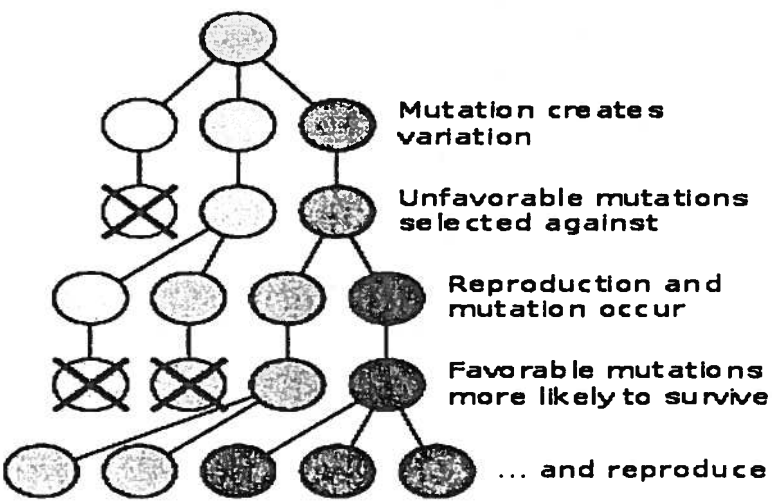
- **BIO.B.3.3 Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.**
- **BIO.B.3.3.1 Distinguish between the scientific terms: hypothesis, inference, law, theory, principle, fact, and observation.**

Observation	The process of obtaining information by using the senses; the information obtained by using the senses
Hypothesis	A proposed, scientifically testable explanation for an observed phenomenon.
Theory (Scientific)	An explanation of observable phenomena based on available empirical data and guided by a system of logic that includes scientific laws; provides a system of assumptions, accepted principles, and rules of procedure devised to analyze, predict, or otherwise explain the nature or behavior of a specific set of phenomena.
Law (Scientific)	A law that generalizes a body of observations. At the time it is made, no exceptions have been found to a law. It explains things but does not describe them; serves as the basis of scientific principles.
Fact	Any observation that has been repeatedly confirmed and accepted as true; any scientific observation that has not been refuted
Inference	A conclusion or opinion that is formed from known facts, evidence, or observations
Principle (Scientific)	A concept based on scientific laws and axioms (rules assumed to be present, true, and valid) where general agreement is present.

Pre-1950s – evidence for evolution and the theory of natural selection has been gathered by investigations rather than experimentation.

Today – The theory of natural selection continues to be formed, challenged and revised through investigations and our new understandings of genetics.

- **BIO.B.3.1 Explain the mechanisms of evolution.**
  - **Natural Selection**
    - Organisms in a population adapt to their environment as the proportion of individuals with genes for favorable traits increases.
    - Those individuals that pass on more genes are considered to have greater fitness.



- **BIO.B.3.1.1 Explain how natural selection can impact allele frequencies of a population.**
  - ***Allele***- A variation of a gene's nucleotide sequence (an alternative form of a gene).
    - Examples: gene A, gene a
  - ***Allelic Frequency***- The measure of the relative frequency of an allele in a population; expressed as a proportion or percentage.
    - Examples: AA = 25% Aa=50% aa=25%
  - **Natural selection does not necessarily favor a "dominant" trait. It usually favors the most beneficial trait. This trait may be dominant or recessive.
  - Alleles for traits may be beneficial, harmful or neutral

- **BIO.B.3.1.2 Describe the factors that can contribute to the development of new species (e.g., isolating mechanisms, genetic drift, founder effect, migration).**

Gene Flow – movement of genes from one population to another (by migration or dispersal of seeds/spores)

Genetic Drift – allele frequencies in a population change as a result of random events or chance. Examples: small populations hit by a natural disaster or a disease; failure to reproduce

Migration may affect a population by bringing in new genes/traits to an area or taking genes/traits out of an area.

Founder effect is the loss of genetic variation that occurs when a new population is established by a very small number of individuals from a larger population. Example: A flood kills all but a few squirrels in an area. The resulting population will have the same traits as those few. This may be good or bad for the group!

Speciation – the process of forming new species. Existing species are basically changed versions of older species (many now extinct). How does this happen? Usually due to types of **isolating mechanisms**:

1. **Geographic Isolation**- physical separation of a habitat divides a population into two (prevents individuals from meeting mating with each other).
   a. Examples: Grand Canyon, a mountain range, a river
2. **Habitat Isolation** - high up in a tree is a long way from the ground though both share geographical ranges; an individual that sticks to the canopy will only rarely contact an individual who sticks to the ground
3. **Mechanical Isolation** – the "parts" don't fit - flowering plants that may be adapted to pollination by one insects but not another.
4. **Behavioral Isolation** - Mating calls change in frogs – do not recognize...therefore don't mate.
5. **Gametic Isolation** - an incompatibility between sperm and egg, usually due to physical changes between subpopulations
6. **Temporal Isolation** - Two individuals who breed only at certain times and not at overlapping times (ex. Day vs Night)
7. **Reproductive Isolation** – does *not* mean that individuals within two populations are *not* mating nor producing offspring within populations; instead, if there are offspring, those offspring are not contributing their alleles to either of the parental populations (e.g., because these hybrid offspring are sterile and/or do not survive to reproduce)
   a. Translated: Offspring do not develop completely to be able to reproduce or they die early ....no new offspring. Ex. Horse + Donkey = Mule

TYPES of EVOLUTION

- **Convergent Evolution** is the process by which different species evolve similar traits
  - Example: the evolution of sharks and dolphins

- **Divergent Evolution** is a process in which the descendents of a single ancestor diversify into species that each fit different parts of the environment.
  - Example: Darwin's Finches

- Sometimes, a new population in a new environment will undergo divergent evolution until the population fills many parts of the environment. This pattern of divergence is called adaptive radiation
  - Example: Caribbean anole lizards

- **Artificial Selection** is a process when a human breeder chooses individuals that will parent the next generation
  - Example: Breeding Dogs

- **Coevolution** is when two or more species have evolved adaptations to each other's influence
  - Evolution is ongoing and many species can be evolving at once
  - Each species is part of the forces of natural selection that act upon the other species
    - Example: humans have developed and used antibiotics, but many bacteria have evolved adaptations to resist the effects of some antibiotics!

- **BIO.B.3.1.3 Explain how genetic mutations may result in genotypic and phenotypic variations within a population.**
  - POPULATION GENETICS IS THE STUDY OF EVOLUTION FROM A GENETIC POINT OF VIEW.
  - MICROEVOLUTION IS A CHANGE IN THE COLLECTIVE GENETIC MATERIAL OF A POPULATION.
  - POPULATION GENETICISTS USE THE TERM GENE POOL TO DESCRIBE THE TOTAL GENETIC INFORMATION AVAILABLE IN A POPULATION.

Mutation – a random change in a gene that is passed to offspring. May be beneficial, harmful or neutral.

1. If the gene is passed on, there is now more variation for a trait in the population.
2. If the gene is dominant, it will be expressed phenotypically. (Examples DD or Dd)
3. If the gene is recessive, it will be hidden unless the individual mates with another recessive. (dd)

- **BIO.B.3.2.1 Interpret evidence supporting the theory of evolution (i.e., fossil, anatomical, physiological, embryological, biochemical, and universal genetic code).**
  - **Fossil s** – scientists compare age of fossils by their position in the layers of the earth. The deeper the fossil is the older it is. (relative age).

  - **Biogeography** – the study of locations of organisms around the world. Ex. Marsupials in Australia probably evolved in isolation.

  - **Biochemical** – Biologists compare the DNA, RNA and proteins between organisms.
    - The more similarities the more closely related through a common ancestor.
    - The greater the number of different base pairs, the more distant the evolutionary relationship.
    - All living things share the same 20 amino acids, differing in arrangements & numbers

  - **Universal Genetic Code** – all living things share the same 4 nucleotides – A, T, C, G

  - **Anatomy** – the study of body structure
    - **Homologous Structures** – similar in *structure* but may differ in *function* (human arm, bat wing, penguin flipper)...organisms are more closely related

    - **Analogous Structures** – similar in *function* but differ in *structure* (birds, bats, moths)...organisms are less closely related

    - **Vestigial Structures** – seem to serve no function in one animal, but resemble structures with functions in other animals (a pelvis in a whale?! Human appendix, Wisdom teeth

  - **Embryology** – the study of how organisms develop (stages of early embryo/fetal development is very similar in some vertebrates – suggesting a common ancestor)

Keystone Biology Review Guide – Ecology

- **BIO.B.4.1.1 Describe the levels of ecological organization (i.e., organism, population, community, ecosystem, biome, and biosphere).**
    1. The Biosphere
        - The broadest, most inclusive level
        - The **biosphere** is the thin volume of Earth and its atmosphere that supports life
        - All organisms are found in the biosphere
        - Living things are not distributed evenly throughout the biosphere
    2. Ecosystem
        - An **ecosystem** includes all of the organisms and the nonliving environment found in a particular place.
            - Consider a pond ecosystem
    3. Community
        - A **community** is all the interacting organisms living in an area.
        - Ecologists often focus on how species interact and how these interactions influence the nature of the community.
    4. Population
        - A **population** includes all the members of a species that live in one place at one time.
    5. Organism
        - The simplest level of organization in ecology

- **BIO.B.4.1.2 Describe characteristic biotic and abiotic components of aquatic and terrestrial ecosystems.**
    - The living components of the environment are called **biotic factors** – they include all of the living things that affect the organism
    - The nonliving factors, called **abiotic factors**, are the physical and chemical characteristics of the environment.
        - Temperature
        - Humidity
        - pH
        - Salinity
        - Oxygen concentration
        - Amount of sunlight
        - Availability of nitrogen
        - Precipitation

- **BIO.B.4.2.1 Describe how energy flows through an ecosystem (e.g., food chains, food webs, energy pyramids).**
    - Most **producers** are photosynthetic and make carbohydrates by using energy from the sun.
    - **Consumers** obtain energy by eating other organisms and include herbivores, omnivores, carnivores, detritivores, and decomposers.
        - **Food Chains and Food Webs** A single pathway of energy transfer is a **food chain.**
        - A network showing all paths of energy transfer is a food web.

- **Energy Transfer**
  - Ecosystems contain only a few trophic levels because there is a low rate of energy transfer between each level.
  - Energy is passed from producers to consumers to decomposers.

- **BIO.B.4.2.2 Describe biotic interactions in an ecosystem (e.g., competition, predation, symbiosis).**
  - In **predation**, and individual of one species, called the *predator*, eats all or part of an individual of another species, called the *prey*.
  - Examples:
    - Carnivores – predators that eat animals
    - Herbivores – predators that eat plants
  - Predator Adaptations:
    - Natural selection favors the evolution of predator adaptations for finding, capturing, and consuming prey.
    - Prey detection mechanisms, camouflage, adapted mouthparts, speed, are all examples of adaptations
    - Natural selection also favors adaptations in prey that allow the prey to escape, avoid, or otherwise ward off predators.
  - A **symbiosis** is a close, long-term relationship between two organisms.
  - Three examples are:
    1. **Parasitism**
       - Is similar to predation in that one organism, called the *host*, is harmed and the other organism, called the *parasite*, benefits
       - Does not result in the immediate death of the host
       - Hosts have evolved defense mechanisms – skin, tears, saliva, mucus, cells of the immune system
    2. **Mutualism**
       - Is a relationship in which two species derive some benefit from each other
       - Some are so close that neither species can survive without the other
       - Pollination is one of the most important mutualistic relationships on Earth
    3. **Commensalism**
       - Is an interaction in which one species benefits and the other species is not affected
       - Species that scavenge for leftover food items are often considered commensal species

- **BIO.B.4.2.3 Describe how matter recycles through an ecosystem (i.e., water cycle, carbon cycle, oxygen cycle, and nitrogen cycle).**

The Water Cycle

- Key processes in the **water cycle** are evaporation, transpiration, and precipitation.

The Carbon Cycle

- Photosynthesis and cellular respiration are the two main steps in the **carbon cycle.**

Nitrogen Cycle

- **Nitrogen-fixing bacteria** are important in the **nitrogen cycle** because they change nitrogen gas into a usable form of nitrogen for plants.

Phosphorus Cycle

- In the **phosphorus cycle,** phosphorus moves from phosphate deposited in rock, to the soil, to living organisms, and finally to the ocean.

Oxygen Cycle

- A plant does Photosynthesis to let off Oxygen for organisms to use.
- The humans use up the Oxygen through Respiration and let off Carbon Dioxide.
- The Carbon Dioxide is then passed from the humans to the green plants once again.

- **BIO.B.4.2.4 Describe how ecosystems change in response to natural and human disturbances (e.g., climate changes, introduction of nonnative species, pollution, fires).**

  - ONE OF THE MOST IMPORTANT CHARACTERISTICS OF A COMMUNITY IS HOW IT RESPONDS TO DISTURBANCE. **DISTURBANCES** ARE EVENTS THAT CHANGE COMMUNITIES, REMOVE OR DESTROY ORGANISMS FROM COMMUNITIES, OR ALTER RESOURCE AVAILABILITY.
    - ABIOTIC DISTURBANCES – DROUGHTS, FIRES, FLOODS, VOLCANIC ERUPTIONS, EARTHQUAKES, STORMS
    - BIOTIC DISTURBANCES – ELEPHANTS TEARING UP TREES WHILE EATING, BULLDOZING, CLEAR-CUTTING, PAVING, PLOWING, AND MOWING LAND.
    - SOME ORGANISMS MAY DEPEND ON DISTURBANCES TO SURVIVE
    - MAY CREATE THE OPPORTUNITIES FOR NEW SPECIES TO OCCUPY A NEW HABITAT
  - THE GRADUAL, SEQUENTIAL REGROWTH OF A COMMUNITY OF SPECIES IN AN AREA IS CALLED **ECOLOGICAL SUCCESSION**
  - TWO TYPES OF SUCCESSION:
    1. **PRIMARY SUCCESSION** IS THE DEVELOPMENT OF A COMMUNITY IN AN AREA THAT HAS NOT SUPPORTED LIFE PREVIOUSLY, SUCH AS BARE ROCK, A SAND DUNE, OR AN ISLAND FORMED BY VOLCANIC ERUPTION.
    2. **SECONDARY SUCCESSION** IS THE SEQUENTIAL REPLACEMENT OF SPECIES THAT FOLLOWS DISRUPTION OF AN EXISTING COMMUNITY; OCCURS WHERE SOIL IS ALREADY PRESENT.
  - THE COMMUNITY PROCEEDS THROUGH A PREDICTABLE SERIES OF STAGES UNTIL IT REACHES A STABLE END POINT, CALLED THE **CLIMAX COMMUNITY.**
    - EACH STAGE PAVES THE WAY FOR THE NEXT LEADING TO THE CLIMAX COMMUNITY WHICH REMAINS CONSTANT FOR A LONG PERIOD OF TIME.

- **BIO.B.4.2.5 Describe the effects of limiting factors on population dynamics and potential species extinction.**
  - When the **carrying capacity** is reached, the number of individuals the environment can support is reached and population growth becomes stable.
  - Any factor that restrains the growth of a population is a **limiting factor**. (Space, sunlight, food, water, availability of mates)
  - As the population grows, competition for resources increases. Thus reproduction shrinks over time. This may lead to species extinction.