Basic Biological Principles

I. Distinguish among the scientific terms: hypothesis, inference, law, theory, principle, fact, and observation.

A. **Hypothesis**: is a proposed explanation for a phenomenon.

1. Is an idea about the solution to a problem utilizing knowledge & research.
2. Used to help guide scientists through the experimental process.

B. **Inference**: is a conclusion drawn from specific observations.

C. **Law**: Is the summarizing statement of observed experimental facts that have been tested many times and is generally accepted to be true.

D. **Theory**: It represents a hypothesis or group of related hypotheses, which has been confirmed through repeated experimental tests.

E. **Principle**: A basic truth, law, or assumption.

F. **Fact**: Something demonstrated to exist or known to have existed.

G. **Observation**: An inference or a judgment that is acquired from or based on observing.

1. Typically, the first step in a scientific process.

a) **Quantitative** - involves numbers
b) Comparing observation to an accepted standard

2. **Qualitative** - Opinions

a) Disputed characteristics

H. Controlled experiments have variables

1. **Independent variable** - (manipulated variable)

a) Variable changed by investigator (what you're testing)

2. **Dependent variable** - (responding variable)

a) Variable data is collected on (data)

Cells and Cell Processes

I. Explain the characteristics common to all organisms.

A. **Made of Cells** - unicellular or multicellular

B. **Maintain Homeostasis** - maintain a stable internal environment

C. **Maintain Metabolism** - used food to build molecules and carry out processes to maintain homeostasis.

D. Reproduce

E. Genetic material

F. **Respond to Stimuli**

G. Grow and Develop

II. Describe the characteristics of life shared by all prokaryotic and eukaryotic organisms.

A. **Prokaryote**
1. Lack organelles.
2. Contain ribosomes.
3. Lack a nucleus.
4. Single-celled.

B. **Eukaryotes**
1. Contain organelles.
2. Contains a nucleus.
3. Contain ribosomes.
4. Single and/or multicellular.

III. Describe relationships between structure and function at biological levels of organization.

A. Multicellular Organisms have different levels of cellular organization
1. **Organelles—>Cells—>Tissues—>Organs—>Organ systems—>Multi-cellular organisms**

2. Unicellular organisms function at just the cellular level

B. Compare cellular structures and their functions in prokaryotic and eukaryotic cells.

1. Eukaryotic Organelles

a) **Nucleus**:
(1) Contains DNA
(2) Control cell's activities

b) Nucleolus
(1) Site of ribosome synthesis (create)
(2) Found in nucleus

c) **Mitochondria**:
(1) Site of major ATP production (usable energy)
(2) ATP Synthase/Chemiosmosis

d) **Rough Endoplasmic Reticulum**:
(1) Transports proteins and other substances within cell

e) **Smooth Endoplasmic Reticulum**:
(1) Creates lipids

f) **Ribosomes**:
(1) Site protein synthesis

g) **Chloroplast**:
(1) Found in photoautotrophs
(2) Synthesis carbohydrates using light energy

h) **Golgi Apparatus**:
(1) Protein packaging

i) **Cytoplasm**:
(1) Supports and protects organelles
(2) Cytosol
(a) Fluid component of cytoplasm

j) **Centrioles**:
(1) Paired cylindrical organelles utilized in cell division

k) **Cytoskeleton/Microtubules**:
(1) Supports cell
(2) Provides shape used in cell movement

l) **Lysosome**:
(1) Breaks down food molecules, and old organelles

m) **Vacuoles**:
(1) Storage
(2) Digestion
(3) Waste removal

n) **Contractile Vacuole**:
(1) Pumps water out of cell
(2) Large in Plants

o) **Vesicle**:
   (1) Moves proteins, lipids, and carbohydrates through cell

p) **Cell Membrane**:
   (1) Protects contents of the cell,
   (2) Controls what enters and leaves cell

q) **Cell Wall**:
   (1) Protects contents of cell
   (2) Prevents cells from bursting

Vocabulary:

Agriculture - The artificial cultivation of food, fiber, and other goods by the systematic growing and harvesting of various organisms.

Biology - The scientific study of life

Cell - The basic unit of structure and function for all living organisms. Cells have three common components: genetic material, cytoplasm, and a cell membrane. Eukaryotic cells also contain specialized organelles.

Controls - Factors in an experiment that must be kept the same or the outcome of the experiment will be altered.

Dependent Variable (Responding Variable) - Variable in an experiment that is represented by data. The variable that is measured.

Ecology - The study of the relationships between organisms and their interactions with the environment.

Embryology - The branch of zoology studying the early development of living things.

Eukaryote - A type of organism composed of one or more cells containing a membrane bound nucleus, specialized organelles in the cytoplasm, and a mitotic nuclear division cycle.

Forensics - The science of tests and techniques used during the investigation of crimes.

Hypothesis (Null hypothesis) - A proposed, scientifically testable explanation for an observed phenomenon.

Independent variable (Manipulated Variable) - Variable in an experiment being investigated, what the investigator changes.

Law - 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.

Organ - An anatomical unit composed of tissues serving a common function.

Keystone Review

OrganSystem - An anatomical system composed of a group of organs that work together to perform a specific function or task.

Organelle - A subunit within a cell that has a specialized function.

Organism - A form of life; an animal, plant, fungus, protist or bacterium.

Principle - A concept based on scientific laws and axioms (rules assumed to be present, true, and valid) where general agreement is present.

Prokaryote - A single celled organism that lacks a membrane bound nucleus and specialized organelles.

Science - A body of evidence based knowledge gained through observation and experimentation related to the natural world and technology.

Theory - 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.

Unicellular - Made up of a single cell.

The Chemical Basis for Life

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

A. 70-75% of your body is made of water

1. Water can be found in all three states of matter: solid, liquid, and gas.
2. Water is polar molecule

B. Unequal sharing of electrons - Covalent Polar Molecule

1. Oxygen more electronegative
   a) Shared electrons move closer to Oxygen
   b) Oxygen in of the molecule more negative
   c) Hydrogen end of molecule more positive
   d) Dissolves other polar compound
   e) NON-POLAR MOLECULES WILL NOT DISSOLVE (Lipids)

C. Unequal sharing allows for hydrogen bonding to occur

1. Accounts for the IMPORTANT PROPERTIES of WATER
   a) Cohesion
      (1) Water molecules are attracted to other water molecules
      (2) Surface tension is due to cohesion

   b) Adhesion
      (1) Water molecules are attracted to other polar molecules
         (a) Allows for capillary movement
         (b) Meniscus in graduated cylinder

   c) **Water has a high specific heat**.
      (1) The property of absorbing significant energy before showing temperature change is a measure called "specific heat."
         (a) Water boils at 212F (100C)
         (b) Water freezes at 32F (0C)

      (2) As energy is added to water, the molecules tend to increase vibration and movement causing hydrogen bonds to break.

   d) Latent Heat of Vaporization
      (1) As water molecules are broken from all hydrogen bonds, they escape into the atmosphere in a process called evaporation.

      (2) When water evaporates from an organism, it permits the organism to cool down because it pulls heat from it.

e) Water's volume expands as it cools

(1) Allows ice to float

(2) Allows organisms to live in lakes during winter months
(a) Insulates organisms

II. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).

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

1. Organic compounds are distinguished from inorganic compounds by the presence of both carbon and hydrogen.

2. Carbon, atomic number six, has six electrons.

3. Two are in the first electron shell and four are in the second electron shell.

4. Carbon must share four electrons with other atoms to fill its outer most electron shell and attain a stable configuration.

5. Carbon atoms can share electrons with a wide variety of elements also commonly found in organic compounds, the most notable being other carbon atoms, hydrogen atoms and oxygen atoms.

III. Describe how biological macromolecules form from monomers.

A. Macromolecules (Polymers) form by chemically joining two or more monomers together by a dehydrations synthesis reaction

1. Dehydration synthesis reaction the OH group from one monomer and the H atom from another monomer join to form H_2O

2. Water is released and a new compound (macromolecule) is formed

3. Macromolecules are broken down by a hydration or hydrolysis reaction

a) The OH and H from water are placed back on their original molecules to break the bond of the macromolecule.

IV. Compare the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms.

A. Four Biological Macromolecules (Polymers)

B. **Most composed of Monomers** (lipids have no monomers)
1. Carbohydrates: Monosaccharides (Monomer) Disaccharides Polysaccharides (Polymer/ Macromolecule)

a) **Composed of Carbon, Hydrogen and Oxygen in a 1:2:1 ratio**

b) **Key source of energy**

c) Found in most foods

d) Typically sugars
   (1) Glucose, Fructose and Galactose major monomers (simple sugars) used to make macromolecules

e) **Starches** - energy storage plants
   (1) Composed of simple sugars
      (a) Branch chain
      (b) Linear

   (2) Glycogen - energy storage animals
      (a) How animals store excess glucose

   (3) Cellulose - structural molecule plants

   (4) Chitin - structural exoskeletons

2. Lipids: No Monomers, large complex molecules

a) **Composed of Carbon, Hydrogen with little Oxygen**

b) Nonpolar molecules that aren't soluble in water.

c) Fatty acids major portion of large lipid molecules

d) There are different types of lipids each with different functions:
   (1) Phospholipids: make up the lipid bilayer of cell membranes.
   (2) Sterols: Tend to perform as hormones or signaling molecules include cholesterol, estrogen and testosterone.
   (3) Glycerol: stores large amounts of energy.

e) Fats found in foods:
   (1) Dietary fats: necessary to facilitate absorption of fat-soluble vitamins (A, D, E, and K) and carotenoids.
   (2) Omega-3 fatty acids: helps infant development, cancer, cardiovascular diseases, and various mental illnesses, such as depression, attention-deficit hyperactivity disorder, and dementia
   (3) Saturated fats:
      (a) Increase the levels of bad cholesterol (LDL) in your body
   (4) Unsaturated fats:
      (a) Increases the amount of good cholesterol (HDL)
      (b) Takes bad cholesterol (LDL) to liver to be broken down
   (5) Trans fats:

(a) Produced during production of vegetable oil
(b) Risk for cardiovascular disease.

3. Proteins: Amino Acid (Monomer) Polypeptide Chains Protein (Polymer/Macromolecule)

a) Composed of Carbon, Hydrogen, Oxygen, Nitrogen and Sulfur

b) Building block for many structures in the body.

c) Amino acids(monomer)—>Polypeptide chains—>Proteins(Polymer/macromolecule)
(1) 20 different amino acids make up 2 million different proteins in the human body.

d) Function of proteins:

(1) Antibodies: travel through the blood stream and are utilized by the immune system to identify and defend against bacteria, viruses, and other foreign intruders.

(2) Enzymes: referred to as catalysts because they speed up chemical reactions.
(a) Most enzymes end with the suffix ase.
i) Lactase – breaks down the sugar lactose.
ii) Fructase – breaks down the sugar fructose.

(3) Hormones - messenger proteins which help to coordinate certain bodily activities.
(a) Examples : insulin and oxytocin

(4) Structural proteins - provide support.
(a) Examples include keratin (hair and feathers) and collagen (tendons and ligaments).

(5) Transport proteins: move molecules from one place to another around the body.
(a) Example: Hemoglobin found in our bodies red blood cells o Nucleic acids – used for protein production and hereditary information storage.

4. Nucleic Acid: Nucleotide (Monomer) DNA/RNA (Polymer/Macromolecule) Compare and contrast the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms.

a) Composed of Carbon, Hydrogen, Oxygen, Nitrogen and Phosphorus

b) Nucleotides (Monomer) Nucleic acids (Polymer/Macromolecule) Two different types:

(1) DNA: Deoxyribonucleic Acid
(a) Stores hereditary information
(b) Consists of two strands of nucleotides twisted around each other.

(2) RNA: Ribonucleic Acids

(a) Used in the manufacturing of proteins.
(b) Single strand of nucleotides that code for a specific protein to be made by the cell.

C. Explain how enzymes regulate biochemical reactions within a cell.

1. Function of enzymes:

a) Enzymes reduce the activation energy. The energy needed to start the chemical reaction

b) Enzymes also increase the speed of the chemical reaction.

c) Without enzymes chemical reactions would not occur quick enough to sustain life.

d) The molecule that an enzyme acts on is called the substrate.
(1) Substrate molecules are changed, and product is formed.
(2) The enzyme molecule is unchanged after the reaction, and it can continue to catalyze the same type of reaction over and over.

e) Enzymes are substrate specific.
(1) The enzyme fits into the substrates active site like a key into a lock.
(2) Each substrate has a different active spot which causes each substrate to have a different enzyme.

D. Explain how factors such as pH, temperature, and concentration levels can affect enzyme function.

1. **pH effects on enzymes**:

a) Each enzyme functions best in a specific ph range.

b) When the pH changes, the active site progressively distort and affect enzyme function. If the enzyme doesn't fit properly into the active spot, the enzyme works ineffectively.

2. Temperature effects on enzymes

a) Chemical reactions speed up as temperature is increased, so, in general, catalysis will increase at higher temperatures.

b) However, each enzyme has a temperature optimum, and beyond this point the enzyme's functional shape is lost.

c) Boiling temperatures will denature most enzymes.

d) Salts (Ions)

e) Each enzyme functions best at a specific ion concentration

f) Increases or decrease from specific concentration decreases enzymes activity

3. **Concentration effects**:

a) Increasing substrate and/or enzyme concentration, increases the rate of reaction.

E. Describe the role of an enzyme as a catalyst in regulating a specific biochemical reaction.

1. When cells consume energy, the activation energy needed to start the chemical reaction is reduced by enzymes.

2. Enzymes also increase the speed of the chemical reaction.

a) Without enzymes chemical reactions would not occur quick enough to sustain life.

3. The molecule that an enzyme acts on is called the substrate.

a) Substrate molecules are changed, and product is formed.

b) The enzyme molecule is unchanged after the reaction, and it can continue to catalyze the same type of reaction over and over.

4. Enzymes are substrate specific.

a) The enzyme fits into the substrates active site like a key into a lock.

b) Each substrate has a different active spot which causes each substrate to have a different enzyme.

Vocabulary:

Adhesion - The intermolecular attraction between unlike molecules. Capillary action results from the adhesive properties of water and the molecules that make up plant cells.

Atom - The smallest unit of an element that retains the chemical and physical properties of that element.

Boiling Point - Temperature at which a liquid turns to a vapor

Carbohydrate - A macromolecule that contains atoms of carbon, hydrogen, and oxygen in a 1:2:1 ratio and serves as a major source of energy for living organisms (e.g., sugars, starches, and cellulose).

Catalysts - A substance that enables a chemical reaction to proceed at a usually faster rate or under different conditions (e.g., lower temperature) than otherwise possible without being changed by the reaction.

Keystone Review

Cohesion - The intermolecular attraction between like molecules. Surface tension results from the cohesive properties of water.

Concentration - The measure of the amount or proportion of a given substance when combined with another substance.

Covalent Bonds - When two or more atoms share one or more pairs of electrons

Enzyme - A protein that increases the rate of a chemical reaction without being changed by the reaction; an organic catalyst.

Freezing Point - The temperature at which a liquid changes state to a solid.

Ionic Bonds - Bond formed when one atom donates one or more electrons to another atom.

Lipid - A group of organic compounds composed mostly of carbon and hydrogen including a proportionately smaller amount of oxygen; are insoluble in water, serve as a source of stored energy, and are a component of cell membranes.

Macromolecule - A polymer with a high molecular mass. Within organisms there are four main groups: carbohydrates, lipids, proteins, and nucleic acids.

Molecule - The smallest particle of a substance that retains the chemical and physical properties of the substance and is composed of two or more atoms held together by chemical forces.

Monomer - A molecule of any compound that can react with other molecules of the same or different compound to form a polymer. Each biological macromolecule has characteristic monomers.

Nucleic Acid - A biological macromolecule (DNA or RNA) composed of the elements C, H, N, O, and P that carries genetic information.

Polar Molecule - Molecule that has a partial positive and negative charge due to uneven sharing of electrons.

pH - The measure of acidity or alkalinity (basicity) of an aqueous solution scaling from 1 (highly acidic) to 14 (highly alkaline) with a midpoint of 7 (neutral).

Protein - A macromolecule that contains the principal components of organisms: carbon, hydrogen, oxygen, and nitrogen; performs a variety of structural and regulatory functions for cells.

Temperature - A measure of the average kinetic energy (energy of motion) of particles in a sample of matter. This physical property can determine the rate and extent to which chemical reactions can occur within living systems. It is commonly measured in degrees Celsius (°C) or Fahrenheit (°F).

Valence orbital - Outer most orbital in any atom. Important in bonding properties of the atom. Octet rule becomes important

Bioenergetics

I. Identify and describe the cell structures involved in processing energy.

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

1. **Plastids: only found in plants**.

2. Is composed of stacks of thylakoid sacks.

3. Chlorophyll covers each stack.

4. With a combination of water and carbon dioxide, the light is converted into glucose, where it is then used by the mitochondria to make ATP molecules This chemical process of producing glucose is called photosynthesis.

B. Mitochondria: found in all eukaryotic cells.

1. **Where adenosine triphosphate (ATP) molecules are produced and stored**.

a) ATP is a result of cellular respiration and requires a food source

b) How does the mitochondria function:

c) It is covered in cristae created by multiple folds of the membrane to maximize surface area.
(1) The mitochondrion uses the vast surface of the inner membrane to perform many chemical reactions.
(2) The chemical reactions include filtering out certain molecules and attaching other molecules to transport proteins.
(3) The transport proteins will carry select molecule types into the matrix, where oxygen combines with food molecules to create energy.

II. Identify and describe how organisms obtain and transform energy for their life processes.

A. Compare the basic transformation of energy during photosynthesis and cellular respiration

1. Photosynthesis: the process by which plants use solar energy to convert the raw materials carbon dioxide (CO_2) and water (H_2O) into glucose ($C_6H_{12}O_6$) for use as an energy source.

a) Oxygen gas is produced as the byproduct

b) The general chemical equation for photosynthesis is:
(1) $6H_2O + 6CO_2$ + light energy ----------> $C_6H_{12}O_6 + 6O_2$ (ANABOLIC)
(a) Occurs in the chloroplasts of plants.

2. **Cellular respiration: is the release of energy from energy-storing compounds (i.e. glucose, fructose, starch).**

   a) The cells of all organisms, and therefore, all organisms, require a continuous supply of energy for the performance of their daily, vital activities.

   b) Respiration It is represented by the chemical equation:
   (1) $C_6H_{12}O_6 + 6O_2$ ----> $6CO_2 + 6H_2O$ + energy (heat, light, ATP, etc.) (CATABOLIC)

   c) You should be careful to notice that the process of cellular respiration is essentially the reverse of photosynthesis.

   d) The catabolic breakdown (burning) of glucose requires the presence of oxygen and yields energy and carbon dioxide

   e) Releases carbon dioxide as a byproduct, which may then be used by plants in the photosynthetic process
      (1) Occurs in the mitochondria of eukaryotes.

B. Describe the role of ATP in biochemical reactions.

1. **ATP (Adenosine Triphosphate) is a nucleotide used for energy storage**

2. **Composed of:**

   a) Adenine nitrogen base

   b) Ribose sugar molecule

   c) Phosphate group(s)
      (1) Number of phosphate groups determines the power of the nucleotide:
      (2) AMP: Adenosine monophosphate – 1 phosphate group – acts like a very weak battery
      (3) ADP: Adenosine diphosphate – 2 phosphate groups – acts like a dollar store battery (has power but not the best)
      (4) ATP: Adenosine triphosphate – 3 phosphate groups – acts like a Duracell lithium battery

3. ATP is fuel for cells – it is consumed by a variety of different processes.

   a) Once it is spent, it reverts back to adenosine diphosphate and adenosine monophosphate.

4. ATP transports chemical energy within cells for metabolism.

5. **ATP is produced by**

    a) photophosphorylation (photosynthesis)

    b) substrate level phosphorylation (respiration/fermentation)

    c) oxidative phosphorylation (respiration)

6. **ATP is used by**:

    a) Enzymes function

    b) Structural proteins in many cellular processes; metabolism, cell division, movement

Vocabulary:

Adenosine Triphosphate (ATP) - A molecule that provides energy for cellular reactions and processes. ATP releases energy when one of its high energy bonds is broken to release a phosphate group.

Cellular Respiration - A complex set of chemical reactions involving an energy transformation where potential chemical energy in the bonds of "food" molecules is released and partially captured in the bonds of adenosine triphosphate (ATP) molecules.

Chloroplasts- An organelle found in plant cells and the cells of other eukaryotic photosynthetic organisms where photosynthesis occurs.

Electron Transport Chain - Series of proteins that transport electrons

Glycolysis - First phase of cellular respiration, conversion of one six carbon molecule into two three carbon molecules.

Krebs Cycle - Series of oxidation reaction to extract energy from a six carbon compound

Photolysis (Photosynthesis) - Process by which water is broken down by absorbing photons during photosynthesis

Photosynthesis - A process in which solar radiation is chemically captured by chlorophyll molecules and through a set of controlled chemical reactions resulting in the potential chemical energy in the bonds of carbohydrate molecules.

Plastid - A group of membrane bound organelles commonly found in photosynthetic organisms and mainly responsible for the synthesis and storage of food.

NADPH (NADH) - Nicotinamide adenine dinucleotide High energy electron carries found in respiration and photosynthesis.

Oxidation - Loss of electrons, Reducing agent

Reduction - Gaining electrons, Oxidizing agent

Homeostasis and Transport

I. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

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

1. Plasma membranes are sheet-like structures composed mainly of lipids and proteins.

a) Membrane lipids are organized in a bilayer (two sheets of lipids making up a single membrane).

b) **The proteins, on the other hand, are scattered throughout the bilayer and perform most membrane functions**.

c) Both lipids and proteins are constantly moving within the membrane.

2. **The cell membrane is selectively permeable to ions and organic molecules and controls the movement of substances in and out of cells.**

a) Controls what enters and leaves the cell

b) The basic function of the cell membrane is to protect the cell from its surroundings.

c) Other functions of the cell membrane:

(1) cell adhesion

(2) ion conductivity

(3) cell signaling

(4) serve as the attachment surface for several extracellular structure

B. **Compare the mechanisms that transport materials across the plasma membrane (i.e., passive transport—diffusion, osmosis, facilitated diffusion; and active transport—pumps, endocytosis, exocytosis).**

1. The cell employs a number of transport mechanisms that involve biological membranes:

a) **PassiveTransport**:substances move from an area of high concentration to an area of low concentration.

(1) **No energy** is required to move from high to low concentrations.

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(a) Types of passive transport:

i) **Diffusion**: Some substances (small molecules, ions) such as carbon dioxide (CO_2), oxygen (O_2), and water, can move across the plasma membrane

ii) **Osmosis**: is the diffusion of water from areas of high concentration to areas of low concentration.

iii) **Facilitated diffusion**: is the spontaneous passage of molecules or ions across a biological membrane passing through specific trans-membrane integral proteins.

(1) The facilitated diffusion may occur either across biological membranes or through aqueous compartments of an organism.

(2) Polar molecules and charged ions are dissolved in water but they cannot diffuse freely across the plasma membrane due to the hydrophobic (water fearing) nature of the fatty acid tails of phospholipids that make up the lipid bilayers.

(3) Only small nonpolar molecules, such as oxygen can diffuse easily across the membrane.

(4) This process does NOT use energy – molecules travel from areas of high to low concentration.

(b) **Active transport:** moves molecules from areas of low concentration to areas of high concentration.

i) This movement uses energy (typically ATP). Types of active transport:

(1) **Sodium-potassium pumps**: is responsible for cells containing relatively high concentrations of potassium ions but low concentrations of sodium ions.

(a) The pump, while binding ATP, binds 3 intracellular Na+ ions.

(b) A change in the pump exposes the Na+ ions to the outside, so they are released.

(c) The pump binds 2 extracellular K+ ions - transporting the K+ ions into the cell.

(d) The pump has a higher affinity for Na+ ions than K+ ions, so the two bound K+ ions are released.

(e) ATP binds, and the process starts again.

(f)

(2) **Endocytosis**: is the process in which cells absorb molecules by engulfing them.

(a) The plasma membrane creates a small deformation inward, called an invagination, in which the substance to be transported is captured.

(b) The deformation then pinches off from the membrane on the inside of the cell, creating a vesicle containing the captured substance.

(3) Two types of endocytosis:

(a) **Phagocytosis** - cell eating -small molecules and ions

(b) **Pinocytosis** - cell drinking

(4) **Exocytosis**: occurs in various cells to remove undigested residues of substances brought in by endocytosis.

(a) Secrete substances such as hormones and enzymes, and to transport a substance completely across a cellular barrier.

C. Describe how membrane-bound cellular organelles (e.g., endoplasmic reticulum, Golgi apparatus) facilitate the transport of materials within a cell.

1. **Endoplasmic reticulum**: the transportation system of the eukaryotic cell.

a) Secretory proteins are moved across the endoplasmic reticulum membrane.

b) Proteins that are destined for places outside the endoplasmic reticulum are packed into transport vesicles and moved along the cytoskeleton toward their destination.

2. **Golgi apparatus**:

a) The vesicles that leave the rough endoplasmic reticulum are transported to the

b) Golgi apparatus, where they fuse with the Golgi membrane and empty their contents into the lumen.

c) The Golgi complex modifies many products from the ER including proteins and phospholipids.

d) The complex also manufactures certain biological polymers of its own.

(1) Once modifications have been made and molecules have been sorted, they are secreted from the Golgi via transport vesicles to their intended destinations.

(a) Some of the molecules are destined for the cell membrane where they aid in membrane repair and intercellular signaling.

(b) Other molecules are secreted to areas outside of the cell. o Still other vesicles contain enzymes that digest cellular components.

i) These vesicle form cell structures called lysosome.

D. Explain how organisms maintain homeostasis (e.g., thermoregulation, water regulation, oxygen regulation).

1. Relies on feedback mechanisms —> Stimulus —> Receptor—> Modulator —> Effector —> Response

a) Thermoregulation - organisms must be able to regulate internal temperature

(1) Correct temperature range allows enzymes to function correctly

(2) Heat gain and Heat loss

(a) Behavioural - organisms change level of activity

(b) Physiological - organism's internal temperature adjusted automatically by the release of chemical signals.

b) Water regulation - water is constantly being lost/used by organisms through metabolic processes (sweat, urine, chemical reactions)

(1) Osmotic pressure

(a) High osmotic pressure - less water, more solutes compared to cell

(b) Low osmotic pressure - more water, less solute compared to cell

(c) Water loss concentrated solutes

i) Hypertonic - higher concentration of solutes outside the cell

ii) Hypotonic - lower concentration of solute outside the cell

iii) Isotonic - concentration of solute equal to that in the cell

c) Gas Regulation - organisms must regulate internal gases for metabolic process.

(1) Aerobic organisms

(a) Oxygen needed to carry out metabolic processes

i) must enter cells

(b) Carbon dioxide produced during metabolic processes

i) must leave cells

d) Regulation of Blood Pressure - humans must regulate blood pressure

(1) Blood circulates hormones, gases, and nutrients

(a) Regulation of temperature, gases, fluids and nutrients

Vocabulary:

Active Transport - The movement of particles from an area of low concentration to an area of high concentration that uses energy provided by ATP or a difference in electrical charges across a cell membrane.

Carrier Proteins (Transport Proteins) - Proteins embedded in the plasma membrane involved in the movement of ions, small molecules, and macromolecules into and out of cells; also known as transport proteins.

Concentration Gradient - The graduated difference in concentration of a solute per unit distance through a solution.

Extracellular - Located outside a cell.

Diffusion - The movement of particles from an area of high concentration to an area of low concentration; a natural result of kinetic molecular energy.

Endocytosis - A process in which a cell engulfs extracellular material through an inward folding of its plasma membrane.

Exocytosis - A process in which a cell releases substances to the extracellular environment by fusing a vesicular membrane with the plasma membrane, separating the membrane at the point of fusion and allowing the substance to be released.

Facilitated Diffusion - A process in which substances are transported across a plasma membrane with the concentration gradient with the aid of carrier (transport) proteins; does not require the use of energy.

Impermeable - Not permitting passage of a substance or substances.

Intracellular - Inside the cell

Osmosis - The movement of water or another solvent through permeable membranes from an area of higher water concentration (dilute) to an area of lower water concentration (concentrated).

Passive Transport - The transportation of materials across a plasma membrane without using energy.

Plasma Membrane - A thin, phospholipid and protein molecule bilayer that encapsulates a cell and controls the movement of materials in and out of the cell through active or passive transport.

Pump (Ion or Molecular) - Any of several molecular mechanisms in which ions or molecules are transported across a cellular membrane requiring the use of an energy source (e.g., glucose, sodium [Na +], calcium [Ca+], and potassium [K+]).

Continuity and Unity of Life - Cell Growth and Reproduction

I. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.

A. Interphase

1. G1 Phase: Cell grows
2. S Phase: DNA is replicated
3. G2 Phase: Cell continues to grow, organelles are copied

B. Mitosis: M phase - Nuclear division

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

C. Cytokinesis

1. Two new identical diploid (2n) daughter cell form

II. Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis.

A. Mitosis: M phase - Nuclear division

1. **Prophase**:
   a) Spindle fibers form
   b) Nuclear envelope dissolves
   c) Chromosomes become visible
2. **Metaphase**:
   a) Chromosomes align at the cell's equator
   b) Spindle fibers attach to chromosomes

3. **Anaphase**:
    a) Spindle fibers pull chromatids apart at centromere
    b) Chromatids move to opposite poles
4. **Telophase**
    a) Chromatin de-condenses
    b) New Nuclei begin to form
5. **Cytokinesis**
    a) Cytoplasm is divided, organelles, partition to each side, new cell membrane or wall formed
    b) Two new identical diploid (2n) daughter cell form

B. **Meiosis** - mitosis twice without a second replication phase

1. **Prophase I**:
    a) Chromosomes become visible
    b) Nuclear envelope disappears
    c) Tetrads form
        (1) Homologous chromosomes appear
        (2) Crossover occurs
2. **Metaphase I**:
    a) Homologous chromosomes move to equator
3. **Anaphase I**:
    a) Homologous chromosomes move to opposite poles
    b) Phase where chromosome reduction occurs
        (1) Allows news cells to become haploid - n (half the full complement of chromosome)
4. **Telophase I:**
    a) Cytoplasm divides

5. **Prophase II**:
    a) New spindle fibers form around the chromosomes
6. **Metaphase II**:
    a) Chromosomes align up at the equator
7. **Anaphase II**:
    a) Centromeres divide
    b) Sister chromatids separate
    c) Chromatids move to opposite poles
8. **Telophase II**:
    a) Chromosomes de-condense
    b) New nuclear membrane forms around de condensed chromosomes
    c) Cytoplasm begins to divide
9. **Cytokinesis**:
    a) four new unlike haploid cells form
    b) become sex cells

C. Mitosis vs Meiosis

1. Mitosis

a) One division
b) Two identical diploid cells.

2. Meiosis

a) Occurs in reproductives cell only
b) Two divisions
c) First division reduces chromosome number to a haploid number
d) Second division produces 4 unlike haploid cells

Keystone Review

III. Explain how genetic information is inherited.

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

1. **DNA replication**: Process of making an exact copy of DNA

a) Occurs in the S phase of the cell cycle.

b) Produces two exact daughter strands of DNA from the parent strand.

c) Semiconservative process

(1) Each strand serves as template strand for synthesis of new strand

(2) Proceeds in a 5'-3' direction

(a) Leading strand

i) Replicated continuously

(b) Lagging Strand

i) Discontinuous replication

d) One strand will be moved into each of the new daughter cells after cytokinesis occurs

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

A. Chromosomes are long strands of DNA

1. DNA is the genetic material that codes for the hereditary traits of organisms.

2. Genes are segments of DNA that is located in a chromosome and that code for a specific hereditary trait.
   a) Alleles are alternative forms of a gene that governs a characteristic, such as hair color

Vocabulary:

Cell Cycle - The series of events that take place in a cell leading to its division and duplication. The main phases of the cell cycle are interphase, nuclear division, and cytokinesis.

Cytokinesis - The final phase of a cell cycle resulting in the division of the cytoplasm.

DNA - A biological macromolecule that encodes the genetic information for living organisms and is capable of self replication and the synthesis of ribonucleic acid (RNA).

DNA Replication - The process in which DNA makes a duplicate copy of itself.

Keystone Review

Interphase - The longest lasting phase of the cell cycle in which a cell performs the majority of its functions, such as preparing for nuclear division and cytokinesis.

Meiosis - A two phase nuclear division that results in the eventual production of gametes with half the normal number of chromosomes.

Mitosis - A nuclear division resulting in the production of two somatic cells having the same genetic complement as the original cell.

Semiconservative Replication - The process in which the DNA molecule uncoils and separates into two strands. Each original strand becomes a template on which a new strand is constructed, resulting in two DNA molecules identical to the original DNA molecule.

Genetics

I. Compare Mendelian and non-Mendelian patterns of inheritance.

A. Punnett squares are used to predict the appearance of the offspring produced from two known parents.

B. **Dominant genes** are those that are always expressed if they are present in an organism's genotype.

1. The **genotype is the pair of alleles** that an organism receives from its parents. (Example: AA, Aa, aa)

a) **Homozygous genotype**: is a genotype that the alleles are the same (Ex: AA – Homozygous dominant, aa – Homozygous recessive)

b) **Heterozygous genotype**: is a genotype that the alleles are different (Ex: Aa – Heterozygous dominant)

2. The **phenotype is the physical expression** of the pair of alleles for a specific trait. (Example: Purple flowers or white flowers)

C. Recessive genes are those that are only expressed if dominant genes aren't present.

II. Exceptions to simple inheritance (NON-MENDELIAN GENETICS):

A. Describe and/or predict observed patterns of inheritance (i.e., dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple alleles).

1. **Polygenic traits:** traits that are determined by the combined effect of more than one pair of genes.

a) The genes may be scattered along the same chromosome or located on different chromosomes.

b) All polygenic traits tend to have varying degrees of intermediate conditions.

c) Examples: Human hair color, eye color, height weight

2. **Incomplete dominance**: results in an intermediate expression of a trait in heterozygous individuals. (Blending of the two traits)

a) For instance, in primroses, snapdragons, and four-o'clocks, red or white flowers are homozygous while pink ones are heterozygous. The pink flowers result because the single "red" allele is unable to code for the production of enough red pigment to make the petals dark red.

3. **Multiple alleles**: Genes with three or more alleles.

    a) Even the traits controlled by genes with multiple alleles, an individual can have only two of the of the possible alleles for that gene.

    b) Example: Human blood type – I^A, I^B, i^O

4. **Codominance**: Two dominant alleles are expressed at the same time.

    a) Both dominant phenotype are expressed at the same time.

    b) Example: Human Blood Type – Parent one with I^AI^A blood type has a baby with parent two who has I^BI^B. They will have a child with AB blood type, because the A and B allele are both dominant.

5. **Sex-linked traits**: A gene that is found only on the X chromosome and not the Y chromosome.

    a) Because the gene controlling the trait is located on the sex chromosome, sex linkage is linked to the gender of the individual.

    b) Usually such genes are found on the X chromosome.

        (1) The result is that females will have two copies of the sex-linked gene while males will only have one copy of this gene.

        (2) If the gene is recessive, then males only need one such recessive gene to have a sex-linked trait rather than the customary two recessive genes for traits that are not sex-linked.

        (3) This is why males exhibit some traits more frequently than females.

III. Describe processes that can alter composition or number of chromosomes (i.e., crossing-over, nondisjunction, duplication, translocation, deletion, insertion, and inversion).

A. **Crossing Over**: the exchange of genetic material between homologous chromosomes that results in recombinant chromosomes.

1. Occurs during Prophase I of meiosis.

2. Crossover usually occurs when matching regions on matching chromosomes break and then reconnect to the other chromosome.

3. This process shuffles the allele content between homologous chromosomes.

    a) Creates more possible combinations of offspring outcomes.

B. **Nondisjunction:** is the failure of chromosomes pairs to separate properly during meiosis stage 1 and stage 2, specifically in the anaphase.

1. The result of this error is a gamete with an imbalance of chromosomes.

2. Loss of a single chromosome, in which the gamete with the defect will have one chromosome missing from one of its pairs, is referred to as a monosomy.

    a) Other than Turner Syndrome (women who are missing one of a pair of X chromosomes), all other cases of full monosomy are lethal and the individual will not survive fetal development.

3. Gaining a single chromosome, in which the gamete with the defect will have one chromosome in addition to its pairs is referred to as a trisomy. Examples:

    a) Trisomy 21 (Down Syndrome)

    b) Trisomy 18 (Edward's Syndrome) Triple X Snydrome

    c) XXY (Klinefelter Syndrome)

C. **Common chromosomal mutations**:

1. **Insertion**: add one or more extra nucleotides into the DNA.

    a) Alters the reading frame of the gene.

    b) They are usually caused by errors during replication of repeating elements.

        (1) Example: Original strand ATCGAT New strand ATCTGAT

2. **Deletion:** removal of one or more nucleotides from the DNA.

    a) Like insertions, these mutations can alter the reading frame of the gene.

        (1) Example: Original strand ATCGAT New strand ATAT

3. **Duplication**: leading to multiple copies of all chromosomal regions, increasing the dosage of the genes located within them.

    a) Example: Original strand ATCGAT New strand ATCATCGAT

4. **Inversion**: a segment of a chromosome is reversed end to end.

    a) An inversion occurs when a single chromosome undergoes breakage and rearrangement within itself.

        (1) Example: Original strand ATCGAT New strand CTAGAT

5. **Translocation**: is a chromosome abnormality by rearrangement of parts between non-homologous chromosomes.

    a) A gene fusion may be created when the translocation joins two otherwise separated genes.

        (1) The occurrence of which is common in cancer.

b) Two types of translocation mutations:

(1) Balanced: an even exchange of material with no genetic information extra or missing, and ideally full functionality

(2) Unbalanced where the exchange of chromosome material is unequal resulting in extra or missing genes.

IV. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).

A. Describe how the processes of transcription and translation are similar in all organisms.

1. The process of transcription and translation occurs in all organisms.

a) While the overall process is similar, the lack of a nucleus makes the process somewhat different in prokaryotes and eukaryotes.

(1) In prokaryotes, both transcription and translation take place in the cytoplasm on ribosome.

(2) In eukaryotes, transcription occurs in the nucleus and translation in the cytoplasm on a ribosome.

b) **Transcription** = DNA → RNA

(1) RNA is chemically very similar to DNA, except that the sugar component of RNA is ribose instead of deoxyribose, and it contains the base uracil in place of thymine.

(2) The RNA that is transcribed from DNA for the purpose of protein synthesis iscalled a messenger RNA or mRNA.

(3) The mRNA is then transported out of the nucleus, where it is translated into a specific protein molecule in the cytoplasm.

2. **Translation** - Translation = RNA → protein mRNA produced by transcription is decoded by the ribosome to produce a specific amino acid chain, or polypeptide, that will later fold into an active protein.

a) Prokaryotes - translation occurs in the cell's cytoplasm, where the large and small subunits of the ribosome are located and bind to the mRNA.

b) Eukaryotes - translation occurs across the membrane of the endoplasmic reticulum in a process called vectorial synthesis.

c) The ribosome facilitates decoding by inducing the binding of tRNAs with complementary anticodon sequences to that of the mRNA.

d) The tRNAs carry specific amino acids that are chained together into a polypeptide as the mRNA passes through and is "read" by the ribosome in a fashion reminiscent to that of a stock ticker and ticker tape.

Keystone Review

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

1. **Ribosomes**: are found in both prokaryotes and eukaryotes.

    a) The ribosome is a large complex composed of many molecules, including ribosomal RNAs and proteins.

    b) The ribosome molecules translate the mRNA genetic code to a specific sequence of amino acids that make up a protein is called translation.

    c) It is the "factory" where amino acids are assembled into proteins.

        (1) tRNAs (small noncoding RNA chains) that transport amino acids to the ribosome.

        (2) tRNAs have a site for amino acid attachment, and a site called an anticodon.

2. The anticodon is an RNA triplet complementary to the mRNA triplet that codes for their cargo amino acid.

3. **Endoplasmic reticulum**: only found in eukaryotic cells.

    a) The ribosome binds to the outer membrane of the rough endoplasmic reticulum

    b) The polypeptide chain that is produced by the ribosome is then released into the endoplasmic reticulum.

    c) The ER then transports the polypeptide chain to the area of the cell where it will be used.

4. **Golgi Apparatus**: is composed of flattened fluid-filled sacs that controls the flow of molecules in a cell.

    a) Produces a product called glycoprotein.

    b) Carbohydrates are added to freshly translated proteins to complete its production.

        (1) These newly formed glycoproteins (proteins with added carbohydrates) are used in a variety of ways, and in light of this, there is a wide variety of proteins in relation to their function.

        (2) This finished product, glycoprotein, is 'pinched off' the Golgi apparatus, and is transported by a vesicle of the cell membrane.

        (3) When this vesicle reaches the cell membrane, it binds to a receptor on the surface and excretes the protein, where it can then undergo its function.

5. **Nucleus**: directs protein synthesis by synthesizing messenger RNA (mRNA) according to instructions provided by the DNA.

Keystone Review

V. Describe how genetic mutations alter the DNA sequence and may or may not affect phenotype (e.g., silent, nonsense, frame- shift).

A. **Point mutations**: often caused by chemicals or malfunction of DNA replication, exchange a single nucleotide for another.

1. Various types of point mutation:

a) **Silent mutations**: are DNA mutations that do not result in a change to the amino acid sequence of a protein, or that do result in amino acid change but do not result in radically different properties of the changed amino acids.

(1) Because silent mutations do not alter protein function they are often treated as though they are evolutionarily neutral.

b) **Nonsense mutations**: is a point mutation in a sequence of DNA that results in a premature stop codon.

c) **Missense mutations**: is a point mutation in which a single nucleotide is changed, resulting in a codon that codes for a different amino acid

(1) Tends to make the resulting protein nonfunctional.

B. **Frameshift mutations**: will in general cause the reading of the codons after the mutation to code for different amino acids.

1. The frameshift mutation will also alter the first stop codon ("UAA", "UGA" or "UAG") encountered in the sequence.

2. The polypeptide being created could be abnormally short or abnormally long, and will most likely not be functional.

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

A. **Selective Breeding**: is the process of breeding plants and animals for particular traits.

1. Benefits:

a) high crop yields

b) resistance to disease

c) improved medicinal production

2. Negative impacts:

a) The other animals or plants become redundant and un-necessary. Could cause genetic problems and the animal may become sick easier. If it is a plant that needs more water then it would be creating an environmental issue.

b) Disrupts the food chain and the natural order of life, there is already a law of nature in place to choose the best aspects (survival of the fittest).

B. **Gene splicing**: cutting the DNA from one organism and attaching it to the DNA of another organism causing the host organism to demonstrate a new phenotype.

1. Example: attaching the insulin gene to bacteria to mass produce the drug.

C. **Cloning**: is the process of producing similar populations of genetically identical individuals that occurs in nature when organisms reproduce asexually.

1. Benefits:

a) Cloning body parts can become a life-saver.

b) Cloning can also provide a viable solution to infertility in organisms. Cloning technologies may help to understand the composition of genes and their effect on traits and behavior in a more comprehensive and elaborate manner.

c) Genetic alteration of plants and animals can also be enabled by cloning. It can also help to replicate animals that can be used for research purposes by scientists.

2. Disadvantages:

a) Since cloning creates identical genes and it is a process of replicating a complete genetic constitution, it can significantly hamper the much needed DNA diversity.

b) The lessening of genes diversity will weaken organism's adaptation ability.

3. Cloning raises a concerning probability of deliberate reproduction of undesirable traits in organisms.

4. On the moral and ethical front as well, cloning raises several serious questions.

D. **Gene therapy**: DNA can be used to supplement or alter genes within an individual's cells as a therapy to treat disease.

E. **Stem cell therapy**: an intervention strategy that introduces new adult stem cells into damaged tissue in order to treat disease or injury.

1. Highly controversial here in the US!

2. Will soon be able to treat cancer, Type 1 diabetes mellitus, Parkinson's disease, Huntington's disease, Celiac disease, cardiac failure, muscle damage and neurological disorders, and many others.

Keystone Review

Vocabulary:

Allele - A variation of a gene's nucleotide sequence (an alternative form of a gene).

Biotechnology - Any procedure or methodology that uses biological systems or living organisms to develop or modify either products or processes for specific use. This term is commonly associated with genetic engineering, which is one of many applications.

Chromosomal Mutation - A change in the structure of a chromosome (e.g., deletion, the loss of a segment of a chromosome and thus the loss of segment containing genes; duplication, when a segment of a chromosome is duplicated and thus displayed more than once on the chromosome; inversion, when a segment of a chromosome breaks off and reattaches in reverse order; and translocation, when a segment of one chromosome breaks off and attaches to a non-homologous chromosome).

Chromosome - A single piece of coiled DNA and associated proteins found in linear forms in the nucleus of eukaryotic cells and circular forms in the cytoplasm of prokaryotic cells; contains genes that encode traits. Each species has a characteristic number of chromosomes.

Cloning - A process in which a cell, cell product, or organism is copied from an original source (e.g., DNA cloning, the transfer of a DNA fragment from one organism to a self replicating genetic element such as a bacterial plasmid; reproductive cloning, the transfer of genetic material from the nucleus of a donor adult cell to an egg cell that has had its nucleus removed for the purpose of creating an embryo that can produce an exact genetic copy of the donor organism; or therapeutic cloning, the process of taking undifferentiated embryonic cells [STEM cells] for use in medical research).

Co-dominance - A pattern of inheritance in which the phenotypic effect of two alleles in a heterozygous genotype express each phenotype of each allele fully and equally; a phenotype which would not be expressed in any other genotypic combination.

Crossing-over - An exchange of genetic material between homologous chromosomes during anaphase I of meiosis; contributes to the genetic variability in gametes and ultimately in offspring.

Dominant Inheritance (gene) - A pattern of inheritance in which the phenotypic effect of one allele is completely expressed within a homozygous and heterozygous genotype.

Frame-shift Mutation - The addition (insertion mutation) or removal (deletion mutation) of one or more nucleotides that is not indivisible by three, therefore resulting in a completely different amino acid sequence than would be normal. The earlier in the sequence nucleotides are added or removed, the more altered the protein will be.

Gamete - A specialized cell (egg or sperm) used in sexual reproduction containing half the normal number of chromosomes of a somatic cell.

Gene - A sequence of nucleotides composing a segment of DNA that provides a blueprint for a specific hereditary trait.

Gene Expression - The process in which a nucleotide sequence of a gene is used to make a functional product such as protein or RNA.

Keystone Review

Gene Recombination - A natural process in which a nucleic acid molecule (usually DNA but can be RNA) is broken and then joined to a different molecule; a result of crossing over.

Gene Splicing - A type of gene recombination in which the DNA is intentionally broken and recombined using laboratory techniques.

Gene Therapy - The intentional insertion, alteration, or deletion of genes within an individual's cells and tissues for the purpose of treating a disease.

Genetics - The scientific study of inheritance.

Genotype - The genetic composition of an organism with reference to a single trait, a set of traits, or the entire complement of traits of an organism.

Incomplete Dominance - A pattern of inheritance in which two alleles, inherited from the parents, are neither dominant nor recessive. The resulting offspring have a phenotype that is a blending of the parental traits.

Inheritance - The process in which genetic material is passed from parents to their offspring.

Multiple Alleles - More than two forms of a gene controlling the expression of a trait.

Mutation - A permanent transmissible change of genetic material (e.g., chromosomal mutations and gene mutations).

Nondisjunction - The process in which sister chromatids fail to separate during and after mitosis or meiosis.

Phenotype - The observable expression of a genotype.

Point Mutation - A single base substitution causing the replacement of a single base nucleotide with another nucleotide (e.g., silent mutation, in which there is no change in an amino acid; missense mutation, in which there is a different amino acid; and nonsense mutation, in which there is an insertion of a stop codon in the amino acid which stops protein synthesis).

Recessive Inheritance (allele) - A pattern of inheritance in which the phenotypic effect of one allele is only expressed within a homozygous genotype. In a heterozygous condition with a dominant allele, it is not expressed in the phenotype.

Sex-linked Trait - A trait, associated with a gene that is carried by either the male or female parent (e.g., color blindness and sickle cell anemia).

Translocation - The process in which a segment of a chromosome breaks off and attaches to another chromosome.

Theory of Evolution

I. Explain the mechanisms of evolution.

A. Explain how natural selection can impact allele frequencies of a population.

1. Evolution is a change in an organisms DNA

2. Natural selection can increase the frequencies of alleles if they are advantageous to a species' survival and reproductive abilities.

3. If they somehow produce a phenotype that is not a selective advantage, their frequency will decrease.

4. The change in allelic frequencies is one way of defining evolution.

5. A population evolves as "better" alleles increase in frequency in the gene pool

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

1. Prezygotic mechanisms: Factors which prevent individuals from mating.

a) **Geographic isolation**: Species occur in different areas, and are often separated by terrestrial and aquatic barriers.

b) **Temporal isolation**: Individuals do not mate because they are reproductively active at different times. This may be different times of the day or different seasons. The species mating periods may not match up. Individuals do not encounter one another during either their mating periods, or at all.

c) **Ecological isolation**: Individuals only mate in their preferred habitat. They do not encounter individuals of other species with different ecological preferences.

d) **Behavioral isolation**: Individuals of different species may meet, but one does not recognize any sexual cues that may be given. An individual chooses a member of its own species in most cases.

e) **Mechanical isolation**: Copulation may be attempted but transfer of sperm does not take place. The individuals may be incompatible due to size or morphology.

f) **Gametic incompatibility:** Sperm transfer takes place, but the egg is not fertilized.

2. Postzygotic isolating mechanisms: Genomic incompatibility, hybrid inviability or sterility.

a) **Zygotic mortality**: The egg is fertilized, but the zygote does not develop.

(1) **Hybrid inviability**: Hybrid embryo forms, but is not viable.

(2) **Hybrid sterility**: Hybrid is viable, but the resulting adult is sterile.

(3) **Hybrid breakdown**: First generation (F1) hybrids are viable and fertile, but further hybrid generations (F2 and backcrosses) are inviable or sterile.

b) **Genetic Drift**: In each generation, some individuals may, just by chance, leave behind a few more descendents (and genes, of course!) than other individuals.

(1) The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals.

(2) Effects of genetic drift:

(a) Drift reduces genetic variation in populations, potentially reducing a population's ability to evolve in response to new selective pressures. Genetic drift acts faster and has more drastic results in smaller populations. This effect is particularly important in rare and endangered species.

(b) Genetic drift can contribute to speciation. For example, a small isolated population may diverge from the larger population through genetic drift.

i) Types of genetic drift:

(1) **Bottleneck effect**: occur when a population's size is reduced (by natural events or by human destruction) for at least one generation.

(2) Reduced genetic variation means that the population may not be able to adapt to new selection pressures, such as climatic change or a shift in available resources, because the genetic variation that selection would act on may have already drifted out of the population.

(a) Example: cheetahs have been over-hunted by humans. With conservation efforts, the cheetah population has rebound; however, the cheetah's gene pool is now very limited.

(b) If the cheetahs gene pool was once illustrated by all the letters of the alphabet; after the human hunting to near extinction, the cheetah's gene pool is now represented by maybe 5 letters of the alphabet

c) **Founders effect**: occurs when a new colony is started by a few members of the original population.

(1) This small population size means that the colony may have:

(a) reduced genetic variation from the original population.

(b) a non-random sample of the genes in the original population.

i) Example: the Afrikaner population of Dutch settlers in South

ii) Africa is descended mainly from a few colonists. Today, the Afrikaner population has an unusually high frequency of the gene that causes Huntington's disease, because those original Dutch colonists just happened to carry that gene with unusually high frequency.

II. Explain how genetic mutations may result in genotypic and phenotypic variations within a population.

A. Interpret evidence supporting the theory of evolution (i.e., fossil, anatomical, physiological, embryological, biochemical, and universal genetic code).

1. **Fossil**: show a pattern of development from early ancestors to modern descendants.

a) Most direct evidence that evolution takes place.

b) Provide an actual record of Earth's past life-forms.

c) Change over time can be seen in the fossil record.

2. **Anatomical**: comparisons of the different types of organisms often reveal basic similarities in body structures even though the structure's function may differ between organisms.

a) Different anatomical structures:

(1) **Vestigial structures**: structures present in organisms, but are reduced in size and either have no or little function than in other related species.

(a) Examples: Human appendix, whale hip bone

(2) **Homologous structures**: structures derived from a common ancestor or same evolutionary or developmental origin.

(a) Examples: The forearm of the crocodile, cat, bat and bird

(3) **Analogous Structures**: Structures of different species having similar or corresponding function but not from the same evolutionary origin.

(a) Examples: The wings of a bat and a butterfly.

b) **Embryological**:

(1) At some time in development, all vertebrates have a tail, buds that become limbs, and pharyngeal pouches.

c) **Biochemical**:

(1) With the increase of anatomical differences, protein and DNA differences also increase.

Keystone Review

Vocabulary:

Allele Frequency - The measure of the relative frequency of an allele at a genetic locus in a population; expressed as a proportion or percentage.

Analogous Structure - A physical structure, present in multiple species, that is similar in function but different in form and inheritance.

Extinction - A term that typically describes a species that no longer has any known living individuals.

Fossil - The preserved remains or traces of organisms that once lived on Earth.

Founder Effect - A decrease in genetic variation caused by the formation of a new population by a small number of individual from a larger population.

Genetic Drift - A change in the allele frequency of a population as a result of chance events rather than natural selection.

Gradualism - A proposed explanation in evolutionary biology stating that new species arise from the result of slight modifications (mutations and resulting phenotypic changes) over many generations.

Homologous Structure - A physical characteristic in different organisms that is similar because it was inherited from a common ancestor.

Hypothesis (Null hypothesis) - A proposed, scientifically testable explanation for an observed phenomenon.

Isolating Mechanisms - Features of behaviors, morphology, or genetics which serve to prevent mating or breeding between two different species.

> **Temporal isolation**, in which individuals are active at different times of the day, seasons, or mating periods.
>
> **Ecological isolation**, in which individuals only mate in their specific habitat.
>
> **Behavioral isolation**, when there are no sexual cues between representatives of the species.
>
> **Mechanical isolation,** when there is no sperm transfer during an attempted mating.
>
> **Gametic incompatibility**, when there is sperm transfer without fertilization occurring). If mating can take place, there are four factors that prevent hybrid viability:
>
> > **Zygotic mortality** (fertilization but no zygote)
> >
> > **Hybrid inviability** (embryo is not viable)
> >
> > **Hybrid sterility** (resulting adult is sterile)
> >
> > **Hybrid breakdown** (first generation is viable but future generations are not).

Keystone Review

Law - 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.

Mechanism - The combination of components and processes that serve a common function.

Migration - The permanent movement of genes into or out of a population resulting in a change in allele frequencies.

Natural Selection - A process in nature in which organisms possessing certain inherited traits are better able to survive and reproduce compared to others of their species.

Principle - A concept based on scientific laws and axioms (rules assumed to be present, true, and valid) where general agreement is present.

Punctuated Equilibrium - A proposed explanation in evolutionary biology stating that species are generally stable over long periods of time. Occasionally there are rapid changes that affect some species which can quickly result in a new species.

Selective Breeding - The process of breeding organisms that results on offspring with desired genetic traits.

Theory - 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

Vestigial Structure - A physical characteristic in organisms that appears to have lost its original function as a species has changed over time.

Ecology

I. Describe ecological levels of organization in the biosphere.

A. Describe the levels of ecological organization (i.e., organism, population, community, ecosystem, biome, and biosphere).

1. In order from smallest to greatest:

a) **Organism**: individual living creature.

b) **Population**: A group of organisms of one species that interbreed and live in the same place at the same time (e.g. muted swan population).

c) **Community**: An group of organisms or a population of different species occupying a particular area.

d) **Ecosystem**: A system that includes all living organisms (biotic factors) in an area as well as its physical environment (abiotic factors) functioning together as a unit.

e) **Biome**: A major ecological community of organisms adapted to a particular climatic or environmental condition on a large geographic area in which they occur. (Ex: Savanna, Tropical rainforest)

f) **Biosphere**: The part of the earth where living things exist.

B. Describe characteristic biotic and abiotic components of aquatic and terrestrial ecosystems.

1. **Biotic**: are the living things (such as plant, animal, fungus, etc.) in an ecosystem as well as their products (e.g. secretions, wastes, and remains)

2. **Abiotic**: is a nonliving (NEVER has lived) physical and chemical attribute of a system, for example light, temperature, wind patterns, rocks, soil, pH, pressure, etc. in an environment.

C. Describe interactions and relationships in an ecosystem.

1. Symbiosis: a long-term relationship between two different species.

a) Examples of symbiosis:

(1) **Competition**: A symbiotic relationship between or among living things for resources, such as food, space, shelter, mate, ecological status, etc.

(a) Ex: Two male lions fighting for a mate.

(2) **Mutualism:** in this type of symbiosis, both organisms of different species rely on one another for nutrients, protection and other life functions, hence, they are usually found living in close proximity.

(a) Ex: E. coli living in the intestines of humans help break down the fiber we eat, while they get food to survive.

(3) **Commensalism**: A form of symbiosis between two organisms of different species in which one of them benefits from the association whereas the other is largely unaffected or not significantly harmed or benefiting from the relationship.

(a) Ex: between the epiphyte orchids on branches of trees. These orchids benefit from the trees by the trees rendering support to the orchids. The orchids can gain more light and air in this way. The trees are neither drastically harmed nor benefiting from the orchids attached to their branches.

(4) **Parasitism**: A form of symbiosis in which one organism (called parasite) benefits at the expense of another organism usually of different species (called host). The association may also lead to the injury of the host.

(a) Ex: A tick on a dog.

(5) **Predation**: A form of symbiotic relationship between two organisms of unlike species in which one of them acts as predator that captures and feeds on the other organism that serves as the prey.

(a) Ex: An owl killing a mouse for food.

D. Describe how energy flows through an ecosystem (e.g., food chains, food webs, energy pyramids).

1. **Water cycle**:

a) Within this cycle, energy is supplied by the sun, which drives evaporation whether it is from the ocean surfaces or from treetops and leaves.

b) The sun, with the help of wind, also supplies the energy, which drives the weather systems, which moves the water vapors, in the form of clouds, from one place to another, or else it would only rain over oceans.

(1) Precipitation occurs when water condenses from a gaseous state in the atmosphere and then falls to earth.

(2) Gravity pulls the water underground (seepage) or groundwater across the surface of the terrain (also called runoff), either way gravity goes on to pull water lower and lower until it reaches the oceans.

(3) Water returns to the atmosphere by:

(a) Evaporation is the reverse process where liquid water becomes gaseous. Once water condenses, gravity takes over and the water is pulled to the ground.

(b) In plants, water is drawn in at the roots and moves to the gas exchange organs, the leaves, where it evaporates quickly. This special case is called transpiration.

(c) As the water vapor moves higher in altitude, the water cools and and forms clouds in a process known as condensation.

2. **Carbon Cycle**: the key events of this cycle are the complementary reactions of respiration and photosynthesis.

a) Respiration takes carbohydrates and oxygen and combines them to produce carbon dioxide, water, and energy.

b) Photosynthesis takes carbon dioxide and water and produces carbohydrates and oxygen.

(1) This might sound a little confusing but, the outputs of respiration are the inputs of photosynthesis, and the outputs of photosynthesis are the inputs of respiration. The reactions are also complementary in the way they deal with energy.

c) The chief reservoirs for carbon dioxide are in the oceans and in rock.

(1) Carbon dioxide dissolves readily in water (also known as erosion).

(2) Once there, it may precipitate (fall out of solution) as a solid rock known as calcium carbonate (limestone).

d) Animals acquire all their carbon in their food, and, because of this, all carbon in biological systems ultimately comes from plants (autotrophs).

e) Through combustion of organic material, which oxidizes the carbon, it contains, producing carbon dioxide (as well as other things, like smoke).

(1) Burning fossil fuels such as coal, petroleum products, and natural gas releases carbon that has been stored in the geosphere for millions of years.

3. **Nitrogen Cycle**:

a) Nitrogen is critically important in forming the amino portions of the amino acids, which in turn form the proteins of your body.

b) The principal reservoir of nitrogen is the atmosphere, which is about 78% nitrogen.

(1) Nitrogen gas in the atmosphere is composed of two nitrogen atoms bound to each other.

(a) It is a non-reactive gas meaning it takes a lot of energy to get nitrogen gas to break up and combine with other things, such as carbon or oxygen.

(b) Nitrogen gas can be taken from the atmosphere (fixed) in two basic ways:

i) Lightning provides enough energy to "burn" the nitrogen and fix it in the form of nitrate, which is a nitrogen with three oxygens attached.

ii) The other form of nitrogen fixation is by nitrogen fixing bacteria.

(1) They use special enzymes instead of the massive amount of energy found in lightning to fix nitrogen.

(2) Most plants can take up nitrate and convert it to amino acids.

(3) Animals acquire all of their amino acids when they eat plants (or other animals).

(4) When plants or animals die (or release waste), the nitrogen is returned to the soil.

(5) The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia.

(a) Ammonia is toxic, but fortunately, there are nitrite bacteria in the soil and in the water, which take up ammonia and convert it to nitrite.

(b) Nitrite is also somewhat toxic, but another type of bacteria, nitrate bacteria, will take nitrite and convert it to nitrate, which can be taken up by plants to continue the cycle.

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

1. Ecosystems undergo constant change

a) Ecological succession is constantly occurring in all ecosystems

b) Within any community some species may become less abundant over some time interval, or they may even vanish from the ecosystem altogether.

c) Within any community some species may become more abundant over some time interval, or even become the dominant species in that community

2. Secondary succession occurs when and ecosystem undergoes some type of major disruption

a) Occurs where no grass or other autotrophs are found

(1) Requires a pioneer species

(a) Grasses

(b) Shrubs

3. Primary succession occurs where no soil exists

    a) occurs where no soil is found

        (1) glacial movement

        (2) volcanoes

        (3) major erosion

F. Describe the effects of limiting factors on population dynamics and potential species extinction.

1. Populations grow at exponential rates in the presence of unlimited resources.

    a) Exponential populations grow continuously, with reproduction occurring at any time, such as among humans.

    b) All populations begin exponential growth in favorable environments and at low population densities.

        (1) Because of this, exponential growth may apply to populations establishing new environments, during transient, favorable conditions, and by populations with low initial population density.

    c) However, exponential growth cannot continue indefinitely.

        (1) In nature, population growth must eventually slow, and population size ceases to increase.

    d) As resources (ex: food, water, shelter) are depleted, population growth rate slows and eventually stops: This is known as logistic growth.

        (1) The population size at which growth stops is generally called the carrying capacity (K), which is the number of individuals of a particular population that the environment can support.

        (2) At carrying capacity, because population size is approximately constant, birthrates must equal death rates, and population growth is zero.

    e) No population can increase without limitation.

    f) Instead, populations in natural ecosystems increase or decrease in response to the changes in the factors that restrict growth.

    g) Many factors influence population densities and growth, and these factors may lead to oscillations in population size over time.

        (1) Factors that decrease population growth can be defined as environmental stress including limitations in food, predation, pollutants in the environment, and climate extremes, including seasonal cycles such as monsoons.

(2) In addition, catastrophic factors can also impact population growth, such as fires and hurricanes.

Vocabulary:

Abiotic - A term that describes a nonliving factor in an ecosystem.

Agriculture - The artificial cultivation of food, fiber, and other goods by the systematic growing and harvesting of various organisms.

Aquatic - A term that describes an organism associated with a water environment.

Bioconversion - The changing of organic matter into other chemical forms such as fuels.

Bioenergetics - The study of energy flow (energy transformations) into and within living systems.

Biogeochemical Cycles - The movement of abiotic factors between the living and nonliving components within ecosystems; also known as nutrient cycles (i.e.,water cycle, carbon cycle, oxygen cycle, and nitrogen cycle).

Biology - The scientific study of life

Biome - A large area or geographical region with distinct plant and animal groups adapted to that environment.

Biosphere - The zone of life on Earth; sum total of all ecosystems on Earth.

Biotic - A term that describes the living or once living organism in an ecosystem

Community - Different populations of organisms interacting in a shared environment.

Competition - When individuals or groups of organisms compete for similar resources such as territory, mates, water, and food in the same environment.

Consumer - An organism that obtains energy by feeding on other organisms or their remains.

Decomposer - An organism that obtains nutrients by consuming dead and decaying organic matter which allows nutrients to be accessible to other organisms.

Ecology - The study of the relationships between organisms and their interactions with the environment.

Ecosystem - A system composed of organisms and nonliving components of an environment.

Endemic Species - A species that is found in its originating location and is generally restricted to that geographic area.

Energy Pyramid - A model that illustrates the biomass productivity at multiple trophic levels in a given ecosystem.

Energy Transformation - A process in which energy changes from one form to another form while some of the energy is lost to the environment.

Keystone Review

Environment - The total surroundings of an organism or a group of organisms.

Food Chain - A simplified path illustrating the passing of potential chemical energy (food) from one organism to another organism.

Food Web - A complex arrangement of interrelated food chains illustrating the flow of energy between interdependent organisms.

Habitat - An area that provides an organism with its basic needs for survival.

Limiting Factor - Chemical or physical factor that limits the existence, growth, abundance, or distribution of an individual organism or a population.

Nonnative Species - A species normally living outside a distribution range that has been introduced through either deliberate or accidental human activity; also can be known as introduced, invasive, alien, non-indigenous, or exotic.

Population - A group of individuals of the same species living in a specific geographical area and reproducing.

Population Dynamics - The study of short and long term changes in the number of individuals for a given population, as affected by birth, death, immigration, and emigration.

Producer - An organism that uses a primary energy source to conduct photosynthesis or chemosynthesis.

Species - The lowest taxonomic level of biological classification consisting of organisms capable of reproduction that results in fertile offspring.

Succession - A series of predictable and orderly changes within an ecosystem over time.

Symbiotic Relationship - A relationship between two organisms (i.e., mutualism, in which both organisms benefit; parasitism, in which one organism benefits and the other organism is harmed; and commensalism, in which one organism benefits and the other organism does not benefit or is not harmed).

Terrestrial - A term that describes an organism associated with a land environment.

Trophic Level - The position of an organism in relation to the flow of energy and inorganic nutrients through an ecosystem (e.g., producer, consumer, and decomposer).