Keystone Biology Quick Review

Prefixes & Suffixes

Homo= same   Hetero= different   Cyto= cell   Karyote= nucleus   Eu= true

Pro= before   Mono= one   Poly= many   Saccharide= sugar   Hypo= below

Hyper= above   Iso= same   Photo= light   Chloro= green   Endo= in   Exo= out

Characteristics of Life

All living organisms (prokaryotes and eukaryotes) share the following characteristics:

1. Made up of cells   2. Reproduce   3. Energy use (metabolism)   4. Respond to Enviro

4. Grow & Develop   5. Use DNA   6. Change and evolve (species)

Prokaryotes vs. Eukaryotes

Prokaryotes	Characteristic	Eukaryote
Bacteria	**Example**	Animal, plant, fungi, protist
Simple- single celled	**Complexity**	Complex- single or multi-celled
Small	**Size**	Large
Absent	**Nucleus**	Present

Cell Features

Name		Function	Prokaryotes	Eukaryotes	
				Animals	Plants
Cell wall		Structure, support & protection	Yes	No	Yes
*Cell membrane		Controls entry into the cell- selectively permeable	Yes	Yes	Yes
*Cytoplasm		"Cell jelly"	Yes	Yes	Yes
O R G A N E L L E S	Vacuole	Water & food storage	No	Yes	Yes
	Lysosomes	Digests wastes	No	Yes	Yes
	Golgi Apparatus	Sorts, modifies & packages proteins	No	Yes	Yes
	Nucleus	Control center; contains DNA	No	Yes	Yes
	*Ribosomes	Protein synthesis	Yes	Yes	Yes
	Mitochondria	Energy production (cell respiration)	No	Yes	Yes
	Chloroplasts	Photosynthesis	No	No	Yes
	Rough ER	Transports proteins	No	Yes	Yes
	Smooth ER	Transports lipids	No	Yes	Yes

***Present in ALL cells**

Water

Water is a <u>polar molecule</u> has many unique features which help it support life:

-Cohesion   -Adhesion   -Capillary Action   -High Specific Heat- resists temp changes

-Solid is less dense than liquid (ice floats)   -Expands when frozen

Carbon

Carbon is the most important organic atom. Carbon can form many different molecules

Important Organic Molecules Classes

|	Carbohydrates	Lipids	Proteins	Nucleic Acids
Building Blocks (monomers)	Monosaccharides "one" "sugar"	Fatty Acids	Amino Acids	Nucleotides
Function(s)	-Short-term energy -Structures	-Long-term E storage -Insulation -Membrane structure	-Structures -Cell transport -Chemical Reactions	Stores genetic info
Examples	Monosaccharides: Glucose $C_6H_{12}O_6$ Polysaccharides: Starch, Glycogen & Cellulose	Saturated: Butter (solid at room temp) Unsaturated: Olive oil (liquid at room temp)	-Collagen -Transport proteins -Enzymes	DNA RNA

Molecular Structure Examples

Carbohydrate- Glucose
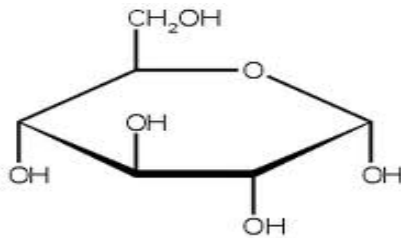
Lipid- Triglyceride
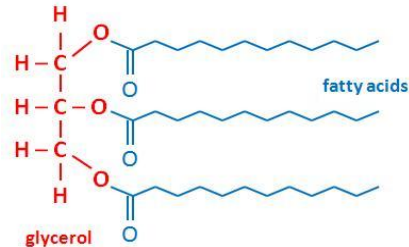

Nucleic Acid- Nucleotide
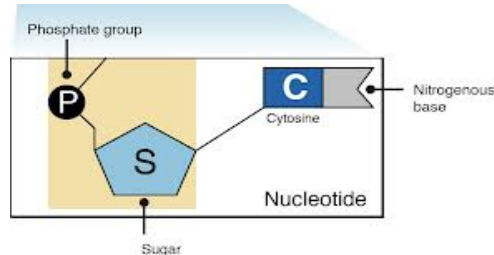
Enzymes

Enzymes – proteins which reduce the **activation energy** of reactions. **Substrate** and **enzyme** fit together like a *lock & key*. Enzyme activity affected by 3 factors:

       1. Concentration levels   2. pH   3. Temp
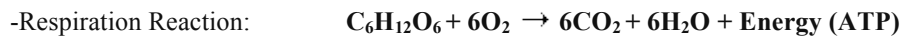
Photosynthesis and Cell Respiration

*The processes of **photosynthesis** and **cellular respiration** are interdependent. That is, each process is necessary to fuel the other. The chemical products of photosynthesis are the chemical reactants of cellular respiration, and the products of cellular respiration are the reactants of photosynthesis.*
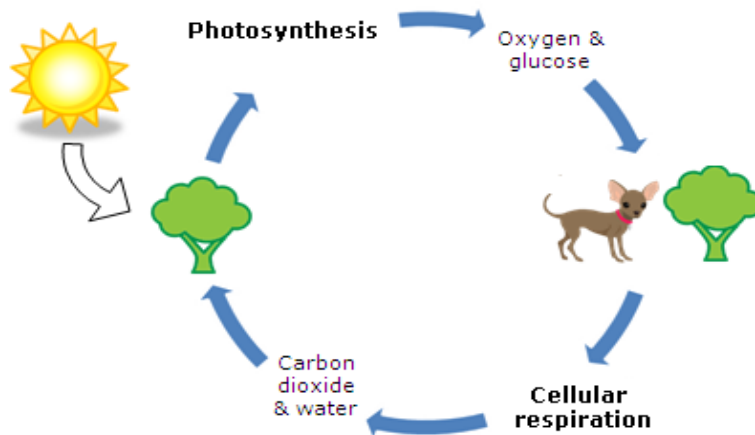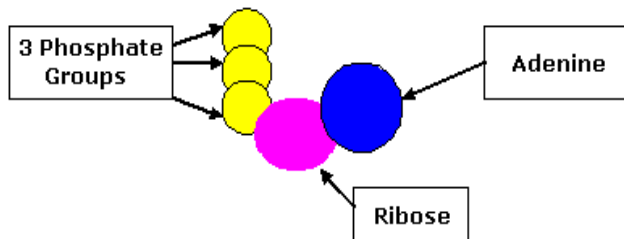

A) **Photosynthesis** – occurs in **chloroplasts:**
   -Photosynthesis Reaction: $6CO_2 + 6H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6O_2$

B) **Cellular Respiration-** occurs in **mitochondria**

   -Respiration Reaction: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (ATP)}$

ATP- Adenosine Triphospahte- energy molecule used for majority of cell activities


Cell Membrane aka Plasma membrane

Function– **Plasma membrane** is **selectively permeable** meaning that it allows some substances to cross the membrane more easily than others and blocks the passage of some substances altogether.

Structure- phospholipid bilayer- membranes are made of a double layer of phospholipids

Model- The Fluid Mosaic Model- membrane is composed of many parts which can move about freely
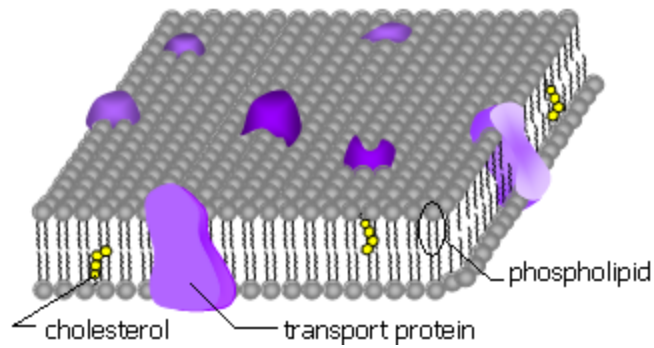
Cell Transport

Passive Transport-. **Does not require energy.** 3 types:

1. **Diffusion**- move from areas of high concentration to areas of low concentration

2. **Osmosis**- movement of water across a membrane.

3. **Facilitated Diffusion**- use transport proteins to carry large molecules (glucose) across membrane.

Note: Passive Transport always follows **concentration gradients**- areas of high concentration to low conc.

Active Transport- Requires energy 3 types:

1. **Pumps**- transport against concentration gradient. Ex: Sodium Potassium Pump (nerve signals)

2. **Exoocytosis**- movement out of a cell in a vesicle

3. **Endocytosis**- movement into a cell in a vesicle

ENDOCYTOSIS AND EXOCYTOSIS
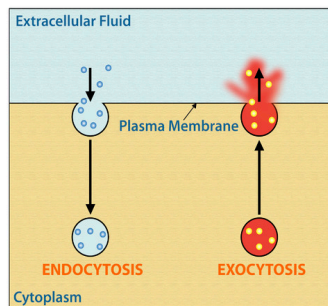
Homeostasis

Homeostasis is the regulation of metabolic processes to maintain the stable internal conditions required for survival. Every organism has mechanisms that allow it to respond to changing external conditions in order to maintain a stable internal temperature, pH, and ion concentrations.

In order to maintain homeostasis, positive and negative feedback mechanisms are both involved in organism responses to stimuli.

1. **Positive Feedback- increases or amplifies reaction**

   Ex: platelets at injuries. Initial platelets signal others **increase** platelet response forming a clot
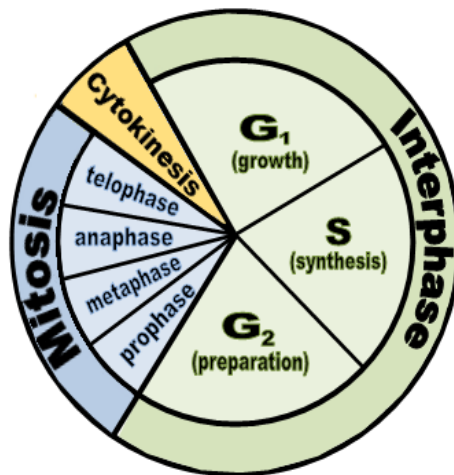
2. **Negative Feedback- decreases reaction**

   Ex: Blood sugar & insulin. If blood sugar is too high insulin is released to **reduce** blood sugar

Cell Cycle

*The **cell cycle** involves the growth, replication, and division of a eukaryotic cell.*

All cells come from pre-existing cells. Cell division is a key process involved in growth, repair, and reproduction of organisms.

Two phases of the cell cycle**:**
   1. **Interphase**- includes **G_1, S, G_2. S stage is when DNA replicates prior to division**
   2. **Mitosis**- includes **mitosis**- division of nucleus & **cytokinesis**- division of rest of cell

Mitosis

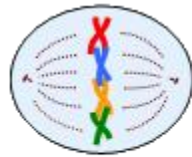**Mitosis-** cell division for growth. Produces 2 identical diploid (2n) daughter cells

Diploid- cells with two homologous sets of chromosomes. Human Diploid #= 46 chromosomes or 23 pair
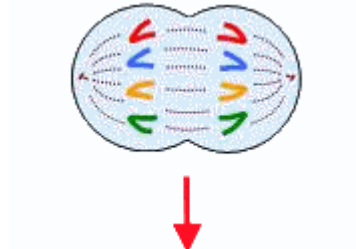
Stages of Mitosis

1. Prophase (chromatin) condenses into chromosomes

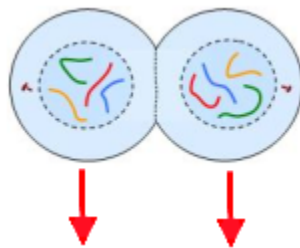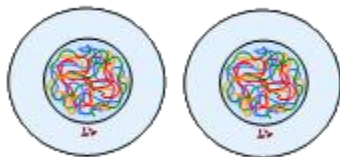*2. Metaphase*-chromosomes line up in the middle

3. Anaphase- chromosomes pulled apart

4. Telophase- chromosomes separated, nuclear membrane reforms

Cytokinesis- membrane and organelles separate. 2 identical Diploid (2n) cells result

Meiosis

Meiosis- cell division for sex. Produces 4 unique haploid daughter cells. Produces *gametes* (sperm & eggs)

Haploid- cells with one set or ½ normal chromosome number. Human Haploid #= 23 chromosomes

Stages of Mitosis
Meiosis I

Prophase I- Chromosomes condense. Homologous chromosomes pair. **<u>Crossing over</u>** occurs
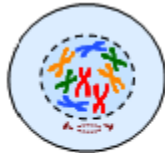
Metaphase I- chromosomes line up in the middle
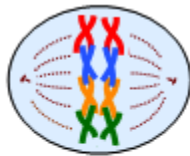
Anaphase I- chromosomes are pulled apart
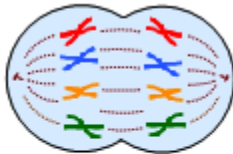
Telophase I- nuclear membrane forms around each set of chromosomes. 2 Haploid (n) cells result
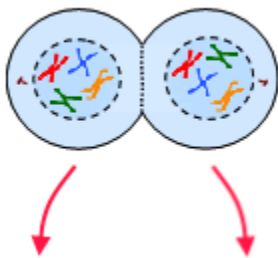
Prophase II - Chromosomes condense.
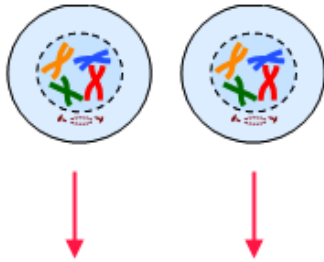
Metaphase II- Chromosomes line up in the middle

Anaphase II- chromosomes are pulled apart
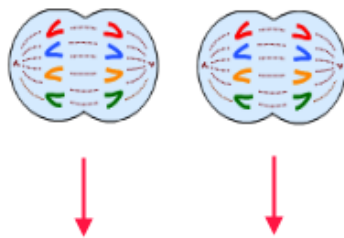
Telophase II- nuclear membranes form around each set of chromosomes
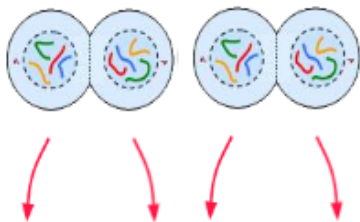
Cytokinesis- cytoplasm divides, cell membranes pinch in forming 4 haploid (n) cells

Genetic Diversity & Meiosis- meiosis leads to genetic diversity in 2 ways:

   1. **Crossing over-** occurs during *Prohase I*, Chromosomes pair up and exchange parts of their DNA
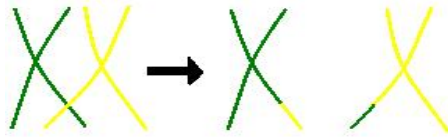
   2. **Random allele sortment-** each offspring receives different combos of alleles

Mitosis vs Meiosis
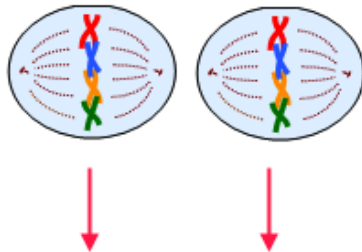
	Mitosis	Meiosis
Which cells?	Body (somatic) cells	Sex cells (sperm & eggs)
# & type of cells produced	2 Diploid cells (2n)	4 Haploid cells (n)
Genetic Variation	None- Identical to parent	Unique due to *crossing over*
Used for	Growth, replication and repair	Produces *gametes* (sperm & eggs)

DNA

DNA replication is the molecular mechanism of inheritance. Occurs during the **S Stage of Interphase**

Structure- polymer made up of nucleotides. Forms a 2 stranded *double helix*.
   Complementary Base Pairing – **A** : **T**   **G** :<u>**C**</u>
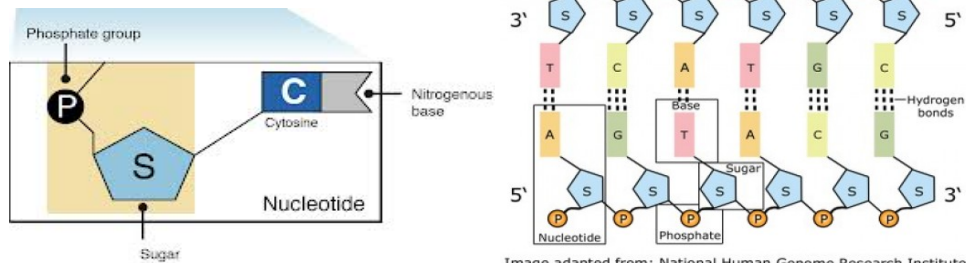
Image adapted from: National Human Genome Research Institute.

DNA Replication

DNA replication begins when enzymes unwind and separate the two strands of the molecule. Each strand serves as a template for polymerases to add complementary nucleotides (A-T and C-G). The process results in two identical DNA molecules.

DNA Replication is said to be *semi-conservative*. Each copy contains one newly-replicated strand and one strand from the original molecule.

Genes

Genes- portions of DNA responsible for observed traits. Each gene has a specific location of chromosome.

Alleles- one form of a gene. Ex: R= red flower; r= white flower

Homozygotc individual – two identical alleles. Ex. –RR, rr

Heterozygotc individual – two different alleles for a gene. Ex - Rr

Genotype is the type of alleles is has. Ex: Rr

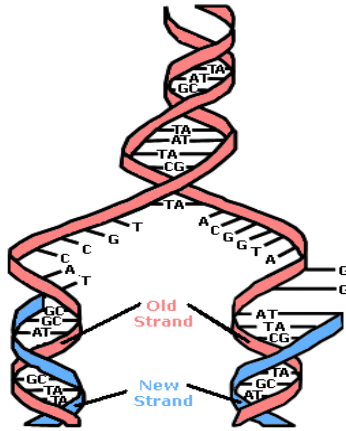**Phenotype** is the physical expression of its genes. Ex: Red

Law of Segregation each allele pair separates during gamete formation. Each parent contributes one allele

Genetics

Genetics – the scientific study of heredity

Patterns of Inheritance
- *Dominant vs. Recessive*– one allele dominant over another. Dominant trait shown when one dominant allele is present. Recessive is only expressed when both alleles are recessive.
  - Ex. - Free earlobes (F) dominant to attached earlobes (f). FF, Ff= free; ff=attached

- *Co-dominance* – Both alleles are fully expressed. May be dominant over another.
  - Ex. – Blood types- A & B allele are codominant. This produces the AB blood group.

- *Incomplete dominance* – Both alleles partially expressed; resulting phenotype is a mix.
  - Ex. – A red snapdragon (R) crossed with a white (W) produces pink (RW) offspring.

- *Sex-linked* – Genes for traits located on X chromosome, no allele on Y chromosome.
  - Ex. – color blindness, hemophilia

- *Polygenic* – multiple genes involved in a trait; allows for more variation in phenotypes.
  - Ex. – skin color, height

- *Multiple alleles* – more than two alleles exist in a pop. Increases # of genotypes and phenotypes
  - Ex. – 3 blood type alleles – I^A, I^B and i. Produces 4 blood types A, B, AB and O.

Protein Synthesis

*The genetic information that is passed from a parent to its offspring is found in **DNA** molecules. Segments of DNA known as **genes** code for the production of **proteins**. These proteins cause specific **traits** to be expressed.*

Central Dogma

DNA —Transcription→ RNA —Translation→ Protein
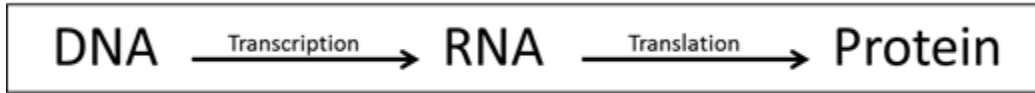
2 main steps:
- **Transcription-** DNA in the nucleus of a cell is copied into messenger RNA, or mRNA
- **Translation-** mRNA moves into cytoplasm and attaches to a ribosome, where it is **translated** into proteins

DNA	RNA
Double-stranded	Single-stranded
Deoxyribose sugar in nucleotides	Ribose sugar in nucleotides
Bases = G, C, A, T	Bases = G, C, A, U (uracil instead of thymine)
One type of DNA per organism	Three types of RNA (mRNA, tRNA, rRNA)

Protein Synthesis Overview
1. **Transcription- DNA→mRNA**
   - Occurs in nucleus

   - mRNA is transcribed from a DNA template using base pairing rules.
        Note: in RNA Uracil (U) replaces Thymine (T).

   - mRNA leaves nucleus and enters the cytoplasm.

2. **Translation- mRNA→Proteins**

   - Occurs at the ribosomes in the cytoplasm

   - mRNA, tRNA, and rRNA come together.

   - 3 Base Pair = **codon**. Each **codon** codes for one amino acid

   - The *Start codon AUG* starts translation.

   - Codons matched with correct amino acid using "middle man" Transfer RNA (tRNA). tRNA has 3-base pair *anticodon* and a specific amino acid to build protein

   - Translation continues until a *Stop Codon* (UAA, UAG, or UGA) is reached

What happens to the proteins?
- Proteins that remain in the cytoplasm are translated by ribosomes in the cytoplasm.

- Proteins destined for ER, Golgi apparatus, plasma membrane or that will be secreted by the cell are synthesized by ribosomes on the rough ER.

Mutations

The sequence of nucleotides in a gene determines the sequences of amino acids in the resulting protein. A protein's function depends on its sequence of amino acids. If that sequence changes, then it can change or harm the protein's function. A *mutation* can change the DNA sequence and, therefore, impact the resulting protein. Mutations can be beneficial or harmful.

Chromosomal Mutation: Processes that can alter composition or number of chromosomes:

- **Crossing-over**- occurs during *Prophase I* of meiosis. Homologous chromosomes pair up. and exchange equivalent pieces of DNA.

- **Non-disjunction-** chromosomes or sister chromatids fail to separate during meiosis. Can occur in Anaphase I or II. Results in *Trisomy or monosomy*. Ex: Down's syndrome= Trisomy 21

- **Addition-** produces extra copies of parts of a chromosome

- **Translocation** - occurs when part of one chromosome breaks off and attaches to another

- **Deletion-** Mutation that involves the loss of all or part of a chromosome

- **Inversion-** Part of a chromosome is removed and reinserted backwards

Gene Mutations- impacts portions of DNA. Can impact resulting proteins

- *Point Mutations*
    - <u>Insertion</u> – a nucleotide is added
    - <u>Deletion</u> – a nucleotide is deleted
    - <u>Substitution</u> – one nucleotide is substituted for another

Point Mutations can result in:
- **Silent Mutation-** does not impact the final protein for 2 reasons:
    - occurs in a noncoding region and does not affect the protein
    - nucleotide substitution changes the codon to another that codes for the same amino acid.

- **Missense Mutation-** nucleotide substitution that results in a different amino acid.

- **Non-sense Mutation-** substitution causes premature stop codon. Protein is shorter, usually not functional.

<u>Frameshift Mutations</u> –insertion / deletion of nucleotide(s) causing the codon "reading frame" to shift. All codons after the insertion or deletion will read incorrectly.

Note: Does not occur when multiples of 3 nucleotides are inserted or deleted. "Reading frame" not shifted.

Mutations can create new alleles and introduce *genetic variation* in a population.

Genetic Engineering

Genetic engineering – manipulating the genetic code (DNA) to produce desirable traits. Several types:

- *Selective breeding*- breed organisms to amplify desired traits
  Ex: Hunting dog bred for scent tracking

- *Gene splicing (recombinant DNA)*- combines DNA from different sources. Results in *transgenic organisms (bacteria, animals or plants)*
  Ex: Transgenic plants that contain genes which provide protection from pests

- *Cloning*- produces genetically identical organisms

- *Gene therapy*- absent or faulty gene replaced w/ working gene

Evolution

Evolution – change in a population of a species over time. The changes are the result of changes in the gene pool of a population of organisms.

Mechanisms of Evolution
- *Nonrandom mating/Sexual Selection* – organisms selecting mate based on desired traits

- *Immigration or emigration (gene flow)* – individuals enter population and introduce new genes

- *Mutations* - produce new alleles that result in a new phenotype. May provide an advantage

- *Genetic drift* – changes caused by random events in a small population
  - *Bottleneck* – drastic reduction in a population. Some alleles may be eliminated
  - *Founder effect*- individuals enter a new habitat. Gene pool based on founders'

- *Natural selection* – unequal survival and reproduction of those individuals best suited to their environment based on inherited traits i.e. the most fit will reproduce more and those traits will be "selected" and increase in following generations.

Speciation

Speciation – creation of a new species, occurs when organisms becomes reproductively isolated
Types of speciation
- *Allopatric speciation* – Two populations of a species are separated geographically or by a physical barrier.

- *Sympatric speciation* – A species evolves into a new species without a physical barrier.

- *Isolating mechanisms (reproductive isolation)* – features, behaviors, or genetics which prevent mating or breeding between two organisms

Evidence of Evolution

- *Fossil record* – compare different aged fossils to show how life has changed
- *Anatomical evidence*
  - **Homologous structures** – anatomically similar structures from a common ancestor
    Ex.: forelimbs of mammals

    Mammalian Forelimbs

    cat whale bat
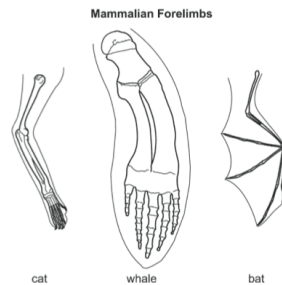
  - **Analogous structures** - structures that are used for the same purpose, but are NOT inherited from a common ancestor.
    Ex: the wing of an eagle and the wing of a fly

  - **Vestigial structures** – structures that are the reduced forms of functional structures in other organisms
    Ex.: Tailbone in humans.

- *Embryological evidence* – Vertebrate embryos display homologous structures during certain phases of development. Suggests common ancestry
  .
- *Biochemical evidence* – organisms use same complex metabolic molecules

- *Universal genetic code (DNA)* – all organisms use DNA, the more similar the DNA code, the more closely related the species.

Ecology

Ecology – the study of relationships among living organisms and the interaction the organisms have with their environment

Levels of Ecological Organization

Organism → Population → Community → Ecosystem → Biome → Biosphere

- Population – individuals of a single species living in the same area at the same time
- Community –groups of populations that occupy the same geographic area at the same time
- Ecosystem – a biological community and all the abiotic factors
- Biome – group of ecosystems that share the same climate and have similar types of communities
- Biosphere – all of the biomes on Earth

Biotic factors – the living factors in an organism's environment   Ex: Fish, worm

Abiotic factors – the non-living factors in an organism's environment   Ex: Sand, saltwater

Autotroph – aka "*Producers*"- organisms that produce their own food (e.g., plants).
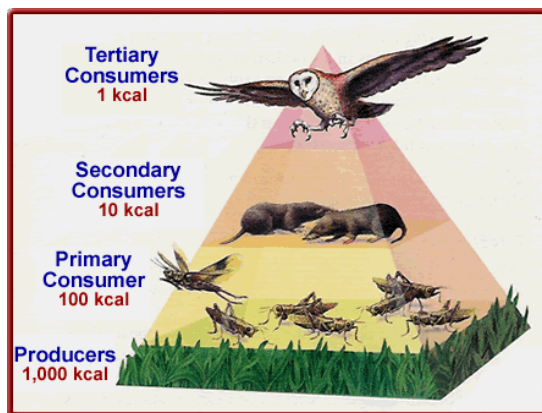
Heterotrophs- aka "*Consumers*"- organisms that obtain energy by consuming other organisms
        Types:
- *Herbivore* – "plant eater"- eats plants only. First consumer in food chains / webs
- *Carnivore* – "flesh eater"- eats other animals
- *Omnivore*- "all eater"- eats both plants & animals
- *Detritivore* –"dead eater"- consumes dead organic materials

Models of Energy Flow
- *Trophic level* – each step in a food chain or food web.

- *Energy pyramids* – model that shows the relative amounts of energy, biomass, or numbers of organisms at each trophic level in an ecosystem. 90% of energy is lost between each trophic level.

Tertiary
Consumers
1 kcal

Secondary
Consumers
10 kcal

Primary
Consumer
100 kcal

Producers
1,000 kcal

- *Food chain* – simple model that shows how energy flows through an ecosystem

- *Food webs* – model representing the many interconnected food chains and pathways in which energy flows through a group of organisms

Biotic Interactions in an Ecosystem
- *Competition* – organisms competing for the same resource

- *Predation* – one organism (predator) feeds on another (prey)

- *Symbiosis* – close relationship between two or more species

    o **Mutualism**– relationship which both organisms benefit
            Ex: Cleaner shrimp & fish- shrimp gets fed; fish get parasites removed

    o **Commensalism** –one organism benefits the other organism is neither helped nor harmed
            Ex.: Remora fish & shark- remora eats scraps, shark no impact

    o ***Parasitism*** –one organism benefits and the other organism is harmed
            Ex.: ticks on humans

Biogeochemical Cycles

Biogeochemical cycle – the exchange of matter through the biosphere.

Water Cycle

Transpiration -- the movement through plants

Condensation -- the clouds form

Precipitation -- the rain falls

Evaporation -- the vapor rises

Carbon Cycle

Carbon dioxide in the atmosphere

Carbon is released into the atmosphere when fossil fuels are burned

Carbon is released into the atmosphere during respiration

used in photosynthesis to produce carbohydrates

plants are eaten by animals

Carbon Dioxide in decaying matter and waste

decaying plants produce

Carbon Dioxide in fossil fuels (coal & oil)

<u>Oxygen Cycle</u>

<u>Nitrogen Cycle</u>

Atmospheric Nitrogen (N$_2$)

Plants

Assimilation

Denitrifying Bacteria

Nitrogen-fixing bacteria living in legume root nodules

Decomposers (aerobic and anaerobic bacteria and fungi)

Nitrates (NO$_3^-$)

Nitrifying bacteria

Ammonification

Nitrification

Ammonium (NH$_4^+$)

Nitrites (NO$_2^-$)

Nitrogen-fixing soil bacteria

Nitrifying bacteria
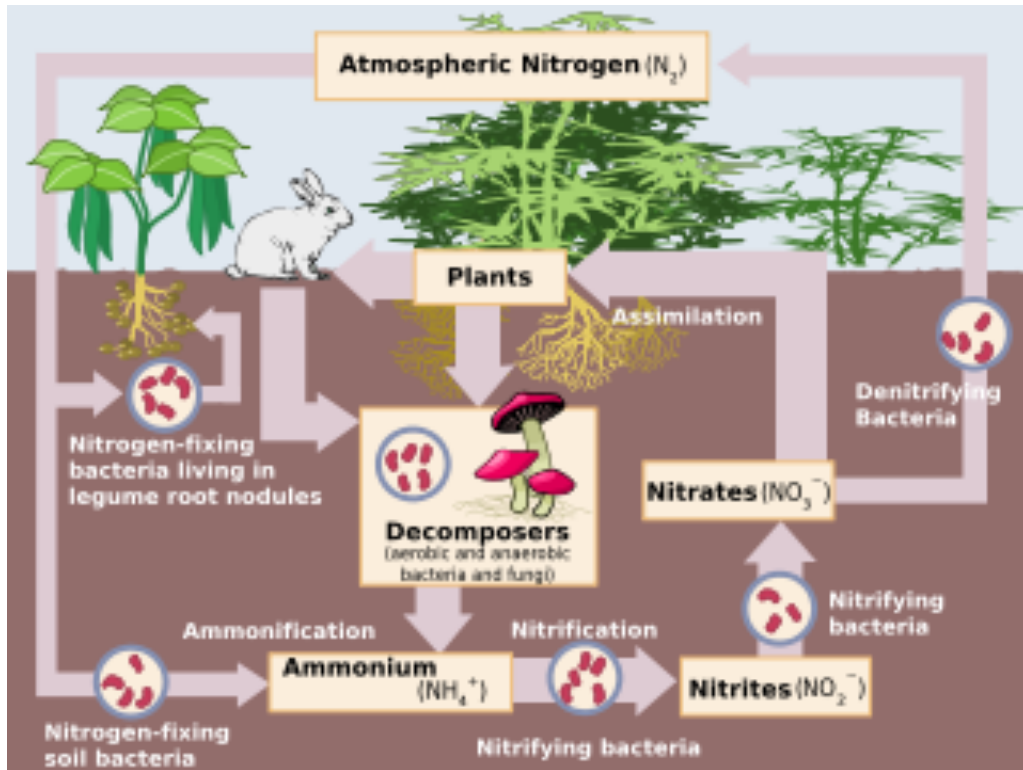
Environmental Disturbances

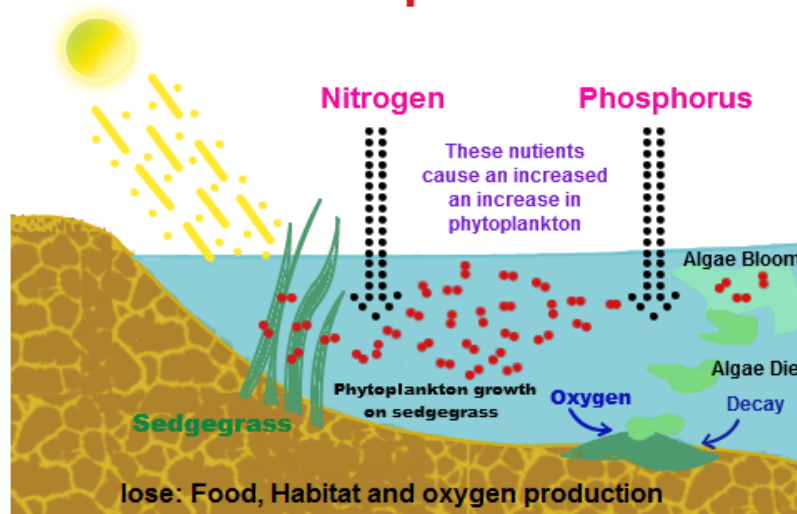**Environmental Disturbances-** disturbances that destroy biodiversity in ecosystems.

Examples of disturbances include:
- Overexploitation- excessive use of species   Ex.: overfishing

- Habitat loss- native species must relocate or they could die   Ex.: Deforestation

- Fragmentation of habitat- separation of an ecosystem into small pieces of land. Ex: Road in forest

- Pollution- changes the composition of air, soil, and water, which can harm species. Results in:

    o *Biomagnification* – toxins increase as they make their way through each trophic level

    o *Acid precipitation* – caused by burning fossil fuels. Acidifies lakes

    o *Eutrophication* – occurs when substances rich in nitrogen and phosphorus such as fertilizers flow into waterways causing algal blooms. Decomposition of dead algae uses O$_2$ causing other species to die.

- Nonnative species- species either intentionally or unintentionally transported to a new habitat. Introduced species may outcompete native species or lack predators

- Climate Change - Evidence shows that the average temperature of the biosphere is increasing (*global warming*). Long-term changes in climate will affect ecosystems.

Eutrophication

Nitrogen   **Phosphorus**

These nutients cause an increased an increase in phytoplankton

Algae Bloom

Algae Die

Decay

Sedgegrass   Phytoplankton growth on sedgegrass   Oxygen

lose: Food, Habitat and oxygen production

Scientific Investigations

Scientific investigations are organized attempts to seek out, describe, explain, and predict natural phenomena.

- <u>Hypothesis</u>- proposed, scientifically testable explanation for an observed phenomenon.
- <u>Inference</u>- an assumption based on prior experience.
- <u>Law</u>- generalizes a body of observations. At the time it is made, no exceptions have been found to the law. Serves as the basis for scientific principles
- <u>Theory</u>- explanation of natural phenomenon based on many observations and investigations over time.
- <u>Principle</u>- concept based on scientific laws and axioms (rules assumed to be present, true, and valid) where general agreement is present.
- <u>Fact</u>- indisputable observations
- <u>Experiment</u>- a direct method of gathering information in an orderly way

<u>**Scientific method**</u>- systematic method for testing a hypothesis

1. **Form Hypothesis-** possible explanation for a set of observations. Must be testable
2. **Test Hypothesis-** scientists use experiments to test a hypothesis
   - **Controlled Experiments-** experiment where only one **variable** is changed at a time
   - **Variables-** any factor that can change in an experiment

       i.   **Independent Variable:** factor which is changed by experimenter

       ii.   **Dependent Variable:** factor that changes in response to the independent variable

       iii.   **Control-** used as comparison factors to test magnitude of results

3. **Data Collection**
4. **Interpret Data**
5. **Draw Conclusion**- accept or reject hypothesis

Test Taking Tips:

1. Read the question carefully:
   a. What info do they want?
   b. What info (if any) is unnecessary?

2. Eliminate the most obvious wrong answers first

3. Don't spend too much time on any one question. Skip and go back.
   Tip: If you've answered a Q but aren't sure, circle the number on your answer sheet as a reminder to go back if there's enough time.

4. Go with your gut. Your first choice is often your best.

5. When in doubt, eliminate the wrong and take a guess. Don't leave blanks.