Ecology, Biochemistry, Cell Structure, and Enzymes

~Biology AP~

A Meridian[®] Biology AP Study Guide by Tim Qi, John Ho, Lei Gong, Raymond Tan, Dennis Shung,

❖ Ecology

➢ Population

Definitions:

Population Density		# of individuals per unit (volume/area)
Population Dispersion		Pattern of spacing among individuals
	Clumped	Individuals aggregated in patches
	Uniform	Individuals are evenly spaced
	Random	Position of each individual is independent from others
Carrying Capacity		Maximum number of individuals an environment can maintain

How do you count a population?

Method	Description
Count All Individuals	Effective for small individuals. Most accurate.
Average Density	Estimation based on population density. Less accurate.
Mark Capture Method	(Number tagged 1st time(*)/Number captured with tags 2nd time)*Number Captured

(*)-Number tagged=number captured

Survivor Ship Curve-tracks numbers of a population alive at each age

Curve	Description
Type I	Low death rates early on in life
Type II	Death rate constant throughout
Type III	High death rates early on in life

Population growth is either:

Exponential (r)	Very rapid, Rate of growth constantly increases
	Assumes unlimited resources (ideal conditions)
Logarithmic (K)	Population will increase until it hits carrying capacity
	Is more accurate because it puts a limit on resources

Reproductive Strategies

Strategy Type	Description
r Strategist	Makes lots of babies but have low life expectancy, reproduces quickly, little or no parental care, very small at birth
	Generally follows Type III curve
K Strategist	Prolonged development, few babies with longer lifespan, extensive parental care, larger at birth
	Generally follows Type I curve

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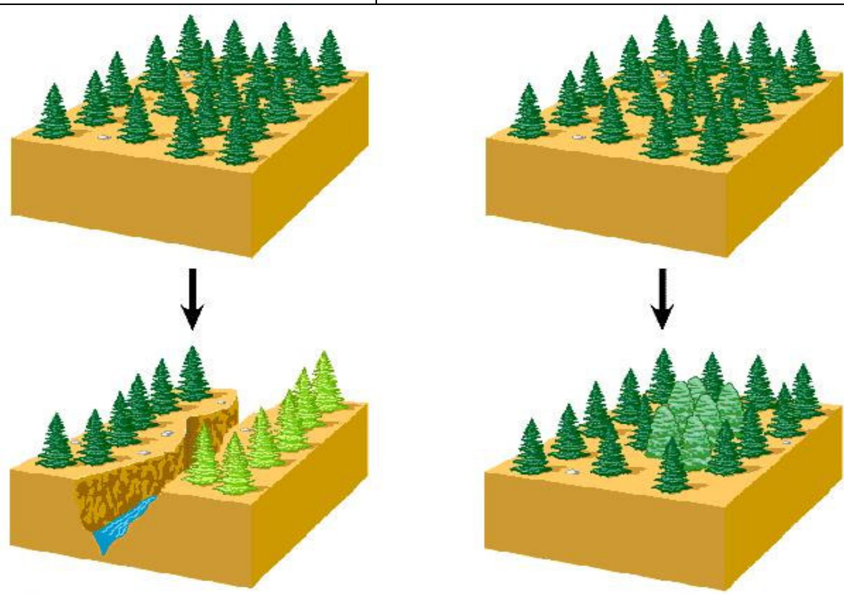
Population Fluctuation - Populations fluctuate based on interactions between/amongst different organisms. One type of fluctuation is a predator-prey interaction

In a predator-prey interaction the population change of the predator lags behind the prey.

- ## Community Ecology:

Relationships		
Interaction	**Type**	**Description**
Predation	+/-	Predator consumes a prey for nutrition.
Herbivory	+/-	Herbivore consumes *part* of a plant for nutrition.
Parasitism	+/-	A parasite derives its nutrients directly from the host.
Mutualism	+/+	Both organisms benefit from the interaction.
Commensalism	+/o	One species benefits while the other is not directly affected.

Character Displacement	
Allopatric Speciation:	Speciation through geographical separation of two populations.
Sympatric Speciation:	Speciation through habits and behavior rather than isolation from a similar population.



(a) Allopatric speciation (b) Sympatric speciation

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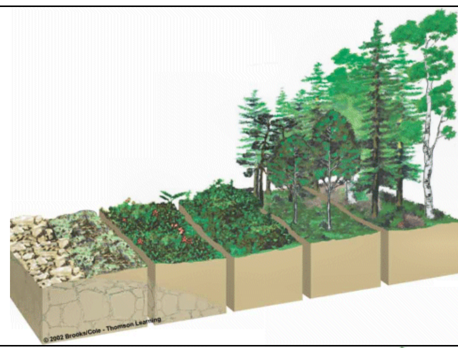
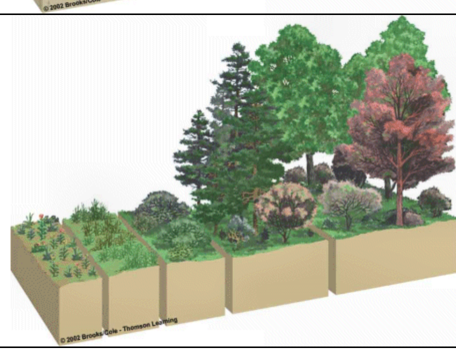
Predator-Prey Interactions		
Interaction	**Type**	**Description**
Cryptic Coloration	Camouflage	Prey avoids predators by blending in environment.
Aposematic Coloration	Warning	Prey avoids predators by displaying warning signals, usually conspicuous colors. Includes *Batesian* and *Muellerian* types.
Batesian Mimicry	Warning (harmless)	A species adapts the coloring and appearance of a known harmful species in order to avoid predators.
Muellerian Mimicry	Warning (harmful)	Two species with similar defenses mimic each other for mutual benefit. • Example: Honeybee and wasp both sting. They mimic each other in coloring so that if a predator is stung once, it will avoid *both* species.

Ecological Succession		
Primary Succession *(no soil)*		Process of species growing in a lifeless area where soil is not intact (e.g. after a volcanic eruption).
Secondary Succession *(soil intact)*		Process of species growing in an area where all previous life is cleared but soil is still intact (e.g. forest fire)
Intermediate Disturbance Hypothesis	Asserts that *a minor disturbance in an area can actually increase the diversity of the habitat*, as opposed to the belief that diversity is greatest in an undisturbed environment.	

Ecosystem: Includes all organisms living in a community and the abiotic factors that affect/are affected by those organisms.

Thermodynamic Laws:
1. Energy cannot be created or destroyed, only transformed.
2. Energy conversions cannot be 100% efficient. No matter what happens, there will always be some energy lost as heat.

Primary Producer: [a.k.a. autotroph] mostly made up of all organisms that derive energy from photosynthesis. This trophic level supports all the other levels. [Like a food pyramid, these little guys are at the bottom, supporting everything]

Heterotrophs: Any organism in a higher trophic level than primary producers. These organisms depend on the photosynthetic output of primary producers.

Primary Consumers: Herbivores or omnivores [only when they eat plant material or primary producers]

Secondary Consumers: Carnivores that eat herbivores; anything that eats a primary consumer.

Detritivore: [a.k.a. decomposers] consumers that get their energy from nonliving organic matter [also known as **detritus**] such as dead animals, feces, fallen leaves, and wood. They are crucial to an ecosystem because they replenish the nutrients in soil that primary producers require to survive. Decomposition carried out by these organisms includes that of organic materials from all trophic levels to inorganic compounds that are useable by primary producers.

Primary Production: Total amount of light energy converted to chemical energy by autotrophs during a given amount of time. The amount produced here controls how large the ecosystem will be, due to the fact that all the energy you can gain is set by how much is produced here. Every day we get 10^{22} joules of solar radiation. Most of it is absorbed, scattered, or reflected. A lot of it also strikes places where there are no autotrophs, and is thus wasted. Only about 1% of the rays are converted into chemical energy.

Gross Primary Production: Total amount of light energy that is converted into chemical energy by photosynthesis per unit of time. Not all of it is converted into biomass; some of it is lost through cellular respiration.

Net Primary Production: Equal to the GPP minus the energy used for cellular respiration. This representsthe storage of chemical energy available to the ecosystem. This can be expressed as energy per unit area per unit time (joules/meter^2/year or as biomass [in terms of dry weight, because water doesn't give energy of any sort, and the amount in a plant varies constantly] of vegetation added to the ecosystem per unit area per unit time (grams/meter^2/year).
This refers to the amount of *new* biomass added in a given period of time.

Standing Crop: <u>DIFFERENT</u> from NPP. This represents the *total* biomass of photosynthetic autotrophs present at a given time.

<u>**Ecosystem Limitations**</u>
Light: More than 50% of light is absorbed in the first meter of water.
Nutrient:
-Limiting Nutrient = element that must be added in order for production to increase in a particular area. Most often it is Nitrogen or Phosphorous

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Eutrophication: A process by which nutrients, particularly phosphorous and nitrogen, become highly concentrated in a body of water, leading to increased growth of organisms such as algae.

Actual Evapotranspiration: amount of water transpired by plants and evaporated from a landscape every year. Usually measured in millimeters. Increases with the amount of precipitation in a region and the amount of solar energy available to drive evaporation and transpiration.

Secondary Production: Amount of chemical energy absorbed from a consumer's food that is turned into their own new biomass.
Production Efficiency: (net energy stored as biomass represented by growth and reproduction)

divided by (total energy taken in and used for growth)
this is the fraction of energy not used for respiration.

Trophic Efficiency: 10% rule, only 10% of energy actually transfers from lower to higher tropic levels.

Green World Hypothesis

- Herbivores consume relatively little biomass due to a variety of factors.
- Plants have defenses against herbivores such as spines and noxious chemicals
- There are not enough Nutrients to sustain many plants, limiting how much energy herbivores can attain.
- Abiotic factors such as unfavorable weather.
- Intraspecific competition such as territoriality and competition.
- Interspecific interactions such as predators, parasites, and diseases keep the populations lower than what they could be.

Nitrogen Cycle (add picture and crap)

- Nutrient cycle rates are heavily dependent upon decomposers.
- Humans often wreck nutrient cycles by removing excess amounts of nutrients from on area, and introducing large amounts in other areas.
- Nitrogen is the main nutrient lost through agriculture. Industrialized synthesized fertilizer is used to make up for the loss of nitrogen.

Critical Load: The amount of added nutrient [usually Nitrogen/Phosphorous] that can be absorbed by plants without damaging the ecosystem. If you exceed this, it eventually runs into the groundwater, and gets into freshwater and marine ecosystems where it is toxic to both wildlife and humans.

Biological Magnification (clarify this): When toxins become extra concentrated at higher trophic levels. Ex: mercury.

Depletion of the ozone (O_3) is due to free chlorine in the air. The chlorine take one O atom, and the O_3 becomes O_2 (Oxygen). Then two ClO molecules bind, and separate into two O_2 molecules and two Cl atoms, and the process keeps repeating itself.

- **Biomes:**
  1. **Tropical Forest:** Constant rainfall, high species diversity
  2. **Desert:** Low precipitation, varying temperatures
  3. **Savanna:** Dry climate, warm all year-round
  4. **Chaparral:** Seasonal climate, shrubs and trees (e.g. Mediterranean)
  5. **Temperate Grasslands:** Includes parries and veldts, seasonal and mostly grass
  6. **Coniferous Forest:** Largest biome, long winters and hot summers, consists mostly of cone-bearing trees
  7. **Temperate Broadleaf Forest:** Consists of a canopy and shrub layer, animals usually hibernate during the winter
  8. **Tundra:** Cold year-round, contains a permafrost

❖ Chemistry & Biomolecules

- **Bonds and Interactions:** Determined by electronegativity

Nonpolar Covalent	Electrons equally shared
Polar Covalent	Electrons found more on one side than the other
Ionic	Elections found only on one side
Hydrogen Bonds	Bonds formed with hydrogen atoms, where the H is

	attached to a highly electronegative atom, rendering its charge positive, and then attracting a lone electron pair. Common among water molecules.
Van Der Waals	Temporary bonds where polar molecules attract briefly an opposite charged molecule.

- **Molecular Diagrams:** 6 C, 10 H -------> 

  Carbons are located at each junction. Each carbon has 4 bonds; bonds not shown are hydrogen molecules.
- **Activation Energy:** Initial energy required for and reaction to start.
  - **Endergonic:** Endothermic, absorbs heat as product of reaction.
  - **Exergonic:** Exothermic, release heat as product of reaction.
- **pH Scale:** Concentration of hydrogen ions from a scale of 1-14; 1 being the most acidic and 14 being the most basic.
- **Properties of Water:** High specific heat, Solid form is less dense than liquid, versatile solvent; evaporate cooling (high heat of vaporization).
- **Biomolecules:** Organic molecules part of a living organism
- **Condensation and Hydrolysis reactions:**

Condensation	Also called dehydration synthesis, losing a water molecule to form a covalent bond between polymers.
Hydrolysis	Adding a water molecule between polymers to break a covalent bond.

- **Basics of the Water Molecule:**
  - It is shaped like the letter V, with the base as oxygen and the two ends as each Hydrogen atom. They are joined together by a polar covalent bond.
  - It is a polar molecule, meaning that the ends of the molecule have opposite charges.
  - The two polarized sides allows for hydrogen bonding with other water molecules.

- **Properties of Water**

Cohesion	Because hydrogen bonding is constantly forming, a force holds the water molecules tightly and it is known as cohesion.
Adhesion	The clinging of individual substance to another. Water on walls is a fine example of adhesion.
Surface tension	Measurement of the difficulty to break up the cohesion in liquids.
High Specific Heat	Water has a high specific heat. It is defined as amount of heat energy required to change 1 gram of a substance by 1° Celsius.
High Evaporative Cooling	It is defined as how much energy that is required to change 1g of water or any liquid substance into gas.

- Solid Water (ice) is less dense that liquid water. This property enables it to float which then creates a layer of a surface of water, protecting organism under the layer.

➢ Biomolecules

Type	Properties	Functions
Carbohydrate	1:2:1 C:O:H ratio	Energy, Cell to Cell Recognition
Lipids	Mostly Hydrocarbons, nonpolar/hydrophobic, Filled with C-C, C-H bonds	Energy storage (more compact due to hydrophobic nature), insulation, structural, protection, communication, pigments
Proteins	Has Amino, carboxyl, and R	Enzymes, structural, hormones, immune

	group as well as Hydrogen	functions, energy storage, transport, muscle contraction
Nucleic Acids	Has a nitrogenous base, 5 carbon sugar, and a phosphate group	Store genetic information, part of ribosome, energy carriers

- **Carbohydrates:**

Disaccharides-two monosaccharides linked together by a glycosidic linkage (dehydration reaction). Three disaccharides are:

Fructose + Glucose→Sucrose + H_2O
Fructose + Galactose→Lactose + H_2O
Glucose + Glucose→Maltose + H_2O

Polysaccharides		
Energy Storage		Stores energy in a branched structure to increase surface area (easier to access)
	Amylopectin	Found in plants
	Glycogen	Found in animals
Structural		Oriented in long unbranched chains parallel to each other for greater strength
	Cellulose	Found in structural support of plants
	Chitin	Found in exoskeleton of invertebrates

- **Lipids:**
  - Used for energy storage, structural, protection for organism, insulation.
  - Mostly made of hydrocarbons (nonpolar and hydrophobic)
  - Glycerol + 3 fatty acids
  - Saturated = solid (single bond), unsaturated = liquid (double bond)

Saturated	Solid, single bond, straight structure
Unsaturated	Liquid, double bond, bent structure

  - Phospholipids: hydrophilic phosphate head, hydrophobic tails
  - Steroids: chemical messenger, hormones and in cell membrane
- **Nucleic Acids:**
  - Used to carry genetic materials, form part of ribosomes, and act as energy carriers. Contains the phosphate group, nitrogenous base, and five-sugar base.
  - Made up of nucleotides (monomers)
  - DNA and RNA are all nucleic acids
- **Proteins:**
  - Used for enzymes, structural, hormones, contraction, storage, transport. Contains the H_3N^+ amino acid functional group.
  - Components to an Amino Acid

Component	Description/Properties
Carboxyl Group	-COOH-, polar
Amino Group	-NH2, polar
Hydrogen	Nonpolar
R-Group	Determines property of specific amino acid, can be polar, nonpolar, or ionic

  - Made up of animo acids, which are made up of a same amino and carboxyl group that differs only at the R group.
  - Condensation reaction forms a peptide bond in proteins
  - Four levels of protein structure:

Level		Description
Primary		Is a sequence of amino acids (all other structures based on this)
Secondary		Either forms a helical coil (Alpha Helix) or a pleated sheet (Beta Sheet). Based on Hydrogen Bond interaction between non-adjacent amino acids
Tertiary		3D folding of the polypeptide based on the different R-Groups 4 different interactions.
	Hydrogen Bonding	Happens between polar R groups
	Hydrophobic Interaction	Happens between non polar R groups
	Ionic Interaction	Happens between ionic R groups (opposites attract)
	Disulfide Bridge	Happens between two Cystienes
Quaternary		Interactions between 2 or more polypeptide chains

❖ Cell Structure

Cell Structure		
Organelles	**Descriptions**	
Nucleus	The organelle in the cell that contains most of the genetic material in forms of chromosomes. (eukaryotic)	
Nucleolus	A "suborganelle" within the Nucleus responsible for the production and assembly of ribosomes. (eukaryotic)	
Ribosome	Organelles responsible for the assembly of proteins, which is composed of rRNA and ribosomal protein. Ribosomes can be found floating freely in cytoplasm or attached to rough ER (eukaryotic and prokaryotic)	
Smooth Endoplasmic Reticulum	Organelles connected to the nuclear envelope with ribosomes attached to it. The rough ER is responsible housing the production of proteins destined to leave the cell. (eukaryotic)	
Rough Endoplasmic Reticulum	Organelle that is responsible for cell metabolic processes. The smooth ER holds various enzymes, synthesizes lipids, and metabolizes carbohydrates. (eukaryotic)	
Golgi Apparatus	Organelle that will modify, sort, and ship proteins transported from the rough ER. The Golgi will do the final "packaging" for the protein before it is secreted out of the cell. (eukaryotic)	
Lysosome	Organelles that contains digestive enzymes responsible for digestion of macromolecules. Lysosomes is responsible for destroying old organelles within the cell.	
Mitochondria	Organelle responsible for converting organic material into energy (ATP) by the process of oxidative phosphorylation (or electron transport chain). (eukaryotic)	
Chloroplast	Organelles found only in plant cells that are responsible photosynthesis. (eukaryotic)	
Peroxisome	Organelles similar to lysosomes and are responsible for disposing toxic wastes from the cell.	
Cytoskeleton	Thin "skeleton" within a cell's cytoplasm that provides cell shape, cell motion, and assists in movement of organelles inside the cell. (eukaryotes)	
	Microtubules (large)	Responsible for structure, cell division, and vesicular transport.
	Microfilaments (small)	Mainly responsible for cell shape and motion. (cilia and flagella)
	Intermediate filaments (medium)	Mainly responsible for support and the cell's 3D structure.

Extracellular Matrix - Any tissue that is not part of a cell is part of the ECM. The ECM is responsible for anchorage of cells and intercellular communications.

Membrane Properties

- Phospholipids constantly move laterally but rarely flip-flop
- Fluidity of membrane is adjusted by temperature and cholesterol
- Different cellular components are embedded in the membrane (ex. Proteins and carbohydrates)
- Integral proteins server different functions in the membrane and have a hydrophobic and hydrophilic areas.
- Carbohydrate serves in intercellular communications.
- Membranes are selectively permeable to keep harmful substance out and controls concentration of substances inside the cell.

➢ Methods of Transport

Passive Transport (no energy required)	
Type	**Description**
Simple diffusion	Movement of a substance with concentration gradient from high concentration to low concentration by directly diffusing through the cell membrane.
Facilitated diffusion	Some substances are too big or insoluble to diffuse directly across the membrane so they move through transport proteins. However, they are still moving with the concentration gradient.
Osmosis	The simple diffusion of H_2O.

Active Transport (requires energy, ATP)	
Type	**Description**
Active transport	Transport proteins will pump a substance against the concentration gradient with the consumption of ATP.
Endocytosis	The method of how cell absorbs large molecules by completely engulfing it with part of its membrane. This is further divided into phagocytosis (cell eating) and pinocytosis (cell drinking).
Exocytosis	The opposite of endocytosis where a large waste molecule is released from the cell through the fusion of a transport vesicle and cell membrane.

❖ Enzymes

- ➢ **Affect on reactions:** Lowers activation energy, catalyzing the process.
- ➢ **Interactions with substrates:** Substrates bind at the active site.
  - **Inhibition:**

Competitive	Inhibitor binds to active site preventing substrate from attaching.
Non-Competitive	Inhibitor binds to non-active site and alters the enzyme's active site so that the substrate can no longer bind.

  - ▪ Cofactors: Non proteins that help catalyze reactions; bind to enzyme and change shape of active site
    - ▪ Coenzymes: organic (vitamins) molecules that binds to enzyme to improve its function
- ➢ **Enzyme control mechanisms:**
  - **Phosphoylation:** Tri-phosphate group from ATP is added intot he enzyme changing its shape and possible inactivating it.
  - **Feed-Back Inhibition:** The product of the process binds to the enzyme inactivating it.
  - **Allosteric Regulation:** Similar to non-competitive inhibition where a molecule binds to a non-active site to change the shape of the enzyme either activating or inactivating it.