Unit 7 Notes
Transport Systems

I. Transport Systems in Animals

A. As animals increase in complexity, more specialized circulatory systems are required.

1. Thin animals such as hydra and planaria only require a "gut" area water can pass though for exchange.

2. Arthropods have an open circulatory system – there is no separation between blood and other intercellular fluids.

3. Closed circulatory systems use heart tissue to pump blood through vessels – tissues are not directly exposed to blood.

B. All vertebrate cardiovascular systems share several things in common.

1. The heart is divided into 1+ atria to receive blood from the body and 1+ ventricles to pump blood to the body.

2. Arteries carry blood away from the heart to capillaries in tissues throughout the body.

3. Gas and nutrient exchange take place in the capillary beds.

4. Veins collect blood from the capillaries and take it back to the heart.

C. The evolution of the vertebrate circulatory system has supported higher levels of activity and cell respiration.

1. Fish have a two chambered heart which can only provide for "single circulation."

a. O_2 poor blood leaves the heart and enters the gill capillaries where it loses most of its pressure.

b. O_2 rich blood leaves the gills and slowly makes its way to other tissues and then the heart.

2. Amphibians and most reptiles have a three chambered heart that pumps "mixed" blood from a single ventricle into two arteries – one to the lungs, the other to the body.

a. The problem of sluggish blood flow to body tissues has been solved by separating pulmonary circulation.

b. The new problem is neither the lungs nor body tissues receive blood that is ideally suited to their functions.

3. The completely divided, four chambered heart allows birds and mammals to maintain high energy activities for long periods of time.

   a. The right side of the heart receives O_2 poor blood from the body which it pumps to the lungs.

   b. The left side of the heart receives O_2 rich blood from the lungs which it pumps to the body.

   c. The pacemaker initiates each cardiac cycle.

II. Regulation and Transport

A. The structure of blood vessels is based on the pressures they are exposed to.

1. The elasticity and muscularity of arteries helps to move blood and keep its pressure within normal range.

   a. As the ventricles contract, arteries bulge to reduce normal systolic blood pressure (110 – 130 mm Hg).

   b. When the ventricles are relaxed, artery elasticity helps push blood along and maintain normal diastolic blood pressure (70 – 80 mm Hg).

   c. High blood pressure (hypertension) can lead to strokes and atherosclerosis.

2. Blood pressure drops when it is spread throughout a capillary bed, therefore capillaries can be one cell thick to aid in diffusion.

3. Veins must return blood to the heart even though there is not much pressure.

   a. Veins have thinner walls with less muscle and elastic tissue, but have valves to prevent backflow.

   b. Gravity and/or the contraction of skeletal muscles help push blood back to the heart.

B. The body monitors blood pressure, physical activity levels, and other conditions affected by the circulatory system.

1. Regional changes in blood pressure can cause an increase or decrease in overall blood pressure accordingly. (ex: standing up from a reclining position)

2. Muscular contractions can shunt blood from low to high need areas of the body (exercise, cold temp, digestion, etc).

3. Consistently high blood pressure can damage the heart and blood vessels leading to stroke, heart attack, and other conditions.

C. Blood is a mixture of fluid, cells, and cell fragments.

1. Plasma is the fluid portion of blood that suspends cells and dissolves nutrients, wastes (CO_2), ions, etc. (55%).

a. Plasma seeps into tissues where it bathes cells as intercellular fluid which seeps into lymph vessels.

b. The lymphatic system filters this lymph through nodes and returns it to the blood stream as plasma once again.

2. Red blood cells (erythrocytes) transport O_2. (44%)

a. Hemoglobin is an iron-based protein that gains or loses O_2 based on concentration.

b. Mature erythrocytes have no nucleus which causes them to wear out after about 120 days.
c. Red bone marrow is stimulated to produce more erythrocytes when the kidneys sense low O_2 levels.

3. White blood cells (leukocytes) defend against invading organisms (bacteria), increasing greatly in number during times of infection. (1%)

4. Platelets are cell fragments that cause clotting when they interact with a wound cite.

a. As they attract and bind to each other (partially sealing the wound), they release enzymes which trigger clotting factors in the plasma.

b. A cascade of enzymatic reactions occurs, ending with the conversion of the soluble protein fibrinogen into insoluble fibrin which completes the seal of the wound.

c. Hemophiliacs cannot form fibrin because they lack clotting factor VIII (received through blood donation).

D. What are some examples of the circulatory system maintaining homeostasis?

III. Transport Systems in Plants

A. Evolutionary relatives of green algae began to colonize the land about 430 MYA.

1. The dryness of land selected for plants with a waxy cuticle and protective structures for sex cells and embryos.

2. The nonvascular plants (Mosses, Bryophytes) evolved no complex transport systems; they are small and confined to damp habitats.

3. Vascular plants further adapted to land in several ways:

a. non-waxy, high surface area root systems to absorb minerals and water from soil.

b. aerial stems and leaves for food production.

c. cell walls with lignin for added support.

d. elongated xylem (water) and phloem (phood) tubes for transport of materials between the specialized tissues.

B. Several factors combine to make xylem tubes effective at transporting water from roots to leaves w/o a pump.

1. Root pressure caused by osmosis draws water into the roots and helps push it up the xylem.

2. The cohesion-tension hypothesis is based on thin xylem tube diameter and adhesive/cohesive properties of water.

a. Water adheres to the sides of the xylem, drawing it up.

b. Water molecules are cohesive to each other, so the "side water" pulls the "middle water" along.

3. Individual xylem cylinders have pores on both ends, allowing water to flow from one to another.

4. Transpiration and photosynthesis in the leaves create negative pressure at the top of the plant.

C. Phood phloes through phloem phrom source to sink thousands of times phaster than through diphusion alone.

1. Sucrose is actively transported into phloem at a source, bringing water along through osmosis → high pressure.

2. Sucrose is actively transported out of phloem at a sink, bringing water along through osmosis → low pressure.

3. Phood goes from high to low pressure, passing from one phloem cylinder to the next through small pores.

Unit 8 Notes: The Cell Cycle

I. The Life of a Eukaryotic Cell

A. Eukaryotic cells divide at the end of a series of stages called the cell cycle.

1. Unicellular eukaryotes divide to produce a new organism.

2. Multicellular eukaryotes divide to increase cell surface area, produce specialized cells for tissues, and replace worn-out cells.

3. The cell cycle is very similar in all eukaryotes, suggesting a common origin.

B. The cell cycle has two major divisions, each of which has several subdivisions.

1. Interphase: period between cell divisions; takes up most of the cell cycle.

a. G1 (gap 1): prereplication; cell grows, makes RNA, proteins, etc.; performs tissue's specific function(s).

i. G0: a stopping point in G1; not gearing up for division; nerve cells; most adult cells.

ii. R (restriction point): cell in G1 or G0 receives signals to divide and begins process – no turning back.

b. S (DNA synthesis): DNA of each chromosome is replicated, doubling each gene in the nucleus.

c. G2: cell prepares for mitosis by making specific types of RNA and proteins.

2. Mitosis: even nuclear division ensures each daughter cell gets a full set of chromosomes; cytokinesis splits the cells apart.

II. DNA Replication

A. The synthesis of DNA depends on the structure of nucleotides and a host of enzymes and other proteins.

1. Special proteins bind to specific regions of chromosomes called replication origins.

2. At the replication origin, helicase unwinds the DNA while single-strand binding proteins hold the strands apart.

3. Primase attaches 5 – 15 nucleotides of RNA at the origin, running 5′ to 3′.

4. DNA polymerase adds complimentary nucleotides to the RNA primer, also in the 5′ to 3′ direction.

   a. The leading strand can be made as one long polymer.

   b. The lagging strand must be made in short (100 - 300 nucleotide) segments called Okazaki fragments.

      i. When DNA polymerase reaches an RNA primer, it replaces the RNA with DNA.

      ii. DNA ligase joins the new fragment to the old one.

5. Replisomes (DNA polymerases, associated enzymes, and proteins) move in both directions from replication origins, speeding the process of replication.

6. Each “new” DNA strand is half “old” – semiconservative.

B. DNA repair mechanisms exist to fix base mismatches and other problems.

1. DNA polymerase is only about 99.99% accurate at matching base pairs during replication (1 mistake per 10,000 nucleotides).

   a. To improve accuracy, DNA polymerase checks its work and pauses to replace mismatches.

   b. Accuracy is improved to 99.99999% (1 mistake per 10 million nucleotides).

2. Mutations caused during interphase by mutagenic chemicals or radiation are fixed through excision repair.

a. A repair enzyme cuts out the damaged section.

b. DNA polymerase replaces the nucleotides and DNA ligase links them to the old DNA.

3. These are only 2 of many ways to repair DNA.

4. Without these mechanisms, DNA would degrade fairly quickly, making life and reproduction impossible.

III. Mitosis and Cell Division

A. After the S and G2 stages of interphase, the cell has organized itself for mitosis.

1. Each chromosome has been copied resulting in two sister chromatids held together by a centromere.

a. The centromere helps to organize the sister chromatids for even chromosome segregation in mitosis.

b. Uneven division results in aneuploidy which can lead to cancer, an inability to perform mitosis again, etc.

2. Mitosis is a continuous process which is considered to have four distinct steps.

a. Prophase can be recognized by condensed, unorganized chromosomes.

i. Microtubules form around the nucleus, creating a mitotic spindle.

ii. Centrioles (or an equivalent) are pushed to either side of the cell and are surrounded and anchored by spindle poles that form around them.

iii. Microtubules attached to the centrioles bind to a protein complex called a kinetochore within the centromere of each sister chromatid.

b. The beginning of metaphase is defined by the chromosomes lining up at the cell's equator.

i. Sister chromatids are pushed to the equator region by the spindle fibers they are attached to.

ii. The metaphase plate helps ensure that each daughter cell gets one copy of each chromosome.

c. Sister chromatids separate during anaphase.

i. Enzymes break down the centromeres.

ii. Motor proteins of the kinetochores pull the chromatids along the spindle microtubules to opposite spindle poles.

iii. Cytokinesis may begin.

d. In telophase, the chromosomes begin to expand, nuclear envelopes form (creating two new nuclei), and cytokinesis advances until the daughter cells separate.

B. Some small differences exist between eukaryotes.

1. Primitive eukaryotes attach their chromosomes to the nuclear envelope for division (similar to prokaryotes).

2. Plants have no centrioles and form a cell plate in the middle of the cell during telophase.

3. Some fungi bud a new nucleus with imbedded spindle poles.

IV. Regulation of the Cell Cycle

A. All eukaryotes use the same basic mechanism to regulate the progression of the cell cycle – cyclins.

1. Cyclins work by varying their concentration, causing specific kinase enzymes to become active or inactive.

a. Kinase enzymes transfer phosphate groups from ATP to specific enzymes or other proteins, activating them.

b. Activated proteins perform their job until their phosphate is transferred elsewhere.

c. The concentration of the various kinases and proteins remains constant in the cell, but they are not active during all of the cell cycle.

2. G1 cyclins activate replication, accumulating late in G1 and peaking in S.

3. Mitotic cyclins control the order of mitotic events.

   a. Low mitotic cyclin levels in G2 activate kinases that activate the breakdown of the nuclear membrane and condensation of chromosomes.

   b. As more cyclins build up, other kinases activate pathways controlling the stages of mitosis.

   c. The last pathway activated breaks down specific proteins including centromeres and the mitotic cyclins themselves.

B. Cell cycle regulators prevent the reproduction of defective cells and control when cells leave G0.

1. If checkpoint control proteins find defects, the cell is brought into cell cycle arrest until the problem is fixed.

   a. If p53 finds mismatched bases, it activates cell cycle inhibitors that keep the G1 cyclin-kinase system from activating S.

   b. other arrest points: S (unreplicated DNA), G2 (damaged DNA), and mitosis (spindle problems).

2. Certain genes can encourage or dissuade a cell from leaving G0.

   a. Protooncogenes (signal receivers, transcription regulators, etc.) promote while tumor suppressor genes (checkpoint proteins) inhibit cell division.

   b. A mutation to one type of G0 control gene is kept in check by the other, but mutations to both = cancer.

3. Cancer cells reproduce as quickly as possible, neglecting their G0 duties.

   a. Constant division leads to a tumor which can interfere with the functionality of the tissue it invades.

   b. Some types of cancer metastasize into the blood stream, are deposited in other tissues, and start tumors there.

Unit 9 Notes: Expressing Genetic Information

I. Transcription

A. In both prokaryotes and eukaryotes, transcription of DNA by RNA polymerase is the beginning of gene expression.

1. Prokaryotes only use one type of RNA polymerase to the various types of RNA.

2. Eukaryotes have three kinds, whose combined efforts make rRNA, mRNA, and tRNA.

   a. In the nucleolus, rRNA and proteins are assembled into ribosomal subunits (large & small).

   b. mRNA serves as the code to be read by ribosomes.

   c. tRNA carries amino acids to ribosomes for translation.

B. Transcription has a beginning, middle, and end.

1. Initiation begins when RNA polymerase is attracted to and binds a promoter region on DNA.

2. In elongation, RNA polymerase unwinds DNA and binds RNA nucleotides based on the DNA's coding strand.

3. When RNA polymerase reaches the terminator region, the enzyme and primary transcript are released.

C. Before leaving the nucleus, all three types of RNA are modified.

1. mRNA is modified in three ways.

   a. A methyl-guanine (mG) cap is added to mark the starting end.

   b. The other end gets a poly-A tail (100-200 A's) for protection from enzymes.

   c. Segments of the mRNA that don't code for its protein (introns) are spliced out, leaving the parts to be expressed (exons).

2. tRNA is spliced, chemically modified, and folded into a stable "cloverleaf" shape with an anticodon and amino acid binding site.

3. rRNA is spliced, modified, and bound to proteins to form the large and small subunits of ribosomes.

II. Translation

A. Protein synthesis translates the codon sequence of mRNA into the amino acid sequence of a protein.

1. In initiation, two ribosomal subunits attach to an mRNA with a mG cap and a tRNA carrying methionine binds at the P site which holds the start codon (AUG).

2. Elongation creates a bond between amino acids.

a. A charged tRNA enters the ribosome's A site.

b. The growing protein (held by a tRNA at the P site) binds to the amino acid at the A site.

c. The uncharged tRNA from the P site leaves via the E site while the tRNA holding the protein at the A site moves to the P site.

3. Termination occurs when a stop codon reaches the A site: a releasing factor (protein) pairs with the stop codon and causes the release of the mRNA.

B. Many proteins must be modified and/or transported.

1. Chemical modification (adding sugars, cutting, etc.) causes the protein to fold into its active tertiary structure.

2. The ER can be used to move proteins.

a. An amino acid signal sequence binds to an ER receptor during translation, allowing the protein in.

b. After the signal sequence is removed and sugars are added, the protein is transported to the plasma membrane or Golgi apparatus (vesicle).

C. Errors in translation can produce nonfunctional proteins.

1. The starting point of the reading frame can be shifted by one or two bases.

2. Mistakes in DNA can cause frame shift errors (splicing error, loss of a base) or partial proteins (new stop codon).

III. Viruses

A. Viruses are tiny, non-cellular particles that depend on other cells for respiration, gene expression, and reproduction.

1. Typically a virus is made of: a protein or lipid membrane coat, a small bit of DNA or RNA, and maybe a few enzymes.

2. Virus reproduction falls into two patterns.

a. In lytic infections, the host cell's enzymes and ribosomes replicate, transcribe, and translate the viral DNA or RNA into new viruses which lyse (break) the cell.

b. Viral DNA (or a copy of viral RNA) is inserted into cellular DNA and is replicated whenever the cell divides – lysogenic.

i. Viral particles wrapped in the host cell's plasma membrane may be given off from time to time.

ii. Stress to the host cell may activate a lytic cycle.

B. Viruses have impacted humanity in a variety of ways.

1. Antibiotics which attack bacterial metabolism don't cure viruses; weakened viruses are used in vaccinations.

2. Rare, deadly viruses may be spread through trading and rapid transit.

3. Disarmed viruses can deliver DNA for biotech. research.

Unit 10 Notes:
Meiosis & Patterns of Inheritance

I. Cell Division for Reproduction

   A. Asexual reproduction uses mitosis to produce clones (ex: budding, fragmentation, vegetative reproduction).

   B. In sexual reproduction, two parents contribute 1/2 of their chromosomes to their offspring.

      1. Every species has a characteristic number of chromosomes.

         a. Somatic (body) cells have a double (diploid or 2n) set of homologous (matching) chromosomes.

         b. Gametes (sperm & egg cells) have a single (haploid or n) set of chromosomes.

      2. For sexual reproduction, the parents use meiosis to generate haploid gametes which fertilize each other, producing a diploid somatic cell – the first of a new organism (zygote).

   C. Meiosis involves 1 DNA replication and 2 nuclear divisions to produce 4 haploid gametes.

      1. Two significant events occur in meiosis one.

         a. In prophase I, homologous chromosomes cross over to swap mom and dad's genetic material, creating a unique combination of genes.

         b. Metaphase – telophase I create the haploid condition.

      2. Meiosis two splits the sister chromatids apart.

      3. Males typically produce 4 equally sized sperm.

      4. Females typically produce one ovum (egg) and two polar bodies.

II. Genes and Chromosomes

A. Heredity was once thought of as a process of "blending" -- the averaging of parents' traits.

1. Once blended, the parents traits could not be passed on separately to future generations.

2. This theory was reasonable for a variety of traits (controlled by multiple factors), but could not explain how some traits in offspring are not exhibited by parents.

B. Gregor Mendel used garden peas to study aspects of heredity blending did not explain.

1. The peas have several "either-or" traits that do not blend and are inherited independently of each other.

2. Mendel spent eight years researching these traits.

a. Plants were inbred for several years to make sure they were true-bred (produce offspring identical to parents each generation).

b. When true-breeding plants with opposite traits were cross-bred, only one trait showed in the offspring.

c. When the offspring were allowed to self-fertilize, the missing trait was exhibited again but made up only 25% of the population.

3. Mendel concluded that in fertilization, two non-blending genetic *factors* were given to the offspring.

a. One of the *factors* was hidden in the offspring (F_1) generation.

b. When two hidden *factors* from the F_1 generation were inherited by following (F_2) generation, the hidden trait returned.

C. Today we know that Mendel's *factors* are genes – sections of DNA with a specific nucleotide sequence that are found in a particular region of a chromosome.

1. Most genes exist in more than one form or allele (ex: the pea color gene has two alleles: yellow and green).

2. The alleles have slightly different DNA sequences, causing small changes to the 3-D shape (and function) of the enzymes they code for.

III. Patterns of Inheritance

A. The inheritance of alleles is governed by two principles.

1. Principle of segregation: parent organisms possess two alleles for each gene, but only put one in a gamete (monohybrid crosses were the evidence).

2. Principle of independent assortment: alleles for different characteristics are put into gametes independently (dihybrid crosses were the evidence).

B. Mendel only worked with traits that had a simple, two allele, dominant/recessive relationship.

C. There are many types of inheritance that follow Mendel's principles, but exhibit different genotypic and phenotypic ratios in the F_1 and F_2 generations.

1. Sex linked traits are carried on a portion of the X chromosome that does not have a matching section on the Y chromosome.

a. Because males only receive one of these traits, they express recessive phenotypes more often than females.

b. Common examples include color blindness and hemophilia.

2. Two types of alleles (incompletely dominant and codominant) create new phenotypes when mixed.

a. inc. dom. alleles blend: snapdragons possessing a white allele and a red allele exhibit pink flowers.

b. codominant alleles are both expressed: if a human has an A allele and a B allele, they have type AB blood.

3. Sometimes there are multiple alleles for a gene, each having a certain degree of dominance.

a. Human blood type has three alleles: A (I^A), B (I^B), and O (i).

b. The A and B alleles are codominant, while O is recessive.

4. Some phenotypes (height, skin color, etc.) are influenced by many genes and/or environmental factors, producing a bell shaped distribution of the phenotype in the population.

IV. Breaking the Rules?

A. Alleles can break the principle of segregation through nondisjunction.

1. In nondisjunction, chromosomes fail to separate evenly during meiosis.

2. Individuals receiving more or less chromosomes than normal exhibit characteristic symptoms based on the chromosome "pair" affected.

a. Down syndrome is caused by trisomy of chromosome 21.

b. Trisomy or monosomy of the sex chromosomes typically causes sterility and a degree of retardation.

B. Alleles can break the principle of independent assortment if they occur near each other on the same chromosome.

1. Linked genes are usually inherited together, creating unexpected phenotypic ratios.

2. The frequency of crossing over between the linked genes can be used to determine the distance between them.

Unit 12 Notes: Evolution

I. Natural Selection

A. During a five year voyage around the world as a naturalist, Darwin made many observations concerning organisms.

1. Not all organisms reproduce because of limited resources and other environmental factors.

2. Variation occurs within populations.

3. Individuals with the most advantageous variations reproduce while those with unfavorable characteristics do not.

B. In *The Origin of Species* (1859), Darwin proposed the theory of decent with modification based on his observations.

1. Populations change over time as individuals reproduce at different rates – the population comes to resemble the most reproductively successful members (best suited to current environmental cond.).

2. The more similar two populations are, the more recently they shared a common ancestor.

C. Natural selection (modern term for descent w/ mod.) is accepted as the driving force for evolution.

1. N. S. is regarded as just as true as atomic theory.

2. What is a *scientific* theory?

II. Origin of Species

A. Genetic isolation causes speciation -- populations' gene pools become so different, they can no longer interbreed.

1. Prezygotic isolation mechanisms keep members of different populations from fertilizing each other.

a. Geographic isolation: a barrier (mountains, canyons, oceans, etc.) keeps members from meeting each other.

b. Ecological isolation: populations do not crossbreed because their habitats differ → adaptive radiation.

c. Behavioral/reproductive isolation: differences in courtship and/or mating seasons.

d. Chemical isolation: sperm may not be attracted to an egg or may not penetrate the egg when they find it.

2. Postzygotic isolation mechanisms keep populations from producing viable or fertile offspring.

a. Zygotes may not develop properly → death.

b. Odd chromosome numbers in hybrids (mules, ligers, zonies, etc.) complicate meiosis.

c. Plants can become polyploid, making mating difficult with plants having the parental # of chromosomes.

B. Although evolutionary processes are always at work, the rate of change in a population is highly variable.

1. Speciation can occur as a slow but constant accumulation of changes – gradualism.

2. Species can experience long periods of stasis between short bursts of change – punctuated equilibrium.

a. Has been verified by evolution of *E. coli* bacteria in nutrient-poor growth conditions.

b. Explains gaps in the fossil record between related species; short transition = little chance for fossils.

III. Bringing Order to Diversity

A. The field of taxonomy classifies species with regard to shared characteristics.

1. Homologous structures (including chemicals) shared by species indicate common evolutionary ancestry.

2. Analogous structures can have similar appearance and function, but are not useful for classification.

B. The Linnean classification system uses homologies to group species into ever larger and more generalized categories.

1. Similar species can share the same genus; related genera form a family ➔ order ➔ class ➔ phylum ➔ kingdom.

2. Binomial nomenclature is used to assign a species scientific name: *Genus species* (ex: *Canis lupus*).

C. Taxonomy is inherently subjective in its classification schemes which leads to revision based on improved understandings.

   1. Early taxonomists used an intuitive, non-systematic approach (orthodox) of grouping similar organisms.

   2. Two systematic approaches were developed in the 1950's.

      a. Phenetics gives equal importance to all characteristics, grouping species according to overall similarity.

      b. Cladistics groups organisms by possession of derived characteristics (currently the most accepted method).

IV. The Kingdoms / Domains of Life

A. The "Five Kingdoms" is somewhat outdated now because of new, molecular evidence…

   1. Monera: two prokaryote groups – Eubacteria & Archaea

   2. Protozoa: wide variety of eukaryotes (currently being divided into many kingdoms), some single cellular, others multicellular, some photosynthetic (like algae), others not

   3. Plantae: multicellular, photoautotrophic eukaryotes – tissues, organs, systems…

   4. Animalia: multicellular, heterotrophic eukaryotes – tissues, organs, systems…

   5. Fungi: multicellular, heterotrophic eukaryotes – t., o., s…; (decomposers)

B. Molecular evidence has been used to rethink the old five kingdom system into a three domain system.

   1. The three domains include eubacteria, archaea, and eukarya.

   2. The eubacteria and archaea lines split a looooooooong time ago and later the eukaryote line split from the archaea.

   3. The kingdom classifications within the domains are currently being revised.

Unit 13 Notes: Ecology

I. The Structure of Ecosystems

A. Abiotic factors such as temperature, water availability, fires, and soil composition affect the distribution of organisms in the biosphere.

1. The diversity of abiotic environments is largely responsible for the diversity of organisms.

2. Organisms inhabiting a region affect the abiotic factors through processes as soil formation, erosion prevention, and transpiration.

B. Trophic relationships between organisms determine the flow of energy and biomass in an ecosystem.

1. Organisms transform most of energy they consume into heat and motion, causing the 10% rule.

2. Productivity and the resulting biomass also decline in higher trophic levels.

3. Ecosystems can sustain far fewer top predators than low-level consumers and producers.

C. Each species has a particular niche, or role it plays in an ecosystem.

1. Each species is adapted to exploit certain ecosystem resources including habitat, energy, and water.

2. Competition for resources keeps two species from occupying the same niche (prin. of competitive exclusion).

3. Adaptive radiation through natural selection helps to divide resources between similar species.

D. Many species have symbiotic (close-contact) relationships.

1. Mutualistic symbiosis benefits both species.

2. Parasitism benefits one species at a cost to the other.

3. In commensalism, one species benefits while the other is not appreciably affected.

II. Ecosystem Dynamics

A. Biogeochemical cycles exchange important nutrients between living things and their environment.

1. The carbon cycle “begins” with the CO_2 reservoir in the atmosphere and water.

    a. Producers fix CO_2, turning it into sugars and cellulose.

    b. Respiration returns CO_2 to the environment.

    c. Carbon deposited in the ground is still part of the cycle, but is stuck for an extended period of time.

2. The nitrogen cycle also occurs between the atmosphere and organisms.

    a. N_2 gas is fixed into the soil by lightning and bacteria.

    b. Plants uptake NH_3 and NO_3^- from the soil to make proteins.

    c. Animals make their proteins from their nitrogen containing food.

    d. Decomposition of dead organisms and wastes returns nitrogen to the soil.

    e. Other bacteria convert soil nitrogen into N_2.

3. Major events that circulate water include: evaporation, precipitation, respiration, and transpiration.

B. The productivity of ecosystems and their organisms is affected by limiting factors.

1. A resource in short supply normally keeps growth in check (rain in deserts).

2. Even if a resource is abundant in one biome as compared to another, competition for that resource keeps individual populations in check.

C. Population exhibit certain patterns with regard to limiting factors.

1. If there is little competition for a resource, the population may experience a period of exponential growth.

2. As population density (and competition) increases, growth becomes logistic and then levels at the carrying capacity.

3. If growth is exponential until the carrying capacity is reached (and overshot), a massive death rate will follow (boom-and-bust cycle).

4. If the limiting factor is inconsistent, population size emulates the fluctuations with a bit of lag (as seen in predator-prey cycles).

III. Ecosystems in Time

A. Natural selection favors organisms that can disperse and then colonize (successfully settle) new territory.

1. Plants use wind and animals for dispersal while animals can move great distances across land or sea.

2. Continent borders, mountains, and inhospitable conditions provide barriers (geographic isolation, independent evolution).

3. Lately, humans have provided a breach to these barriers for many exotic species.

a. Exotics can invade/damage host ecosystems because they evolved with similar abiotic factors in a separate location.

b. The host ecosystem has evolved no "checks" on the exotic species – balance is upset, sometimes with devastating consequences.

B. Ecosystems naturally change over time as species are introduced by natural means or abiotic factors change.

1. Primary succession begins with bare rock (etc.) and lichens, mosses, and/or small annuals (enrich soil).

2. If decent soil is present, secondary succession will continue to change the site as species more competitive for current conditions replace the established species.

3. A stable, climax community can result…?