Ecology

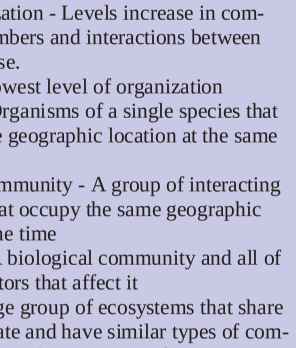
Scientific discipline in which the relationships among living organisms and the interaction the organisms have with their environments.

A. Biotic Factors - Living factors in an organism's environment.
B. Abiotic Factors - Nonliving factors in an organism's environment. Organism adapt to survive in the abiotic factors present in their natural environment.
C. Levels of Organization - Levels increase in complexity as the numbers and interactions between organisms increase.
   1. Organism - Lowest level of organization
   2. Population - Organisms of a single species that share the same geographic location at the same time
   3. Biological Community - A group of interacting populations that occupy the same geographic area at the same time
   4. Ecosystem - A biological community and all of the abiotic factors that affect it
   5. Biome - A large group of ecosystems that share the same climate and have similar types of communities (i.e., tundra, temperate forest, etc.)
   6. Biosphere - A thin layer around the Earth that supports life
C. Symbiotic Relationships:
   1. Mutualism - Both organisms benefit
   2. Commensalism - One organism benefits, the other is unaffected
   3. Parasitism - One organism benefits and causes harm to the host

Flow of Energy Specialized Components

A. Autotrophs - Organisms that collect energy from the sunlight or inorganic substances to produce food (i.e., producers).
B. Heterotrophs - Organisms that get their energy requirements by consuming other organisms (i.e., consumers).
   1. Herbivores - Eat only plants
   2. Carnivores - Prey on other heterotrophs
   3. Omnivores - Organisms that eat both plants and animals
   4. Detritivores - Organisms that eat fragments of dead matter in an ecosystem, and return nutrients to the soil, air, and water where the nutrients can be reused by organisms

B. Ecological Models:
   1. Food chain
   2. Food web
   3. Ecological Pyramids - Available energy, biomass and population size decreases as you move up the pyramid.



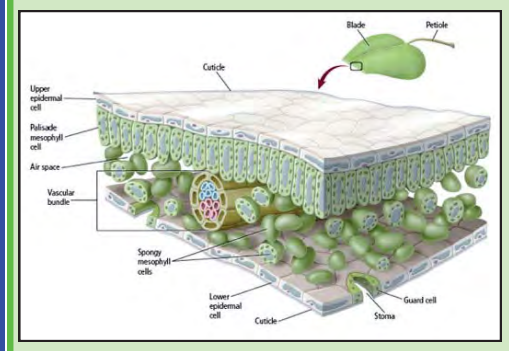
C. Biosphere Cycles:
   1. Carbon Cycle
   2. Nitrogen Cycle

D. Ecological Succession - Change in an ecosystem that happens when one community replaces another as a result of changing abiotic and biotic factors.
E. Limiting Factors - Any abiotic or biotic factor that restricts the numbers of organisms (i.e., sunlight, climate, temperature, water, nutrients, fire, soil chemistry, and living things).

Plant Systems

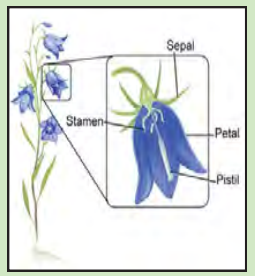
Specialized Components

A. Types of Cells:
   1. Parechyma Cells - Found throughout the plant. Its functions are storage, photosynthesis, gas exchange, protection, tissue repair and replacement.
   2. Collenchyma Cells - Found throughout the plant. Its functions are to support, flexibility, tissue repair and replacement.
   3. Sclerenchyma Cells - Cells that lack cytoplasm. Its functions are support and transport of materials.
B. Types of Plant Tissue:
   1. Meristematic - Stem and root
   2. Dermal - The epidermis
      a. Stomata, guard cells, trichomes, root hairs
   3. Vascular
      a. Xylem and phloem
   4. Ground
      a. Parenchyma, collenchyma, sclerenchyma

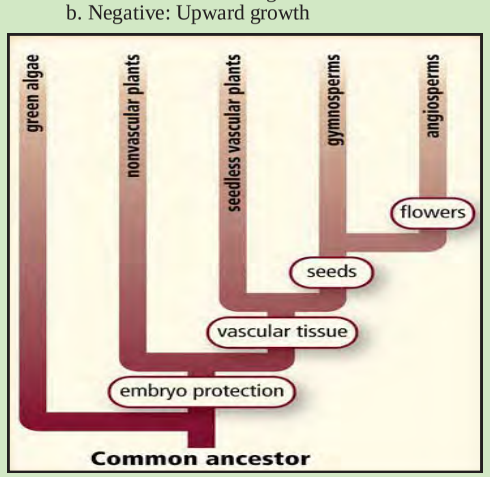


Plant System Interactions

A. Transport:
   1. Xylem - Transport substance away from roots
   2. Phloem - Transport dissolved sugars and other organic compounds throughout the plant
   3. Stoma - Small openings through which CO_2, H_2O, O_2, and other gases pass.
   4. Guard Cells - Cells that border and control stoma dilation
B. Reproduction:
   1. Petals - Attract animal pollinators
   2. Pistil - Female reproductive plant organ
   3. Stamen - Male reproductive plant organ
   4. Pollen - A male gamete that can fertilize
   5. Seeds - Flowering plant's unit for reproduction



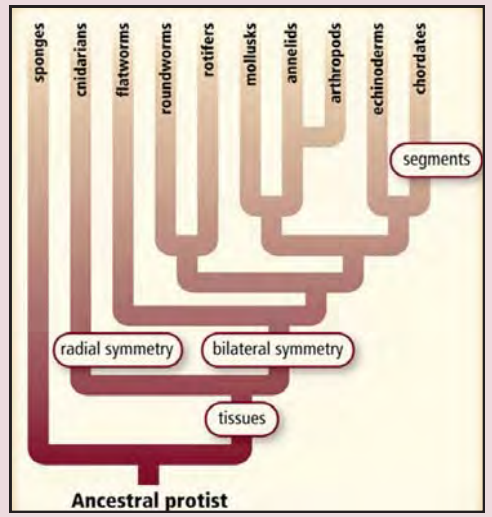
C. Response (i.e., tropism):
   1. Thigmotropism (Mechanical): Growth toward point of contact
   2. Phototropism (Light): Growth toward light source
   3. Geotropism (Gravity):
      a. Positive: Downward growth
      b. Negative: Upward growth



Animal Systems

Evolutionary Milestones in Animals

1. Cell specialization and levels of organization (cell, tissue, organ, system)
2. Development of body symmetry and segmentation
3. Development of an internal body cavity and tissue layers
4. Animals can be divided into two categories:
   a. Invertebrates (no backbone)
   b. Vertebrates (backbone)



Animal System Interactions

A. Regulation:
   1. Nervous - Recognize and coordinate the body's response
      Structures: neuron, brain, spinal cord
   2. Excretory - Eliminate wastes
      Structures: nephrons, kidney, bladder, ureter, urethra
B. Nutrient Absorption:
   1. Digestive - Converts and absorbs food into simple molecules and eliminates wastes
      Structures: mouth, esophagus, stomach, small and large intestine
   2. Respiratory - Provides oxygen for respiration and eliminates carbon dioxide
      Structures: nose, trachea, bronchioles, lungs, alveoli
   3. Circulatory - Transports nutrients and wastes; fights infection; regulate body temperature
      Structures: heart, blood vessels, blood
C. Defense:
   1. Immune/Lymphatic - Protects the body from disease and regulates body fluids
      Structures: white blood cells, spleen, lymph node
   2. Integumentary - Barrier against infection/injury; regulate body temperature
      Structures: skin, hair, sweat/oil glands, hair
   3. Skeletal - Supports and protects body; allows movement; stores minerals; produce blood cells
      Structures: bones, cartilage, ligaments, tendons
   4. Muscular - Produce movement
      Structures: skeletal, smooth, and cardiac muscle
D. Reproduction:
   1. Reproductive - Produces reproductive cells
      Structures: testes, ovaries
   2. Endocrine - Controls growth, development, and metabolism
      Structures: hypothalamus, pancreas, thyroid

Internal feedback mechanisms maintain homeostasis by regulating the internal stability of an organism.

Booklet #

EOC BIOLOGY REVIEW

Basic Concepts

Biological Science: The Study of Life

A. The Scientific Method: How scientists study biology
   1. Observe phenomena and formulate testable and falsifiable (in case they are wrong) hypotheses
   2. Test hypotheses, collect data, and analyze statistically (if necessary)
B. What is life?
   1. Characteristics: Metabolism, reproduction, growth, movement, responsiveness, complex organization

Evolution

Theory that all organisms are related to each other by common ancestry. The unifying theme in biology.
A. Natural Selection: A mechanism for the occurrence of evolution.
   1. Survival of those offspring best adapted to the conditions in which they live:
      a. Individuals produce sexually many more offspring than could possibly survive
      b. These offspring are not identical, but show variations based on genetic differences
      c. Essentially, those individuals with variations that allow them to survive (i.e., adaptations) to the age of reproduction and pass their genes on to the next generation
      d. Thus, nature is selecting offspring and shaping the evolution of species
   2. Charles Darwin and Alfred Wallace, 19th century biologists, formulated the concept of natural selection
B. Evidence for Evolution:
   1. Fossil record
   2. Comparative anatomy
      a. homologous structures
      b. vestigial structures
      c. analogous structures
   3. Comparative embryology
   4. Comparative biochemistry
   5. Geographic distribution
C. Effects of Evolutionary Mechanisms:
   1. Genetic Drift: Change in frequency of genotype
   2. Gene Flow: Transfer of genes between one population to another
   3. Mutation: Gene structure change
   4. Recombination: Rearranging of genetic material

Cells

Cell Theory

All living things are composed of cells and come from cells.

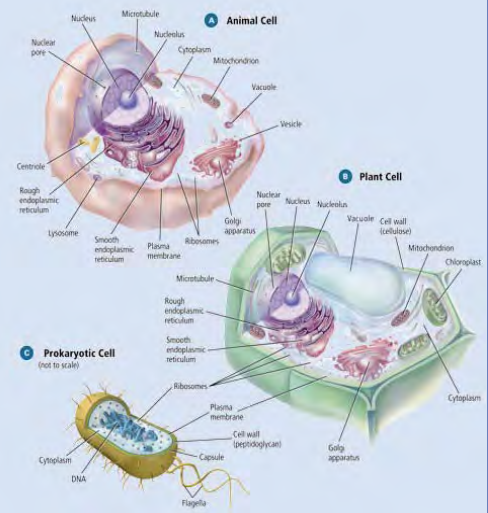
A. Cell Size: Small to maximize surface area to volume ratio for regulating internal cell environment.
B. Cell (Plasma) Membrane: Composed of fluid-like phospholipid bilayer, proteins, cholesterol, and glycoproteins.
C. Cell Wall: Outside of cell membrane in some organisms; composed of carbohydrate (i.e., cellulose or chitin) or carbohydrate derivative (i.e. peptidoglycan)
D. Cytoplasm: Material outside nucleus.
   1. Site for metabolic activity
   2. Cytosol: Solutions with dissolved substances such as glucose, CO_2, O_2, etc.
   3. Organelles: Membrane-bound subunits of cells with specialized functions.
E. Cytoskeleton: Supportive and metabolic structure composed of microtubules, microfilaments, and intermediate filaments.

Prokaryotic Cells:

Simpler cellular organization with no nucleus or other membrane-bound organelles. Additionally, they contain a plasma membrane.

Eukaryotic Cells:

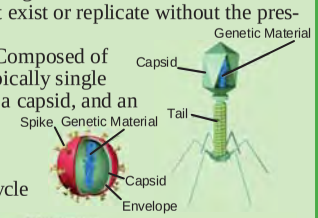
Complex cellular organization
A. Membrane-bound organelles including the following
   1. Nucleus: DNA/chromosomes, control cellular activities via genes
   2. Nucleolus: Located within nucleus, site for ribosome synthesis
   3. Rough endoplasmic reticulum: With ribosomes, involved in protein synthesis
   4. Smooth endoplasmic reticulum: Without ribosomes, involved primarily in lipid synthesis
   5. Golgi apparatus: Packaging center for molecules; carbohydrate synthesis
   6. Lysosome: Contains hydrolytic enzymes for intracellular digestion
   7. Chloroplast: Site of photosynthesis
   8. Mitochondrion: ATP production
   9. Vacuole: General storage and space-filling structure
   10. Cell Wall: Rigid structure, consisting mainly of cellulose
   11. Ribosome: Synthesis polypeptides and proteins
   12. Flagellum: Whip-like appendage for movement
   13. Cilia: Hair-like structure that propels the cell

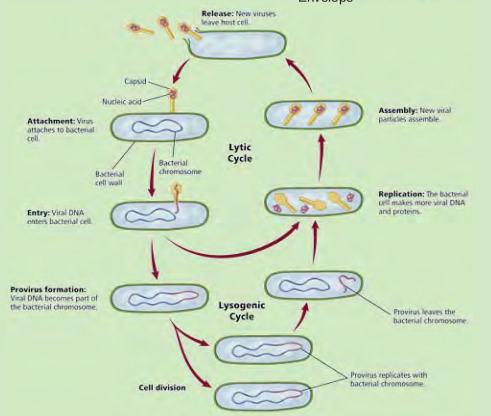


Viruses

Biological Science: The Study of Life

Viruses: An infective agent which is considered nonliving. Viruses cannot exist or replicate without the presence of a host cell.
A. Virus Structure: Composed of nucleic acid (typically single stranded RNA), a capsid, and an envelope.
B. Replication
   1. Lytic Cycle
   2. Lysogenic Cycle



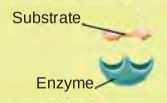


C. HIV: Human Immunodeficiency Virus, destroys the helper t-cells of the immune system until the immune system can no longer fight off infections that it could typically prevent.

Biochemistry

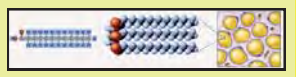
Our Sun

Organisms must use the sun's energy (directly or indirectly) to become and remain in an organized state.
A. Metabolism: Series of chemical reactions involved in storing or releasing energy
B. Enzymes: Biological Catalyst: Facilitate metabolic chemical reactions by speeding up rates and lowering heat requirements.



C. Macromolecules: Constitute all living matter and made of long complex chains of molecules (polymers) made of simpler, small subunits (monomers).
   1. Carbohydrates:
      a. Polymers of sugars
      b. Used as main source of energy

   2. Lipids:
      a. Polymers of fatty acids & glycerol
      b. Used to store energy, a structural component of cell membranes, and important in signaling molecules



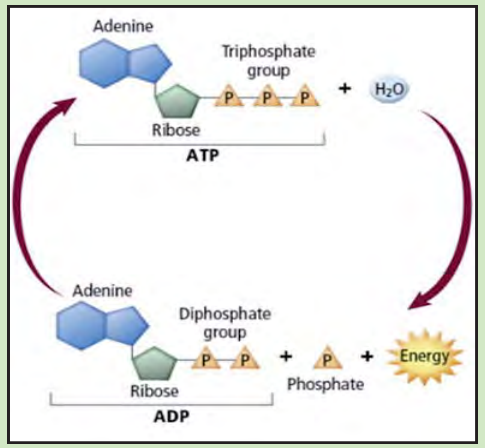
   3. Nucleic Acids:
      a. Polymers of nucleotides
      b. Used to store and transmit hereditary or genetic information

   4. Proteins:
      a. Polymers of amino acids
      b. Used to control the rate of reactions and regulate cell processes (Some transport substance into or out of cells or help to fight diseases)

Energy & Life

Adenosine Triphosepate (ATP)

A. A high-energy molecule. Energy stored in ATP is released by breaking phosphate-to-phosphate bonds and creating adenosine diphosphate (ADP) or adenosine monophosphate (AMP). ATP is recycled by adding back phosphate groups using energy from the sun.



Photosynthesis

Sunlight or solar energy is captured by chlorophyll in the chloroplasts in two main steps:

$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

A. Light-dependent reactions (Light Reactions): The captured light energy is transferred to electrons that come from H_2O . O_2 is a by-product.

B. Light-independent reactions (Dark Reactions/The Calvin Cycle): Energized electrons are transferred to CO_2 (reduction reactions) to form glucose.

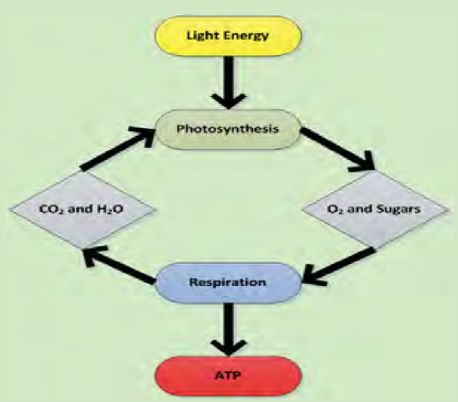
Cell Respiration

Highly energized electrons stored temporarily in glucose are removed (oxidation reactions) in a step-wise fashion to maximize energy capture at each step:

$$C_6H_{12}O_6 + 6O_2 \xrightarrow[\text{Enzymes}]{\text{Energy}} 6CO_2 + 6H_2O$$

Aerobic - Uses O_2 to produce ATP
- A. Glycolysis: Occurs in the cytoplasm where glucose is broken down into two pyruvates.
- B. Krebs cycle: Occurs across the mitochondrion membrane; pyruvate is broken down and CO_2 produced.
- C. Electron Transport Chain: Occurs across the inner folds of the mitochondrion; ATP molecules are produced from ADP; H_2O is produced as waste.

Anaerobic - Produces ATP in the absence of O_2
- A. Glycolysis: (See Aerobic)
- B. Fermentation
  - i. Alcoholic Fermentation
  - ii. Lactic Acid Fermentation

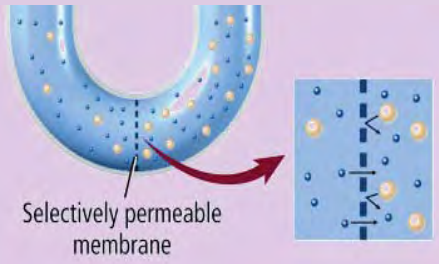


Cell Transport

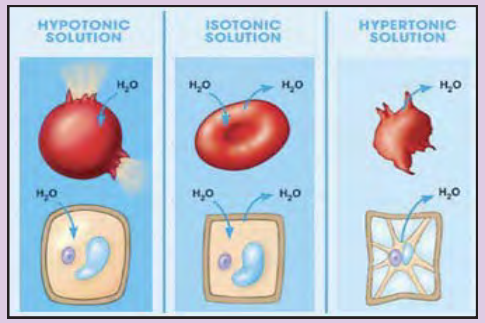
Passive Transport

A. Relies on thermal energy of matter; the cell does not do work. There are four categories:

1. Diffusion: Movement from an area of high to low concentration.



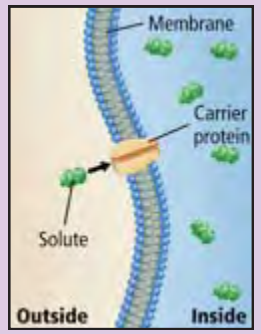
2. Facilitated diffusion: A permease, or membrane enzyme, carries substance.
3. Osmosis: Diffusion of water across a semi-permeable membrane.
   a. Hypotonic (below/under): Contains a low concentration of solute relative to the solution.
   b. Hypertonic (above/more): Contains a high concentration of solute relative to the solution.
   c. Isotonic: Contains the same concentration of solute relative to the solution.



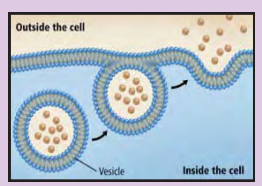
Active Transport

A. Relies on the cell providing energy supply (ATP), there are three categories:

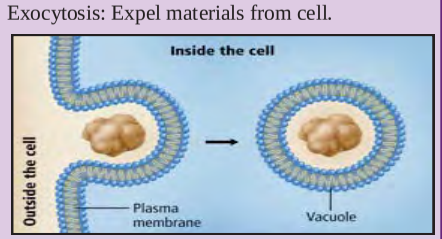
1. Membrane pumps: Permease used to move substance, usually in the opposite direction of diffusion.



2. Endocytosis: Materials are brought into cell via:
   i. Phagocytosis: Solids
   ii. Pinocytosis: Liquids



3. Exocytosis: Expel materials from cell.



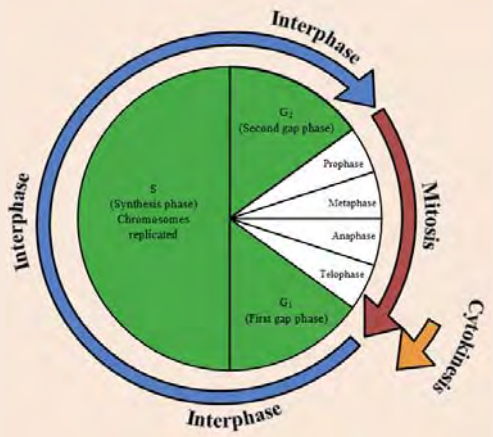
Cell Reproduction

Cells reproduce in 2 steps:

A. Mitosis: Division of nuclear material. Its purpose is for somatic cells to create genetically identical daughter cells.
B. Cytokinesis: Division of remaining cellular contents of the cytoplasm.

Cell Cycle:

A. Cells go through 4 stages:
1. G_1: Active growth and metabolism
2. S: DNA synthesis and duplication
3. G2: Synthesis of molecule in preparation for cell division
   a. Stages G_1, S, & G_2, above are collectively referred to as Interphase.
1. Mitosis & Cytokinesis:
   a. 4 Mitotic Stages:
   Prophase, Metaphase, Anaphase, Telophase



B. Failure in Regulation of Cell Cycle (i.e., Cancer):
1. The uncontrolled growth and division of cells

Organism Reproduction

Sexual Processes

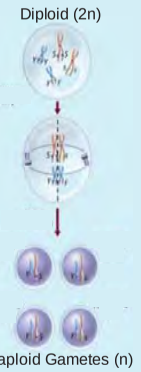
A. Sexual Reproduction: Involves the fusion of genetic material (gametes from two parental organisms).
B. To ensure the proper chromosomal numbers in the zygote (fertilized egg), each gamete must have half or haploid (n) of the original diploid (2n) amount of DNA.
C. Meiosis: Reduces the chromosome number by half and results in new genetic combinations in the gametes.

Meiosis - 2 distinct stages

Preceded by interphase. Many meiotic events similar to mitosis. Differences are noted below.

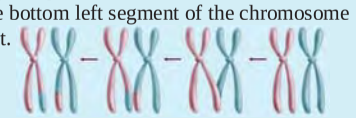
A. Meiosis I:
1. Prophase I, Metaphase I, Anaphase I, Telophase I

B. Meiosis II:
1. Prophase II, Metaphase II, Anaphase II, Telophase II



Crossing Over

A. The results of crossing over are new combinations of genes (bottom right segment of the chromosome on the left and the bottom left segment of the chromosome on the right.



Chromosomal Mutations

A. Types:
1. Deletion
2. Duplication
3. Inversion
4. Translocation

Karyotyping:
A technique that helps to identify chromosomal mutations.

Genetics

Introduction

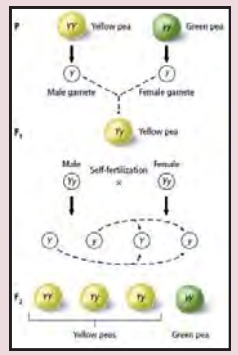
A. Genetics: The study of traits and their inheritance
1. Allele: An alternative form of a single gene passed from generation to generation.
2. Dominant: Trait which can express over another
3. Recessive: Trait "masked" by dominant trait
4. Genotype: An organism's allele pairs
5. Phenotype: Observable expression of allele pair
6. Homozygous: Two of the same alleles for a particular trait (i.e., YY)
7. Heterozygous: Two different alleles for a particular trait (i.e., Yy)
8. P Generation: Parent generation (i.e., P_1)
9. F Generation: Offspring generation (i.e., F_1, F_2)

B. Gregor Mendel provided the most plausible hypothesis for genetics; Mendelian genetics: Two laws were developed by using statistics to analyze results of crosses involving distinguishing traits of garden peas.

I - Law of Segregation

Developed by Mendel using single-trait crosses

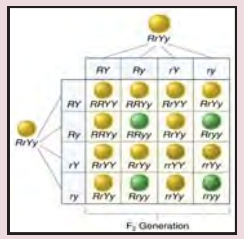
A. Single-trait crossbreeding:
1. Two true-breeding (those that consistently yield the same form when crossed with each other) parents (P_1) but different strains were crossed (i.e., yellow versus green peas).



2. The offspring (F_1) from this cross all showed only one trait (i.e., yellow peas) and this was called the dominant trait. The traits from the parents did not blend.
3. The F_1 individuals were crossed with each other to produce F_2 individuals.
4. 3/4 of the F_2 expressed the dominant trait. 1/4 expressed the trait of the other P_1 parent (i.e., green seed) which had not been expressed in the F_1 generation and was thus recessive.

II - Law of Independent Assortment

A. Genes are found on chromosomes, and thus multiple traits assort independently as long as they are located on different chromosomes. Mendel studied traits in peas that were each on separate chromosomes. Genes on the same chromosome are linked and thus will not normally assort independently.



Non-Mendalian Genetics

A. Interactions between alleles:
1. Complete dominance: One allele dominates another allele
2. Incomplete dominance: Neither allele is expressed fully (i.e., blended traits)
3. Codominance: Both alleles are expressed fully (i.e., strips & spots)
4. Multiple alleles: More than two alleles for a gene are found within a population (i.e., blood types)
5. Polygenic inheritance: Many genes contribute to a phenotype (i.e., eye color)
6. Environmental influences: Where the genotype and environment interact to form a phenotype
7. Sex-linked traits: The Y chromosome contains the determinant for maleness, the X contains many genes. If a male gets a recessive (or dominant) allele on the X chromosome from his mother, he will express the trait. Thus, males are frequently afflicted with X-linked disorders.

DNA & Protein Synthesis

Genes, DNA & Nucleic Acid

A. Gene functions:
1. To be preserved and transmitted
2. To control various biological functions through the production of proteins (i.e., large, complex sequences of amino acids) and RNA

B. Gene structure: Two types of nucleic acids:
1. Deoxyribonucleic acid (DNA)
2. Ribonucleic acid (RNA)

C. Nucleotides: The components of nucleic acids; three subunits:
1. Sugar (deoxyribose in DNA; ribose in RNA)
2. Phosphate
3. Nitrogenous base: (5 possible bases)
   a. In DNA, the nucleic acid of chromosomes, four nitrogenous bases are found: adenine (A), guanine (G), cytosine (C), and thymine (T)
   b. RNA consists of similar bases, except uracil (U) replaces thymine (T)
   c. DNA is a double helix molecule: (Similar to a spiral staircase or twisted ladder), with the sides formed by repeating sugar-phosphate groups from each nucleotide, and the horizontal portions (i.e., steps) formed by hydrogen bonds involving A with T or C with G.
   d. Hereditary information: (i.e., genes) found along the linear sequence of nucleotides in the DNA molecule.

DNA Replication & Protein Synthesis

A. Replication:
1. DNA is copied from other DNA by unzipping the helix and pairing new nucleotides with the proper bases (i.e., A with T and C with G) on each separated side of the original DNA.

B. Transcription:
1. Messenger (m)RNA is copied from DNA by unzipping a portion of the DNA helix that corresponds to a gene.
2. Only one side of the DNA will be transcribed and nucleotides with the proper bases (A with U and C with G) will be sequenced to build pre-mRNA.
3. Sequences of nucleotides called introns are removed and the remaining segments called exons are spliced together.
4. The mature mRNA leaves the nucleus to be transcribed by the ribosomes.

C. Translation:
1. Proteins are synthesized from (m)RNA by ribosomes (which are composed of ribosomal (r) RNA and proteins) which read from a triplet code (i.e., codons) that is universal.
2. The ribosomes instruct the transfer (t)RNA's to bring in specific amino acids in the sequence dictated by the mRNA, which in turn was built based on the sequence of nucleotides in the original gene portion of DNA.

Mutations

Any random, permanent change in the DNA molecule. Many are harmful, some have no effect, and a few actually benefit the organism. Nature selects those mutations that are beneficial or adaptive in organism to help shape the course of evolution.

A. Point mutation: Change that occurs at the gene level
1. Types: Substitution, deletion, insertion, duplication, repeating

Biotechnology

Genetic Engineering

The direct human manipulation of an organism's genome using DNA technology.

A. Restriction enzymes:
1. Functions: Cut DNA strands into fragments
2. Applications: Used to create DNA fragments with sticky ends or blunt ends

B. Gel electrophoresis:
1. Functions: Separates DNA fragments by size
2. Applications: Used to study DNA fragments of various sizes

C. DNA fingerprinting:
1. Functions: Identify and compare relatedness of organisms using fragments of DNA
2. Applications: Identifying individuals in criminal investigations and paternity, medical diagnostics, paleontology, taxonomy, etc.

D. Recombinant DNA technology:
1. Functions: Combines a DNA fragment with DNA from another source
2. Applications: Studying individual genes, produce engineered organisms, and in the treatment of certain diseases

E. Cloning:
1. Functions: Produces genetically identical genes, cells, tissues, organs, and organisms
2. Applications: Gene therapy for diseases, create transplant tissues, assist endangered species dev.

F. DNA sequencing:
1. Functions: Identifies the DNA sequence of organisms
2. Applications: Helps identify errors in the DNA, predict the function of genes, and to compare genes with similar sequences

F. Polymerase chain reaction (PCR):
1. Functions: Makes copies of specific regions of sequenced DNA
2. Applications: Used to copy DNA for any scientific investigation, including forensic analysis and medical testing

Classification

Organization & Characteristics

A. Cladogram: A branching diagram that represents the proposed phylogeny (i.e., evolutionary history)

B. Taxonomic Categories:
1. Domain, Kingdom, Phylum, Class, Order, Family, Genus and Species
2. Example:
   American Black Bear (*Ursus americanus*)
   a. Eukarya, Animalia, Chordata, Mammalia, Carnivora, Ursidae, *Ursus, americanus*

Domain	Bacteria	Archaea	Eukarya			
Kingdom	Bacteria	Archaea	Protista	Fungi	Plantae	Animalia
Cell Type	Prokaryote		Eukaryote			
Cell Walls	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls with cellulose in some	Cell walls with chitin	Cell walls with cellulose	No cell walls
# of Cells	Unicellular		Unicellular and Multicellular	Most Multicellular	Multicellular	
Nutrition	Autotroph or Heterotroph			Heterotroph	Autotroph	Heterotroph