Water
- Hydrolysis:
  - Addition of H2O to break it apart.
- Dehydration:
  - Removal of H2O to form a bond.

Carbohydrates
- Monosaccharide: 2 common types
  - Glucose (Hexopyranose RLRR), fructose
- Disaccharide: 3 common types
  - glucose + fructose alpha glucocsidic bond = sucrose (table sugar)
  - glucose + galactose beta galactosidic bond = lactose
  - glucose + glucose = maltose
- Polysaccharide: 4 common types
  - Starch: alpha 1,4 & 1,6 bonds btwn glucoses. amylose and amylopectin
  - Glycogen: different branching than starch. Found in animals
  - Cellulose: beta glucose polymer. Plant cell walls
  - Chitin: similar to cellulose with extra nitrogen containing group. Fungus cell wall and exoskeleton

Lipids
- Triglyceride
  - 3 fatty acids attached to glycerol.
- Phospholipid
  - One fatty acid in triglyceride replaced with a R containing phosphate group
- Steroids
  - 4 carbon rings. 3 cyclohexane and 1 cyclopentane

Proteins
- Primary structure
  - AA sequence
- Secondary
  - 3D shape resulting from hydrogen bonding btwn amino and carboxyl group. Alpha helix and beta pleated sheets
- Tertiary
  - Hydrogen bonding btwn R groups
  - Ionic bonding btwn R groups
  - Hydrophobic and hydrophilic effects
  - Disulfide bonds btwn Cysteine
- Quaternary
  - Multiple tertiary structures come together. H-bond, disulfide bond, hydrophilic/phobic interactions

Nucleic acids
- Polymer of what?
  - nucleotides
- Parts of DNA
  - Nitrogen base, 5 carbon sugar, phosphate group
- Structure
  - 1' attached to base, 5' attached to phosphate group, 3' attached to another nucleotide, antiparallel

- Base types & number of H-bonds
  - A-G: Purine - two rings
  - C-T: Pyrimidine - one ring
  - C-G: 3 h-bonds
  - A-T: 2 h-bonds
- RNA vs DNA
  - 2' extra OH in RNA; Single stranded; U instead of T

Chemical reactions in metabolic processes
- Breakdown/synthesis of products is called
  - Catabolism/anabolism(synthesis)

********** CELLS **********
Structure and functions of cell
- Basic structure
  - Plasma membrane (lipid bilayer) surrounds cytoplasm with suspended organells
- Plasma membrane composition
  - Lipd bilayer with integral and peripheral proteins, and cholesterol. Everything flows like fluid.
- What molecules may/may not pass freely across membrane?
  - Small, uncharged, polar & hydrophobic molecules may pass. H2O, O2, Hydrocarbons
  - Large, charged polar molecules may not pass. Charged particles, glucose
- Proteins of the plasma membrane
  - Channel proteins
    - Open passageway for certain hydrophilic molecules
  - Ion channels
    - Allow ions to pass
  - Porins
    - Allow passage of certain ions and small polar molecules. E.G. Aquaporins in kidneys for H2O
  - Carrier proteins
    - Binds to specific molecule and carry them across. E.G. Glucose
  - Transport proteins
    - Use energy to transport against gradient
  - Recognition proteins
    - Fingerprint of cell types
  - Adhesion proteins
    - Anchors cells with neighbor. Gives stability
  - Receptor proteins
    - Binding site for hormones or other trigger molecules
- Organells
  - Endoplasmic reticulum
    - Stacks of flattened sacs.
    - Rough: Ribosomes attach. Creates glycoproteins for secretion and cell membrane
    - Smooth: Synthesis of hormones, lipids, breakdown of toxins, drugs.
  - Golgi apparatus
    - Group of flattend sacs arranged like stack of bowls
    - Modify and package proteins and lipids into condensed transport vesicles.
  - Lysosomes
    - Acidic environment containing enzymes to breakdown food, cell debris, and foreign invaders.
  - Peroxisomes

Breakdown of substances including H2O2, fatty acids, and AA.
Common in liver and kidney cells in animals to break down toxins
Modify by-products of photorespiration in plants
Mitochondria
Carry out aerobic respiration
Chloroplasts
Carry out photosynthesis
Microtubules, intermediate philaments, microfilaments
3 protein fibers in decreasing diameter.
Microtubules
Composed of Tubulin; provide support and motility; foudn in spindle apparatus
Intermediate filaments
Support for maintaining shape of cell
Microfiliaments
Composed of actin. Provide cell motility.
Flagella & cilia
9+2 array of microtubules
Centrioles and basal bodies
Microtubule organizing centers (MTOCs).
Centrioles are located in centrosome. Give rise to microtubles that make up the spindle apparatus
Basal bodies are located at base of flgellum and cilium and appear to organize their development
Vacuoles and vesicles
Fluid filled, membrane-bound bodies
Vacuoles
Temporary receptacles of nutrients. Often merge with lysosomes to breakdown food
Transport vesicles
Move material between organells or plasma membrane
Sorage vacuoles
Store starch, pigments, toxic substances (e.g. nicotine) in plants
Central vacuoles
Large bodies occupying most of the interior of plant cells. Exert turgor (pressure) on cell walls.
Contractile vacuoles
Specialized organells in single celled organism that pump excess water out of cell
Extracellular region
Cell walls
Found in plants, fungi, and bacteria.
Extracellular matrix
Found in animals; occupied by fibrous structural proteins, adhesion proteins and polysaccharides
Cell junctions
Anchoring juctions
Desmosome (spot welding). Provide mechanical support and stability
Tight Junctions
Tightly stiched seams between animal cells. Provides a seal that prevent passage of materials btwn cell
communicating juctions

Gap junctions
Narrow tunnels btwn animal cells. No free exchange of cytoplasm except for ions
Plasmodesma
Narrow channels betwen plant cells. Allows for exhange of materials.
Movement of substances
Hypo/hypertonic
Refers to the concentration of ions. Hyper=high concentration. H2O will move from hypo to hyper
Bulk flow
Collective movement of substance in the same direction due to a force or pressure. E.G. blood flow
Passive transport
Movement of substance from higher to lower concentration
Simple diffusion
Net movement of substande from higher to lower concentration
Osmosis
Diffusion of water across selective permeable membrane
Dialysis
Diffusion of solutes across selective permeable membrane
Plasmolysis
Movement of water out of a cell that results in collapse
Facilitated diffusion
Diffusion of water or solutes through channel proteins
Active transport
Movement of solutes against gradient. ATP required.
Vesicular transport
Use vesicles to move macromolecules across plasma membrane
Exocytosis
Expel contents to the ouside of cell
Endocytosis
Phagocytosis
Engulfing undissolved materals into the cell
Pinocytosis
"to drink" dissolved materials enter the cell
Receptor-mediated
Form of pinocytosis. Occurs when specific molecules enter through binding of receptors

********** CELLULAR RESPIRATION **********

Overall equation
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36ATP$

Glycolysis
Glucose + 2ATP -> 2NADH + 4ATP + 2pyruvate; cytosol; anaerobic

Kerbs Cycle
2Pyruvate -> 2AcetylCoA + 2NADH + $2CO_2$
2AcetylCoA -> 6NADH, 2FADH, 2ATP, $2CO_2$

How many ATP per NADH & FADH?
- NADH = 3 ATP (2ATP if NADH needs to cross mito membrane)
- FADH = 2 ATP

Mitochondria
- Outer membrane
- Inner membrane
  - H+ ions accumulate btwn here and outer membrane
  - Has cristae and contain ETC protein complex.
- Matrix
  - Where Krebs cycle and pyruvate to acetylCoA occurs here

Chemiosmosis in Mito
- Definition
  - Mechanism of ATP generation from H+ concentration gradient
- Steps
  - NADH and FADH2 generated in matrix
  - Electrons removed from FADH2 and NADH; e- moves along ETC from one protein to the next
  - H+ ions transported from matrix to intermembrane space. Inc. [H+] in intermembrane space.
  - pH and electrical gradient is created.
  - ATP synthase generates ATP using the flow of H+ into matrix

Two types of phosphorylation
- Substrate level
  - Occurs when a phosphate group AND energy is donated by the substrate to ADP to form ATP.
- Oxidative phosphorylation
  - Occurs when a phosphate group is donated to ADP to form ATP, but the energy comes from the ETC.

Anaerobic Respiration
- Alcohol vs lactic acid fermentation: regenerates NAD+
- Alcohol Fermentation
  - Occurs in plants, fungi, and bacteria; 2ATP formed from 1 glucose
  - Steps
    - Pyruvate -> acetaldehyde + CO2 + NADH
    - Acetaldehyde + NADH -> EtOH + NAD+
- Lactic Acid fermentation
  - Occurs in animals; Pyruvate + NADH -> lactate + NAD+
  - Liver converts lactic acid back into glucose when ATP is available

********** PHOTOSYNTHESIS **********

Overall equation
- $6CO_2 + 6H_2O + light \rightarrow C_6H_{12}O_6 + 6O_2$

Noncyclic Photophosphorylation
- Generates NADPH & ATP. Uses P700 and P680
- Steps
  - Photosystem II. P680 energize two electrons

Two electrons passed to the primary electron acceptor
e- passed through electron transport chain
e- losses energy and generate ATP
Potosystem I. P700 energize the two electrons again
e- moved through a second ETC. The energy is used to move H+ into thylakoid
NADPH is generated from NADP+, H+, and 2 e-.
H2O -> 2H+ and 1/2O2 + 2e-; e- is regenerated

Cyclic Photophosphorylation
Generates ATP only. Uses P700 Photosystem I

Calvin cycle
"Fixes" CO2 by taking inorganic CO2 and incorportate into useful organic molecule
Overall reaction for each cycle of Calvin
1CO2 used. Therefore 6 cycles req'd to form 1 glucose
Steps
Carboxylation - 6CO2 + 6 RuBP -> 12PGA catalyzed with rubisco
Reduction - 12ATP + 12NADPH + 12 PGA -> 12G3P (PGAL)
Regeneration - 6ATP + 10G3P -> 6RuBP
Carbohydrate syntehsis - 2G3P -> 1glucose

Chloroplasts
Site of light dep and indep rxn
Double phospholipid bilayer - like mito.
Stroma
Calvin cycle takes place here
Thylakoid
Pancake-like membrane. Site of light-dependent rxn
Grana
Stacks of thylakoid
Thylakoid lumen
H+ accumulates here

Chemiosmosis in chloroplasts
Mechanism of ATP generation from proton gradient. Similar to mito ATP generation
Steps
H+ ions accumulate inside thylakoids from splitting of H2O
ATP synthase generate ATP from H+ gradient

Photorespiration
"Fixing" of O2 with RuBP catalyzed with rubisco
Competing reaction with calvin cycle due to rubisco non-specificity
A waste product which is borken down by peroxisomes inside thylakoid

C4 photosynthesis
Compartimentalize CO2 from O2. Increase rubisco efficiency

CAM photosynthesis
Desert plant adaptation to allow for photosynthesis during the day when the stroma is closed.

Note: normal plants open their stroma during the day to allow CO2 in. Desert plant require closed to save H2O

********** CELL DIVISION **********

Two phases
- Nuclear division - occurs first, division of genetic material
- Cytokinesis - division of cytoplasma

Mitosis
- Prophase
  - Nucloid disappear & chromatin condense into chromosomes
  - Nuclear envelope disappears
  - MItotic spindle assemble. MTOC forms and segragate to opp side of cell. Microtubule connects to kinetichore
- Metaphase
  - Chromosomes line up at metaphase plate.
- Anaphase
  - Chromosmes separate and migrate towards the MTOC
- Telophase
  - Nuclear envelope reappears. Chromosome disperase into chromatin. Nucleoid reappear

Cytokinesis
- Plants
  - Forms cell plate from golgi bodies
- Animals
  - Forms cleavage furrow
  - Circular micro filaments decrease in radius and pulling the cell membrane inwards

Meiosis
- Gemetophyte
  - Multicellular haplid structure. Produces haploid gametes via mitosis

Regulation fo cell cycle
- surface to volume ratio
  - Proper maintenance of extracellular communication limits the ratio
- Genome to volume ratio
  - Limited genome products limits the ratio
- Checkpoints
  - G1 checkpoint:
    - end of G1. Determines whether cell should divide
  - G2 :
    - End of G2. Evaluate accuracy of DNA replication
  - M :
    - checks proper attachment of micro tubule to all kinetichore
  - Cdk's:
    - Phosphorylates cell cycle regulation proteins
  - Growth factors:
    - stimulates cell division

Density-dependent inhibition:
may cells stop dividing when neighbors reach a certain density
Anchorage dependence:
Most cell only divide when anchored to adjacent cell or flat surface

********** HEREDITY
****

Incomplete dominance
Phenotype expressed is a combination of the two alleles. E.G. pink flower from red and white alleles

Codominance
Both genotype expressed. E.G. Blood type

Multiple Alleles
Phenotye is a combination of multiple alleles. E.G. blood type. i, IA, IB

Epistasis
One gene affects the pheotypic expression fo a second gene. E.G. Pigment. One gene turn on/off pigment.
Another controls the amount or color of pigment

Pleiotropy
Occurs when single gene has more than one phenotypic expression.

Polygenic inheritance
Coninuous varieties of phenotype. E.G. height

Linked genes
Genes that reside on the same chromosome. Segragates dependently

X-inactivation
One of two X chromosomes in each cell does not uncoil creating a barr body.
Thus, 1/2 of the cells express one X while the other half express the other
E.G. Calico cats

Human genetic defects
Point mutation
singel nucleotide in DNA of gene is incorrect
Aneuploidy
A genome containing extra or missing chromosomes. Often caused by non-disjunction
Chromosome aberrations
Changed chromosome segment
Dulication: a segment of chromosome is repeated
Inversion: a segment of chromosome is inverted
Translocation: a segment of chromosome is moved to another chromosome

********** MOLECULAR GENETICS
****

Replication

Semiconservative replication
Bidirectional
Reads 3' to 5', but synthesizes the complimentary strand 5' to 3'
Steps:

1. Helicase unzips the double helix;
2. RNA Polymerase builds an RNA primer;
3. DNA Polymerase assembles the leading and lagging strands;
4. the primers are removed;
5. Okazaki fragments are joined by DNA ligase

Telomerase: repeated 6 nucleotide units that protects chromosomes from being eroded through multiple replication.

Mutations
Silent
New codon codes for the same AA.
Missense
New codon codes for a different AA
Nonsense
New codon codes for a stop codon

DNA organization
Euchromatin
Region where DNA is loosely boudn to nucleosomes. Active transcription
Heterochromatin
Region where DNA is tightly compacted and inactive

Bacterial gene regulation
Operon
Unit of DNA that control gene expression
Components
Promoter - Place where RNA pol attach to begin transcription
Operator - Region that can block action of RNA pol if bound by repressor
Structural genes - codes for desired genetic product
Regulatory genes - codes for repressors or activators for the operon

********** MOLECULAR GENETICS **********

Lamarkian
Inheritance of acquired characterists - inheritance based upon use or disuse. Wrong.

Darwin
Natural selection. Survival of the fittest.

Homologous strcture
Body parts that resemble one another in different species due to same origin. May look different.
E.G. forlimbs of cats, dogs, whales, human.

Analogous structure
Independent adaptation to same environment. E.G. body shape and fins of sharks, pinguin, dolphins

- Natural selection
  - stabilizing selection
    - Favor middle instead of extremes
  - Directional
    - Favors one extreme out of a set of extremes
  - Disruptive selection
    - Enviornment favors extremes instead of common trait.
  - Sexual selection
    - Differences btwn male vs female

- Speciation
  - Allopatric
    - Geographic isolation
  - Sympatric
    - Non-geographic isolation
  - Adaptive radiation
    - Rapid evolution of many species from single ancestor

- Maintaining reproductive isolation
  - Mechanisms that prevent gene flow
  - Prezygotic isolating mechanism
    - Mechanism that prevent fertilization
    - Habit isolation
      - Occurs when species do not encounter on eanother
    - Temporal isolation
      - Occurs when species mate or flower during different seasons or a different time of the day
    - Behavioral isolation
      - Occurs when species do not encounter one another due to mating rituals, signals, etc
    - Mechanical isolation
    - Genetic isolation
  - Postzygotic isolating mechansim
    - Mechanism that prevent the formation of fertile progeny
    - Hybrid inviability
      - Occurs when zygote fails to develop properly and aborts
    - Hybrid sterility
      - Occurs when hybrids become functional adults but are steril
    - Hybrid breakdown
      - Occurs when offsping tha thave reduced viability or fertility

- Patterns of evolution
  - Divergent evolution
    - Two or more species that originate from common ancestor and becomes different over time
  - Convergent evolution
    - Two unrelated species converge together due to environmental factors
  - Parallel evolution
    - Two related species make similar adaptation after diverging from same ancestor
  - Coevolution
    - Two or more species evolve together, responding to each other's new feature

Macroevolution
Describes patterns of evolution for groups of species over extended period fo geologic time
Phyletic gradualism
Argues that evolution occurs by gradual accumulation fo small changes over long periods of time
Punctuated equilibrium
Argues that evolutionary history consists of long periods of stasis with little change puncutated with
short, rapid evolution

Origins of life
Primorial soup -> complex molcules -> polymers -> isolation of organic molecules in cells (protobionts) ->
Heterotrophs -> autotrophs -> O2 & ozone -> Eukaryotes.

********** BIOLOGICAL DIVERSITY **********

Eukaryotic cells characteristics
Linear DNA in histones
Nucleous
Distinct organells
Flagella & cillia in 9+2 arrangement

Prokaryotic cells
Single circular chromosome
NO nucleous
No organells
Flagella composed of flagellin

Domain Archaea
Prokaryotes
Distinct characteristics
Cell walls and plasma membrane contain distinct polysaccarides NOT peptidoglycans, clluose, or chitin
Plasma membrane is distinct from prok. or euk.
Similarity to eukaryotes
DNA associates wiht histones
Ribosome not inhibitied by antibiotics targeted towards bacteria
Methanogens (produce methane); extremophiles - halophiles (salt lovers), thermophiles (heat lovers)

Domain Bacteria
Distinct features
peptidoglycan cell wall
DNA bare, not associated with histones
Ribosome activity inhibited by streptomycin and chloramphenicol
Common groups of bacteria
Cyanobactera
Photosynthetic bactera, blue green algae
Nitrogen fixing bacteria

Many are mutualistic with plants to fix nitrogen
Spirochetes
Coiled bactera that moves with a corkscrew motion

Domain Eukarya
Kingdom Protista
Algaelike
Obtain energy by photosynthesis.
Types
Euglenoids - 1 to 3 flagella.
Dinoflagellates - 2 flagella. Some bioluminescent. Others produce toxin concentrates in shellfish.
Diatoms - have silica shells that fit together like box with lid
Brown algae - Kelps
Rhodophyta - red algae.
Chlorophyta - green algae.
Protozoa
Animal like protists.
Types
Rhizopoda - amoebas that moves by extending pseudopods
Foraminifera - made up of calcium carbonate
Apicomplexans - parasites of animals.
Ciliates - move with cilia. E.G. paramecium
Fungus-like
Similar to fungus. duh.
Types
Slim molds - plasmodial or cellular.
Oomycota - water molds, mildew, whit rusts. Form filaments, lack septa so they are coenocytic
Kingdom Fungi
Growth
Grows as filaments called hyphae.
Mycelium
Mass of hyphae
Coenocytic
Some lack septa, so they are multi nucleated.
Sexual reproduction steps
Predominantly haploid, but forms diploid during sexual reproduction
Plasmogamy - fusion of cells from two different fungal strain to produce single cell with two nuclei
Karyogamy - fusion of two haploid nuclei of dikaryon to form single diploid nucleus
Meiosis - diploid nucleus restores to haploid condition. Germinates and forms haploid hyphae
Asexual reproduction
Spores
Sporangiospores - produced in sacklike capsules
Conidia - formed at tips of specialized hyphae, not enclosed in a sack
Types
Zygomycota - lack septa. Reproduce sexually. Bread mold
Glomeromycota - mutualistic relationship with roots of plants

- Ascomycota - have septa. Yeast, truffles
- Basidiomycota - have septa. Mushrooms
- Deuteromycota - imperfect fungi. artificial group. Penicillium
- Lichens - Mutualistic relationship btwn fungi and algae.

Kingdom Plantae

- Bryophytes
  - Moss, liverwarts, hornworts
  - Gametophytes.
  - Male antheridium produce flagellated sperm that swim to fertilize female archegonium
- Tracheophytes
  - Seedless plants
    - Lycophyta - club moss.
    - Pterophyta - ferns
  - Seeded plants
    - Microsprangium - produce male spores
    - Macrosprangium - produce female spores
    - Gymnosperms
      - Coniferophyta. Cone bearing. Pine, fir, spruce, juniper, cedar, etc
    - Angiosperms
      - Anthophyta. Flowering plants.
      - Female reproductive system
        - Pistil - made from overy, style, and stigma
      - Male reproductive system
        - Stamen - made from anther, stalk, and filament
      - Sepals - aka petals. Function to attract pollinators

Kingdom Animalia

- The coelom
  - Fluid filled body cavity arising from the mesoderm
  - Acoelomates
    - Primitive animals that have no coelom.
  - Psudocolomates
    - Nematoes
  - Coelomates
    - Animals having coelom
    - Protosomes
      - 1st opening forms the mouth
    - Deuterostomes
      - 1st opening forms the anus. 2nd forms the mouth.
- Porifera
  - Sponges
  - Water drawn through spongocoel by coenocytes (cells having cillia).
  - Amoebocytes takes food from coenocytes and distributes them.
  - Water exits through osculum.
- Cnidarians
  - Jellyfish, corals, hydrozoans, sea anemones
  - Two body forms - medusa (floating umbrella-shaped body typical of jellyfish) or polyp (sessile cylinder shaped)
  - Acolomates.
  - Cindocytes - stinging cells

- Platyhelminthes
  - Flatworms such as tapeworm
  - Acolomates
  - 3 layer cells
  - true tissues and organs
  - One opening for both digestion and ingestion
  - Flat to increase surface area for O2 exchange
- Nematoda
  - Round worms
  - Protostomic psudocolomate
  - Many are parasitic. E.G. Trichinella from uncooked pork
- Annilida
  - Earth worms, leeches
  - Protostomic cholomate
  - Open circulatory system
  - Contains nephridia which expells nitrogenous waste
- Molluska
  - Snails, cuttlefish, squid, octopus
  - Largest class
  - Visceral body contains organs
  - Open circulatory system with large opening called hemocoel
  - Protostomic colomate
- Arthropod
  - Insects, spiders
  - Chitin exoskeleton
  - Jointed appendages
  - Malpighian tube to remove Nitric acid waste
  - Open circulatory system
  - protostomic colomate
- Echinoderm
  - Starfish, sea urchins, sand dollars
  - Deuterostomic colomate
  - Radial symmetry
  - Regenerates lost limbs
- Chordate
  - Deuterostomic colomate
  - Dorsal hollow nerve cord
  - Pharyngeal gill slits
  - Notochord arised from mesoderm
  - Tail

********** PLANTS **********

Di vs monocots

- Dicots
  - 2 cotyledons (storage tissue that provide nutrients to teh developing seedling)
  - Netted leaf venation
  - Circular vascular bundles (xylem and phloem) in stems
  - Taproot (single large root)
- Monocots

1 cotyledons
Parallel leaf venation
Scattered vascular bundles
Fibrous root (cluster of many roots)

Plant tissues

3 distinct groups

Ground tissues

Parenchyma - most common. Thin walls. Storage, photosynthesis, secretion
Collenchyma - thick but flexible cell walls. Mechanical support
Sclerenchyma - thick cell walls. Mechanical support

Dermal tissues

Epidermis cells that cover the ouside of plant parts. Guard cells, hair cells, stinign cells, glandular cells

Vascular tissue

Xylem and phloem. usually occurs together in vascular bundle
Xylem - water and mineral conduction. Secondary cell wall to give additional strength
Phloem - conduction of sugars.

The seed

Parts of the seed

Epicotyl - top portion of the embryo
Hypocotyl - becomes the young shoot
Cotyladon - endosperm (major storage material) E.G. Peas have two halves so they are dicots

Germination and development

imbibtion (absorption) of water swells and cracks the seed cloat.
Growth occurs at the tip of roots and shoots called apical meristems

For roots

Meristematic cells actively divide protected by root cap.
Zone of cell division - actively dividing cells of the meristem
Zone of elongation - elongation of tip. Perception of growth occurs due to this region
Zone of maturation - forms xylem, phloem, parenchyma (epidermal cells)

For shoots

Same as for roots, except for lack of root cap

Primary vs seondary growth

Primary

Growth occuring at the apical meristems. Increase length of shoot or root. E.G. primary xylem, phloem

Secondary

Growth that increase the girth.
Vascular cambium and cork cambium responsible for growth. Makes secondary xylem and phloem

Primary structure of roots

Epidermis

Lines the outside surface of root.
Protection and absorption (may increase absorption by producing root hairs)

Cortex

Bulk of the root. Storage of starch

Endodermis

Ring of tightly packed cells at th einnermost portion of cortex.
Contains casparian strip around the packed cells to control water flow into, but not out of the

cortex
- Vascular cylinder
  - Tissues of the endodermis. Xylem, phloem, endodermal cells

Primary structure of the stem
- same as root, except for lack of casparian strip, instead cutin forms in the epidermis for protection

Leaf structure
- Epidermis
  - Protective covering covered by cuticle (protective layer consting of waxy material cutin). Reduce H2O loss
- Palisade mesophyll
  - Cells with large surface areas specializing in phorosynthesis
- Spongy mesophyll
  - Paranchyma cells with numerous intercellular space that provide air chambers for CO2 and O2 exchange
- Guard cells
  - Specialized epidermal cells that control opening and closing of stomata (opening allowing for gas exchange)
- Vascular bundles
  - "leaf veins" Composed of xylem, phloem, bundle sheath cells

Water transportation
- Osmosis
  - From soil through root and into xylem cells. Too small for significant contribution to water movement
- Capillary action
  - Comes from adhesion forces. Small contribution
- Cohesion-tension theory
  - Transpiration
    - evaporation of water from plant leaves create negative pressure to pull water up
  - Cohesion
    - Btwn water molecules to create a polymerlike water train from root to leaves
  - Bulk flow
    - One water molecule evaporatin from leaves pull a "train" of water upwards

Stomata control
- When stomata are open CO2 may enter, but plant risk desiccation from transpiration. Two guard cells controls the opening
- Close when temp are hihg
- Open when CO2 low inside leaf allows for photosynthesis to continue

Sugar transportation
- Tranlocation
  - movement of carbs through phloem from a source (leaves) to a sink
- Sugars enter sieve-tube members
  - Active transport of soluble sugars into phloem sieve-tube member of phloem
- Water enters sieve-tube members
  - Osmosis occurs to move water into the sieve-tube member
- Pressure increase
  - Pressure inside sieve-tube member increase becasue cell wall is rigid. Water and suger moves via bulk flow
- Pressure reduced at sink
  - Active transport of sugar out of sieve tube member decrease osmolarity. Water diffuse out,

dropping pressure
- Sink vs source
  - depends on which cell is converting sugar -> starch and vice versa. Starch is not soluble vs sugar is.
  - Sink = sugar -> starch
  - Source = starch -> sugar

Plant hormones
- Auxin (IAA)
  - promote plant growth by facilitating elongation of developing cells
- Gibberlins
  - Promote cell growth, flowering, stem elongation
- Cytokinins
  - Promote cytokinesis (cell division)
- Ethylene
  - Promote fruit ripening
- Abscisic acid (ABA)
  - Growth inhibitor

Plant response to stimuli
- Phototropism
  - Light response
- Gravitropism (aka geotropism)
  - response to gravity
- Thigmotropism
  - Touch. E.G. climbing plants

Photoperiodism
- Response due to change in phtoperiod (length of day/night)
- Phytochrome is involved
- Flash of red during night will reset plant clock. Brief period of night during day have no effect

********** ANIMAL FORM AND FUNCTION **********

Thermoregulation
- Two groups of animals based upon thermoregulation
- Ectotherms
  - Animals that obtain body heat from environment. E.G. invertebrates, reptiels, fish
- Endotherms
  - Animals that generate own body heat
- Mechanisms of temp regulation
  - Cooling by evaporation
  - Warming by metabolism
  - Adjust surface area to regulate temp

The respiratory system
- Direct with environment - Small animals w/ large surface area. O2 exchange directly. E.G. Platyhelmenthes
- Gills - E.G. Internal gills in fish using countercurrent exchange. External gils on Annelida.
- Tracheae - Insects have chitin lined trachaea opening on spiraclees
- Lungs
- Human control of respiration

Chemoreceptors monitor [H+] in the carotid arteries.

Circulartory system
- Open circulatory system
  - Pump blood into an internal cavity called hemocoel which tissues are bathed in. The fluid is called hemolymph.
  - Insects and mollusks
- Closed circulatory system
  - Blood is confined to vessels.
  - Annelida, certain mollusks such as octopuses and squids, and vertebrates

Excretory system
- Marine fish
  - Hypoosmotic relative to environment. Water constantly lost by osmosis.
  - Constantly drink, rarely urinate, and excrete accumulated salts through gills
- Fresh water fish
  - Hypoosmotic relative to environment. Water constantly diffuse into fish.
  - Rarely drink, urinate constantly, and absorb salts through gills
- Types of excretory system
  - Contractile vacuoles
    - Found in cytoplasm of protists. Release water into environment by exocitosis.
  - Flame cells (protonephridia)
    - Platyhelminthes.
  - Nephridia
    - Annelids.
  - Malpighian tubules
    - Arthropods. Nitric acid solid waste.
  - Kidney
    - Ammonia -> Urea. Less toxic, require less H2O to excrete.

Digestive system
- Mouth
  - Salvary amylase. Starch -> maltose.
  - Mechanical breakdown
- Pharynx
  - Epiglottis blocks trachea so bolus can pass
- Esophagus
  - Peristaltis moves bolus into stomach
- Stomach
  - Stores food so we can eat less often
  - Mixes food with gastic juice
  - Physical breakdown
  - Chemical breakdown
    - Pepsinogen -> Pepsin - break down proteins
    - Pepsin may cause peptic ulcers if mucus membrane breaks down
- Small intestine
  - Duodenum -> Ilium -> Jijunum
  - Duodenum digests food.
  - Walls contain many digeestive enzymes such as maltase, lactase, aminopeptidase, and phosphatase

(nucleotide digest)
- Pancrease
  - Trypsin, chymotrypsin (proteases)
  - Lipase (fat digestion)
  - Pancreateic amylase (starch digestion)
  - These along with bicarbonate solution to neutralize food digest from stomach
- Liver
  - Bile - emulsifies fat. Does not digest food. Stored in gall bladder and released as necesary.
- Ilium and Jijunum
  - Absorbs the digested food through villi and microvilli
  - AA, sugar, and nucleotides are absorbed into the bood capillaries
  - Fatty acids and glycerol absorbed into the lymph system
- Large intestine
  - Reabsorb water to form solid waste
- Hormones invoved in digestion
  - Gastrin
    - Produced by cells of the stomach lining when food enters the stomach or stimulated by smell. Stimulate gastric juice production
  - Secretin
    - Produced by cell lining of the duodenum when food enters. Stimulate bicarbonate production
  - Cholecystokinin
    - Produced by small intestine in the presence of fats. Stimulates bile release and pancrease enzymes.

Nervous system
- Nerve impulse
  - Resting
    - Na/K pump constantly pumps 2K in and 3Na out of cell. K/Na leaks through cell. In equilibrium. Negative potential
  - Action potential
    - Threshold reached, Na channels flood in, cell potential spike into the positive, polarizing cell. All or nothing event
  - Repolarization
    - K channels open in response to polarizatoin. K floods out, repolarizing the cell. Na channels close.
  - Hyperpolarization
    - K channels open too long, the cell potential becomes less negative than resting.
  - Refractory period
    - Period of time where stimulus will not trigger an action potential
- Myelin
  - Insulation for neurons.
  - Created by Schwann cells in PNS and oligodendrocytes in CNS
  - causes saltitory conduction, increase transmission speed.
- Synaptic cleft and signal transduction
  - Calcium gates open on the presynaptic cleft
  - synaptic vesicles release neurotransmitter via exocytosis
  - Neurotransmitter binds with postsynaptic receptors
  - Postsynaptic membrane is exited or inhibited
    - If Na+ channels open -> excitatory postsynaptic potential (EPSP)

- If K+ channels open -> inhibitory postsynaptic potential (IPSP)
- Neurotransmitter is degraded and recycled
- Nervous system composition
  - Central nervous system
    - Brain, spinal cord
  - PNS
    - Sensory neurons and motor neurons
    - Two divisions of motor neurons
      - Somatic nervous system
        - Directs contraction of skeletal muscles. Voluntary
      - Autonomic nervous system
        - Controls activitiees of organs and other involuntary muscles
        - Two divisions of ANS
          - Sympathetic
            - Fight or flight
          - Parasympathetic
            - Rest or digest

Muscular system

- Sarcolemma
  - Plasma membrane of the muscle cell. Highly invaginated by transvers tubules (T tubules)
- Sarcoplasm
  - Cytoplasm of the muscle cell. Contain Ca++ storing sarcoplasmic reticulum.
- Myofibrils fill nearly the entire volume of the muscle cell
  - Composed of two types of fillaments
  - Thin filament
    - Two strands of actin in a double helix
    - Troponin with Ca++ binding sites dot the length of tropomyosin
  - Thick filament
    - groups of filamentous protein myosin with protuding head
- Muscle contraction
  - ATP bind to myosin head and forms ADP + Pi. Head is cocked and ready for binding
  - Ca++ expose binding site on actin
  - Myosin head bind to actin
  - ADP released, head position moves to resting state, sliding the filaments past each other
  - ATP bind to head, causing release of cross bridge
- Neuromuscular juction
  - Steps of muscle stimulation
  - Action potential release acetylcholine into neuromuscular junction
  - Action potential generated on sarcolemma and throughout the T-tubules
  - Sarcolasmic reticulum release Ca++
  - Myosin bridge form
- Muscle types
  - Skeletal
    - Attached to bones. Multinucleated. Striated
  - Smooth
    - Involuntary non striated. Mononucleated
  - Cardiac
    - Involuntary striated. Multinucleated.

Highly branched, connected by gap junctions.
Ca++ required. Causes longer contraction

Immune system
First line of defense
Skin - physical barrier of all invading organisms
Antimicrobial proteins - contained in saliva, tears, and other mucous membranes
Cilia - line the lungs to sweep microbes out
Gastric juice - kills most microbs
Symbiotic bacteria - in digestive tract and vagina to outcompete invading microbes
Second line of defense
Phagocytes
WBC that engulfs pathogens via phagocytosis. Nutrophils. Monocytes turns into macrophages.
Natural killer cells kill abnormal body cells or pathogen infected cells
Complement
Proteins that complement defense reactions. Help attract phagocytes and promote cell lysis.
Interferons
Substance secreted by cells invaded by viruses. Helps neighbors to produce anti viral proteins
Inflammatory response
Series of non-specific events that occure in reponse to pathogens
Sequence of events
Histamine released by basophils
Vasodialation increase blood supply to damaged area
phagocytes attracted to injury by chemical gradient
Complements help phagocytes to engolf foreign body
Third line of defense
Targets specific antigens (any substance that can be identified as foreign: toxin, bacteria, virus, etc)
Major histone complex
Collection of glycoproteins that exist on cell membranes of all cells that identify self-cells.
Unique among individuals. Coded by 20 genes. Extremely unlikely that two people will posess same set of MHC
Two major kinds of lymphocytes
B cells
Originate adn mature in the bone marrow (B is for bone)
Generate antibodies
Antibodies are proteins
Each antibody indentifies one antigen
5 types: M,A,D,E,G
Inactivate antigens by binding to them followed by phagocytosis.
Once B cell encounter antigens that it recognize, it proliferates into two cells with the help of T-helper
Plasma cells
Actively manufactures antibodies
Memory cells
Long-lived B cells that remembers and quickly react to subsequent infection of the antigen
T cells
Lyumphocytes that originate in bone marrow and mature in the Thymus gland (T for thymus)

- Receptors on plasma membrane recognize sites for nonself cells
- Recognition of self cells
  - MHC markers on plasma membrane of cells
  - Cells display random markers on surface. T cells react to potential foreign proteins
- When activated
  - Divide into two type of cells
    - Cytotoxic T cells (aka killer T cells) - lyse nonself cells
    - Helper T cells - stimulate proliferation of B cells and cytotoxic T cells
- Two types of reaction
  - Cell-mediated response
    - T cells responds to nonself cells
      - T cells produce cytotoxic T cells that destroy nonself cells
      - T cells produce helper T cells
        - Bind to macrophages that engulfed nonself cells
        - Produce interleukins "between leukocytes" to stimulate production of T and B cells
  - Humoral response
    - Involves responding to antigens that are ciruculating the body
    - B cells produce plasma cells to create antibodies
    - Helper T cells stimulate B cell production

Endochrine system

- Produce hormones that help maintain homeostasis and regulate reproduction and development
- Posterior pituitary
  - Peptide hormones. Stores the followin hormones.
  - ADH (increase water retention in collecting tubule)
  - Oxytosin (increase uterine contraction during labor and milk let down)
- Anterior pituitary
  - Peptide hormones
  - ACTH (adrenal cortcotropic hormone) stress response to stimulate increase in blood glucose
  - LH
  - FSH
  - TSH (thyroid stimulating hormone) stimulates thyroid
  - Prolactin (production of milk)
- Hypothalamus
  - Produce ADH and Oxytosin
  - Produce GnRH (gonatoropin releasing hormone)
- Adrenal cortex
  - Steroid hormones
  - Mineral corticoids
    - Aldosterone
  - Glucocorticoids
    - Cortisol - increase blood glucose
- Pancrease
  - Peptide hormones
  - Insulin - decrease blood glucose (beta islet cells)
  - Glucacon - increase bood glucose (alpha islet cells)
- Adrenal medulla
  - Tyrosine derivative, catecholamines
  - Epinephrine and norepinephrine

- Thyroid
  - Tyrosine derivatives
  - T3 (triiodal..), T4(thyroxine)
  - Calcitonin (Decrease blood Ca++ level)
- Parathyroid
  - PTH (increase blood Ca++ level)

********** ANIMAL REPRODUCTION AND DEVELOPMENT **********

Primary sex characteristics
- Structures directly involved in reproduction - testes, ovaries, etc.

Secondary sex characteristics
- E.G breasts, hair distribution, body shape, antlers in deer, mane in lion

Human reprodution anatomy
- Female
  - Ovary, oviduct (fallopean tube), Uterus, vagina
- Male
  - Testies
    - contains seminiferous tubules and leydig cells to produce testosterone
  - Epididymis
    - coiled tube attached to each testies that act as a final maturation site of sperm
  - Vas deferens
    - Two tubes transfers sperm from epididymis to urethra
  - Seminal vesicles
    - Two glands secrete mucus, fructose, and prostagladins (stimulate uterine contraction)
  - Prostate gland
    - Secrete milky fluid into urethra to neutralize acidity of urine and vagina
  - Bulbourethra glands (aka cowper's glands)
    - Two glands secrete unknown fluid into urethra
  - Penis

Sperm composition
- Sperm head
  - Contain DNA
  - Tip of head contains acrosome, a lysosome containing hyaluronidase to digest zona pallucida.
- Midpiece
  - 9+2 microtubule array. lots of mitochondria for energy production
- Tail
  - Remainder of flagellum

Gemetogenesis in humans
- Oogenisis
  - Primary oocyte arrested at prophase I until puberty
  - One primary oocyte per cycle continues to secondary oocyte (arrested at metaphase II)
  - Granulosa cells secrete zona pellucida around primary oocyte
- Spermatogenesis
  - Spermatogonia divide by mitosis to produce primary spermatocyte
  - Primary spermatocyte begin meiosis
  - Sertoli cells in semeiniferous tubule provide nurishment as they mature into sperm

Leydig cells produce testosterone, a necessary hormone for sperm production

Hormonal control of human reproduction
- Steps
  - Hypothalamus monitor estrogen and progesterone in negative feedback fashion. Low level stimulate GnRH production
  - Anterior pituitary produce FSH and LH stimulated by GnRH
  - Follicular stage
    - FSH stimulates development of follicle development
    - Follicle secrete estrogen (estradiol)
    - Rising estrogen stimulate LH spike from anterior pituitary
    - Endometrium thickens due to estrogen and progesterone
  - Ovulation stage
    - Ovulation occurs due to LH spike.
  - Luteal stage
    - Secretion of estrogen and progesterone by follicle (now called corpus luteum)
    - Endometrium thickens due to estrogen and progesterone
  - Hypothalamus and anterior pituitary terminates cycle via negative feedback
  - Corpus luteum disintegrates due to low levels of FSH and LH
  - Endometrium disintegrates in the absense of estrogen and progesterone secreted by corpus luteum.
  - If embryo implants, HCG is secreted which maintains the corpus luteum.

Embryonic development
- Fertilization
  - Recognition
    - Sperm recogize zona pellucida to ensure proper reproduction
  - Penetration
    - Plasma membranes of sperm and egg fuse. Sperm nucleus enters oocyte
  - Formation of fertilization membrane
    - Ca++ mediated polarization of membrane blocks polyspermy
  - Completion of meiosis II in secondary oocyte
    - In humans, penetration triggers meisis II.
  - Fusion of nuclei and replicaton of DNA
    - Fusion of nuclei, forming a zygote.
- Cleavage
  - Series of divisions without cell growth.
  - Embryo polarity
    - Animal pol and vegetal pol.
  - Polar and equatorial cleavages
    - Polar - divide egg into segments that stretch from pole to pole
    - Equatorial - parallel cleavages with the equator
  - Raidal and spiral cleavages
    - Deuterostomes - radial
    - Protostomes - spiral
  - Indeterminate adn determinate cleavages
    - Deuterostomes - radial cleavage usually inderterminate
    - Protstomes - spiral cleavage usually derterminate
- Morula
  - Solid ball of cells with 8 or more cells

Bastula

Liquid filled cavity ball of cells. The fluid filled cavity is called blastocoel.

Gastrula

Gastrulation forms gastrula. group of cells invaginate, forming two layerd embryo with a central cavity.

3 germ layers

a 3rd cell forms between inner and outer layer of invaginated embryo

Archenteron

Center cavity formed by gastrulation. Primitive gut

Blastopore

The opening into the archenteron. Becomes the mouth in protosomes. Or becomes the anus in deuterostomes.

Extraembryonic membrane development

Outside of the embryo proper. In birds, reptiles, and humans

Chorion

Outer membrane. Implants into endometrium. Combines with maternal tissue to form placenta.

Exchange gas, nutrients and waste.

Allantois

Begins as sac that buds off from archenteron. Eventually encircles the embryo, forming a layer below chorion

Eventually forms the embillical cord to transport gas, nutrients, and waste btwn embryo and placenta

Amnion

Encloses amniotic avity. Cushins and protect developing embryo

Yolk sac

Degests enclosed yolk in birds and reptiles

In mammals, yolk sac is empty

Organogenesis

Development of tissues and organs

Notochord

Derived from the mesoderm. Stiff rod that provide support for lower chordates

Neural tube

A layer of cells from ectoderm directly above the notochord forms the neural plate

The neural plate indents forming the neural groove

The neural groove rolls up into a cylinder and forms the neural tube, forming the CNS

Important differneces of specific species.

Frog

Gray crescent

A grey crescent region derived from reorganizatin of the cytoplasm where the sperm penetrates the egg.

An experiment done showed that individual cells will develop into a frog if and only if parts of

the gray cresent is attached to the cell.

Bird

Blastodisc

blastulation in birds

Primitive streak

Flattened disk where gastrulation occurs, instead of a round blastopore

Humans and most other mammals

Blastocyst
The blastocyst consts of two parts -
Trophoblast
outer ring of cells
Produce HCG
Embed into endometrium of uterus
Forms the chorion which develops into the placenta
Inner cell mass "embryoblast"
inner mass of cells clusters at one ole and flattens into the embryonic disc
Analogous to blastodisc of birds and reptiles where gastrulation occurs

********** ANIMAL BEHAVIOR
****
Kinds of behavior
Instinct
Mammals taking care of offspring
Fixed action pattern
Innate behavior that once triggered, will follow to completion. E.G. herding pattern
Imprinting
Innate programming of behavior if stimulus is experienced during critical period. E.G. gosling imprinting on mom
Associative learning
Classical conditioning - where animal performs a behavior in resopnse to a substitute stimulus rather than
the normal stimulus
Trial-and-error learning
Operant conditioning - where animal learns by feedback from environmental response (positive or negative)
Spatial learning
type of associate learning. associate spacial ques with return to an importatnt location. E.G. nest
Habituation
Repeat stimulus decreases response
Observational learning
Animal copy behavior of another without experiencing positive reinforcement beforehand
Insight
Animal exposed to new behavior uses prior experience to gain desirable outcome
Social behavior
Agonistic behavior
Most are ritualized aggression and submission to reduce injuries and time
Dominance hierarchies
Indicate power and status in a group
Territoriality
Active posession and defense of a region of space
Altruistic behavior
Risk of self to help another. Seemingly unselfish, but most increase fitness of the group as a whole.

********** ECOLOGY
****

Population
- Group of same species living in the same area

Community
- Group of populations living in the same area

Ecosystem
- Inerrelationships between organisms and environment

Biosphere
- All regions of the earth that contain living things

Habitat
- Type of place where an organism lives

Niche
- Describes all the biotic and abiotic resources in the environment that an organism uses.

Population ecology
- Dispersion
  - Describes how individuals in a population are distributed
- Age structure
  - Abundance of individuals of each age
- Survivorship cuves
  - Describes how mortality of individuals in a species varies during their lifetime

Population growth
- Biotic potential
  - maximum growth rate of population under ideal conditions
- Carrying capacity
  - maximum number of individuals of a populatin that can be sustaned by a particular habitat
- Limiting factors
  - Factors that limit population from reaching biotic potential
  - Density-dependent factors
    - Limiting effects becomes more intense as population density increase. E.G. predation, resource.
    - K selecttion do better due to competition
  - Density-independent factors
    - Factors that occur independently of the density of populatin. E.G. flood, extreme climate
    - R selection do better due to quick reproduction

Symbiosis
- Mutualism
  - both species benefit
- Commensalism
  - One species beneft whie the other is neither helped nor harmed
- Parasitism
  - One specie benefit while harming the other

Coevolution
- Contests between predator and prey evolve together to outcompete each other
- Secondary compounds
  - Toxic chemicals in plants to discurage herbivores
- Camouflage
  - Blending in of color & pattern with surrounding
- Aposematic coloration
  - Warning coloration

- Mullerian mimicry
  - Two or more species with some special defense mimic each other's coloration
- Bastesian mimicry
  - An animal wihtouth any special defense mimics coloration of animal with special defense

Ecological succession
- Taking over a community over time. Eventually a climax community is reached. (equilibrium)
- Pioneer species
  - Initial plant and animals to inhabit a newly exposed community. Lichen, r-selected insects, etc.
- Two types
  - Primary succession
    - Occurs on substrate that never before previously supported living things
  - Secondary succession
    - Occurs in communities that was partially destroyed by some kind of damaging event such as flood, fire, etc

Ecosystems
- Primary producer
  - Autotrophs such as Plants, photosynthetic protists, cyanobacteria
- Primary consumer
  - Herbivores
- Secondary consumer
  - Eat primary consumer
- Detritivores
  - Consumers that obtain energy by consuming dead plants and animals

Biogeochemcial cycles
- Hydrologic cycle
  - Reservoir - ocean, air, galciers
  - Assimilation - Plants absorb water, animals drink
  - Release - Plants transpire; decomposition of animals & plants
- Carbon cycle
  - Reservoir - Atmosphere (CO_2), fossil fules
  - Assimilation - Photosynthesis, animals consume
  - Release - release CO_2 by respiration
- Nitrogen cycle
  - Reservoir - Atmosphere (N_2), soil (NH_4, NO_2^-, nitrate)
  - Assimilation - plants absorb NO_2^- or NH_4^+. Animals eat plant
    - Nitrogen fixation - N_2 to NH_4^+ by prokaryotes
    - Nitrification - NH_4^+ to NO_2^- to NO_3^- by nitrifying bacteria
  - Release - Denitrifying bacteria NO_3^- to N_2; animals release urine
- Phosphorus cycle
  - Reservoir - rocks and ocean sediments
  - Assimilation - plants absorb PO_4^-; animals eat plants
  - Release - decomposition

Biomes
- Tropical rain forest
  - high temp. Heavy rain fall

Savannas
Grassland with scattered trees. Tropical, but less rain
Temperate grasslands
Less rain & temp. E.G. North american prairie
Temperate deciduous forest
Warm summer, cold winters, moderate precipitation. Trees shed leaves during winter.
Deserts
Hot, dry.
Taigas
Coniferouts forests. Cold winters.
Tundras
Cold. Ground freezes in winter. Permafrost in summer. Grass, sedges.