**Macromolecules: Fats** - do not have a polar end like phospholipids; contains 3 fatty acids; aka triglyceride, triacylglycerol fatty acids don't need to be identical energy stored in the C-H bonds of fats clump together in water to form globules since they lack polar ends saturated fats - carbon atoms in fatty acids each bonded to at least 2 hydrogen unsaturated fats - has double bonds between 1+ carbon atoms polyunsaturated fats - has more than 1 double bond; have lot melting points (usually liquid at room temperature) terpene - long-chain lipids usually found in chlorophyll and visual pigment retinal steroid - has 4 carbon rings; can function as hormones prostaglandins - about 20 lipids acting as chemical messengers, with 2 nonpolar tails attached to a five-carbon ring. **Phospholipids** - form the core of all biological membranes glycerol - 3 carbon alcohol; forms the phospholipid's backbone fatty acid - long chains of CH2 groups, ending in a carboxyl; 2 chains phosphate group - attached to an end of the glycerol; usually has an organic molecule attached to it phosphate group serves as the polar "head"; fatty acids serve as the nonpolar "tails" micelle - spherical forms w/ the tails pointed inward phospholipid bilayer - 2 phospholipid layers w/ the tails pointed towards each other; basic framework of biological membranes. **Proteins** - have 7 main functions enzyme catalysis - faciliates/speeds up certain chemical reactions; ex. enzymes defense - recognizes foreign microbes; forms the center of the immune system; ex. immunoglobulins, toxins, antibodies transport - moves certain small molecules/ions; ex. hemoglobin, proton pump support - structural role; ex. fibers, collagen (most abundant protein in vertebrates), keratin, fibrin motion - contracting muscles; ex. actin, myosin regulation - receives/sends information to regulate body functions; ex. hormones storage - holds molecules such as calcium and iron; ex. Ferritin. **Amino acid** - 20 different kinds used in specific orders to form proteins molecule consists of an amino group, carboxyl group, hydrogen atom, and side group (determines the molecule's characteristics) connected to a central carbon atom nonpolar amino acids have CH2 or CH3 as side group polar amino acids have oxygen or hydrogen as side group charged amino acids have acids/bases as side group aromatic amino acids have organic rings w/ alternating single/double bonds as side group special-function amino acids have unique individual characteristics peptide bond - bonds between amino acids; forms between the hydrogen and carboxyl groups polypeptide - protein composed of 1+ long chains. **Protein structure** - shape determines function shape found through x-ray diffraction internal amino acids are generally nonpolar most polar/charged amino acids are found on the surface 6 levels of structure - primary, secondary, motifs, tertiary, domains, quaternary factors of protein shape - hydrogen bonds between amino acids, disulfide bridges between side chains, ionic bonds, Van der Waals attractions (weak attractions due to electron clouds), hydrophobic exclusion (polar portions gather on the outside, nonpolar portions go towards the interior). **Denaturation** - unfolding of proteins can occur if pH, temperature, or ionic concentration is changed leads to biologically inactive proteins (venoms, made of proteins, stop working in high temperature or in presence of acids/bases) salt-curing/pickling used high concentrations of salt/vinegar to stop the enzymes of microorganisms from working most enzymes can only function well in very specific conditions usually, only smaller proteins can fully refold themselves after being denatured dissociation - different from denaturation; subunits can dissociate and still go back to their quaternary structure. **KINGDOMS**: **Bacteria** - prokaryotic organisms w/ peptidoglycan cell wall **Archaebacteria** - prokaryotes w/o peptidoglycan in cell wall **Protista** - eukaryotic, unicellular (except for certain types of algae); can be photosynthetic/heterotrophic **Fungi** - eukaryotic, multicellular (except for yeast), heterotrophic; have chitin cell walls **Plantae** - eukaryotic, multicellular, photosynthetic **Animalia** - eukaryotic, multicellular, motile, heterotrophic. **Eukaryotic Structures: nucleus** - largest organelle in a eukaryote 1st descried by Robert Brown in 1831 surrounded by cytoplasmic filaments in some cells some cells have multiple nuclei erythrocytes - mammalian red blood cells; lose nuclei as they mature nucleolus - dark region where synthesis of ribosomal RNA takes place. **nuclear envelope** - 2 phospholipid bilayers surrounding the nucleus outer membrane continuous w/ the endoplasmic reticulum nuclear pores - shallow depressions scattered over the surface; contain proteins that determine what substances can enter or leave the nucleus 2 types of molecules allowed to pass through nuclear envelope: proteins moving into the nucleus for nuclear structures, catalyze reactions RNA, protein-RNA complexes made in the nucleus. **chromosomes** - extended into strands called chromatin except when the cell divides histones - packaging proteins which DNA wraps around nucleosomes - clusters of histones more extended form allows RNA copies to be made from the DNA condenses into tight rods when the cell divides. **endomembrane system** - divides the cell into compartments **endoplasmic** **reticulum** - largest internal membrane; made of lipid bilayer embedded w/ proteins cisternal space - inner region of ER cytosol - exterior region of ER rough endoplasmic reticulum - surface studded w/ ribosomes; used for protein synthesis proteins made here eventually sent out from the cell signal sequences - special amino acid sequences found on proteins about to be exported proteins go from the cisternal space to the Golgi apparatus to the plasma membrane smooth endoplasmic reticulum - organizes internal activities w/ enzymes abundant in cells that carry out lots of lipid synthesis endocytosis - process where plasma membrane forms vesicles by budding inward; some move in to the cytoplasm and fuse w/ smooth ER. **Golgi apparatus** - named for Camillo Golgi, 19th century Italian physician abundant in glandular cells (manufacture/secrete substances) contains 1 to a few hundred Golgi bodies cis face - front, receiving end; located near the ER trans face - back, discharging end; substances sent into secretory vesicles modifies proteins/lipids traveling through it by adding sugar chains (making glycoproteins/glycolipids) cisternae - stacked membrane folds where newly formed glycoproteins/glycolipids gather; periodically pinches off small vesicles containing the substances. **lysosomes** - digestive vesicles; break down old organelles, recycle component molecules function best in acidic environments keeps a low internal pH by pumping protons inside primary lysosome - does not maintain an acidic internal pH secondary lysosome - forms when primary lysosome fuses w/ food vesicle to activate hydrolytic enzymes phagocytosis - engulfing foreign cells. **microbodies** - enzyme-bearing vesicles found in all eukarytoes glyoxysome - plant microbody containing enzymes that convert fats into carbohydrates peroxisome - contains enzymes that catalyze removal of electons/hydrogen; would short-circuit cell metabolism if oxidative enzymes weren't isolated. **ribosomes** - where protein synthesis takes place large RNA-protein complexes outside the nucleus consist of 2 subunits that only join when attached to messenger RNA (mRNA) proteins that function in the cytoplasm are formed by free ribosomes not found in the ER nucleolus - where ribosomes are assembled in the nucleus. **mitochondria** - bacteria-sized organelles that produce energy bounded by smooth outer membrane and cristae (inner/folded membrane) matrix - area within the inner membrane intermembrane space - area between inner/outer membranes proteins on the surface of the inner membrane carry out oxidative metabolism contains DNA that codes for proteins needed for oxidative metabolism in mitochondria cannot grow/split by themselves, still need proteins coded by DNA in the nucleus. **chloroplasts** - where photosynthesis takes place in plants contain chlorophyll, gives plants their green color have inner/outer membranes like mitochondria grana - stacked membranes lying inside the inner membrane; contain thylakoids (disk-shaped structures on which photosynthetic pigments are located) surrounded by liquid stroma also contain DNA like mitochondria, lacks DNA for self-replication plastid - organelle acting as storage; includes chloroplasts, leucoplasts, amyloplasts; produced only through division of existing plastids amyloplast - leucoplast (simple plastid) that stores starch. **centrioles** - barral-shaped organelles occur in pairs; each composed of 9 triplets of microtubules centrosome - region surrounding a pair of centrioles in animal cells help assemble microtubules. **Prokaryotic Structures:** **cell wall** - surrounds most prokaryotic cells peptidoglycan - sugar polymers cross-linked by polypeptides; found in bacteria walls protects cell, maintains shape, prevents overdose of water gram-positive bacteria - have thick, single-layered cell wall; turns purple from gram staining gram-negative bacteria - more complex bacteria w/ multilayered cell wall; doesn't turn purple, turns red drugs often destroy bacteria's cell wall to kill it disease-causing bacteria secrete a jellylike capsule of polysaccharides to allow it to cling to different surfaces. **flagellum** - long threadlike structure used by some prokaryotes to move protein fibers extending from the bacteria cell could be more than 1 per cell, depending on the species of bacteria rotated like a screw to propel the cell forward uses proton gradient on the membrane to power the flagellum's mov't (process also used by some enzymes that produce ATP in mitochondria/chloroplasts). **Transport:** **diffusion** - mov't of molecules from higher to lower concentration continues until concentration is uniform allows certain polar molecules to enter through the channels inner, polar lining of channels allow polar molecules to enter each channel is selectively permeable, only allowing certain molecules to pass through ions need transport proteins to move in/out of the cell ion channels - have hydrated interiors so that ions never come in contact w/ nonpolar fatty acids. **Evolution: natural selection** - mechanism for evolution individuals w/ better traits tend to produce more surviving offspring Lamarck’s theory - inheritance of acquired characteristics individuals pass on body/behavior changes acquired throughout lives Darwin ’s theory - inheritance of preexisting genetic differences population genetics - study of gene properties in populations evidence for evolution - proven by modern day evidence correspondence between finch beaks and food supply Peter/Rosemary Grant - studied ground finch, found that frequency of a certain beak size change predictably as food supply differed pollution after 1850 allowed dark colored moths to survive more easily than light-colored ones increase in number of dark colored moths after industrial revolution industrial melanism - darker organisms prevail over lighter ones in industrial areas artificial selection in agriculture - differences due to selection for favorable traits current crops look far different from ancestors corn can no longer survive by itself in the wild **fossil record** - absolute dating (w/ radioactive decay) has replaced relative dating (w/ rock strata) fossil record (especially for vertebrates) show how they’ve changed/evolved **anatomical record** - w/o evolution, it’s hard to explain many things in biology **homologous** structures - structures w/ different functions, derived from same body part **imperfect** structures - like vertebrate eye, don’t function as efficiently as a result of evolution **vestigial** structures - have no function, but resembles structures of ancestors **analogous** structures - due to convergent evolution, has similar functions but derived from different body parts. **Prokaryotic Cell Division, Chromosomes:** prokaryotic cell division - division by binary fission genome made of single, circular DNA found in nucleoid area replication of DNA begins at specific site and goes bidirectionally around to specific site of termination cell elongates, DNA gets attached to the membrane septum - new membrane growing near the midpoint during division composed of FtsZ protein ring eukaryotic cells developed mitosis to deal w/ larger, nucleus-enclosed genomes **mitosis** - occurs differently in different organisms protists - 2 ways microtubules (w/ tubulin) pass through nucleus membrane tunnels and sets up axis for division (nucleus remains intact) microtubule spindle forms between centrioles at opposite sides; kinetochore microtubules pull chromosomes to each pole (nucleus remains intact) yeasts - spindle microtubule forms inside nucleus between poles single kinetochore microtubule attaches to chromosomes, pulls them to each end animals - spindle microtubule forms between centrioles outside the nucleus nucleus envelope breaks down kinetochore microtubules attach chromosomes to poles **chromosome** - found in cells of all eukaryotes; 40% DNA, 60% protein most eukaryotes have 10-50 chromosomes (humans have 46, 23 pairs) **monosomy** - condition where organism lacks a chromosome; won’t survive embryonic development **trisomy** - extra copy of a chromosome; fatal unless extra copy of very small chromosome (genetic defects still take place) **chromatin** - DNA/protein complex heterochromatin - chromatin domains not expressed euchromatin - chromatin domains expressed DNA coiled to allow it to fit in smaller space nucleosome - 200 nucleotides coiled around 8 histones solenoid - coils of a string of nucleosomes wrapped together; radially loops around protein scaffold during mitosis histones (positively charged) attract negatively charged phosphate groups in DNA karyotype - specific chromosome array (different between organisms) **haploid** (n) - # of chromosomes needed to define an organism **diploid** (2n) - 2x haploid number; # of chromosomes in humans, some other species **centromere** - condensed area found on all eukaryotic chromosomes 2 sister chromatids share common centromere after replication chromosomes counted by # of centromeres. **Cell Cycle**: cell cycle - 5 phases **G1** – primary growth phase of cell includes major part of a cell’s life for most organisms **S** - phase where genome is replicated **G2** - 2nd growth phase; preparations made for separation of genomes organelles replicate, chromosomes condense, microtubules assemble interphase - collective name for **G1, S, G2** phases M (mitosis) - phase where microtubules pull sister chromatids apart divided into prophase, metaphase, anaphase, telophase C (cytokinesis) - cytoplasm divides, forms 2 daughter cells actin acts as drawstring to pinch animal cells in 2 plate forms between dividing cells w/ cell walls embryonic cells have shortest cell cycles **G0** phase - resting state before DNA replication most cells in body are in this state at any given time neurons/muscle cells never leave this phase after maturing **interphase** - prepares for mitosis major portion of growth during G1 phase chromosome creates 2 sister chromatids attached at centromere during S phase kinetochore - protein disk bound to specific DNA sequence at centromere proteins made, organelles produced during G1/G2 phases DNA only replicates during S phase condensation - DNA coils together w/ help of motor proteins centrioles - microtubule-organizing centers that form during G2 tubulin - protein that makes up microtubules **mitosis phases** prophase - forming mitotic apparatus begins when condensed chromosomes become visible to light microscope ribosomal RNA synthesis stops when area of chromosome that codes for rRNA condenses centrioles move towards poles as spindle fibers form between them; spindle apparatus made of microtubules form nuclear envelope breaks down, gets absorbed by endoplasmic reticulum during spindle formation aster - radial arrangement of microtubules on centrioles towards membrane; braces centrioles against membrane; no asters in plant cells microtubules must link sister chromatids to opposite sides or they won’t separate later metaphase - centromere alignment chromosomes align in center of the cell in circular array metaphase plate - imaginary plane perpendicular to axis of chromosome circle anaphase - shortest phase centromeres split in 2, freeing sister chromatids separase - enzyme that cleaves the cohesin protein holding the chromatids together anaphase-promoting complex (APC) - makes centromeres divide at the same time poles move apart, centromeres move towards poles microtubules shortens as tubulin subunits are removed (microtubules don’t contract) telophase - nuclei reforms spindle disassembles microtubules broken down into tubulin that can be used for cytoskeleton of daughter cells nucleus forms around sister chromatids cytokinesis - phase where cell actually divides relocation of organelles takes place in S/G2 phase cleaves cell into equal halves animal cytokinesis - uses constricting actin filament belt actin filaments slide by each other, forms cleavage furrow, eventually slices into cell’s center plant cytokinesis - creates cell plates between daughter cells middle lamella - space between daughter cells, filled w/ pectins fungi/protist cytokinesis - nucleus doesn’t dissolve during mitosis nucleus divides after mitosis completes nothing determines how organelles get distributed