AP Biology Review

Unit 1:

- Chemical Bonds
  - Covalent bonds: share valence electrons
    - Nonpolar/polar
  - Ionic bond: transfer of charges
    - IONIC BONDS ARE STRONGER
- Property of Water
  - Polar: Oxygen is more electronegativity
  - Hydrogen bonds: Hydrogen of one, to negative Oxygen
    - Water can form 4
      - Cohesion: Water to water (surface tension)
        - Adhesion: water to another surface
        - Transpiration: how water moves up plants. Water to water; water to xylem
  - Specific heat: the amount of heat necessary to change substance by 1*C. Water has high specific heat, so temp is stable
  - Insulation/Density: Ice is less dense than water
  - Universal solvent
    - Hydrophilic- water soluble
    - Hydrophobic- not soluble in water
  - pH: 0-14
    - acids, base, buffer, carbonic acids
  - Dehydration synthesis, Hydrolysis
- Biological Molecules
  - All organic molecules have Carbon. Why?
    - Has 4 valence electrons; can form up to 4 covalent bonds
    - Single, double, and triple covalent bonds possible
    - Can form large molecules
    - Backbone can be chained, rings, or branched
      - ISOMERS: molecules with same chemical formula, but different atom arrangement==diff. properties
  - Functional Groups:

Functional Group		Class Name	Examples	Characteristics
—OH	hydroxyl	alcohols	ethanol, glycerol, sugars	polar hydrophilic
—C(=O)OH	carboxyl	carboxylic acids	aceticacid, aminoacids, fattyacids, sugars	polar, hydrophilic, weakacid
—N(H)H	amino	amines	aminoacids	polar, hydrophilic, weakbase
—P(=O)(O⁻)O⁻	phosphate	organic phosphates	DNA, ATP, phospholipids	polar, hydrophilic, acid
—C(=O)—	carbonyl	ketones	acetone, sugars	polar, hydrophilic
—C(=O)—H	carbonyl	aldehydes	formaldehyde, sugars	polar, hydrophilic
—C(H)H	methyl	—	fatty acids, oils, waxes	nonpolar, hydrophobic

  - Macromolecules!
    - Carbohydrates : monosaccharides, disaccharides, polysaccharides, glycosidic linkages

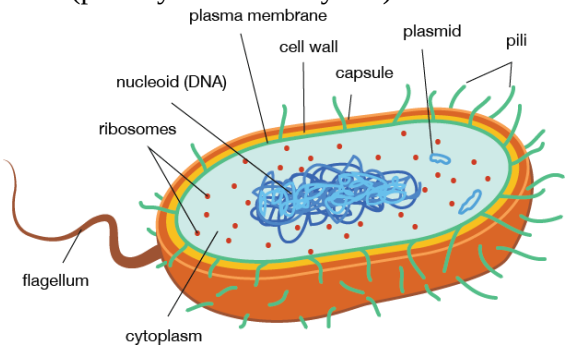
- Main functions of polysaccharides: energy storage and structural support
    - Energy storing
        - Starch (plants)
        - Glycogen (animals)
    - Structural support
        - Cellulose
        - Chitin
- Proteins: amino acids, peptides, polypeptides, peptide bonds
    - Primary structure, secondary, tertiary, quaternary
        - Alpha helix, beta pleated sheets
    - Protein shape ; denaturation
        - Denatration caused by heat, pH change, others
- Nucleotides: DNA and RNA, nucleotides, phosphodiester bonds, hydrogen bonds, etc.
    - Nucleotides: nitrogenous base, pentose sugar (deoxyribose or ribose), phosphate group
        - Purines (double ring): A, G
        - Pyrimidines (single ring): C, U, T

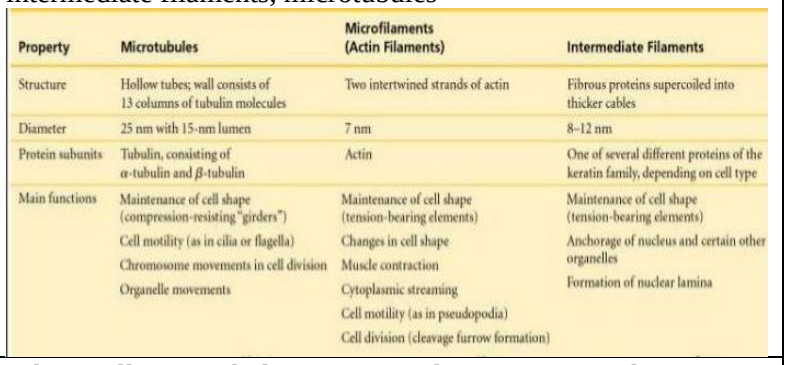
- Lipids (not technically a macromolecule, b/c can't form polymers)
    - All hydrophobic
        - Fats (triglycerides) made off one glycerol and three fatty acids
            - Fatty acids=nonpolar/hydrophobic
                - Saturated fatty acid (no double links, solid, animals)
                - Unsaturated (double links, liquid, plants)
    - Function:
        - Energy storage, insulation/protection of organs
        - Phospholipid membranes
        - Steroids (cholesterol, estrogen, testosterone)

- REMEMBER: Change structure changes function

Unit 2

- Cells (prokaryote vs. eukaryotes)



Organelle	Animal/Plant	Function
Rough ER	Both	Protein synthesis for secretion using ribosome, hydrogen peroxide and steroid hormone for secretion
Smooth ER	Both	Regulates and release calcium ion and processing of toxins
Nucleus	Both	Contains hereditary information; nuclear envelope, nucleolus, chromatin
Plasma Membrane	Both	Made of phospholipids encloses membrane
Ribosome	Both	Makes protein by translating mRNA, bound to ER/nuclear envelope or free in cytoplasm
Golgi apparatus	Both	Synthesis, modification, sorting, and secretion of cell products, namely proteins
Lysosome	Animal	Digests and recycles macromolecules by hydrolysis
Mitochondria	Both	Cellular respiration and ATP generation
Peroxisome	Both	Metabolizes hydrogen peroxide
Microvilli	Both	Increase cell surface area for more efficiency
Cytoskeleton	Both	Reinforce cell shape, cell movement; microfilaments, intermediate filaments, microtubules 
Centromere	Both	Where cell microtubules are initiated, contain centrioles in A, but not in P
Centrioles	Animals	Formation of spindle fiber for cell division
Flagellum	Animal, some plant sperm	In some animal cells (sperms), for transport, made of microtubules
Chloroplast	Plant	Photosynthesis
Central Vacuole	Plant	More found in older plant cells, storage and breakdown of waste, hydrolysis of macromolecules. Enclosed by the tonoplast membrane
Plasmodesmata	Plant	Channels through cell walls; connect cytoplasm of adjacent cells
Cell wall	Plants	Protection, structural integrity of plant cell
Extracellular Matrix	Animal	Tight Junctions: cell membrane of neighbor cells fused=watertight Desmosomes: fasten adjacent cells together, like rivets, fasten cells into strong sheets Gap junctions: provide channels for ions, sugars, communication molecules, and other small molecules to pass

Property	Microtubules	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes; wall consists of 13 columns of tubulin molecules	Two intertwined strands of actin	Fibrous proteins supercoiled into thicker cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, consisting of α-tubulin and β-tubulin	Actin	One of several different proteins of the keratin family, depending on cell type
Main functions	Maintenance of cell shape (compression-resisting "girders") Cell motility (as in cilia or flagella) Chromosome movements in cell division Organelle movements	Maintenance of cell shape (tension-bearing elements) Changes in cell shape Muscle contraction Cytoplasmic streaming Cell motility (as in pseudopodia) Cell division (cleavage furrow formation)	Maintenance of cell shape (tension-bearing elements) Anchorage of nucleus and certain other organelles Formation of nuclear lamina

Membrane Mosaic: (more unsaturated fats means more flexibility)

- Phospholipid= the membrane base
- Proteins
    - transport channel
    - receptors for ligands (signal molecules)
    - peripheral proteins (hang loosely from membrane surface, like G protein)
- Carbohydrates=cell-cell recognition ; crucial for immune response and tissue differentiation
- Selective permeability
    - Nonpolar molecules easily pass
    - Ions and polar molecules struggle b/c hydrophilic. Require facilitated transport. Require transport proteins
        - Work by:
            - Provide channel so molecule can pass
            - Bind loosely to molecule and carry through membrane
        - Water move in aquaporins
- Active transport (move against concentration gradient) (use energy aka ATP)
    - Ex. Sodium-potassium pump
        - Creates a membrane potential which is restored to resting by a chemical force (ion conc. Gradient) and a voltage gradient, together "electrochemical gradient
- Exocytosis/endocytosis

Tonicity

- Isotonic: balanced on both sides, water travel at same rate
- In hypertonic cell, cell lose water b/c more solute in water around the cell. Cell shrivel
- In hypotonic cell, cell enter water faster than leaves b/c fewer solutes in water surrounding than in cell

---

Unit 3

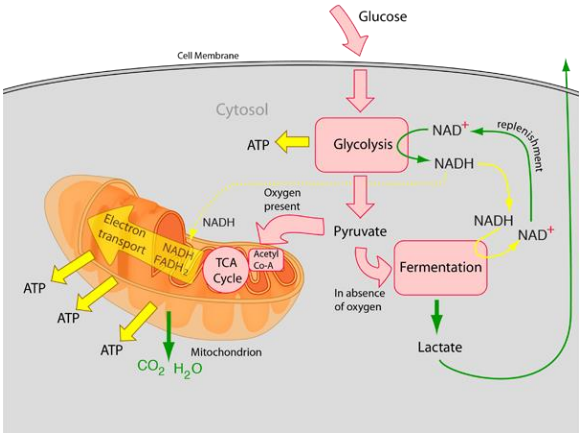
Enzyme: macromolecules that are biological catalust

- Work by lowering the activation energy of a reaction w/o changing the free energy change of reaction
    - Reactant of enzymatic reaction "substrate"
    - Enzyme most important has ACTIVE SITE (has a shape specifically complementary to substrate). Enzyme+substrate= enzyme-substrate complex
    - Enzyme shape/activity affected by pH, temp, etc. b/c made up of proteins
        - Cofactors: nonprotein helpers of reaction, like metal ions etc.
            - If organic "coenzyme": vitamins ex.
        - Competitive inhibitor: occupy active site and prevent activity
        - Noncompetitive inhibitor: change shape of active site by binding to another site nearby and changing enzyme shape
            - Enzyme regulator mostly bind to allosteric site (specific binding site not the active site)
        - Inhibition: feedback inhibition (product inhibits reaction by binding to allosteric site). Allow more efficiency by turning pathway off when end product is too much

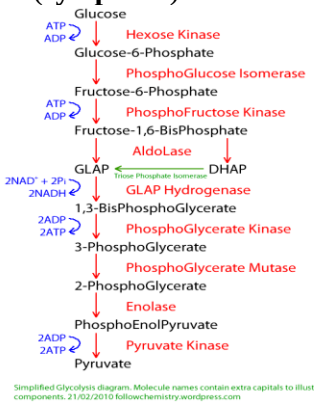
Metabolism: the totality of an organism's chemical reaction

- Catabolic pathway: release of energy b/c of breakdown of complex molecules
- Anabolic pathway: consume energy to build
- Energy: ability to do work. Kinetic, potential, chemical
- Laws of Thermodynamics:
    - First law: energy of universe is constant, and energy can only be converted; not created/destroyed
    - Second law: every energy transformation increases the entropy (disorder) of the universe
- Free energy: the part of a system's energy that is able to perform work when the temperature is constant
    - Exergonic: release energy; $\Delta G<0$
    - Endergonic: absorb energy ; $\Delta G>0$
- Energy coupling: use exergonic process to drive endergonic process (ATP production).

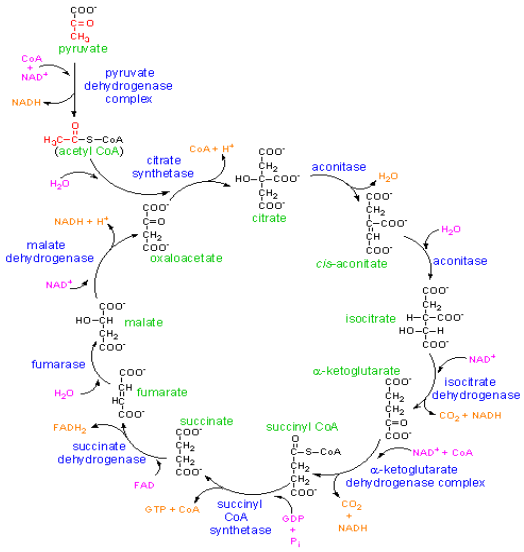
- Cellular Respiration



- Glycolysis (**cytoplasm**)

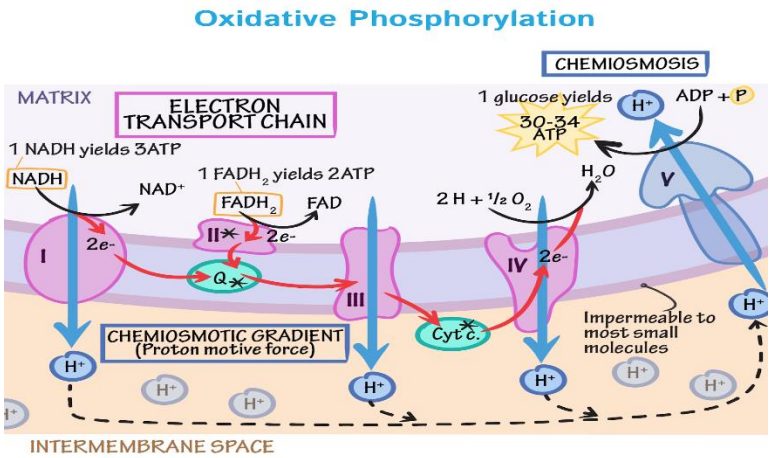


- Citric Acid/Krebs Cycle (in Matrix of Mitochondria, Cytoplasm in Prokaryotes)

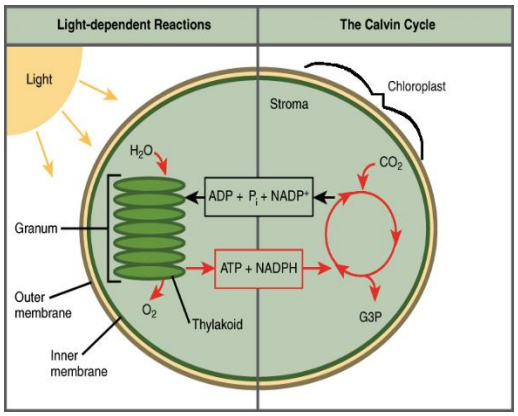


-
- Function is to provide electrons to fuel oxidative phosphorylation

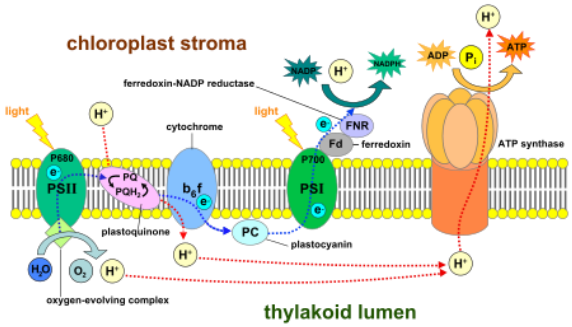
- Oxidative Phosphorylation



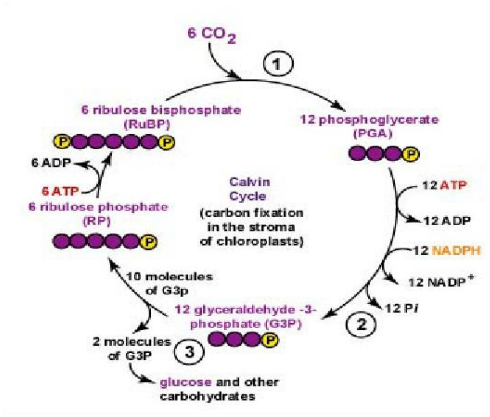
-
- Coenzyme q “ubiquinone”
- V= “ATP synthase”

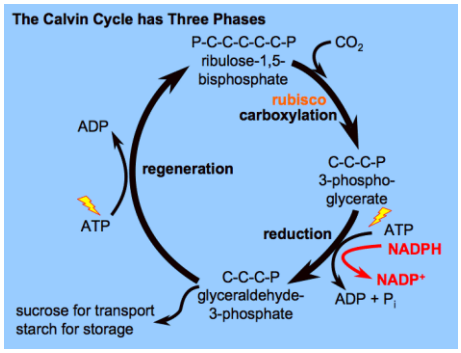
- Photosynthesis
  -


- Light Dependent Reaction (across thylakoid membrane)



  -
  - (cyclic photophosphorylation): synthesis of ATP coupled to electron transport activated by Photosystem I solely. Photolysis of water doesn't occur
  - (noncyclic photophosphorylation): both PSII and PSI. photolysis occurs
- Light Independent Reaction (Calvin Cycle) (in stroma of chloroplast) (takes two turns for 1 glucose





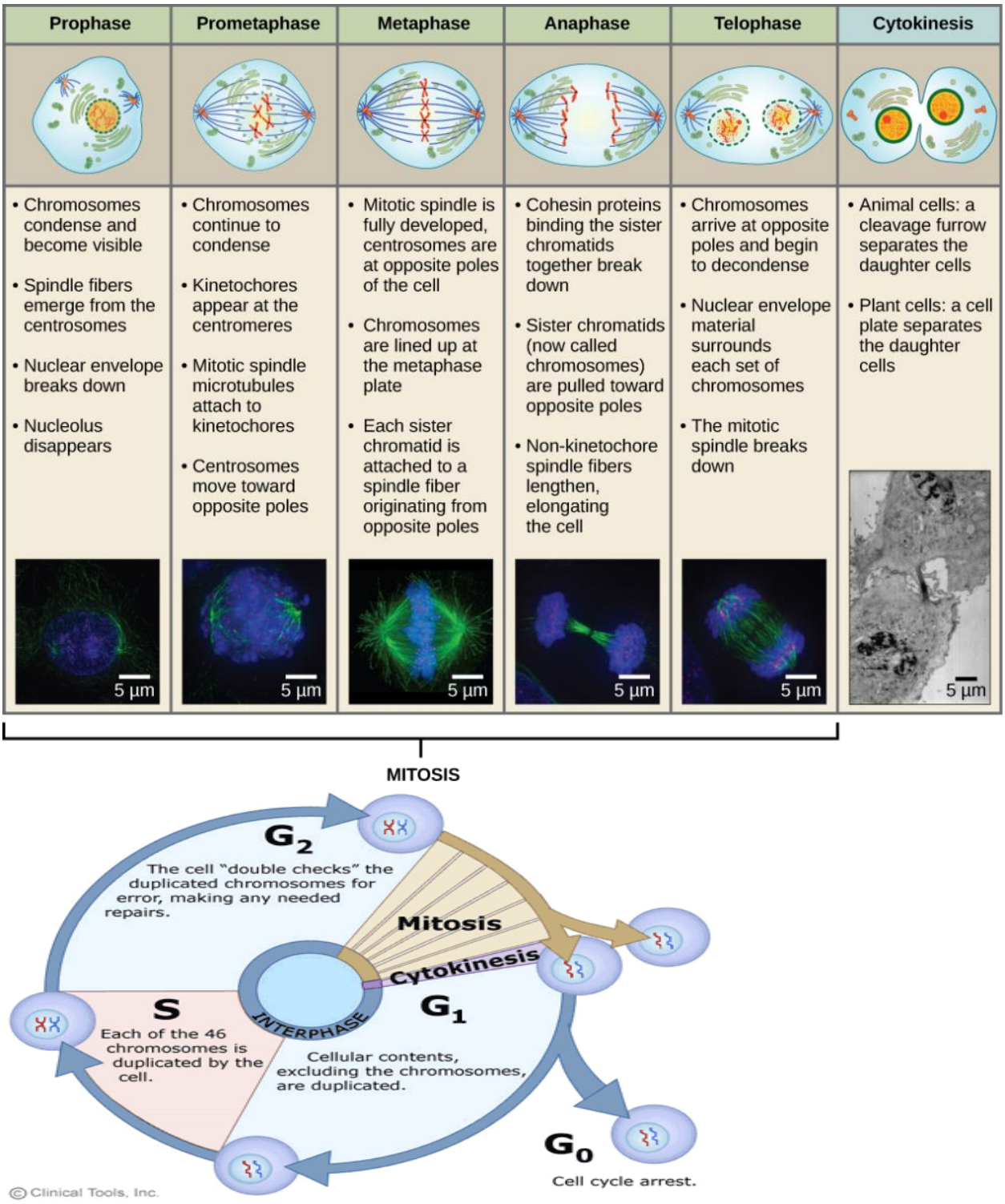
Unit 4

Cell Communication: Reception, Transduction, Response, Ligands, Receptors

- Intracellular receptors : found within the plasma membrane; hydrophobic ligands b/c the signal molecule must be able to cross plasmam membrane
- Plasma membrane receptor: bind to water-soluble ligands
- G protein-coupled receptor: ligand binds to G protein receptor; G protein is activated with GTP; G protein binds to specific enzyme and activates
- Receptor tyrosine kinase: ligand binds and causes dimer conform which causes ATP to become ADP, activates phosphorylated tyrosine
- Ligand-gated ion channels: open and close to regulate specific ions' flow, opens when ligand is attached
- Phospohorylation cascade, protein kinases, protein phosphatase (remove phosphate group from kinase and turn off response), second messengers (Ca2+, cAMP)
- Receptors depend on shape of binding site, so temp. pH and environment matter

Feedback: Positive and Negative, examples

Cell Cycle: Apoptosis, stages,



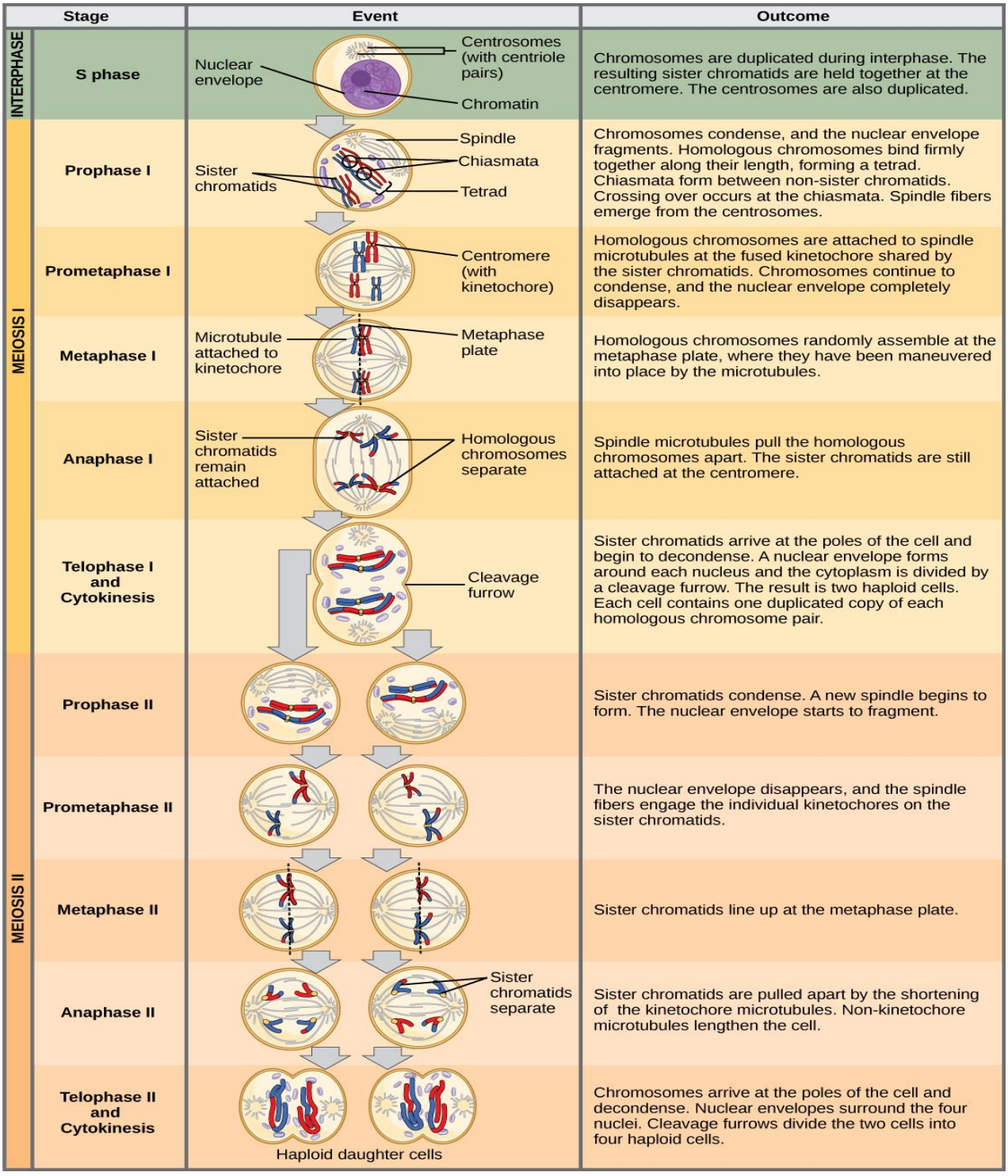
Density-dependent inhibition: cell too crowded so stop divided

Anchorage deppendncy: cell eeds to bind to some substratam to divide

Transformation: normal cell to cancer one. Cancer (benign/malignant tumor, metastasis)

Unit 5:

Meiosis: (chiasmata; chiasma is the point of contact, the physical link, between two chromatids belonging to homologous chromosomes. Kinetochore: a complex of proteins associated with the centromere of a chromosome during cell division, to which the microtubules of the spindle attach)



Mendelian Genetics: genes, alleles, gametes, locus, asexual reproduction, clone, sexual reproduction, life cycle, somatic cells, karyotype, homologous chromsomes, sex chromosomes, autosomes (chromosomes that aren't X or Y), fertilization, zygote, diploid, heterozygoys, genotype, phenotype, testcross, monohybrid cross, dihybrid cross, complete dominance, codominance, incomplete dominance (pink flowers), pedigree. Parental generation (both true bred), F1 generation (both mixed), then F2 (mixed)

Recessively inherited disorder: cystic fibrosis (mutation in an allele that codes for cell membrane rotein for transport Cl ions), tay-sachs disease (allele codes for dysfunctional enzyme that is unable to break down certain lipids in brain), sickle cell (allele code for mutated hemoglobin protein)

Lethal dominant alleles (require only one copy of allele in order for disorder to express (Huntington's disease

Multiple alleles: gene has more than two alleles like blood types

Pleiotropy: one gene has multiple phenotyphic effects

Epistasis: one gene at one locus affects another gene at another locus

Polygenic inheritance: two or more genes add to one phenotype

Crossing over: prophase 1

Independent assortment of chromosomes: metaphase I, homologous chromsomes pair up randomly on the metaphase plate

Random fertilization:

Mendelian laws:

- Alternative versions of genes account for variations in inherited characteristics among offspring, b/c alleles
- For each character every organism inherits one allele from each parent
- Dominant and recessive alleles
- Law of Segregation: alleles separate when gamete form
- Law of independent assortment: anaphase I, alleles will segregate independently during gamete formation

Phenotype (Blood type)	Genotype
Type A	I^AI^A or I^Ai
Type B	I^BI^B or I^Bi
Type AB	I^AI^B
Type O	i i

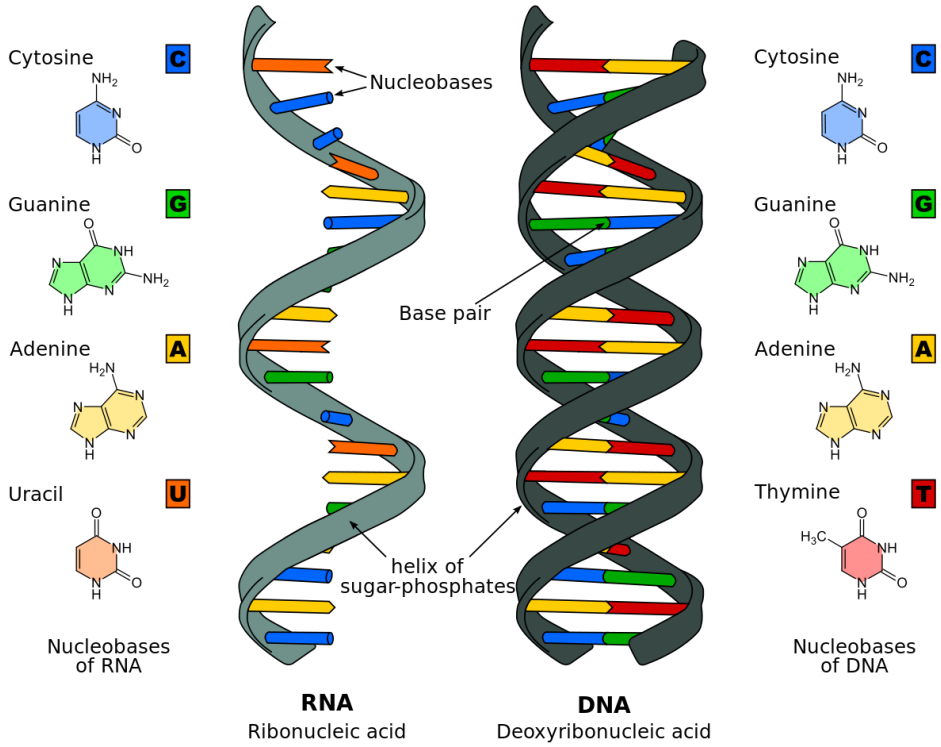
Chromosomal Inheritance: genes have specific location on chromosome. And this affects inheritance

- Sex linked gene, x-inactivation, methylation, barr body, linked genes, genetic recombination, parentaly types and recombinants, crossing over, linkage map, map unit=1% recombination, nondisjunction (meiosis I and II), aneuploidy (faulty number of chromosomes), trisomic, monosomic, polyploidy (more than normal sets of chromosomes like 3n instead of 2n),
- Aneuploidy is more dangerous.
    - Kinds of chromosomal mutations:
        - Deletion: part of the chromosome is missing
        - Duplication: part of the chromosome is repeated
        - Inversion: chromosome fragment breaks off and rejoins but backwards
        - Translocation: deleted chromosome fragment joins to a nonhomologous chromosome
- The closer two genes are, the less likely to recombine
- Genomic imprinting: during gamete formation, and result in the silencing of particular alleles of certain genes
- Disorders:
    - Duchenne muscular dystrophy (x-linked disorder; gradual weakening of muscles, rarely live past 20)
    - Hemophelia (x-linked; blood that can't clot b/c the protein for blood clotting isn't there)
    - Down syndrome (aneuploidy resulting in extra trisomy chromosome 21)
    - Klinefelter (aneuploidy of male possessing extra X (XXY))
    - Turner syndrome (monosomic with female just XO. Female just sterile and taller than normal)
- Most organisms, as long as have 1 Y, its male
- Most sex-linked disorders are x-linked. Most y-linked have only to do with male organ developents, etc.

Environment effect on phenotype: phenotypic plasticity (when individuals with same genotype express different phenotype b/c of different environments, like flowers and soil pH, seasonal fur color, sex determination in snakes.

Unit 6:

Griffith, Hershey and Chase, Watson and Crick, X-ray crystallography, double helix,



replication (semiconservative): origins of replication, replication bubble, DNA polymerase, leading strand (5'3'), lagging strand (3'5'), Okazaki fragments, DNA ligase, mismatch repair, nucleotide exision repare, nucleases, telomeres

- DNA+protein= chromatin
    - Euchromatin: extended and lose form, for transcription
    - Heterochromatin: more condensed chromatin, not able to transcribe
- Gene expression, transcription, mRNA, RNA processing, translation, template strands, codons
- One gene-one polypeptide hypothesis, each gene code for a polypeptide, a protein
- Template strand, complementary for the original DNA strand, triples=codons (written in 5'3' direction)
- Genetic code is redundant, more than 1 codon can code for an amino acid
- Promoter, terminator, transcription unit (the stretch of DNA that is transcribed into an RNA molecule)
- Initiation, transcription factors (bind to RNA polymerase to promoter and initiate transcription)
    - RNA polymerase II+transcription factors= (transription initiation complex)
    - Elongation : RNA polymerase moves along, unwinding and adds RNA base
    - Termination: transcribes termination
- 5'cap and polyA tail added to RNA, and export mRNA from nucleus protect mRNA from degradation)
- RNA splicing, introns (spliced out), exons (glued together by spliceosome), small nuclear RNA (snRNA; catalyzes the excision of introns, etc.), ribozyme (RNA serving catalytic role), tRNA, anticodon, rRNA, P-A-E sites,
- Point mutation (alterations of just one base of a gene); nucleotide-pair substitution (replacement of one nucleotide and its partner with another pair of nucelotides

    - Missense (substitution that enables the codon to still code for an amino acid); nonsense (substitution causes regular amino acid codon into a stop codon)
    - Insertion and deletion cause frameshift mutations. Mutagens; interact with DNA in ways that cause mutations
    - Operons: operator (controls acecss of RNA polymerase to the gene), promoter (where the RNA polymerase attaches), genes of the operon (the entire stretch of DNA required for all the enzymes produced by the operon)
    - Regulatory genes (produce repressor proteins that may bind to the operator site
- Kinds of operons; repressible operon (normally on but can be inhibited; anabolic, building an essential organic molecule); if the organic molecule being produced by the operon is provided to the cell, act as a corepressor, bind to repressor protein and activate it.
    - Inducible operon; normally off but can be activated on, requires inducer to bind and inactivate the repressor protein (ex. Lac operon)
- Differential gene expression: the expression of different genes by cells with the same genome
- DNA methylation (add methyl group to DNA and make more tightly packaged, thus reduce gene expression)
- Histone acetylation (acetyl group added to amino acid, and thus make chromatin less tightly packed, encourage transcription)
- Epigenetic inheritance, transcription initiation, enhancer regions, activators
    - Enhancer regions, DNA far from gene, bind to promoter regions by proteins "activators"
    - microRNA, small interfering RNA; bind to mRNA and degrade mRNA to prevent gene expression
- Zygote undergoing transformation: cell division, cell differentiation, morphogenesis (gives and organism its shape)

Stuff:

- Cytoplasmic determinants (maternal substances in the egg that influecnt the course of early development)
- Cell-cell signals, like growth factors, which influence neighboring cells "induction"
- Determination, is the series of events that lead to observable differences
- Pattern formation, sets uo body plan as a result of cytoplasmic determinants, inductive signals
- Homeotuc genes- master control genes that control pattern formation

Cancer, oncogenes (genes cause cancer); proto-oncogenes (code normal cell growth)

Tumor-suppresor genes; p53 genes-which activate p21 gene halts cell cycle by binding to cyclein kinases; apoptosis

Mutations: changes in genotype can mean changes in phenotype b/c of changes in gene expression

Biotechnology: genetic engineering, biotechnology, recombinant DNA, gene cloning, restriction enzymes, restriction sites, restriction fragments, sticky ends, DNA ligase, cloning vectors, nucleic acid hybridization, probe, PCR, gel electrophoresis, restriction fragment length polymorphisms

1. Gene expression- the physical expression/appearance/effect that a gene plays on the larger organism.
2.

Gene Expression Steps	Molecules Involved: What molecules and proteins are involved in this step?	Summary: What happens during this step?
Transcription	RNA Polymerase, DNA, RNA nucleotides	RNA Polymerase enzyme transcribes DNA into RNA using RNA nucleotides. Base pairings go G-C and A-U. RNA transcription occurs in the 5'3' direction.
RNA Splicing	Spliceosome, intron/exon, mRNA	Pre-mRNA contains segments of noncoding genes (introns). Using chemical markers, spliceosomes remove intron segments and stick exons back together.
mRNA Transport	Cytoplasm, mRNA, nucleus	The edited mRNA is transported out of the nucleus into the cytoplasm through nuclear pores. These mRNA molecules will be used to create polypeptides.
Translation	Ribosome, rRNA, mRNA, amino acids, tRNA	Using the mRNA as a guide, tRNA amino acids to form polypeptides using anticodons. Each amino acid is coded for by multiple tri-codon combinations. The mRNA is read through by the ribosome, which is composed of rRNA sequences with proteins.
Protein Processing	Cytoplasm, endoplasmic reticulum, golgi system	Completed polypeptide chain folds into 3-D functional protein. This occurs in either the cytoplasm or endoplasmic reticulum. Proteins often finish folding in the golgi system.

3.

Genetic Medicine	Short Summary	Detailed Description
CRISPR-Cas9	CRISPR-Cas9 utilizes genetic markers to cut out DNA segments.	CRISPR-Cas9 is most often used to knock out a gene so that it is not expressed,a s well as edit/correct disease-causing mutations. The technology is currently being used on sickle cell disease and cystic fibrosis.
Gene Therapy	Gene therapy inserts properly-functioning segments of DNA or genes to repair disease causing ones.	Gene therapy utilizes a variety methods of inserting genes, most commonly using viral vectors. By mimicking the cellular receptors and markers found on cell-infecting viruses, gene therapy is able to insert therapeutic genes into the cell's genome.
Gene Switches	Gene switches utilizes the already present switch	Gene switches turn on and off genes by placing or taking out certain targeted regulatory

	sequences to turn off and on certain gene expressions.	proteins. Gene switches are currently being experimented on sickle cell disease.
Exon Skipping	Exon skipping changes how pre-mRNA is cut and which gene sequences get cut out as introns and which are kept as exons.	Exon skipping changes how the primary RNA transcript of a gene with a disease-causing mutation is spliced, removing the mutation from the final mRNA molecule. Currently being tested on Duchenne muscle dystrophy.
RNA interference	RNA interference involves small RNA segments that target various mRNAs for destruction, reducing the expression of certain genes.	Scientists synthesize short RNA segments with a sequence complementary to that of a target sequence. This double strand is then cut into smaller pieces, and incorporated into silencing complexes, which cleave the mRNA, preventing expression. Huntington's disease.
Small Molecule Drug	Utilizes drugs of low molecular weight, which interact with disease-causing proteins.	Block protein translation and transcription pathways. Used in cystic fibrosis treatments.

4.

Name of Disease	What are the key characteristics of the disease and whom does it affect? How can the featured technologies be utilized as a cure.
Leber Congenital Amaurosis	-eye disorder affecting the retina. Mostly affects young infants. Sluggish pupillary responses, severe acute vision and photophobia. - caused by mutation in the CRX or IMPDH1 genes. Autosomal dominant pattern of inheritance - possible cure in gene therapy
Sickle Cell Disease	• Disorder caused by protein misfolds in the red blood cell hemoglobin • Mutation in gene, inherited. • Possible cure in stem cell transplant and gene switches
Duchenne Muscular Dystrophy	• Progressive form of muscle dystrophy • Genetic mutation resulting in protein misfold of dystrophin • Possible cure in exon skipping of 51 and RNA splicing
Huntington's Disease	• Progressive breakdown of nerve cells in brain • Caused by inherited defect in autosomal gene • Possible cure in RNA interference
Cystic Fibrosis	• Hereditary disease that creates mucus that clogs lungs and obstructs the pancreas • Defect in the CFTR gene that makes the protein responsible for the movement of salt and water in and out of body cell's

	• Possible cure in small molecule drug

1. The step we would want to target would be the transcription process, as it is the gene expression step that occurs most upstream of all other affected processes. Therefore, the best treatment would be gene therapy. Gene therapy utilizes functional genes which are inserted into the patient's genome. Another alternative treatment would be CRISPR-Cas9. However, CRISPR would just cut out the mutated genes, without replacing the necessary genes for protein expression.