AP Biology Course Study Guide

by- Simple Studies!

Protein & Nucleic Acids

Macromolecules

Proteins (CHONS)- Monomer = Amino Acids

- Enzymes = Proteins (not all proteins are enzymes!)
- Amino acids have directionality (amino (NH2) end & a carboxyl (COOH) end). Amino acids are added on the carboxyl end through covalent bonds
- R groups differ from each amino acid (they give them their different properties such as hydrophobic hydrophilic, or ionic)
- Amino Acids are monomers that bond together with a peptide bond to form a polypeptide through **dehydration synthesis** (monomers join together to form a polymer through the release of Water (H2O))
    - Multiple amino acids will form a polypeptide chain.
- **Hydrolysis** (A polymer is broken into monomers by adding water (H2O)) is used to break apart polypeptides into amino acids
- Protein Structure:
    - The Primary structure is determined by the sequence order of their constituent amino acid. The specific order of amino acids in a polypeptide (primary structure) determines the overall shape of the protein. They are bonded with peptide/covalent bonds.
    - The Secondary structure arises through local folding of the amino acid into elements such as alpha helices & beta pleated sheets due to their *hydrogen bonds*. They are bonded through hydrogen bonds *(No covalent bonds)*.
    - The Tertiary structure is the overall three-dimensional shape of the protein & often minimizes free energy. As a result of decreasing free energy, the

stability increases. They are bonded through hydrogen, disulfide, ionic bonds, & Van der Waals/hydrophobic interactions *(No covalent bonds)*.

- The Quaternary structure is composed of multiple peptides that come together as a single macromolecule. They have the same bonds as the tertiary structure *(No covalent bonds)*.

Nucleic Acids (CHOPN)- Monomer = Nucleotides (consists of a Nitrogenous base, a 5 carbon sugar, & a phosphate group)

- *Covalent bonds* are formed between nucleotides (monomers) to form Nucleic Acids (polymer) through Dehydration Synthesis. The phosphate end of one nucleotide bonds to the hydroxyl 3' end of the other nucleotide.
- *Hydrogen bonds* connect the nucleotides in one strand to the opposite strand (seen in DNA structure), or between the nitrogenous bases.
- Nitrogenous Bases:
  - There are 2 types of nitrogenous bases (purine = 2 rings & pyrimidine = 1 ring)
  - Purine = Adenine & Guanine
  - Pyrimidines = Thymine, Cytosine, & Uracil (RNA)
  - Cytosine - Guanine (3 hydrogen bonds)
  - Adenine - Thymine (2 hydrogen bonds -> These pairs will break apart more easily because they have less hydrogen bonds)
- DNA and RNA Comparison

Both	DNA	RNA

• Have 3 components:
  ○ 5- carbon sugar
  ○ Phosphate group
  ○ Nitrogenous Base
• Nucleotides are joined together with *covalent bonds* to form a linear molecule
• 5' & 3' ends
• Nitrogenous bases perpendicular to the sugar-phosphate backbone
	• Double stranded
	• 5-Carbon Sugar is Deoxyribose
	• Thymine (not Uracil)
	• Runs Antiparallel
	• *Hydrogen bonds* hold the two strands together by connecting the strands' nitrogenous bases.
		• Single Strand
		• 5-Carbon Sugar is Ribose
		• Uracil

Carbs- 1C:2H:1O

They function to provide readily available energy to organisms & also functions as a monomer of polysaccharides

Lipids- 1C:2H:Very few Os

- There are many kinds of lipids, but they are all characterized by the fact that they are hydrophobic and nonpolar.
- Phospholipids
  - They are amphipathic (has a polar & nonpolar end). It functions as a component of cell membranes

Organelles & Cell Size

Cellular Organelles

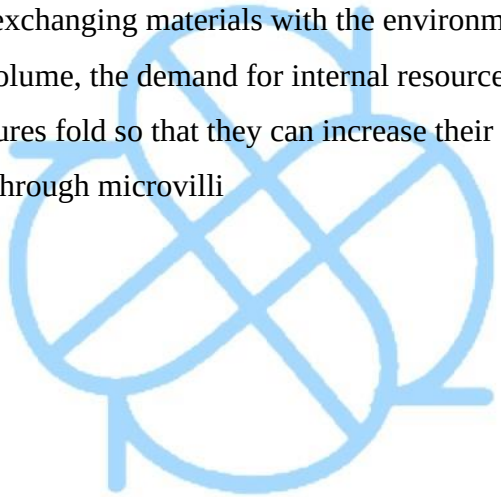
- **Nucleus**
    - Contains hereditary information/DNA/chromosomes
    - Site of RNA synthesis
- **Ribosomes**
    - Made up of ribosomal RNA (rRNA) & protein
    - They synthesize protein according to an mRNA sequence that is transcribed from the instructions found in DNA
    - They are found in ALL living things (prokaryotes & eukaryotes -> reflects common ancestry)
    - They are not membrane bounded organelles
- **Endoplasmic Reticulum (ER)**
    - It occurs in 2 forms (smooth & rough)
    - Free ribosomes are used to make protein that will be used in the cell itself
        - **Rough ER**: *Protein Synthesis* (since ribosomes are attached) & manufactures secretory proteins (that the ribosomes made) in transport vesicles & sends them to the Golgi body C
            - Compartmentalizes the cell
        - **Smooth ER:** Used to *detoxify poison/alcohol/waste* (liver) & *creates lipids* (NO ribosomes)
- **Golgi body**
    - A membrane-bound structure that consists of a series of flattened membrane sacs
    - It folds & chemically modifies the newly synthesized proteins from the ER & packages/ships them in transport vesicles
    - Cis face = imports the protein
    - Trans faces = exports the protein
- **Mitochondria**
    - Produces ATP
    - It has a double membrane (the space between the 2 membranes is called the Intermembrane space)

        - Inner membrane: Highly folded (allows for greater surface area → more ATP to be synthesized) & compartmentalization for different metabolic reactions)
        - Outer Membrane: Smooth
    - The Krebs cycle occurs in the matrix of the mitochondria
    - The Electron Transport Chain (ETC) & ATP synthesis occur on the inner mitochondrial membrane
- **Lysosomes**
    - They are membrane-enclosed sacs that contain hydrolytic enzymes (used for all the organelle's functions)
    - Break down any foreign particles and worn out organelles
    - Digest food vacuoles
    - Can initiate cell death (apoptosis)
- **Vacuoles**
    - A membrane-bound (tonoplast) sac that is found in plant & animal cells
    - Purpose: Storage
    - Pumps out extra water (helps avoid swelling)
    - Release of macromolecules/waste
        - Plants: helps maintain turgor pressure by storing water & solutes
        - Animals: pumps out water to maintain equilibrium & stores food/waste products (until they can be digested/removed from the cell)

- **Chloroplast**
    - Specialized organelles that are found in plants (site of photosynthesis)
    - Have a double outer membrane
    - Stroma (the fluid within the inner chloroplast): Where carbon fixation/dark reactions of photosynthesis occurs
    - Thylakoid (stacks of them = granum): Where the light absorbing reactions of photosynthesis take place (contains chlorophyll & ETC proteins which make up the photosystems).

Cell Size

- If cells have a **large Surface Area to Volume ratio (high SA & low Volume)** they will be **more efficient** in exchanging materials with the environment
- As cells increase in volume, the demand for internal resources increases
- Many complex structures fold so that they can increase their SA to Volume ratio
- SA can be increased through microvilli



Membrane Transport

Cell Membrane/Cell Wall

- Made up of a phospholipid bilayer, proteins, steroids, glycoproteins, & glycolipids (glyco = carbohydrate chain)
- **Selectively permeable**
    - Small, nonpolar molecules can easily pass through (including N2, O2, & CO2)
    - Hydrophilic substances (large polar molecules & ions) need embedded channels (positively charged) or transport proteins
    - Polar uncharged molecules (H2O can pass through the membrane in small amounts
- Separates the internal environment of the cell from the external environment
- The cell wall of plants/prokaryotes/fungi is composed of complex carbohydrates (cellulose for plants or chitin for fungi)
- **Phospholipids** have a *hydrophilic* phosphate head & a *hydrophobic* tail (fatty acid chain tail)
- **Embedded proteins** can be hydrophilic (with charged polar side groups) or hydrophobic (with nonpolar side groups)

Transport

- **Passive transport** *(No energy/ATP)*:
    - Molecules moving from high to low concentration down the concentration gradient (plays a primary role in the import of materials & the export of waste)
    - **Facilitated Diffusion**
        - **Aquaporins** (No energy required): Helps a few water molecules pass through the membrane from a high to low concentration
        - Charged ions (Na+ & K+) require channel proteins (positively charged) to pass through the membranes from a high to low concentration
            - Na+ Channels & K+ Channels/ Sodium-Potassium Pump:
                1. Sodium enters the cell through the Sodium channel
                2. The cell's charge becomes positive & the Potassium channel opens
                    i. Occurs with neurons

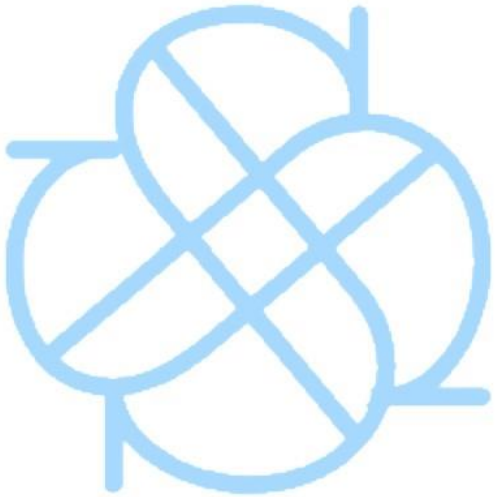
3. Potassium exits the cell
4. The **sodium potassium pump** prevents this process and maintains the membrane potential by pumping the K+ back in & the Na+ out (this part of the process requires energy, and is therefore active transport)

- **Active transport** *(Needs energy/ATP):*
    - Molecules moving from low to high concentration; against the gradient
    - Membrane proteins
    - **Endocytosis** (Needs energy):
        - Moves *large* molecules into/out of the cell. Macromolecules enter through vesicles from the plasma membrane & are then digested through lysosomes
        - **Phagocytosis** (food): Eating large molecules
        - **Pinocytosis** (water): Drinking small molecules
        - **Receptor Mediated:** Molecules need to bind to the receptors in order for a vesicle to be formed
    - **Exocytosis**
        - Used to export protein produced in the ER through vesicle that will fuse with the membrane
- Membranes may become polarized by the movement of ions across the membrane

Tonicity & Osmoregulation

- **Tonicity**: A measure of the osmotic pressure gradient/water potential
- **Osmoregulation**: Maintains water balance & allows organisms to control their internal solute concentration/water potential

    - Water moves from a *high water potential* (low solute concentration) *to a low water potential* (high solute concentration)
- **Hypertonic**: *More solute* & *less water* (low osmotic pressure)
- **Hypotonic**: *Less solute* & *more water* (high osmotic pressure)
- **Isotonic***:* Same concentration & allows for the free movement of water across the membranes without changing the concentration of either side
- **Plasmolyzed (shrinks)**: Water leaves the cell
- **Flaccid (neither swelling or completely shrunk)**: Free movement of water
- **Turgid (swells):** Water enters the cells



Enzymes

- The **active site** of enzymes specifically interact with specific **substrate molecules**
    - Can be used to break a polymer into 2 monomers (catabolic & exergonic)
    - Can be used to join 2 monomers into a polymer (anabolic & endergonic)
- The charge of the substrate & enzyme must be compatible
- They are ***catalysts***: speed up reactions by lowering the **activation energy**
- Change in the molecular structure of an enzyme may change its function/efficiency
    - **Denaturing**: The protein structure of an enzyme is disrupted & it can't catalyze reactions
        - Caused by: Temperatures & pH outside of the optimal range
- **Rate of Reactions**
    - Increase in concentrations of substrates & enzymes can increase the rate of the reactions
    - Increases as temperature increases (within optimal range) since molecules will collide more often (molecules are faster)
- As the amount of product increases, **feedback inhibition** can occur (to maintain homeostasis)
    - **Inhibitors** can reversibly (once removed, the enzyme can be used again)/irreversibly prevent substrates from binding to an enzyme's active site
    - **Competitive inhibition**: Binds to the active site, competes with substrate
    - **Non-Competitive Inhibition:** Does not bind to the active site (binds to *allosteric sites*), but changes the *shape* of the active site and prevents the binding of the substrate
    - **Negative feedback inhibition** is required to maintain homeostasis
- Enzymes need to be activated through *non-protein* cofactors & coenzymes
    - **Cofactors***:* Small *inorganic* compounds/ions that are bound within the enzyme molecule
    - **Coenzymes***: Organic* molecules that bind loosely to the active site of an enzyme & aid in substrate recruitment (vitamins)

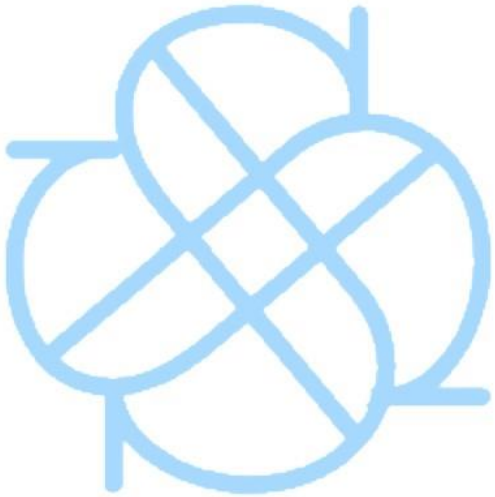
Photosynthesis

- A process that captures energy from the sun & produces sugars
- First evolved in prokaryotic organisms (**cyanobacteria**) & were responsible for the productions of an oxygenated atmosphere
- **Chloroplast**: Sites for photosynthesis in plants
    - *Thylakoid Membranes*: Site for the the ***light dependent*** reactions (needs light)
        - If the ETC didn't function, there would be less ATP, NADPH, & Oxygen produced. The Calvin cycle wouldn't take place (it needs NADPH)
        - The final electron acceptor is **NADP+**
    - *Stroma* (A dense liquid solution outside of the granum): Site for the ***light independent/Calvin Cycle*** reactions (does not need light)
        - Produces 3-C sugar G3P (2 rounds will produce 6-C sugar glucose)
        - 3 phases:
            - Carbon Fixation
            - Reduction
            - Regeneration of RuBP
    - **Compartmentalization** allows for various processes to take place within the chloroplast
- **Light = Energy = electromagnetic radiation**
    - Shorter wavelengths = higher energy
    - Plants are green because their chlorophylls reflect green light & absorb red/blue-violet

Cellular Respiration

- Mitochondrial gene is found on a single chromosome & *it is only inherited from the mother.*
- **Glycolysis (occurs in the cytoplasm of the cell):**
    - A biochemical pathway that takes in glucose & produces *2 ATP* (from ADP & inorganic phosphate) & *2 pyruvate , & 2 NADH* (from 2 NAD+). Doesn't require oxygen!
    - NADH will carry the electrons to the ETC
- ***Anaerobic*** **(absence of oxygen):** After glycolysis, cells in anaerobic conditions can go through:
    - **Fermentation**: converts NADH to NAD+ *(NAD+ is needed in glycolysis to continue making ATP)*
        - Produces organic molecules, alcohol, lactic acid, & waste products
    - **Lactic Acid Fermentation** produces lactate/lactic acid & ATP
- ***Aerobic (*****presence of oxygen):** Pyruvate is transported from the cytosol to the mitochondrion
    - Activator proteins (2 pyruvate release 2 CO_2, & produces 2 NADH & 2 Acetyl-CoA)
    - 2 Acetyl-CoA is taken into the Krebs cycle
- **Krebs/Citric Acid Cycle (occurs in the matrix of the mitochondria):**
    - Produces 2 ATP, 4 CO_2, & 6 NADH & 2 $FADH_2$ are loaded with electrons
    - All the electrons from NADH & $FADH_2$ are transported to the ETC (occurs in the inner mitochondrial membrane)
- **Electron Transport Chain (ETC)**
    - NADH drops off its electrons and becomes NAD+ again (can be used for glycolysis)
    - $FADH_2$ drops off its electrons and becomes FAD again (can be used for Krebs cycle)

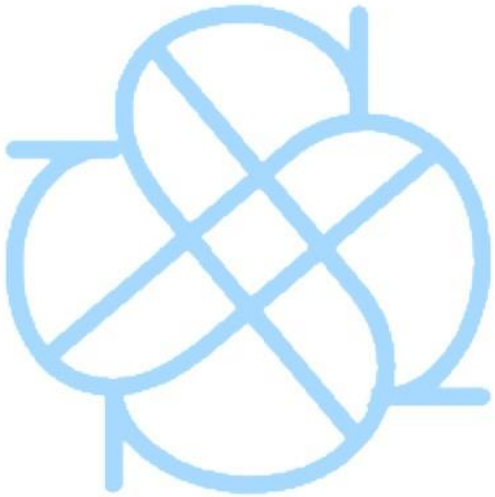
    - When electrons pass through the ETC, an **electrochemical gradient** of protons across the inner mitochondrial membrane is established (a bunch of hydrogen ions move to the intermembrane space)
    - **Oxygen** is the *final electron acceptor* & it bonds with 2 H+ to form H2O
    - **Oxidative Phosphorylation**: The H+ ions flow through **ATP Synthase** & chemiosmosis drives the formation of ATP from ADP & inorganic phosphate
- The ETC is present in chloroplasts, mitochondria, & prokaryotic plasma membranes



Cell Communication

- **Ways Cells Communicate:**
  - **Cell-to-Cell Contact**
    - Immune system cells (Antigen-presenting/Macrophages cells & Helper T cells)
    - Plasmodesmata
  - **Short distance**: Uses local regulators that target nearby cells
  - **Long distances:** signals released by one cell type can travel long distances to target cells of another cell type
    - Steroid hormones (since they are lipids, they can go through the plasma membrane)
    - Insulin (will need a receptor)
- **Signal Transduction Pathway:**
  - **Reception**: Ligand binds to the receptor protein (it might change shape)
  - **Transduction**: A multistep pathway in which molecules communicate & change each other
    - Secondary messengers (ex. Cyclic AMP) are molecules that relay & amplify the intracellular signal
    - Protein modification
    - Phosphorylation (adding phosphate groups)
  - **Cellular Response**: cell growth, cell death, secretion of molecules, or gene expression
  - A change/ mutation in the structure any signaling molecule affects the activity of the signaling pathway & can alter the cellular response
- **Quorum Sensing:** Microbes communicate with other nearby cells with the use of chemical messengers to regulate specific pathways in response to population density
- **Negative feedback**: maintains homeostasis by regulating physiological processes - moves back to the set point
  - Ex. Body temperature & blood sugar (too high = insulin is released & too low = glucagon is released)

- **Positive feedback**: keeps amplifying responses/processes until the system is changes- moves away from the set point
    - Ex. Child labor, blood clotting, & ripening of fruit



Cell Cycle

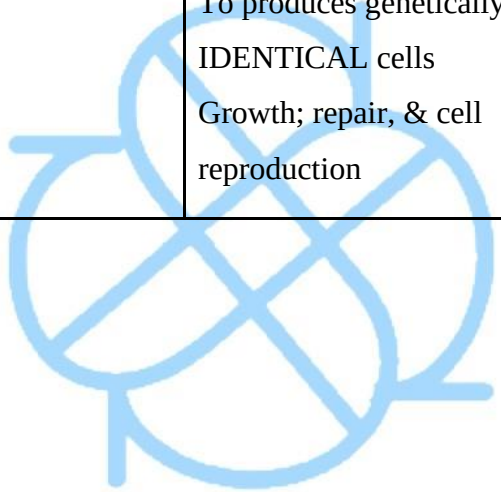
- Anything with a centromere is a chromosome
- In eukaryotes, cells divide & transmit genetic information via Mitosis & Meiosis
- Cells divide for growth & maintenance
- Cells know when to divide through chemical signals
- **Interphase**
    - Phase of cell growth (cells spend a majority of their life in this stage)
- **Checkpoints**: Ligand signals that allow/regulate a cell to continue its process
    - **G1**= growth
        - **G1 checkpoint** (before the cell begins the S phase): Checks for cell size, growth factor, & environment
    - **S**= Chromosomes duplicate (DNA synthesis)
    - **G2** = growth/preparation for mitosis
        - **G2 checkpoint** (before the cell begins the Mitosis): Checks for MPF (CDK + cyclin)
            - **MPF**: Controls the cell's transition of G2 into Mitosis by phosphorylating & activating proteins that involves with chromosomes condensation, nuclear envelope breakdown, spindle assembly, & an enzyme that will breakdown the MPF itself
- **Cyclin/CDKs:** Cyclin binds to the CDK (Cyclin Dependent Kinases) enzyme (they phosphorylate) & they produce MPF (this bumps the cell into mitosis)
    - Cyclins are created during the S & G2 phases
    - CDKs are inactive until they bind with cyclin
    - When cyclin is created & is present in high amounts, it allows for MPF production & will allow for Mitosis to begin
    - MPF & cyclin activity peak during mitosis
    - During mitosis, cyclins get degraded and the CDKs become inactive again
    - The amount of CDK always remains constant
- **Mitosis**: The division of genetic material in the nucleus (used in tissue repair)
    - **Prophase**

    - **Metaphase**
        - M checkpoint: If the kinetochores remain unattached to spindles microtubules, anaphase will not begin
    - **Anaphase**
    - **Telophase**
- **Cytokinesis**: The division of the cytoplasm and produces 2 genetically identical daughter cells (in **Mitosis**)
- **G0**: A stage where the cell no longer divides/doesn't divide as often (but it can reenter the cell cycle at some point).
    - Ex. Heart/nervous system cells
    - A cell exits the cycle & enters this stage if it doesn't pass the G1 checkpoint
- Disruptions to the cell cycle may result in **cancer** or **apoptosis** (programmed cell death)
    - **Cancer** is the failure of cell-division-control (uncontrolled cell growth)
        - Control is lost when checkpoints stop functioning or if the p53 gene is shut off
        - **P53** prevents cell growth by inhibiting the cell cycle (damaged DNA is not replicated & the CDK inhibitor is stimulated so cell division can't take place)
        - **Mutations** that cause Cancer:
            - UV radiation
            - Chemical exposure -Carcinogens
            - Radiation exposure - X-rays
            - Pollution
            - Gender
            - Age (the older you are the longer you have been in contact with radiation)
            - Genetics
- **Gametes**: Produced by Meiosis

- **Meiosis (Diploid to Haploid):** Produces 4 non-identical daughter cells that each have only one set of chromosomes & ½ as many chromosomes as the parent cell.
    - Involves 2 rounds (meiosis 1 & meiosis 2)
    - **Meiosis 1**
        - Single stranded chromosomes replicate, creating two sister chromatids connected by a centromere
        - **Prophase 1:** Homologous chromosomes (1 maternal set & 1 paternal set) perform **synapsis**
            - Synapsis/crossing over/recombination: Homologous chromosomes exchange DNA segments to increase genetic diversity among the produced gametes
            - Parental: Daughter cells that look like the maternal/paternal
            - Recombinant: Daughter cells that have different pieces of DNA**7**
        - **Anaphase 1:** The homologous maternal & paternal pairs separate
    - **Meiosis 2**
        - **Prophase 2:** No synapses
        - **Anaphase 2:** The chromatids are separated
        - It produces gametes (sperms/eggs)
        - Evolved from mitosis because its process is similar
        - **Diversity/Variation through Meiosis:**
            - Crossing over (homologous chromosomes swap over pieces of chromosomes)
            - Independent/ Random Assortment of chromosomes
            - Random fertilization
        - **Synapsis** is the pairing of two homologous chromosomes that occurs during meiosis
        - **Humans**: Diploid cell (2n) = 46 chromosomes & Haploid cell (n) = 23 chromosomes (# of chromosomes in a gamete)

	Mitosis	**Meiosis**

Chromosomes # of parent cells	Diploid (2n)	Diploid (2n)
# of DNA Replications	1	1
# of Divisions	1	2
# of Daughter Cells produced	2	4
Chromosome # of Daughter Cells	Diploid (2n)	Haploid (n)
Purpose	To produces genetically IDENTICAL cells Growth; repair, & cell reproduction	To produce GENETIC VARIATION in GAMETES



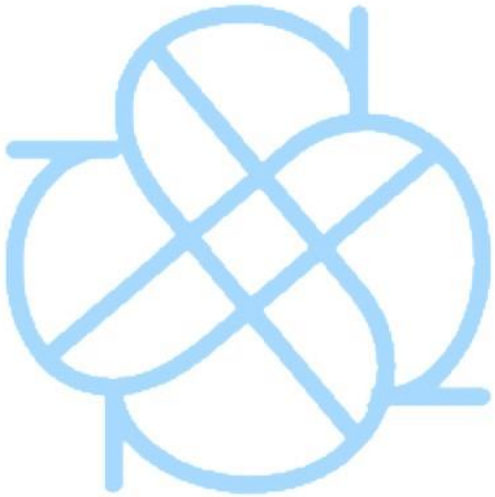
DNA Structure & Replication

- DNA, & sometimes RNA, is the primary source of heritable information
    - DNA & RNA are composed of nucleotides
- **Plasmids**: Circular, double stranded DNA molecules that provide genes; may aid in survival of the prokaryotic cell; *DNA is synthesized in the 5' to 3' direction*
- DNA has a **negative charge** (DNA moves towards the positive/oppositely charged pole)
- Replication is a **semi conservative process** (the old strand serves as the template for the new strand
- **Helicase** unwinds the DNA strand by breaking the hydrogen bonds between the nitrogenous base pairs. These strands serve as the template
- **Topoisomerase** relaxes supercoiling in front of the replication fork
- **DNA polymerase 3** *requires RNA primers* to initiate DNA synthesis
    - **Primase** facilitates the constructions of RNA primers
    - DNA polymerase synthesizes new strands of DNA continuously (towards the replication fork) on the leading strand & discontinuously (away from the replication fork) on the lagging strand
- **DNA polymerase 1** removes the RNA primers & replaces them with nucleotides
- **DNA Ligase** glues the fragments (***Okazaki fragments***) on the lagging strand
- DNA Polymerase proofreads newly made DNA & replaces any incorrect nucleotides
- **Summarized Process of DNA Replication**
    1. Helicase unwinds the parental double helix
    2. Molecules of **SSBP** (single stranded binding protein) stabilize the unwounded template strands
    3. The leading strand is synthesized continuously in the 5' to 3' direction by **DNA polymerase 3**
    4. Primase begins synthesis of the RNA primer for the 5th Okazaki fragment
    5. **DNA polymerase 3** is completing synthesis
    6. **DNA polymerase 1** removes the primers & replaces them with nucleotides
    7. **DNA ligase** joins the 3' end of fragment 2 to the 5' end of fragment 1

Protein Synthesis

- Genetic information flows from a sequence of nucleotides in DNA to a sequence of bases in a mRNA molecule to a sequence of amino acids in a protein
- Cause of an amino acid **substitution**: A change occurred in the DNA sequence encoding that protein
    - Amino acid substitution can change the shape of the protein (changes the function)
- **Transcription**: RNA polymerases use a single template strand of DNA to direct the inclusion of bases in the newly formed RNA molecule.
- **Messenger RNA Processing** (produces Mature RNA)
    - Introns (the junk): They are cut from the DNA (Stay inside the nucleus)
    - Extrons join together & a poly-A tail & a GTP cap is added
    - mRNA molecules carry information from DNA to the ribosome
- Distinct **tRNA** molecules bind to specific amino acids & have anti-codon sequences that base pair with the mRNA
    - tRNA is recruited to the ribosome during translation to generate the primary peptide sequence based on the mRNA peptide sequence
- **rRNA** molecules are functional building blocks of ribosome
- **Translation** is initiated when the rRNA in the ribosome interacts with the mRNA at the start codon
    - The sequence of nucleotides on the mRNA is read in triplets called codons
        - Many amino acids are encoded by more than one codon
    - tRNA brings the correct amino acid to the correct location according to the mRNA
    - The process continues until a stop codon is reached
        - It terminates by the release of the newly synthesized protein
    - Translation of the mRNA to create a polypeptide/protein occurs on Ribosomes (present in the cytoplasm & rough ER)
- In **prokaryotic** organisms, translation of the mRNA molecules occurs while it is being transcribed
    - They don’t have a nuclear envelope that separates the genome from the ribosomes in the cytoplasm of the cell, unlike eukaryotes

- Nearly all living organisms use the same genetic code, which is the evidence for the **common ancestry** for all living organisms



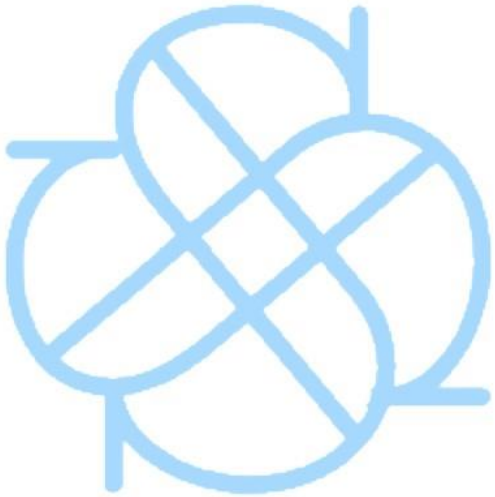
Gene Regulation

- **Regulatory sequences** are stretches of DNA that interact with regulatory proteins to control transcription
- **Activator proteins** can turn on/off gene regulation in eukaryotes
- Gene regulation in Eukaryotes includes blocking translation (occurs at the ribosome)
- All cells do not only contain genes for the proteins of that particular tissue (which is why specific ones need to be turned on/off)
- Each Eukaryotic gene has a **promoter** (DNA sequence where RNA polymerase binds start transcription, proceeding "downstream")
- **RNA processing**:
    - Addition of a **5' cap**
    - Addition of a **3' Poly-A tail** (the longer the tail, the more proteins will be produced)
    - **Splicing**: removing introns and connecting exons
- Eukaryotic DNA is packing using **histone** proteins
- **Epigenetic inheritance:** The inheritance of traits transmitted by mechanisms not directly involving the nucleotide sequence
- Specific **transcription factors** made in a cell determine which genes are expressed
- In prokaryotes, groups of genes called **operons** are transcribed in a single mRNA molecule
- **Operon**: The entire stretch of DNA that includes the operator, the promoter, & the genes that they control
    - A group of functionally related genes that can be coordinately controlled by a single "on-off switch" (the regulatory "switch")
    - The 2 types of Operons in Prokaryotes:
        - **Repressible**: A system where *the gene is on* but it can be turned off (ex. the trp operon)
        - **Inducible**: A system where *the gene is off* but it can be turned on (ex. the lac operon)
- Steroid hormones act directly to activate/repress transcription factors
- Protein hormones act via a signal transduction pathway

- **Negative regulatory molecules** inhibit gene expression by binding to DNA & blocking transcription
    - Ex. DNA **methylation** (methyl groups are added to certain bases in DNA (usually cytosine) and this restricts RNA polymerase from binding)
    - Individual genes are usually *more heavily methylated* in cells where they are *not expressed*
    - The methylation pattern is inherited because it remains through cell division
- **Ways Genes Are Regulated In Eukaryotes:**
    - **Chromatin Modification**
        - The histones that are wrapped around the genes can be either loosened or tightened to enhance/decrease transcription
        - **Histone acetylation**: Makes the DNA more accessible to transcribe → increases transcription
        - **DNA methylation**: blocks the ability of RNA polymerase to transcribe the genes → decreases transcription
    - **Transcription**
        - DNA *control elements* in enhancers bind specific transcription factors
        - Bending of the DNA enables **activators** to contact proteins at the promoter (initiates transcription)
        - Genes that are in a coordinately controlled group all share a combination of control elements
    - **mRNA Degradation**
        - Each mRNA has a characteristic life span
    - **RNA Processing**
        - Alternative RNA splicing
    - **Translation**
        - Initiation of translation can be controlled via regulation of initiation factors
    - **Protein Processing & Degradation**
        - Protein processing & degradation are subject to regulation

Gene regulation in Prokaryotes VS Eukaryotes

Prokaryotes	**Eukaryotes**
Operons present	No operons present
+ & - control (ability to induce & repress genes from being transcribed)	Primarily + control (ability to induce genes from transcribed)
Enhancers rare	Enhancers common
None	Methylation & Acetylation



Evolution

- **Wild type** = the normal strain that doesn't have any mutations
- **Angio-genesis** = new blood vessels form from pre-existing vessels
- **Endosymbiosis theory**
    - Organelles have a double membrane
    - Organelles have their own DNA

Prokaryotes	**Eukaryotes**
No Introns	Introns (junk parts of the DNA) are present
DNA is not in the Nucleus (it's in the nucleoid region)	DNA is in the nucleus (As well as in the mitochondria & Chloroplasts)
No histone proteins surrounding the DNA	Has histone proteins surrounding the DNA
Only one chromosome	More than one chromosome
Plasmids (extracellular pieces of DNA) are common	Plasmids are rare (some are in yeast though)

Experimental Design

- If the **chi value** is *lower* than the **critical value,** the null hypothesis cannot be rejected (we fail to reject the null hypothesis/we accept the null hypothesis)
    - Results aren't significant
- If the **chi value** is *higher* than the **critical value**, the null hypothesis can be rejected
    - Results are significant
- Lower mortality = Greater survival
- A **control** to improve the validity of the experiment = measure the dependent variable in another group with the same environment except it should be treated with a **placebo**/comparison