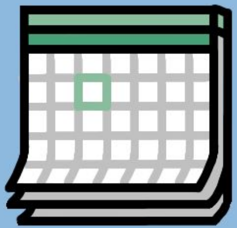
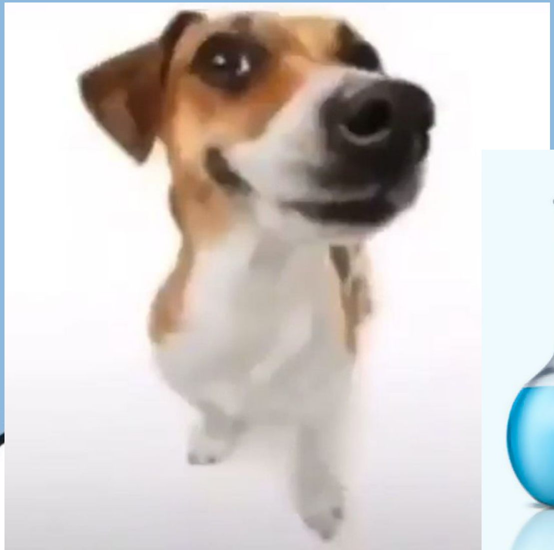
AP Bio Midterm Prep Session!

By your amazing kitty hawk tutors!!

TABLE OF CONTENTS



Unit 1: The Chemistry of Life



Water!!! They call it the solvent of life...

- What makes water SO special?? It's all about the molecule's structure.
  - Polarity - 2 H and 1 O bond covalently in a situation where the electrons are shared unequally
  - All you should know is that the oxygen has a slight negative charge and hydrogen has a slightly positive charge (O is hogging the electrons a bit)
  - This is what allows for many of water's properties!

Water is quirky contd.

- Molecules of water are held together in what are called hydrogen bonds, which are possible because of what we just discussed about polarity
- Responsible for many properties of water that are essential to life
- Ex. water is weird! The solid form of water aka ice is less dense than the liquid form, allowing ice to float on top of water
  - Because of hydrogen bonds, frozen water forms a “crystalline lattice structure” that allows for that low density
  - Property is essential to life (ex. Fish in a frozen pond or polar bears)

Things Water Can Do :D

- Cohesion
  - The attraction between water molecules
  - Ex. Cohesion due to hydrogen bonding contributes to the transport of water and nutrients against gravity in plants
- Adhesion
  - Water adheres to other molecules and substances pretty well
- Surface Tension
  - To an extent water's surface is hard to break
  - Due to cohesive forces
  - Ex. water strider insects rely on this surface tension to walk on water
- Specific Heat
  - Refers to the amount of heat energy it takes to raise or lower the temperature of one gram of a substance by one degree Celsius
  - Water has a high specific heat, meaning relatively, it takes more energy to heat it
  - Water is everywhere (our oceans, our bodies, etc.) so we need it to be resistant to extreme temperature changes
- Evaporative Cooling
  - Water has a high heat of vaporization (it takes a good amount of heat to cause evaporation) so water can absorb a lot of heat, leaving the surface below it cooler

Water is quirky contd.

- Solvent of Life!
  - Remember "like attracts like" - water is polar and it dissolves other polar substances
  - Hydrophilic: attracted to water
  - Hydrophobic: repelled by water
- Also know: pH!
  - pH is a measure of the hydrogen ion concentration in a solution
  - Scale: Ranges from 0 to 14, logarithmic scale
  - pH < 7: Acidic (higher concentration of hydrogen ions)
  - pH = 7: Neutral (pure water)
  - pH > 7: Basic (lower concentration of hydrogen ions)
  - pH is important when it comes to biological concepts such as homeostasis (ex. Enzymes, which will be covered soon)

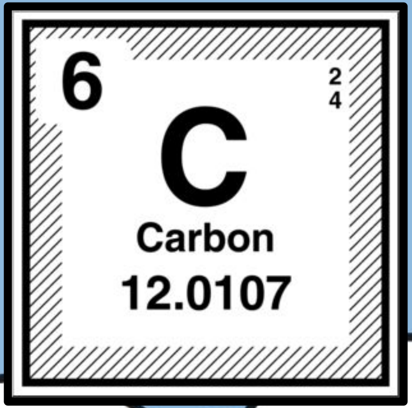
Chemistry of Life 101

ACRONYM ALERT!!!
"CHNOPS" refers to the six essential elements for life on Earth: Carbon (C), Hydrogen (H), Nitrogen (N), Oxygen (O), Phosphorus (P), and Sulfur (S)

- Everything is made of matter; matter takes up space and has mass
- Matter is made up of these tiny particles called atoms, which are made up of smaller, subatomic particles (protons, neutrons, electrons)
- Elements are substances that cannot be broken down by further chemical reactions
- The important elements when it comes to AP Bio (and life in general) are oxygen (O), carbon (C), hydrogen (H), nitrogen (N), calcium (Ca), phosphorus (P), potassium (K), sulfur (S), sodium (Na), chlorine (Cl), and magnesium (Mg)

Chemistry of Life 101

- Compounds are substances that we can break down through chemical reactions because they are composed of a fixed ratio of elements (ex. H20 is made up of a fixed ratio of 2H : 1O)
- The atomic number of an element is determined by the number of protons in the nucleus
    - In the figure to the right, the number six is the atomic number of carbon
    - The atomic mass number is the sum of the protons and neutrons in the nucleus
    - The atomic mass number from the figure is 12.0107

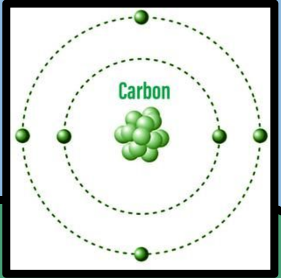


Chemistry of Life 101

- Isotopes
- Two atoms of an element with different numbers of neutrons
- Radioactive Isotopes:
- Used in fossil dating and medical imaging
- Decay spontaneously, releasing energy
- Ex. Carbon-14 (Radiocarbon):
  - Used for dating sites, fossils, and artifacts
    - Atomic nucleus contains six protons and eight neutrons

- Electron Shells
- An electron's potential energy is called an energy level or electron shell
- Energy Absorption:
- Electrons move to a higher energy level, farther from the nucleus
- Energy Release:
- Electrons move to a lower energy level, closer to the nucleus

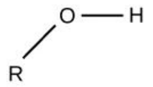
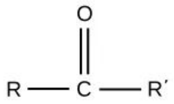
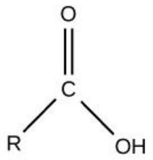
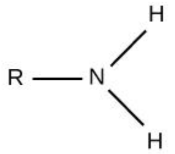
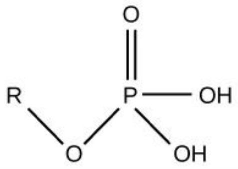
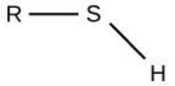
Every element's favorite: Carbon!



- Carbon is known as the "building block of life" in biology
- It looks like this, meaning it can form 4 covalent bonds (the term is tetravalence), which means it is super versatile in terms of creating various complex molecules
  - It needs 4 electrons from other atoms to fulfil the octet rule, which states that atoms must have 8 electrons in their outermost "valence" shells to be stable

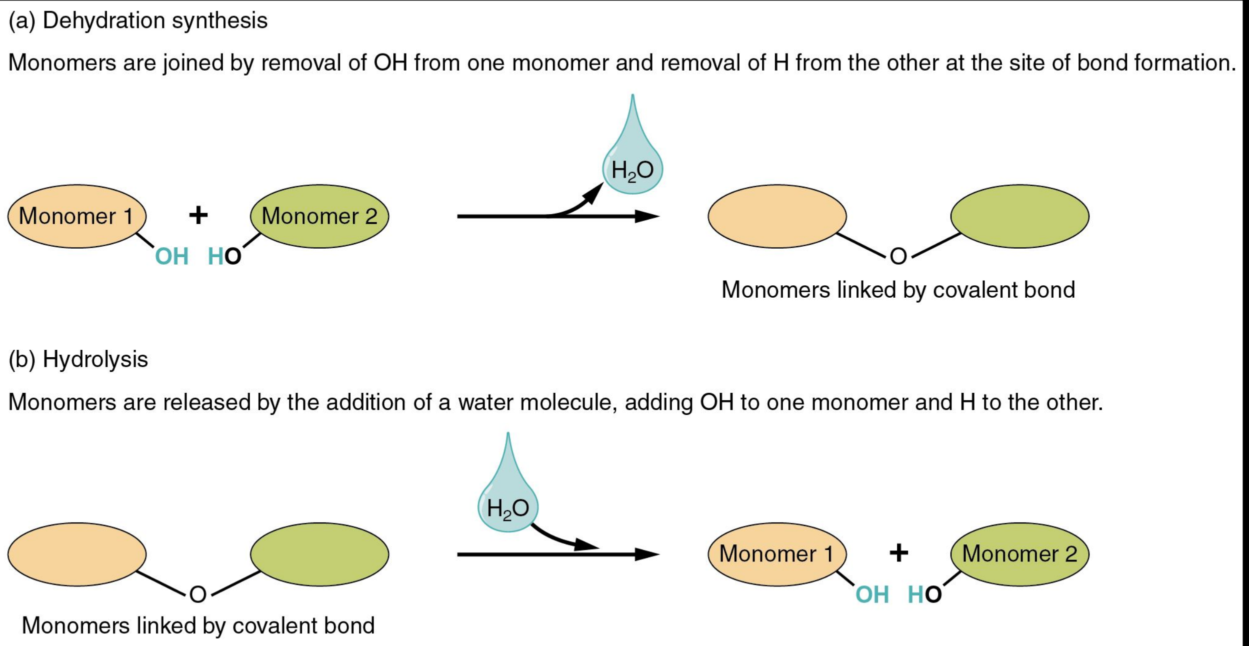
Functional Groups

These can be thought of "accessories" that change the structure of molecules, therefore changing molecular function.

Functional Group	Structure	Properties
Hydroxyl		Polar
Methyl	$R - CH_3$	Nonpolar
Carbonyl		Polar
Carboxyl		Charged, ionizes to release H^+. Since carboxyl groups can release H^+ ions into solution, they are considered acidic.
Amino		Charged, accepts H^+ to form NH_3^+. Since amino groups can remove H^+ from solution, they are considered basic.
Phosphate		Charged, ionizes to release H^+. Since phosphate groups can release H^+ ions into solution, they are considered acidic.
Sulfhydryl		Polar

Macromolecules

- Monomers are building blocks that make polymers*
- You get monomers when hydrolysis occurs
- You get polymers when dehydration synthesis occurs between monomers



Macromolecules

- <u>Carbohydrates:</u>
- Monosaccharides: Simple sugars (e.g., glucose)
- Disaccharides: Two monosaccharides linked together (e.g., sucrose)
- Polysaccharides: Long chains of monosaccharides (e.g., starch, glycogen, cellulose)
- Glycosidic bonds
- Provides energy (short and long term storage)
- Structural support in plants (cellulose)
- Cell signalling/recognition

- <u>Lipids:</u>
- Fats: Made of glycerol and fatty acids
- Saturated Fats: No double bonds between carbon atoms; solid at room temperature
- Unsaturated Fats: One or more double bonds between carbon atoms; liquid at room temperature
- Phospholipids: Major component of cell membranes.
- Steroids: Include hormones like testosterone and cholesterol
- Long term energy storage
- Insulation
- Formation of cell membrane (lipid bilayer)

Macromolecules

- Proteins:
- Amino Acids: Building blocks of proteins
- Levels of Structure: Primary, secondary, tertiary, and quaternary structures
- Functions: Enzymes, structural proteins, signaling molecules, etc.
- Peptide bonds

- Nucleic Acids:
- DNA and RNA: Store and transmit genetic information
- Nucleotides: Building blocks of nucleic acids
- Phosphodiester bonds

Unit 2: Cell Structure & Function

Battle of the Cells

Prokaryotic

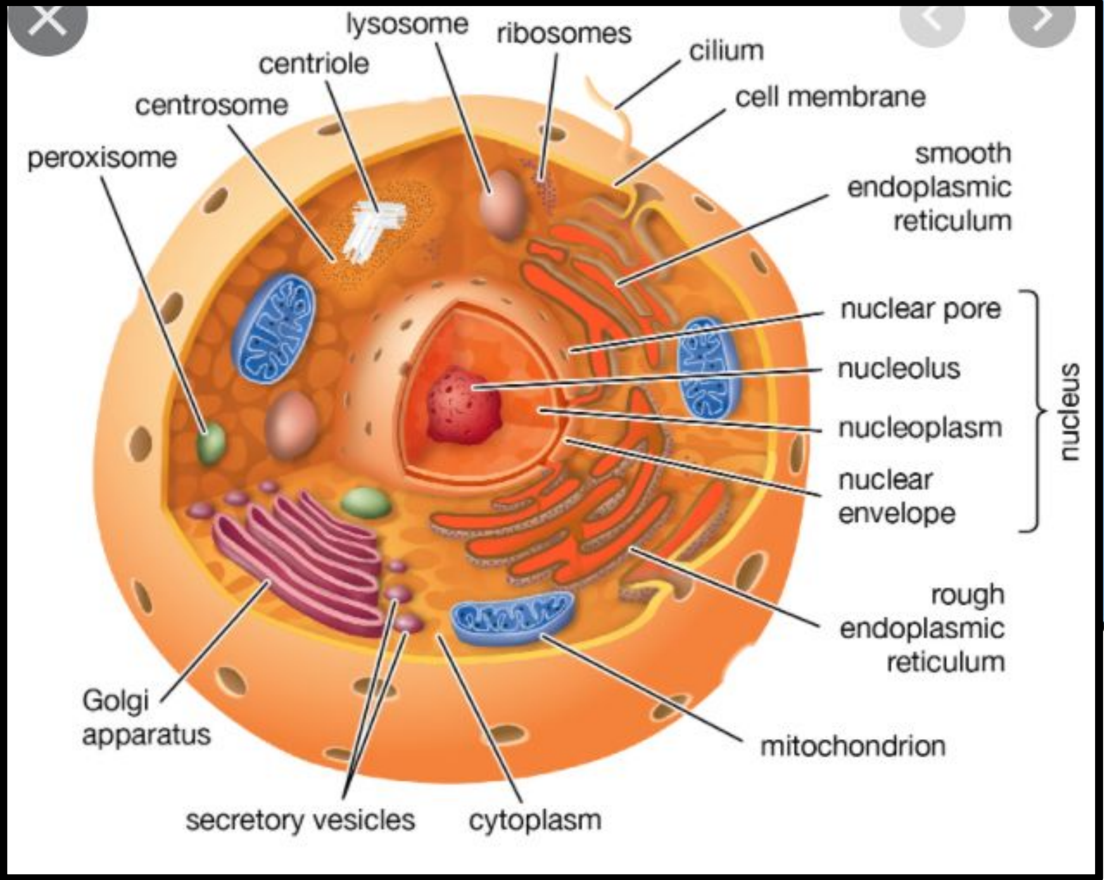
- Generally smaller
- No true nucleus; DNA located in nucleoid region
- No nuclear envelope
- Circular DNA molecule
- Single chromosome
- Organelles not membrane-bound
- Asexual reproduction; binary fission
- Ex. bacteria, archaea

Eukaryotic

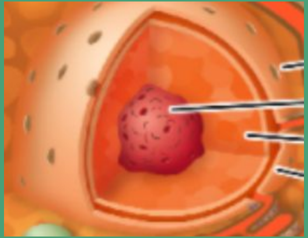
- Generally larger
- Contains nucleus enclosed with nuclear envelope; has pores for transport
- Linear DNA molecules
- Several chromosomes
- Has membrane-bound organelles
- Asexual and sexual reproduction (mitosis for somatic cells and meiosis for gametes)
- Ex. plants, animals. Fungi, protists

Eukaryotic Cells

- You want to learn each of the organelles and their functions within the cell
- Features of animal cells and some plant cell specifics

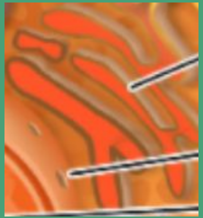


Eukaryotic Cells



- Nucleus: Function as the control center of the cell, containing DNA in the form of chromatin
- Nuclear Envelope: Double membrane structure surrounding the nucleus, with nuclear pores for transport
- Nucleolus: Site of ribosome synthesis within the nucleus

Ribosomes: Small structures responsible for protein synthesis, can be free in the cytoplasm or attached to the rough ER

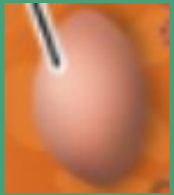


Smooth ER: lacks ribosomes, involved in lipid synthesis and detoxification.

Rough ER: studded with ribosomes, involved in protein synthesis and modification.

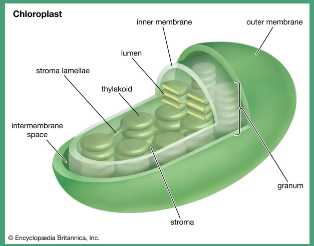
Eukaryotic Cells

Golgi Apparatus: Modifies, sorts, and packages proteins received from the ER.

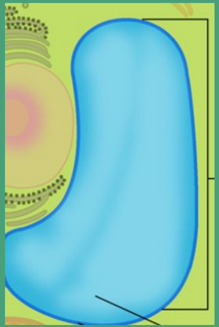


Lysosomes: Membrane-bound organelles containing digestive enzymes for breaking down waste materials.

Mitochondria: "Powerhouse of the cell," responsible for ATP production through cellular respiration.



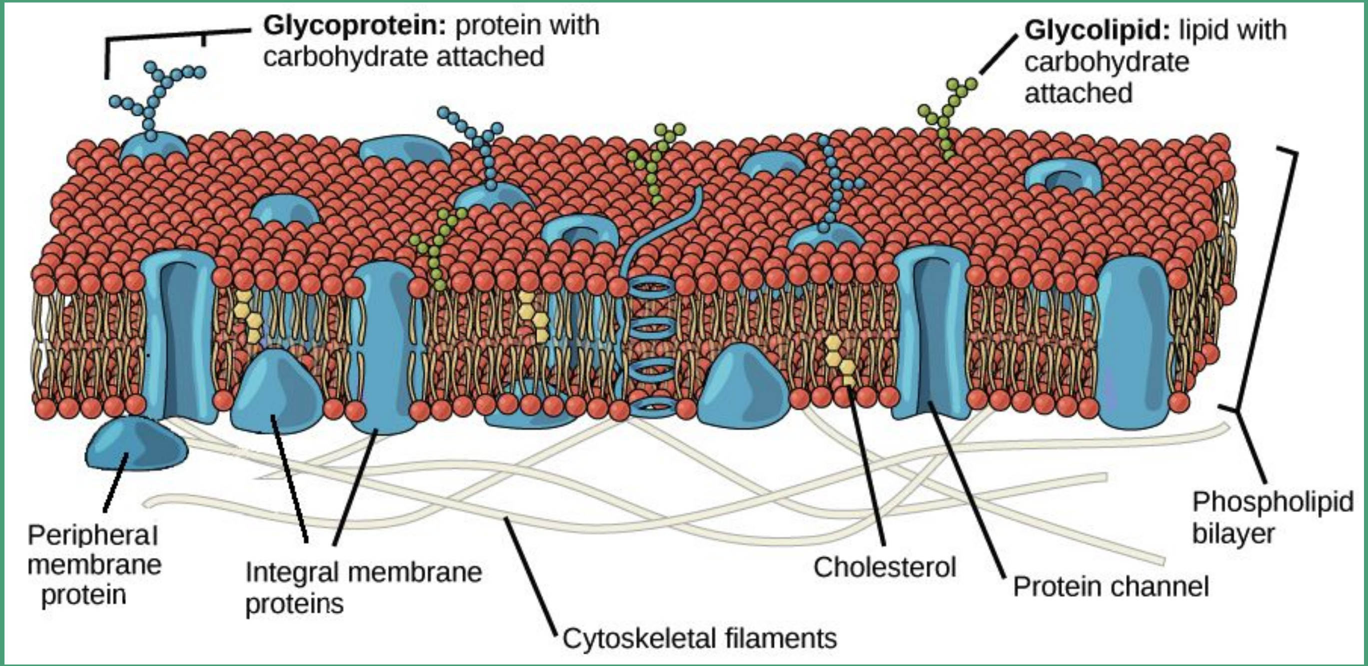
Chloroplasts (plant cells only): Site of photosynthesis in plant cells.



Vacuole (plant cells only): Large storage organelle in plant cells.

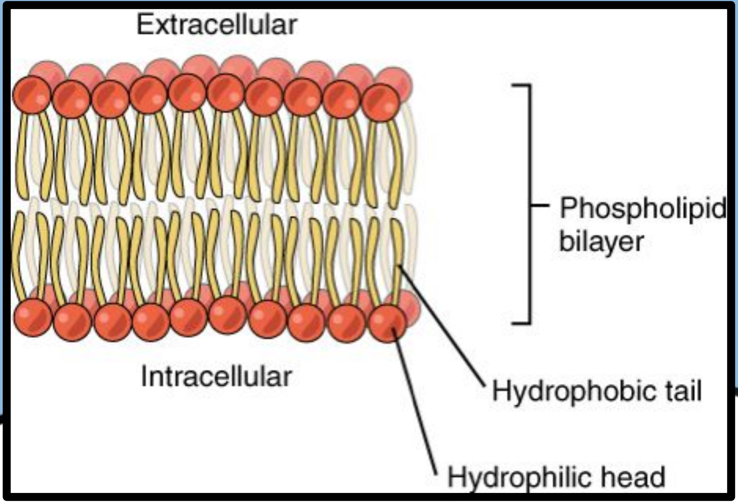
Cell Membranes

!!!KEY CONCEPT ALERT!!!
Cells with a higher Surface Area : Volume ratio can exchange materials (like nutrients and waste) more efficiently ; Cells may have adaptations like microvilli to increase surface area without significantly increasing volume



Cell Membranes (are a big deal)

- The primary component of a cell's membrane is the phospholipid bilayer
- Each unit contains a hydrophilic head and a hydrophobic tail
- The membrane is selectively permeable, meaning it encloses the cell and only allows for the passage of certain things
- The Fluid Mosaic Model allows you to imagine the cell membrane as a fluid structure with embedded units like proteins, channels, etc.



More on (in) Cell Membranes

- Channel Proteins: Allow specific ions or molecules to pass through the membrane via a hydrophilic channel
- Carrier Proteins: Bind to specific molecules and facilitate their transport across the membrane.
- Recognition Proteins: Identify the cell type and are involved in cell-cell signaling

- Carbohydrates: These are attached to proteins and lipids on the extracellular surface of the membrane, forming glycoproteins and glycolipids
- They play a key role in cell recognition and communication

- Cholesterol: This lipid is interspersed within the phospholipid bilayer, contributing to membrane fluidity and stability

Cell Transport Mechanisms

<u>Active Transport</u>

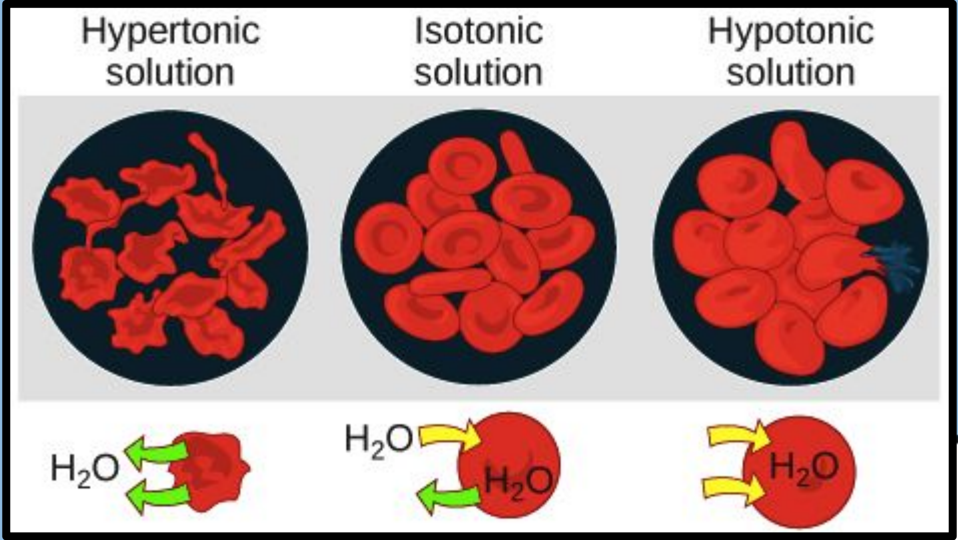
- Direct use of ATP to transport molecules against their concentration gradient
- Sodium-potassium pump moves Na^+ out of the cell and K^+ into the cell through active transport
- Requires energy expenditure!***

<u>Passive Transport</u>

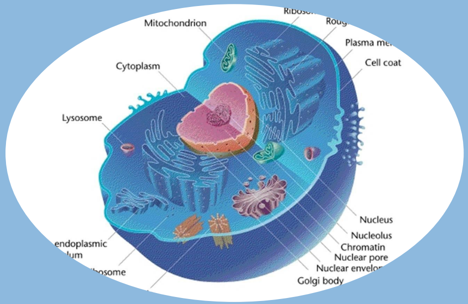
- Diffusion: Movement of molecules from an area of higher concentration to an area of lower concentration until equilibrium is reached
  - No energy required
- Osmosis: Diffusion of water molecules through a selectively permeable membrane from an area of lower solute concentration to an area of higher solute concentration
- Facilitated Diffusion: Movement of molecules through transport proteins down a concentration gradient

Cells in Solutions

- Cells in solutions with solute concentrations different from the solute concentrations within their own walls will react in different ways
- Cells in hypertonic solutions shrivel up
- Cells in isotonic solutions are happy :D (turgid)
- Cells in hypotonic solutions burst (lyse)



Unit 3: Cellular Energetics



+

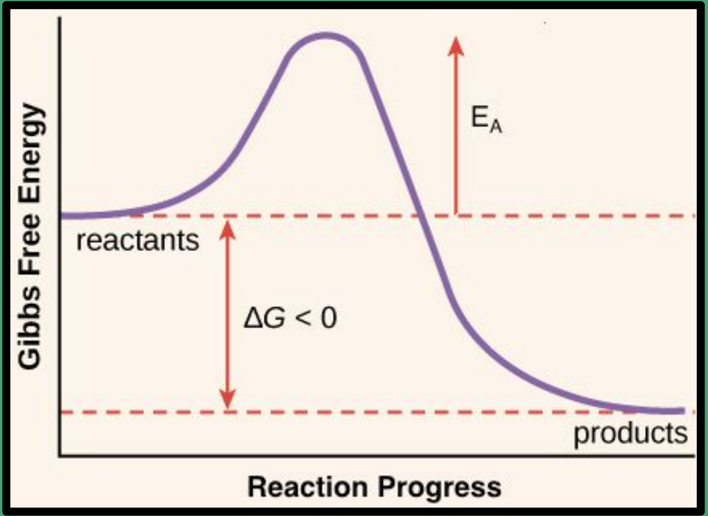
=

Activation Energy!

What is it?

- An initial energy input required for a reaction to take place
- Typically in the form of heat
- Often abbreviated E_A
- Think of a boulder on a hill
  - It only starts rolling down once you push it
- In bio terms, the chemical bonds in the reactants must be weakened enough to be rearranged into the products
  - Called the transition state

Exergonic reaction: energy is released, so ΔG is negative

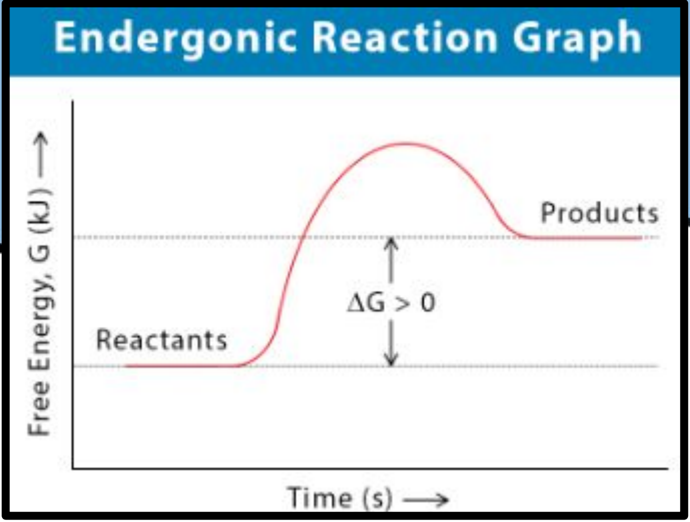


More Activation Energy!

- Example: think of ATP as a reactant
  - Broken down into ADP and a phosphate group (the products) to release energy, meaning the reaction is exergonic
  - If the reaction is endergonic, the activation energy would be quite large because the products must end with more free energy than the reactants

REMINDER:

Gibbs free energy (ΔG) is the energy change in a system. Exergonic means a negative value for ΔG, while endergonic means +ΔG



WAIT! We have a problem...

When the E_A for a reaction is high (meaning it takes a lot of energy to give that initial "shove" for the reaction to take place), it's difficult for that reaction to occur. These reactions are also *way* slower because reactants rarely have the energy they need to proceed with the reaction. Unfortunately, many vital reactions in the body require a high E_A. Wouldn't it be nice if the body had something that could actually lower the E_A of chemical reactions? Well, never fear...

Enzymes are here!

They lower activation energy!

Enzymes act as catalysts by lowering the E_A for reactions in the body. This process is called catalysis.

They speed up reactions!

By lowering E_A, enzymes make it way easier for reactions to occur, which in turn speeds them up.

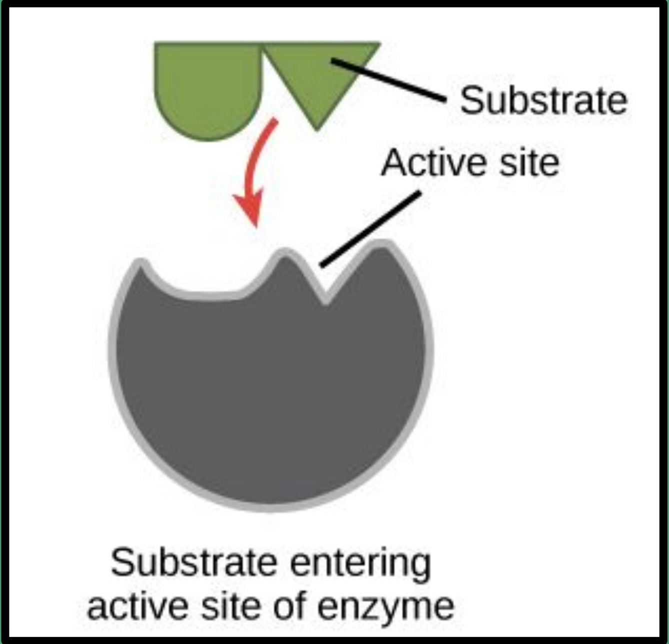
They're reusable!

Enzymes aren't used up in reactions—this is actually a requirement for something to be a catalyst.

How do you do it, enzymes?

Step 1:

- Enzymes are typically proteins and larger than the reactants
    - The reactants that pair with a specific enzyme are called its substrates
- Enzymes bind (grab on) to substrates at their active site
    - Each enzyme has an active site that is specifically structured to allow substrates to bind and react more efficiently



How do you do it, enzymes? (cont.)

Step 2:

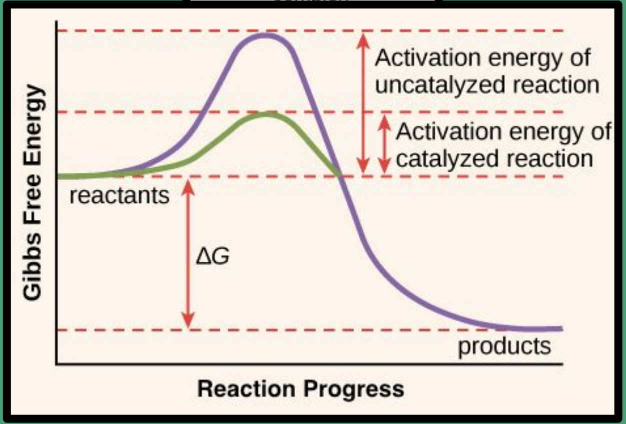
- Once bound, enzymes and their substrate(s) form an enzyme-substrate complex
- The active site gets its properties from the amino acids it's made of
- These amino acids form an ideal environment for the reaction to take place
    - Specific shape, size, charge, chemical behavior, structure, etc.


Enzyme/substrate complex

How do you do it, enzymes? (cont.)

Step 3:

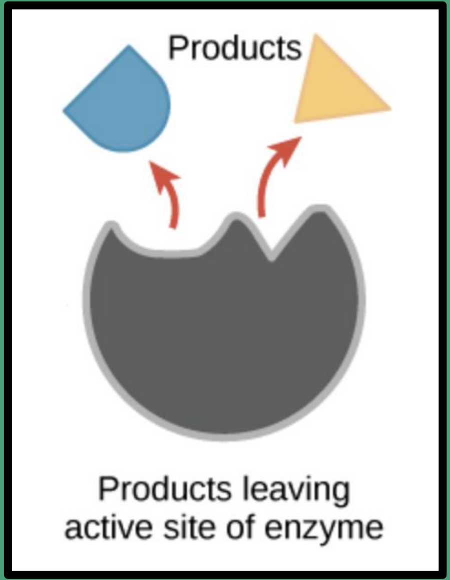
- The unique properties of the active site make it easier for the reaction to occur
  - This lowers the E_A and speeds up the reaction
- The reaction takes place in the active site, and the reactants become the products
  - Examples: two substrates combining, one substrate splitting, two substrates swapping parts



How do you do it, enzymes? (cont.)

Step 4:

- The completed products are released and the enzyme is free to bind to new reactants and repeat the process!



Enzymes are dainty little things...

IMPORTANT NOTE:

- Enzymes are picky and work best under certain conditions
- Temperature: a higher temperature speeds up reactions, but too high or too low and the enzyme will denature (lose its shape and functionality)
- pH: enzymes have ideal pH ranges—a pH that's too high or too low can decrease efficiency or trigger denaturation

MORE IMPORTANT NOTES:

- Enzyme concentration: increasing the amount of enzymes will speed up a reaction as long as there's enough substrate to bind to
- Substrate concentration: same idea! Adding more substrate will make more substrate available to be bound by enzymes, speeding up the overall reaction
- These concentrations restrict each other's efficiency

Induced Fit!

- Enzymes like to get snug and will actually change shape slightly when they bind with their substrate(s)
- This is called induced fit
- When the reaction is complete and the products have been released, the enzyme returns to its original shape (this is what makes enzymes reusable!)
    - This means there does not have to be a 1:1 ratio of enzymes to substrates

NOTE 1:

Enzymes are sometimes called "biological catalysts" because they speed up biological reactions

NOTE 2:

Enzymes are generally specific to one or a couple substrates; some are more specific than others

Enzyme overload? Never fear

If enzymes were left to their own devices, they would just keep churning away, and away, and away, which could cause problems. Luckily, your body has some ways to regulate them:

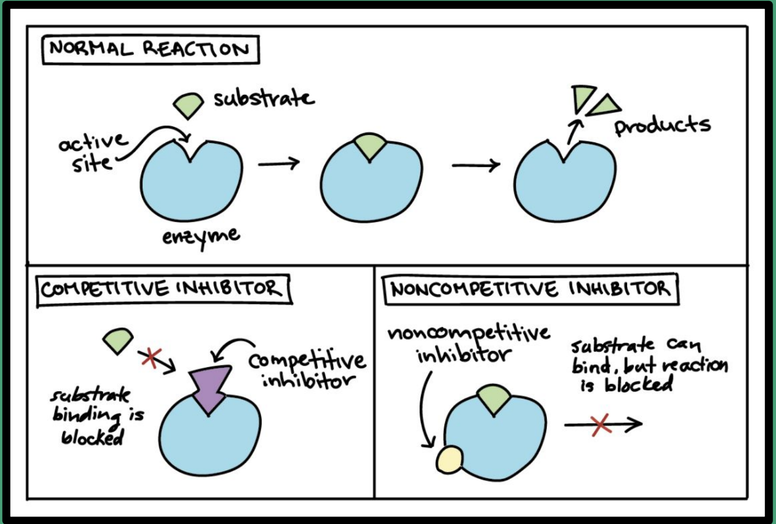
- **Regulatory Molecules**
- **Cofactors & Coenzymes**
- **Compartmentalization**
- **Feedback Inhibition**

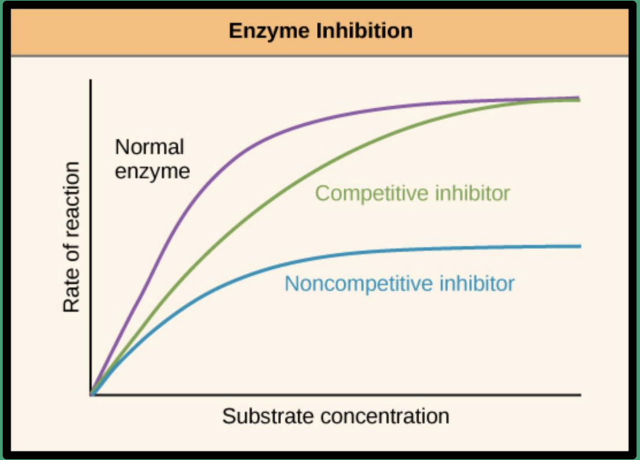
Let's take a gander, shall we?

Regulatory Molecules

- Activators increase enzyme activity; inhibitors decrease activity
- Competitive inhibitors bind to enzymes at their active site and prevent the substrate from attaching
  - They can be “out-competed” if there is enough substrate, allowing the reaction to achieve its maximum rate
- Noncompetitive inhibitors attach to enzymes not at the active site, but at a place where they can alter the enzyme in a way that prevents the reaction from taking place
  - They cannot be “out-competed” even with an abundance of substrate, preventing the reaction from ever reaching its maximum rate

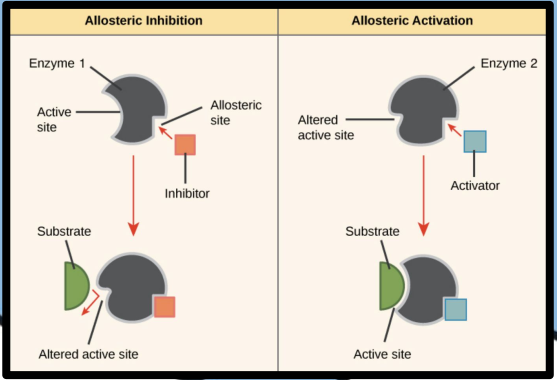
Regulatory Molecules (cont.)





Regulatory Molecules (cont.)

- Allosteric regulation is *any* situation where an activator or inhibitor binds to an enzyme somewhere other than the active site
    - Noncompetitive inhibition fits in this category
- Allosteric enzymes are special and have multiple active sites
    - When an allosteric activator or inhibitor binds to one, all active sites are affected
- Cooperativity is when a substrate acts as an allosteric activator and increases the activity of multiple active sites



Cofactors & Coenzymes

Cofactors

Many enzymes depend on helper molecules (called cofactors) to function properly.

Coenzymes

Coenzymes are a type of cofactors that are organic (carbon-based) molecules. Dietary vitamins are a primary source of coenzymes.

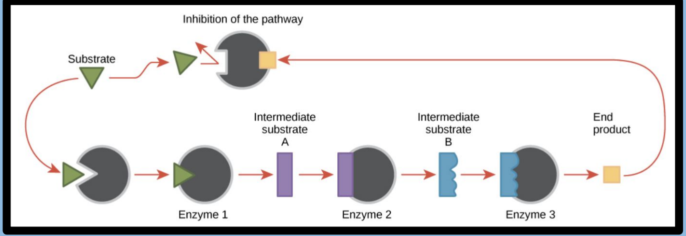
Examples

Magnesium ions (cofactor) are crucial to the function of DNA polymerase, and vitamin C (coenzyme) plays a vital role in building collagen, a type of connective tissue.

Compartmentalization

- Enzymes are usually kept in a specific area of the body or cell
  - Ensures the enzymes work in an <u>ideal microenvironment</u>
  - Ensures that substrate for the enzyme can be <u>concentrated</u> at a high-enough level for proper function
  - <u>Prevents harm</u> to other parts of the body/cell
  - Think of a teacher trying to make a seating chart—they have to strategically separate students to prevent a rowdy classroom!
- The lysosome is a great example: its digestive enzymes require a low pH of around 5.0 that the lysosome interior provides (cytosol is ~7.2 pH)
  - If the lysosome bursts, the pickiness of digestive enzymes regarding ideal pH means they won't start digesting the cell

Feedback Inhibition



- The end product of a reaction acts on the enzyme that enables the reaction to occur, inhibiting the metabolic pathway
    - Prevents too much product from being made—once enough of the product is used up, inhibition will cease and the enzyme can once again help create the product
    - Feedback inhibition can occur at a single or multiple steps of a pathway
- Example: when too much ATP is produced, ATP acts as an allosteric inhibitor, preventing excess ATP from being wasted

Thermodynamics... so cool

It's time to move on to thermodynamics! Don't worry—thermo might sound complicated, but it's actually really simple. There are two major laws you should know.

1st Law: energy can only change form or be transferred, and is never created or destroyed

2nd Law: every energy transfer increases the entropy of the universe

Thermo Laws Explained

1st Law: energy can only change form or be transferred, and is never created or destroyed

This law is pretty simple, but one important thing to note is that with every reaction, some energy is lost as heat energy.

2nd Law: every energy transfer increases the entropy of the universe

Heat energy is sorta MID because it can never be converted 100% into a form of energy that can perform work. Even worse, heat tends to increase entropy (the randomness/disorder in a system). If you have a collection of ice cubes in water, the transfer of heat between the two and into the surroundings will cause the previously ordered arrangement (warmer and colder substances) to become more random.

Thermodynamics definitions (easy-peasy)

System

The item or items we're interested in (a cell, an ecosystem, your body, etc.)

Surroundings

Everything that's, well, *surrounding* the system.

Universe

In the context of thermodynamics, this is the combination of the system *and* surroundings.

More thermodynamics definitions!

Open system

Can exchange both energy and matter with its surroundings

Ex. a pot with boiling water

We are open systems!

Closed system

Can exchange energy, but not matter, with its surroundings

Ex. putting a lid on the boiling pot

Isolated system

Cannot exchange energy or matter (hard to find a perfect example)

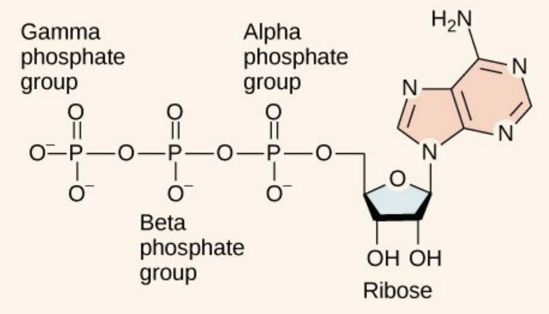
Ex. a closed hydroflask

Your metabolism

You've probably heard the term metabolism, which refers to the cumulative chemical reactions that take place in something. Two of the biggest metabolic processes that take place in cells are **cellular respiration** (releasing energy) and **photosynthesis** (storing energy).

You should also be familiar with metabolic pathways—a series of chemical reactions that lead into each other. Anabolic pathways build complex molecules from simpler ones, while catabolic pathways break complex molecules into simpler ones.

Apateu? APT? ATP!



Adenosine triphosphate is *one of the most important molecules* in living things. Due to the high-energy bonds between its phosphate groups, the hydrolysis (water-mediated breakdown) of ATP releases considerable amounts of energy.

ATP can be broken down into ADP or even AMP, molecules which can be “recharged” by adding back phosphate groups (and thus infusing energy) into the molecule (this is called phosphorylation). For this reason, ATP is considered the “energy currency” of living things.

Photosynthesis: The Intro

Let's put everything together!

Photosynthesis is the process where light energy is converted to chemical energy in the form of sugars. This accomplishes 2 things:

1. Light energy powers the creation of glucose (or other sugars) from water and CO_2, storing energy that can be harvested to replenish ATP (via cellular respiration).
2. Inorganic carbon from CO_2 is incorporated into organic molecules, making it available for use as a building block for other molecules. This is called carbon fixation.

Photosynthesis: The Definitions

Photoautotrophs

Are organisms that produce their own food (a.k.a. producers). The "photo-" part refers to autotrophs that use light to do this!

Heterotrophs

Are organisms that must rely on other organisms for food (a.k.a. consumers). They cannot produce food themselves.

<u>Photoautotrophs:</u>

Plants, algae, some bacteria

<u>Heterotrophs:</u>

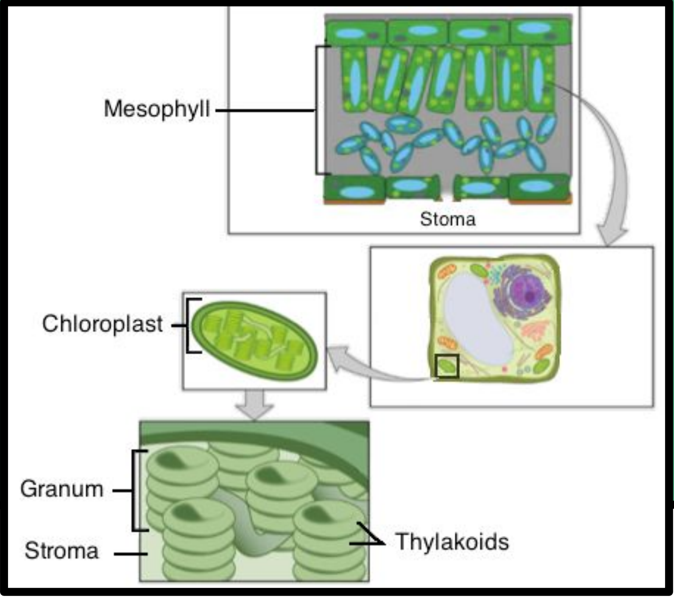
Animals, fungi, and many prokaryotes and protists

Photosynthesis: The Location

We'll be looking at plants!

- Primarily occurs in mesophyll cells (in the middle layer of leaf tissue)
- Stomata (small pores) allow CO_2 to reach the mesophyll cells and oxygen to leave them
- Chloroplasts (organelles that carry out photosynthesis) contain thylakoids (disc-like structures) arranged in piles called grana
- Thylakoid membranes contain chlorophyll pigments that absorb light and give plants their color

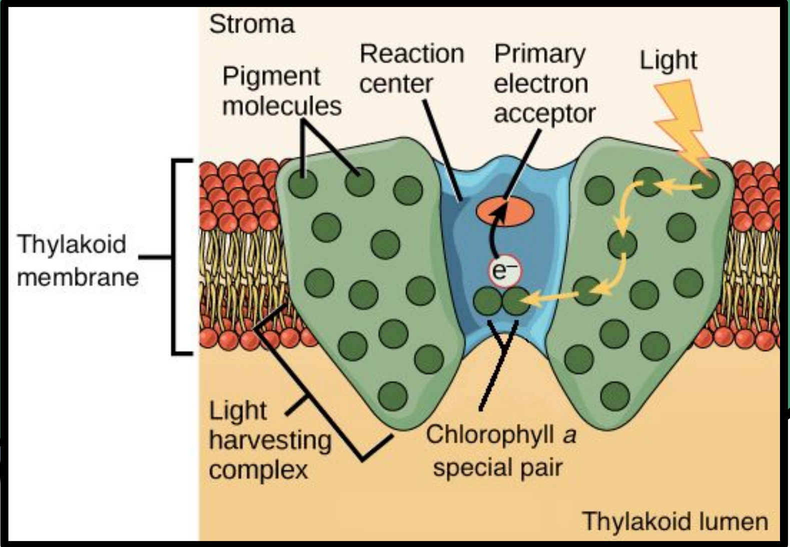
- The fluid-filled space around the grana is the stroma
- The space inside the thylakoid discs is the thylakoid space



Photosynthesis: The Details Part 1

Light-dependent reactions

- Photosystems (large complexes with proteins, chlorophylls, and other pigment molecules) harvest light
- There are two types, PSI and PSII
- Each photosystem has a special pair of chlorophyll molecules
  - *P700* in PSI and *P680* in PSII
- When a pigment absorbs light, it's "excited" (an electron is raised to a higher-energy orbital)
- Each pigment can pass on this energy to another, than another
- Eventually reaches the reaction center and excites the special pair
- The special pair can actually pass on its excited electron to the primary electron acceptor

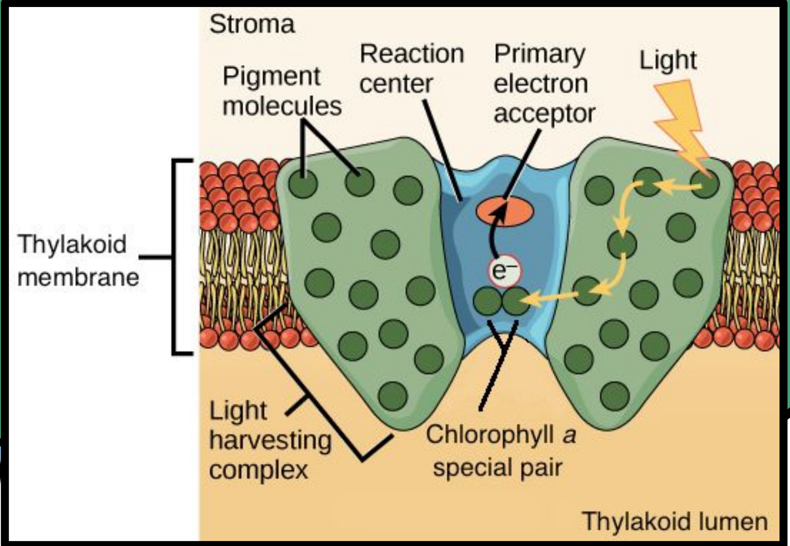


Photosynthesis: The Details Part 2

Light-dependent reactions

- Energy must be passed through both PSII and PSI, in that order
- Light is absorbed by PSII and the energy is passed to P680, which passes an electron on to its primary electron acceptor
- Replaced by an electron from water (H_2O), releasing O_2
- The high-energy electron is passed through an electron transport chain, releasing energy that pumps H+ ions from the stroma to the thylakoid interior

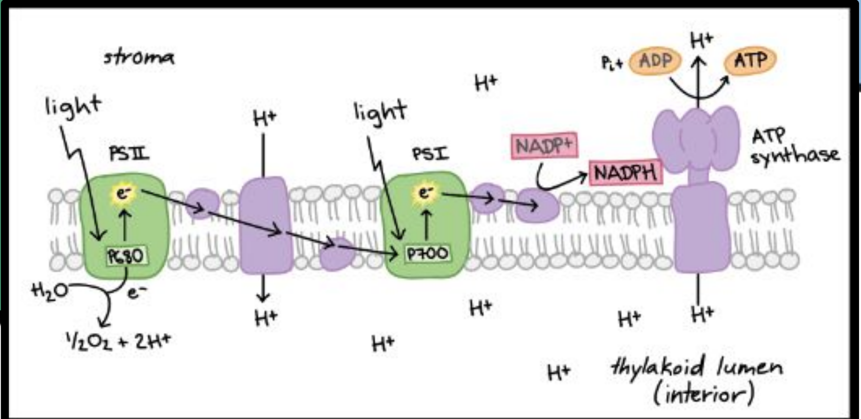
- The H+ gradient allows ions to flow down their gradient and pass through ATP synthase to the stroma, powering ATP production (this is called chemiosmosis)



Photosynthesis: The Details Part 3

Light-dependent reactions

- The electron finishes its run through the electron transport chain and arrives at PSI
- Light energy is absorbed by pigments in PSI and triggers the same chain reaction of "excited" electrons
- An electron in P700 is excited and passed to an acceptor molecule, beginning its journey down a second, shorter electron transport chain
- Replaced by electron from P680
- The electron from P700 is passed to NADP+ along with another electron from the same pathway to form NADPH (an electron carrier)
- ATP and NADPH both hold energy that will be harnessed in the **Calvin cycle**



Differences between PSII and PSI!

Special pairs

P680 (in PSII) absorbs light with a wavelength of 680 nm best; P700 (in PSI) absorbs best at 700 nm.

Primary acceptor

PSII's primary acceptor is pheophytin (resembles chlorophyll); PSI's primary acceptor is a chlorophyll

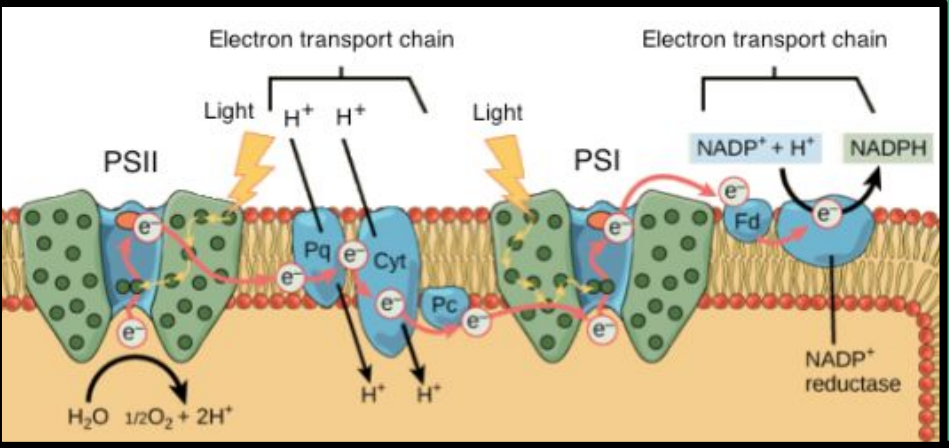
Source of electrons

PSII gets electrons from water; PSI gets electrons from the first electron transport chain (so from PSII)

Photosynthesis: The Details Part 4

First electron transport chain

- The electron is passed from PSII to plastoquinone (Pq), then to a cytochrome complex (Cyt), then to plastocyanin (Pc)



Second electron transport chain

- The electron is passed to ferredoxin (Fd), then to NADP+ reductase, which transfers electrons to NADP+ to make NADPH
- This entire process is called linear photophosphorylation (PSII → PSI → NADPH)
- In cyclic photophosphorylation, electrons from PSI loop back to the first electron transport chain, meaning <u>NADPH is not produced</u>
- Maintains NADP+ to NADPH ratio

Photosynthesis: The Details Part 5

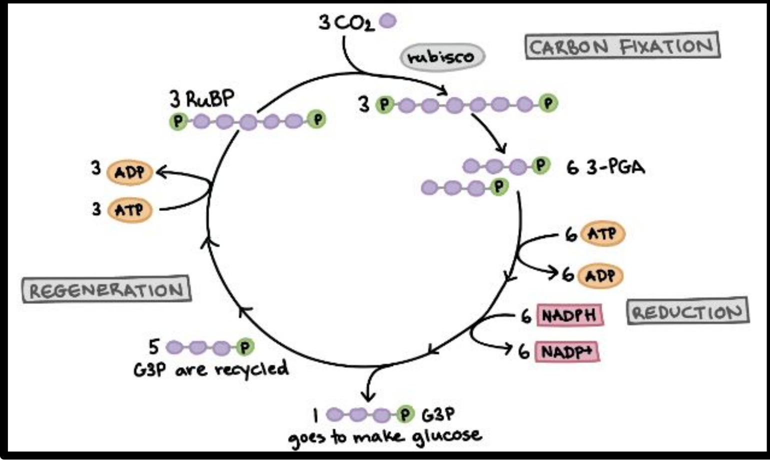
The Calvin cycle

- Carbon atoms from CO_2 are fixed into sugars in the stroma
- Can be split into 3 steps:

1. CO_2 combines with RuBP to form a 6-carbon molecule that splits into two molecules of 3-PGA in a reaction catalyzed by rubisco
2. ATP and NADPH power the conversion of 3-PGA molecules into G3P molecules
3. One GP3 is used to make glucose; the other five are used to regenerate three RuBP molecules

a.k.a light-independent reactions

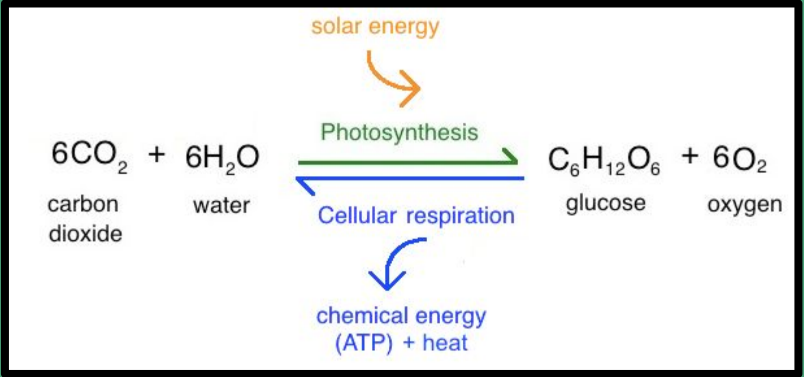
- 3 CO_2 molecules must be input for 1 GP3 molecule to exit the cycle
- 9 ATP are converted to ADP
- 6 NADPH are converted to NADP+
- Takes 2 GP3 molecules to make 1 glucose, which is 6 cycles



Photosynthesis: The End

The chemical equation

That was a lot. But now that you've seen the entire process, you should be able to understand part of this:



So what?

The ultimate goal here is to get ATP to heterotrophs—us. Now, we're halfway there. We have energy stored in sugars like glucose that we can consume by digesting autotrophs like plants. Now, we have to harness that stored energy and convert it into ATP once more. Cellular respiration, here we come!

And speaking of plants, please remember that they're green because <u>they reflect green light</u>—they do NOT absorb green light!!!

Hollup. C3 and C4 plants... what are those?

Photorespiration

This is *the opp* of plantkind. It's a metabolic pathway that occurs when rubisco acts on O_2 rather than CO_2, using up fixed carbon and wasting energy.

Photorespiration usually occurs when plants close their stomata to conserve water loss (like in high temperatures) because O_2 cannot escape and thus builds up. For the same reason, CO_2 cannot enter the leaf, denying access to its carbon.

C3, C4, and CAM plants

- C3 plants, which are the majority, lack adaptations to address photorespiration
- C4 plants concentrate CO_2 by fixing carbon into malate (enabled by PEP carboxylase) and moving it into separate bundle-sheath cells, ensuring rubisco grabs CO_2.
- CAM (crassulacean acid metabolism) plants only open their stomata at night, storing CO_2 so the Calvin cycle can continue even in the heat of daytime

Redox (oxidation-reduction) reactions

What are they?

- Refers to molecules losing or gaining electrons
- Can also refer to molecules "hogging" or having electrons "hogged from" them
- Reduced = gaining electrons
  - The charge is "reduced" as it becomes more negative
- Oxidized = losing electrons
- In general, adding H or taking away O reduces; adding O or taking away H oxidizes

Applications for cellular respiration

- Electrons are at a higher energy level when they are less comfortable
- This happens when they're bound to elements with lower electronegativity, like C and H (in sugars)
- O is highly electronegative, so electrons are comfortable and thus low-energy when bound
- In cellular respiration, electrons pass from C and H to O, releasing energy

Cellular Respiration: The Intro

During cellular respiration, a glucose molecule is gradually broken down into CO_2 and water. Some ATP is produced along the way, but most is produced at the end in oxidative phosphorylation. The process can be divided into four steps:

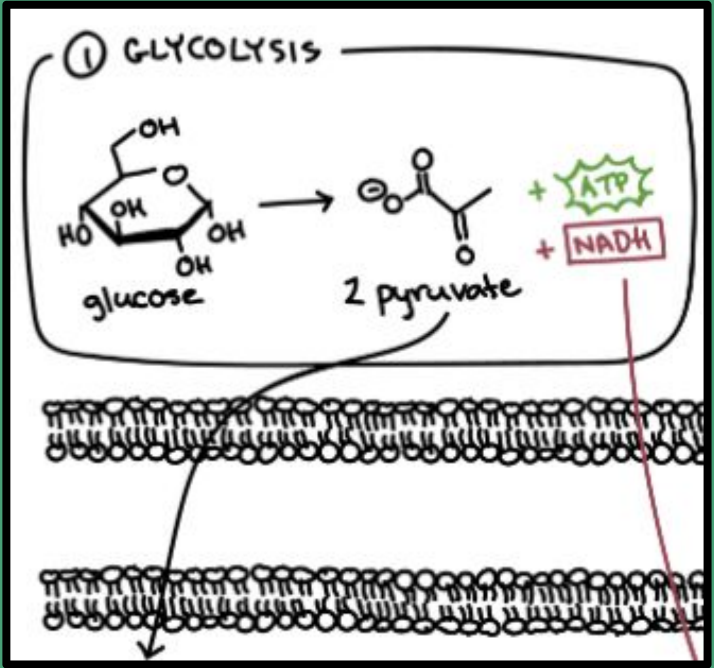
-Glycolysis
-Pyruvate oxidation
-Citric Acid/Krebs Cycle
-Oxidative Phosphorylation

NAD+/NADH and FAD/$FADH_2$ are the electron carriers here.

Cellular Respiration: Glycolysis

What happens?

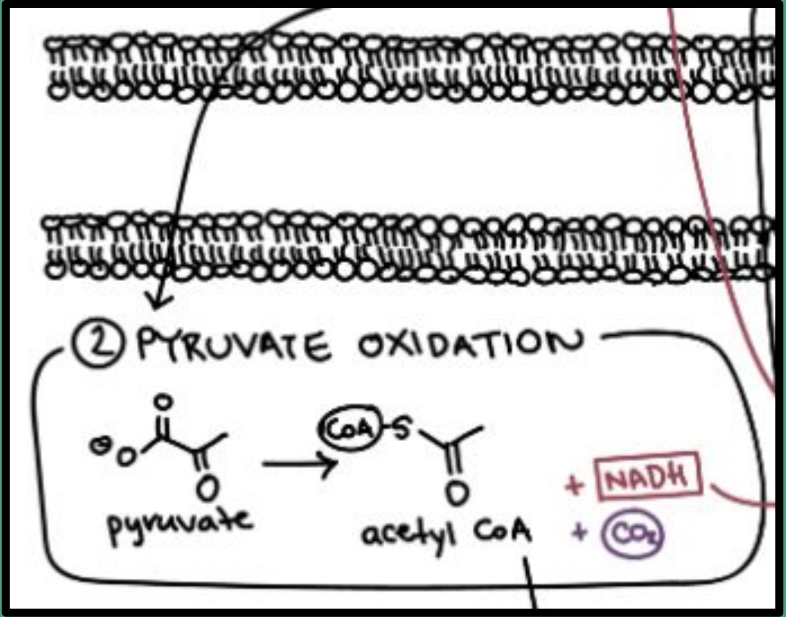
- Glucose is converted into two molecules of pyruvate (a 3-carbon molecule)
- 4 ATP are produced but 2 are used to power the process, for a <u>net gain of 2 ATP</u>
- 2 NAD+ are converted into <u>2 NADH</u> through reduction, storing energy in these molecules
- Common to almost all organisms



Cellular Respiration: Pyruvate Oxidation

What happens?

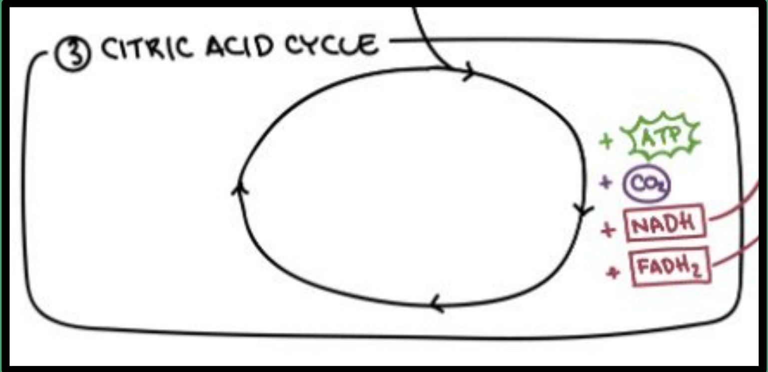
- Each pyruvate molecule from glycolysis passes into the mitochondrial matrix
- Converted into a 2-carbon molecule bound to Coenzyme A, forming acetyl-CoA
- 6 CO_2 produced
- 2 NADH produced
- Everything is doubled because the cycle runs twice: once for each pyruvate
  (1 glucose → 2 pyruvate → 2 acetyl CoA)



Cellular Respiration: Citric Acid/Krebs Cycle

What happens?

- The acetyl-CoA combines with a 4-carbon molecule and undergoes a cycle of reactions
- The 4-carbon molecule is regenerated in the process
- 2 ATP produced
- 4 CO_2 produced
- 2 $FADH_2$ and 6 NADH produced
- <u>Again, everything is doubled</u> because the cycle runs twice: once for each acetyl-CoA (1 glucose → 2 pyruvate → 2 acetyl CoA)



Cellular Respiration: Oxidative Phosphorylation

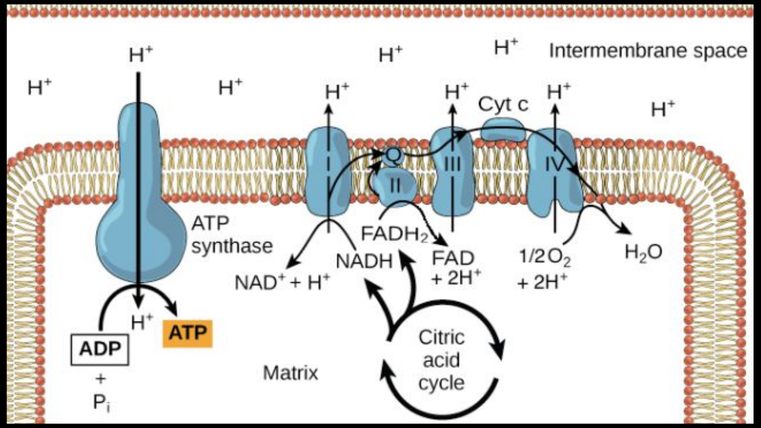
What happens?

- NADH and $FADH_2$ produced earlier pass electrons on to an electron transport chain, and are oxidized back to NAD+ and FAD to be reused
- The chain is organized into four large complexes labeled I to IV
- NADH electrons are very high-energy and thus donated to complex I (highest-energy level)
- $FADH_2$ electrons are less energetic and thus donated to complex II (lower energy level)
- Both complex I and II pass electrons to the small electron carrier ubiquinone (Q), which carries electrons to complex III
- Complex III passes electrons to the carrier cytochrome C (cyt C), which carries electrons to complex IV
- Complex IV passes electrons to O_2, which splits into two O atoms and nabs H+ floating around in the mitochondrial matrix to form H_2O

Cellular Respiration: Oxidative Phosphorylation

What happens? (cont.)

- All the while, the electrons release energy which powers the pumping of H+ ions into the intermembrane space
- This proton-motive force (gradient) is harnessed as H+ ions flow back into the mitochondrial matrix via ATP synthase
- The enzyme is powered by the flow of H+, catalyzing the phosphorylation of ADP into ATP
- The gradient can also be harnessed to produce heat



Stage	Direct products (net)	Ultimate ATP yield (net)
Glycolysis	2 ATP	2 ATP
	2 NADH	3-5 ATP
Pyruvate oxidation	2 NADH	5 ATP
Citric acid cycle	2 ATP/GTP	2 ATP
	6 NADH	15 ATP
	2 $FADH_2$	3 ATP
Total		**30-32 ATP**

Other ways to make ATP

Anaerobic cellular respiration

Molecules like sulfate or nitrate are substituted for O_2 in the electron transport chain. Used in environments with low/no oxygen.

Lactic Acid Fermentation

After glycolysis, NADH donates electrons to pyruvate, creating lactate. Used by red blood cells and by muscle cells (when oxygen is low).

Alcohol Fermentation

NADH donates electrons to a derivative of pyruvate, creating ethanol. Performed by yeast; responsible for alcohol in drinks.

almost donee (huzzah!)

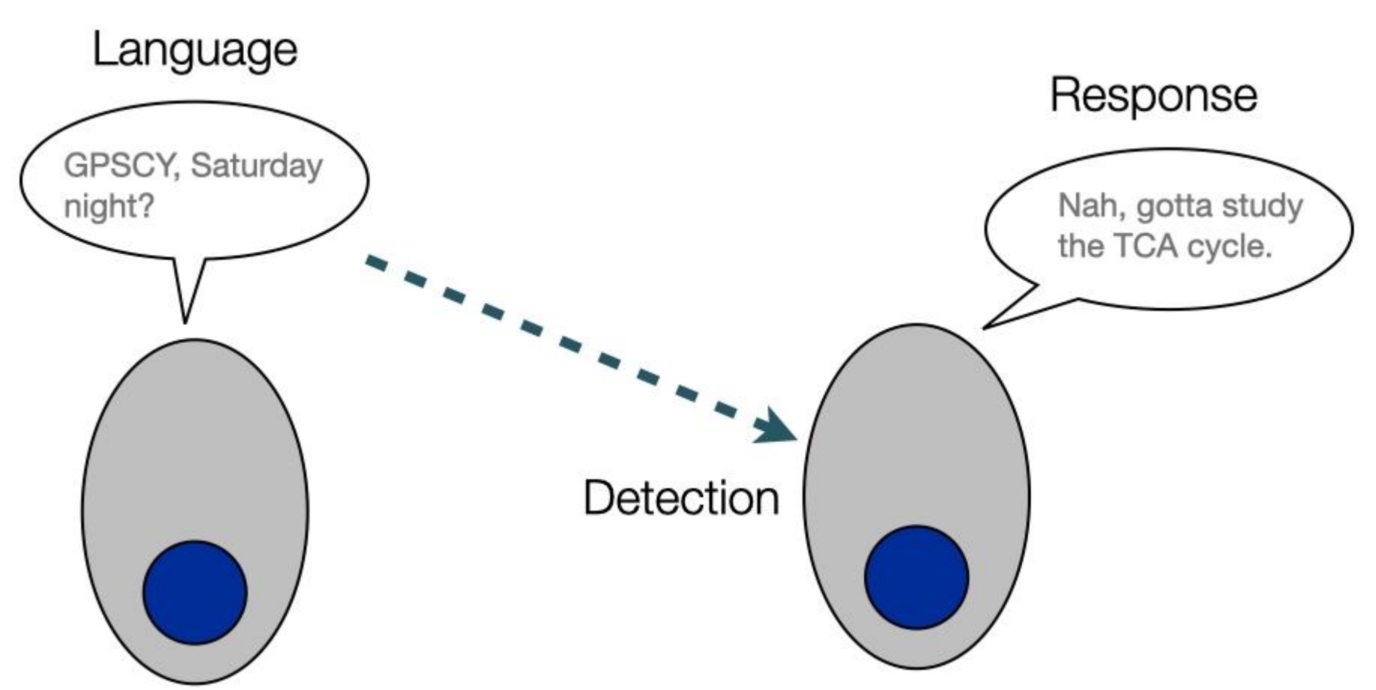
Facultative anaerobes

- Many bacteria and archaea
- Can switch between aerobic and anaerobic pathways depending on oxygen availability
- Since aerobic respiration is more efficient, they can take advantage of this as long as oxygen is abundant

Obligate anaerobes

- Can only live and grow in the absence of oxygen (killed on exposure)

Unit 4: Cell Communications and Cell Cycle



Cells TALK ~~tuah~~ and communicate!

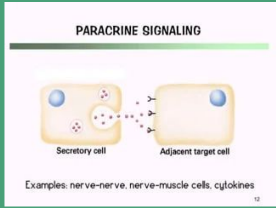
Cells have to find a way to communicate due to issues and processes that are essential for the organism to function.

There is one main way that cells communicate, which are signal transduction pathways. It's a series of molecules that are sent, bound, and received with certain signals, as the name suggests!

WOOHOO! THE TYPES OF SIGNALING

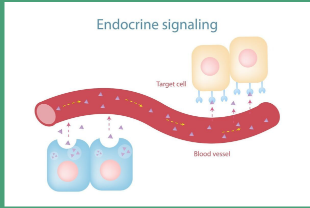
Type 1: Paracrine Signaling

- Paracrine signaling is where cells send out chemical messengers (ligands) to nearby cells
- Paracrine signaling is only used for short distances! They get tired and can't walk v far :snore: (idk you can ask them if they truly get tired)



Type 2: Endocrine Signaling

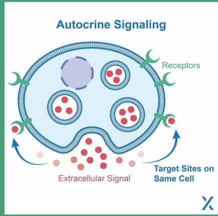
- Endocrine signaling is where cells send out chemical messengers (ligands) through the bloodstream to far away cells!
- This type of signaling is used to target *specific* cells far away!



WOOHOO! THE TYPES OF SIGNALING pt.2

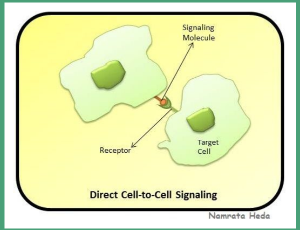
Type 3: Autocrine Signaling

- Autocrine signaling is where cells send out chemical messengers (ligands) to their own cell!
- Autocrine signaling is used for causing a cascade of reactions within the cell. Sometimes the chain reactions must start from the outside.



Type 4: Direct Signaling

- Direct signaling is where cells send out chemical messengers (ligands) through gap junctions to cells that are already connected to it!
- It's often used between groups of tissues or cells that are all interconnected.



PROTEINS IN SIGNALING

G Proteins:

- One of the most important proteins
- They induce transmitting of signals into the cell from the outside
- Can also be thought of as GPCRs (G-protein coupled receptors)

IP3:

- IP3 is a signaling molecule that induces calcium release in the cytoplasm
- They regulate calcium levels within the cell

Ligand:

- A ligand is a molecule that binds to another molecule connected to a cell called the receptor to trigger a response

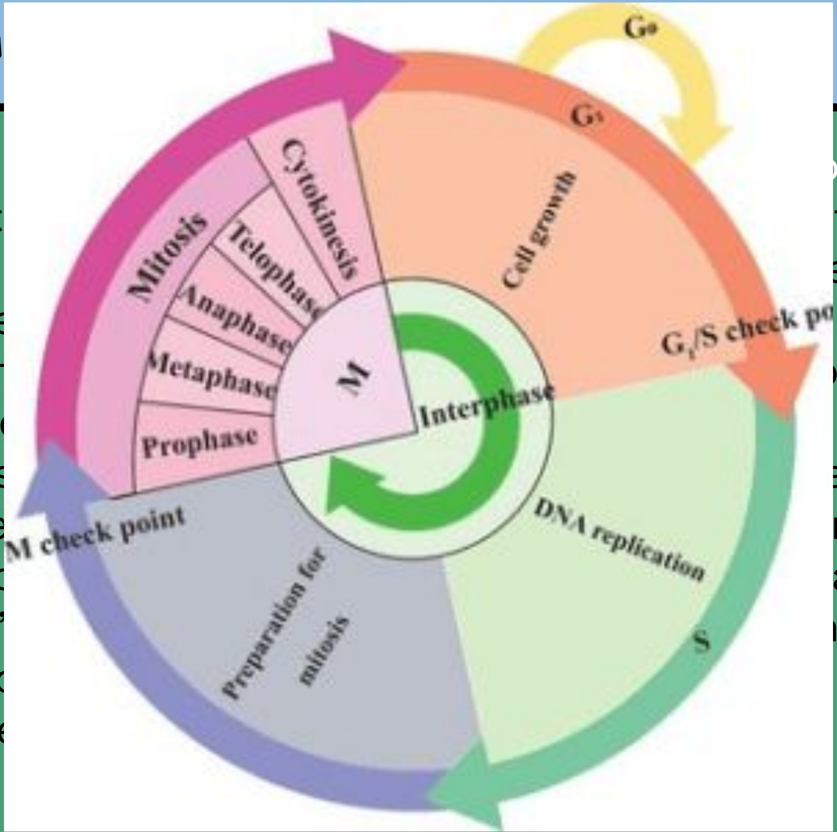
The Cell Cycle!

The Cell Cycle is the process that cells grow, duplicate, and DIE. (or remain the same!). It includes mitosis, duplication of DNA, cell growth, and other checkpoints and phases to regulate cell activity.

Phases of th

Interphase:

- Interphase is t
cell cycle. It is
grow, duplicate
prepare for mi
- G0 is considere
It's where cells
grow/duplicate
like a holding
- G1 is the "first"
where cells gr
fully for DNA re
their purpose!



point is
t scanned
e cleared to
They must
ough for DNA

ere the true
n happens.
and and
d merge

Phases of the cell cycle pt.2

Interphase:

- After S Phase, the cells pass another checkpoint called the S Checkpoint. This is to check if the DNA has properly synthesized and is ready to go through final preparations.
- The last phase of Interphase is the G2 phase. The G2 phase is simply allowing the cells to make final preparations before they continue onto mitosis.

Mitotic Phase:

- The Mitotic phase is as the name suggests; when cells go through mitosis!
- There is a Mitotic Checkpoint after metaphase, which determines whether or not the sister chromatids are properly attached.
- If they are, the cell divides and then the cell cycle repeats!

MITOSIS!

Mitosis is where the cell divides into 2, perfectly new and functional cells. It includes:

- Prophase (prometaphase)
- Metaphase
- Anaphase
- Telophase
- Cytokinesis

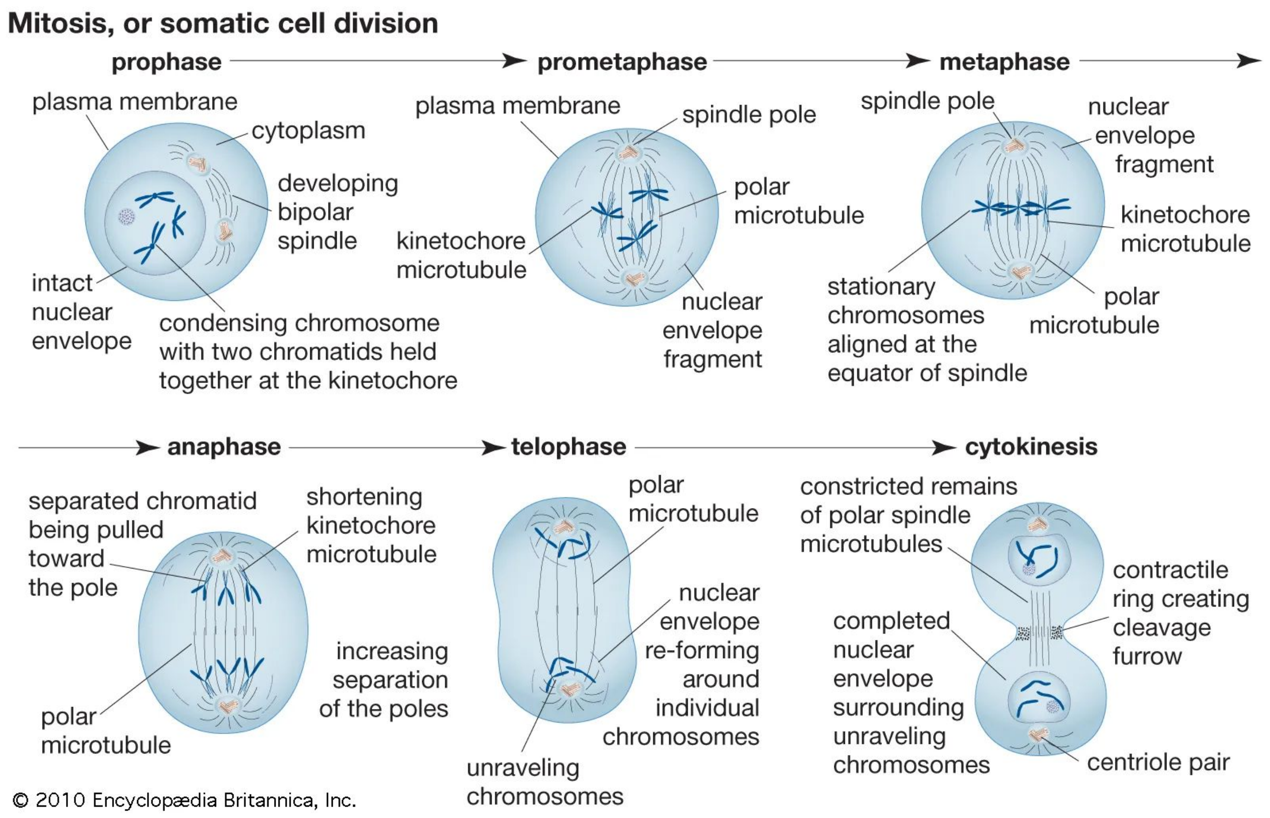
The ph

PROPHASE

- The c
the c
the fo
the m

METAPHAS

- The c
align
of the
spind



cleus
form, so
leavage

ge furrow
separate
individual
new
mes and

MEIOSIS!

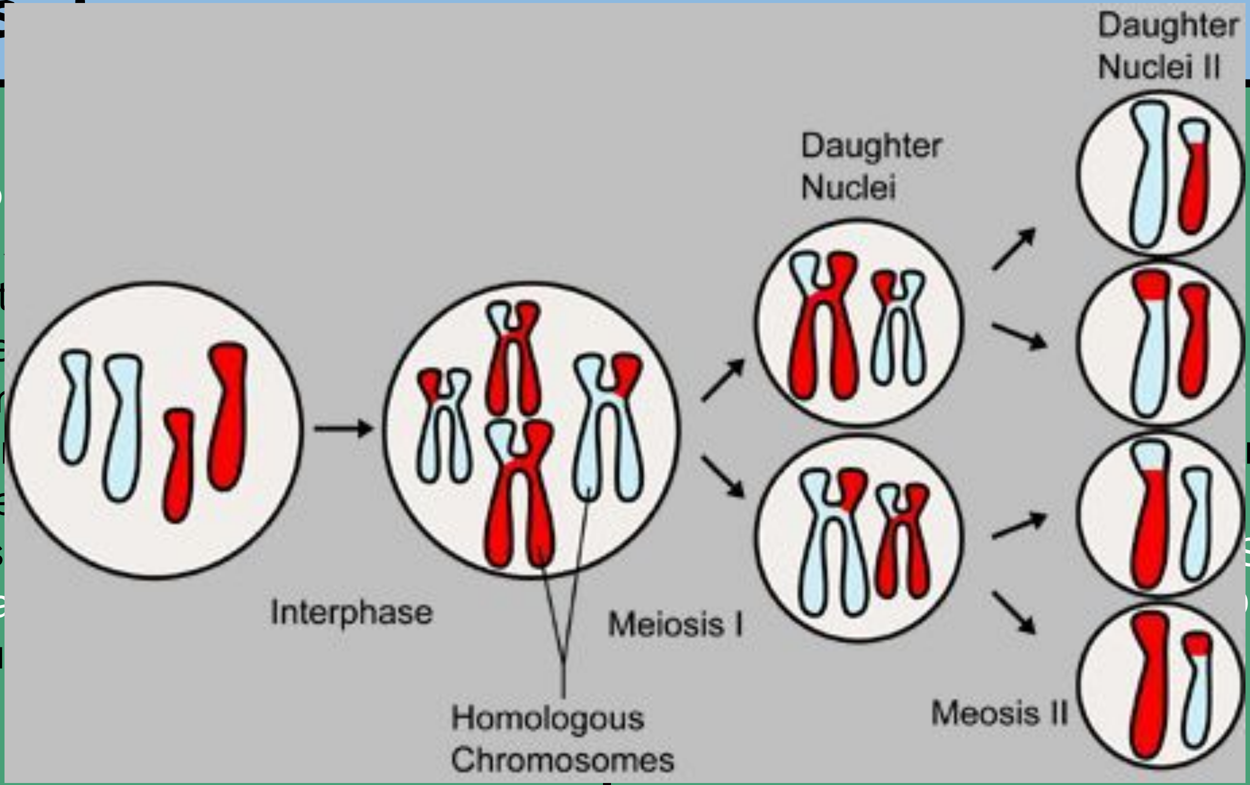
Meiosis is where the cell divides into 2, perfectly genetically varied and functional cells. It includes:

- Prophase I/II
- Metaphase I/II
- Anaphase I/II
- Telophase I/II
- Cytokinesis I/II

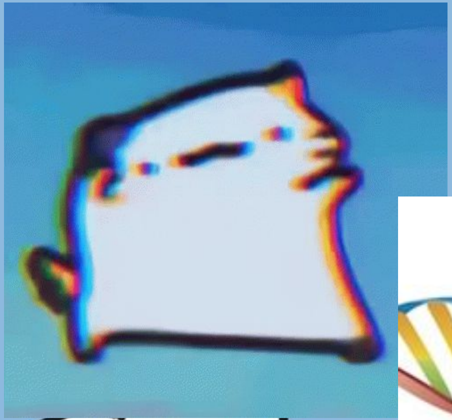
Meiosis I

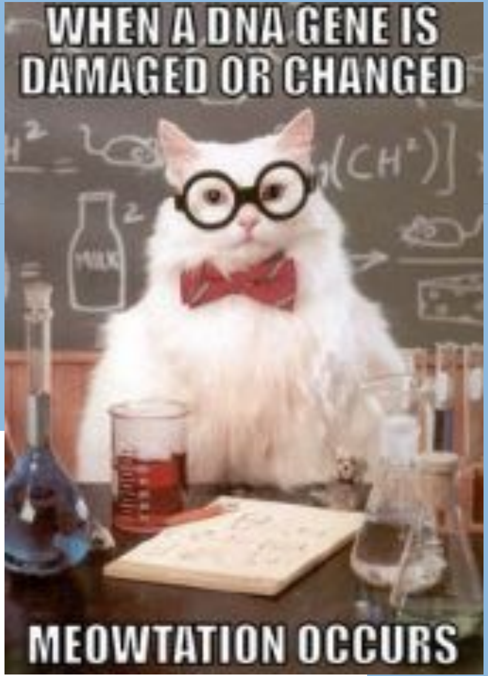
Meiosis

- Meio
mito
creat
- Gene
wher
chro
close
ng
- Thes
meta
occu
S I
N



Unit 5: Heredity





HEREDEITITITY!!!!

Heredity is how genetics work with organisms. The main experiment of the Bio textbook is Mendel and his silly little pea plants!

Mendel mostly focused on dominant/recessive alleles within a single gene. This is a simple heterozygous phenotype cross.

Important terms for Heredity

Heterozygous/homozygous:

- Heterozygous - A genotype with 2 alleles (Aa Bb etc.)
- Homozygous dominant - A genotype with only the dominant allele (AA BB etc.)
- Homozygous recessive - A genotype with only the recessive allele (aa bb etc.)

Types of representation:

- Complete dominance - A phenotype that only represents 1 allele
- Incomplete dominance - A blend of both alleles
- Codominance - A representation of both alleles individually but on the same organism

Oops moments:

- Epistasis - When the representation of 1 allele affects a 2nd allele
- Pleiotropy - When an allele has more than 1 phenotypic effect

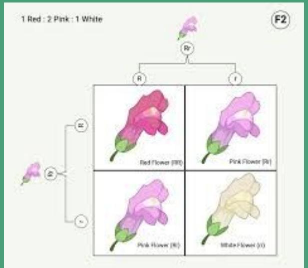
Important terms for Heredity pt.2

Oops moments:

- Aneuploidy - A mutation within chromosome sets that causes diseases like Down Syndrome
- Polyploidy - Possessing more than 2 complete sets of chromosomes

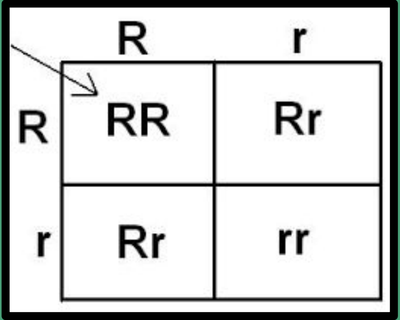
Laws + theories:

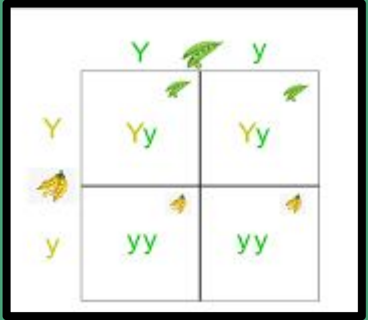
- Law of Segregation - Alleles are separated randomly into gametes
- Law of Independent Assortment - Alleles of different genes..
- .. get sorted into different gametes independently from one another
- Chromosomal Theory of Inheritance - genes are found at specific places on the chromosomes

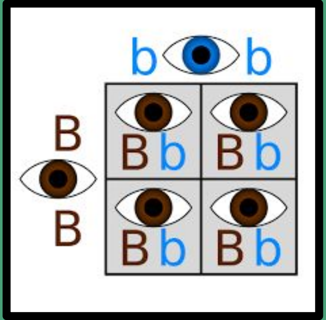


Punnett squares!! (Unit 5)

Punnett squares are how you can predict the genotypes and therefore phenotypes of theoretical offspring when given the parents. It is usually indicated whether or not there is a dominant allele, but if not then it would be incomplete/codominance. It's almost like a factoring box.

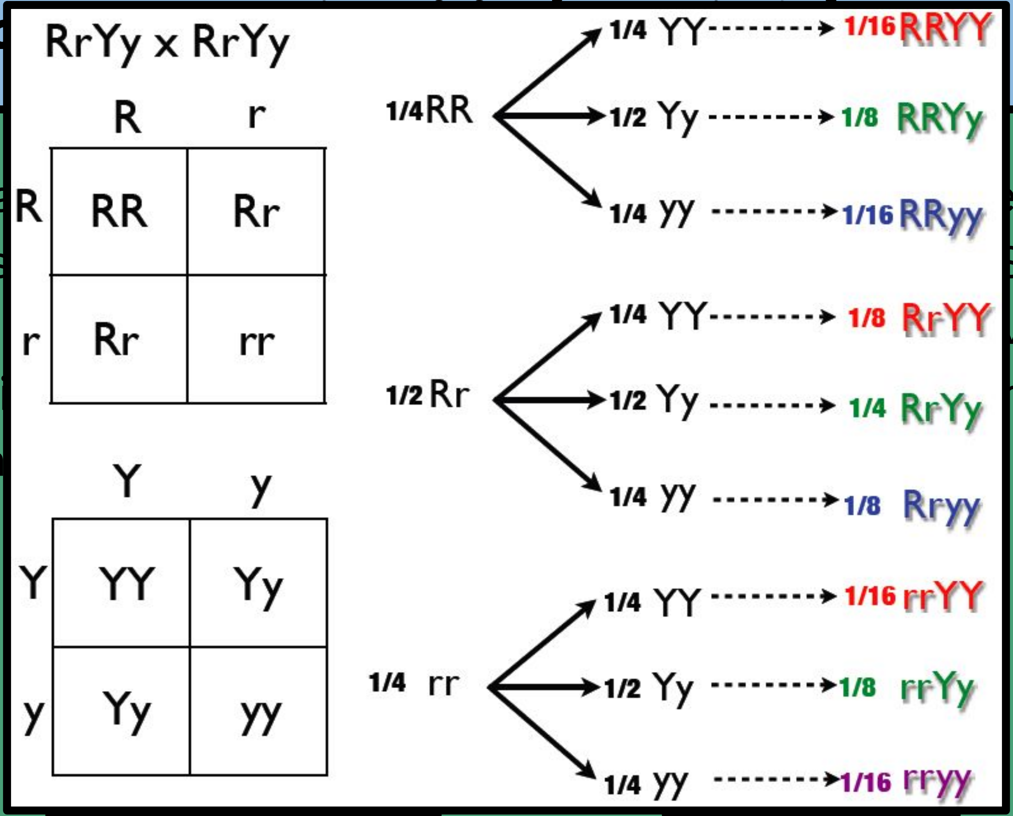






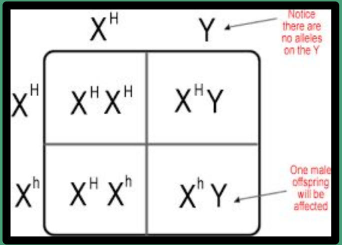
Punnett sq

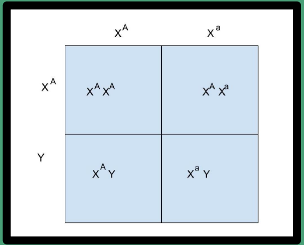
When doing a … er to do 2
smaller cross … Say your
dihybrid is a … ve YY ¼
times, Yy ½ ti … , and rr.
Now, you can



Sex-linked alleles!! (Unit 5)

Sex-linked genes are pretty simple. Whenever a certain gender has a gene linked with a chromosome, usually the X chromosome, it sometimes passes down to the children of the individual, but it depends the specific chromosome that is passed down. If the son received an X from the mother but a Y from the father, but the X happened to have the gene, the son would just so happen to inherit the gene.





ADDITIONAL RESOURCES!!!

Worksheet

Answer Key

2023-2024 Kitty Hawk AP Bio Study Session Presentation

College Board

ZCole Easy Notecards

GetKnowt

ANY QUESTIONS?

Ask now!! we don't bite (usually)