Biochemistry

Dehydration Synthesis(monomer → polymer)

- How monomers turn into polymers (Eject a H_2O and join the monomers)
- Monomers are covalently linked by removing water for each covalent bond
- Ether linkage [R-O-R']
    - Reaction between 2 hydroxyl groups
    - Alcohol + alcohol → ethane + water
    - Hydroxyl + hydroxyl → Ether + Water
    - R-OH + HO-R' → R-O-R' + H_2O
- Ester linkage
    - Reaction between carboxyl and hydroxyl
    - Carboxyl + acid → ester + water
        - The OH and H will form a water molecule and the rest of the two molecules should join - check whether its legit before moving on (nitrogen can make 3 bonds, carbon can make 4 bonds)
    - Carboxyl + Hydroxyl → ester + water
    - R-COOH + HO-R' → R-COOR'
    - NOT testing on naming
    - Just testing on drawing molecules, the reactions between the molecule

=O -H

- Peptide linkage [R - C - N-R]
    - Reaction between one carboxyl and one amino group
    - Carboxyl + amino → amide + water
    - R-COOH + H_2N → R-CONH-R' + H_2O

Hydrolysis (polymer → monomer)

- Breaking covalent bonds between monomers by the addition of a water molecule
    - Effectively reverse dehydration synthesis, work backwards from a molecule to its monomer groups
- Molecules of Life
    - H,C,O (these guys hang out everywhere)
    - N (amino acids)
    - P (DNA backbones)
    - Carbohydrates, fats, proteins, DNA are made of the ^above^

Carbohydrates (sugars)

- Contains C, H, O
- Refers to the “sugar” family
    - Glucose, fructose, starch, cellulose (fruits like broccoli have tons of cellulose)
- Body’s most important source of energy
- Are building material and cell communication
- Come from plants
- Named with -OSE

3 groups

Monosaccharides(simple sugars)

- Examples:
    - Glucose
    - Fructose (you’ll see more of these in your food)
    - Galactose
    - LACTOSE
- Simple sugars → monomers = 1
- One building block of a larger molecule
- Contains Cn, H2n, On
- Most widely used group
- **Sweetness is proportional to the number of saccharides (more monosaccharides reduces the sweetness)**
- Occur in linear form when in water w 5 or more carbons
- Or as a ring when 5 carbons bend back to make a ring
    - The ring is more of a lie - it’s still really the single linear molecule but an oxygen atom connects the ends (we START numbering monosaccharides with the carbon that HAS the carboxyl group)
- 2 arrangements of the -OH ring → isomers
- Are identified based on the positions of the hydroxide groups
    - a glucose (alpha) → OH are both on bottom
        - From the rightmost hydroxide, the location of hydroxides are:
            - Down, Up, Down, Down
    - b glucose (beta) → 1 OH on top, other on bottom
        - Down, Up, Down, Up
    - Galactose is up up down down
- Other examples: glucose + galactose → optical isomers
    - Both have aldehyde group → aldose
    - Fructose has a ketone group, is numbered differently than other sugars smh
- Typically have many polar functional group → hydrophilic

- Small sugars are highly soluble in water
- Sweetest of the three sugar groups

Disaccharides(double sugars)

- 2 monosaccharides linked together through dehydration synthesis
- How to make sugars:
    - a-Glucose + a-Glucose = Maltose
    - Glucose + Fructose = Sucrose → table sugar
    - Glucose + Galactose = Lactose → milk
- Dehydration synthesis
    - One monosaccharide loses a hydroxyl group (OH) and one loses a hydrogen atom (-H)
    - These two monosaccharides produce water and disaccharide is formed
        - Process can be reversed when water is added
    - Bonds between monosaccharides are called glycosidic bonds
- Beta-linkage
    - What happens when two beta glucose are put together? Cellulose
    - Dehydration synthesis: one of the beta glucose's are flipped over so that a hydroxide reacts with another hydroxide to produce water and let the oxygen form the glycosidic bond
    - Beta 1,4-glycosidic linkage

Polysaccharides(complex sugars)

- Polymer of a few hundred or thousand molecules
- Polymerization - process in which small sub units are linked to form a large molecule
- Complex carbs, not sweet, very polar = hydrophilic
- Don't dissolve in water because they are so big
- Examples:
    - For Storage: Starch, glycogen
    - Structure: cellulose and chitin
- Starch
    - Polymer of alpha glucose
    - Plant storage
    - Simplest form of starch = amylose (unbranched)
    - Amylopectin → branched and more complex
    - Our saliva is amylase to break down amylose
- Glycogen
    - Energy storage for animals
    - Stored in muscles + liver
    - More extensively bonded than amylose and amylopectin
- Cellulose

- Structural component of cell wall in plants
- Polymer of b glucose joined together by b 1,4-glycosidic linkage
- Enzymes that digest starch can't digest b-linkage cellulose because of the active site of the enzyme

Summary of sugars:

Name		Structural Unit	Linkages	Occurrence
storage	Amylose	α glucose	α 1,4	Plant starch
	Amylopectin	α glucose	α 1,4 & α 1,6	Plant starch
	Glycogen	α glucose	α 1,4 & α 1,6	Muscles, liver
structural	cellulose	β glucose	β 1,4	Plant cell wall
	chitin	Glucosamine (β glucose + N)	β 1,4	Arthropod cuticle (shell)

- Steric Repulsion (Why mono/di/polysaccharides have a spiral shape)
    - More compact, store more in same space → like the concept of DNA
    - Amylose, amylopectin and glycogen
        - Composed of a-glucose units linked together by a-1,4,glycosidic linkage
            - These linkages are polar covalent bonds that leave the hydrogens slightly electro-positive
            - The hydrogens HATE this, and so tries to get away by bending away
                - They form spirals instead of rings to fit more
    - Cellulose
        - Composed of beta-glucose units linked together by beta-1,4-glycosidic linkage
            - These linkages are polar covalent bonds that leave the hydrogens slightly electro-positive
            - The hydrogens HATE this, and so tries to get away by bending away
                - They form zigzags because of the Up-Down-Up-Down shape of the beta polysaccharide
        - Successive monosaccharides are inverted relative to one another (zig zag shape)
        - Zigzag is very strong and inflexible → used in cell wall

- https://www.youtube.com/watch?v=jQi84TnstI4

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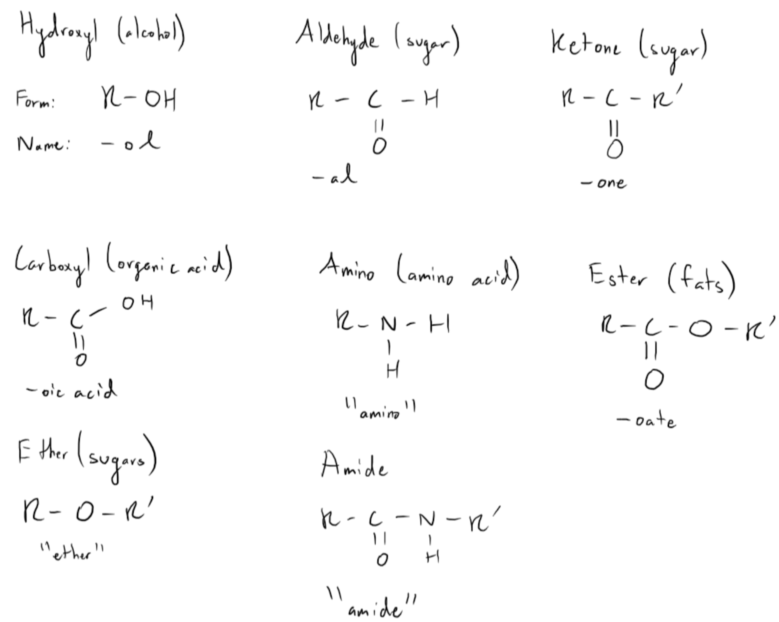
Nomenclature Quiz (after lesson, beginning at 10:45)

- Brightspace
- Covers all nomenclature stuff (sept 22 - 24) + review in MC
- Part A: 7 - 10 MC
- Part B: 3 questions - Naming molecules → give structure or give name
- Identify functional groups within structure
- Part C: 3 questions - Draw structural diagrams given name or chemical formula
- Chemical formula given → form where carbons are separated to make it easier (chemical formula will be in the form that tells you what is attached to each carbon
- Part D: 3 - 4 questions - short answers, similar to what we did on the worksheets



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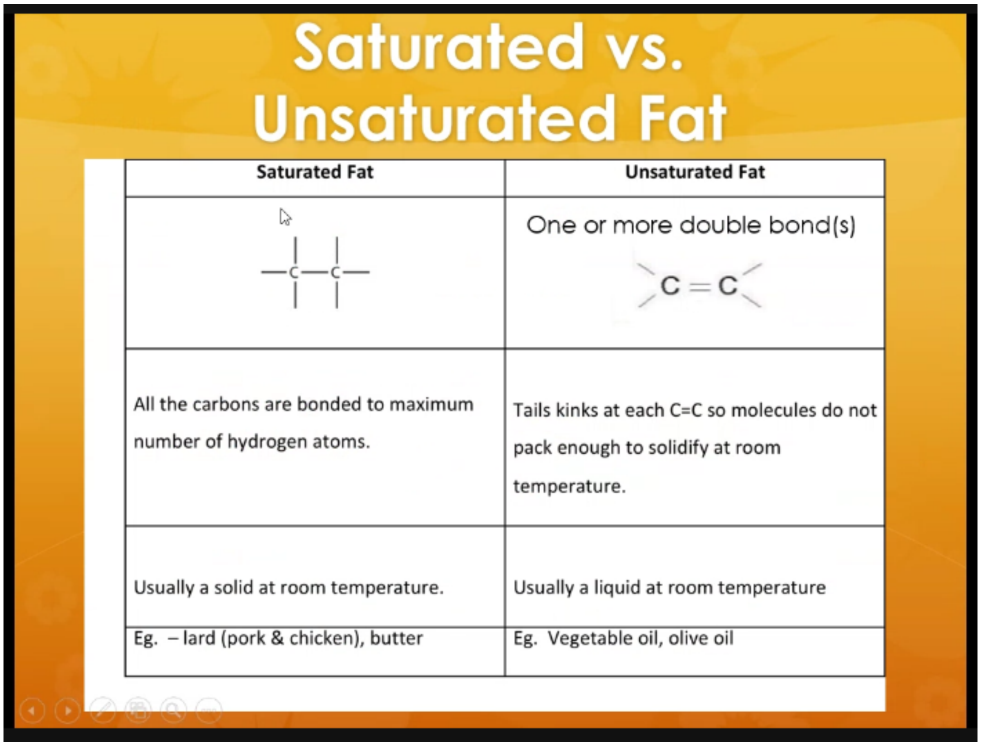
Lipids

- Insoluble in water
- Hydrophobic, nonpolar
    - Have a hydrophilic head
- Composed of c, h, o (no specific ratio)
- Used by organisms to
    - Store energy long term
    - Build membranes and other cell parts
    - Hormones that regulate cell activities
    - Vitamins
- Four groups of lipids
    - Fats

- Phospholipids
- Steroids
- waxes

1 / 4 Groups of Lipids: Fats

- Most common energy storing molecule in living organism
- 20-35% of daily intake
- Carbohydrates are converted to fat
- Store droplets in cells of adipose (fat) tissue
- Other uses of fats:
    - Warmth / insulation
    - Cushioning for organs
- Functions
    - 1 gram of fat stores 9 calories compared to 1g of carbohydrate which stores 4 calories
    - Also weighs less than carbs
    - Cushioning effect for internal organs
    - Insulation for cold temperatures
- Made from 2 types of molecules: fatty acids and a glycerol
    - Glycerol makes the backbone of most lipids
    - Fatty acids consists of carboxyl group and a hydrocarbon chain
    - Most common fats in plants n animals are triglycerides
        - 1 glycerol molecule + 3 fatty acid chains
    - Hydrophilic head, Hydrophobic tail
        - Glycerol slurp water, fatty acids nono water
    - Triglycerides form through dehydration synthesis and form an ester linkage
    - Sometimes triglycerides will have a double bond on their tail resulting in a kink
    - Most common forms have even-numbered fatty acids chains of 14-22
    - As chain length increases, fatty acids become less water soluble
        - Fatty acids nono water
- Saturated vs Unsaturated fats:
    - Saturated
    - Unsaturated → better for you



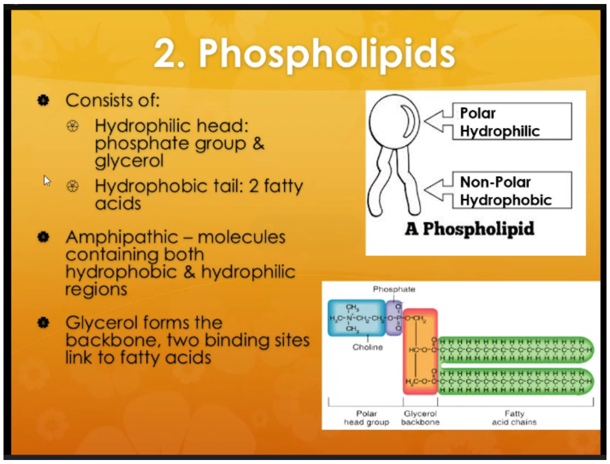
Saturated vs. Unsaturated Fat

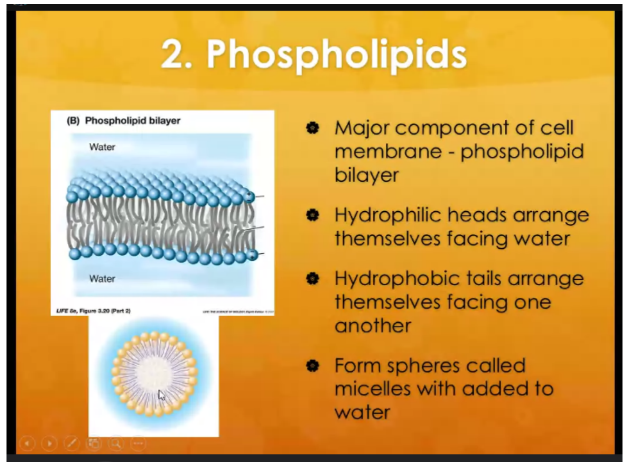
Saturated Fat	Unsaturated Fat
	One or more double bond(s) C = C
All the carbons are bonded to maximum number of hydrogen atoms.	Tails kinks at each C=C so molecules do not pack enough to solidify at room temperature.
Usually a solid at room temperature.	Usually a liquid at room temperature
Eg. – lard (pork & chicken), butter	Eg. Vegetable oil, olive oil

    - Saturated fats are solid due to long straight chains allowing to be packed close together
    - Diets rich in saturated fats can lead to heart disease
    - Inuits have high fat and protein diet beneficial for cold climates
- Rich in fat diets can result in blocked arteries as atherolsclerotic plaque builds up from → atherosclerotic plaque is called that when the fat builds up in the artery
- Polyunsaturated fatty acids (PUFAs) many C double bonds
    - Industrial process called hydrogenation adds hydrogen atoms to the double bond making it → semisolid
- What is fat? - George Zaidan
    - https://www.youtube.com/watch?
- v=QhUrc4BnPgg
    - “Partially hydrogenated” → trans fat = bad
- Medical Procedures
- Balloon angioplasty
    - Clearing out plaque from arteries
    - Put balloon in artery and expand it so that plaque is pushed to the walls
- Bypass surgery
    - Severe surgery when other surgeries have failed
    - Take another artery from the body and replace the coronary arteries near the aorta to divert blood flow around aorta

2 / 4 Groups of Lipids: Phospholipids

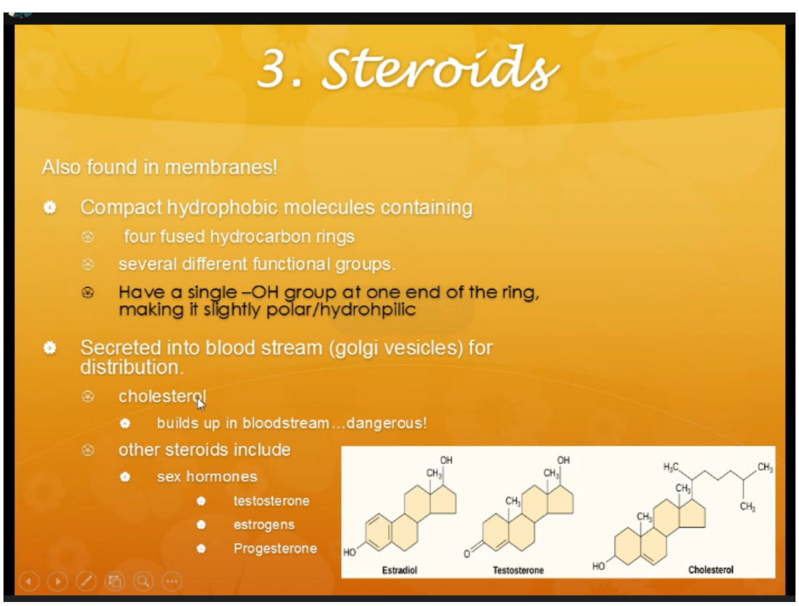
- Hydrophilic head: phosphate group + glycerol
- Hydrophobic tail: 2 fatty acids





- Application of phospholipids: detergents and soaps
- Detergents and soaps are amphiatic (have both hydrophillic and hydrophobic parts)
- Dirt and grime tend to be nonpolar or oily → bind to non polar tails of detergents → pickup and take off of clothing
- Essential fatty acids
- essential fatty acids are essential → who wudda guessed
    - Some lipids are essential
    - This means the body can't make the molecule and must eat it
    - Eg. linoleic or linolenic fatty acids

3 / 4 Groups of Lipids: Steroids



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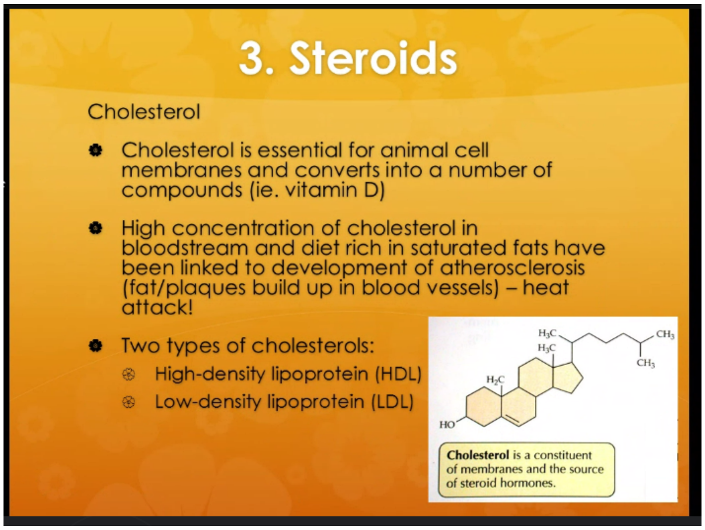
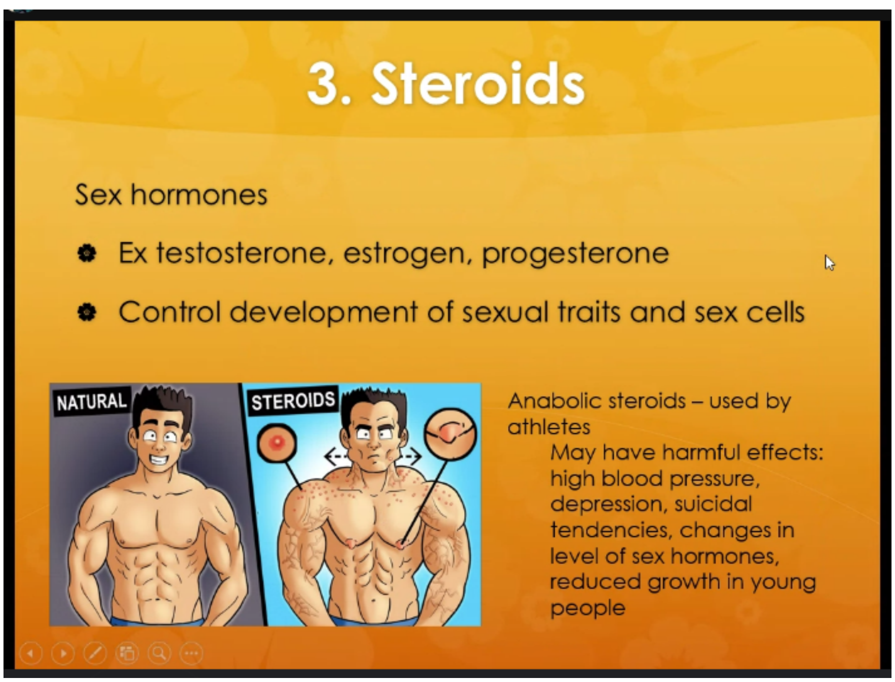
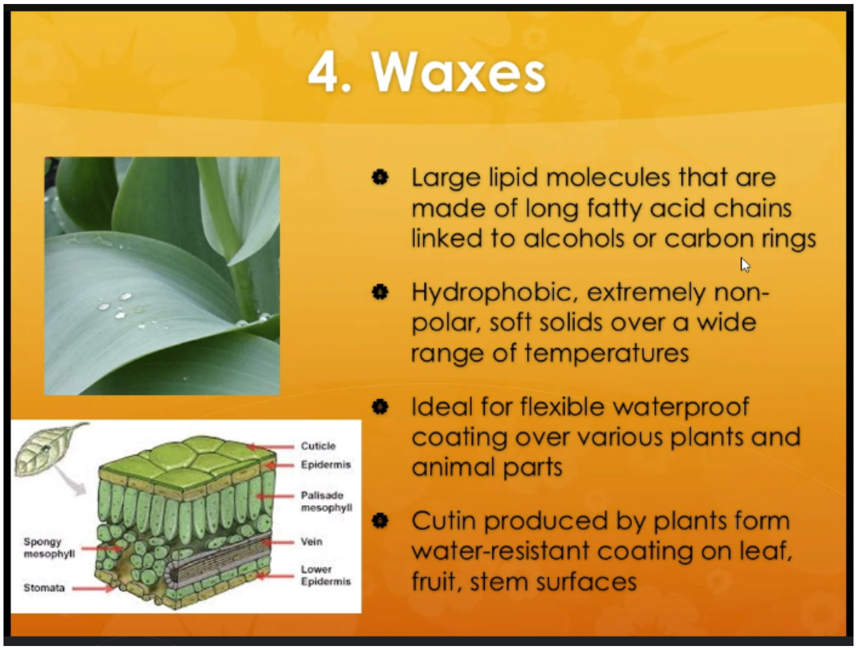
- Four fused hydrocarbon rings
- Slightly polar with the end OH
- Dangerous build up of cholesterol

- 

- *heart
- HDL is good, when checked you want your HDL to be H (high)
- LDL is bad, when checked you want your LDL to be L (low)

- 

4 / 4 Groups of Lipids: Waxes

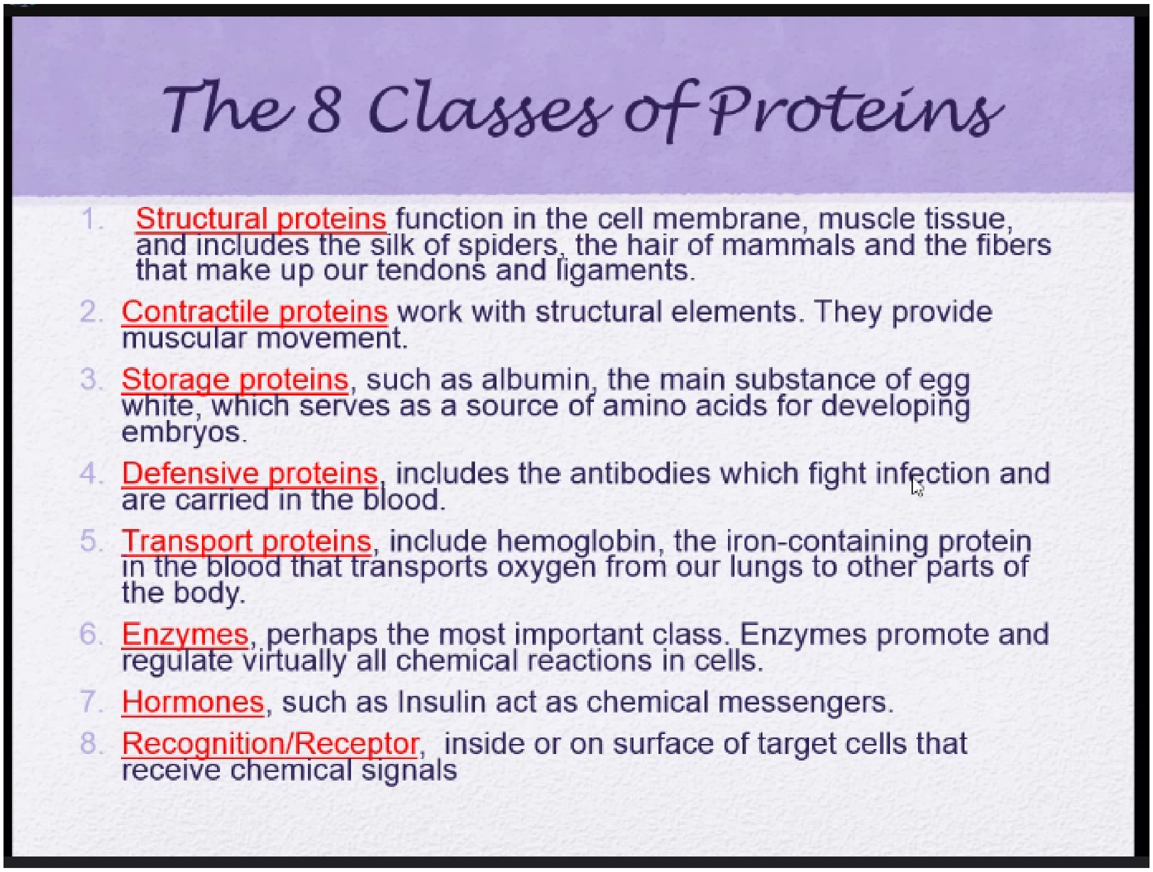
- 

    - Cutin part of the cuticle meant to prevent water loss

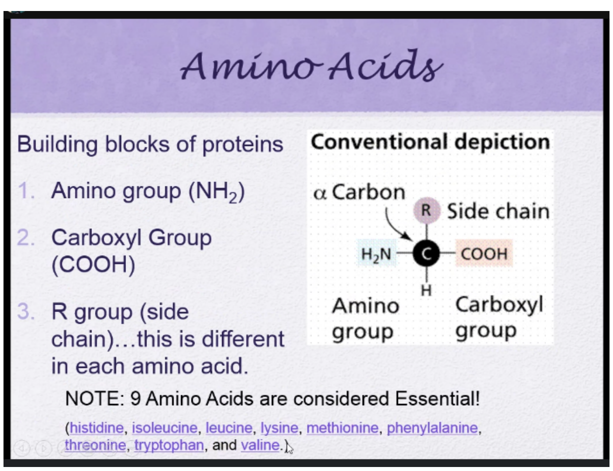
Test → lipids, polymers, carbohydrates, proteins
- Quiz give back on mon-ish

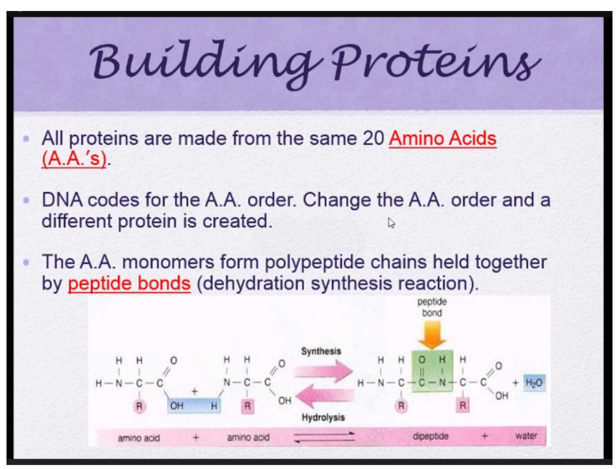
Proteins

- Proteins account for more than 50% of the dry weight of most cells and involved in almost everything the cell does
- Recommened 20%, though we eat closer to 40%
- 8 Classes of proteins
    - Structural proteins
    - Contractile proteins
    - Storage proteins
    - Defensive proteins
    - Transport proteins
    - Enzymes → most important class of proteins
    - Hormones
    - Recognition/ receptor



- Amino acids are building blocks of proteins
    - Amino groups + carboxyl group + side chain which is different in each amino acid
    - 9 amino acids are considered essential → essential means the body cant produce and must get another way
    - 20 standard amino acids

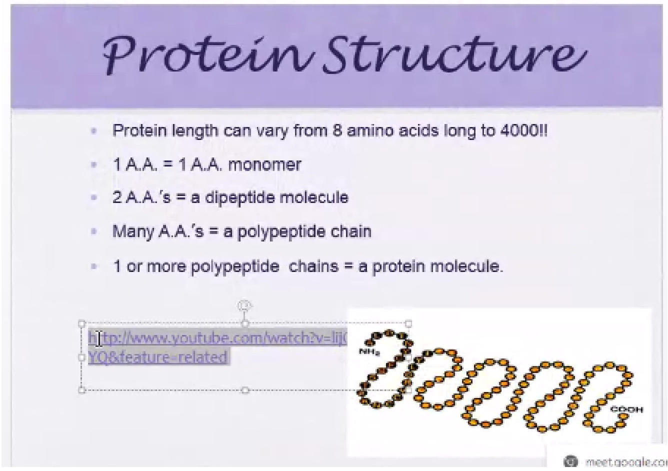


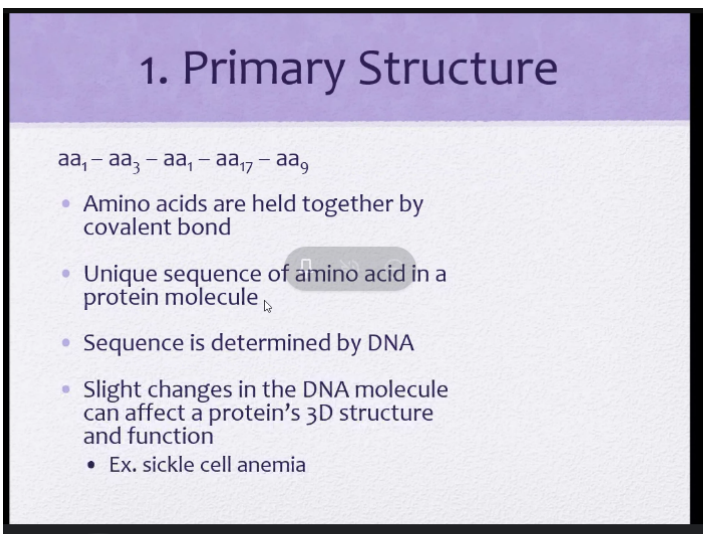


- Proteins are built from the same 20 amino acids (A.A.s)

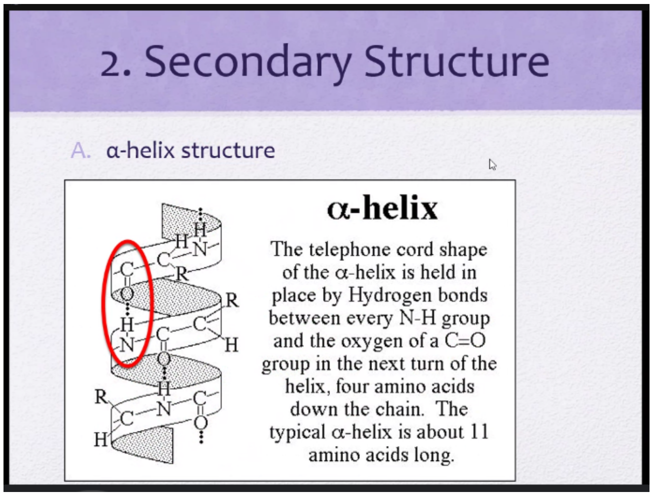
Protein structure

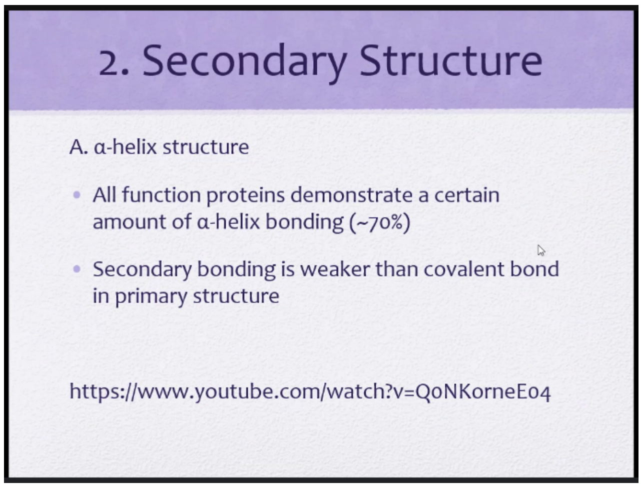
- Polypeptide chains

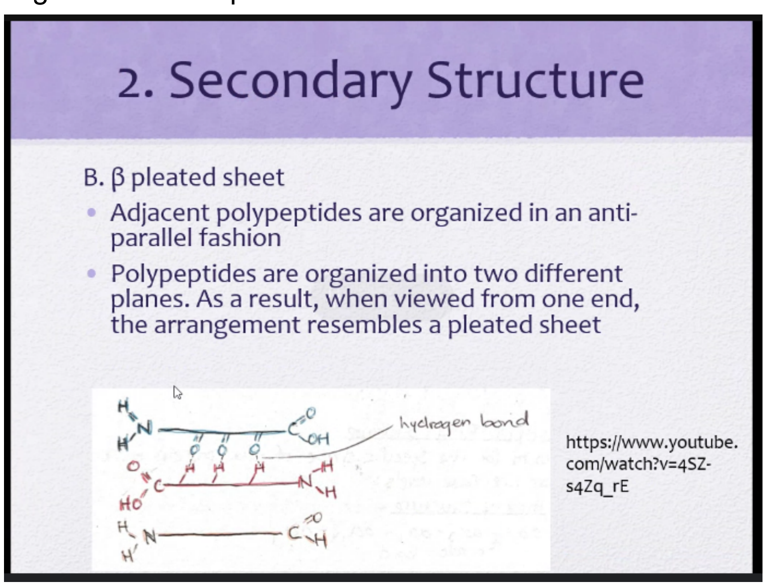


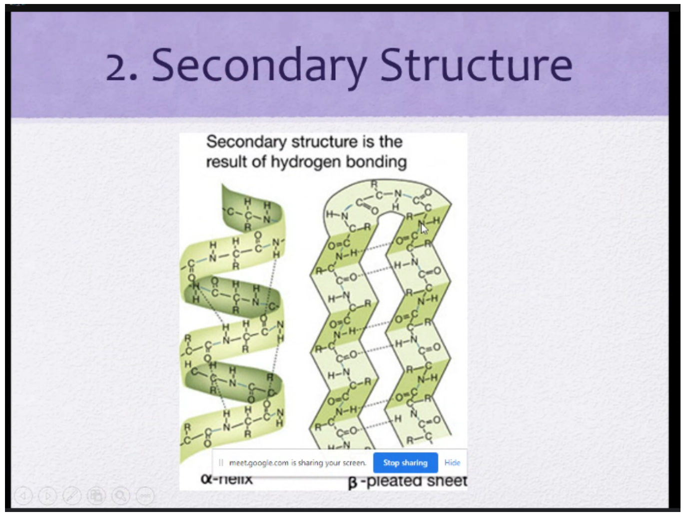
- 4 levels of protein structure:
- Primary structure
    - AAs are held together by covalent bonds
    - Unique sequence of amino acid in a protein molecule
    - 

    - Sickle-Cell Anemia
        - Block blood flow due to curved "sickle" shaped cells
        - Cant transport oxygen as easily
        - Genetic mutation, helps prevent contraction of malaria
    - Primary bonds are stronger than secondary and tertiary
- Secondary structure
    - Alpha-helix

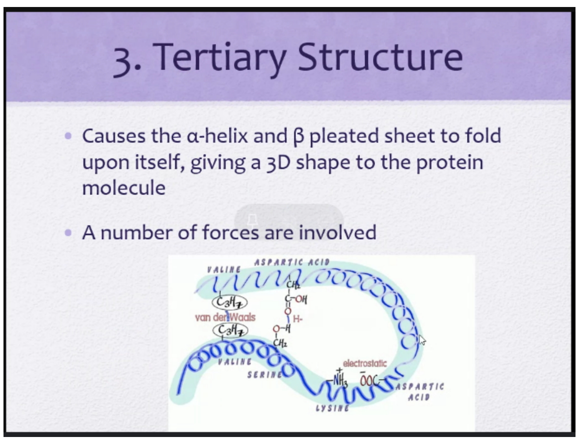
- 

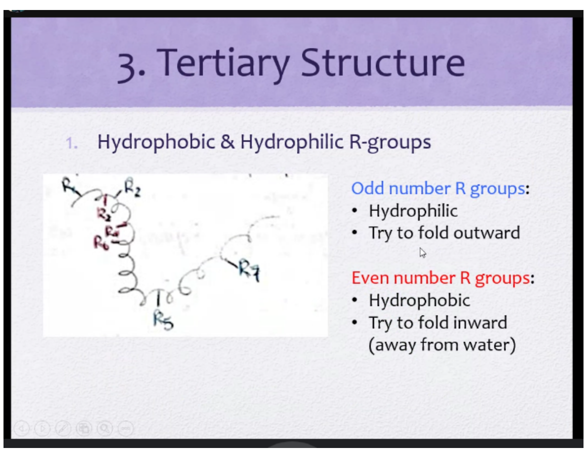
    - Secondary bonds not as strong as primary covalent bonds
    - 

- Beta-pleated sheet
    - Organized in anti parallel fashion
    - 

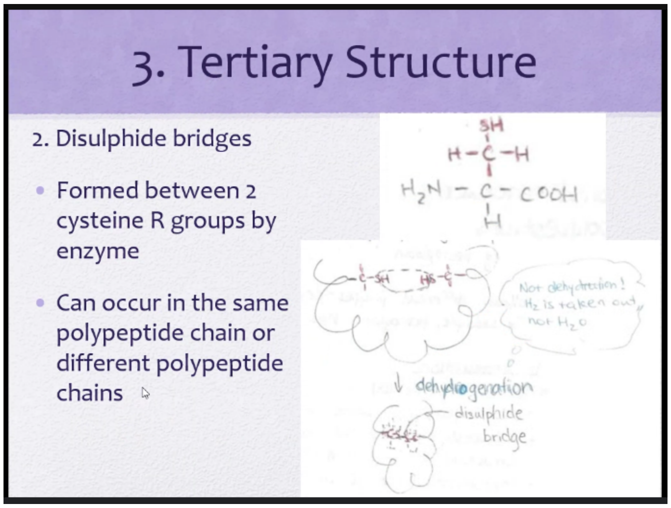
- Ex: silk which is very elastic
- 

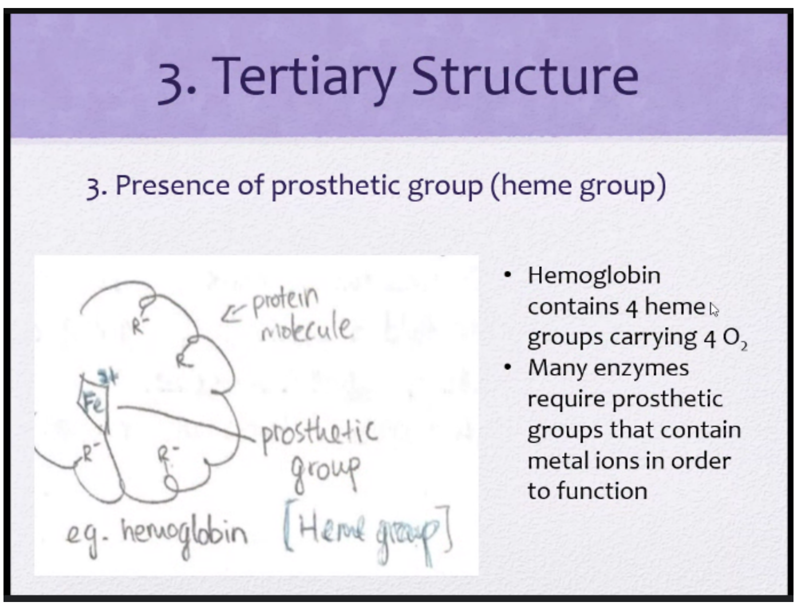
- This is what a beta pleated sheet looks like in comparison to a-helix
- In a big protein molecule, it can have both a-helix and b-pleated

- Tertiary structure
  - 

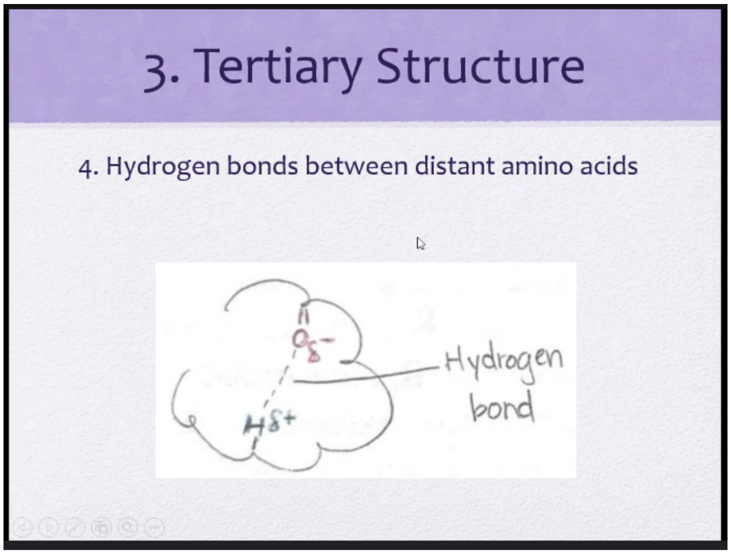
  - 

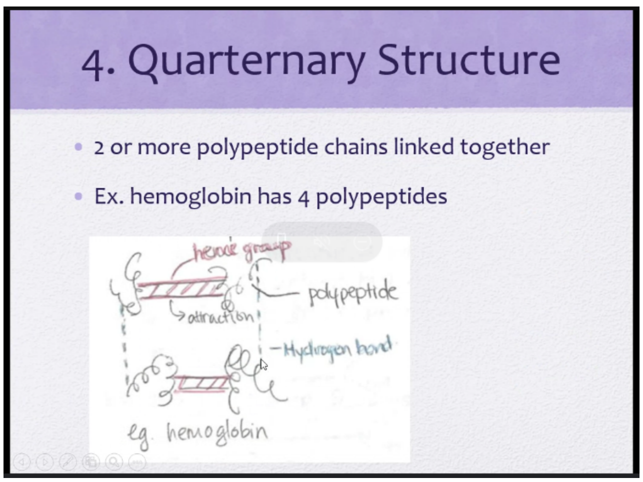
  - Changes in folding causes weird shapes of tertiary structure

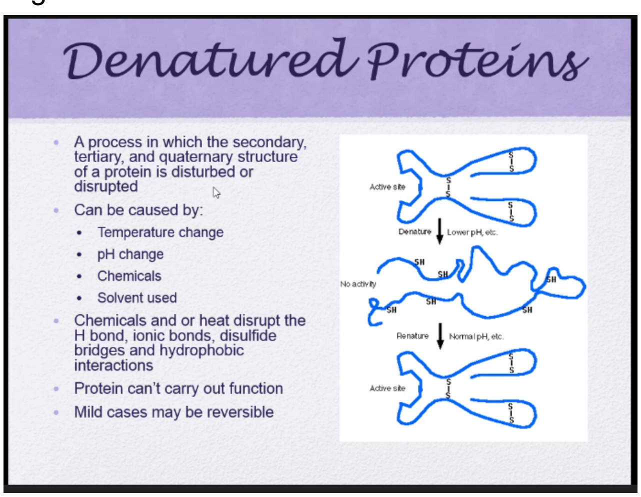
- 

- Dehydrogenation to take out the hydrogen resulting in a sulfur-sulfur bond known as a disulphide bridge
- Hair grows really fast → i am speed
    - Hair salon uses reducing agent to break down sulfide bridges and then a oxidizing agent to reform them in the way you want → usually to get a perm
- 

- Prosthetic group is anything with an iron in it
- Hemoglobin contains 4 heme groups

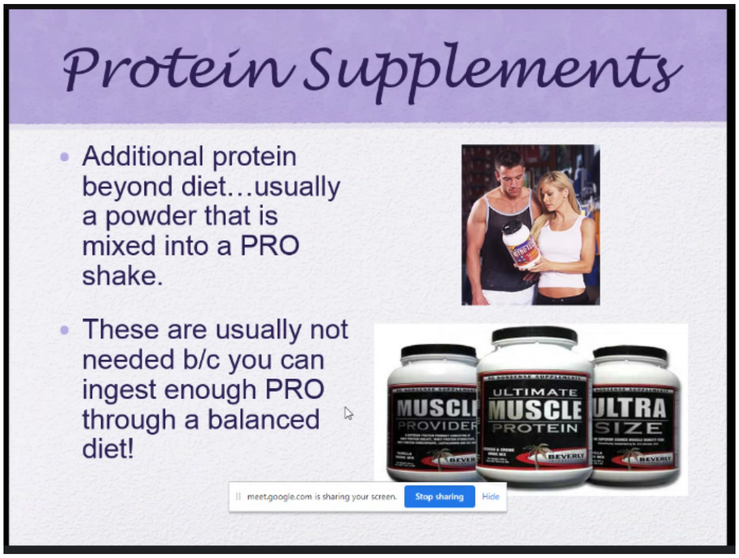
- 

    - Not a real bond, just an attractive force
- Quaternary structure
    - 

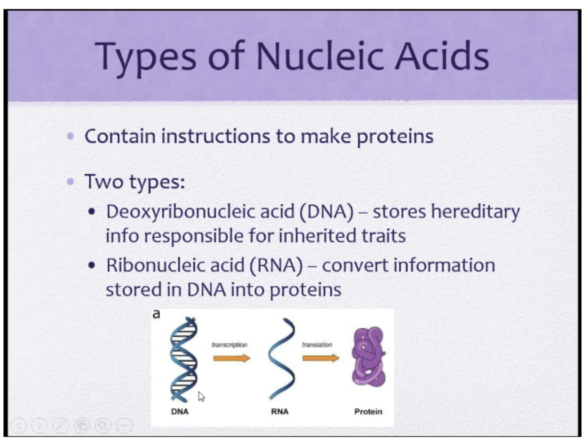
- Denaturing Proteins
    - 

- Protein supplements

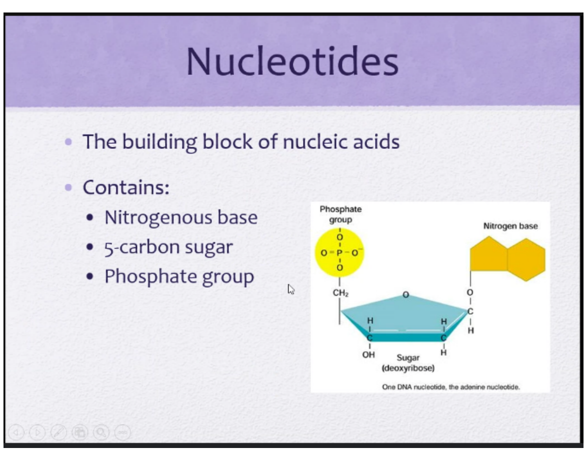
- Get swole by eating protein supplements

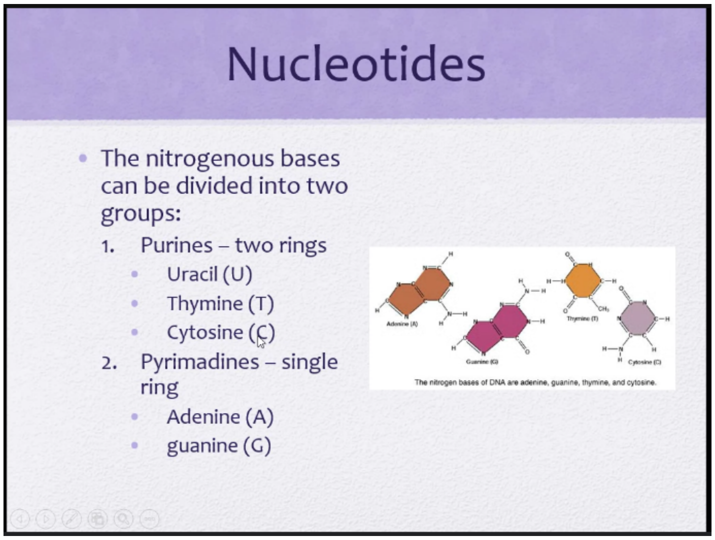


- Nucleic acids
    - like DNA and RNA
    - Contain instruction to make proteins

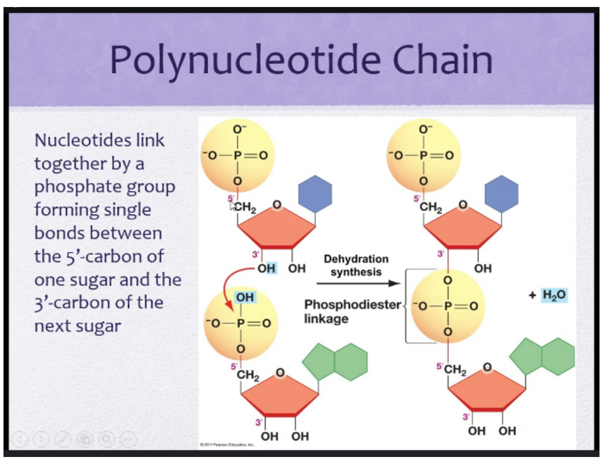


    - Nucleotides → the building blocks of nucleic acids
    - Nucleotide Structure

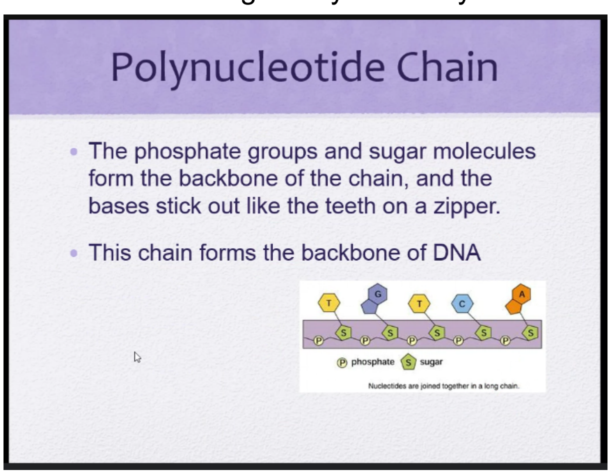


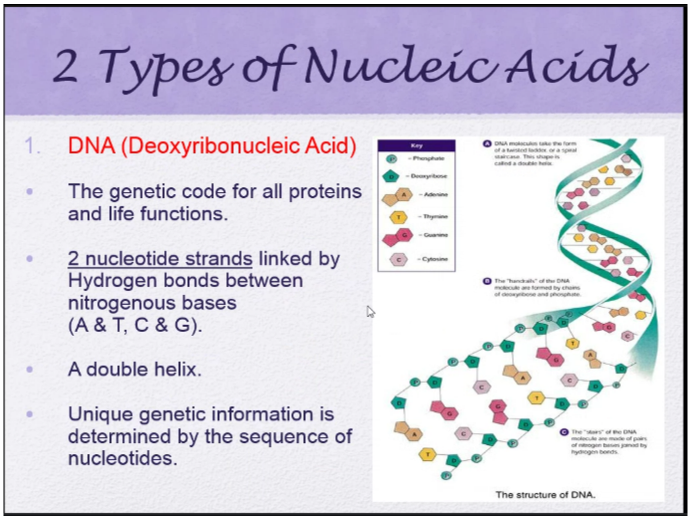
- 

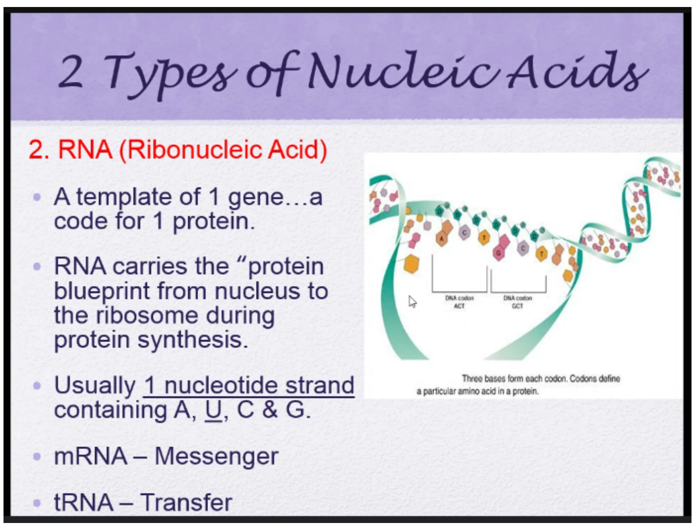
    - Purines: 2 rings
        - Uracil, thymine, cytosine
    - Pyrimadines - single ring
        - Adenine, guanine

- 

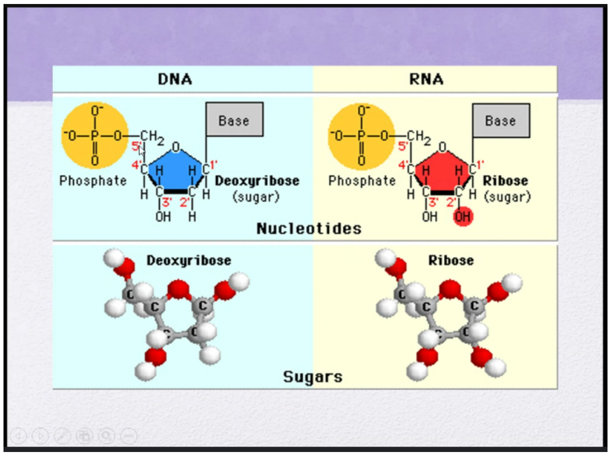
    - Done through dehydration synthesis

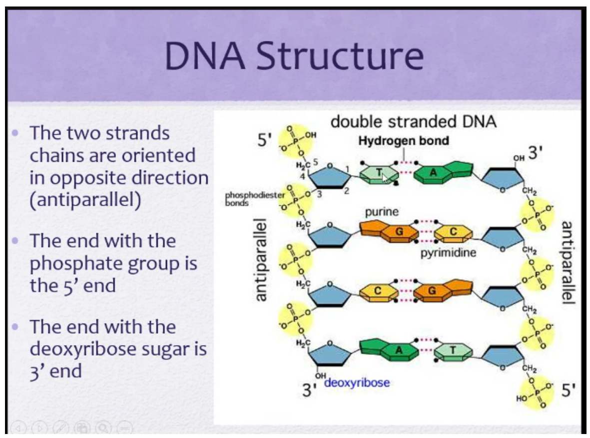
- 

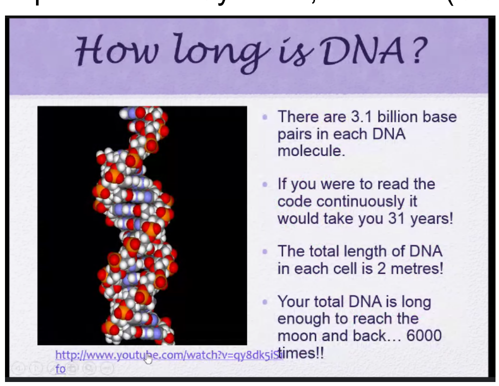
- DNA and RNA
- 

    - Double bond between A&T and triple bond between C&G
- 

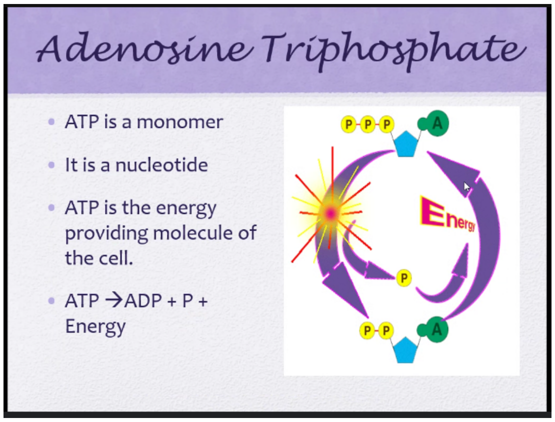
- RNA → A&U, C&G
- mRNA - leaves nucleus to deliver messages (m) to ribosomes
- rRNA - ribosomal rna to link amino acids together to form a coated protein
- tRNA - match AAs together

- 

    - Dont need to memorize these, just know big structure
- DNA structure - deoxyribonucleic acid, D for the name of the sugar
    - Antiparallel
    - 

    - Pyrimidines: Cytosine, Thymine
    - Purines: Adenosine, Guanine
    - Double bonded: Adenosine, Thymine (AT)
    - Triple bonded: Cytosine, Guanine (CG)
    - 

- ATP



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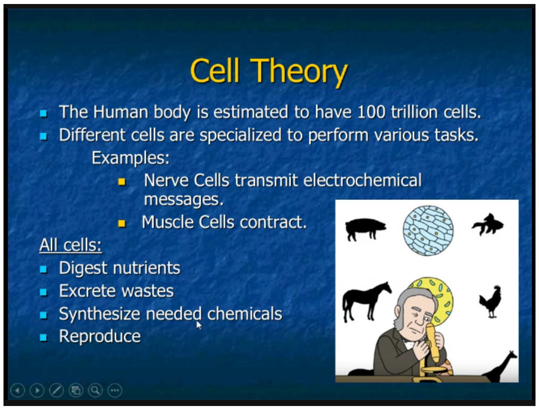
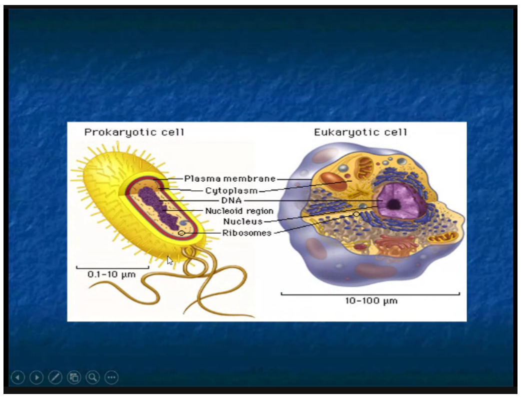
Levels of Biological Organization

1. Atoms
2. Chemical building blocks
3. Macromolecules
    - Dna, proteins
4. Organelles
    - Mitochondria
5. Cells
    - Heart muscle cells
6. Tissue
    - Cardiac tissue
7. Organs
    - Heart
8. Organ Systems
    - Circulatory system
9. Individual / Person
10. Population

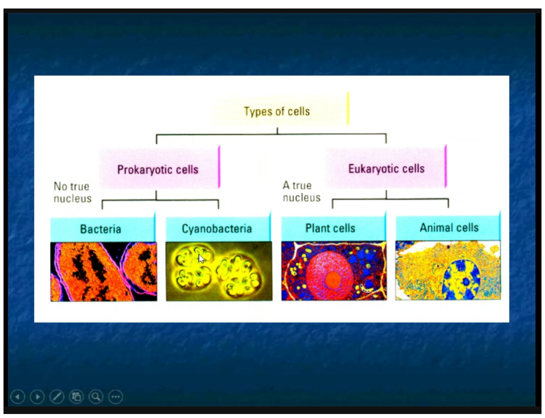
Cells

- 10 x more cells in body than stars in the milky way
- Cell theory
    - All living things are made up of cells
    - Basic unit of living organisms
    - All cells come from preexisting cells

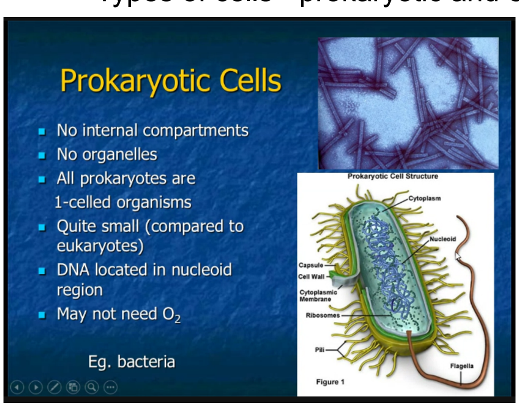
- 

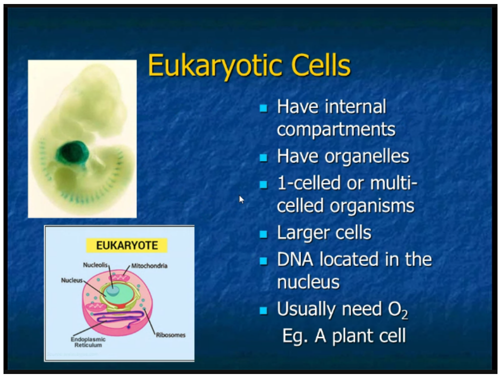
- 

    - Prokaryotic cells don't have a full nucleus

- 

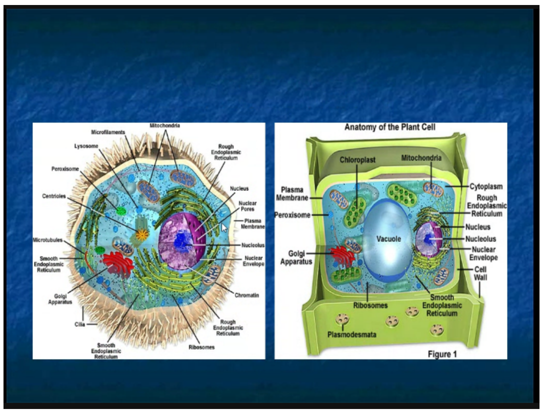
    - Types of cells - prokaryotic and eukaryotic

- 



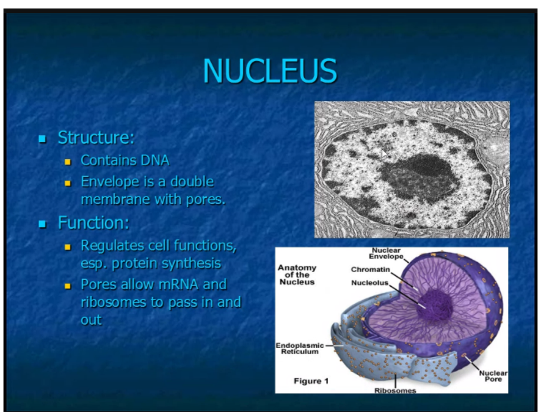
-

- Cell anatomy



-

- Nucleus



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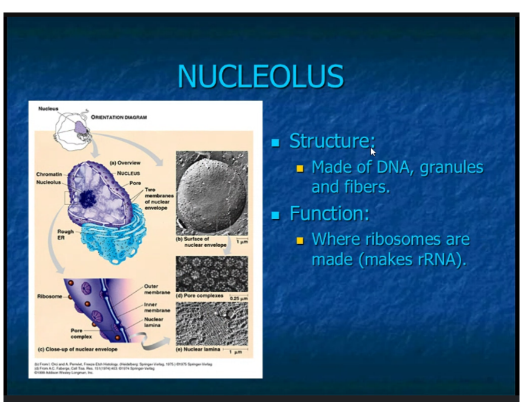

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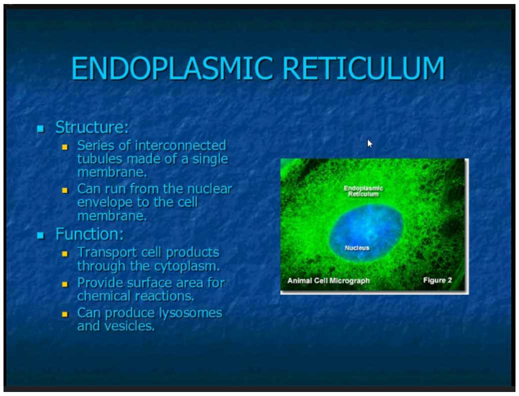
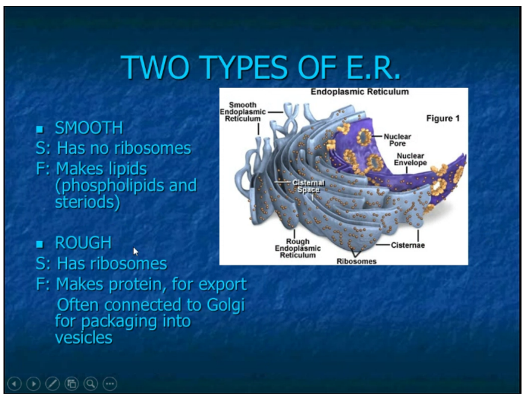
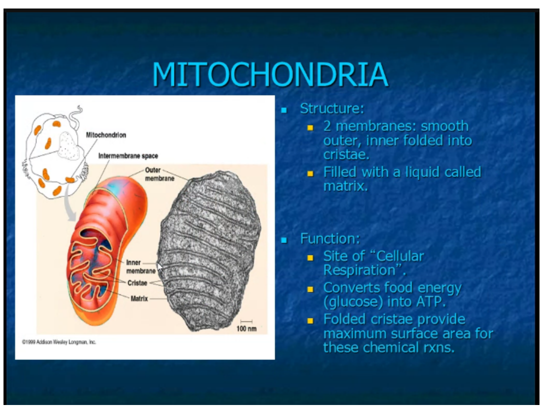
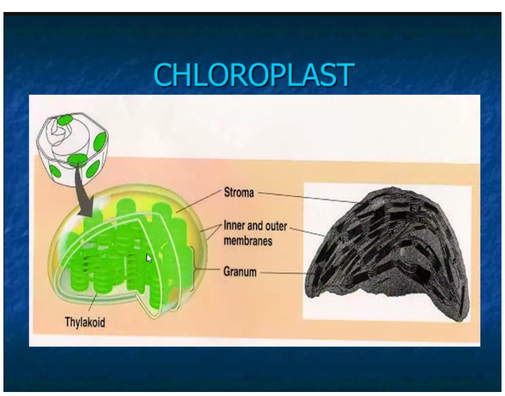

ENDOPLASMIC RETICULUM
Structure:
Series of interconnected tubules made of a single membrane.
Can run from the nuclear envelope to the cell membrane.
Function:
Transport cell products through the cytoplasm.
Provide surface area for chemical reactions.
Can produce lysosomes and vesicles.
Endoplasmic Reticulum
Nucleus
Animal Cell Micrograph
Figure 2


TWO TYPES OF E.R.
SMOOTH
S: Has no ribosomes
F: Makes lipids (phospholipids and steriods)
ROUGH
S: Has ribosomes
F: Makes protein, for export
Often connected to Golgi for packaging into vesicles
Endoplasmic Reticulum
Smooth Endoplasmic Reticulum
Figure 1
Nuclear Pore
Nuclear Envelope
Cisternal Space
Rough Endoplasmic Reticulum
Ribosomes
Cisternae


MITOCHONDRIA
Mitochondrion
Intermembrane space
Outer membrane
Inner membrane
Cristae
Matrix
100 nm
Structure:
2 membranes: smooth outer, inner folded into cristae.
Filled with a liquid called matrix.
Function:
Site of "Cellular Respiration".
Converts food energy (glucose) into ATP.
Folded cristae provide maximum surface area for these chemical rxns.

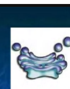

CHLOROPLAST
Stroma
Inner and outer membranes
Granum
Thylakoid

CHLOROPLAST

- Structure:
  - Green (b/c they contain chlorophyll)
  - Found only in plant cells and a few protists
  - Double membrane on outside and a series of stacked internal membranes called "Grana"
  - Filled with a fluid called "Stroma"
- Function:
  - Site of Photosynthesis (Converts light E into glucose)
  - Chlorophyll traps the sunlight
  - Membranes provide a large surface area for the reactions

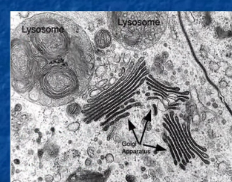
-

GOLGI APPARATUS



- Structure:
  - Flattened stacks of membrane.
  - Small vesicles form (are pinched off) at the end of the folds.
- Function:
  - Receive, modify and transport proteins of polypeptides made by the ER.
  - Membranes provide surface area for chemical rxns.
  - Various polypeptides are combined here to make 1 large protein molecule.
  - These are stored in vesicles and are released when needed.

  Eg. Adrenalin



-

RIBOSOMES

- Structure:
  - Dense-looking granules
  - 2 spheres
  - Made of rRNA and protein
  - Found on E.R. floating free in cytosol
- Function:
  - Site of "Protein Synthesis"
  - mRNA is held b/w 2 spheres. Proteins are coded for and built using amino acids.
  - Proteins are then either used by or exported from the cell.

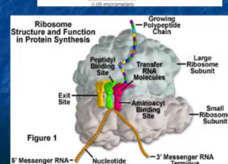


Figure 1

-

VACUOLES

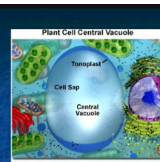
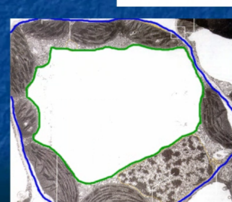


Figure 1

- Structure:
  - Single membrane bags, filled with water and dissolved molecules.
  - Mainly in plant cells
- Function:
  - STORAGE
  - Starch molecules or hold water to create TURGOR pressure to support the plant.



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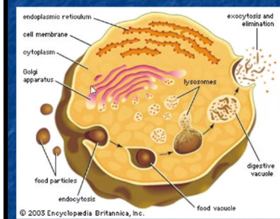
VESICLES



- Structure:
  - In plant and animal cells.
  - Round, temporary sac made by the Golgi.
- Function:
  - Store hormones and transport materials through cell...messengers.
  - Bring in food (ENDOCYTOSIS) and digest it. Then excrete waste (EXOCYTOSIS).

-

LYSOSOMES

(A.K.A. "suicide" or "death" sacs!)

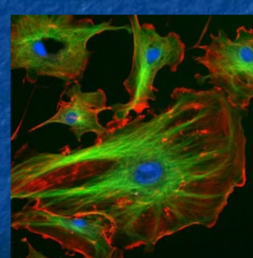
- Structure:
  - Single membrane sac. Full of Hydrolytic Enzymes (take things apart).
- Function:

  -Found only in animal cells
  - In a 1-celled organism: Join with food vacuole and enzymes digest the food.
  - In certain White Blood Cells: Destroy bacteria taken in.
  - In most cells: break down old organelles or destroy dead cells or unwanted tissue for 'recycling'.
  - Eg. Tadpole tail

-

CYTOSKELETON

- Structure:
  - A support network of fine protein fibres.
  - Comprised of microfilaments, intermediate filaments and microtubules
  - If outside membrane they form cilia and flagella.
- Function:
  - Gives animal cells their shape.
  - Anchors organelles
  - May relay messages between the cell membrane and interior of the cell.



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CILIA AND FLAGELLA

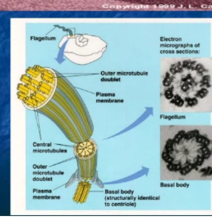
- Cilia – Short and very numerous.

  Eg. Paramecium

- Flagella – Long and few in number

  Eg. Euglena

- Function: Locomotion



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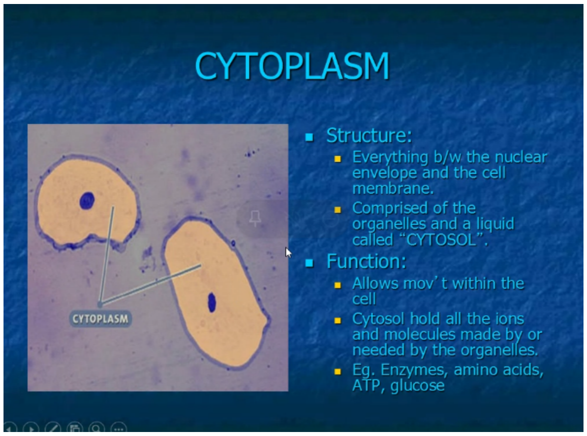
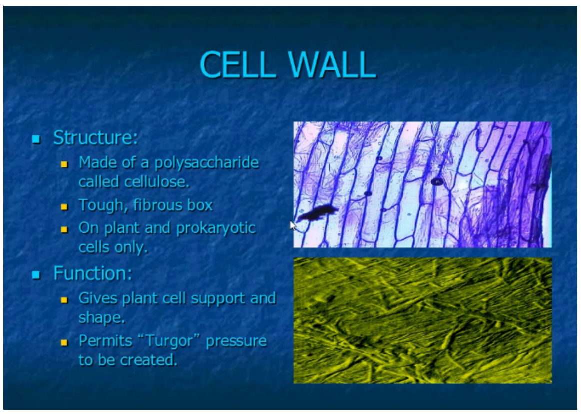
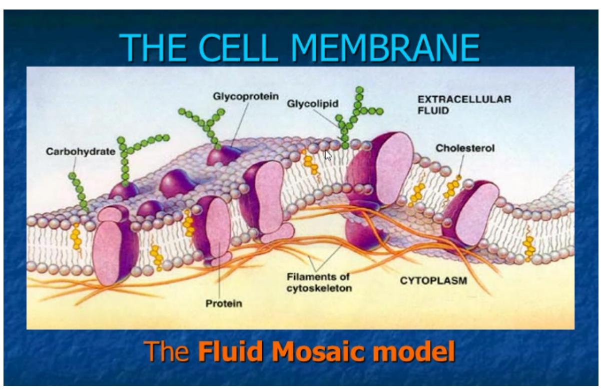
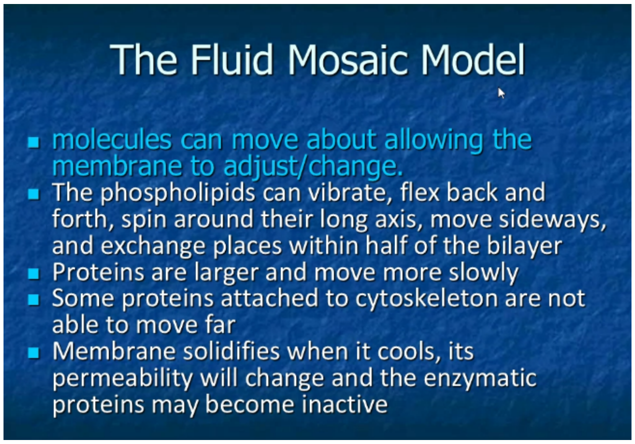
- 

- 

- New stuff starts here lol
    - 

    - Fluid mosaic model



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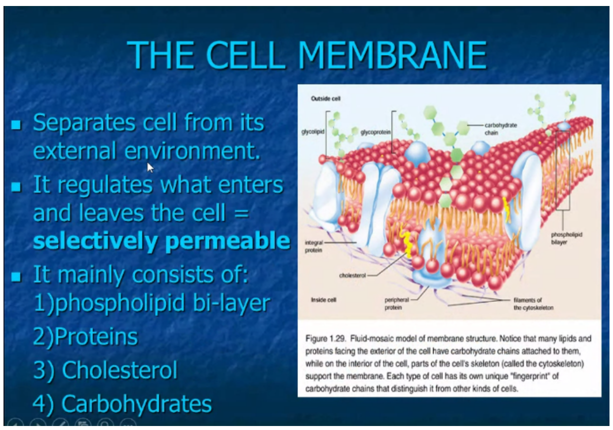
- Cell membrane



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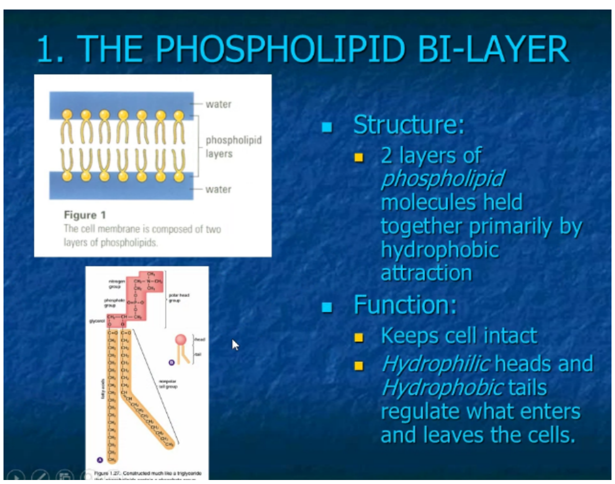
- Phospholipid bi-layer



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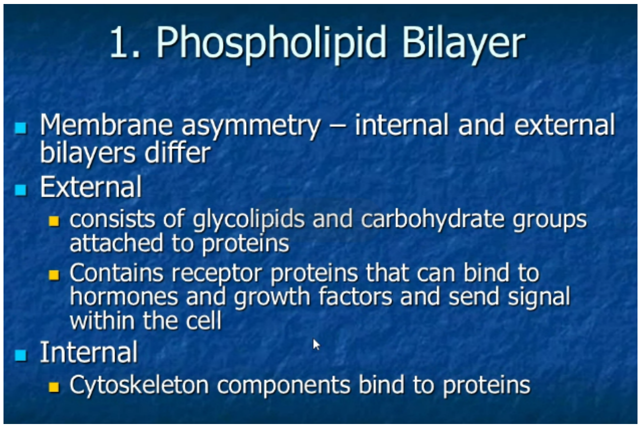
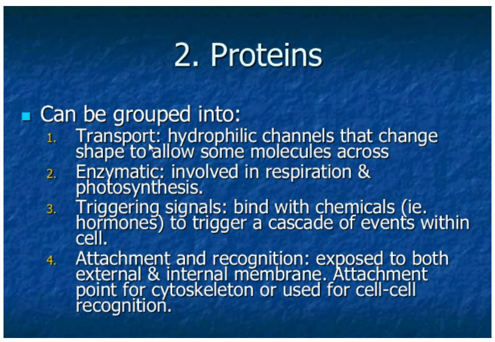
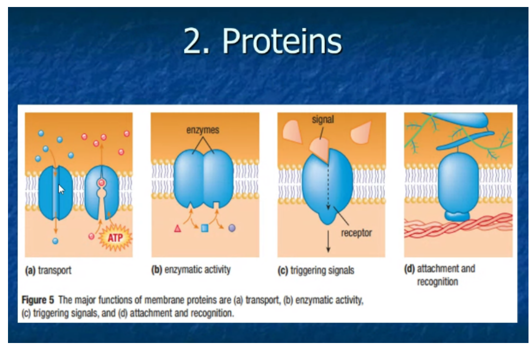
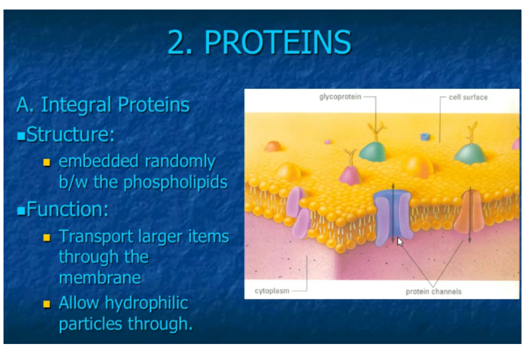
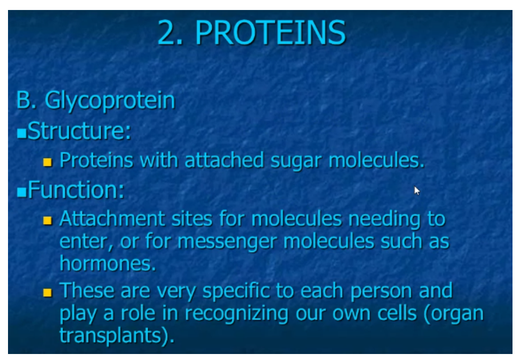
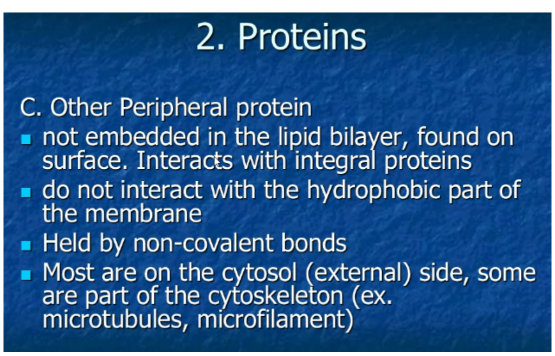
- 

- Example of external layer: serotonin binds to end of cell to send a signal to it
- Proteins
- 



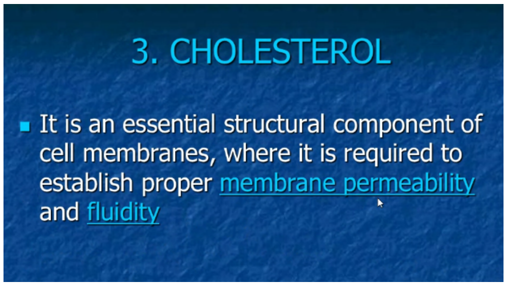
- 



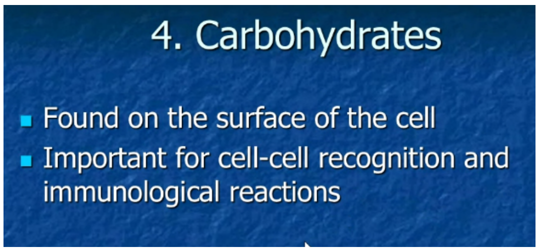
- 

- *Cytosol should be on the inside
- Cell-cell recognition

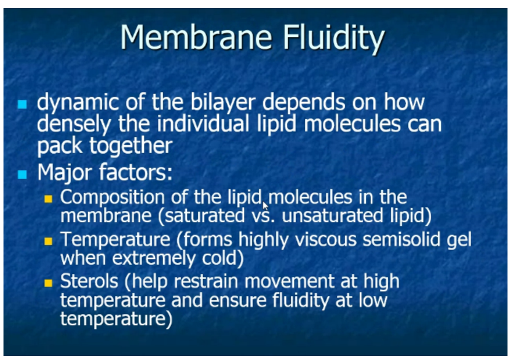
- Cholesterol



-
- Carbohydrates



-
- Membrane fluidity



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Experimental Quiz over the weekend → not for marks, just to practice

Test → Tuesday

Time → Will give us more time?

- Will take ~1 hour, shes gonna reduce uploaded questions
- Mostly typing answers
- 1 hour lesson + 1 hour test
- Starting at latest 10:30

On → everything after nomenclature, starting from carbohydrates

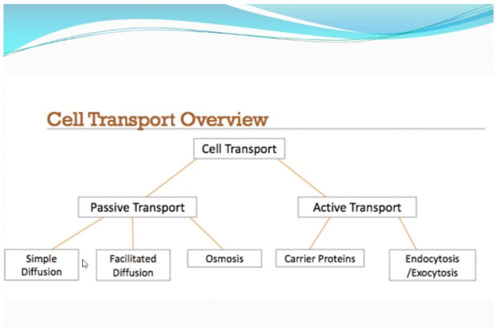
- Includes dehydration synthesis
- Everything up to tomorrow
- Diagrams will be optional if they help you explain

Homework

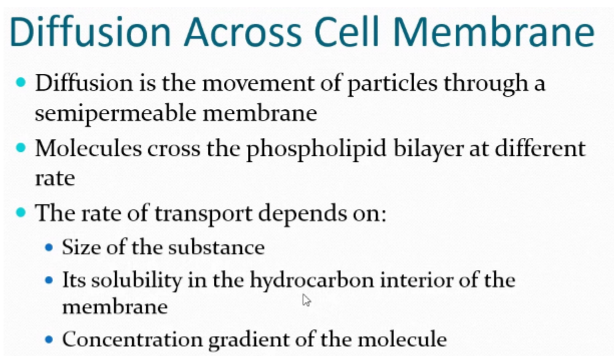
- 81-85 in textbook
- Cell membrane questions

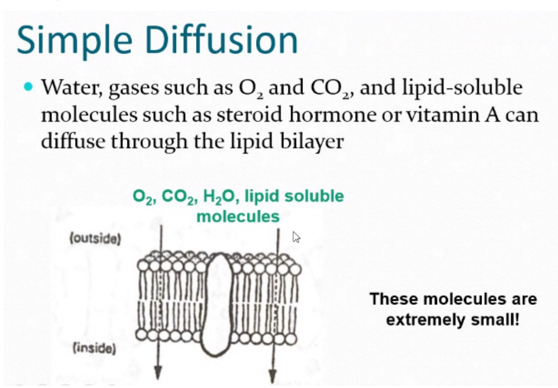
//

Cell Transport

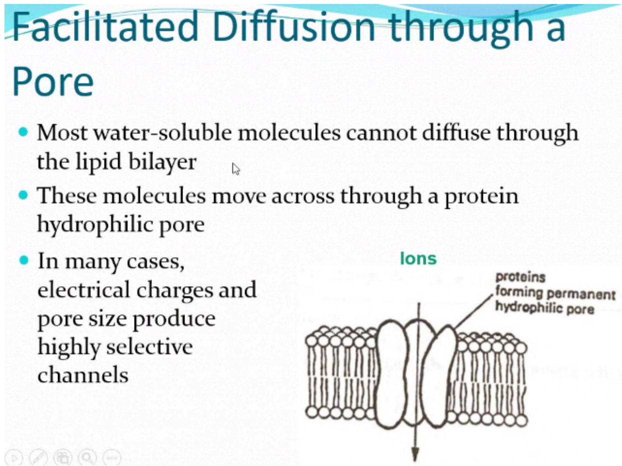


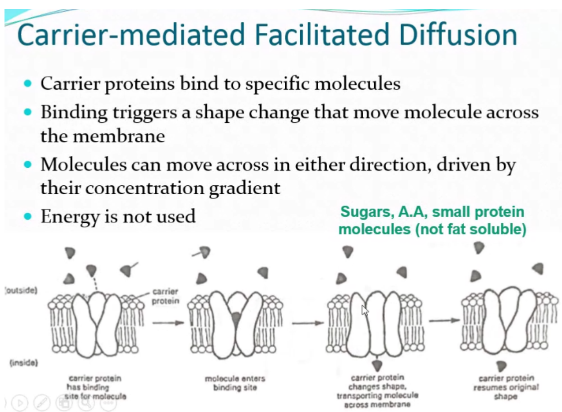
Diffusion

- 

- Simple Diffusion
- 

- Facilitated diffusion



- 

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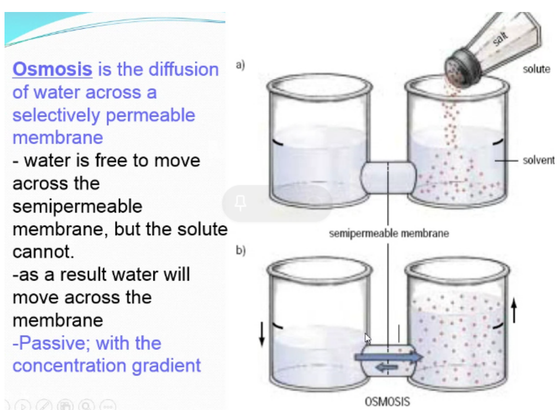
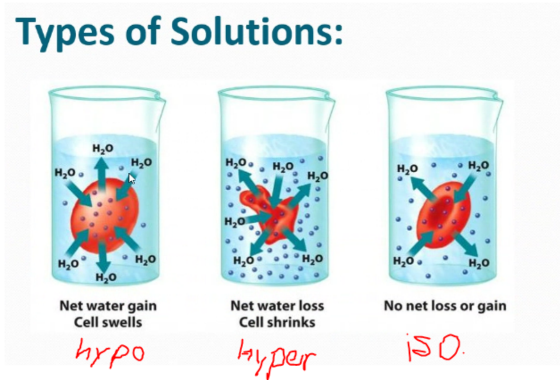
Osmosis

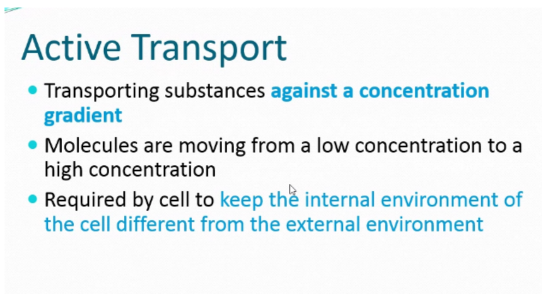


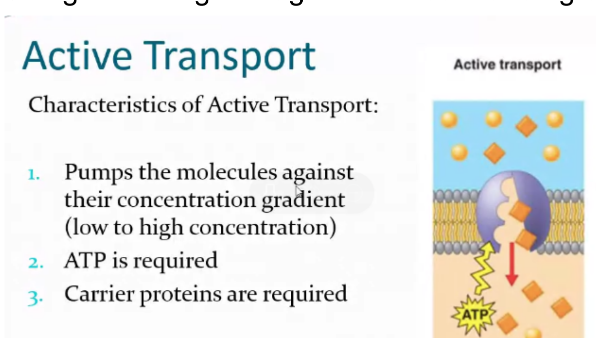
-
    - Water moves to the salt side to maintain the concentration gradient

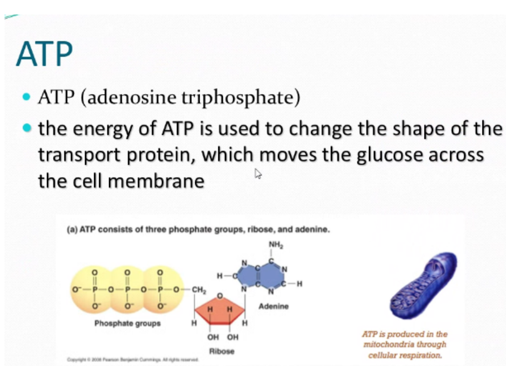
- 

    - Good way to remember → hypertonic is like a cucumber going into a salt water pool and becoming a pickle

Active Transport

- 

- Going low to high → against concentration gradient
- 

- ATP
- 

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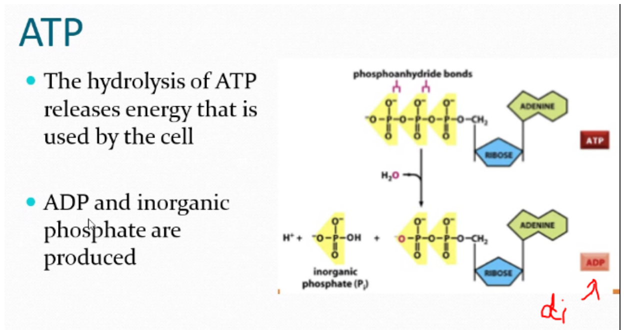
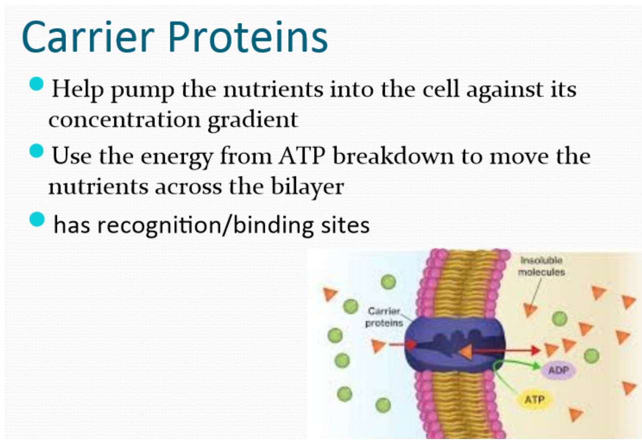


- Carrier protiens



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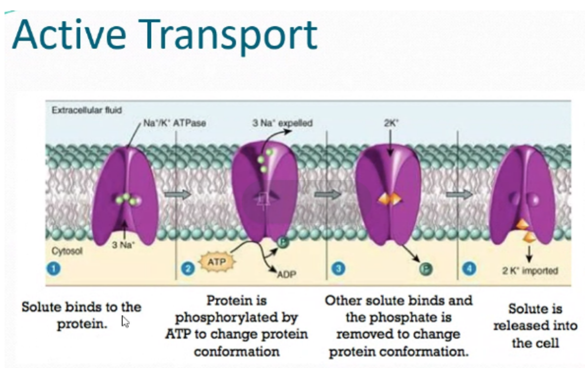

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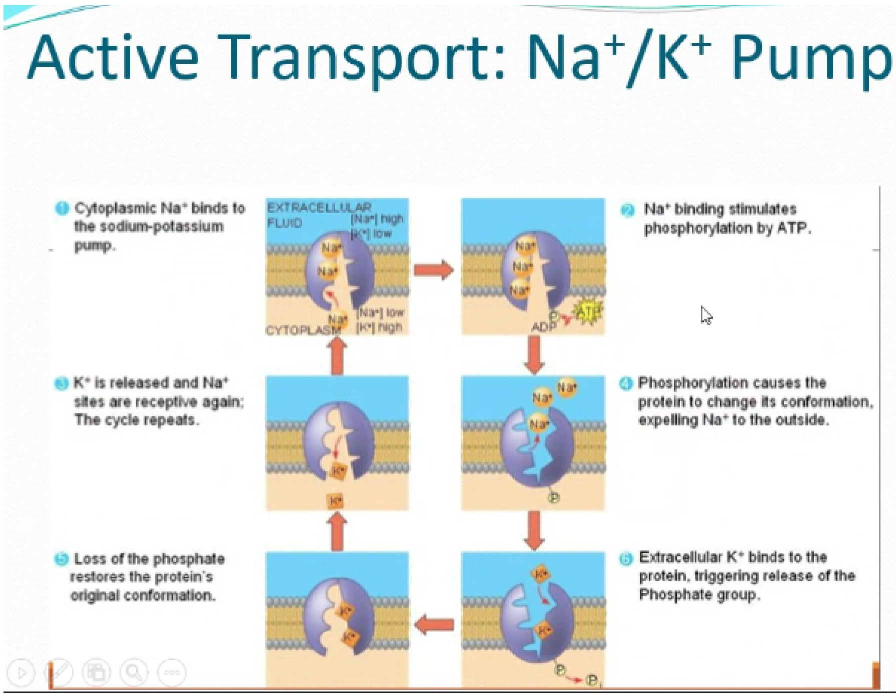
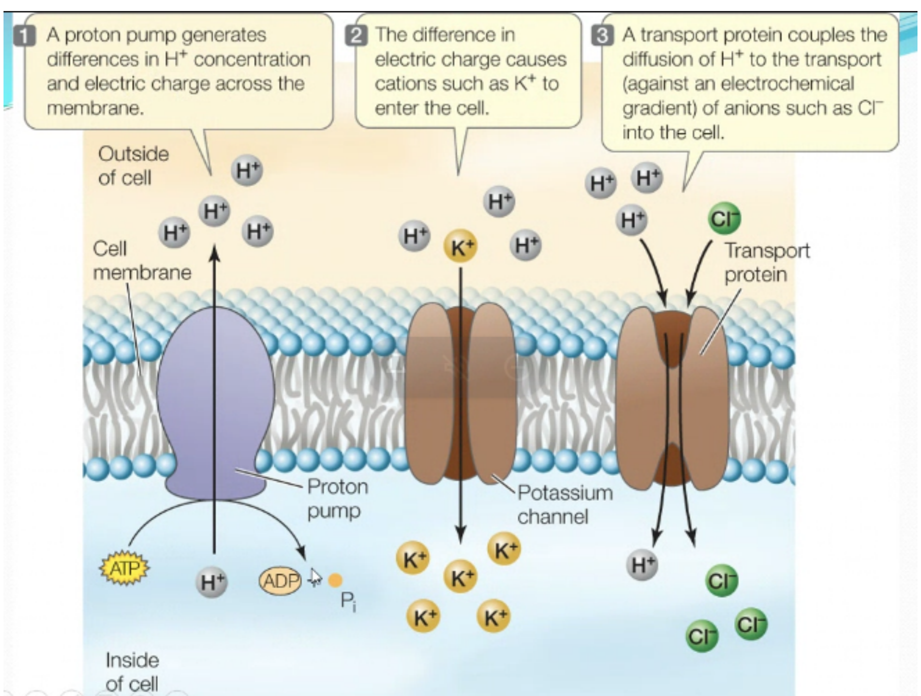
Active Transport - Sodium Potassium channels

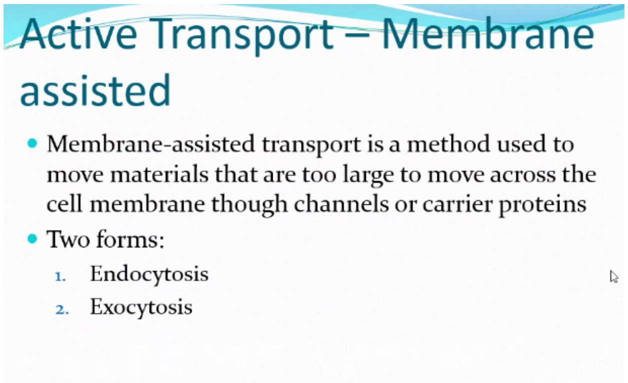
- 

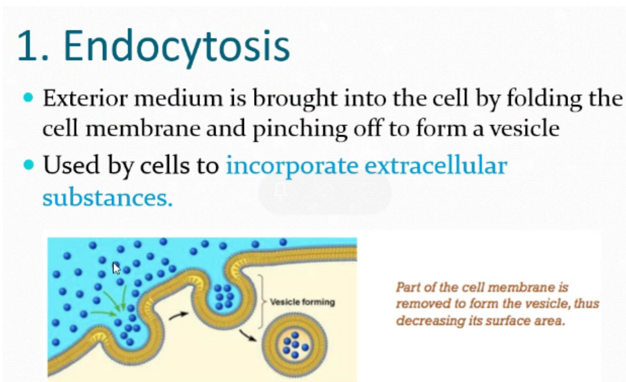
- Basically just amoeba sisters everything for this unit

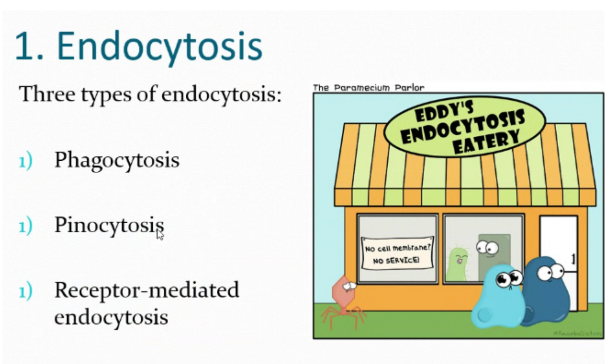
Active transport - Co transporter / proton pumps

- 

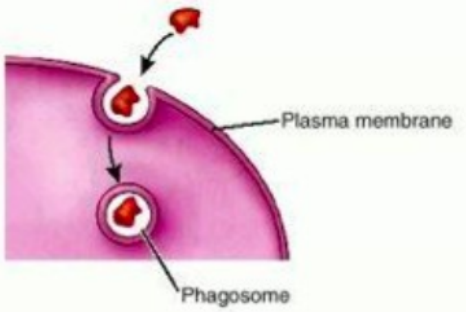
Active transport - Membrane Assisted

- 

- Endo coming in, exo leaving
- Endocytosis
- 

    - Blue is outside
- 

Phagocytosis (aka cell eating):

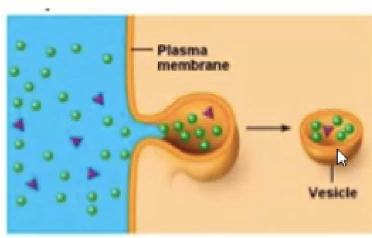


The large particle is enclosed within a membrane-enclosed vacuole. Particles are digested when the vacuole binds to a lysosome.

-

1. Endocytosis

Pinocytosis (aka cell drinking):



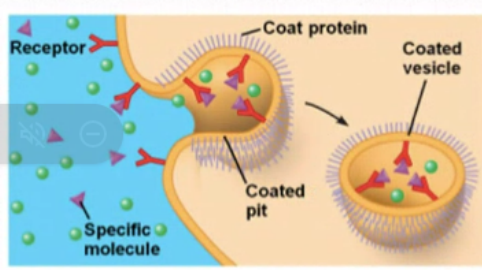
The cell gulps droplets of extracellular fluid into vesicles.

-

1. Endocytosis

Receptor-Mediated:

- The membrane has receptors that bind to specific molecules
- The receptors are clustered in 'coated pits' which are coated proteins that ine the interior part of the cell



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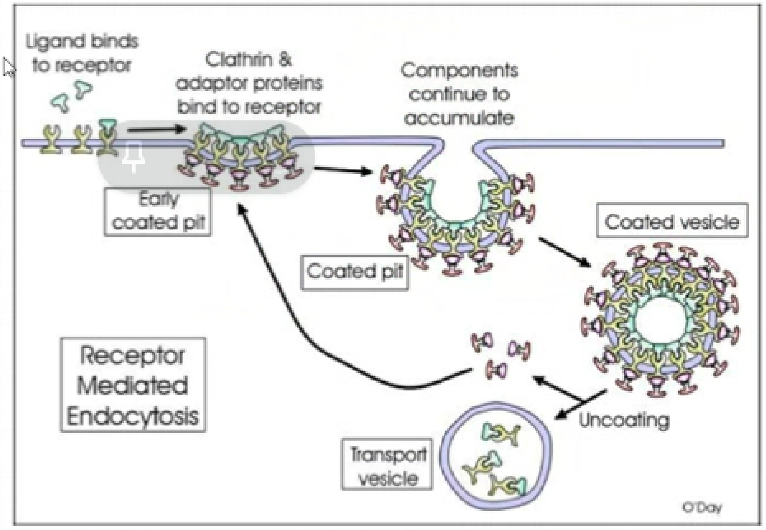
1. Endocytosis

Receptor-Mediated:

- Example: LDL
- LDLs are ligands that bind to the LDL receptors on the surface of the membrane
- Cholesterol enters the cell through receptor-meditated endocytosis
- Defective protein receptors can lead to hypercholesterolemia (accumulation of cholesterol in the blood)



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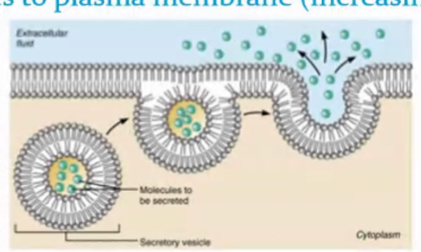
Hypercholesterolemia.

- the cholesterol receptors on the liver cells are either absent or greatly reduced in number.
- People who completely lack cholesterol receptors are unable to remove excess cholesterol from their blood and may die from heart disease while still in childhood.
- Others who have fewer than normal receptors are also at risk, but may be treated with a low-fat diet and cholesterol-lowering drugs.

-
- Exocytosis

2. Exocytosis

- The cell secretes macromolecules by fusing a vesicle with the cell membrane
- Vesicle usually budded from the ER or Golgi and migrates to plasma membrane (increasing its S.A.)



-
- Kind of the opposite of endocytosis

//
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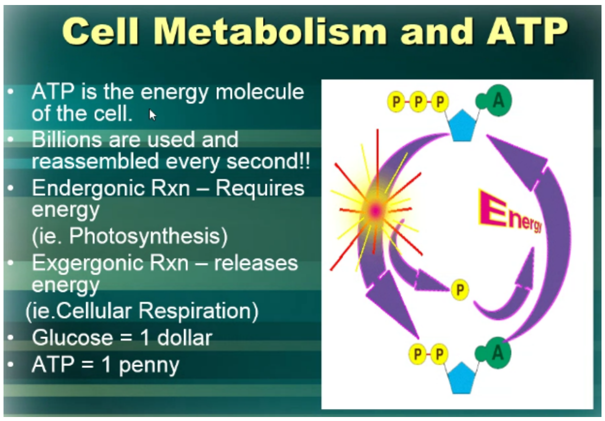
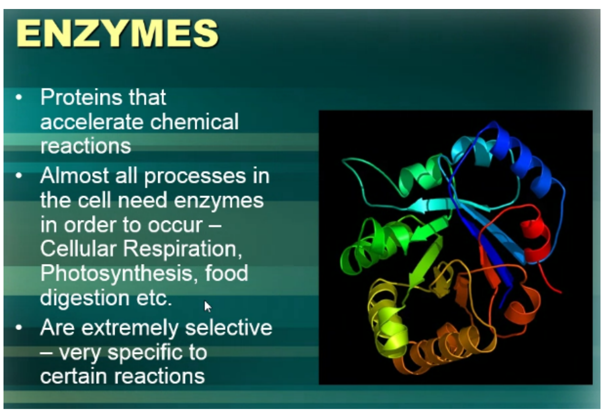
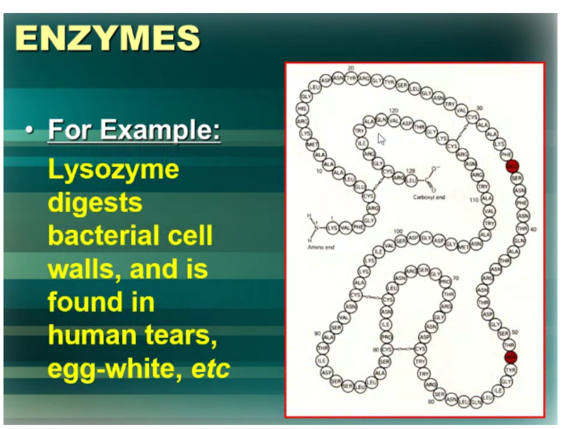
EVERYTHING PAST HERE IS NOT ON TEST

Cells at work

- 

- Enzymes → key to biochemical reactions
    - 

    - 

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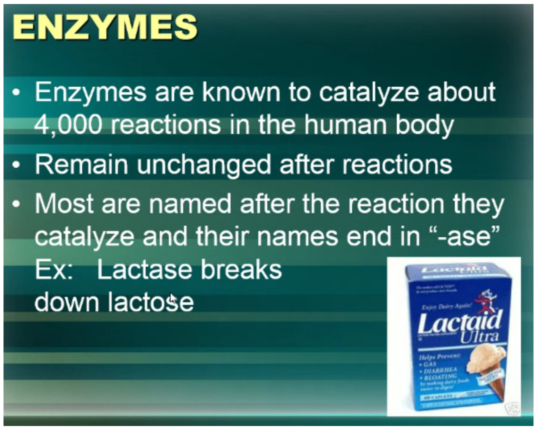
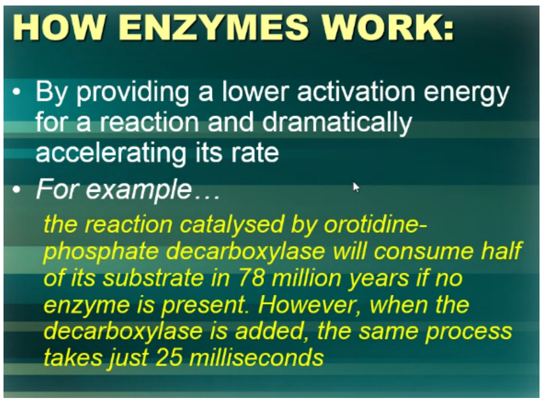
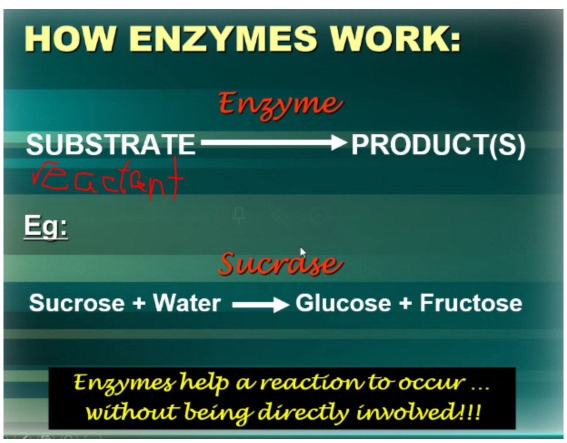
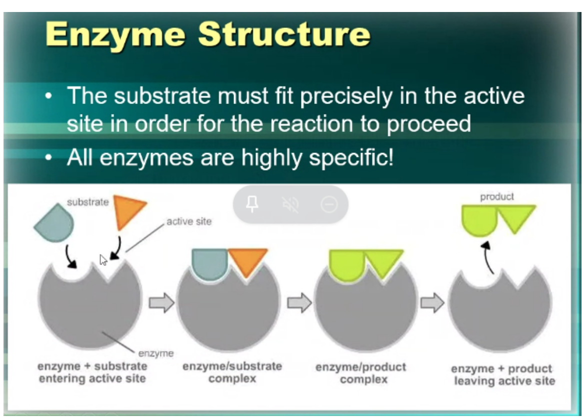
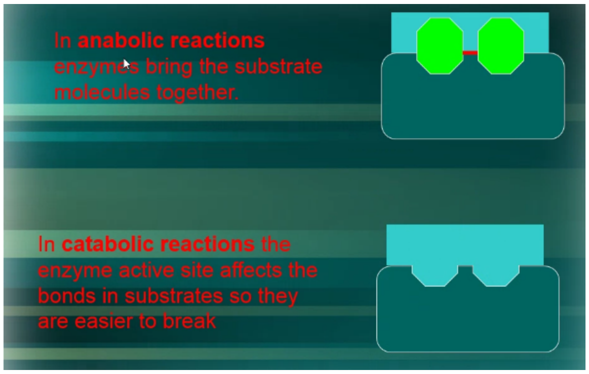
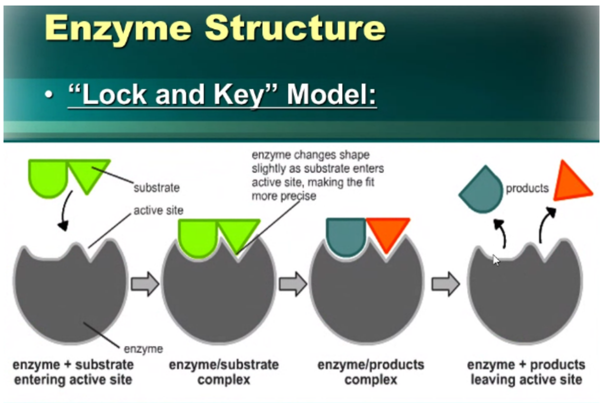

ENZYMES
Enzymes are known to catalyze about 4,000 reactions in the human body
Remain unchanged after reactions
Most are named after the reaction they catalyze and their names end in "-ase"
Ex: Lactase breaks down lactose
Lactaid Ultra

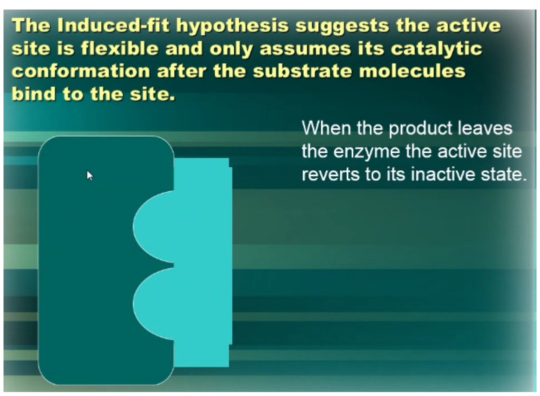
-

HOW ENZYMES WORK:
By providing a lower activation energy for a reaction and dramatically accelerating its rate
For example…
the reaction catalysed by orotidine-phosphate decarboxylase will consume half of its substrate in 78 million years if no enzyme is present. However, when the decarboxylase is added, the same process takes just 25 milliseconds

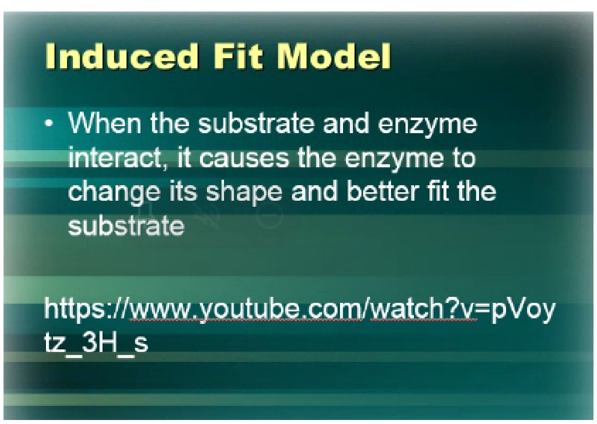
-

HOW ENZYMES WORK:
Enzyme
SUBSTRATE → PRODUCT(S)
reactant
Eg:
Sucrase
Sucrose + Water → Glucose + Fructose
Enzymes help a reaction to occur … without being directly involved!!!

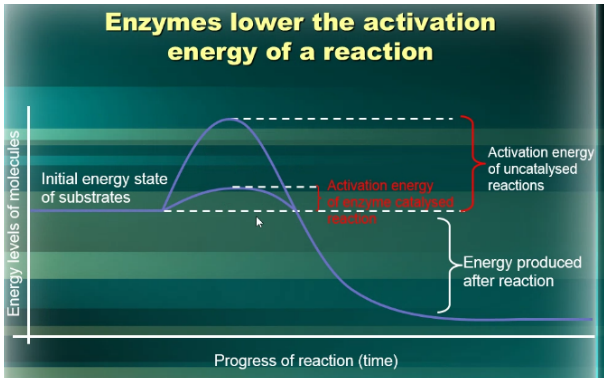
-

Enzyme Structure
The substrate must fit precisely in the active site in order for the reaction to proceed
All enzymes are highly specific!
substrate
active site
product
enzyme
enzyme + substrate entering active site
enzyme/substrate complex
enzyme/product complex
enzyme + product leaving active site

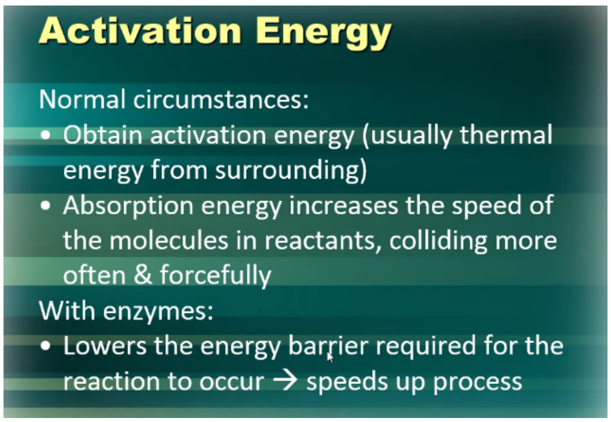
- 

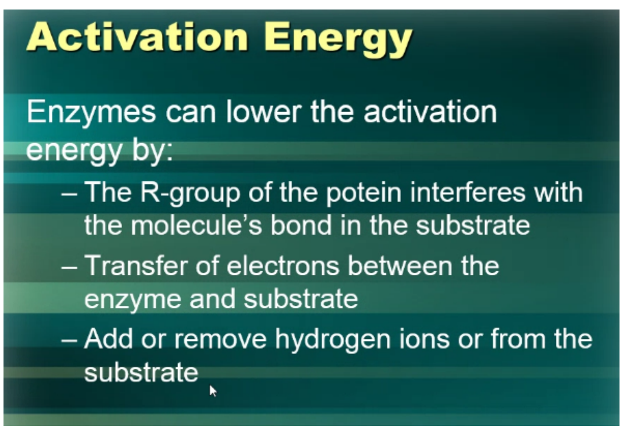
    - A is like add, C is like cut
- 

- Lock and key is prob wrong cuz proteins have been proven to be flexible
- 

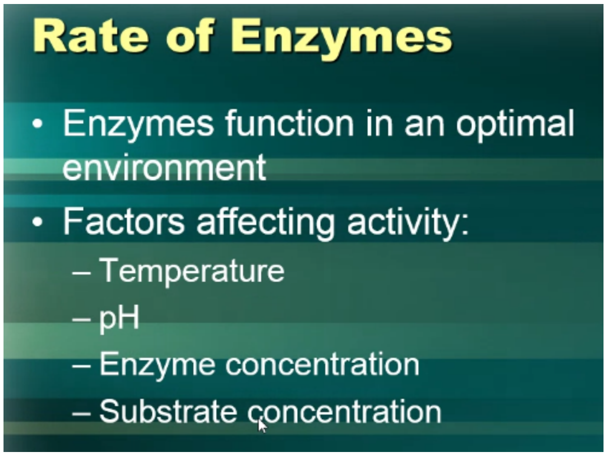
- 

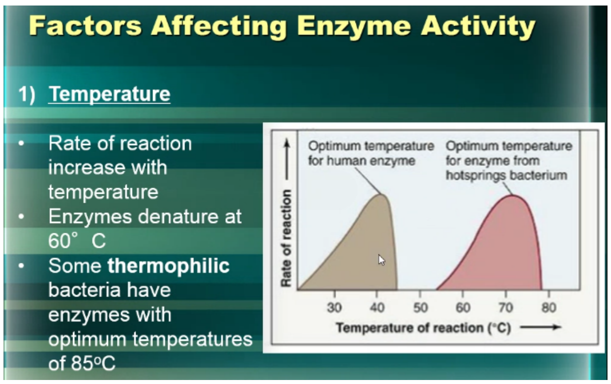
- 

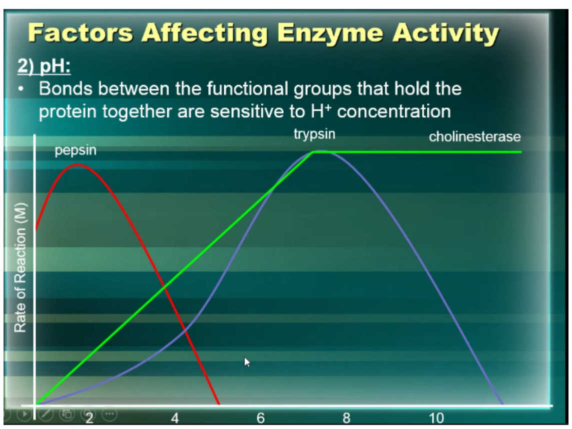
- 

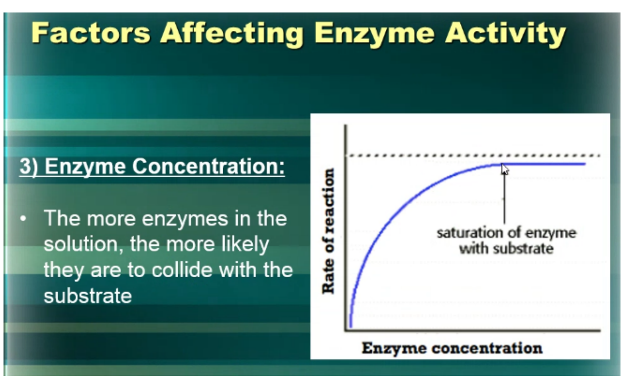
- 

- Factors affecting enzyme activity

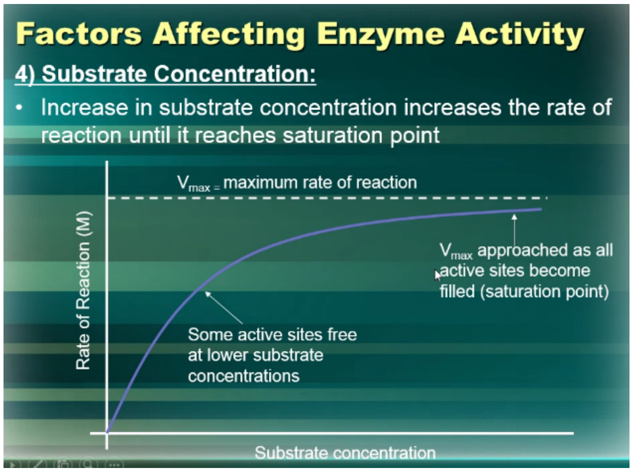
- 

- 

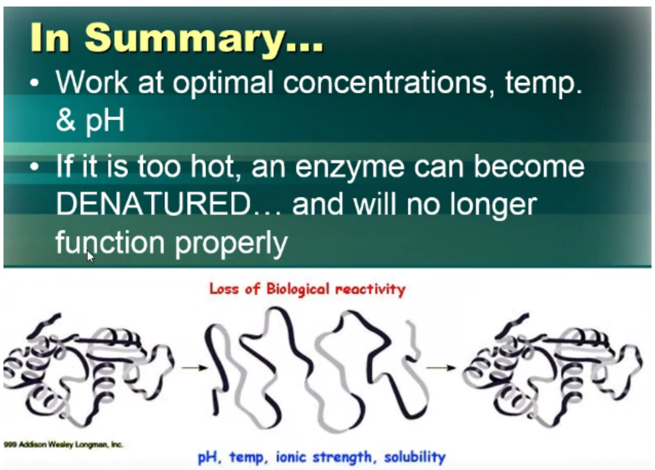
- 

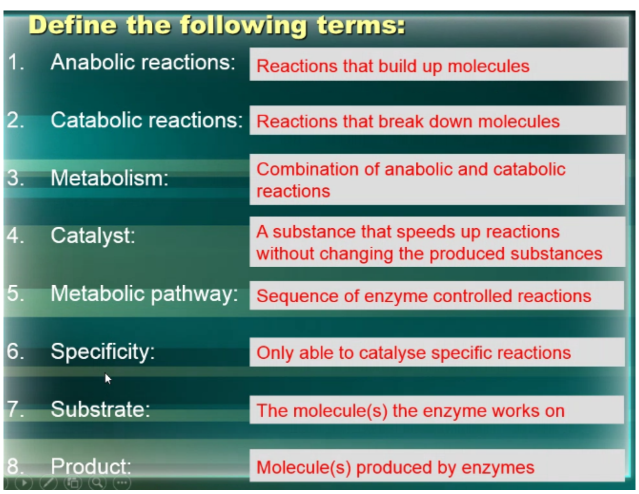
- 

- The more seats u have in a movie theater, the more people that can sit

- 

- Summary

    - 

    - 

- Enzyme regulation

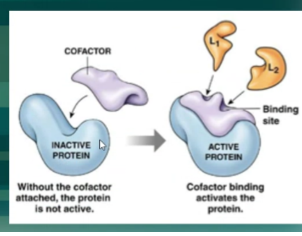
Enzyme Regulation

- Regulation mechanisms:
  - Cofactors/ Coenzymes
  - Competitive inhibitors
  - Non-Competitive inhibitors
  - Allosteric Changes
  - Feedback Inhibition
  - Precursor Activation

-

1. Cofactors/Coenzymes

- Non-protein helper
- Enzymes can't speed up reaction without them



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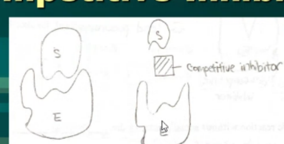
1. Cofactors/Coenzymes

- Example: Vitamin B_2 (riboflavin)
- Involved in energy metabolism (ie. metabolism of fat, carbohydrates and proteins)
- Deficiency: body will have problem metabolizing (fats, carbs, proteins)
- Often caused by dietary inadequacy
- Can be obtained from meat, nuts, cheese, eggs
- Diagnosis: measure activity of enzyme gluthathione
- Symptoms: bloodshot eyes, mouth, inflammation, sores, burning tongue
- Not common because most countries fortify their breads and cereals with vitamin B_2

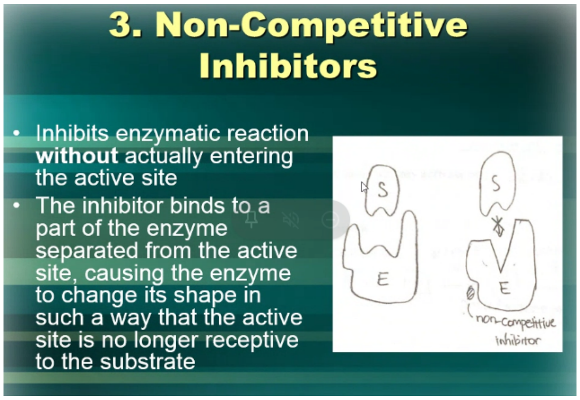
-

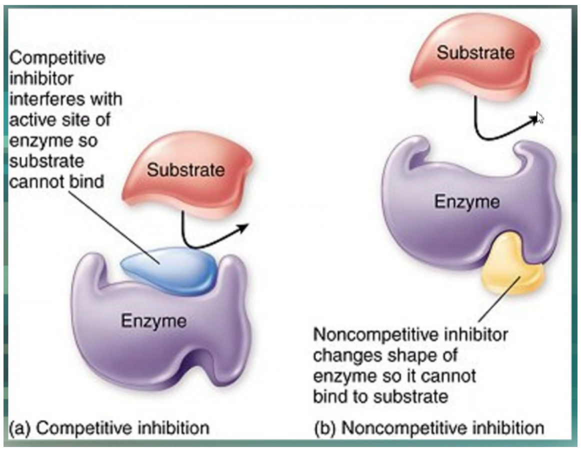
2. Competitive Inhibitors

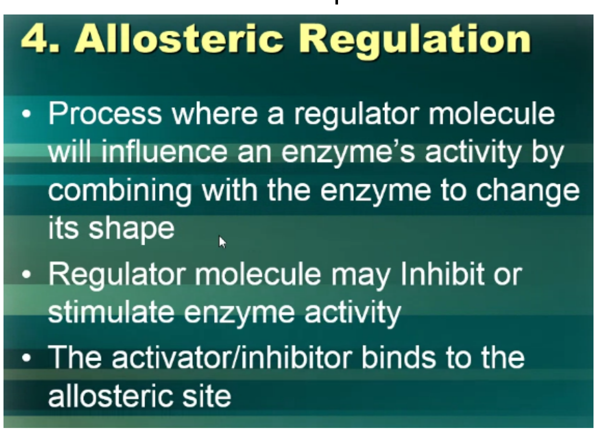


- Resembles the normal substrate and compete for admission into the active site
- Reduces the productivity of the enzyme by locking the active site from substrate
- If the inhibitor attaches to the enzyme by covalent bond, the inhibition is usually irreversible (ex. nerve gas, cyanide, arsenic)
- If the inhibitor bins to the enzyme by a weak bond, the inhibition is reversible, it can be overcomed by increasing the concentration of substrate

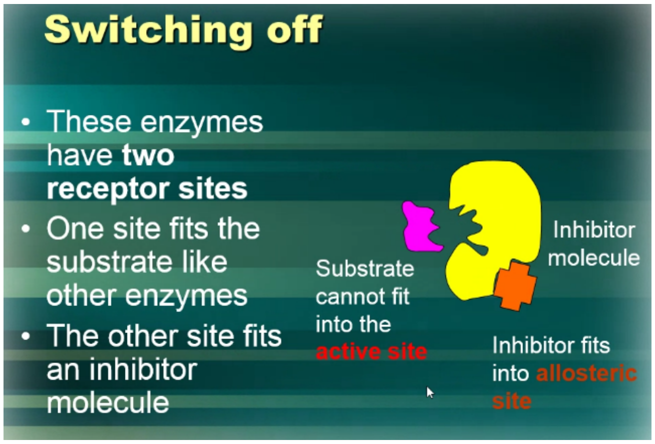
-

- 

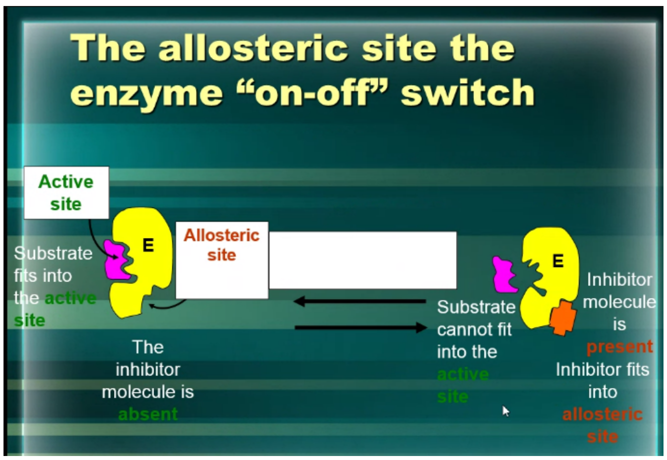
- 

- Inhibitors r there to either poison or to save energy
- 

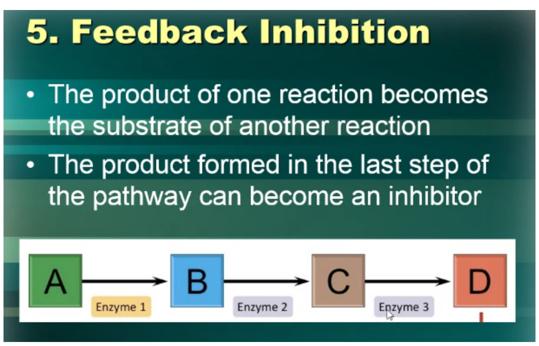
    - This one can also start the reaction
- Missed one

- 

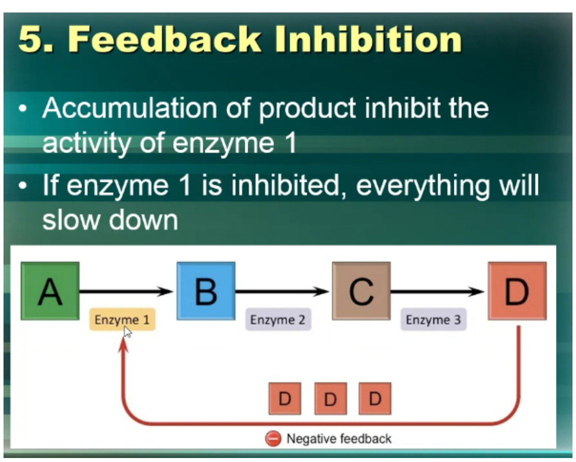
Switching off
These enzymes have two receptor sites
One site fits the substrate like other enzymes
The other site fits an inhibitor molecule
Inhibitor molecule
Substrate cannot fit into the active site
Inhibitor fits into allosteric site

- 

The allosteric site the enzyme “on-off” switch
Active site
Allosteric site
E
Substrate fits into the active site
The inhibitor molecule is absent
Substrate cannot fit into the active site
Inhibitor molecule is present
Inhibitor fits into allosteric site

- 

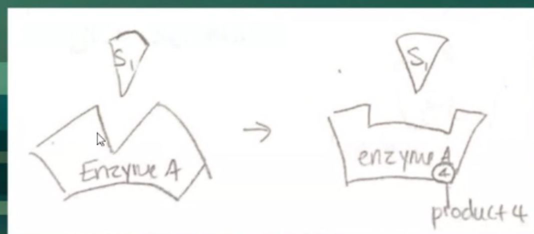
5. Feedback Inhibition
The product of one reaction becomes the substrate of another reaction
The product formed in the last step of the pathway can become an inhibitor
A
Enzyme 1
B
Enzyme 2
C
Enzyme 3
D

- 

5. Feedback Inhibition
Accumulation of product inhibit the activity of enzyme 1
If enzyme 1 is inhibited, everything will slow down
A
Enzyme 1
B
Enzyme 2
C
Enzyme 3
D
D
D
D
Negative feedback

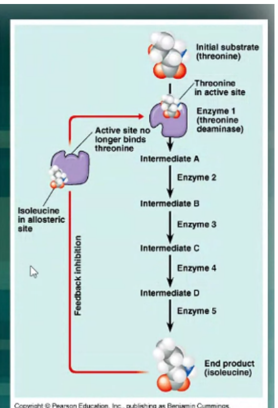
5. Feedback Inhibition

- Product 4 binds to allosteric site of enzyme 1, changing its shape



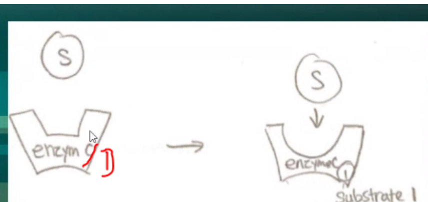
This example demonstrates how an end product can inhibit the first step in its production.

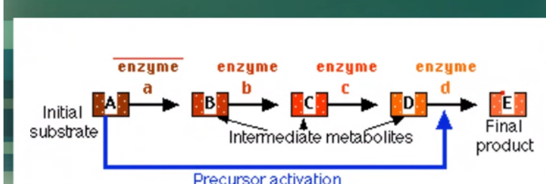
1. Isoleucine binds to the allosteric site of threonine deaminase and prevents threonine from binding to the active site because the shape of the active site is altered.
2. When the level of isoleucine drops in the cell's cytoplasm, the isoleucine is removed from the allosteric site on the enzyme, the active site resumes the activated shape and the pathway is "cut back on" and isoleucine begins to be produced.

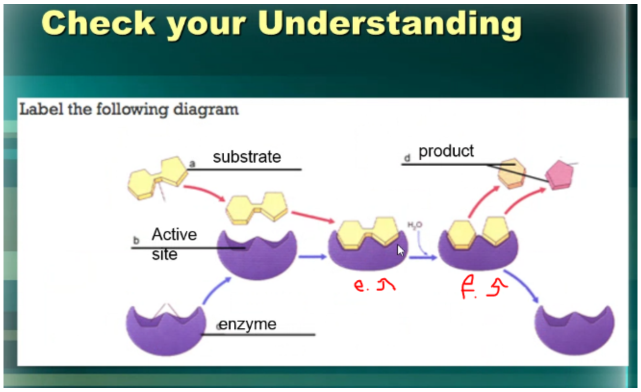


6. Precursor Activation

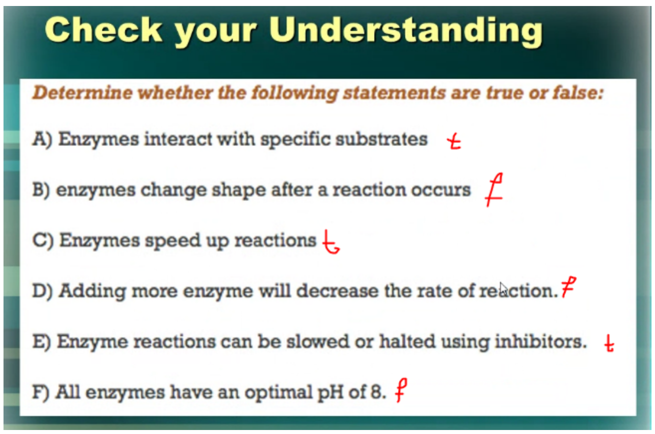
- Requires a reactant to activate enzyme further along a reaction series
- It may combine with the enzyme, changing its shape, so that the active site fits with its substrate
- Substrate 1 activates enzyme C





- 

    - E. substrate-enzyme complex
    - F. product-enzyme complex

- 

Homework

- 50 - 56 textbook
- Optional enzyme worksheet
- Enzyme gizmo lab → for marks

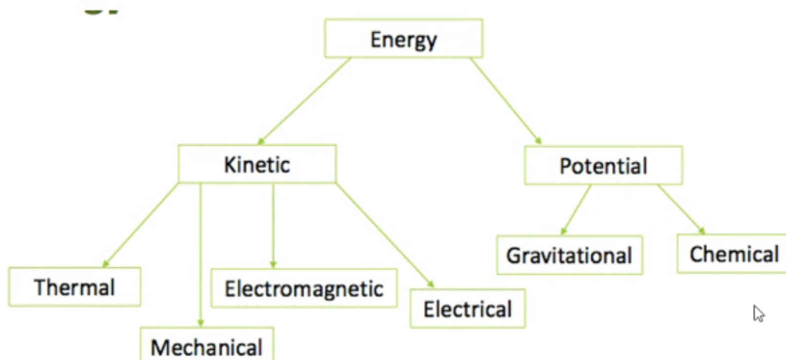
Nomenclature Functional Group Priority for Bio

- Carboxylic Acid + derivatives like ester
- Amino
- Aldehyde
- Ketone
- Alcohol
- Alkyne
- Alkene
- /33, 10 marks for MC, 3 naming diagrams,
- Acetone is the common name for 2-propanone
- Prioritize triple over double bonds

Metabolism

Energy

- Ability to do work
- Must continuously capture, store and use energy
- Organisms do majority of work on a cellular level
- Must manage amount of energy used w amount produced
- Anabolic reactions:
    - Energy + small molecules → larger molecules
- Catabolic reactions:
    - Large molecules → energy + smaller molecules
- Kinetic energy (Ek) has to do with movement, potential energy (Ep) is stored



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Laws of Thermodynamics

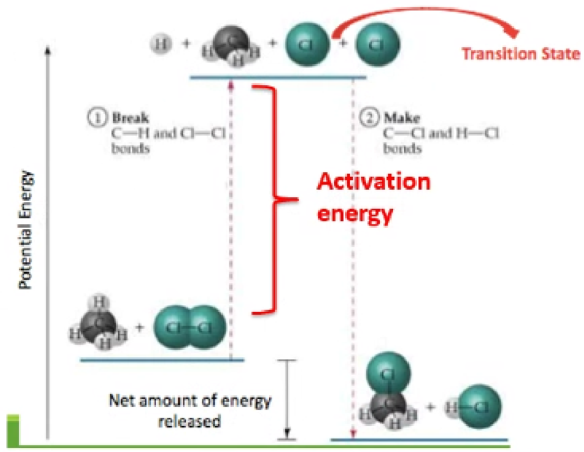
- Looks at physical rules of organisms and how energy is transferred between them

1. Total amount of energy in any closed system is constant. Energy cannot be created or destroyer, only converted from one form to another
    - Bond energy
        - Measured in kJ/mol
        - Farther the electrons away from nucleus the more potential energy
        - Energy is released when bonds break and is absorbed when they form new bonds
        - Enthalpy: sum of internal energy (heat content) of a system
            - $H = U + P(v)$
            - Energy is absorbed when reactant bonds break and energy is released when product bonds form

Enthalpy

A few terms…

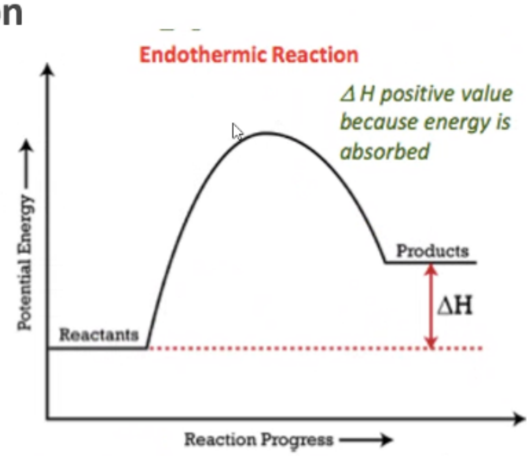
- Activation energy (E_a) – the minimum amount of energy that reactants must absorb to start a reaction
- Transition state – a temporary condition during a chemical reaction in which the bonds in the reactants are breaking and the bonds in the products are forming
- Change in potential energy (ΔH)



- Exothermic reactions
    -

Endothermic Reaction

- energy absorbed, products have higher E_p than reactant
- Positive ΔH



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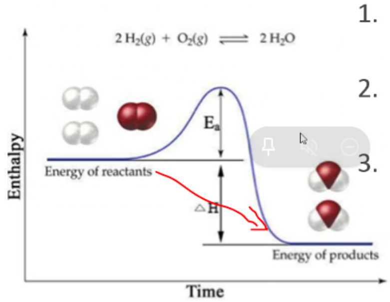


1. What does E_a stand for?
2. What does ΔH stand for?
3. Is this endothermic or exothermic? Why?

-

2. In every transfer or conversion, some of the useful energy in the system becomes unusable and increases the entropy
    a. Energy transformation in never 100% efficient
    b. Entropy is a measure of disorder in a system
    c. Think of a room and how it always gets messier
    - Entropy: in chemical reactions, entropy will increase in following circumstances
        - Solid becomes liquid
        - Liquid becomes gas
        - Complex molecule becomes simpler
        - .
    - Catabolic reaction → energy released, entropy increases
        - exothermic reaction and spontaneous process
    - Anabolic reactions → cells trying to become less messy as their building things
        - While it seems this way, its prob not cuz anabolic reactions require energy which they most likely get from catabolic reactions
        - There is order within the disorder
    - Look at cells and atp using entropy tomorrow
    - Gibbs free energy
        - Gibbs discovered relationship between energy change and temperature of reaction n how relationship could help determine…

• The free energy change can be calculated:

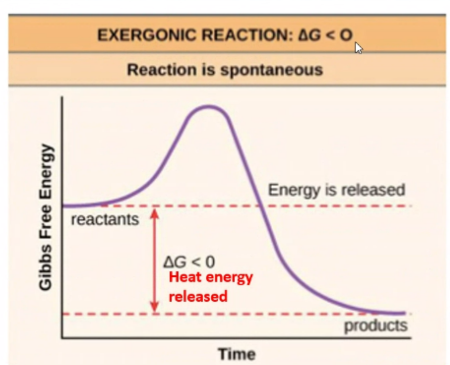
$$\Delta G = \Delta H - T\Delta S$$

Where
ΔG = change in free energy
ΔH = change in enthalpy
T = Temperature in Kelvin
ΔS = change in entropy

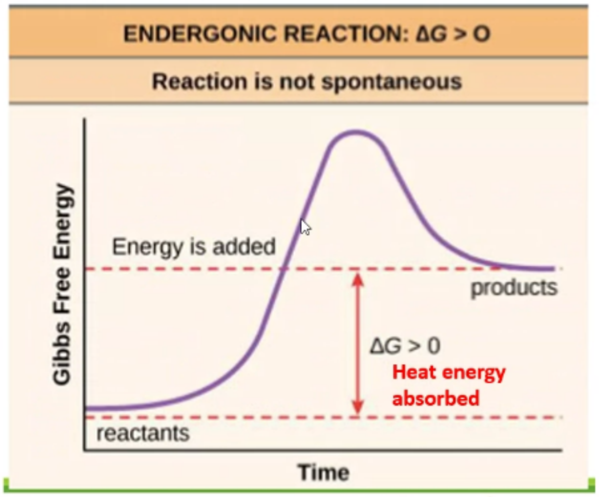
Gibb's Free Energy $\Delta G = \Delta H - T\Delta S$

	$\Delta H < 0$	$\Delta H > 0$
$\Delta S > 0$	$\Delta G < 0$	$\Delta G < 0$ at higher temp $\Delta G > 0$ at lower temp
$\Delta S < 0$	$\Delta G < 0$ at lower temp $\Delta G > 0$ at higher temp	$\Delta G > 0$

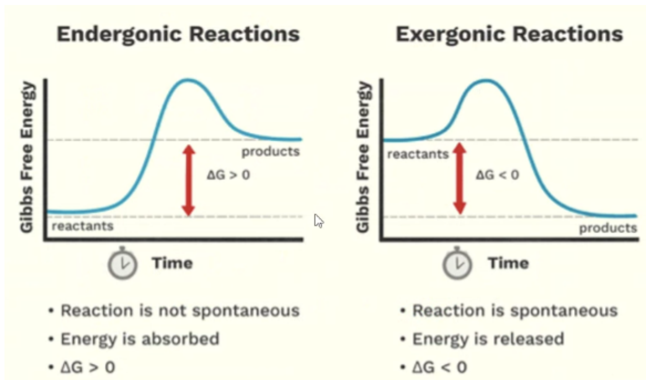
    -



    - Ex. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
    - Exergonic means like if theres free energy



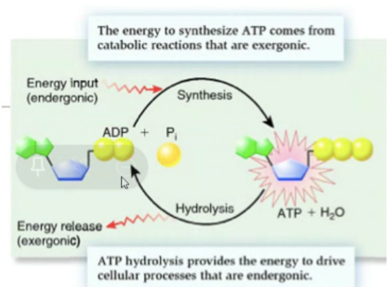
- Ex. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
- So many words starting with E → review lol



- Delta G not affected by enzyme
- Coupled reactions

  Cells are able to make endergonic reactions from the energy supplied by the exergonic reactions.

  Energy coupling is the transfer of energy from one reaction to another in order to drive the second reaction.

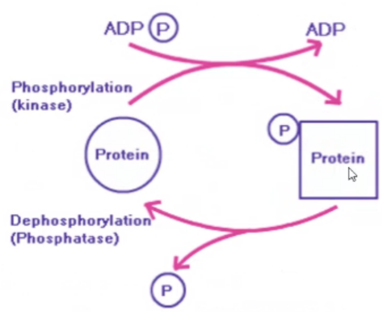


ADP and Inorganic Phosphate

The inorganic phosphate can participate in a wide range of chemical reactions:

1. Phosphorylation
2. Substrate level Phosphorylation
3. Oxidative phosphorylation

1. Phosphorylation

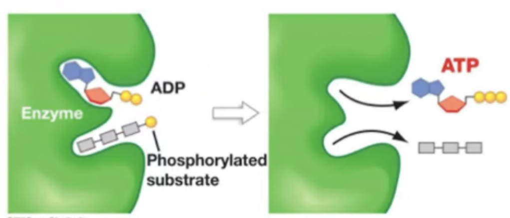


The inorganic phosphate attaches to a protein. This process is known as ***phosphorylation.***

2. Substrate Level Phosphorylation

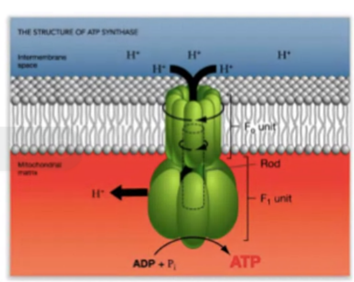
Used to form ATP directly in an enzyme-catalyzed reaction.

The inorganic phosphate is removed from the protein and attached to ADP to make ATP.



3. Oxidative Phosphorylation

- Used in cellular respiration within mitochondria to produce ATP
- Channel opens when there is a high concentration of H^+ in the intermembrane space
- H^+ are pumped back in to create ATP



- Redox oml LEO says GER
    - Oxidation or “Ox”
        - Energy metabolism in cells involves oxidation reactions
        - Oxidation involves the transfer of an electron from a molecule which is said to be oxidized to another molecule which is said to be reduced
        - .
    - Reduction
        - Overall charge is reduced i.e. gains electrons

Oxidation	Reduction
Addition of Oxygen	Removal of Oxygen
Removal of Hydrogen	Additional of Hydrogen
Loss of electron	Gain of electron

    -

In general:

Oxidation

Reducing agent + Oxidizing agent → Oxidizing product + Reducing product

Reduction

    -

Redox Reactions & Coenzymes

The redox reactions of cellular respiration commonly involve the following coenzymes:

1) NAD: Nicotinamide adenine dinucleotide

$$NAD^+ + H^+ + ½O_2 \rightarrow NADH + H^+$$

3ADP 3ATP

Oxidative phosphorylation

2) FAD: Flavin adenine dinucleotide

$$FADH_2 + ½O_2 \rightarrow FAD + H_2O$$

2ADP 2ATP

    -

- LEO the lion says GER
    - **L**ose
    - **E**lectrons
    - **O**xidized!
  SAYS...
    - **G**ain
    - **E**lectrons
    - **R**educed!

  OIL RIG
    - **O**xidation
    - **I**s
    - **L**oss of electron
    - **R**eduction
    - **I**s
    - **G**ain of electron
-

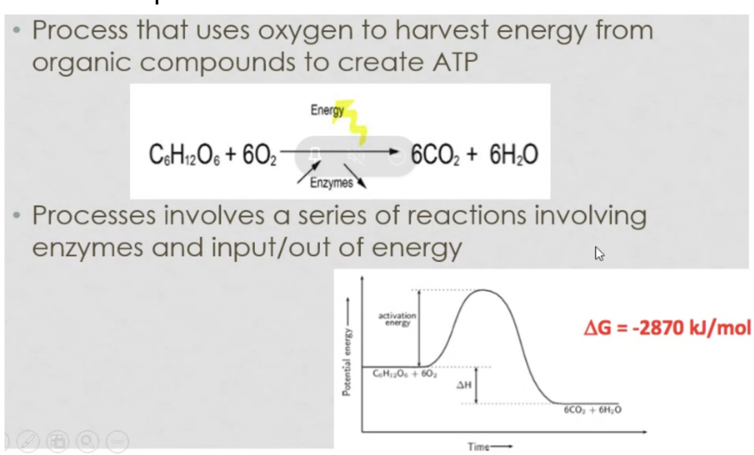
3. a

Cellular respiration

Introduction

- Most energy entering the biosphere is solar radiation
- Energy from food → stored as ATP
- Obligate aerobes → animals that require oxygen??

Aerobic cellular respiration

- 

- Exothermic reaction
- Recall in cellular respiration:
    - Many exothermic reactions in this process are REDOX reactions
    - Redox involves the transfer of electrons between 2 molecules
    - NAD and FAD are electron carriers and become NADH and FADH2

3 main goals of cellular respiration:

Three main goals:

1. To break the bond in glucose (6C molecule) to create $6CO_2$ molecules
2. To move hydrogen atoms from glucose to oxygen to create $6H_2O$ molecules
3. To trap a large quantity of free energy so that it can be used to create ATP

-

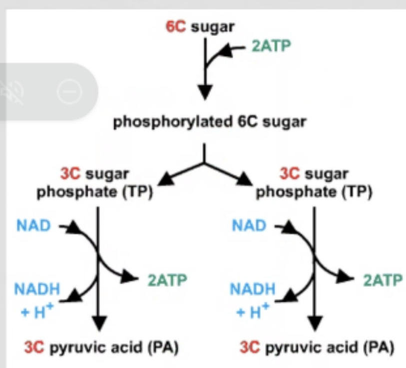
4 stages of cellular respiration

- Glycoiss
- Pyruvate oxidation
- Krebs cycle (citric acid cycle)
- Electron transport chain and chemiosis (ETC)

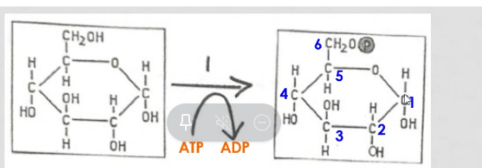
- Make sure u didnt miss anythign

Glycolisis

- Glucose → $2C_3H_4O_3$ (pyruvic acid) + $2NADH_2$ + 2ATP
- First stage in cellular respiration
- Can be broken down into 10 steps



-
- Step 1: activation
    - A phosphate from ATP is added on a glucose to form glucose 6-phosphate



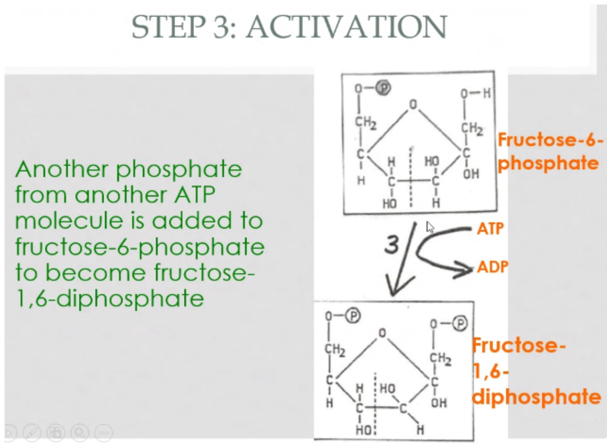
a-glucose

Glucose-6-phosphate

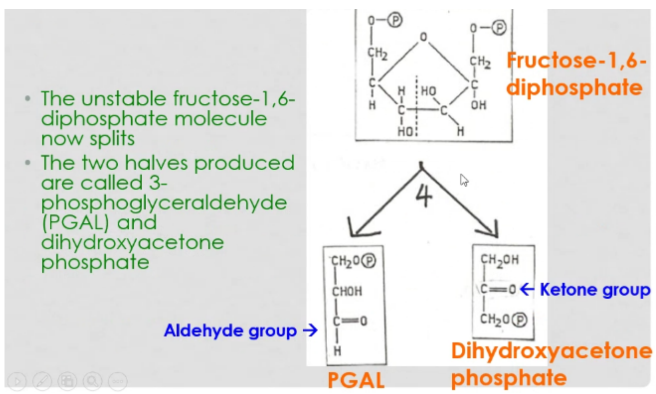
- A phosphate from ATP is added onto a glucose to form glucose-6-phosphate.
- Requires energy input in the form of ATP
- Phosphate binds to carbon 6

-

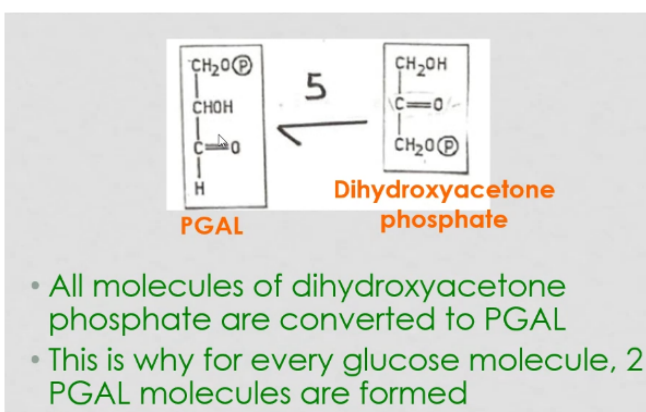
- Step 2: isomerization
    - Glucose 6 phosphate is rearranged to become fructose phosphstae
- Step 3:



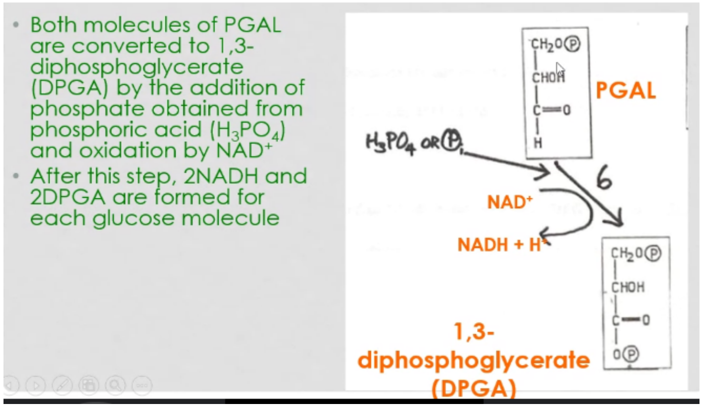
    -
- Step 4 - cleavage



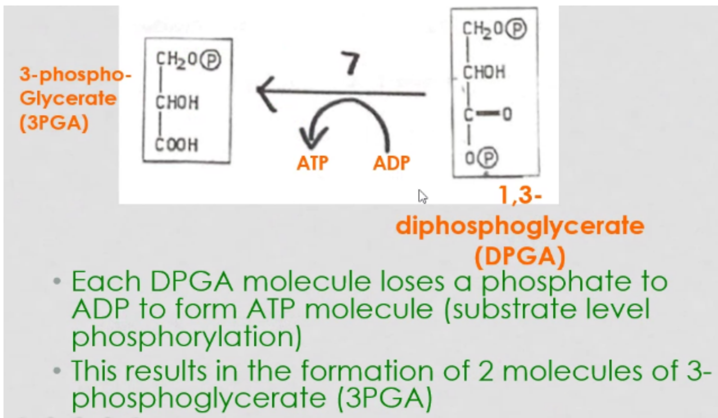
    -
    - Just call it PGAL and dihydroxyacetone phosphate :_)
- Step 5: isomerization



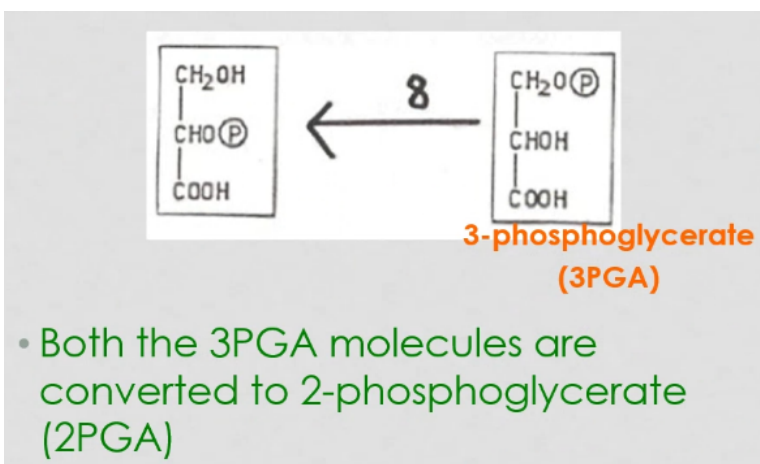
    -
- Step 6: phosphorylation oxidation



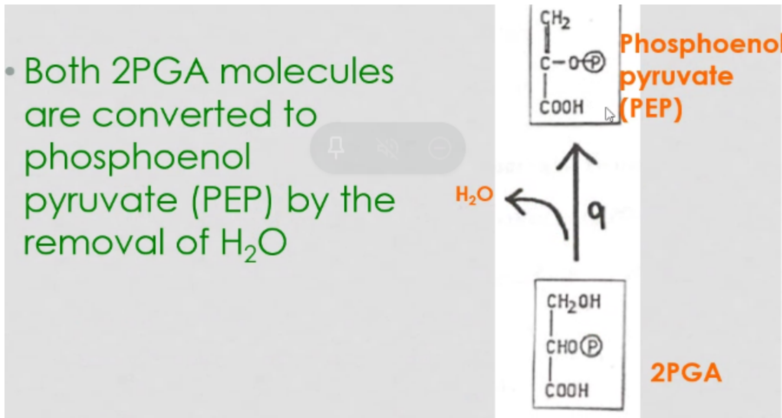
- Step 7: phosphorylation

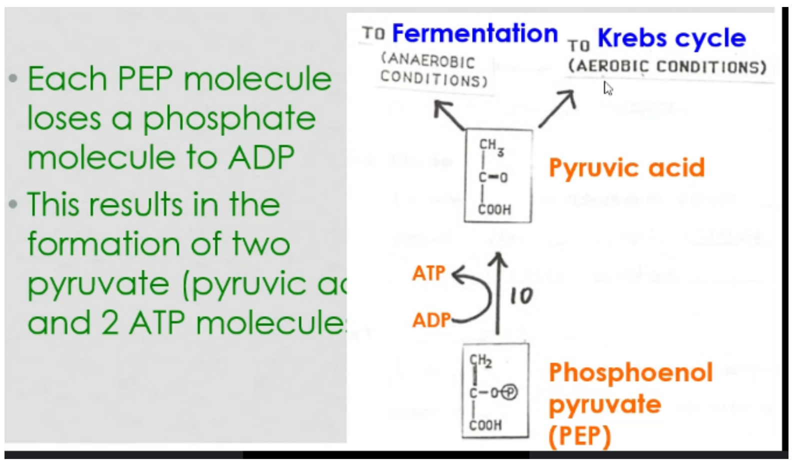


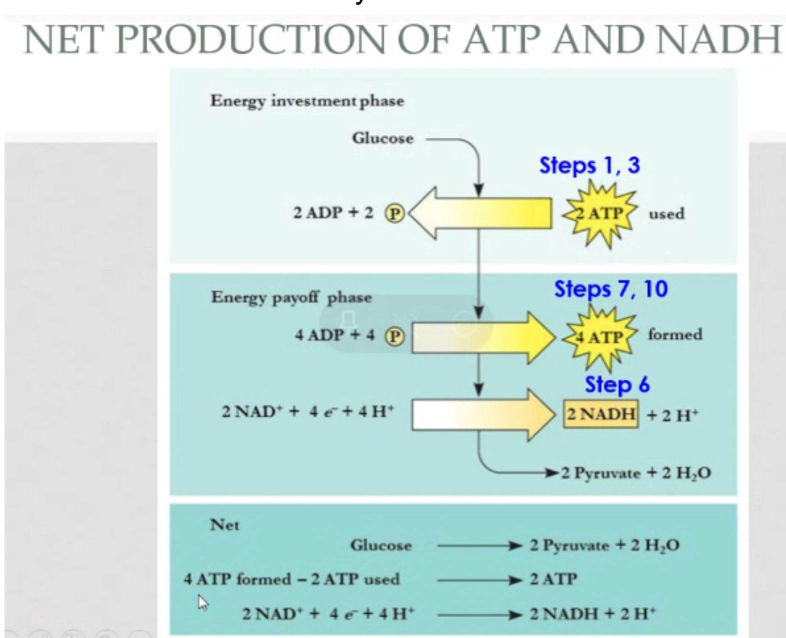
- Recall substrate level phosphorylation
- Step 8: isomerization



    - Not losing a P, just moving it
- Step 9: dehydration

- 

- Step 10: phosphorylation
- 

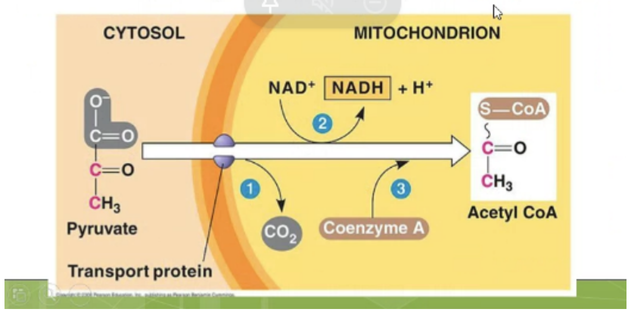
- Time for some killlleeeerrrr youtube videos
- 

Homework - 172-174
Complete the puzzle name and structure
Glycolysis fill in the blank worksheet

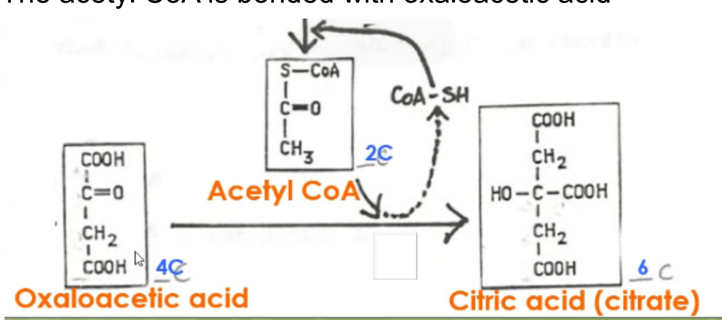
Krebs Cycle

2. Pyruvate oxidation

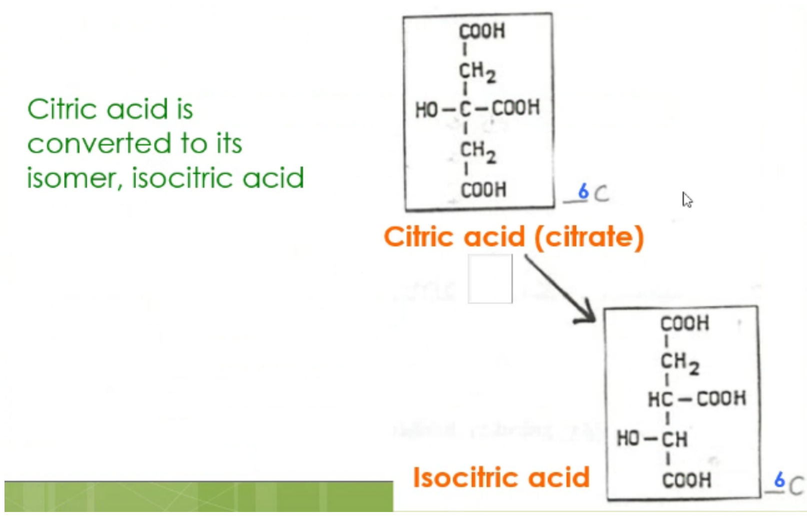
- Two pyruvate molecules actively transported into mitochondrial matrix
- Carboxyl group of the pyruvate acid loses a CO_2
- The remaining 2C fragment ix oxidized to acetyl CoA while NAD^+ is reduced to NADH + H^+

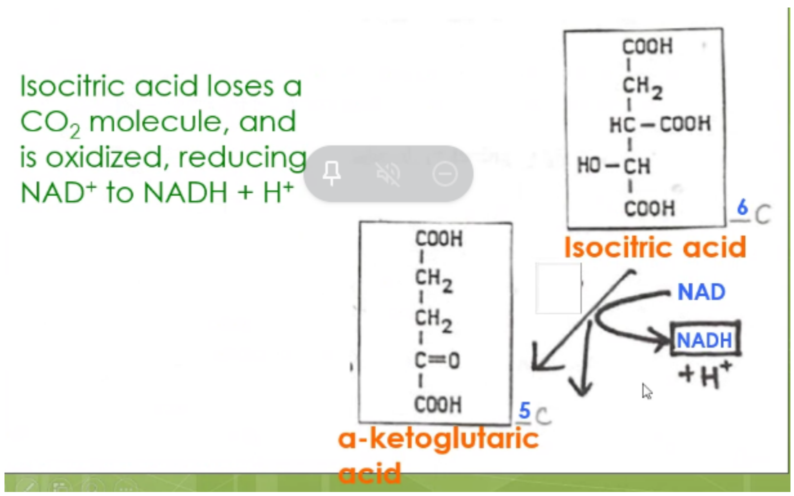
- 

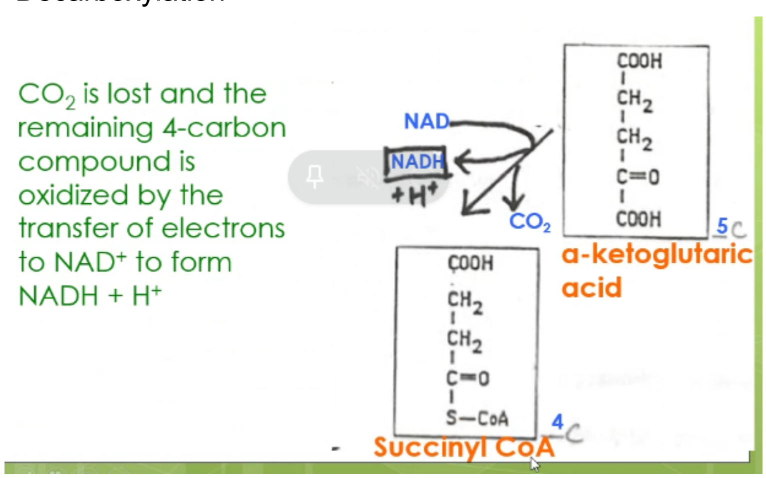
- At the end you have Acetyl CoA left

3. Krebs cycle
- Aka citric acid cycle
  - Occurs in the mitochondrial matrix
  - Main goal is to produce energy
  - Many enzymes, coenzymes and other molecules are in an organized pattern on the inner membrane.
- Can be divided into 8 steps.
- Step 1 - formation of citric acid cycle
  - The acetyl CoA is bonded with oxaloacetic acid
  - 

- Step 2 isomerization

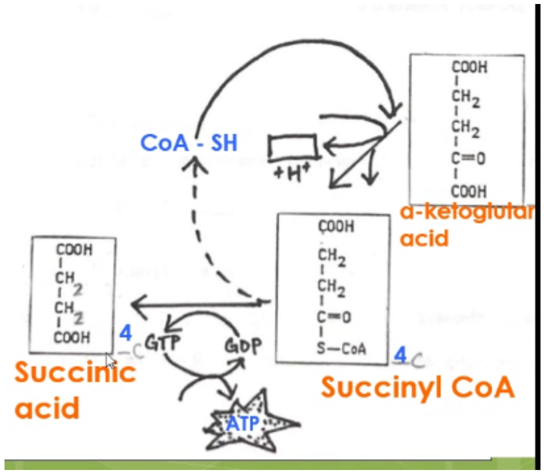
- 

- Step 3 - Decarboxylation
- 

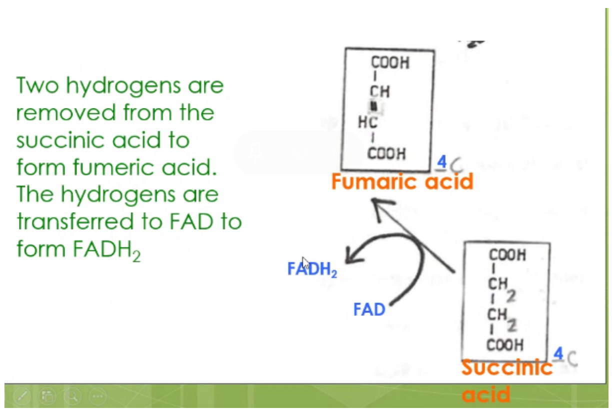
    - NADH will be later used to help make ATP
- Step 4 - Decarboxylation
- 

- Step 5 - Substrate level phosphorylation
    - CoA is displaced by a phosphate group to form guanosine triphosphate (GTP)

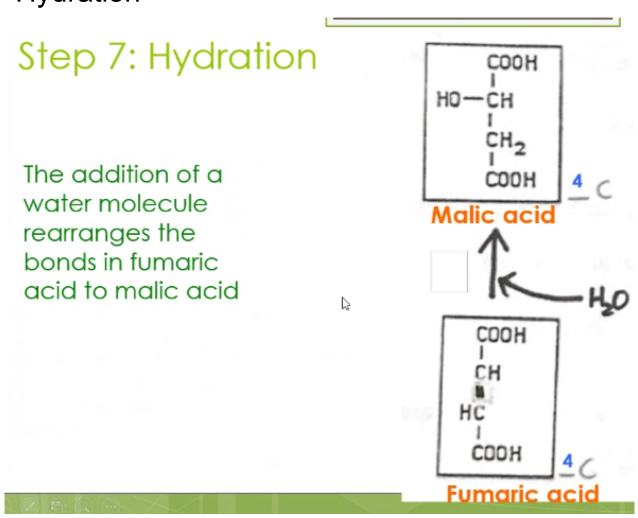
- GTP is similar to ATP which is formed when GTP donates a phosphate to ADP



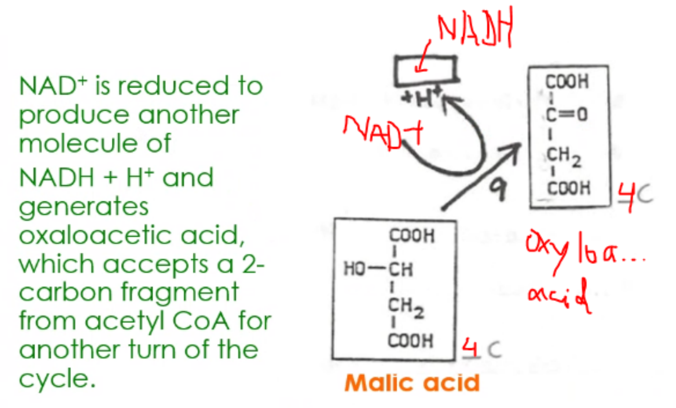
- Step 6 - Decarboxylation (again yay)
    - Two hydrogens are removed from the succinic acid to form fumeric acid
    - The hydrogens are transered to FAD to form FADH



- Step 7 - Hydration



- Step 8 - formation of oxaloactetic acid



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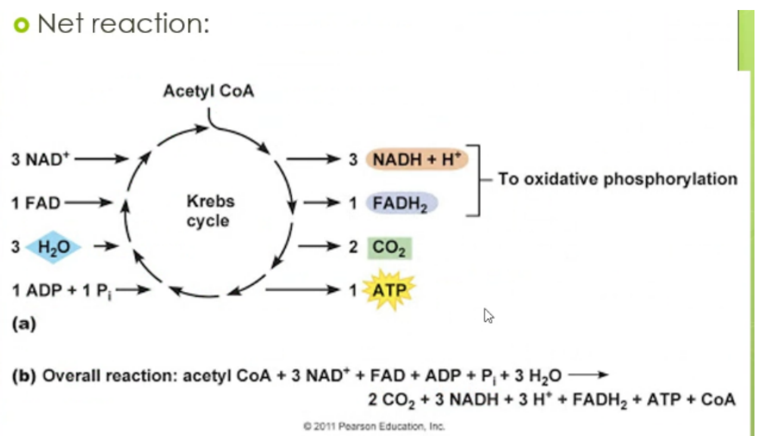
Krebs Cycle (again?)

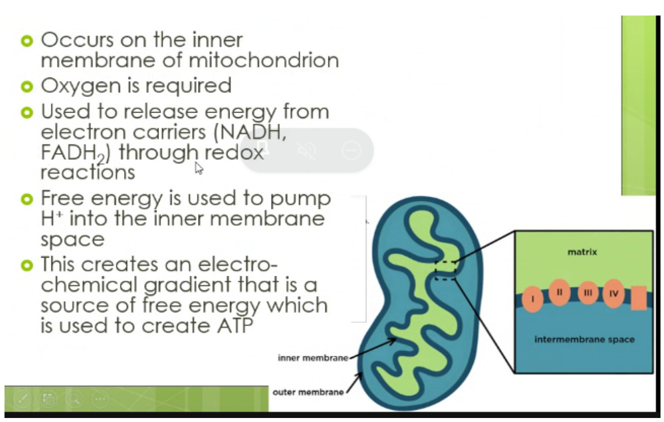
- Net reaction



-
- She's going to put up a sheet that has the entire cycle
- Glycolysis
    - In assignments somewhere

Stage 4: Electron transport chain (ETC)

- Occurs on inner membrane of mitchondria



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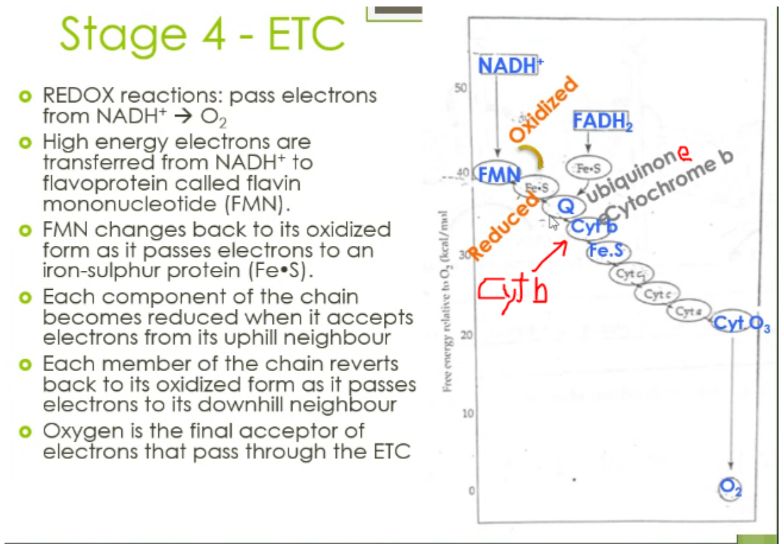
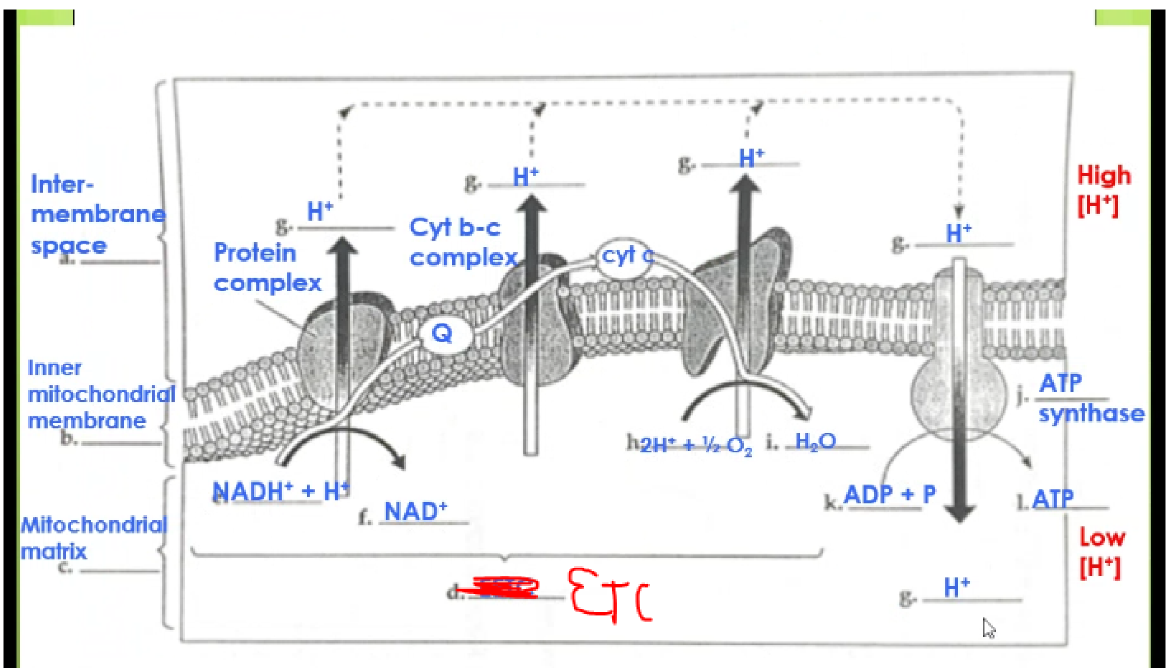


- ^Overall energy drop:
    - Just know what these stand for, don't need to memorize this process

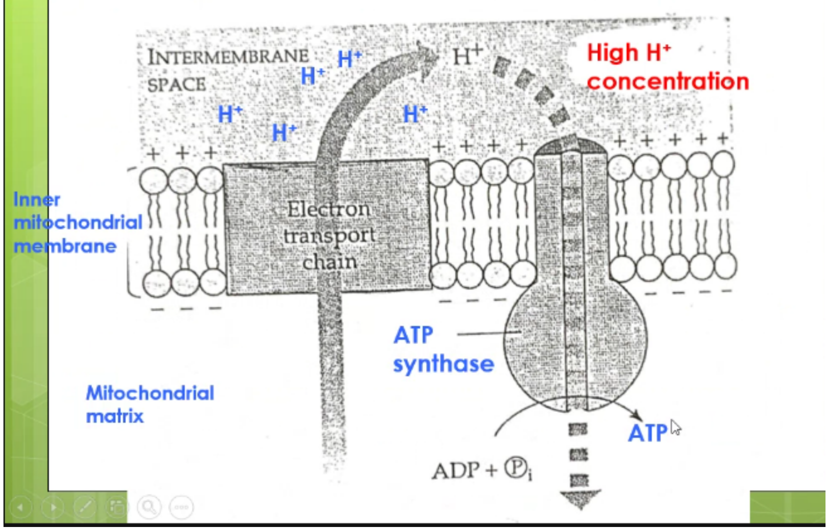


- Stage 4: Chemiosmosis

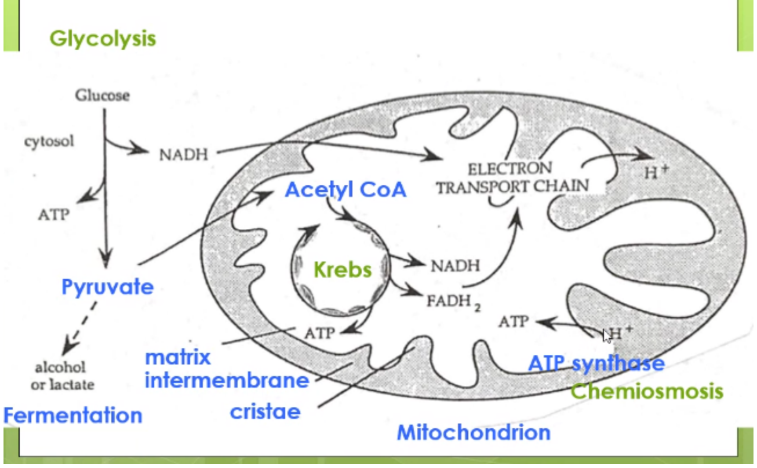
Stage 4: Chemiosmosis

- As the protons are pumped out of the matrix to the intermembrane space, it creates an electrochemical gradient
- The potential energy stored in the proton gradient is called proton motive force
- Protons can diffuse back into the matrix through ATP synthase molecule channels
- As the protons diffuse back into the matrix, they lose their energy, permitting the ATP synthase to make ATP through chemiosmosis

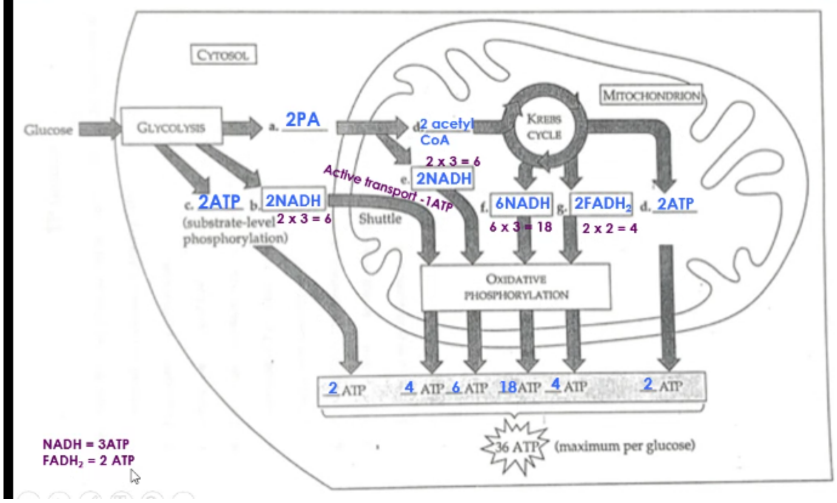
Stage 4: Chemiosmosis



Summary



Counting ATP



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ATP Games

How many ATP's would be gained by a cell from the aerobic respiration of:

a) 1 molecule of fructose-1,6-disphosphate?

b) 2 molecules of phosphoenol pyruvate?

-

ATP Games

How many ATP's would be gained by a cell from the aerobic respiration of:

a) 1 molecule of fructose-1,6-disphosphate?

Glycolysis: 2 NADH – 2ATP = 4 ATP

4 ATP = 4 ATP

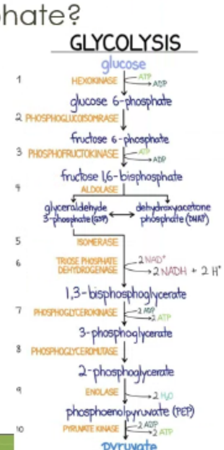
Krebs Cycle:

8 NADH = 24 ATP

2 $FADH_2$ = 4 ATP

2 ATP = 2 ATP

Total: 38 ATP



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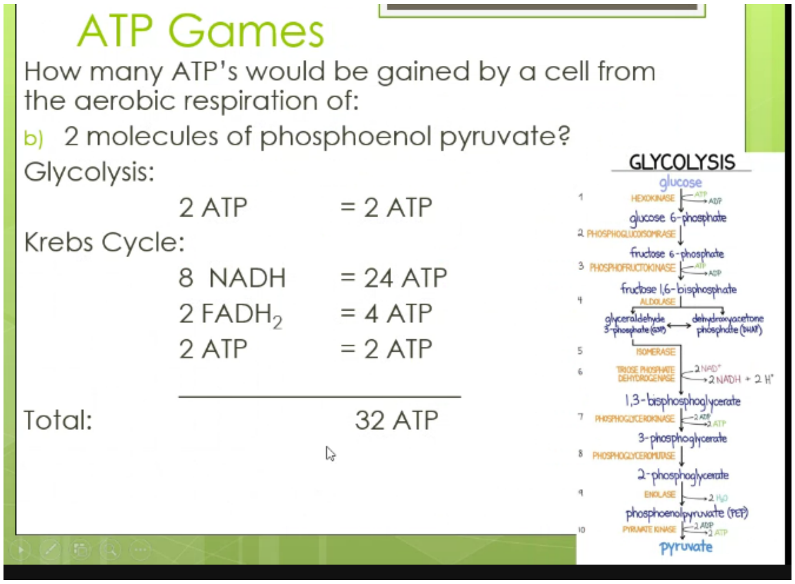
- 

- Homework
- Potato lab