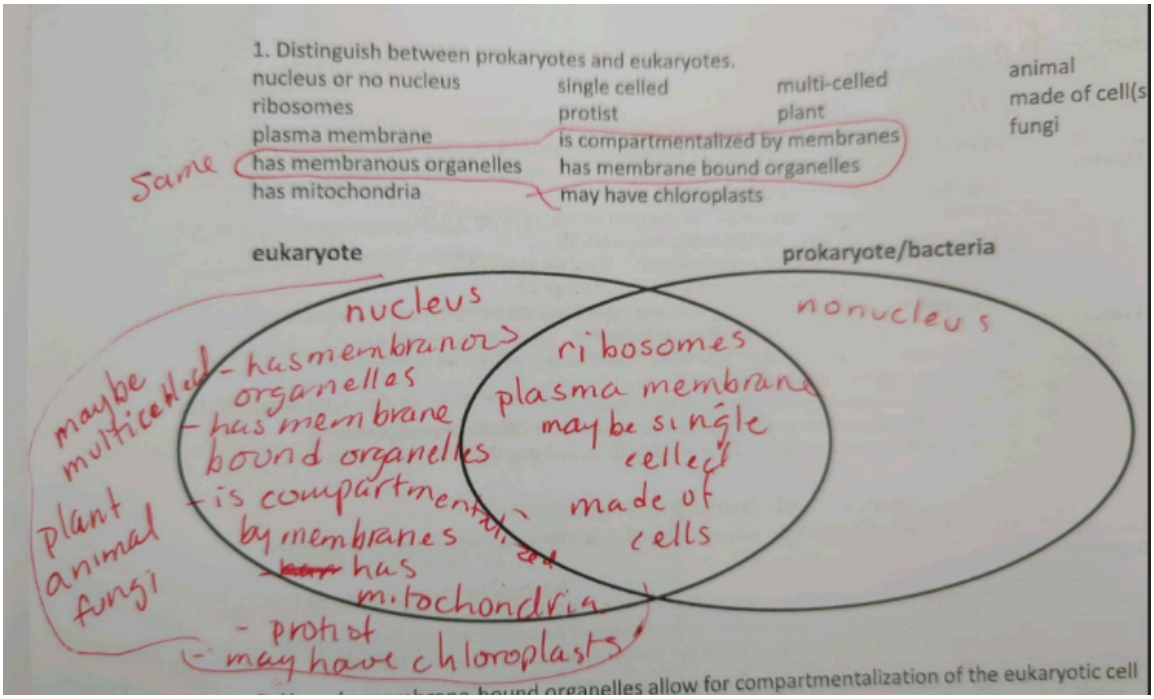
Name: Answer Key Unit 2: Cells

Topic 2.1: Cell Structure: Subcellular Components
Topic 2.2: Cell Structure and Function
Topic 2.10: Compartmentalization

1. Distinguish between prokaryotes and eukaryotes.



2. How do membrane-bound organelles allow for compartmentalization of the eukaryotic cell and its functions?

ANSWER: They physically separate different areas of the cell and serve as a boundary between different areas. This way, cellular respiration can happen efficiently in one area (mitochondria) while DNA is protected in another area (Nucleus) and old organelle digestion and recycling can take place in another area (lysosomes) .

3. How does the membrane of organelles allow for specific processes to take place?

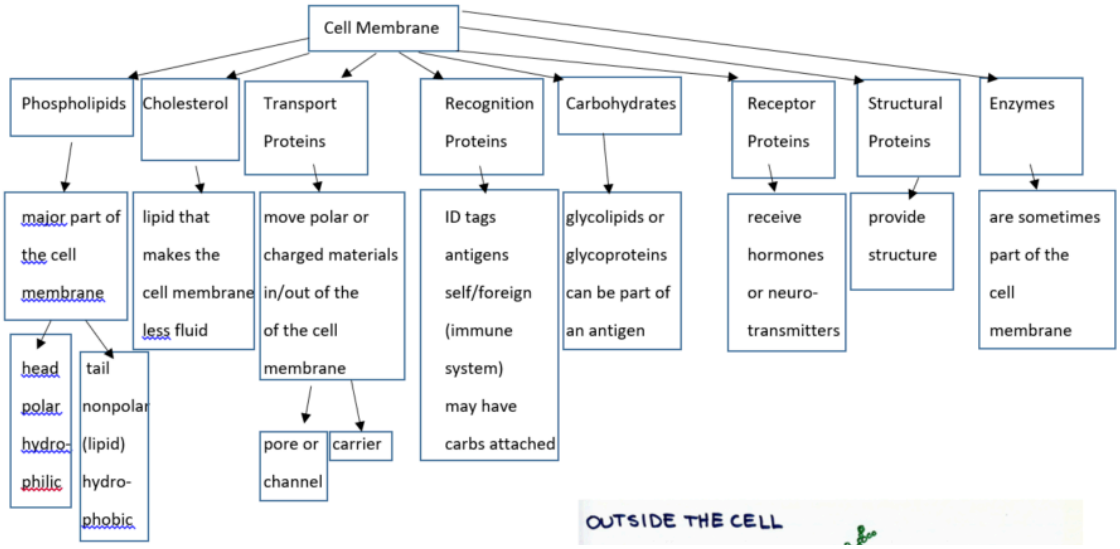
Membranes can prevent ions and large polar molecules from moving through or away from the organelle.

a. Membranous organelles can therefore sequester certain reactants and enzymes together so they are more likely to come into contact with each other (see next question).
b. They can maintain a particular pH, which might be important for certain enzymes to function well. **MORE BACKGROUND:** The membrane of the lysosomes also keeps the lysosome environment acidic (by sequestering hydrogen ions and not letting them flow

through the membrane and out of the lysosome). This pH is important for the proper functioning of the lysosome enzymes.

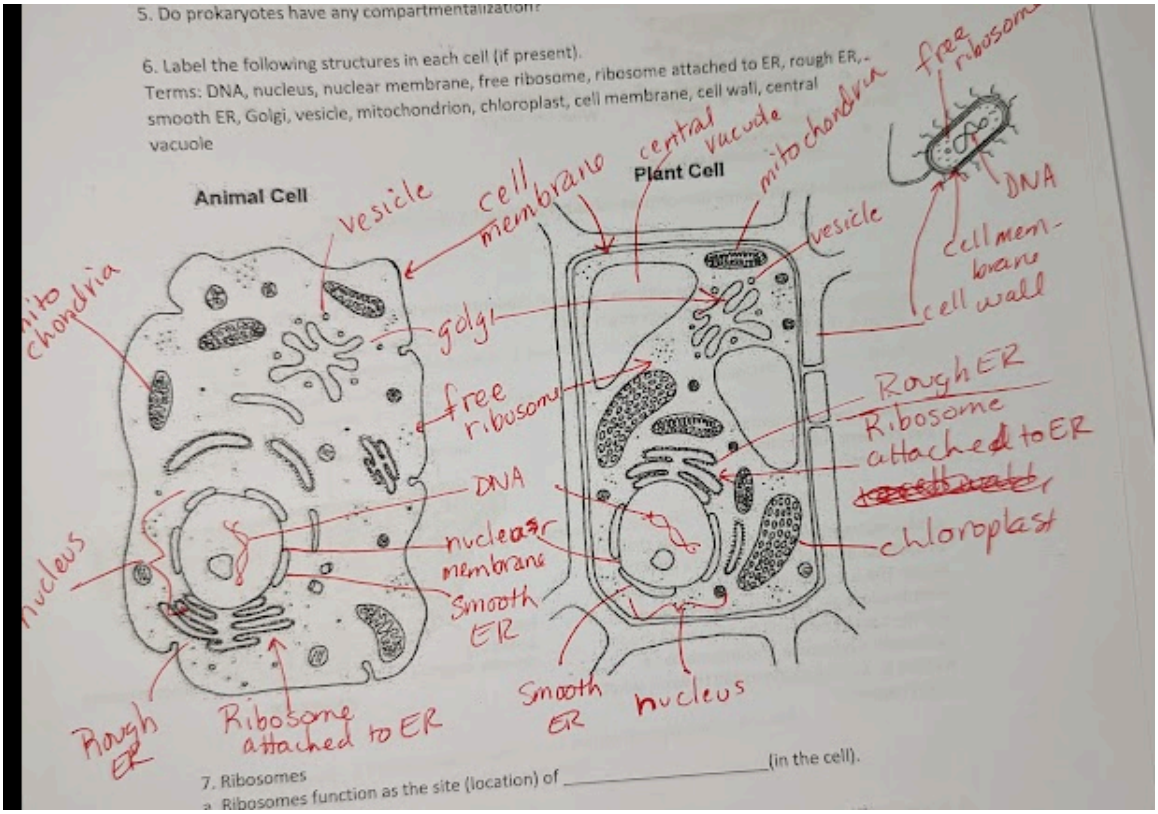
c. They can hold ions that might be necessary as chemical signals (more on this in unit 4).
d. They can make concentration gradients, which is a way to store energy (like a battery) - more on this in unit 3!! **MORE BACKGROUND:** more on this later, but the ability of the mitochondria to keep hydrogen ion gradients is really important for its function. (Sort of like the charge separation that occurs in a battery - without it, the batter doesn't work).

4. How does the membrane of organelles allow for enzymatic processes to take place?
They can sequester certain reactants and enzymes together so they are more likely to come into contact with each other.The enzymes may be found inside the watery part of the organelle or bound to/sticking out of the organelle's membrane (probably facing in). This will promote certain metabolic reactions/pathways, especially if there are several enzymes involved in several chemical reactions that need to take place, one after the other. All of the enzymes needed for the consecutive reactions could be located near each other in the membrane.



5. Do prokaryotes have any compartmentalization?
Short answer: yes, but NOT using membranes
Long answer: Yes - bacteria actually have proteins that compartmentalize their cell. Proteins are not as efficient in compartmentalization, but they are still able to keep certain reactants and products near each other. Cool, huh? This is beyond the scope of the course, but if you are interested, here is a very cool article about it!

6. Label the following structures in each cell (if present).
Terms: DNA, nucleus, nuclear membrane, free ribosome, ribosome attached to ER, rough ER, smooth ER, Golgi, vesicle, mitochondrion, chloroplast, cell membrane, cell wall, central vacuole

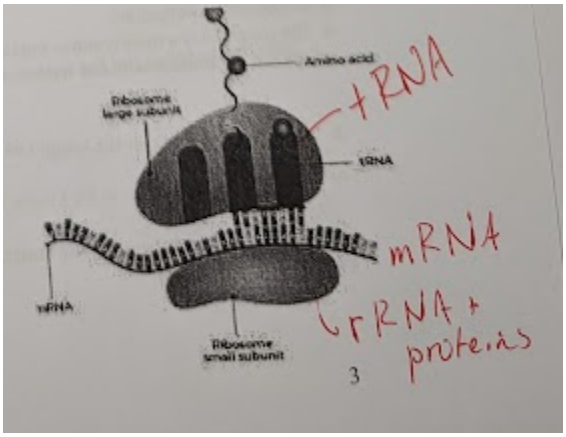


7. Ribosomes

a. Ribosomes function as the site (location) of protein synthesis (in the cell).

b. Ribosomes are made up of two molecules. What are they?

protein and rRNA (ribosomal RNA)



c. What are the three types of RNA involved in protein synthesis and how are each involved with the structure or function of the ribosome?

more on this in unit 6….

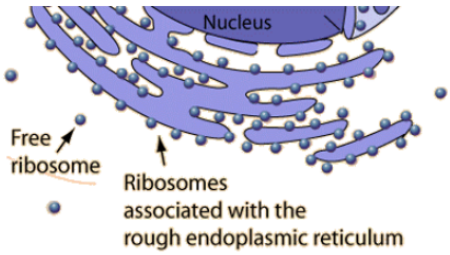
mRNA (messenger RNA) - code for a particular polypeptide

tRNA (transfer RNA) - bring the right amino acid to the ribosome

rRNA (ribosomal RNA) - part of what physically makes up the ribosome

d. How does the structure of the ribosome aid in the function?

rRNA is made up of the nucleotides adenine, uracil, cytosine and guanine. Being the same building blocks as tRNA and mRNA, it is able to recognise these molecules and work with them. RNA and proteins can also have enzymatic qualities, so they are able to facilitate making the peptide bonds between amino acids important in making the growing of the polypeptide chain.

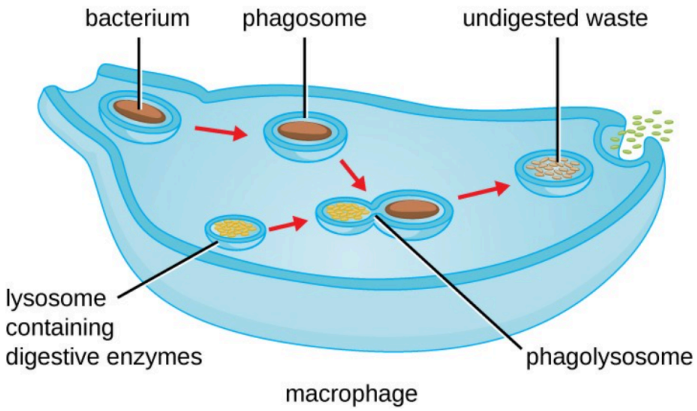


e. Ribosomes are found in two locations in the cell. What are they?
free in the cytoplasm and also attached to the rough endoplasmic reticulum (RER)

f. How does the ribosome demonstrate a common ancestry of all known life?
All living organisms use ribosomes to produce their proteins. Therefore, it is logical that the common ancestor of all life forms on this planet used ribosomes.

8. Lysosomes (lysosome rhymes with ribosome, so students sometimes mix them up. Try to remember Lysol spray cleans/breaks down stuff)
a. What is the function of a lysosome?
To break down stuff (food if you are an amoeba, bad bacteria if you are a white blood cell, old, worn out cell parts for all eukaryotic cells). They are also involved in apoptosis (programmed cell death) important in development of multicellular organisms and important in the body's response to cancer. More on this in unit 4.

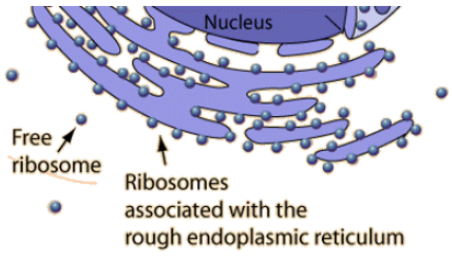
b. How is compartmentalization important to the efficient functioning of lysosomes?
Lysosomes need to keep an acidic environment for their enzymes to work properly. In order to do this, the hydrogen ions must not diffuse out of them. Thankfully, the lipid bilayer of the lysosome keeps those hydrogen ions inside the lysosome, along with hydrolytic enzymes (enzymes that do hydrolysis/breaking down molecules).
If all of the enzymes in a lysosome are released into the cell, bad things happen. (The cell is digested from inside).



c. Macrophages are white blood cells that take in bacteria by phagocytosis (more on this later). The bacteria will end up inside a small membranous sac inside the white blood cell, but the bacteria will still be alive until the sac fuses with a lysosome. If someone has a disease in which lysosomes fail to work, what might happen?
The bacteria may continue to live inside the eukaryotic cell, which isn't great! The bacterial infection continues and the person can get very sick.

9. Endoplasmic Reticulum.
a. The rough ER is a membranous organelle composed of highly convoluted, flattish sealed sacs which are continuous with the nuclear membrane. Why is the rough ER called "rough?"
Because it has so many ribosomes attached to it, that it actually looks rough under the microscope.

b. What is the function of the rough ER?
The function of the rough ER is to



a. take in the polypeptides made on its surface
b. help the polypeptides to fold properly (There are even enzymes that help for tertiary structure as they help form disulfide bonds between certain R groups)
c. modify the polypeptides (by adding small carbs or to them (making glycoproteins) or by cutting a small piece off of the protein). Most modifications, however, occur in the Golgi.
d. to form vesicles which will then transport the proteins to the Golgi.

c. How does the folded membrane structure of the rough ER aid in the function?
The extra folds provide more surface area for more membrane enzymes and more reactions to take place, and also for more ribosomes to fit on its surface.

d. The smooth ER is a membranous organelle composed of tube-like sealed membranes. Why is the smooth ER called "smooth?"
It looks smooth under a microscope because there are no ribosomes attached to it.

e. What is the function of the smooth ER?
Lipid synthesis and detoxification.

f. How does the structure of the smooth ER aid in the function?
It has a high surface area, so there is more space for enzymes and reactants involved in the synthesis of lipids and in cell detoxification.

10. Golgi Bodies/Apparatus/Complex
• Note: any of the names could appear on the exam so be knowledgeable about the different ways you might see this structure
a. The Golgi consists of a stack of flattened membranous sacs and associated vesicles. What is its function?
The Golgi receives vesicles containing proteins from the rough endoplasmic reticulum. The Golgi functions to correctly fold and chemically modify newly synthesized proteins. It also sorts and packages the proteins into vesicles for protein trafficking (sending them to their proper locations, such as secreting them outside of the cell, embedding them in the cell membrane, moving them to another location inside the cell, or concentrating enzymes to become a lysosome).

b. How do the multiple membranes and sacs of the Golgi aid in the function?
It has a high surface area, so there is more space for enzymes and reactants involved in the chemical modification of proteins. It also forms vesicles for transport, so it needs a lot of membrane for this.

7. What is a vesicle?
A vesicle is a small membranous sac, often used for transport. It can fuse with other membranous organelles, such as the ER, golgi, lysosomes, and even with the plasma membrane.

11. Vacuole - a membranous vesicle (sac) within the cytoplasm of a cell. Vacuoles have many roles, including storage and release of macromolecules and cellular waste products.

a. What is the function of the food vacuole?

A vacuole is a membrane-bound sac that plays many and differing roles. A food vacuole is a small sac that stores food.

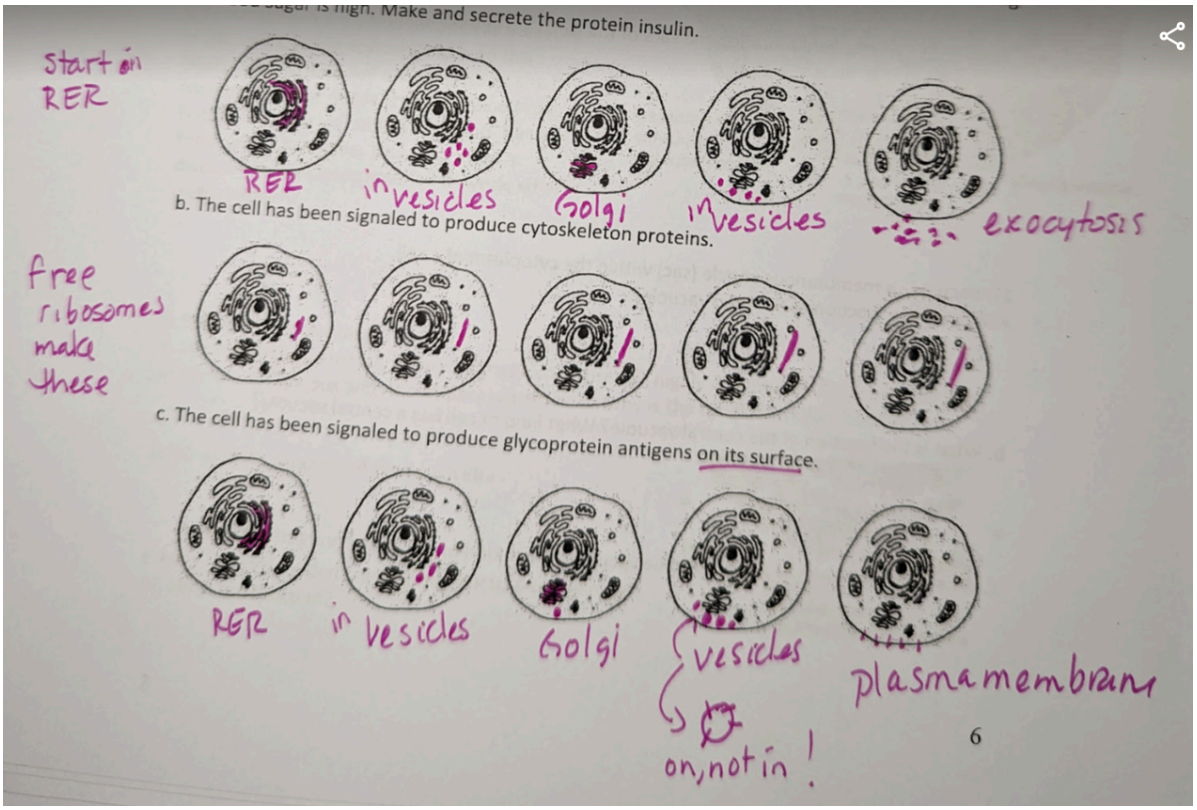
b. What is the function of the central vacuole? What kind of cell has a central vacuole?
Plants have a central vacuole which aids in retention of water for turgor pressure. It may also be used to store water soluble materials.

c. What is the function of the contractile vacuole? What kind of cell has a contractile vacuole?
Freshwater protists(hypotonic environment) may have a contractile vacuole if they do NOT have a cell wall. The contractile vacuole removes excess water from the cell so that it does not burst (lyse).

12. Each type of protein has a special shape which is needed for it to perform its function. There are proteins that float around in our cytoplasm, proteins that are embedded in our cell membranes or in the membranes of our organelles. There are even proteins that are secreted out of the cell to perform a specific function outside the cell. All of these proteins are made on ribosomes, but ribosomes can be found floating freely in the cytoplasm or attached to the rough endoplasmic reticulum (RER).
a. If a ribosome is floating freely in the cytoplasm, what is the destiny of the proteins that it makes?
The proteins will be used inside the cell where they are made!

b. If a ribosome is attached to the rough endoplasmic reticulum (RER), what is the destiny of the proteins that it makes?
They will be secreted out of the cell or end up in the plasma membrane or become part of a lysosome or other organelle.

13. The endomembrane system consists of membranes and organelles in eukaryotic cells that work together to modify, package, and transport proteins and lipids. It includes the nuclear envelope, lysosomes, ER, Golgi, and the plasma membrane. For each scenario below, color the path of protein production, transport and modification to its final location within or outside of the cell. Each diagram is a time lapse, with the first time on the left and successive times moving right.

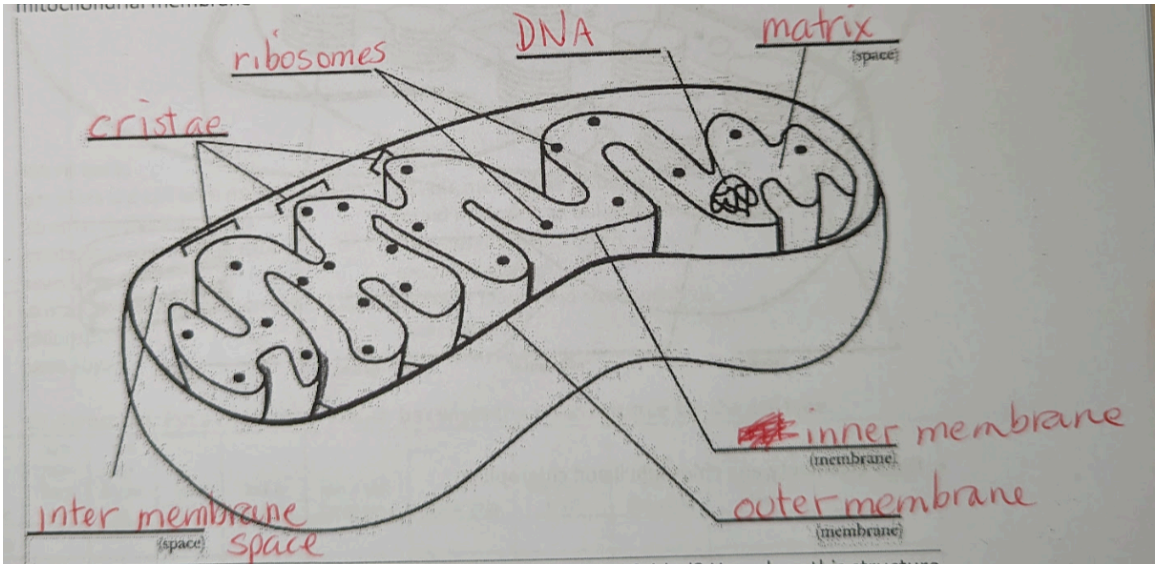


14. Mitochondria

a. What process occurs in the mitochondria and what important energy molecule is produced?
Aerobic cellular respiration produces ATP!

b. Do Bacteria have mitochondria? Can any bacteria perform aerobic cellular respiration?
No. Mitochondria are membranous (membrane bound organelles). Bacteria do NOT contain membrane bound organelles.
Many bacteria can perform aerobic cellular respiration, but they do their chemical reactions on their only membrane (the plasma membrane) or in their cytoplasm, not in a mitochondrion.
(Fun fact: Other bacteria do similar processes that don't use oxygen, but all use ATP as an energy molecule.)

c. Label the diagram of the mitochondrion with the following terms:
matrix, DNA, intermembrane space, cristae, ribosomes, outer mitochondrial membrane, inner mitochondrial membrane



d. Why is the inner mitochondrial membrane so convoluted and folded? How does this structure aid in the function?
It increases the surface area for more enzymes (and other important cellular respiration machinery), so more reactions/processes can take place.

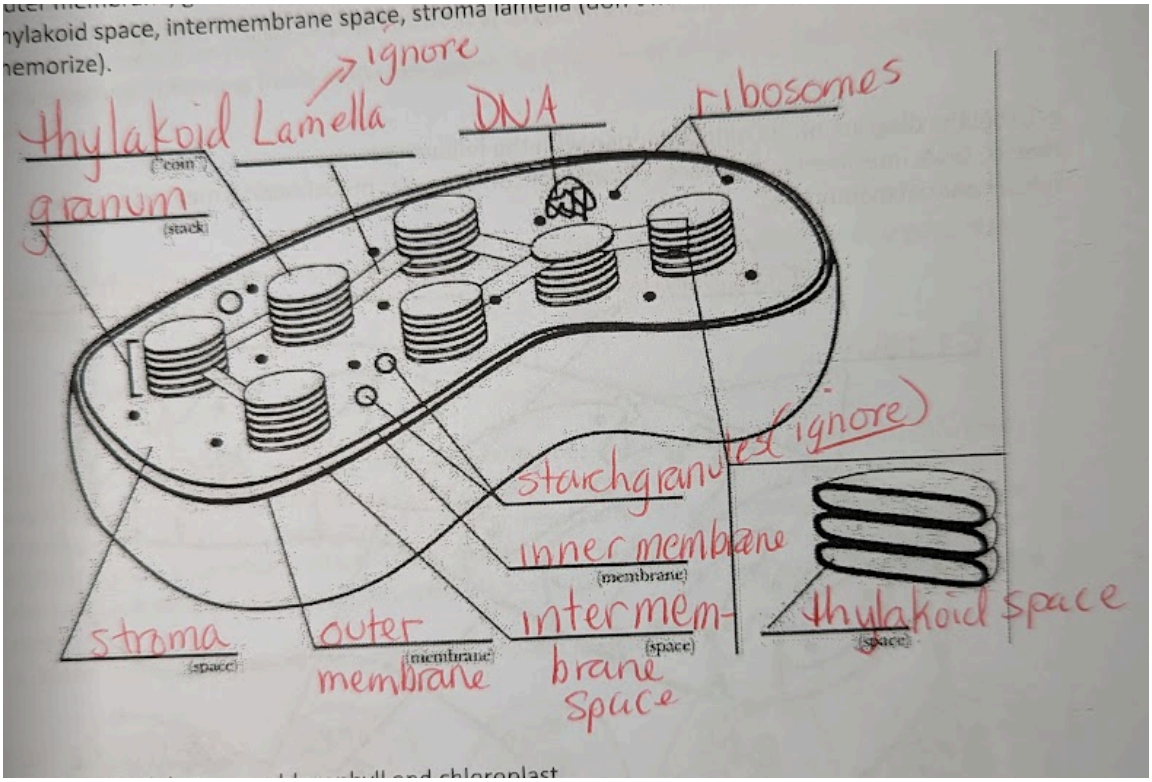
e. How is compartmentalization important to the efficient functioning of the mitochondria?
The mitochondrial double membrane provides compartments for different metabolic reactions. More on this in unit 3, but the intermembrane space provides a chamber (bound by different membranes) for the accumulation of hydrogen ions. This makes a proton gradient (you know, like the charge separation in a batter. OMG!! Unit 3 will be so exciting!)

15. Chloroplast
a. What process occurs in the chloroplast and what important energy molecule is produced?
Photosynthesis which makes a half of a sugar molecule. (ATP is involved, too - more on this in unit 3 - can you even hardly wait?)

b. What types of organisms have chloroplasts?
Photosynthetic eukaryotes - plants and some protists (such as algae and some others).

c. Do Bacteria have chloroplasts? Can any bacteria perform photosynthesis?
No. Chloroplasts are membranous (membrane bound organelles). Bacteria do NOT contain membrane bound organelles.
Many bacteria can perform photosynthesis (such as cyanobacteria), but they do their chemical reactions on their only membrane (the plasma membrane) or in their cytoplasm, not in a chloroplast.

d. Label the diagram of the chloroplast with the following terms:
outer membrane, grana, inner membrane, thylakoid membrane, stroma, DNA, ribosomes, thylakoid space, intermembrane space, stroma lamella (don't memorize), starch granule (don't memorize).



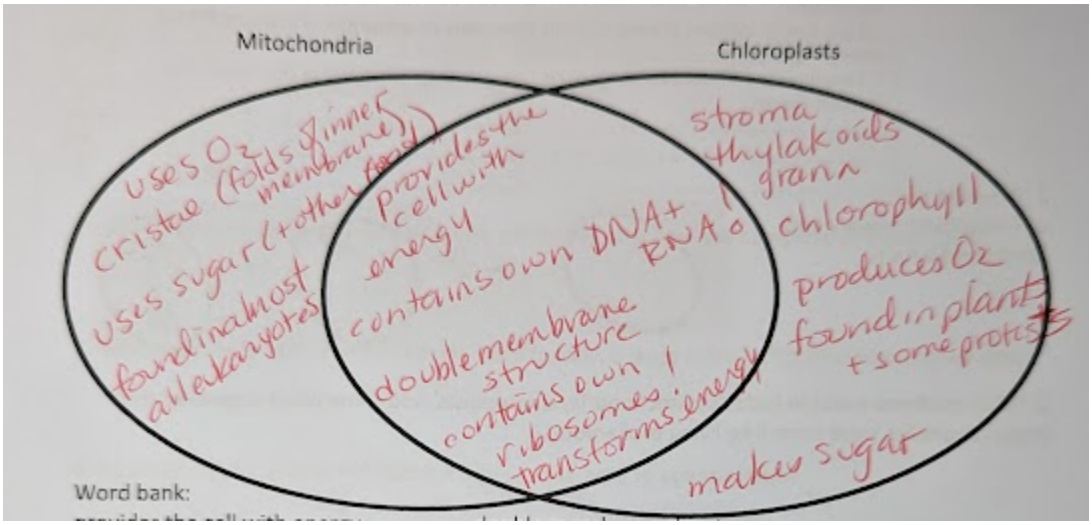
e. Distinguish between chlorophyll and chloroplast.
Chlorophyll is a light gathering pigment (it's green). Chloroplast is an organelle that contains chlorophyll in its thylakoid membranes.

f. Where in the chloroplast is chlorophyll found?
thylakoid membranes

g. How do the multiple thylakoid membranes in the chloroplast aid in the function?
It increases the surface area for more enzymes (and other important photosynthetic machinery), so more reactions/processes can take place.

h. How is compartmentalization important to the efficient functioning of the chloroplast?
The multiple thylakoid membranes in the chloroplast provide compartments for different metabolic reactions. Some reactions happen on the thylakoid membrane while others happen in the stroma. More on this in unit 3, but the thylakoid space also provides a chamber (bound by a membrane) for the accumulation of hydrogen ions. This makes a proton gradient (you know, like the charge separation in a batter. OMG!! Unit 3 will be so exciting!)

16. Compare mitochondria to chloroplasts using the Venn diagram below.

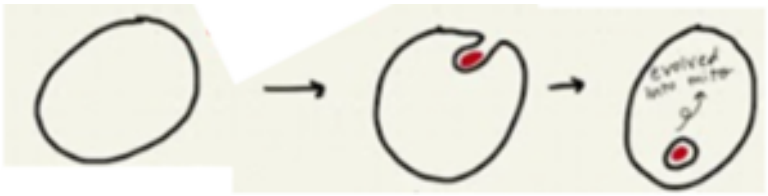


17. Directions: Put a check mark in each box when the column is true for the cell type.

Cell Type	is a pro-kary ote	is a eu-karyo te	has DNA	has a nucleus	has a cell membrane	Has ribosomes	Requires ATP	Has mito-chondria	May have chloro-plasts	May do photo-synthesis
Bacteria	✓		✓		✓	✓	✓			✓
Protist		✓	✓	✓	✓	✓	✓	✓	✓	✓
Fungi		✓	✓	✓	✓	✓	✓	✓		
Plant		✓	✓	✓	✓	✓	✓	✓	✓	✓
Animal		✓	✓	✓	✓	✓	✓	✓		

Topic 2.11: Origins of Cell Compartmentalization

1. Describe the endosymbiotic theory and label the diagram.



Some organelles (mitochondria, chloroplasts, and any organelle that ends with "plast") appear to have evolved from free living bacteria that were engulfed by a larger cell. THe larger cell did not digest the smaller cell, but kept it around. OMG - so cool!!!
Label - the black line is the eukaryotic cell membrane, and the red part is the prokaryotic cell.

2. What evidence exists in today's mitochondria, chloroplasts, and some other organelles that these organelles were once free living prokaryotes?
They have their own circular DNA (just like bacteria!), their own prokaryotic ribosomes, a double membrane, and their gradients are made by protons (just like bacteria!!).

3. What was the likely niche of the free living ancestor of chloroplasts?
They must have been photoautotrophs.

4. Which organelle was obtained first: mitochondria or chloroplast? Justify.
Mitochondria because almost all eukaryotic cells have them, but not all have chloroplasts.

Topic 2.3: Cell Size

1. Calculate the surface areas, volumes, and the surface area to volume ratios in the table below for each cube.

Cube	cm x cm	Surface Area (cm)	Volume (ml)	Surface Area:Volume Ratio
A	2 x 2 x 2	24	8	3
B	3 x 3 x 3	54	27	2
C	4 x 4 x 4	96	64	1.5

2. If you put each of the blocks above into a solution, which would complete diffusion first?
Block A, the smallest

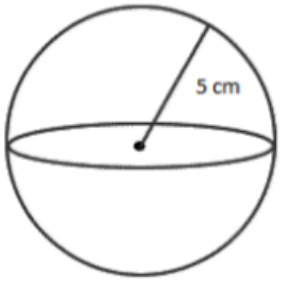
3. Which allows for diffusion to happen more quickly, a large sa/vol ratio, or a small sa/vol ratio?

4. Do small cells or large cells have a high surface area to volume ratio?
Small cells have a high surface area to volume ratio

5. What type of surface area to volume ratio is most favorable for cells?
Large surface area to volume ratio is most favorable for cells.

6. Why are cells small?
Because their diffusion is most efficient since they have a very high surface area to volume ratio. THere are more places for materials to diffuse into/out of the cell and less goop inside.

7. What is the surface area/volume ratio for this spherical cell?
SA = $4\pi r^2$ = 314.2 cm^2
Vol = $V=(4/3)\pi r^3$= 523.6^3
SA/Vol ratio - 314.2/523.6 = 0.6
There are no units typically used for this calculation



8. Calculate the surface areas for the following "cells": Please let me know if you got different numbers - I'll double check my math!!

Shape of "cell"	Surface Area	Volume	Surface Area/Volume Ratio
Sphere with a radius of 2	50.08	33.5	1.5
Cube with a side length of 3	54	27	2.0
Rectangular solid with dimensions of 2x3x4	52	24	2.2
Cylinder with a radius of 2 and a height of 4	75.36	50.24	1.5

9. Which "cell" from the question above would be the most efficient? Justify.
Most efficient would be largest SA/Vol ratio, which would be the rectangular solid.

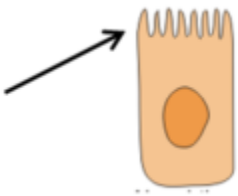
10. How does an increase of surface area affect the increase in volume? As the size of the cell increases, the surface area increases by a square, while the volume increases by a cube, so the volume increases at a faster rate than the surface area increases. More goop inside, fewer places for diffusion to occur on the surface.

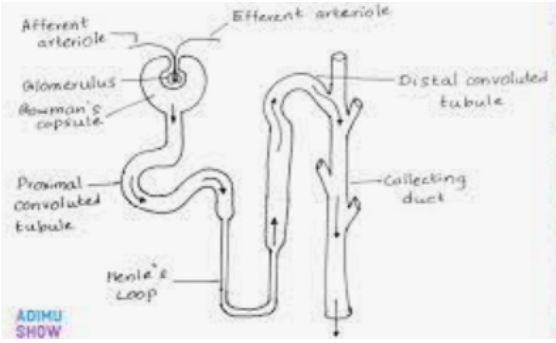
11. How can a cell increase surface area without increasing the volume?
It could have a convoluted surface (lots of squiggles) or it could be really long and thin, like a neuron.

12. How can an increase in surface affect heat exchange?
Heat is lost at the surface, just like gasses or other materials. So, higher surface area to volume ratio means faster heat exchange. Good in hot environments, not so great in cold environments.

Topic 2.3: Cell Size

1. How do microvilli found on cells in the small intestine exchange materials with the environment more efficiently?
The convoluted surface increases the surface area without increasing the volume, so the SA/Vol ratio gets bigger and exchange is faster/more efficient.



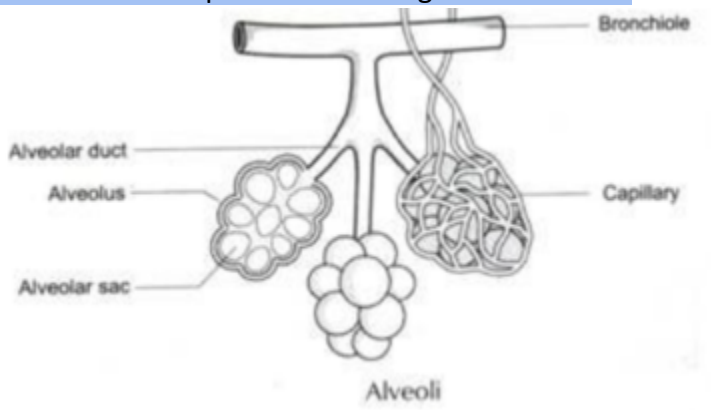


2. The nephron in the kidney (pictured left) is highly convoluted. Explain how this helps us efficiently eliminate waste.

The convoluted surface increases the surface area without increasing the volume much, so the SA/Vol ratio gets bigger and exchange is faster/more efficient.

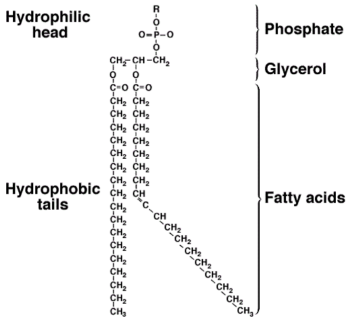
3. Alveoli in the lungs have a huge surface area. Explain how this helps organisms to obtain molecules from the environment.

The very thin tissue also has a very, very high surface area. If you were to lay out all of the alveoli in your lungs, the surface area would be equivalent to a singles tennis court (that's why my old anatomy text book said, anyway). Soooo, lots of surfaces for oxygen to enter and carbon dioxide to exit!



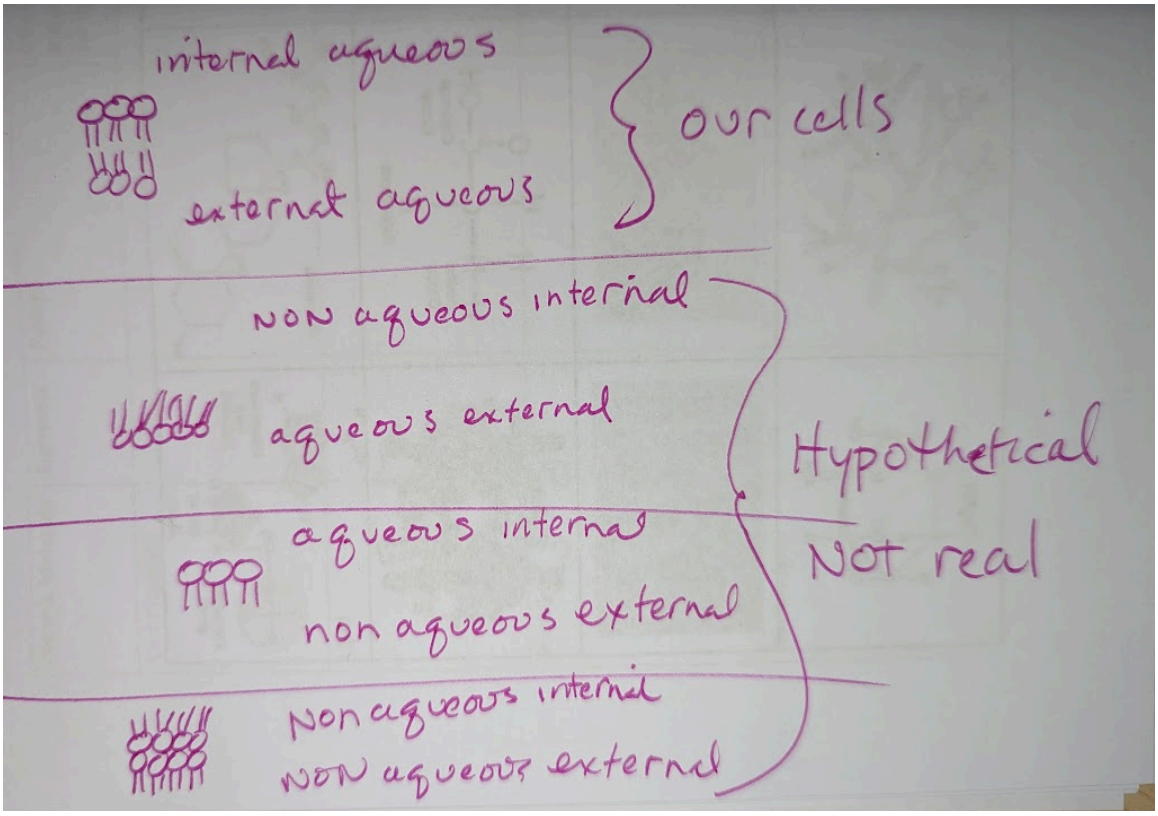
Topic 2.4: Plasma Membranes

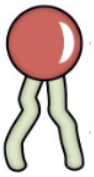
1. Cell membranes are composed of several types of molecules, but the most abundant is the phospholipid. How does the structure of a phospholipid help produce a cell membrane that serves as a barrier to most molecules and as a structure that can be present in an aqueous solution?



It is amphipathic, meaning that it has both hydrophilic and hydrophobic components. The "head" is polar, and sometimes even charged. It mixes with water. The "tails" are made of fatty acids and are therefore hydrophobic. All biological membranes are made of a phospholipid bilayer, with the hydrophilic heads facing water/aqueous solutions. For the plasma membrane (cell membrane), one set of phospholipids has the heads facing the aqueous solution outside the cell and the other set of phospholipids has the heads facing the cytosol/cytoplasm, which is also an aqueous solution. The hydrophobic tails face each other, inside the membrane, serving as a barrier for all things aqueous.

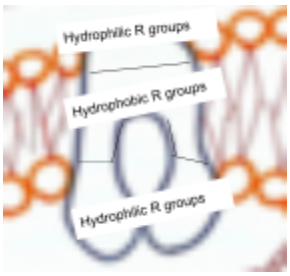
2. Based on the following internal and external conditions of the cell, how would the phospholipid molecules be oriented? (Note: aqueous means that it contains water)





3. Which condition is normal for life on this planet?
The first condition, with aqueous (watery) internal and external environments.

4. How does the polarity of various R groups in a membrane protein affect its orientation in the membrane?
We would expect that amino acids with hydrophobic R groups would exist in the part of the protein that is hanging out next to the hydrophobic tails of the phospholipid bilayer. We would expect that amino acids with hydrophilic (polar and charged) R groups would exist in the part of the protein that is hanging out next to the hydrophilic heads of the phospholipid bilayer and/or the aqueous internal or external environment.



5. What is the function of receptor proteins in a cell membrane?
They receive stuff (like hormones, neurotransmitters, etc.). They are just the right shape and size to fit with their specific ligands (signal molecules).

6. What is the function of recognition proteins found in a cell membrane?
Recognition proteins are like ID tags to say “hey, I’m a mammal,” or “hey, I’m a liver cell.” They help cells to recognize like cells (OK, guys, we can stop doing mitosis now) and they help immune system cells to recognize like vs. foreign cells.

7. What is the function of steroids (such as cholesterol) in the plasma membrane?
Cholesterol helps to keep the fluidity of the cell membrane correct. They help disrupt the phospholipid tails when it gets colder and they help hold them together when it gets too warm.

8. Describe the "fluid mosaic model" of the cell membrane.
Like a mosaic, there are many different molecules in the cell membrane, and they can all wiggle around, so it is fluid. College board wants you to know about the experiment in which the scientists fused a mouse cell and a human cell, and the resulting cell ends up having all of the mouse and human proteins mixed around each other, showing that the molecules in the cell membrane are NOT fixed in place.

9. Define the following terms:
Glycolipid - a lipid with a carbohydrate attached.

Glycoprotein - a protein with a carbohydrate attached.

10. What is the function of glycolipids and glycoproteins in the plasma membrane?
They generally serve as identification tags (recognition).

Topic 2.5: Membrane Permeability

1. What materials can pass right through the lipid bilayer?
Hydrophobic (nonpolar) materials can pass through pretty quickly (and small, polar molecules can pass through **slowly**, especially if their concentration gradient is great, like water).

4. What materials can NOT pass right through the lipid bilayer?
Ions cannot pass through the lipid bilayer. Larger polar molecules cannot pass through the lipid bilayer. If they are to enter or leave the cell, they'll go through a transport protein (active or passive), or they'll use a vesicle (endo or exocytosis).

5. Fill in the chart using the following phrases:
freely pass through the lipid bilayer
pass through the lipid bilayer slowly in small amounts or through a protein more quickly
move across the membrane through embedded transport proteins

Group	small, nonpolar molecules	Small, polar molecules	Large, polar molecules	Ions
Example	O_2, N_2, CO_2	H_2O	sugar, nucleotides	Na^+, Cl^-
How do these molecules move across the cell membrane?	freely pass through the lipid bilayer	pass through the lipid bilayer slowly in small amounts or through a protein more quickly	move across the membrane through embedded transport proteins	move across the membrane through embedded transport proteins

6. When a cell produces a large amount of carbon dioxide, can its transport across the plasma membrane be controlled? Explain.
No. Carbon dioxide is nonpolar and moves across the lipid bilayer from high to low concentration. We have no control over this.

7. When a cell produces a large amount of sugar, can its transport across the plasma membrane be controlled? Explain.
Yes. Sugar is large (ish) and polar. It does NOT move across the lipid bilayer. Instead, we would need to transport it using a transport protein, which we can control.

8. Ions cannot move through the lipid bilayer part of the cell membrane. How do ions cross a cell membrane? Why is this important?
Ions cross the membrane through transport proteins (either passive (facilitated diffusion) or active (protein pumps)). This is important because we can control this. We can set up gradients and use them to store potential energy. OMG!! When the gradient dissipates, we can harness that energy to do work.

9. True or False? Any molecule can use any transport protein. Explain.
False. Transport proteins, like all proteins, have a special shape (based on the order of their amino acids which allows for very special and precise folding due to the interactions of their R groups, etc.). Since they have a special shape, they are able to transport just very specific molecules or ions. So, for example, the sodium/potassium pump only transports sodium and potassium. The calcium transport protein only transports calcium ions. Aquaporins only transport water.

10. If water can move through the lipid bilayer, what advantage do aquaporin provide?
They provide a faster **rate** of transport.

11. Why are steroid hormone receptors found inside the cell, but protein hormone receptors are found on the cell surface?
Steroid hormones are lipid soluble (since they are, themselves, lipids). So, they diffuse right through the lipid bilayer - we cannot control them. Their receptors are generally found inside the cell (sometimes even inside the nucleus).
Protein or peptide based hormones are water soluble (they do NOT mix with lipids). So, they can NOT diffuse through the lipid bilayer. Their receptors are generally found on the cell surface (embedded in the cell membrane).

12. What types of materials require a vesicle for export or import? Explain.
Large materials - like collagen that could not easily fit through a transport protien
Any material that needs a very quick exit - like neurotransmitters responding to nerve impulses and perhaps causing new, very quick, nerve impulses in the next neuron.

13. Add checkmarks to the chart to match each bulk movement term with its definition.

	Releasing particles outside the cell	Taking in any materials	Taking in water and dissolved materials	Taking in any solid materials	Taking in specific materials
endocytosis		X			
receptor mediated endocytosis		X			X
exocytosis	X				
pinocytosis		X	X		
phagocytosis		X		X	

Topic 2.5: Membrane Permeability

1. Fill in the chart about cell walls. Note that all three are made of complex carbohydrates.

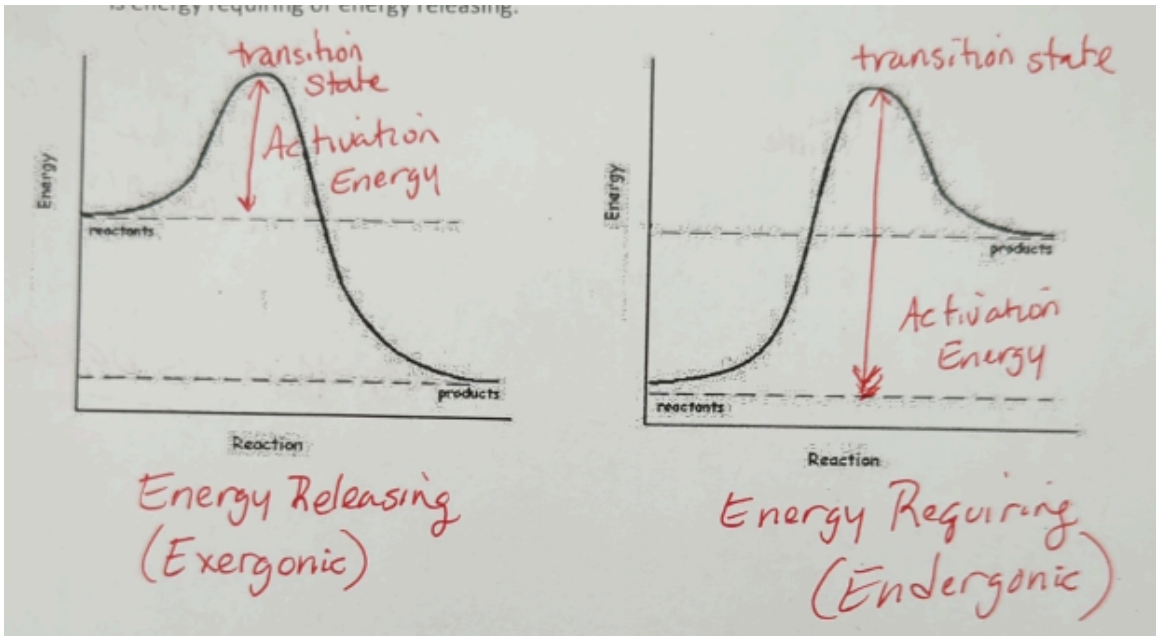
	Animal	Plant	Fungi	Protist	Bacteria
Cell Wall Present?	no	yes	yes	sometimes	usually
Cell Wall Absent?	yes	no	no	sometimes	sometimes
Cell Wall Made of Cellulose		yes		sometimes cellulose, but other materials, too	
Cell Wall Made of Chitin			yes		
Cell Wall Made of Peptidoglycan					yes

2. What is the function of a cell wall?

It provides structural protection for the cell when the cell is placed in a hypotonic environment (more on this at the end of the unit). Protects against infections, to some degree, gives the cell shape.

Topic 3.4: Cellular Energy

1. For each diagram below, label transition state, activation energy, and label whether the reaction is energy requiring or energy releasing.



1. What type of molecule (carb, lipid, protein, nucleic acid) is ATP?

2. How do you make more ATP when you run out?

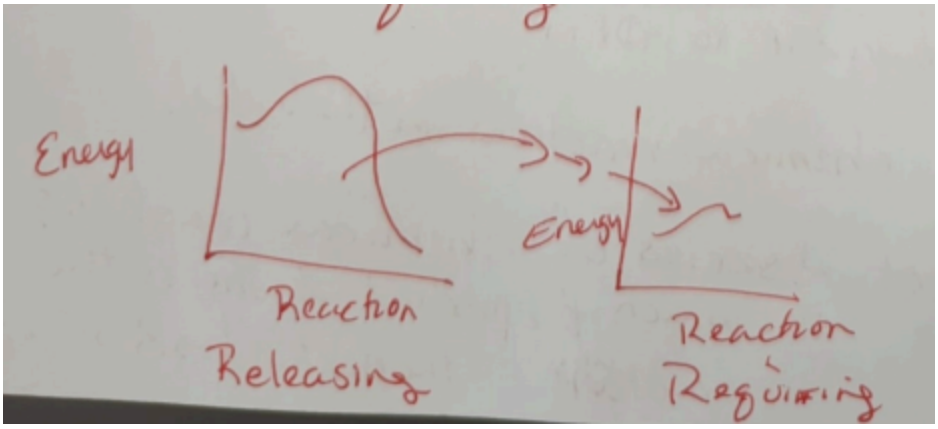
cellular respiration

3. How does the body drive energy requiring processes?

by coupling them with energy releasing processes

4. What does “energy coupling” mean? Draw energy coupling using two energy diagrams.

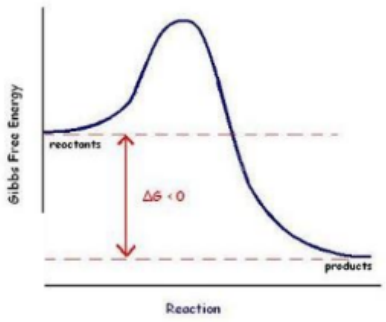
put two reactions together, with the energy releasing reaction driving the energy requiring reaction

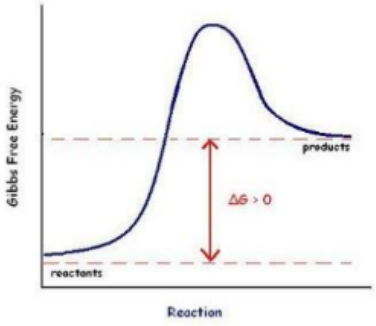


5. What does phosphorylation mean?

to add a phosphate group to something (like ADP or a protein)

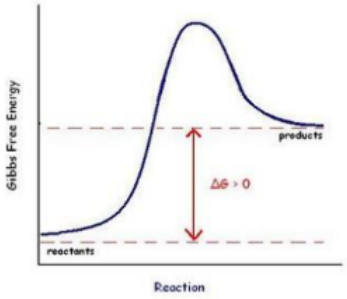
6. Could this set of diagrams represent energy coupling? Why or why not?

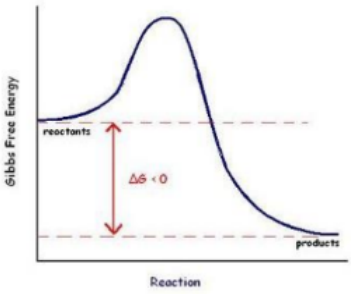




NO! There is not enough energy released to drive the second reaction!

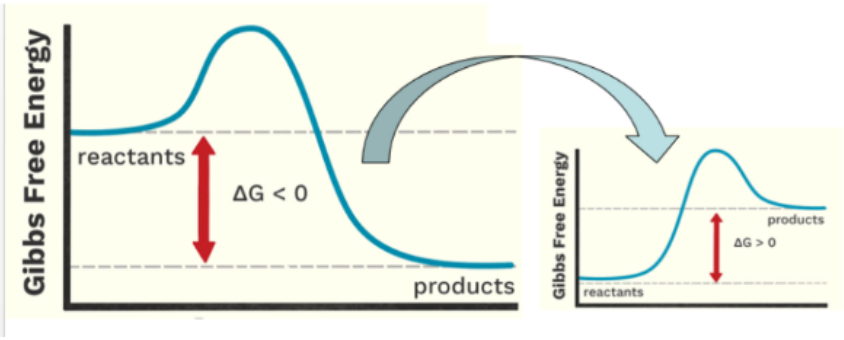
7. Could this set of diagrams represent energy coupling? Why or why not?





No. This is backwards

8. Could this set of diagrams represent energy coupling? Why or why not?



Yes. There is enough energy released to drive the second process

9. What often happens to a protein when it is phosphorylated?

   it changes shape (which often changes function)
10. What is ATP "hydrolysis"? Is it energy releasing or energy requiring?
    Breaking down ATP to ADP and Pi. it is energy releasing.

11. What is metabolism?
    All of the chemical reactions in the body.

12. What is a metabolic pathway?

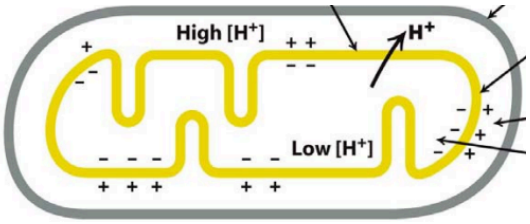
A series of chemical reactions in which the product of one reaction is the reactant of the next. Molecule A is converted into B which is converted into C which is converted into

Topic 2.6: Membrane Transport, 2.7 Facilitated Diffusion, 2.9 Mechanisms of Transport

1. What is a concentration gradient?

A concentration gradient is a difference between two places in terms of the concentration of something. For example, if there is a lot of sugar inside a cell, but not outside the cell, we would say that there is a sugar concentration gradient. We are usually looking at the concentration differences between two places that have a membrane between them.

2. What is an electrical gradient?



An electrical gradient is a difference between two places in terms of electricity, but in our class, we will be looking at the ion/charge differences between two areas separated by a membrane (. For example, if there are a lot of hydrogen ions in the intermembrane space of the mitochondrion, but fewer hydrogen ions in the matrix of the mitochondrion, then we would say that there is an electrical (and a concentration) gradient.

3. What kind of gradient is present between the matrix and the intermembrane space of a mitochondrion?

There is both an electrical gradient and a concentration gradient. Electrical due to the charge difference due to protons/hydrogen ions, and chemical/concentration difference due to the particles (protons/hydrogen ions).

4. What component of a membrane is responsible for keeping ions and large polar molecules in one compartment, so they don't diffuse away and dissipate a gradient?
The tails (fatty acids) of the phospholipid bilayer.

5. Distinguish between active and passive transport.
Active transport requires energy (often in the form of ATP) to pump materials against (up) their concentration gradients (from low to high concentration).
Passive transport does NOT require energy input; Materials naturally move with (down) their concentration gradients (from high to low concentration). They spread out until they are evenly distributed.

6. What is required for active transport?
Energy. This may be in the form of ATP, or it might be in the form of cotransport (in which the movement of one particle with a concentration gradient releases energy needed for pushing another particle against a concentration gradient).

7. Does it make sense to actively transport oxygen?
No. Oxygen is nonpolar, so it diffuses through the lipid bilayer. It doesn't make sense to expend energy to move something that will just diffuse back.

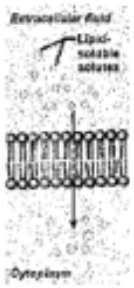
Key

How Materials Move In And Out of Cells (Membrane Transport)

Passive Processes (down/with a concentration gradient; high to low) NO ATP

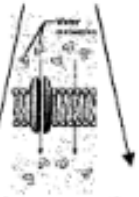
simple diffusion

small, neutral particles move down a concentration gradient (high to low) through a lipid bilayer
ex. O_2, CO_2, lipids



osmosis

diffusion of water

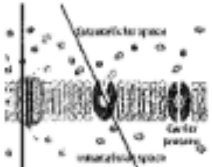


through lipid bilayer

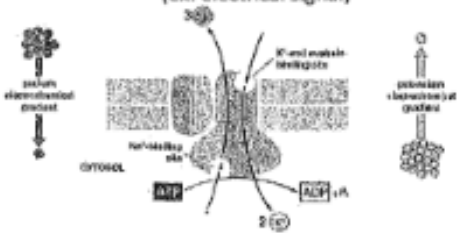
through aquaporins

facilitated diffusion

a protein moves a particle across a membrane without using energy (it moves down a concentration gradient (high to low concentration)



channel (or pore) protein
(tube through the bilayer)
May be gated and open/close
In response to some signal
(ex. electrical signal)



Active Processes ENERGY REQUIRED (up/against a concentration gradient; low to high)

protein pump or active transport

a protein becomes activated into moving a particle from an area of LOW concentration to an area of high concentration;
this requires energy;
movement is against an electrochemical gradient
may use ATP or cotransport



carrier protein
(changes shape)

one type is
Electrogenic pump
A transport protein that generates voltage cross a membrane

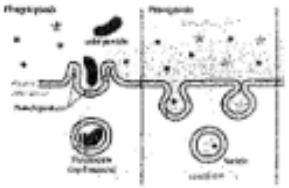
exocytosis

vesicles in the cytoplasm fuse with the plasma membrane and release contents outside the cell

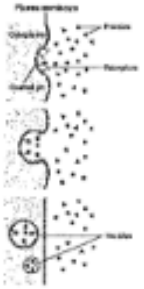
endocytosis

a region of the membrane encloses particles and pinches off to form a vesicle in the cytoplasm

- phagocytosis



- pinocytosis (nonspecific)
- receptor mediated endocytosis (specific)



There is a better version/easier to read version on google classroom that says “page 19”

TYPE OF TRANSPORT			DIRECTION high to low, or low to high?	DIRECTIO with/dow n or against/ up a concent ration gradient	ENERGY Does the cell use energy to transport molecules this way?	MOVEMENT through the lipid bilayer, through proteins, or with a vesicle?	EXAMPLES examples of molecules that move through this way	SPECIFICITY Is this process specific?	IMPORTANCE Key things to rembember
Passive Processes	Simple Diffusion		high to low	down/ with	No	Lipid Bila	CO_2, O_2	No	partiles spread out
	Osmosis	through lipid bilayer	high to low	down/ with			H_2O		water goes high to low water potential
		aquporins	high to low	down/ with		protein		yes	faster rate
	Facilitated Diffusion		high to low	down/ with			ions, polar		transport proteins are specific
Active Processes	Protein Pump (Active Transport)	Primary (Direct)	low to high	against/ up	yes	proteins	ions, polar molecules	yes	ATP is directly required
			low to high	against/ up			ions, polar molecules		
		Secondary (Cotransport) Antiport	low to high	against/ up	yes		ions, polar molecules		One particle moves down a concentration gradient, giving energy to allow another particle to go up its gradient
		Symport	low to high	against/ up			ions, polar molecules		
	Exocytosis				yes	vesicle	neurotrans mitters	yes	exo = out
	Endocytosis	phagocytosis			yes		bacteria getting eaten by a white blood cell	no	to eat; important in immune system cells; vacuole will fuse with a lysosome
		pinocytosis			yes		water and dissovled stuff	no	to drink
		receptor mediated endocytosis			yes		neurotrans mitters being taken back into a cell to get rid of them	yes	specific

8. What produces a concentration gradient? (Is energy needed?)

Energy is always needed to produce a concentration gradient. It may be energy from ATP or it may be coupled with another reaction, such as in cotransport or cellular respiration or photosynthesis.

10. Is energy needed for a concentration gradient to be maintained?

Yes. Particles can very slowly diffuse away, so a constant input of energy is actually required.

11. When a concentration gradient disperses, what is released?
Energy (could be coupled to drive another reaction, or could be released as heat.

12. How do charged molecules or ions pass through the membrane?
They must move through transport proteins or through vesicles.

13. How do large polar molecules pass through the membrane?
They must move through transport proteins or through vesicles.

14. How do small amounts of water pass through the membrane?
Water is small enough and has a high enough concentration that it can slowly move through the lipid bilayer, even though water is polar. Crazy, huh?

15. How do large amounts of water pass through the membrane (or pass through quickly)?
To move quickly across a membrane, water must move through an aquaporin (a transport protein just for water).

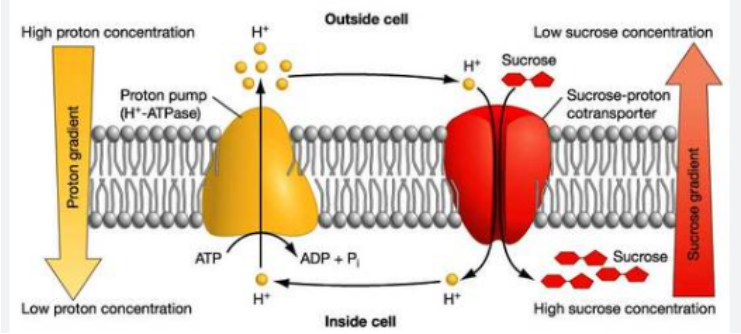
16. What is meant by membrane potential?
The electrical difference (or voltage difference) between each side of a membrane.

17. How do the passage of ions affect the membrane potential?
If they are separating (energy is being put in to separate them), they can create a membrane potential. For example, if more positive ions are on one side of the membrane than the other, then there will be a membrane potential (or voltage or potential energy).
On the other hand, if the ions are dissipating (spreading out, diffusing to even out), then the membrane potential will decrease.

18. What is the function of an ATPase?
It is an enzyme that breaks down or hydrolyses ATP.

19. How does the Na+/K+ ATPase maintain the membrane potential?
It uses energy from the hydrolysis of ATP to force sodium ions out of the cell and potassium ions into the cell. This is the most important protein pump in animal cells. (as long as you don't consider their mitochondria).

20. What is cotransport? Explain using the diagram below.

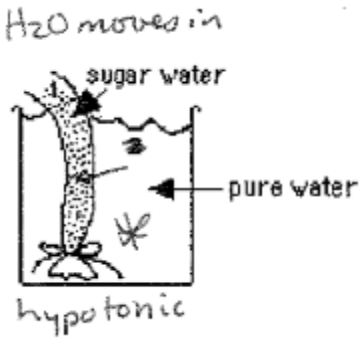


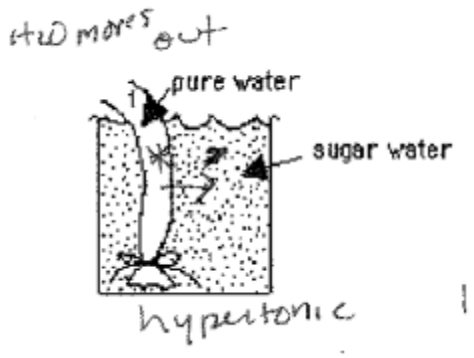
Cotransport uses the dissipating gradient of one particle to drive the active transport of another. This may be symport (both in the same physical direction) or antiport (each in a different direction).
In the diagram, direct active transport is used to force hydrogen ions outside the cell (uses ATP to force protons up/against its concentration gradient) (yellow part of diagram). Then, when the hydrogen ions come back into the cell via facilitated diffusion (passive transport), they release energy, driving the active transport (cotransport) of the sucrose out of the cell, up its concentration gradient (red part of diagram).

21. ATP hydrolysis is required for which types of transport?
Anything that uses ATP energy. Usually, ATP hydrolysis is needed for primary or direct transport (though we will talk about exceptions in unit 3), but often ATP hydrolysis is used indirectly for secondary transport to set up the gradient in the first place (though not always).

Topic 2.8: Tonicity and Osmoregulation

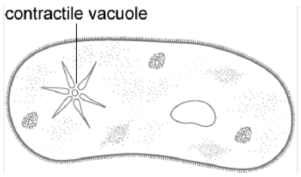
1. In the diagrams below, a semi-permeable membrane tube (tied off at the bottom) is placed into a beaker. Water with or without sugar is placed in the bag and in the beaker. The membrane allows osmosis to occur, but it does not allow sugar to pass through.
For each diagram:
Draw an arrow to show which way water will move.
Label the beaker water as hypotonic, isotonic, or hypertonic.
Draw a star in the location of the higher water potential.





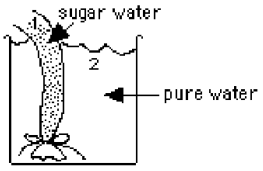
2. Water always moves from an area of _____high____water concentration to an area of _____low_____water concentration

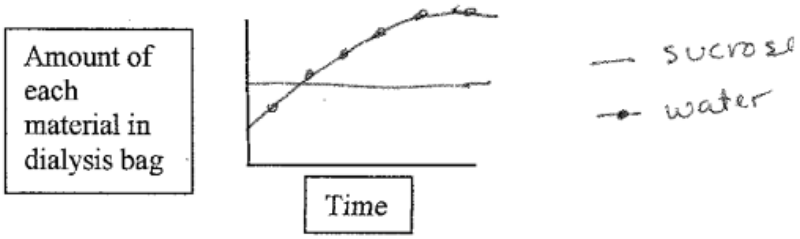
3. Do protists that have contractile vacuoles also have cell walls? Why or why not? In what type of environment do they live (fresh or salt water)?

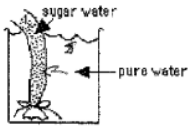


No. Cell walls prevent cell lysis (bursting), so it would be redundant to have both. The protists with contractile vacuoles live in fresh water (hypotonic environments) because water flows into them and the contractile vacuole's job is to pump that water out so the cell doesn't burst (or lyse).

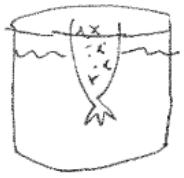
4. A bag of dialysis tubing containing sucrose and water is placed into a beaker of distilled water. In this case, water can move through the tubing, but sucrose cannot. Draw a graph showing the concentration of each material in the tubing over time.

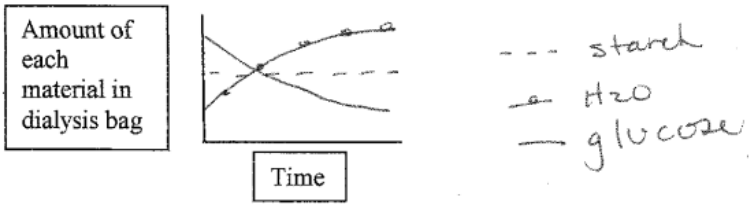






5. A bag of dialysis tubing containing glucose, starch and water is placed into a beaker of distilled water. In this case, water and glucose can move through the tubing, but starch cannot. Draw a graph showing the concentration of each material in the tubing over time.



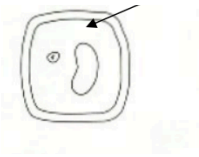


6. Using the following chart, determine which direction the water will flow and the result to the cell.

Intracellular Environment	Extracellular Environment	Direction of Water Flow	Result to the Cell
Hypotonic	Hypertonic	From the cell into the environment	Cell shrinks (plasmolysis if it has a cell wall)
Isotonic	Isotonic	both directions evenly (dynamic equilibrium)	cell remains the same
Hypertonic	Hypotonic	From environment into the cell	Cell expands and may burst if it has no cell wall; the cell will be turgid and happy if it has a cell wall

7. Identify:

Cells in hypotonic solutions, plant cell, turgid (happy) plant cell



Cells in isotonic solutions, plant cell, flaccid plant cell



Cells in hypertonic solutions, plant cell, plant cell with plasmolysis

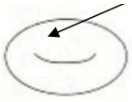


Cells in hypotonic solutions, animal cells, lysed animal cell

This cell is supposed to look ready to burst



Cells in isotonic solutions, animal cells, happy animal cell



Cells in hypertonic solutions, animal cells



This cell is supposed to look shrunken

8. How does the cell wall protect a plant cell from hypotonic solutions?
In a hypotonic solution, water will move into the cell. If it does not have a cell wall, the cell could burst (lyse) due to the water pressure. Thankfully for plants, they have a cell wall which provides strength, so their cells will not lyse due to water pressure (turgor).

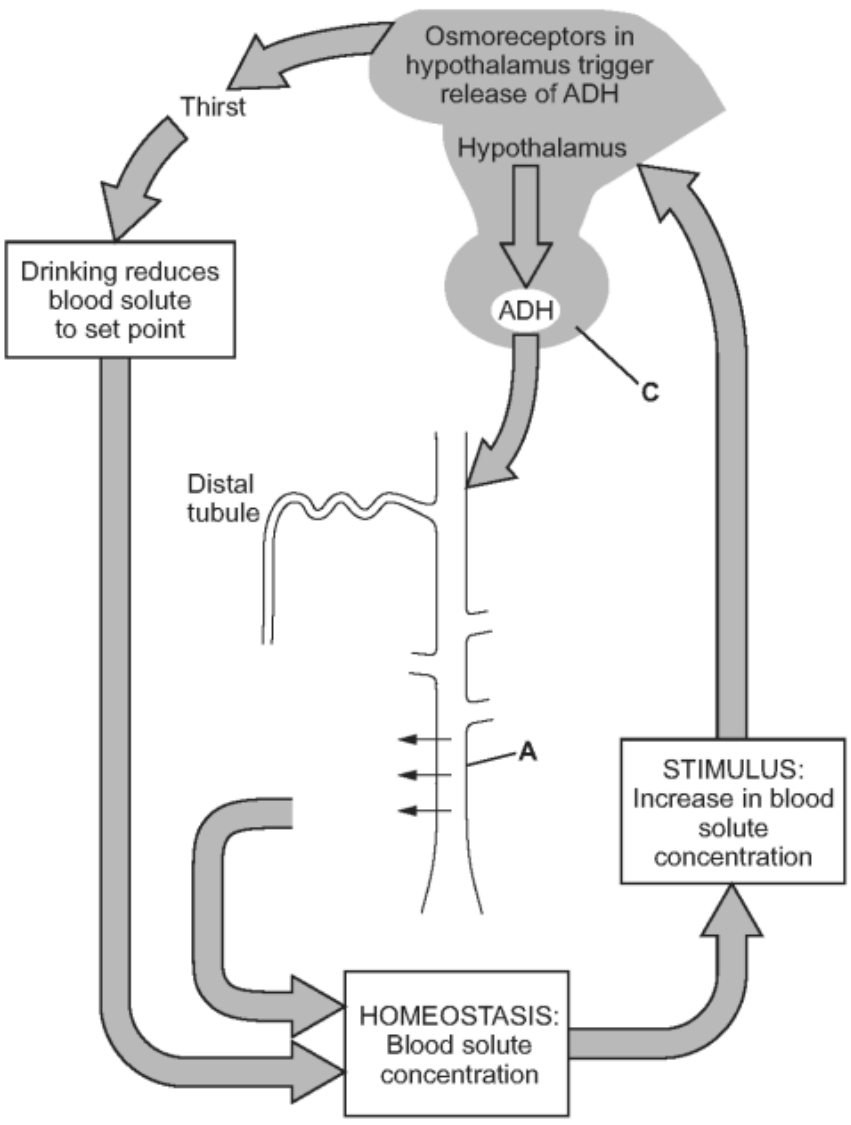
9. What does high osmolarity mean?
Think of osmolarity as all of the different molarities. So if there are lots of solutes, there will be high osmolarity.

10. What is osmoregulation?
The maintenance of a constant osmotic pressure in an organism by controlling water concentrations and solute concentrations. For us, the kidneys do this (along with thirst, which tells us to drink).
Osmotic pressure is the pressure created by water moving across a membrane due to osmosis. The more water moving across the membrane, the higher the osmotic pressure. Don't worry too much about this term.

11. Describe how high tissue osmolarity affects thirst and the release of antidiuretic hormone.

High tissue os**molarity** means that there are lots of solute (dissolved stuff) in cells and tissue fluid, but not as much water. This triggers the hypothalamus to increase thirst. Hopefully, we drink more water, which will lower tissue osmolarity. This is negative feedback (changes away from a set point cause the opposite to happen - come back to the set point). e.g. high tissue osmolarity triggers the hypothalamus to make us drink which lowers tissue osmolarity.

Similarly, high tissue osmolarity also triggers the hypothalamus to signal the pituitary gland to release ADH (antidiuretic hormone), which increase the permeability of nephrons (tiny filters in the kidney) to water reabsorption, which means more water goes from the nephrons back to the



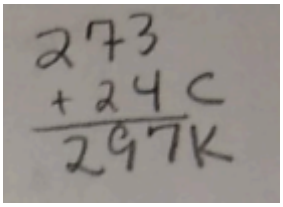
blood, so it conserves water (urine becomes more concentrated), keeping more water in the blood instead of peeing it out.

If tissue osmolarity decreases, the hypothalamus stops sending signals of thirst and stops releasing ADH.

12. Is this an example of positive or negative feedback?

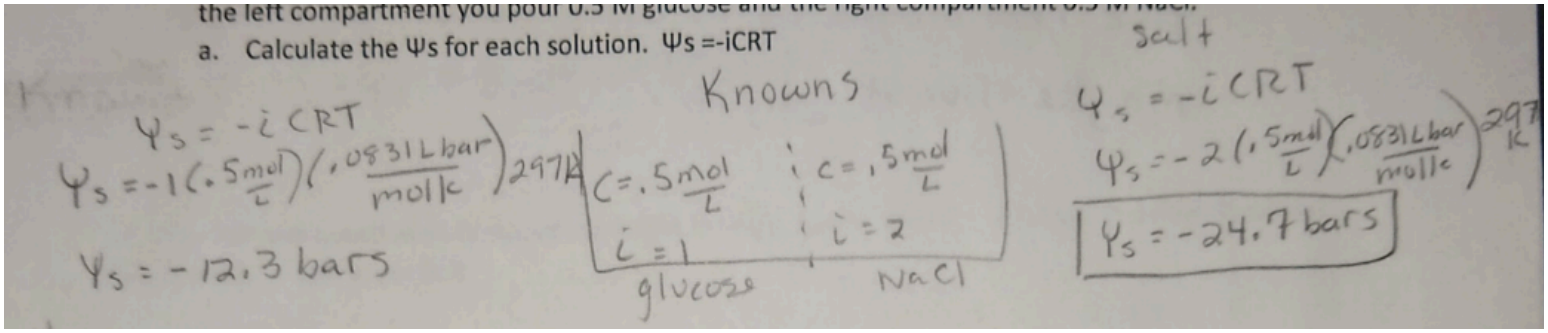
Water Potential Practice Questions

1. A membrane permeable only for water is inserted between two compartments of a container. In the left compartment you pour 0.5 M glucose and the right compartment

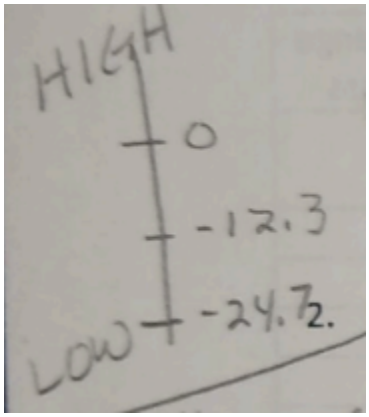


0.5 M NaCl. The temperature is 24C.

   a. Calculate the Ψs for each solution. Ψs =-iCRT



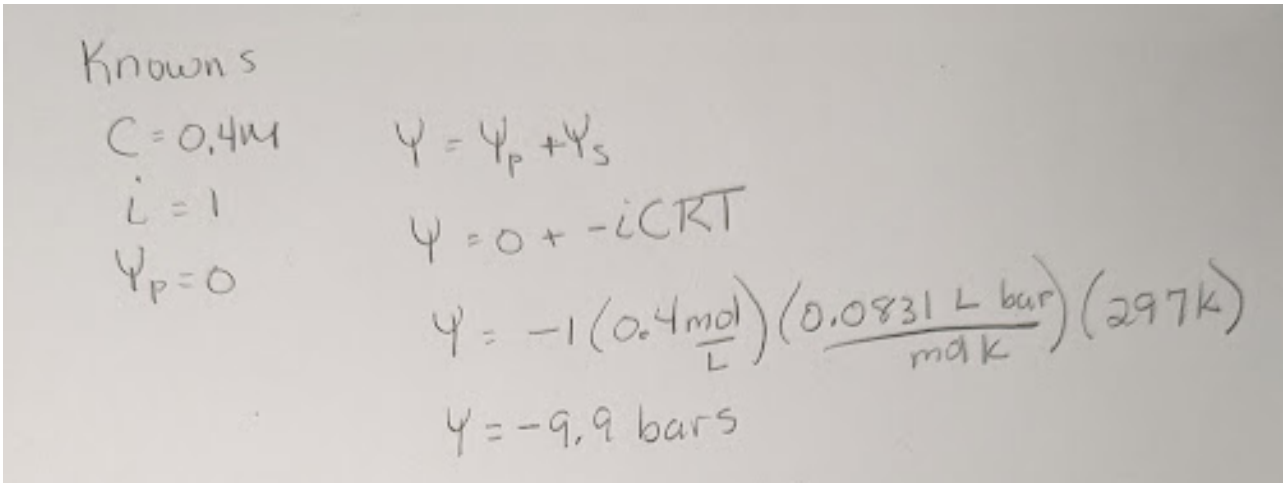
   b. Which way will water move?



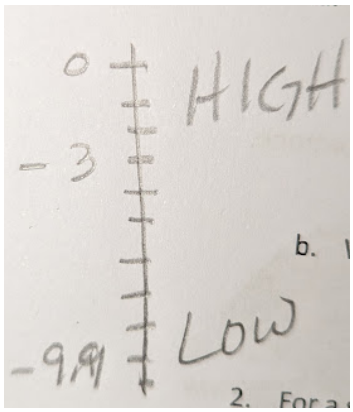
The more negative the number, the lower it is.

So, water will move to the right. From the glucose chamber (high water potential) to the salt chamber (low water potential)

2. For a solution of 0.4 M sucrose in an open container at 24C….
    a. Calculate the water potential



    b. A flaccid cell having a solute potential of -3 bars is placed in the above solution. The cell above will become: turgid/flaccid/plasmolysed
The solution has a water potential of -9.9 bars, and the cell has a water potential of 03 bars.



Water moves from the high water potential (-3 bars), which is the flaccid cell, to the low water potential (-9.9 bars), which is the solution. The cell becomes plasmolysed.



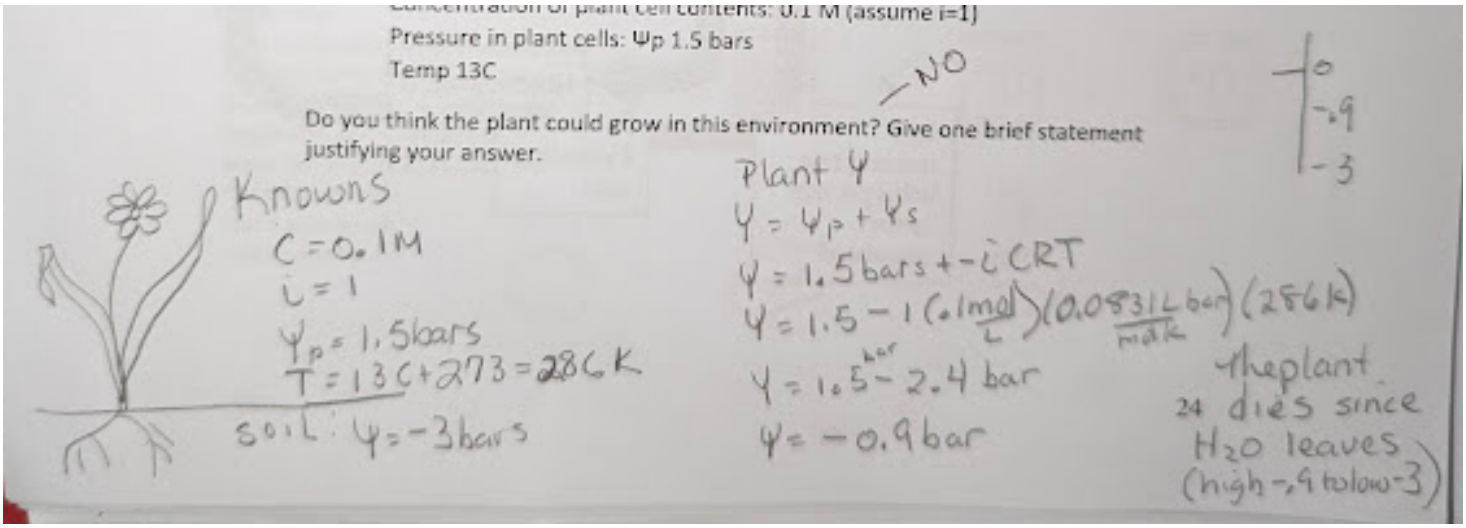
    c. The cell above is (hypo/hyper)tonic, which means that its water potential is higher/lower than the outside solution.

More important: The solution is hypertonic, and it has a lower water potential. Water moves from high water potential to lower water potential.

3. You are asked to estimate if a certain species of plant could live in a certain environment. You are given the following data:

   Overall Ψ of the soil -3 bars
   Concentration of plant cell contents: 0.1 M (assume i=1)
   Pressure in plant cells: Ψp 1.5 bars
   Temp 13C

   Do you think the plant could grow in this environment? Give one brief statement justifying your answer.



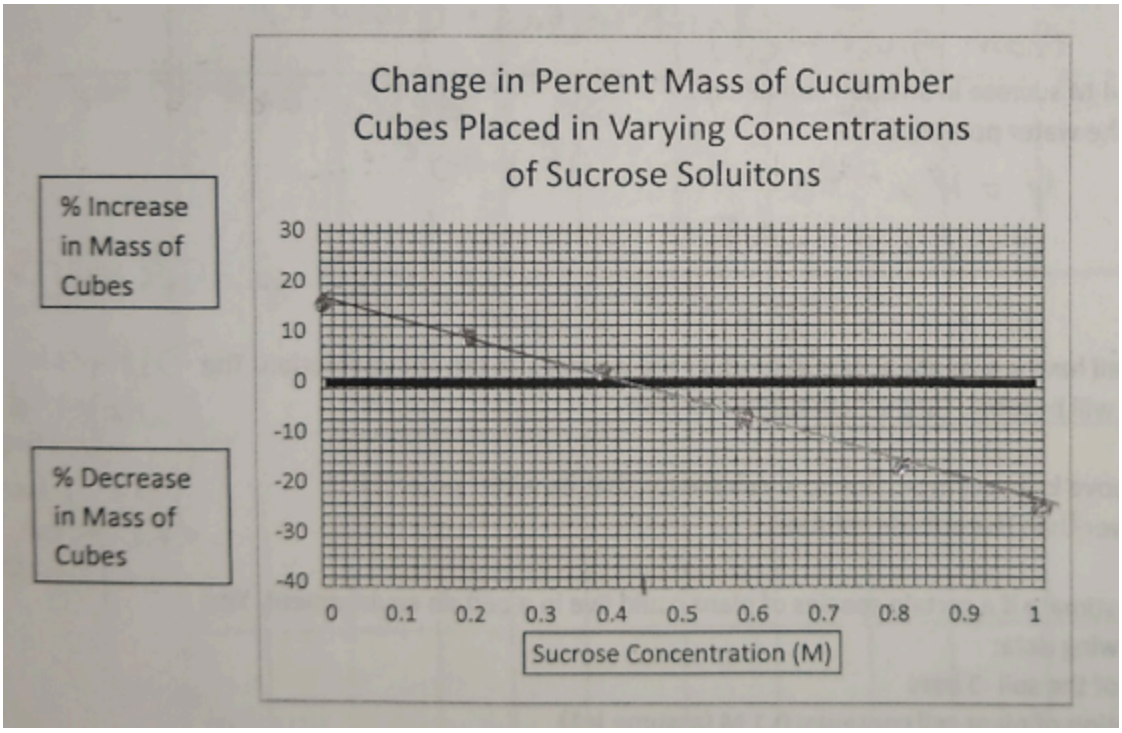
4. A student nurse accidentally injects distilled water into a patient's veins instead of an isotonic saline solution. What will happen to the patient's red blood cells?

   Some of the red blood cells will likely lyse (burst) due to the hypotonic solution.

5. Cucumber cubes placed in sucrose solutions at 25C resulted in the following percent changes after 24 hours.

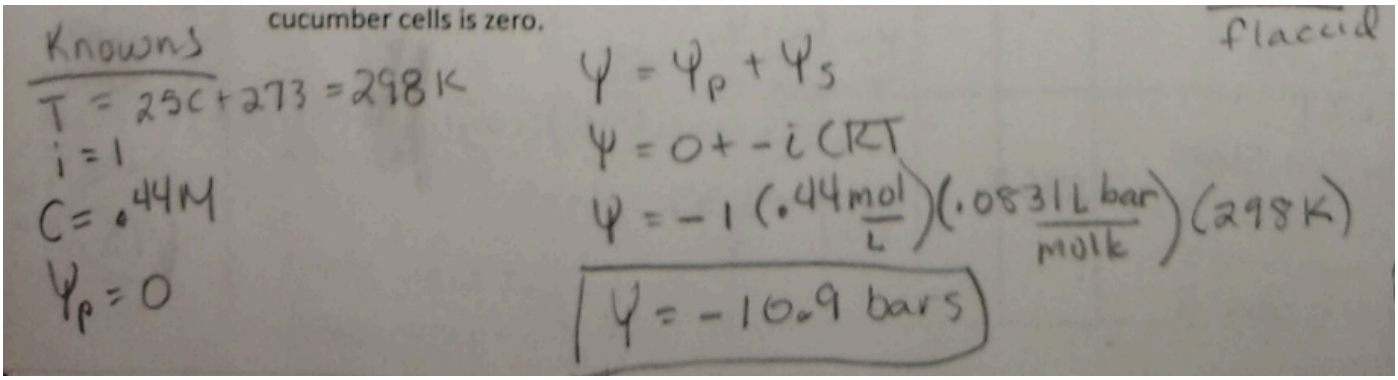
   Graph the results and draw a line of best fit:

Sucrose molarity	% change in mass
Distilled H_2O	15
0.2	9
0.4	1
0.6	-8
0.8	-19
1.0	-25



a. What is the molar concentration of solute in cucumber cells? ___about 0.42_____ Look for the sucrose concentration when the cucumber is not gaining or losing mass (the zero % change on the x axis)

b. Calculate the water potential (Ψ) in the cucumber cells. Assume i = 1, and pressure potential of cucumber cells is zero.



MEMORIZE THIS:

5. Water always moves from an area of _____high_____water concentration to an area of _____low_____water concentration

6. Water always moves from an area of _____high_____water potential to an area of _____low_____water potential

7. Water always moves from an area of _____low_____solute concentration to an area of _____high_____solute concentration

8. Water always moves from an area of _____low_____osmolarity to an area of _____high_____solute osmolarity

