Key

Cell Membrane and Nervous System

›ful Videos and Animations:

1. Bozeman Biology: Cell Membranes - http://www.youtube.com/watch?v=y31DlJ6uGgE&list=PLFCE4D99C4124A27A&index=19
2. Bozeman Biology: Transport Across Cell Membranes http://www.youtube.com/watch?v=RPAZvs4hvGA&list=PLFCE4D99C4124A27A
3. Bozeman Biology: Compartmentalization - http://www.youtube.com/watch?v=2rihCCBzqMc&list=PLFCE4D99C4124A27A
4. Bozeman Biology: Cellular Organelles – http://www.youtube.com/watch?v=aczbMlSMr8U&list=PLFCE4D99C4124A27A
5. Bozeman Biology: The Nervous System
6. McGraw Hill Animation: Action Potential
7. Mcraw Hill Animation: Transmission of a Nerve Impulse across a Synapse

Cell membrane (separates the internal environment of cell from external environment).

a. Phospholipid bilayer (selectively permeable; amphipathic)
b. Fluid mosaic model (in motion; proteins, cholesterol, glycoproteins and glycolipids among phospholipids). Membrane is hydrophilic on inside and outside, hydrophobic within membrane
c. Simple diffusion- from high to low concentration- small and uncharged move freely through phospholipids ex. CO_2, O_2 (passive; no energy;no protein carrier)
d. Facilitated diffusion- large or charged from high to low, passive; with protein carrier: ex. glucose, K+,
e. Active transport- from low to high concentration; uses ATP; uses a protein
f. Endocytosis- phagocytosis (solid) and pinocytosis (liquid); membrane surrounds and forms vesicles; receptor mediated endocytosis has receptors on surface
g. Exocytosis- release of material using vesicles fusing with membrane
h. Osmosis- diffusion of water using a selectively permeable membrane; passive; no proteins
i. Water potential= pressure potential plus pressure potential; water moves from high water potential to low water potential; solutes always lower water potential; pressure can increase or decrease depending on if it is negative or positive.
j. Plant cells have pressure related to cell wall and vacuole; turgor pressure
k. Hypertonic (high solute), hypotonic (low solute), and isotonic solutions(equal concentration)
l. Plasmolysis (plant cells; membrane pull away from cell wall); crenation (animal cell shrivels)

Nervous System

a. function: sensory input, motor function, regulation
b. structure: neuron, axon, dendrites, synapse
c. Polarized neuron: Na^+ outside, K^+ and Cl^- inside
d. Depolarization moves Na into neuron, generating an action potential
e. Repolarization exchanges Na^+ and K^+ through the sodium-potassium pump
f. At synapse, calcium channels open to allow calcium to rush in, stimulating release of neurotransmitters
g. Neurotransmitters released into synapse to generate action potential for motor neuron or muscle cell

AP Investigation 4: Diffusion and Osmosis

Part I- Diffusion in Agar Cubes

Overview: Various size cubes of phenolphthalein agar were placed in NaOH and then diffusion rates were calculated.

IV- Size of cube

DV- percent diffusion

Equations: Volume = L x W x H, volume diffused = total volume – volume not pink, % diffusion = Volume diffused /total volume x 100, surface area of a cube = L x W x # of sides, surface area/volume ratio.

Part II- Osmosis in Living Cells (Potatoes)

Overview: Potato cylinders placed in sucrose (sugar) solutions and massed before and after to get percent change in mass.

IV- Sucrose solutions (varying molarities)

DV- percent change in mass

Equations: $\Psi = \Psi_p + \Psi_S$

Water Potential = Pressure Potential + Solute Potential

Determined by graphing percent changes in mass versus molarity of solution

The solute potential of a sucrose solution can be calculated using the following formula:

$\Psi_S = -iCRT$

where

i = ionization constant (for sucrose this is 1 because sucrose does not ionize in water)

C = molar sucrose concentration at equilibrium (determined above)

R = pressure constant (handbook value R = 0.0831 liter bar/mole°K)

T = temperature °K (273 + °C of solution)

Part III- Design Your Own Experiment (Dialysis Bags)

Overview: Students were provided with dialysis bags, colored sucrose solutions of unknown molarities, and basic lab equipment to use to design an experiment on how to determine the molarities of the colored solutions.

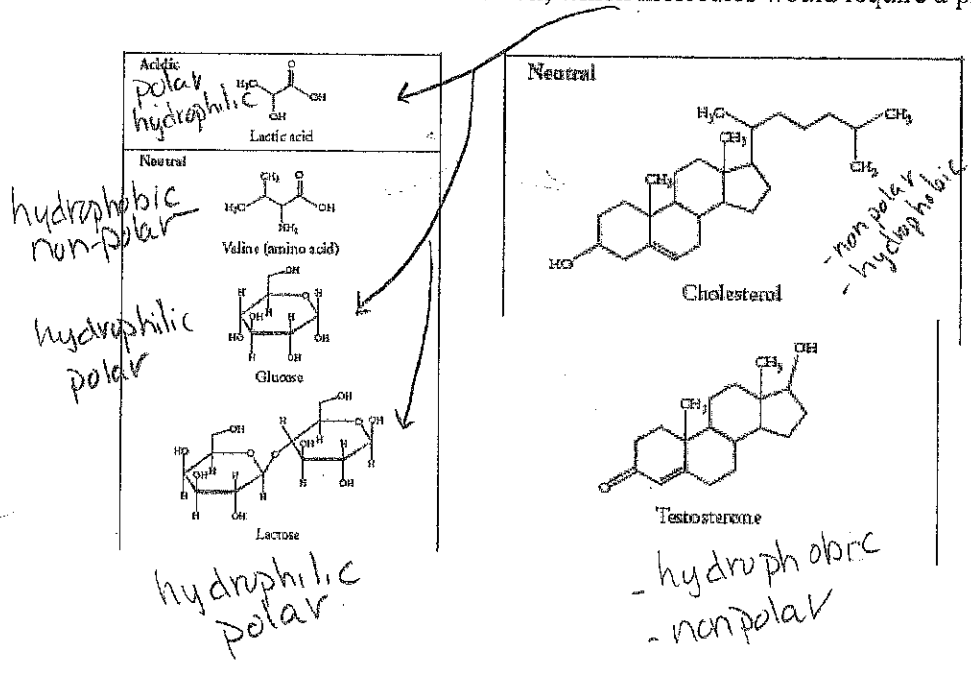
IV- unknown molarities

DV- for most groups it was percent change in mass

Equations: (final mass-initial mass)/ initial mass

Thinking Practice

1. Explain why smaller cells have a more favorable surface area-to-volume ratio for exchange of materials with the environment.
   more efficient, more surface area for diffusion, shorter distance to travel in cell
2. Describe the role of each of the following components of the cell membrane
   a. Phospholipids: - create layer, separate inside from outside
   b. Cholesterol: - maintain fluidity
   c. Proteins: - transport, reactions, communication
   d. Carbohydrates - signaling
3. Describe the orientation of phospholipids in a cell membrane.
   hydrophilic phosphate head — hydrophobic lipid tail
4. Describe the movement of the following through the membrane: small nonpolar molecules (e.g. N_2), Hydrophilic substances (e.g. large polar molecules and ions), and water.
   through membrane
   through proteins
   membrane or aquaporins
5. Explain how membrane proteins play a role in facilitated diffusion of charged and polar molecules in general and in relation to the specific molecules below.
   a. Glucose transport - protein channels
   b. Na+/K+ transport - protein pumps
6. For each molecule shown to the right, answer the following, providing justifications for each:
   a. Is it polar or nonpolar?
   b. Is it hydrophobic or hydrophilic?
   c. In order to be transferred into a cell, which molecules would require a protein channel?



acidic polar hydrophilic
hydrophobic non-polar
hydrophilic polar
- nonpolar - hydrophobic
hydrophilic polar
- hydrophobic - nonpolar

Biological systems rely heavily on the properties of water movement. Excretion, digestion, and blood pressure are just a few examples of situations where water balance is important. Suppose you have a semi-permeable membrane that ONLY water can pass. On one side of the membrane you have 0.1 M $CaCl_2$. On the other side of the membrane, you have 0.1 M Glucose. $CaCl_2$ ionizes in water to produce 3 ions. Glucose does not ionize in water.

0.1 M $CaCl_2$	0.1 M Glucose

7. Calculate the water potential at 25 degrees C for each side of the membrane.

$CaCl_2$: $\Psi = -3(.1)(.0831)(298)$
$= -7.43$
$\Psi = 0 + (-7.43)$ -7.43

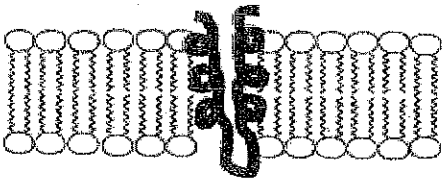
Glucose: $\Psi = -1(.1)(.0831)(298)$
$= -2.48$
$\Psi = 0 + (-2.48)$
$= -2.48$

8. Describe which way water will move and explain your answer.

Glucose → $CaCl_2$

high potential → low

Embedded proteins are often found spanning the membrane of a cell or organelle. These proteins serve as channels for specific molecules to travel through the membrane, either into or out of the cell.



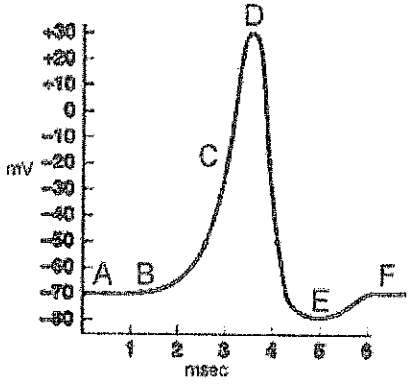
9. What sections of the embedded protein chain are most likely to contain amino acids with hydrophobic R-groups? Explain your reasoning.

- inside w/ lipid tails because they are also hydrophobic

10. What sections of the embedded protein chain are most likely to contain amino acids with hydrophilic R-groups? Explain your reasoning.

outside with the hydrophilic heads

The following diagram shows an action potential of a neuron. For each question, you can answer with one letter or multiple letters.



11. Explain the dynamics of a neuron at point A.

resting

12. What is happening at point B?

Na+ beginning to open channels

13. When will the potassium gated channels open?

D

14. At point F, would there be a more positive charge on the INSIDE or OUTSIDE of the neuron?

outside

15. Tetrodotoxin is a neurotoxin that blocks Na+ voltage gated channels. How would the function of the neuron be altered by the presence of this toxin?

No action potentials

16. Tay-Sachs disease is a human genetic abnormality that results in cells accumulating and becoming clogged with very large and complex lipids. Which cellular organelle must be involved in this condition?

lysosomes - can't digest lipids

17. It has been theorized that the organelles of eukaryotic cells evolved from prokaryotic living symbiotically within a larger cell. Explain three lines of evidence that support this theory.

- mitochondria/chloro have own DNA - energy producing processes
- proteins/DNA resemble prokaryotes
- replicate themselves

18. Compare the three types of transport across a cell membrane.

passive { Diffusion - high to low
Osmosis - high to low of water
Active - low to high, need energy
Bulk Transport - uses vesicles

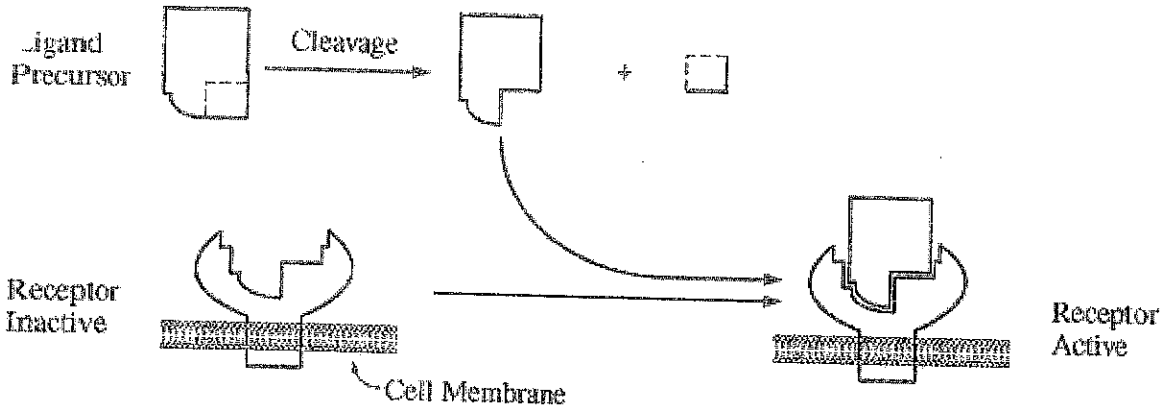
19. What is Quorum sensing and why is it important?

- Bacteria signaling
- determines whether they launch an attack and become harmful

Americans spend up to 100 billion dollars annually for bottled water. The only beverages with higher sales are carbonated soft drinks. Recent news stories have highlighted the fact that most bottled water comes from municipal water supplies, although it may undergo an extra purification step called reverse osmosis. Imagine two tanks that are separated by a membrane that is permeable to water, but not to the dissolved minerals present in the water. Tank A contains tap water and Tank B contains the purified water. Under normal conditions, the purified water would cross the membrane to dilute the more concentrated tap water solution. In the reverse osmosis process, pressure is applied to the tap water tank to force the water molecules across the membrane into the pure water tank.

20. After the reverse osmosis system has been operating for 30 minutes, the solution in Tanks A would
    (A) Be hypotonic to Tank B
    (B) Be isotonic to Tank B
    (C) Be hypertonic to Tank B
    (D) Move by passive transport to tank B

21. If you shut the system off and pressure was no longer applied to tank A, you would expect
    (A) the water to flow from Tank A to Tank B
    (B) the water to reverse flow from Tank B to Tank A
    (C) the water to flow in equal amounts in both directions
    (D) the water to flow against the concentration gradient



22. The figure above shows a model of a ligand precursor being cleaved to produce an active ligand that binds to a specific receptor. Which of the following is most likely to reduce the binding of the active ligand to its receptor?
(A) A change in the cytoskeletal attachment of transmembrane proteins
(B) The presence of a large amount of the precursor form of the ligand
(C) An increase in the ratio of the number of unsaturated to the number of saturated fatty acid tails of the membrane lipids
(D) A mutation in the receptor gene that causes a substitution of a charged amino acid for a nonpolar amino acid in the ligand binding site of the receptor

23. Membrane-bound organelles have been an important component in the evolution of complex, multicellular organisms. Which of the following best summarizes an advantage of eukaryotic cells having internal membranes?
(A) Eukaryotic cells are able to reproduce faster because of the presence of organelles.
(B) Some organelles, such as mitochondria and chloroplasts, are similar to prokaryotic cells in structure.
(C) Organelles isolate specific reactions, increasing metabolic efficiency.
(D) Compartmentalization leads to a higher mutation rate in DNA, which leads to more new species.

24. The concentration of solutes dissolved in the plasma of the blood is a particular concern when adding intravenous fluids to a patient. Suppose that a dog suffering from dehydration is brought into an emergency animal hospital. Choose the best description of the dog's RBC's at the beginning of treatment, and one-hour after treatment with appropriate intravenous fluid.
(A) THE RBC's will be larger than normal at the beginning of treatment and will become smaller after treatment.
(B) The RBC's will be normal sized at the beginning of treatment and many will likely burst after treatment
(C) The size fo the RBC's will not be affected by dehydration or after treatment
(D) The RBC's will be smaller than normal at the beginning of treatment and will become larger after treatment.

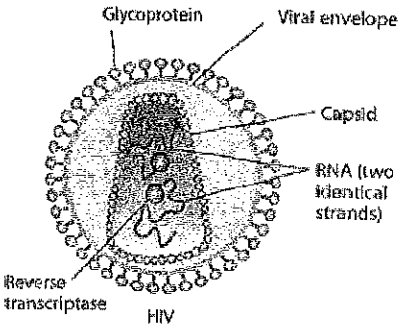
25. Which of the following is one of the ways that the membranes of winter wheat are able to remain fluid when it is extremely cold?
a. by increasing the percentage of unsaturated phospholipids in the membrane
b. by increasing the percentage of cholesterol molecules in the membrane
c. by decreasing the number of hydrophobic proteins in the membrane
d. by co-transport of glucose and hydrogen

26. What kinds of molecules pass through a cell membrane most easily?
a. large and hydrophobic
b. small and hydrophobic
c. large polar
d. ionic

27. A cell whose cytoplasm has a concentration of 0.02 molar glucose is placed in a test tube of water containing 0.02 molar glucose. Assuming that glucose is not actively transported into the cell, which of the following terms describes the tonicity of the external solution relative to the cytoplasm of the cell?
    a. turgid
    b. hypertonic
    c. hypotonic
    d. isotonic

28. In what way do the membranes of a eukaryotic cell vary?
    a. Phospholipids are found only in certain membranes.
    b. Certain proteins are unique to each membrane.
    c. Only certain membranes of the cell are selectively permeable.
    d. Only certain membranes are constructed from amphipathic molecules.

29. Why isn't the mitochondrion classified as part of the endomembrane system?
    a. It is a static structure.
    b. Its structure is not derived from the ER or Golgi.
    c. It has too many vesicles.
    d. It is not involved in protein synthesis.

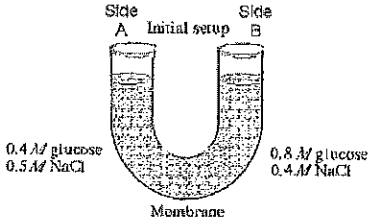


30. A biologist ground up some plant leaf cells and then centrifuged the mixture to fractionate the organelles. Organelles in one of the heavier fractions could produce ATP in the light, whereas organelles in the lighter fraction could produce ATP in the dark. The heavier and lighter fractions are most likely to contain, respectively,
    a. mitochondria and chloroplasts.
    b. chloroplasts and peroxisomes.
    c. peroxisomes and chloroplasts.
    d. chloroplasts and mitochondria.

31. Mammalian blood contains the equivalent of 0.15 *M* NaCl. Seawater contains the equivalent of 0.45 *M* NaCl. What will happen if red blood cells are transferred to seawater?
    a. Water will leave the cells, causing them to shrivel and collapse.
    b. NaCl will be exported from the red blood cells by facilitated diffusion.
    c. The blood cells will take up water, swell, and eventually burst.
    d. NaCl will passively diffuse into the red blood cells.

The solutions in the arms of a U-tube are separated at the bottom of the tube by a selectively permeable membrane. The membrane is permeable to sodium chloride and water but not to glucose. Side A is filled with a solution of 0.4 *M* glucose and 0.5 *M* sodium chloride (NaCl), and side B is filled with a solution containing 0.8 *M* glucose and 0.4 *M* sodium chloride. Initially, the volume in both arms is the same. Refer to the figure to answer the following questions.

32. At the beginning of the experiment,
    a. side A is hypertonic to side B
    b. side A is hypotonic to side B.
    c. side A is isotonic to side B.
    d. side A is hypertonic to side B with respect to glucose.



Human immunodeficiency virus (HIV) infects cells that have both CD4 and CCR5 cell surface molecules. The viral nucleic a molecules are enclosed in a protein capsid, and the protein capsid is itself contained inside an envelope consisting of a J bilayer membrane and viral glycoproteins. One hypothesis for viral entry into cells is that binding of HIV membrane glycoproteins to CD4 and CCR5 initiates fusion of the HIV membrane with the plasma membrane, releasing the viral capsid into the cytoplasm. An alternative hypothesis is that HIV gains entry into the cell via receptor -mediated endocytosis, and membrane fusion occurs in the endocytotic vesicle. To test these alternative hypotheses for HIV entry, researchers labeled the lipids on the HIV membrane with a red fluorescent dye.

33. What would be observed by live–cell fluorescence microscopy immediately after HIV entry if the red fluorescent lipid dye–labeled HIV membrane fuses with the target cell plasma membrane?
    a. A spot of red fluorescence will be visible on the infected cell's plasma membrane, marking the site of membrane fusion and HIV entry.
    b. The red fluorescent dye–labeled lipids will appear in the infected cell's interior.
    c. A spot of red fluorescence will diffuse in the infected cell's cytoplasm.
    d. A spot of red fluorescence will remain outside the cell after delivering the viral capsid.

Cystic fibrosis is a genetic disease in humans in which the CFTR protein, which functions as a chloride ion channel, is missing or nonfunctional in cell membranes.

34. If the sodium ion concentration outside the cell increases, and the CFTR channel is open, in what direction will chloride ions and water move across the cell membrane?
    a. Chloride ions will move out of the cell, and water will move into the cell.
    b. Both chloride ions and water will move out of the cell.
    c. Chloride ions will move into the cell, and water will move out of the cell.
    d. Both chloride ions and water will move into the cell.
    e. The movement of chloride ions and water molecules will not be affected by changes in sodium ion concentration outside the cell.

Read the following information and refer to Figure 7.4 to answer the following question.

Five dialysis bags, constructed from a semi-permeable membrane that is impermeable to sucrose, were filled with various concentrations of sucrose and then placed in separate beakers containing an initial concentration of 0.6 *M* sucrose solution. At 10-minute intervals, the bags were massed (weighed) and the percent change in mass of each bag was graphed.

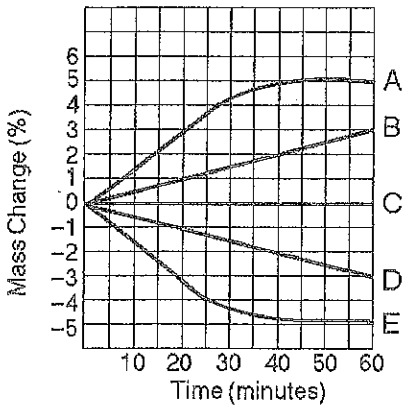


Figure 7.4

35. Which line represents the bag that contained a solution isotonic to the 0.6 molar solution at the beginning of the experiment?
    A, B, C, D, E

No change in mass

A laboratory assistant prepared solution of 0.8 *M*, 0.6 *M*, 0.4 *M*, and 0.2 *M* sucrose, but forgot to label them. After realizing the error, the assistant randomly labeled the flasks containing these four unknown solutions as flask A, flask B, flask C, and flask D.

Design an experiment, based on the principles of diffusion and osmosis, that the assistant could use to determine which of the flasks contains each of the four unknown solutions. Include in your answer

(a) a description of how you would set up and perform the experiment:

(b) the results you would expect from your experiments: and

(c) an explanation of those results based on the principles involved including water potential (Be sure to clearly state the principles addressed in your discussion.)

a) create bags w/ known molarity + measure % change in mass of bag when placed in solution

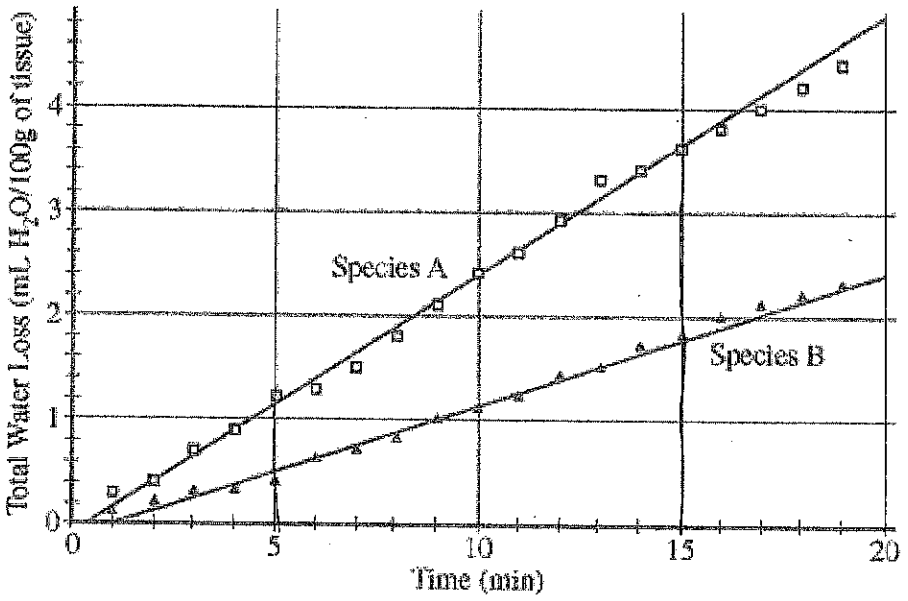
b) depends on choice for b

c) water moves from high to low concentration

The regulation of transpiration is an important homeostatic mechanism in plants.

(a) Under controlled conditions, a transpiration experiment was conducted using two plant species. The data collected are shown in the figure below. Using the data from the experiment, **calculate** the rate of transpiration for species A and species B between the times of 5 and 15 minutes (show your work). **Summarize** the difference between the two transpiration rates.

WATER LOSS VERSUS TIME FOR TWO PLANT SPECIES



(b) **Identify** and **explain** THREE different structural or physiological adaptations that could account for the different transpiration rates of species A and B.

(c) Water potential (Ψ) is described by the following formulas.

$$\Psi = \Psi_p + \Psi_s$$

$$\Psi = -iCRT$$

Discuss the variables in both formulas and how they affect water potential.

a) A- $\frac{3.6-1.2}{10}$ = .24 mL H_2O/min

B- $\frac{1.8-.4}{10}$ = .14 mL H_2O/min

b) See attached

c) See attached

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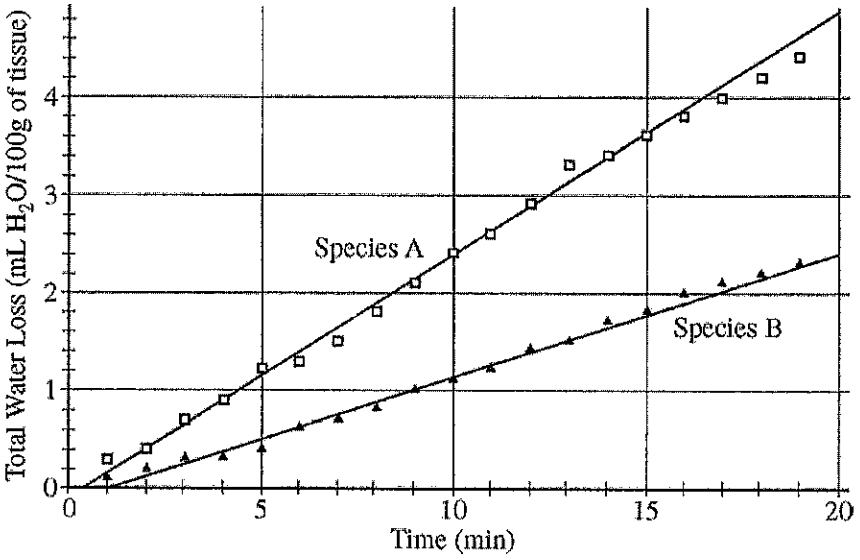
Question 4

The regulation of transpiration is an important homeostatic mechanism in plants.

(a) Under controlled conditions, a transpiration experiment was conducted using two plant species. The data collected are shown in the figure below. Using the data from the experiment, **calculate** the rate of transpiration for species A and species B between the times of 5 and 15 minutes (show your work). **Summarize** the difference between the two transpiration rates.
(3 points maximum)

WATER LOSS VERSUS TIME FOR TWO PLANT SPECIES



- Calculate transpiration rates, with units *(1 point each; 2 points maximum).*
- Correct setups with incorrect results *(1 point maximum).*

Species A
(1 point)

$$\frac{3.6 \text{ mL } H_2O - 1.2 \text{ mL } H_2O}{15 \text{ minutes} - 5 \text{ minutes}} = 0.24 \text{ mL } H_2O/100g/\text{min } (\pm 0.02)$$

OR

$$\frac{3.6 - 1.2}{15 - 5} = 0.24 \text{ mL } H_2O/100g/\text{min } (\pm 0.02)$$

OR equivalent

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Question 4 (continued)

Species B
(1 point)

$\frac{1.8 \text{ mL } H_2O - 0.4 \text{ mL } H_2O}{15 \text{ minutes} - 5 \text{ minutes}} = 0.14 \text{ mL } H_2O/100g/min \ (\pm 0.02)$

OR

$\frac{1.8 - 0.4}{15 - 5} = 0.14 \text{ mL } H_2O/100g/min \ (\pm 0.02)$

OR equivalent

Summarize the difference between the rates *(1 point).*

- Species A is losing water or transpiring faster than species B.

(b) **Identify** and **explain** THREE different structural or physiological adaptations that could account for the different transpiration rates of species A and B.
(6 points maximum)

Identify adaptation (1 point each; 3 points maximum)	**Explain effect and specify directionality (1 point each; 3 points maximum)**
Cuticle	Thicker cuticle decreases transpiration.
Stomata number	Increased number increases transpiration.
Stomata location	Underside location decreases transpiration.
Stomata size	Larger stomata increase transpiration.
Surface area of leaves	Increased surface area increases transpiration.
Root size or structure	Affects rate of water absorption, amount of water lost.
Root hairs	Increased number increases transpiration.
Leaf hairs	Presence decreases transpiration.
Stomatal crypts or recessed pits	Presence decreases transpiration.
C_3 photosynthesis	Requires more water than C_4.
C_4 photosynthesis: CO_2 concentrated as 4-carbon acid	Requires less water than C_3.
CAM photosynthesis: stomata open at night	Reduced water loss during day.
Abscissic acid	Closes the stomata, slows transpiration.
Guard cell regulation	Turgidity opens stomata, increasing transpiration.

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Question 4 (continued)

(c) Water potential (Ψ) is described by the following formulas.

$$\Psi = \Psi_p + \Psi_s$$

$$\Psi = -iCRT$$

Discuss the variables in both formulas and how they affect water potential.
(4 points maximum)

Variables in $\Psi = \Psi_p + \Psi_s$		**Discussion of effect on water potential (1 point each; 2 points maximum)**
Ψ_p	Pressure potential	Water will move from the area of high pressure to the area of low pressure.
Ψ_s	Solute potential	Water will move from the area of high solute potential (low solute concentration) to the area of lower solute potential (higher solute concentration).

	Variables in $\Psi = -iCRT$	**Discussion of effect on water potential (1 point each; 2 points maximum)**
i	Ionization constant	Greater ionization decreases water potential/increases water movement, OR Decrease in ionization increases water potential/decreases water movement.
C	Concentration	Increase in concentration decreases water potential/increases water movement, OR Decrease in concentration increases water potential/decreases water movement.
R	Pressure constant	No change in water potential/movement.
T	Temperature	Increase in temperature decreases water potential/increases water movement, OR Decrease in temperature increases water potential/decreases water movement.

- Discussion stating that the formula allows osmotic potential or water movement to be calculated or predicted *(1 point)*.