# Supplemental Material

CBE-Life Sciences Education

Riedl et. al

# Supplemental Material Table of Contents

## Supplemental Table 1. Prior Experience and Pass Rates of Instructors.

| | Prior Experience of Instructors before the Study | | | Study |
|---|---|---|---|---|
| Instructors | Average semesters at FRCC | Average number of BIO111 sections taught at FRCC | Pass Rates in prior semesters of BIO111 | Pass rates during the study |
| Non-Flipped Sections | 7.4 | 10.8 | 65% | 60% |
| Flipped Sections | 5.8 | 9.5 | 68% | 63% |
| P values | | | 0.2421 | 0.1937 |

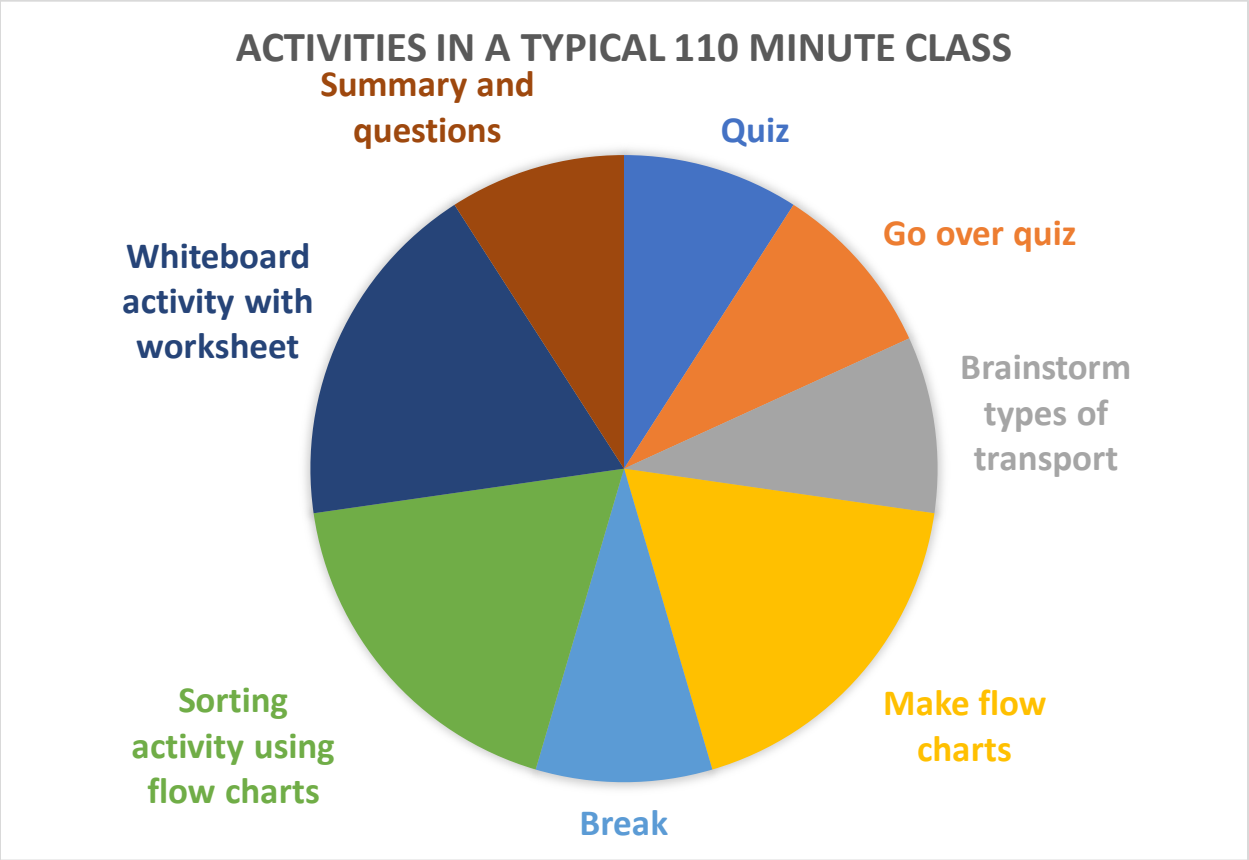
Instructors who taught flipped sections of BIO111 did not have more teaching experience at FRCC and did not have higher pass rates prior to the term of the study.

## Supplemental Table 2. Pass rates in BIO111 Flipped vs. Non-flipped

| | **Passed** | **Total** | **%** | **P values** |
|---|---|---|---|---|
| Flipped fall | 123 | 197 | 62.4% | |
| Flipped spring | 117 | 181 | 64.6% | |
| Total flipped | 240 | 378 | 63.5% | |
| | | | | |
| Non-flipped fall | 133 | 205 | 64.9% | 0.3012 |
| Non-flipped spring | 114 | 205 | 55.6% | 0.0359 |
| Total non-flipped | 247 | 410 | 60.2% | 0.1700 |

**Table 2.** Pass rates for BIO111 were not significantly different for the combined semesters of the study. Although the difference in the spring semester did reach significance, we think that the combined data is more accurate since it evens out possible semester-specific effects.

Supplemental Figure 1. Example of a Typical 110-Minute Flipped Class Period



## Supplemental Figure 2. Quiz and Exam Questions from One Chapter

Provided below is a sample of reading quiz questions, common unit exam questions, and final exam questions from one chapter to allow comparison between the types of questions we asked on quizzes versus exams.

**Cell Membranes and Cell Transport – In-Class Quiz Questions**

**Individual Quiz:**

1. Which of the following is true about a cell membrane?
   A. It has only one layer of phospholipids
   B. It has two layers of phospholipids
   C. The part of the membrane that faces the inside of the cell is hydrophobic
   D. The part of the membrane that faces the outside of the cell is hydrophilic
   E. Both B and D

2. Which of the following types of proteins could be used to carry hydrophilic materials across a cell membrane?
   A. Transmembrane proteins
   B. Channel proteins
   C. Carrier proteins
   D. Pumps
   E. All of the above

3. Which of the following types of transport allows a cell to move molecules from low concentration to high concentration?
   A. Passive diffusion
   B. Facilitated diffusion
   C. Active Transport
   D. Osmosis
   E. All of the above

4. Which of the following types of proteins are specialized to allow water in and out of the cell?
   A. Ion channels
   B. Aquaporins
   C. Carrier proteins
   D. Pumps
   E. All of the above

5. Which of the following types of membrane proteins require ATP?
   A. Channel proteins
   B. Carrier proteins
   C. Ion channels
   D. Pumps
   E. All of the above

**Group Quiz**

1. Channel proteins:
   A. Must have all hydrophobic amino acids
   B. Must have all hydrophilic amino acids
   C. Must have some hydrophobic and some hydrophilic amino acids
   D. Do not have primary structure
   E. Do not have tertiary structure

2. The sodium potassium pump:
   A. Sets up ion gradients that can be used to do work
   B. Directly uses ATP
   C. Is a transmembrane protein
   D. Transports two types of ions
   E. All of the above are true

3. Which of the following are cell membranes most impermeable to?
   A. Water
   B. Small, polar molecules
   C. Charged molecules
   D. Hydrophobic molecules
   E. C and D are equally impermeable

4. When there are more sodium ions inside of a cell than outside of the cell, sodium ions enter the cell by:
   A. Simple diffusion
   B. Facilitated diffusion
   C. Osmosis
   D. Active Transport
   E. A and B are both possible

5. Which of the following is true about secondary active transport?
   A. It directly uses ATP
   B. It can move ions from areas of low concentration to areas of high concentration
   C. It requires a transmembrane protein
   D. It doesn't require energy
   E. B and C

**Cell Membranes and Cell Transport – Unit Exam Questions**

1. The term phospholipid can best be described by which of the following?
   a. A nonpolar lipid molecule that is made amphipathic by the addition of a phosphate group
   b. A nonpolar lipid molecule that is made polar by the addition of a phosphate group
   c. A polar lipid molecule that is made nonpolar by the addition of a phosphate group
   d. A polar lipid molecule that fully interacts with water
   e. A polar lipid molecule that fully repels water

2. During diffusion, individual particles move:
   a. randomly.
   b. only until equilibrium is reached.
   c. toward the region of lower concentration.
   d. toward the region of higher concentration.
   e. Individual particles do not move during diffusion.

3. What will happen to a red blood cell (RBC) if it is placed into a beaker of pure water?
   a. The cell will swell because the water is hypotonic relative to the cytoplasm of the RBC.
   b. The cell will swell because the water is hypertonic relative to the cytoplasm of the RBC.
   c. Nothing will happen.
   d. The cell will shrink because the water is hypertonic relative to the cytoplasm of the RBC.
   e. The cell will shrink because the water is hypotonic relative to the cytoplasm of the RBC.

4. Which of the following means of transport would most likely be used for moving a polar molecule from a low concentration on the outside of a cell to a high concentration on the inside of a cell?
   a. Osmosis
   b. Passive transport
   c. Active transport through a "pump" protein
   d. Facilitated diffusion through a carrier protein
   e. Facilitated diffusion through an ion channel protein

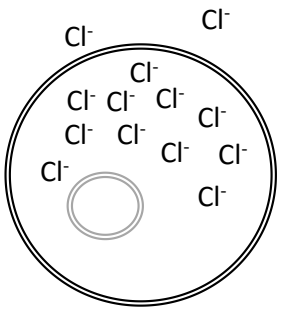
5. Which of the following is most liquid at room temperature?
   a. a triglyceride with unsaturated fatty acids
   b. a triglyceride with saturated fatty acids
   c. hydrogenated corn oil
   d. hydrogenated butter
   e. None of the above would be liquid at room temperature.

**Cell Membranes and Cell Transport – Common Final Exam Questions**

1. A transmembrane protein contains a stretch of amino acids that crosses the plasma membrane. The side chains of the amino acids that associate with the phospholipid tails are:
   a. ionic.
   b. polar.
   c. aromatic.
   d. hydrophilic.
   e. hydrophobic.

2. A scientist diluted a blood sample with a salt solution. However, when she looked at the red blood cells under a microscope, she found that they had swelled and burst. With what type of solution did she mix the blood?
   a. isotonic
   b. hypotonic
   c. hypertonic
   d. hydrophilic
   a. isotonic

3. If Chloride ions are in higher concentration inside the cell compared to the outside of the cell (see picture at right), what method would they use to **enter** the cell?
   a. osmosis
   b. active transport
   c. simple diffusion
   d. facilitated diffusion
   e. receptor-mediated endocytosis



## Supplemental Table 3. Race of Study Participants

| Race | Flipped Number of Students (Percent of Total) | Non-flipped Number of Students (Percent of total) | P value |
|---|---|---|---|
| 2 or More | 18 (5%) | 18 (4%) | 0.2489 |
| American Indian | 3 (1%) | 1 (0%) | N/A |
| Asian | 22 (6%) | 22 (5%) | 0.2689 |
| Black | 10 (3%) | 9 (2%) | 0.1836 |
| Hispanic | 84 (22%) | 98 (24%) | 0.2527 |
| International | 6 (2%) | 8 (2%) | 0.5 |
| Pacific Islander | 1 (0%) | 0 (0%) | N/A |
| Unknown | 16 (4%) | 16 (4%) | 0.5 |
| White | 219 (58%) | 242 (59%) | 0.3880 |

**Table 3** shows demographic data on self-reported race for the students enrolled in our study. The distribution of students by race was not significantly different between flipped and non-flipped sections.

## Supplemental Table 4. First-Generation Status of Participants

| | Flipped (n = 378) | Non-flipped (n = 410) | P value |
|---|---|---|---|
| First-Generation Students (Percent of Total) | 245 (65%) | 256 (62%) | 0.1912 |
| Pass Rates of First-Generation Students | 59% | 57% | 0.2846 |

**Table 4** shows demographic data on first-generation student status for the students enrolled in our study. The percentage of first-generation students was not significantly different between flipped and non-flipped sections. The pass rates of first-generation students were also not significantly different between the two groups.

## Supplemental Table 5. Pass Rates by Race

| Race | Flipped Pass rate | Non-flipped Pass rate | P value |
|---|---|---|---|
| 2 or More | 72% | 56% | 0.000002 |
| Asian | 64% | 68% | 0.1180 |
| Hispanic | 52% | 47% | 0.0800 |
| White | 69% | 65% | 0.1166 |

**Table 5** shows the pass rates of students for the four largest race categories. The only category that reached significance is students who reported that they belonged to two or more races. Since we do not know what races these students belong to, it is difficult to interpret this data point.

## Supplemental Table 6. Graduation Rates of Study Participants.

| Graduation within 3 years of BIO111 course | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BIO111** | **Enrollment** | **Graduated** | **Graduation Rate** | **A** | **B** | **C** | **D** | **F** | **W** |
| Flipped | 378 | 116 | 31% | 46% | 44% | 36% | 22% | 0% | 14% |
| Non-Flipped | 410 | 86 | 21% | 32% | 29% | 23% | 5% | 9% | 15% |
| **Total** | **788** | **202** | **26%** | **39%** | **36%** | **30%** | **13%** | **4%** | **15%** |
| **Graduation within 4 years of BIO111 course** | | | | | | | | | |
| **BIO111** | **Enrollment** | **Graduated** | **Graduation Rate** | **A** | **B** | **C** | **D** | **F** | **W** |
| Flipped | 378 | 107 | 28% | 43% | 38% | 35% | 22% | 3% | 13% |
| Non-Flipped | 410 | 82 | 20% | 34% | 27% | 23% | 7% | 6% | 14% |
| **Total** | **788** | **189** | **24%** | **38%** | **32%** | **29%** | **14%** | **4%** | **14%** |
| **Graduation within 5 years of BIO111 course** | | | | | | | | | |
| **BIO111** | **Enrollment** | **Graduated** | **Graduation Rate** | **A** | **B** | **C** | **D** | **F** | **W** |
| Flipped | 378 | 120 | 32% | 48% | 41% | 38% | 22% | 3% | 14% |
| Non-Flipped | 410 | 94 | 23% | 39% | 31% | 24% | 7% | 6% | 16% |
| **Total** | **788** | **214** | **27%** | **43%** | **36%** | **32%** | **14%** | **4%** | **15%** |

**Table 6** shows the overall three-year, four-year, and five-year graduation rates of study participants (highlighted), as well as graduation rates based on grades in BIO111. Overall graduation rates are significantly different for all three years measured (3-years: $p = 0.00067$, 4-years: $p = 0.00423$, 5-years: $p = 0.00230$).

## Supplemental Figure 3. Graduation Rates by BIO111 Grade.

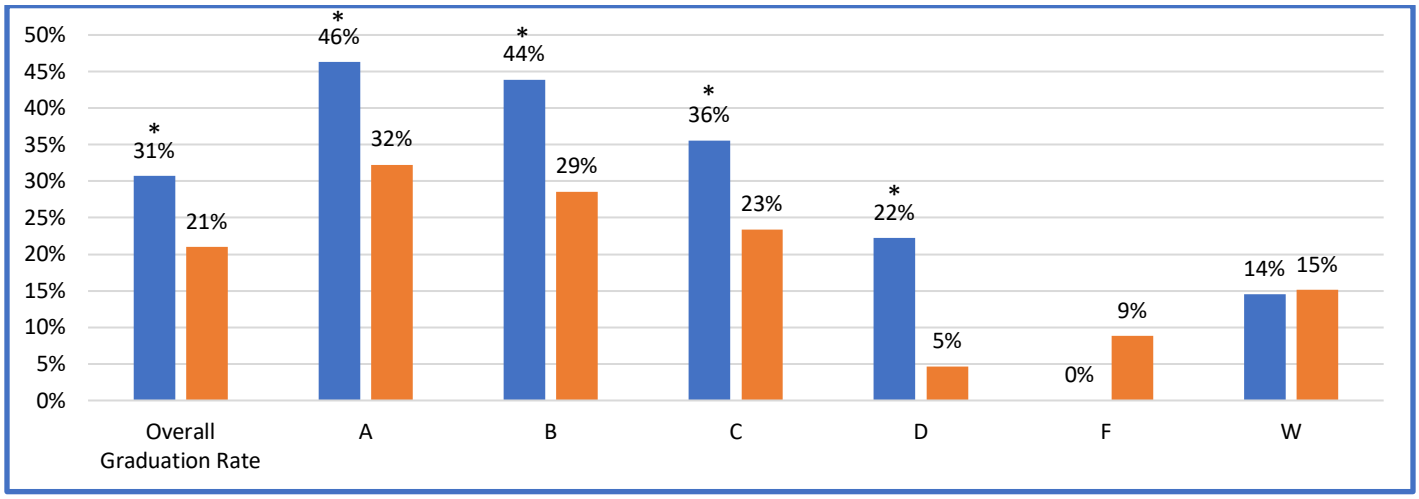



**Figure 3** shows the graduation rates of students from flipped (blue) sections and non-flipped (orange) sections by grade in BIO111. Differences in graduation rates are significant overall and for students who earned A, B, C, or D grades in BIO111 (A: p = 0.000027, B: p = 0.000006, C: p = 0.000030, D: p = 0, W: F: p = N/A, p = 0.34021).

## Supplemental Material Appendix A. Examples of Materials from a Typical Flipped Classroom

### Links to SoftChalk™ Modules:

Membranes, Part 1: https://softchalkcloud.com/lesson/serve/mCLNFlutTpMqbz/html

Membranes, Part 2: https://softchalkcloud.com/lesson/serve/3tLORyrZ8IKcG0/html

# Chapter 6 – Membrane Structure and Function

Part 6a

1. Define
   A. Amphipathic:

   B. Cholesterol:

   C. Glycoprotein:

   D. Diffusion:

   E. Dynamic equilibrium:

   F. Concentration gradient:

   G. Transport protein:

   H. Aquaporin:

2. Describe the fluid-mosaic model of membrane structure:
   A. Draw the structure of a phospholipid bilayer.
   B. Add transmembrane proteins and peripheral membrane proteins to your bilayer.
   C. Add cholesterol, glycoproteins, and glycolipids to your bilayer.

3. Explain why cell membranes are considered semi-fluid.

4. Explain how the following changes affect the fluidity and permeability of the membrane:
   A. Increasing the length of the tails
   B. Increasing the saturation of the tails
   C. Changing the temperature
   D. Changing the amount of cholesterol
5. Explain why cell membranes are selectively permeable.

6. Predict the direction of diffusion, given concentrations of solutes on both sides of a membrane.

7. Differentiate between diffusion and facilitated diffusion.

8. Describe the structure of a channel protein, indicating the hydrophobic and hydrophilic regions.

9. Describe the two forces that form the electrochemical gradient for an ion moving across a membrane.

10. Describe the structure of a carrier protein and explain when they would be used.

Part 6b

1. Define:
   A. Osmosis

   B. Tonicity

2. Describe hypertonic, hypotonic and isotonic solutions and explain what happens to a cell if placed in each.

3. Distinguish between active and passive transport across a cell membrane. Which uses energy?

4. Describe how the sodium potassium pump works.

5. Explain why cells set up ion gradients with the sodium potassium pump.

6. Distinguish between primary active transport and secondary active transport.

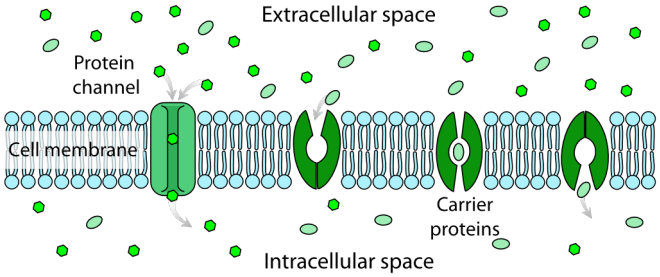
7. Determine which method of transport must be used by a cell when given an example of a molecule at certain concentrations inside and outside of the cell.

8. List and describe the three types of endocytosis and tell what types of substances are brought into the cell by each.

9. Describe the process of exocytosis.

## Magnetic Membrane Scenarios

Instructions: Cut out membrane scenario cards and give one to each group of 2-6 students. Students draw each scenario on a whiteboard or arrange membrane components on a magnetic whiteboard to answer the questions about their scenario. They then report out or pass their scenarios to other groups and repeat.




Label the inside and outside of the cell, a trans-membrane protein, and a peripheral protein. Add cholesterol to your membrane.

SCENARIO 1: Inside the cell there is 1% $K^+$; outside the cell there is 2% $K^+$. The $K^+$ channels are CLOSED. Illustrate these conditions and then answer the questions.

a. Label the hypertonic and hypotonic environments.

b. Draw an asterisk in the region that has the higher concentration of water.

c. Which way will water move?

d. What is the name of the process by which water moves across the membrane?

e. Is energy used to move water? Explain.

Label the inside and outside of the cell, a trans-membrane protein, and a peripheral protein. Add cholesterol to your membrane.

SCENARIO 2: Since cells continuously generate carbon dioxide, there is a higher carbon dioxide concentration inside of cells. Illustrate this by writing $CO_2$ where carbon dioxide levels are high. Answer the questions about this scenario.

a. Name the process by which carbon dioxide EXITS the cell.

b. Is energy used to move carbon dioxide out of the cell?

c. Are proteins needed to move carbon dioxide out of the cell?

d. Can carbon dioxide cross the phospholipid bilayer directly? Why or why not?

Label the inside and outside of the cell, a trans-membrane protein, and a peripheral protein. Add cholesterol to your membrane.

SCENARIO 3: Energy from $Na^+$ ion gradients (established by active transport) is used to transport amino acids (aa) against their gradient into a cell via a shared carrier protein.

a. Illustrate the $Na^+$ concentrations inside and outside of the cell.

b. Illustrate the aa concentrations inside and outside of the cell.

c. Name the process by which aa's enter the cell.

d. Was energy used to move the aa's into the cell? Explain.

Label the inside and outside of the cell, a trans-membrane protein, and a peripheral protein. Add cholesterol to your membrane.

SCENARIO 4: Inside the cell there is 1% $K^+$; outside the cell there is 2% $K^+$. The $K^+$ channels are OPEN. Illustrate these conditions and then answer the questions.

a. What is the name of the process by which K+ EXITS the cell?

b. Is energy used to move K+ out of the cell?

c. What is the name of the process by which K+ ENTERS the cell?

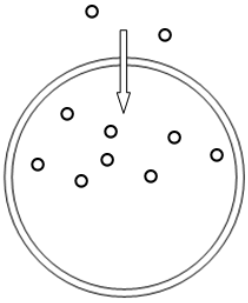
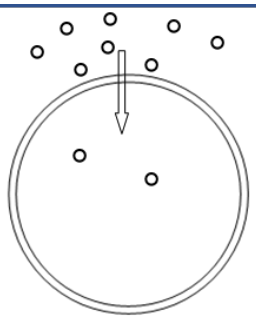
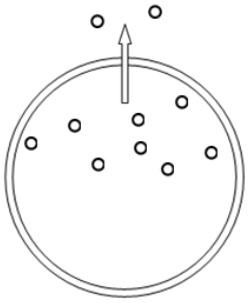
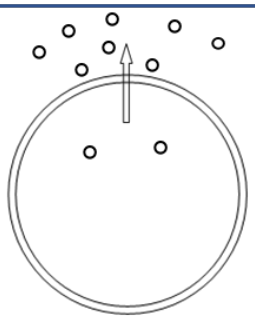
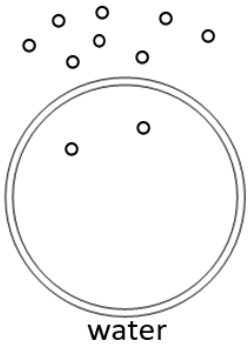
d. Is energy used to move K+ into the cell?

## Cell Transport Grid Game

Instructions: Print one copy of the cell transport grid plus the cards on the next page for each group of 2-6 students. Cut out the cards and give each group a grid and a deck of cards. Students take turns choosing a card, placing it on the correct grid box, and explaining their reasoning. When finished, groups compare their answers, discuss any differences, and make changes if needed.

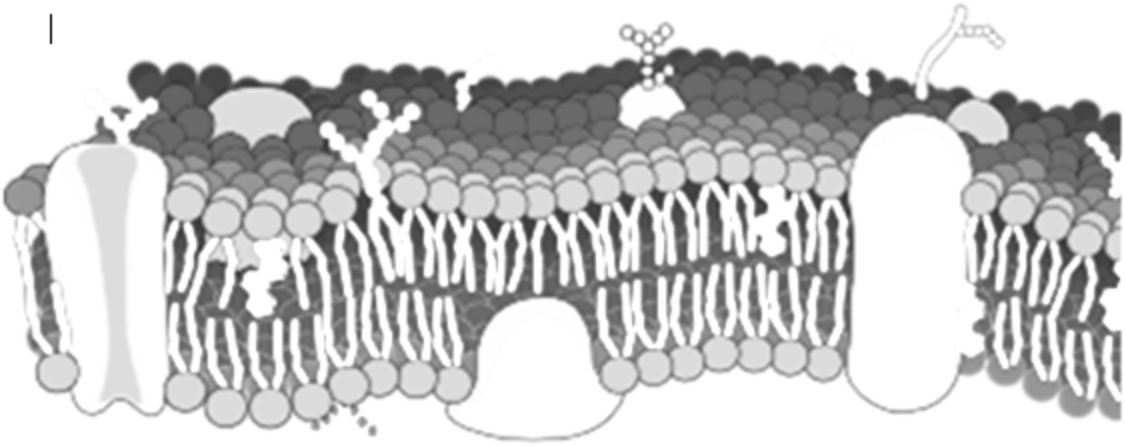
| | | |
|---|---|---|
| Facilitated Diffusion | Phagocytosis | Pinocytosis |
| Simple Diffusion | Secondary Active Transport | Receptor-mediated endocytosis |
| Osmosis | Primary Active Transport | Exocytosis |

Cards for Cell Transport Grid Game: Print and cut out one set of cards for each group.

| | | | |
|---|---|---|---|
| Magnesium ions, which are in higher concentration outside the cell, enter the cell |  $Na^+$ ions |  $Na^+$ ions |  $K^+$ ions |
| Glucose, which is in higher concentration outside the cell, enters the cell | Amino acids, which are in higher concentration outside the cell, enter the cell | Nitrous oxide, a small nonpolar signaling molecule, which is in higher concentration outside the cell, enters the cell |  $Cl^-$ ions |
| Oxygen gas enters the cell from the bloodstream | Glucose, which is in higher concentration inside the cell, enters the cell | Energy from ion gradients, set up by the sodium-potassium pump, is used to transport amino acids into a cell |  water |
| A cell is put into a hypotonic solution | Sodium ions are transported out of a cell, against their concentration gradient | ATP is used to establish an ion gradient | Water moves through tiny pores in a cell membrane |
| A specific protein is taken into a cell after binding to a receptor | Tiny amounts of fluid with dissolved particles are taken into a cell by vesicle | A bacterium is engulfed by a macrophage | A secretory vesicle filled with neurotransmitter is emptied into the extracellular space |

## Membrane Worksheet

**Exterior of cell**



**Interior of cell**

1. Shown above is a diagram of a cell plasma membrane. It is composed of three of the four types of macromolecules. Answer the following questions about this membrane:

   A. The "fluid" portion of the membrane is composed of _____

      A1. Label the hydrophobic portion of this layer.

      A2. Label the hydrophilic portion of this layer.

   B. The "mosaic tiles" floating among the lipids are _____

      B1. Label a transmembrane protein. Which parts have hydrophilic side chains? Which parts are hydrophobic?

      B2. Label a peripheral membrane protein.

   C. Attached to the outside of a membrane are short _____ chains that, among other functions, help the immune system recognize the cells as "self".

      C1. Label a protein that has a carbohydrate chain attached. This is called a _____

      C2. Label a lipid that has a carbohydrate chain attached. This is called a _____

   D. _____ is another lipid in the membrane. It is a small hydrophobic molecule that integrates between the phospholipid tails and affects the fluidity of the membrane. Label it on the diagram.

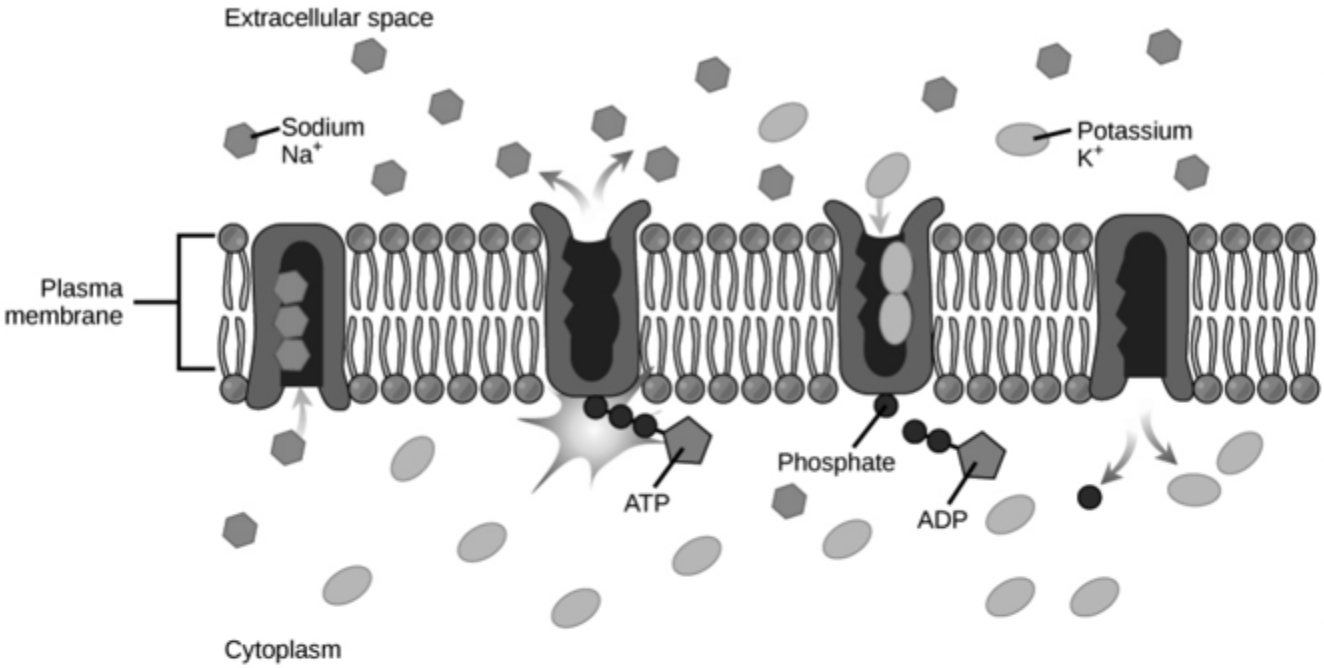
2. What does selectively permeable mean? Why is a phospholipid bilayer selectively permeable?

   A. Name two substances that can pass through a phospholipid bilayer and explain why they are able to cross the membrane.

   B. Name two substances that *cannot* pass through a phospholipid bilayer and explain why they are unable to cross the membrane.

## Sodium-Potassium Pump Activity

Instructions: This activity uses a simple handmade moveable model of the pump, with two different colored beads for ions and a snap bead ATP with detachable phosphate groups. Students model the pump using these components.




Put the following steps in the correct order for the function of the sodium-potassium pump:

_____ Two potassium ions bind to the pump on the outside of the cell

_____ The phosphate group detaches from the pump

_____ The pump changes shape and releases 3 sodium ions outside the cell

_____ The pump changes shape and releases 2 potassium ions inside the cell

_____ 3 sodium ions bind to the pump on the inside of the cell

_____ An ATP binds to the pump on the inside of the cell

_____ ADP detaches from the pump, leaving a phosphate group attached to the pump

1. Use the phospholipids, sodium potassium pump, ions, and ion channels to build a model of the membrane on your table. Put a high concentration of sodium ions inside the cell and a high concentration of potassium ions outside of the cell. Use your model to demonstrate how the sodium-potassium pump works.

2. What is the end result of the sodium-potassium pump functioning in a cell?

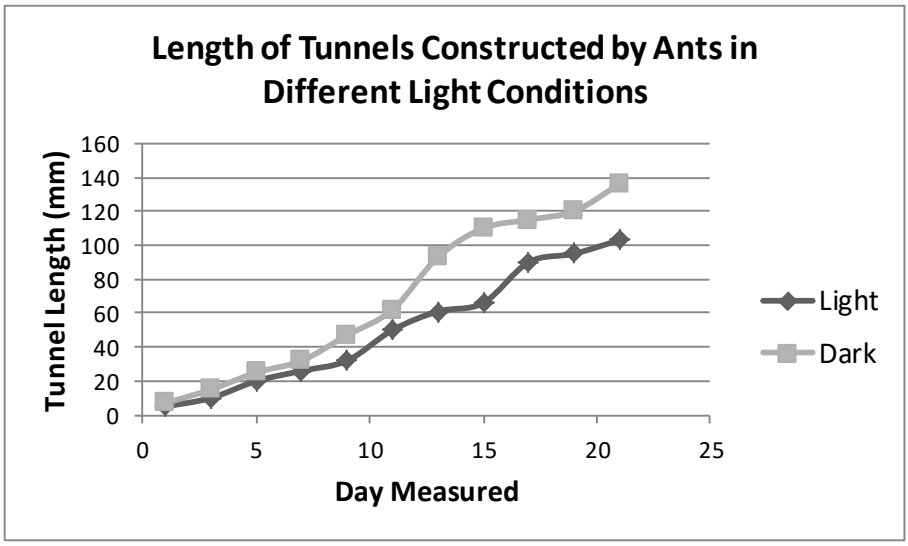
3. Most of the ATP produced by our cells is used to run the sodium-potassium pump, suggesting that it is extremely important. Give an example of how the pump's function is used in our bodies.

## Supplemental Material Appendix B.

### The Fifty Common Comprehensive Final Exam Questions

***Read the information below to answer Questions 1-2:***

Ten ant colonies were set up with the same number and type of ants in each. The same amount of food was given to each colony, and the colonies were kept at the same temperature. Five of the colonies were exposed to light and five were covered with black construction paper so that they did not receive any light. Every other day for three weeks, the length of the tunnels was measured in millimeters. Averages for the light and dark groups were then computed and graphed. The results are presented below.




1. Which of the following is a prediction that is supported by this data?
   a. Ants dig tunnels.
   b. Ants sleep at night.
   c. Ants cannot detect light.
   d. Ants dig longer tunnels when exposed to light.
   e. Ants dig longer tunnels when kept in the dark.

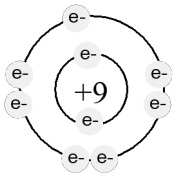
2. In the investigation, the type of food given to the ants was a(n) _____.
   a. experimental group
   b. independent variable
   c. dependent variable
   d. control variable
   e. hypothesis

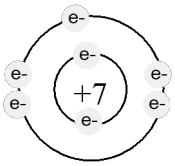
3. A population of lizards in Northern California is brown and is not poisonous to birds. A population of lizards in Southern California is orange and is poisonous to birds. In central California, where the two species overlap, a new species of non-poisonous, orange lizards arose. Which of the following statements best explains the existence of non-poisonous orange lizards?
   a. Non-poisonous brown lizards are more attractive to mates.
   b. Non-poisonous lizards turn orange by eating orange flowers and then pass the trait on.
   c. Non-poisonous orange lizards have a selective disadvantage since they can't blend in.
   d. Non-poisonous orange lizards have a selective advantage since birds avoid orange lizards.
   e. Non-poisonous brown lizards changed color once they noticed birds didn't eat orange lizards.

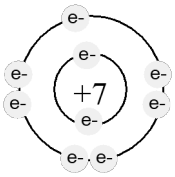
***Use your copy of the periodic table to answer questions 4-5.***

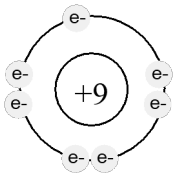
4. If a single atom of phosphorus (P) contains 16 neutrons, what is the mass of this atom?
   a. 15 Daltons
   b. 16 Daltons
   c. 30 amu
   d. 32 amu
   e. 31 Daltons

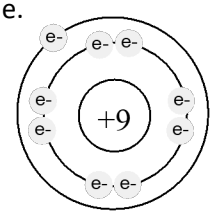
5. Which of the following is the correct electron shell diagram of a fluorine (F) atom?

a. 


b. 


c. 


d. 


e. 


6. Two atoms that have very different electronegativities and that each have one unpaired valence electron will form which type of bond?
   a. non-polar covalent
   b. polar covalent
   c. hydrogen
   d. peptide
   e. none

7. What is the pH of a solution that has a hydrogen ion concentration of 0.0001M (moles per liter)?
   a. 0.0001
   b. 0.1
   c. 1
   d. 2
   e. 4

8. When we eat carbohydrate rich foods, digestive enzymes break starch down into simple sugars that can be absorbed by our cells. The type of chemical reaction used to break polysaccharides into monomers is called:
   a. glycosidic
   b. hydrolysis
   c. condensation
   d. dehydration synthesis
   e. both c and d

9. The substitution of one amino acid for another in a polypeptide chain can affect the _____ of the resulting protein:
   a. primary structure
   b. secondary structure
   c. tertiary structure
   d. quaternary structure
   e. all levels of protein structure can be affected by substituting one amino acid for another.

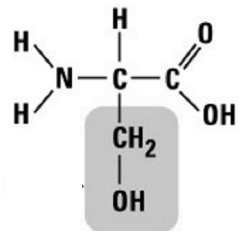
10. Which of the following is a difference between DNA and RNA?

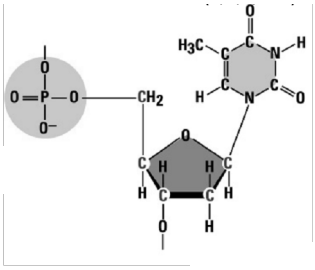
a. DNA is double stranded; RNA is single-stranded.
b. DNA molecules are shorter than RNA molecules.
c. DNA molecules contain uracil; RNA molecules contain thymine
d. DNA has a sugar-phosphate backbone; RNA has a peptide backbone.
e. All of the above are differences.

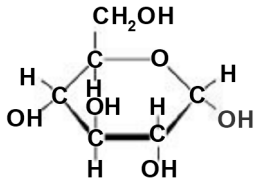
11. An RNA nucleotide (ribonucleotide) has all of the following EXCEPT:

a. a nitrogen-containing base
b. a phosphate group bonded to the 5' carbon
c. a hydroxyl group bonded to the 2' carbon
d. a hydroxyl group bonded to the 3' carbon
e. a hydroxyl group bonded to the 6' carbon

12. Which of the following depicts a monomer that would be found in glycogen?

a. 

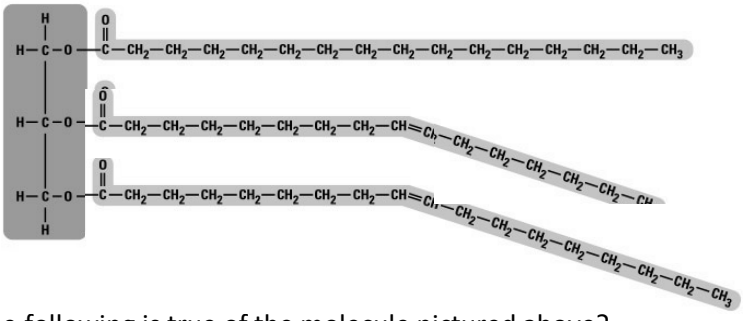
b. 

c. 

13. The main difference between starch and glycogen is:

a. starch is made of ribose, while glycogen is made of glucose.
b. starch is made of glucose, while glycogen is made of ribose.
c. starch is found in plant cells, while glycogen is found in animal cells.
d. starch functions to store energy, while glycogen functions as a structural molecule.
e. glycogen functions to store energy, while starch functions as a structural molecule.

***Question 14 refers to the picture below:***



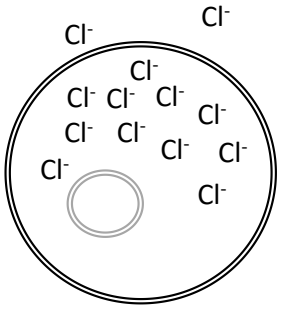
14. Which of the following is true of the molecule pictured above?

a. It would be solid at room temperature because it contains only saturated fatty acids.
b. It would be solid at room temperature because it contains unsaturated fatty acids.
c. It would be liquid at room temperature because it contains unsaturated fatty acids.
d. It would be liquid at room temperature because it contains only saturated fatty acids.
e. It will spontaneously form into biological membranes.

15. A transmembrane protein contains a stretch of amino acids that crosses the plasma membrane. The side chains of the amino acids that associate with the phospholipid tails are:
    a. ionic.
    b. polar.
    c. aromatic.
    d. hydrophilic.
    e. hydrophobic.

16. A scientist diluted a blood sample with a salt solution. However, when she looked at the red blood cells under a microscope, she found that they had swelled and burst. With what type of solution did she mix the blood?
    a. equaltonic
    b. hypotonic
    c. hypertonic
    d. hydrophilic
    e. isotonic

17. If Chloride ions are in higher concentration inside the cell compared to the outside of the cell (see picture at right), what method would they use to **enter** the cell?
    a. osmosis
    b. active transport
    c. simple diffusion
    d. facilitated diffusion
    e. receptor-mediated endocytosis




18. Which of the following pairs is <u>mismatched</u>?
    a. nucleus - location of DNA
    b. ribosome - protein synthesis
    c. mitochondria - perform photosynthesis
    d. smooth endoplasmic reticulum – synthesizes lipids
    e. Golgi apparatus - modification, processing, and sorting of macromolecules

19. Which of the following proteins will **<u>NOT</u>** be made on bound ribosomes that are attached to the rough endoplasmic reticulum?
    a. Actin protein, which will remain in the cytoplasm
    b. Growth factor receptor protein, which ends up inserted into the plasma membrane
    c. Pepsin protein, which is secreted by cells lining the stomach
    d. Acid hydrolase protein, which ends up inside lysosomes
    e. All of the above proteins would be made on bound ribosomes.

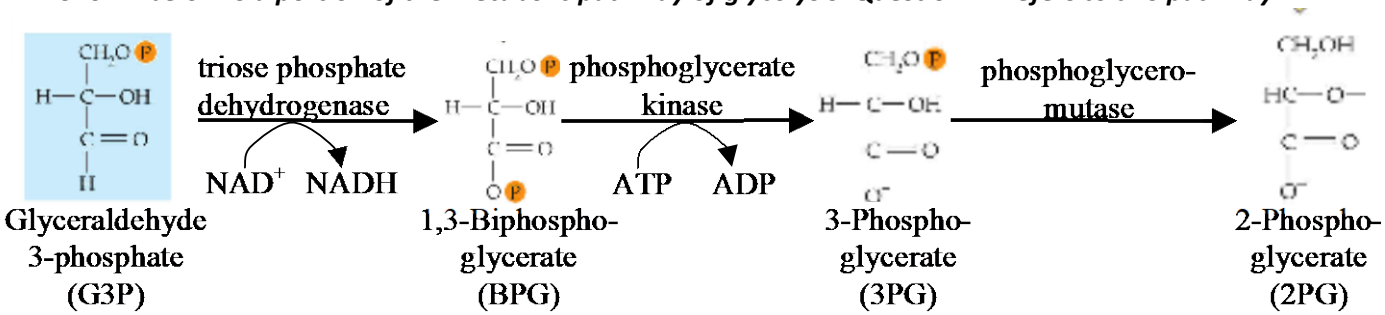
20. A macrophage encounters a bacterium, ingests it, and destroys it. This is an example of:
    a. receptor-mediated endocytosis.
    b. phagocytosis.
    c. pinocytosis.
    d. exocytosis.
    e. diffusion.

21. The chromosomal hereditary material is packaged into this organelle in eukaryotic cells but not in prokaryotic cells. This organelle is the:
    a. plasma membrane.
    b. mitochondria.
    c. chloroplast.
    d. centriole.
    e. nucleus.

22. High temperature may inactivate an enzyme because:
    a. hydrogen bonds between amino acids are disrupted.
    b. the shape of the active site is changed.
    c. it can no longer bind to its substrate.
    d. the tertiary structure is disrupted.
    e. All of the above

23. An allosteric inhibitor attaches to an enzyme and _____ whereas a competitive inhibitor binds to the active site of the enzyme and_____:
    a. blocks substrate attachment … produces a different product
    b. changes the enzymes shape… blocks substrate attachment
    c. produces a different product … activates the enzyme
    d. activates the enzyme… changes the enzymes shape
    e. distorts the active site… adds a cofactor to the substrate

***Shown below is a portion of the metabolic pathway of glycolysis. Question 24 refers to this pathway.***




24. Which molecule is the *substrate* of phosphoglyceromutase?
    a. glyceraldyhyde 3-phosphate (G3P)
    b. 1,3-Biphosphoglycerate (BPG)
    c. triose phosphate dehydrogenase
    d. 3-phosphoglycerate (3PG)
    e. ATP

25. During aerobic glucose catabolism, high energy electrons are taken from glucose and transferred to electron carriers. The cell then uses the energy from these electrons to:
    a. make glucose.
    b. produce oxygen.
    c. reduce electron carriers.
    d. produce carbon dioxide.
    e. pump hydrogen ions across the inner mitochondrial membrane.

26. The energy that fuels the turbine engine of the ATP synthase molecule comes directly from:
    a. oxidized electron carriers.
    b. hydrogen ion gradients.
    c. sunlight.
    d. oxygen.
    e. water.

27. The point of a cell doing lactic acid fermentation is to produce _____ so that glycolysis can continue.
    a. ADP
    b. $NAD^+$
    c. NADH
    d. carbon dioxide
    e. pyruvate

28. The first pathway of glucose catabolism is glycolysis. The net gain of this pathway is:
    a. 2 ATP, 2 NADH, 2 pyruvate
    b. 2 ATP, 0 NADH, 4 pyruvate
    c. 0 ATP, 2 NADH, 2 pyruvate
    d. 4 ATP, 4 NAD+, 2 pyruvate
    e. 0 ATP, 2 NAD+, 4 pyruvate

29. During the light-dependent reactions of photosynthesis in plants, the reaction center of photosystem II ejects a high-energy electron. This electron is replaced by an electron from _____.
    a. chlorophyll
    b. photosystem I
    c. a water molecule
    d. the electron is not replaced
    e. the electron transport chain

30. What two high energy molecules are produced by the light-dependent reactions of the plant?
    a. ATP and $NAD^+$
    b. ATP and NADPH
    c. oxygen and water
    d. organic molecules
    e. carbon dioxide and water

31. The function of the Calvin cycle is to produce:
    a. sugar.
    b. ATP and $NAD^+$.
    c. ATP and NADPH.
    d. oxygen and water.
    e. carbon dioxide and water.

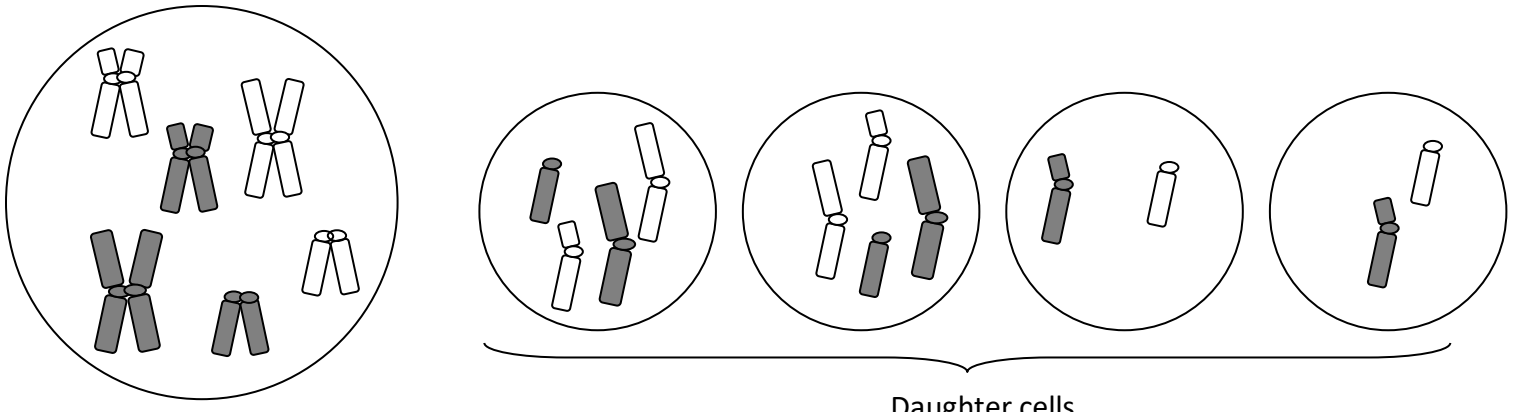
32. During the cell cycle of a typical somatic cell, chromosome replication occurs during:
    a. the S phase.
    b. the $G_1$ phase.
    c. the $G_2$ phase.
    d. the M phase.
    e. interphase II.

33. Chromosomes separate at the centromere and move away from each other during
    a. anaphase.
    b. interphase.
    c. metaphase.
    d. prophase.
    e. telophase.

34. Which of the following is most likely true of cancerous cells?
    a. They have mutated tumor suppressor genes that don't work anymore.
    b. They have mutated tumor suppressor genes that are always on.
    c. They have mutated oncogenes that are always turned on.
    d. a and c
    e. All of the above

35. Paired homologous chromosomes are separated from each other during:
    a. early prophase I.
    b. metaphase I.
    c. anaphase I.
    d. metaphase II.
    e. anaphase II.

***Question 36 refers to the diagrams below:***




36. The four daughter cells pictured above resulted from
    a. meiosis with nondisjunction
    b. mitosis with nondisjunction
    c. fertilization with a normal sperm
    d. normal meiosis
    e. normal mitosis

37. Diploid (2n) cells in mice have 40 chromosomes. Therefore, a normal mouse **EGG** has ____ chromosomes.

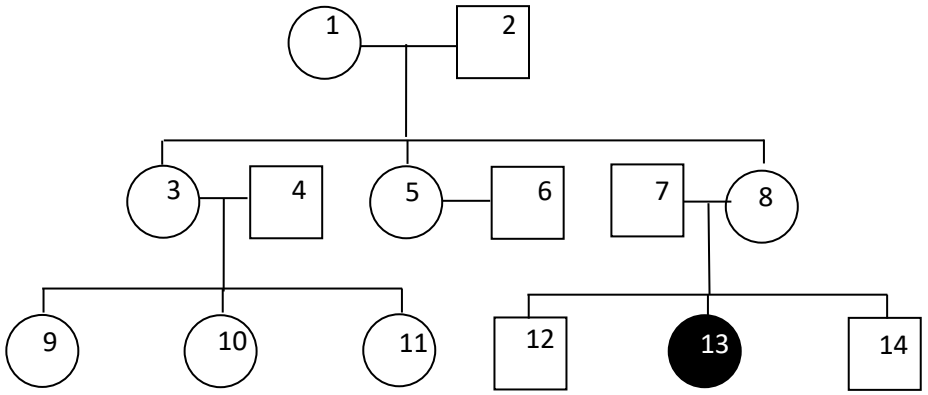
a. 10
b. 20
c. 30
d. 40
e. 80

38. The two versions of a gene that an individual inherits from her parents are called:

a. alleles.
b. gametes.
c. chromatin.
d. linked genes.
e. chromosomes.

***Question 39 refers to the pedigree below.***

This pedigree shows three generations of a family that carries albinism: a recessive, autosomal genetic disease. In the third generation, a child was born with albinism but no other family members have the disease.



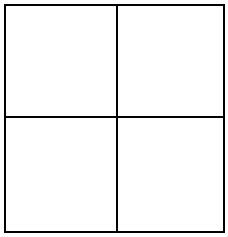

39. What are the genotypes of the parents of the affected child?

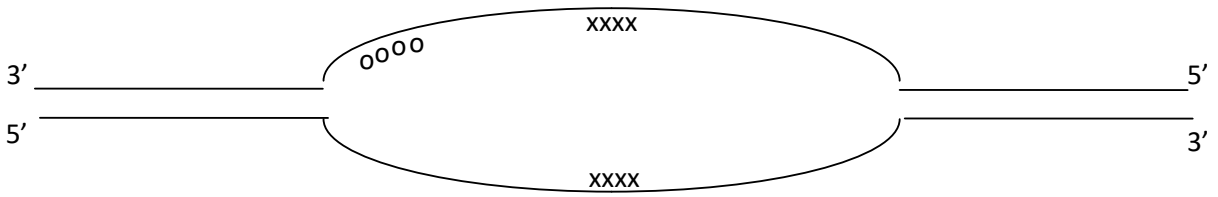
a. Both are homozygous for albinism.
b. Both are heterozygous for albinism.
c. One is homozygous and one is heterozygous for abinism.
d. One is hemizygous and one is heterozygous for albinism.
e. There is not enough information to determine their genotypes.

40. A man with hemophilia, a recessive, sex-linked genetic disease, marries a woman who is a carrier for the same disease. What is the chance that one of their daughters will have hemophilia?

a. 0%
b. 25%
c. 50%
d. 75%
e. 100%

41. Joe and Audra just got married. They have gone to see a genetic counselor because polycystic kidney disease, an AUTOSOMAL, DOMINANT genetic disease, runs in their families. Joe's mom had the disease, but his dad was normal. Audra's dad had the disease but her mom was normal. Neither Joe nor Audra has the disease. What is the percentage chance their first child will be born with the disease? HINT: You might consider drawing a pedigree and using Punnett squares.
    a. 0%
    b. 25%
    c. 50%
    d. 75%
    e. 100%






42. The figure above shows a molecule of DNA with its strands separated prior to **DNA REPLICATION**. On this figure, the primer shown as "oooo":
    a. will be used to construct the lagging strand.
    b. will be added to by RNA polymerase.
    c. is bound to the template strand.
    d. reads 3' to 5' from left to right.
    e. was made by DNA ligase.

43. The enzyme that unwinds the two strands of DNA prior to replication is called:
    a. ligase
    b. primase
    c. helicase
    d. DNA polymerase I
    e. DNA polymerase III

***Use this DNA sequence to answer questions 44-45:*** $^{3'}$AGGATGCACGTAC$^{5'}$

44. The sequence of its complementary strand is:
    a. $^{5'}$TCCTACGTGCATG$^{3'}$
    b. $^{3'}$TCCTACGTGCATG$^{5'}$
    c. $^{5'}$AGGATGCACGTAC$^{3'}$
    d. $^{3'}$AGGATGCACGTAC$^{5'}$
    e. $^{5'}$GTACGTGCATCCT$^{3'}$

45. If the strand of DNA shown above is the template strand, the sequence of the RNA that would be made from it is:
    a. $^{5}$ AGGATGCACGTAC $^{3'}$
    b. $^{5'}$UCCUACGUGCAUG$^{3'}$
    c. $^{3'}$UCCUACGUGCAUG$^{5'}$
    d. $^{5'}$AGGAUGCACGUAC$^{3'}$
    e. $^{3'}$AGGAUGCACGUAC$^{5'}$

46. The materials needed for translation include all of the following except
    a. tRNA.
    b. mRNA.
    c. ribosomes.
    d. amino acids.
    e. RNA polymerase.

***Use your genetic code table to answer questions 47-48:***

47. What type of mutation would result if the sequence of a gene were altered so that the sequence of the mRNA was changed from:

    AUGCCGUGCAGUAAC to AUGCCAUGCAGUAAC

    a. a silent mutation
    b. a missense mutation
    c. a nonsense mutation
    d. a frame-shift mutation
    e. a base insertion mutation

48. A tRNA has the anticodon GCU. What amino acid is attached to it?
    a. serine
    b. alanine
    c. arginine
    d. threonine
    e. methionine

49. During translation, translocation is:
    a. movement of the ribosome to the next codon in the mRNA.
    b. transferring the protein chain to the tRNA in the E site.
    c. the tRNA in the A site leaves the ribosome.
    d. the tRNA in the P site leaves the ribosome.
    e. a new tRNA binds to the E site.

50. Which of the following is NOT something that must happen to a eukaryotic mRNA before it can be translated?
    a. addition of a 5' cap
    b. addition of a 3' tail
    c. formation of a primer
    d. splicing to remove the introns
    e. movement from the nucleus to the cytoplasm