Membranes and Proteins

Cell Membranes

Classwork

1. The main component of the plasma membrane is the phospholipid. Describe the structural features of phospholipids.
2. In addition to the phospholipids, the structure of the membrane is embedded with other components. Sketch and label the plasma membrane with as many components as possible.
3. We are often told to monitor the amount of cholesterol in our diet, and yet, to the cell membrane its presence provides a tremendous benefit. Describe where cholesterol would be found in the plasma membrane and its function.
4. A membrane is often described as being selectively permeable. Provide an overview as to how the membrane is selectively permeable. Describe a “real world model” where barriers are put in place to regulate what can move across and what cannot. Ex. A newspaper advertisement for a job states a college degree is required. This requirement is selective as to the candidates that may apply.
5. Diffusion and osmosis are often used to describe the “passive” movement of material. In your own words, provide a description of this movement and include an example of each.
6. A high salt diet contributes to high blood pressure. If a red blood cell is placed in a beaker that contains 10% NaCl, how will the cell respond? What kind of solution is the NaCl: Isotonic, hypertonic, or hypotonic?
7. A potato cell has a solute potential of –3.5 bar. It is placed in beaker that contain 0.3 M solution of glucose at 27 °C. (a) calculate the solute potential of the glucose solution. (b) When the cell is placed in the solution, which way will the water move?
8. A plant cell has an osmotic potential of -5 MPa and a pressure potential of 3 MPa. What is the \( \psi_w \)?
9. The concentration of NaCl inside an animal cell is 0.2 M. It is placed in a 0.25 M sucrose solution at 30°C. Calculate the water potential of the cell and the surrounding solution. What is the net direction of osmosis?
10. A plant cell with a 0.42 M glucose concentration and 0.12 M NaCl concentration is placed in distilled water at 2°C. What is the pressure potential of the cell?
11. During urine production, active and passive transport are both utilized to maintain the body’s water balance. Discuss these types of transport in terms of location in the nephron and molecules moved.
12. You go to a movie with friends and eat a large bucket of salty popcorn. What effect would this have on your urine production? Explain your reasoning.
13. Explain why one of the signs of uncontrolled diabetes is frequent urination.

Homework

14. The cell membrane surrounds the components within a cell. Describe the many functions the cell membrane provides the cell.
15. In addition to phospholipids, the cell membrane also contains carbohydrates. Describe these carbohydrates and the role they play to the cell.
16. Proteins are found in the plasma membrane in two ways. They also play different roles based on their types. Describe where they can found in the membrane model and include their major roles.
17. Some molecules like water and oxygen can easily pass though the membrane, while other small molecules cannot. Explain the chemical properties that make their passage possible.
18. Although there may be a concentration gradient, large molecules and charged molecules cannot pass through the lipid bilayer. Explain how molecules that cannot diffuse through the lipid bilayer on their own get across the membrane passively.

19. Describe countercurrent exchange of gases in the fish gill. Would this be an example of active or passive transport?

20. Explain water balance in plant cells in terms of turgid, flaccid, and plasmolysis.

21. A protozoan is placed in a beaker containing 0.15 M glucose solution at 5°C. If the protozoan has a $\Psi_s$ of -2 bar, calculate the $\Psi_s$ of the solution and explain which way the water will move.

22. A dialysis bag contains 0.4 M glucose and is placed in a beaker containing distilled water. Assume the temperature is 55°C. Calculate the $\Psi_s$ of both.

23. An animal cell with a 0.32 M glucose concentration is placed in a 1.0 M sucrose solution at 25°C. Calculate the pressure potential of the cell.

24. A bacterium is placed in a glucose solution at 37°C. It has a $\Psi_s$ of -33.1 bar and a $\Psi_p$ of 18.3 bar. Calculate the concentration of the solution at equilibrium.

25. Describe the structure of the loop of Henle and the flow of filtrate through it.

26. How does the human urinary system respond to increase blood osmolarity?

27. Urine production varies by species. What type of vertebrate has the lowest volume of urine production? Why?

**Transport Proteins**

**Classwork**

28. Most molecules need a way to get across the cell membrane. This is where transport proteins step in to assist with the movement. Scientists have divided them into three classes: ion channels, transport proteins, and ATP pumps. Provide a brief description of each.

29. Not all solutes move down the concentration gradient. Sodium and potassium must move against their concentration gradient. What kind of transport is this? Can you give another example of this type of transport?

30. Proteins embedded in the cell wall are useful for moving material back and forth across the cell membrane. Construct a model showing and example of uniport and cotransport.

31. Symport pumps are used to move amino acids out of the kidney and into the blood. What kind of transport is involved in this process? Is energy required and how do you know?

32. The cell is constantly working, creating products and waste material. Name and describe the process of moving material out of the cell. Does this process require energy?

33. Describe the regions of the nephron that are permeable to water.

34. Discuss how a sodium-potassium pump functions.

35. Sodium-potassium pumps maintain the resting potential of neurons. Sodium channels and gated potassium channels are activated during an action potential. What type(s) of transport across the membrane are occurring during the resting and action potentials?

36. What happens when a neuron’s membrane depolarizes?

**Homework**

37. Compare and contrast facilitated diffusion and active transport. Describe the circumstances under which the cell uses each.

38. Active transport can be further classified into symport and antiport. Prepare a persuasive essay that points out the advantages of one over the other.
39. Vesicle-mediated transport is a process used to move material into the cell. Name and describe the process that moves solids and liquids into the cell using vesicles.
40. The sodium/glucose transmembrane protein allows sodium and glucose to enter the cell together. What kind transport does this process describe?
41. Explain how the golgi apparatus is involved in moving material across the cell membrane?
42. Explain how diuretics affect water uptake in the kidneys.
43. Sodium and potassium ions are both positively charged. How then does the Na+/K+ pump create an electrochemical gradient?
44. Describe an “action potential”.
45. What is “hyperpolarization” and what effect does it have on the neuron?

**Signaling Proteins**

**Classwork**

46. Describe some of the reasons cells have adapted signaling mechanisms as part of their everyday actions.
47. It makes sense for signaling mechanisms to coordinate activities in eukaryotic cells, but why would a prokaryotic cell need these processes?
48. What types of diseases occur as a result of a breakdown of cellular communication?
49. Explain the role of transcription factors in the signal transduction pathway. Provide an example of one.
50. Provide example of the 3 types of cellular junctions.
51. What can happen when cell communication breaks down?
52. Describe how an action potential is related to the sodium/potassium pump.
53. Cell signaling is a form of cell-to-cell communication in the living organism. There are two basic types of cell communication: hormonal and nerve signals. What are hormones? What are nerve signals?
54. Describe the fight or flight response.
55. The endocrine system controls many bodily functions such as metabolism, responding to external stimuli, reproduction, sexual development, and growth and maintenance. Their function occurs in the following steps: 1. A stimuli signal is received, 2. A hormonal response occurs, 3. The reaction takes place. Describe how these steps relate to feedback loops using one of the bodily functions above.

**Homework**


56. What process does bacteria and plants share?
57. What did Goforth and Marty find out about the signal recognition particles receptor?
58. What do you think is the significance of these findings?


59. Describe the game the author says is similar to cell-to-cell communication.
60. From the “Fail-safe features Aid Specificity” section: How does a signal know where to go?
61. From the “Scaffold Abound” section: What are neurotransmitters and what do they do to the ion channels on the membrane?
62. How are hormones important in cellular communication?
63. How are nerve signals involved in cellular communication?
64. Plants have cell walls: how does this affect cell-to-cell communication for them?

**Enzymatic Proteins**

**Classwork**

65. Describe an enzyme's role in a chemical reaction.
66. A scientist performed an experiment on an enzyme and got the following data. Graph the data and explain the results.

<table>
<thead>
<tr>
<th>Rate of reaction (sec)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>45</td>
</tr>
</tbody>
</table>

67. Most enzymes in the human body function best at a pH between 6-8. Pepsin is a digestive enzyme found in the stomach. Would you expect it to work best at the same 6-8 ranges? Why or Why not?
68. Allosteric regulation of an enzyme is accomplished when an effector molecule binds to the active site of the enzyme. How will you know if the effector is an allosteric activator or an allosteric inhibitor?
69. Why are allosteric sites popular targets for drug manufacturers?
70. Enzyme action can be affected by a host of inhibitors. What is the key difference between a competitive inhibitor and a noncompetitive inhibitor?

**Homework**

**Article Review:** “Normal Regulation of Blood Glucose” by James Norman MD, FACS, and FACE

71. What is the signal (stimulus) that goes to the pancreas?
72. How does the pancreas respond when the blood sugar is low?
73. What are the two hormones secreted by the pancreas?

**Article Review:** “Diabetes: What is Insulin” by James Norman MD, FACS, FACE

74. How does a cell respond when it has insulin bound to its receptors?
75. What happens when the body cannot make insulin?
76. Is there a cure for people who cannot make their own insulin?
1. The diagram shows a model of intestinal villi (cells that line the intestines of animals). The apical surface represents the lumen or the inside of the intestines with the digested nutrients. Basal surface represents layers of cells under the apical layer of cells. Glucose is a vital nutrient to cells. To get glucose into cells passively (without the use of ATP), the transport of glucose is coupled to the diffusion of Na+ along its concentration gradient facilitated by the integral membrane protein Sglt1. A similar process is used in the nephrons of excretory system (Sglt2 instead of Sglt1). The Glut2 protein moves the glucose with its concentration gradient into the surrounding tissue or the circulatory system.

**Symmetric Transporters for Asymmetric Transport**
Nathan K. Karpowich and Da-Neng Wang
Science 8 August 2008: **321** (5890), 781-782

a. Using the diagram, where is the highest concentration of sodium ions (Na+) found: location A, B, C, or D?

b. If Na+ is moving into the cell constantly under this process, how can the cell maintain the concentration gradient needed for glucose transport?

c. Why do cells have to use proteins to transport Na+ and glucose and not gases such as oxygen, carbon dioxide, nitrogen, etc...?

2. The diagram shows the interplay between the nervous system and excretory system in controlling the amount of solvent concentration in blood.

   a. If sweating from strenuous exercise changes the fluid concentration of blood, use the diagram to describe how the body reacts to the disturbance in homeostasis.

   b. If the water potential of blood plasma is usually around -72 bars, how will the nervous and excretory system respond if the water potential of blood plasma goes up to -50 bars?

   c. Draw an arrow between two steps in the diagram to show a negative feedback loop and describe the effects of the loop.

http://www.unm.edu/~lkravitz/Extras2/ADH.gif
3. The diagram shows *E. coli* bacteria growing in minimal nutrient media at 4 time points as they accumulate into a central 250 μm by 250 μm enclosure (100-μm-wide black walls in the center) via a 40-μm-wide channel. After 3 hours the density of cells is more than seven times greater inside than outside (bright center, dark exterior at the 3 hr mark). The black rectangles are silicone pillars that support the roof of the growing chamber. The attraction of cells to each other is mediated by the sensing of amino acids such as serine, glycine, alanine, cysteine, and aspartate.

a. How are *E. coli* cells able to sense the amino acids that are secreted by other *E. coli* cells?

b. Bacteria use their flagella to carry out the chemotaxis or quorum sensing observed in the above experiment. If a mutant *E. coli* strain is non-motile, predict at which time point (0.5 hr, 1 hr, 2 hr, 3 hr, or some other time point) you would expect to see the growth and experiment to terminate. Describe your rationale for your selection.

c. If you add an excessive amount of the amino acid serine, predict at which time point (0.5 hr, 1 hr, 2 hr, or 3 hr) you would expect to see the growth and experiment to terminate. Describe your rationale for your selection.

*Motion to Form a Quorum*

Park, S et al. Science 11 July 2003: 301 (5630), 188

![Diagram](image-url)
4. Normal function of the thyroid gland is regulated by the pituitary through the hormone thyrotropin (TSH). TSH binds to specific receptors on the membrane of thyroid cells and induces a variety of biological responses. The graph shows the radioactive amounts of cyclic adenosine monophosphate (cAMP) in six experiments with rat thyroid-derived cells that are grown with the chemicals shown on top of each bar. 8-Br-cAMP is a chemical analog of cAMP and mimics the effects of cAMP (chemical formulas shown below graph). The bar designated as basal means no TSH, 8-Br-cAMP, or cAMP were added. Adenylate cyclase is the enzyme that makes cAMP by dehydrating AMP.

a. Describe the effect TSH has on thyroid cells in terms of cAMP concentration.

b. Describe the effect 8-Br-cAMP and AMP (noncyclic AMP) have on the adenylate cyclase in thyroid cells. Based on your knowledge on the regulation of metabolic pathways, why is there a decrease in adenylate cyclase activity for experiment 4?

5. The diagram shows a drug delivery system. Many drugs do not make it to the pharmaceutical market because they are not bioavailable; the drugs have solubility problems, are not transported into the cell, or are degraded by enzymes. Our knowledge of the biochemistry of membranes has led to the creation of molecules that help get drugs into cells, such as the one shown in the diagram.

a. Describe why the amphiphilic (hydrophobic and hydrophilic) molecules self-assemble into a micelle-like structure.

b. Describe why the drug molecules would prefer the core (inside) instead of the corona (outside) of the micelle.

c. How does the micelle interact with the cell membrane?

d. Draw and describe how the micelles would self-assemble if they were put in a hydrocarbon solvent, such as corn oil?

Membranes & Proteins-Answer Key

1. A phospholipid is composed of a phosphate head and two fatty acid tails. The phosphate head is polar and hydrophilic, and faces outside the cell or faces toward the cytoplasm inside the cell. The fatty acid tails are nonpolar and hydrophobic. They face towards the middle of the phospholipid bilayer.

2. Sketch should include, but is not limited to: phospholipid bilayer, integral proteins, cholesterol, glycolipids, glycoproteins, and peripheral proteins.
3. Cholesterol makes the membrane less fluid. It also protects the membrane from freezing at low temperatures.

4. The selectively permeable means that the cell can control what can pass through the membrane and what cannot. *Models should be providing examples as to the type of barrier and condition that must be met to allow passage.*

5. Diffusion is the movement of molecules from an area of high concentration to an area of low concentration. Osmosis is the movement of water from an area of high concentration to an area of low concentration. Both processes are moving down the concentration gradient therefore no energy is required. Facilitated diffusion is passive transport that uses proteins imbedded in the membrane to aid in their transport. Some of these transproteins provide channels; others act as carriers that transport large or charged ions.

6. The red blood cell begins to dump water and shrivel. The NaCl is a hypertonic solution.

7. -7.48 bar. Water will diffuse out of the potato into the solution.

8. -2 MPa

9. -10.1 bar (-1.0 MPa), -6.29 bar (-0.63 MPa), into the cell

10. 15.7 bar (1.57 MPa)

11. Active transport moves NaCl out of the ascending limb. Passive transport of NaCl also occurs in the ascending limb. Passive transport of water occurs in the descending limb and the collecting duct.

12. Increased pumping of salt out of the nephron will cause increased water retention. Urine will be more concentrated.

13. Uncontrolled diabetics have a high glucose concentration in the blood stream. This increases the blood osmolarity, pulling water out of cells. Increased water in the blood creates increased urine production.

14. Provides a barrier, regulates what enters and leaves the cell, anchors the cytoskeleton to provide shape, and physically separates the interior and exterior of the cell.

15. Two common carbohydrates are glycoproteins and glycolipids. Glycoproteins are points of attachment to other cells. These attachment points can help create tissues. Glycolipids provide cell communication between adjacent cells. All of the proteins are embedded in the plasma membrane.

16. Integral proteins go through the center of lipid bilayer, some of which pass from one side to the other. Peripheral proteins are bound to the surface of the membranes. They can be found on either the cytoplasmic side or extracellular side. Membrane proteins can provide transport, enzyme activity, signal transduction, cell to cell recognition intercellular attachments, and attachment to the cytoskeleton.

17. Water and oxygen are both small molecules, which allow them to pass between the phospholipids, even though water has a particle charge, its size allows it to pass. Oxygen has a neutral charge and can readily pass through the membrane.

18. Large molecules utilize transmembrane proteins, such as carrier and channel proteins, to cross the membranes.

19. Fish transfer oxygen from the surrounding water into their blood. The fish move water across their gills in one direction while their blood flows in the opposite direction. By moving the two in opposite directions, this increases surface area. The oxygen diffuses from an area of high (water) to low concentration (fish blood). This is passive transport.

20. When a plant cell takes water into the cell, the membrane will expand out against the cell wall, causing it to become firm or turgid. This will occur when the concentration of solute is greater within the cell, as opposed to the surrounding, causing water to enter the cell. If the plant cells are in an isotonic solution, water will not enter the cell, causing less pressure against the cell wall. The plant becomes flaccid or limp. If the plant cell is in a hypertonic solution, it will lose water from the cells, causing the plant to wilt. The cell may die, causing a condition known as plasmolysis.
21. -3.46 bar for the solution. Water will diffuse out of the protozoan.
22. $\Psi$ of the bag = -10.90 bar. $\Psi$ of the beaker is 0.
23. 0
24. 0.6 M
25. Filtrate enters the descending loop, where water is passively transported back to the blood stream. Then filtrate move up the ascending loop, passively and then actively transporting NaCl out of the filtrate. Finally filtrate descends the collecting duct, again losing water.
26. Increased blood osmolarity increases the production of urine. This occurs because the blood and thus the filtrate have a high water concentration. More water present – more water to excrete.
27. Marine fishes have the lowest urine production. They absorb a high concentration of salt in their environment. Increased salt concentration in the kidneys leads to increased water retention.
28. Ion channels are gated channels that allow ions to pass across the membrane. Transport proteins allow the movement of hydrophilic substances across the membrane. ATP pumps use energy to move material against the concentration gradient. Both are transproteins found in the cell membrane. They move material across the membrane. Facilitated diffusion is a type of passive transport that moves material form an area of high concentration to low concentration.
29. Active Transport requires energy to move material across the cell membrane from an area of low concentration to an area of high concentration. Proton pumps used to assemble ATP are another example.
30. Picture showing uniport and cotransport found in presentation.
31. This is known as Cotransport. Yes, it does require energy because it involves a pump.
32. Exocytosis is movement of material out of the cell. Yes, it requires energy-like active transport.
33. The descending loop of Henle and the collecting ducts are permeable to water.
34. The Na+/K+ pump functions by binding ATP and 3 intracellular sodium ions, which are then actively transported out of the cell. The proteins change of shape allows 2 extracellular potassium ions to attach. The K+ ions are transported into the cell.
35. During the resting potential, Na+/K+ pumps are utilizing active transport. Sodium and potassium are leaking into the cell via facilitated diffusion. During an action potential, sodium and potassium move across the membrane via facilitated diffusion.
36. When the membrane depolarizes, because sodium has entered the cell through voltage gated channels, potassium channels open resulting in K+ ions leaving the cell. This causes a reversal in the polarization of the cell membrane.
37. Facilitated diffusion moves material from a region of high concentration to a region of low concentration using a helper protein carrier. Active transport also uses a protein but to pump material against the concentration gradient, requiring energy.
38. Opinion question
39. Pinocytosis and endocytosis move material into a cell by engulfing it into a vesicle, which fuses with the cell membrane.
40. This is known as Cotransport. Yes, it does require energy because it involves a pump. Once again, this is a type of pump. It does require energy. The material is moving against its concentration gradient.
41. Golgi packages the material in vesicles that fuse with the membrane, allowing the material to move out of the cell.
42. Diuretics put more sodium in the urine causing water to follow.
43. The electrochemical gradient is established because for every 3 sodium ions pumped out of the cell, only 2 potassium ions enter the cell. This results in a higher positive charge in the extracellular space.
44. Initially, the neuron is at rest with approximately a -70mV difference across the membrane. An action potential occurs when the membrane becomes depolarized to such an extent it crosses the threshold for the opening of voltage-gated sodium channels (usually about -40mV). Sodium ions enter the cell, causing the electrochemical gradient of the membrane to reverse (now the intracellular space is positive). This change in voltage causes potassium channels to open; potassium leaves the cell, again reversing the charge gradient. Resting potential is restored through the action of Na+/K+ pumps.

45. Hyperpolarization occurs when potassium has left the cell at the end of an action potential and the voltage difference across the membrane is now lower than -70mV (higher concentration of sodium internally, higher potassium externally). This results in the inability of the neuron to generate another action potential until the voltage has been restored to the resting potential.

46. Signaling allows cells to coordinate activities with adjacent cells that are going to perform similar tasks.

47. Prokaryotic cells will sometimes live in symbiotic relationships.

48. Hormonal, such as hyperthyroidism, diabetes, etc.

49. Transcription factors initiate the transcription of additional genes, which coordinate the cells’ response to stimuli.

50. Tight junctions can bind cells together into leak-proof sheets such as those in the gut. Adhering junctions fasten cells together into strong sheet-like epithelial tissue. Gap junctions allow substances to flow from cell to cell. They are leaky. They unite muscle cells in the heart to coordinate contraction, and are the equivalent of plasmodesmata in plants.

51. The chemical message does not get through, therefore we don’t get our desired response.

52. A nerve impulse causes the ion gates to open making the membrane more positive. When the voltage reaches the threshold the membrane will open more gates, causing the membrane to further depolarize, which causes the signal to move down the cell.

53. Hormones are chemical signals that are made in one part of the body and are transported elsewhere. Nerve signals are electrical stimuli.

54. The fight or flight response occurs when an organism perceives a threat. Stimuli cause the release of hormones, such as ACTH and the neurotransmitter epinephrine. Chemical messengers cause the production of cortisol which increases blood pressure and blood sugar and suppresses the immune system. Breathing accelerates and digestion stops, blood flow to the muscles increases to prepare the body for fighting or running.

55. A woman about to give birth feels pressure on the uterine wall from the baby’s head. A signal is sent to the brain and oxytocin is released. As more pressure occurs, more oxytocin is released. This is a positive feedback loop. Or other example.

56. They have similar mechanisms where one protein gets transported from one location to another through the membrane.

57. They identified the binding mechanism for the signal recognition particle receptor, a membrane-binding protein that helps bring the light harvesting chloroplast protein to the membrane and allows it to bind there.

58. Both the E. coli and the chloroplast receptor proteins react the same way at the membrane.

59. This is like the game Telephone, when a message is passed down the line from person to person.

60. The hormones and receptors produce distinct effects on cells. They attach to specific amino acid complexes.

61. A neurotransmitter is a chemical messenger. The receptors grab the neurotransmitter and then cause the ion channels on the membrane to open.

62. Hormones only affect those cells that have specific receptor proteins embedded in their cell membrane.
63. Neurons send out signals called neurotransmitters to specific receptors, then to another nerve that is connected to the brain, or even another muscle.

64. Plants connect using plasmodesmata that are channels that allow them to share water and food, and communicate.

65. Enzymes bind to the substrate and at the active site. By binding here the substrate will now proceed in the chemical reaction.

66. Graph will show that there is an optimal temperature with which the reaction will take place.

67. No, the stomach has a much lower pH; therefore pepsin would have to be able to work at this pH since it is released in the stomach.

68. The binding of an activator to the regulatory site stabilizes the enzyme that has functional active sites. If it is an allosteric inhibitor, it stabilizes the inactive form of the enzyme and the substrate will not bind to it.

69. Binding to the enzyme doesn’t take place on the active site; it takes place on the enzyme. You don’t have to compete for the active site. Simply make the enzyme accessible or not.

70. Competitive inhibitors block substrates from entering active sites. Non-competitive inhibitors don’t directly bind to the active site; they will bind to another part of the enzyme causing a conformational change in shape.

71. Either high or low blood glucose levels.

72. When blood glucose is low the pancreas, glycogen is released to be converted back to glucose.

73. The two hormones released by the liver are glycogen and insulin.

74. The cell activates other receptors designed to absorb glucose from the bloodstream into the inside of the cell.

75. The body has too much sugar in the blood stream; the cells cannot absorb the sugar. This makes the person very sick.

76. No, but there is a treatment. People can take shots of insulin that will take the place of insulin made by the pancreas.

1. Question 1
   a. The highest concentration of sodium ions (Na+) would be found in location A.
   b. Cells use a form active transport such as the Na/K potassium to exchange 3Na+ from the inside of the cell for 2K+ ions from outside the cell to increase the concentration of Na+ outside the cell.
   c. Gases are nonpolar and small, allowing gases to diffuse freely through the phospholipid. Electrically charged ions and large molecules have difficulty going through the polar heads of the phospholipids (electrical attraction to the polar) and do not interact well with the nonpolar hydrocarbon tails of the phospholipid bilayer.

**Essential knowledge 2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.**

**LO 2.9** The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction. [See SP 1.1, 1.4]

**Essential knowledge 2.B.1: Cell membranes are selectively permeable due to their structure.**

**LO 2.11** The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. [See SP 1.1, 7.1, 7.2]

**Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.**
LO 2.12 The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes. [See SP 1.4]

2. Question 2
   a. A decrease in the osmolarity of the blood plasma is detected by brain. The hypothalamus sends a chemical message to the pituitary gland, promoting the release of antidiuretic hormone (ADH or vasopressin). ADH acts on the nephrons of kidneys to allow water to be retain in the blood, restoring the osmolarity of the blood.
   b. Since the water potential increase from -72 to -52 bars, the blood plasma contains more water than require by homeostasis. The increase in water potential will be detected by hypothalamus, and hypothalamus will prompt the pituitary gland to cease or decrease the release of ADH. The decrease in ADH will allow kidneys to remove the default level of water from the blood, decreasing the water potential and restoring homeostasis.
   c. The increase in blood plasma volume will be detected by the hypothalamus, and the hypothalamus will send a chemical message to the pituitary gland to stop or lower the amount of ADH being released. The lower concentration of the ADH in the blood will let kidneys resume normal loads of water filtration from the blood plasma.

Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

LO 2.28 The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. [See SP 1.4]

3. Question 3
   a. The cells have protein receptors embedded in the phospholipid bilayer of the cell membrane that detect and bind the amino acids, setting a cascade of chemical signals in the cell that lead to a response from the cell, which- in this case, is chemotaxis and/or quorum sensing.
   b. If the E. coli cannot direct movement, the growth pattern would be the same has the dispersal of the initial cell or colony and dependent on the movement of the media. The experiment would not proceed past the first hour (1hr) time point- with the same fluorescence or brightness in all areas of the growth chamber. In the above experiment, you can see that at the 1hr time point there is some detectable concentration of bacteria in the center enclosure. If the bacteria are not motile, you will not see the extra concentration of cells in the enclosure.
   c. You will get the same effect as discussed in the previous question. Cells will grow uniformly throughout the growth chamber without gathering in the center chamber. Excess serine will saturate (bind all or most of) the amino acid receptors on the cell membrane of the bacteria, and the bacteria will not be able to sense a concentration gradient (or the need to move) and to move in the direction of the chemical gradient, growing with random movement.

Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.

LO 2.40 The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior. [See SP 7.2]

Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.
**LO 3.33** The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. [See SP 1.4]


**LO 3.36** The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response. [See SP 1.5]

4. **Question 4**
   a. TSH stimulates the cell to produce cAMP. The graph shows that cells grown with TSH produce almost 4 times as much cAMP as cells that have not been stimulated by the hormone (basal).
   b. 8-Br-cAMP and AMP (noncyclic AMP) experiments show a slight, insignificant increase in cAMP; therefore, 8-Br-cAMP and AMP do not stimulate the cell and activate adenylate cyclase to produce cAMP from AMP. It can be concluded that cAMP or its precursor (AMP) do not regulate cAMP production.
   c. TSH stimulates a production of cAMP by adenylate cyclase (sample 2). When cAMP concentration reaches a threshold (TSH induced cAMP + added 8-Br-cAMP), both cAMP seem to produce negative feedback loop on the signaling pathway. Adenylate cyclase would be the most reasonable target of the inhibition by cAMP overproduction.

**Essential knowledge 4.B.1: Interactions between molecules affect their structure and function**

**LO 4.17** The student is able to analyze data to identify how molecular interactions affect structure and function. [See SP 5.1]

**Essential knowledge 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.**

**LO 3.33** The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. [See SP 1.4]


**LO 3.36** The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response. [See SP 1.5]

5. **Question 5**
   a. The amphiphilic molecules prefer to align themselves in favorable energetic positions (atoms can interact with neighboring atoms: negative with positive, neutral with neutral). The molecules would assemble themselves with the hydrophobic half on the inside and the hydrophilic half on the outside.
   b. If the drug is hydrophobic, it would prefer to be on the inside of the micelle, where it is hydrophobic and water is excluded.
   c. The cell membrane is positively charged on the outside (due to the heads of the phospholipids). The corona of the micelle will interact with the phospholipid heads and electrically charged protein segments. The micelle interaction with cell membrane will promote endocytosis of the entire micelle. The drug will diffuse out of the micelle or the micelle will be disrupted or broken apart by interaction with organelles inside the cell, releasing the drug to have its effects and side effects.
d. The micelles would have the hydrophilic, charged halves on the inside and the neutral, hydrophobic halves on the outside. Corn oil is hydrophobic, does interact well with water or electrically charged molecules.

*Essential knowledge 2.B.1: Cell membranes are selectively permeable due to their structure.*
LO 2.11 The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. [See SP 1.1, 7.1, 7.2]

*Essential knowledge 2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.*
LO 2.12 The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes. [See SP 1.4]