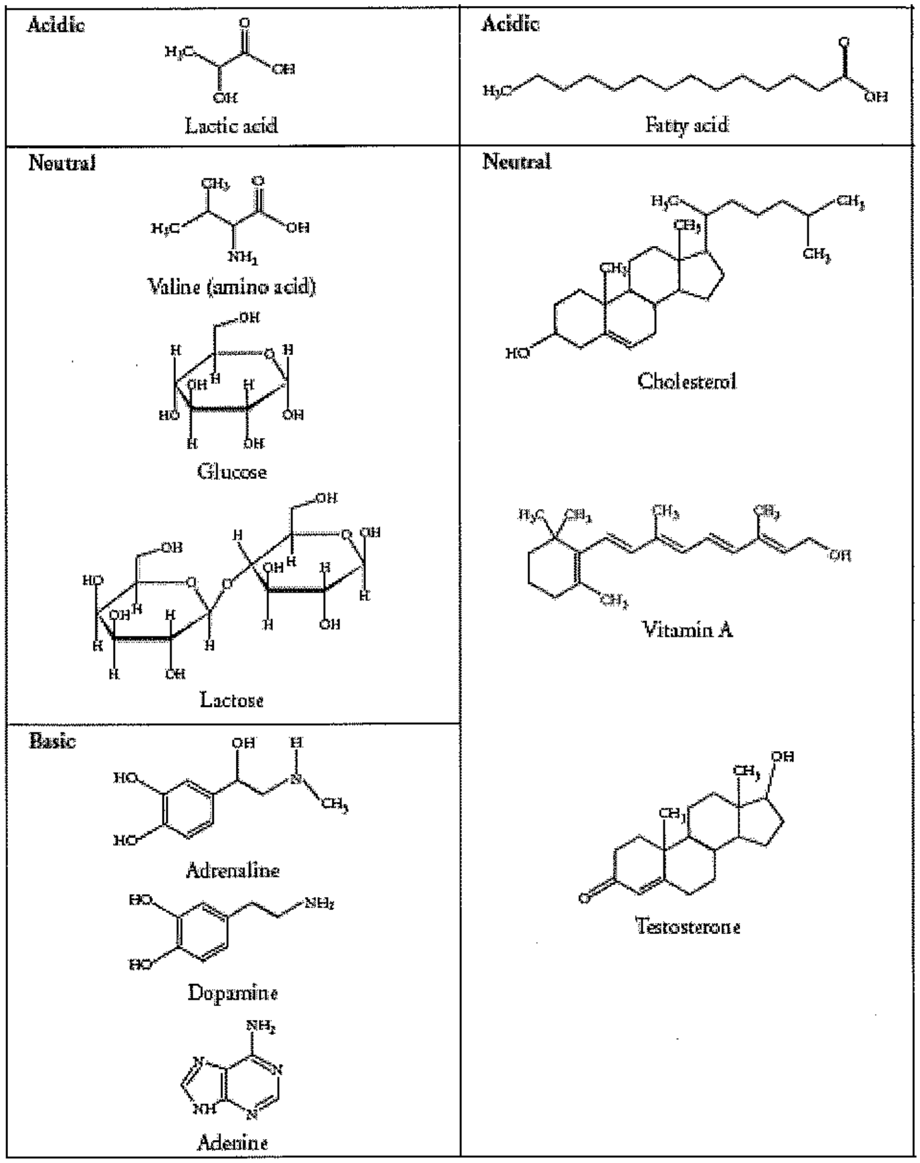
Concept 2: Cells

Thinking Practice Questions

1. 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, would the molecule require a protein channel?



Cholesterol, vitamin A, testosterone, and the fatty acid are all mostly carbon and hydrogen atoms, which makes them nonpolar / hydrophobic. These molecules will not require a protein channel because they are nonpolar and can diffuse through the nonpolar tail region of the phospholipid bilayer (unless they are too large).

Lactic acid, valine, glucose, lactose, adrenaline, dopamine, and adenine all have significant proportions of atoms like oxygen or nitrogen, which make the molecule polar / hydrophilic. These molecules require a protein channel because they are polar and cannot diffuse through the nonpolar tail region of the phospholipid bilayer.

2. 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

Water potential equations

Water Potential (Ψ)

$\Psi = \Psi p + \Psi s$

The Solute Potential of the Solution

$\Psi s = -iCRT$

Ψp = pressure potential

Ψs = solute potential

The water potential will be equal to the solute potential of a solution in an open container, since the pressure potential of the solution in an open container is zero.

i = ionization constant (For sucrose this is 1.0 because sucrose does not ionize in water.)

C = molar concentration

R = pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (273 + °C)

a.

b. Calculate the water potential for each side of the membrane.

Solute potential for CaCl2 solution = -(3)(0.1)(0.0831)(298) = -7.43

Water potential for CaCl2 solution = -7.43 (open container so no pressure potential)

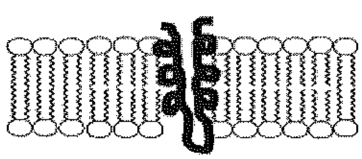
Solute potential for glucose solution = -(1)(0.1)(0.0831)(298) = -2.48

Water potential for glucose solution = -2.48 (open container so no pressure potential)

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

Water will move from the right side (glucose solution) to the left side (CaCl2 solution) because water moves from a high water potential (in this case -2.48) to a low water potential (in this case -7.43).

3. **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.



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

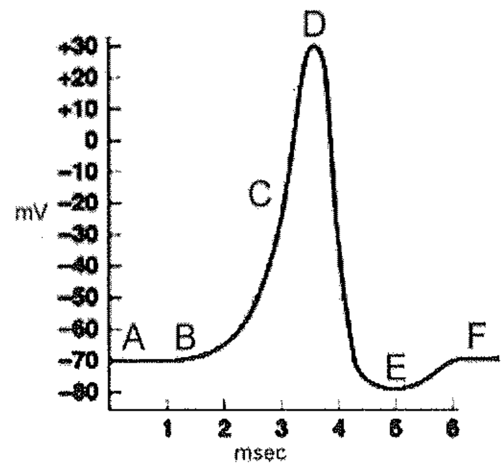
b. What sections of the embedded protein chain are most likely to contain amino acids with hydrophilic R-groups? Explain your reasoning.

3a. The sections of the protein chain inside the tail region of the phospholipid bilayer are most likely to contain amino acids with hydrophobic (nonpolar) R groups because these sections must be able to interact well with the hydrophobic phospholipid tails.

b. The sections of the protein chain outside the tail region (near the head regions) of the phospholipid bilayer are most likely to contain amino acids with hydrophilic (polar) R groups because these sections cannot interact well with the hydrophobic phospholipid tails but they can interact well with the hydrophilic phospholipid heads and the water on the outside and the inside of the cell.

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

   a. At which letters would you find Na+ voltage gated channel OPEN?
   C (allows depolarization of the neuron)



   b. At which letter(s) would you find the Na+/K+ pump WORKING?
   A (resting potential)
   E and F (restabilishes resting potential)

   c. At which letter(s) would you find K+ voltage gated channels OPEN?
   D (allows repolarization / hyperpolarization of the neuron)

   d. At point F, would there be a more positive charge on the INSIDE or OUTSIDE of the neuron?
   Outside the neuron because the inside of the neuron has a negative resting potential (-70 mV)

   e. At point B, would you find more Na+ on the INSIDE or OUTSIDE of the neuron?
   Outside the neuron. The voltage-gated Na+ channels have not opened yet to allow Na+ to rush into the neuron during depolarization.

   f. 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?
   It will not be able to depolarize, preventing an action potential from being sent down the neuron.

5. 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?

If there are too many lipid molecules, this indicates that the enzyme used to break down these lipids is defective. Hydrolytic enzymes that are used to break down molecules are found in the lysosome, so it is likely that defective lysosomes are involved in Tay-Sacchs disease.

Cells – Long Free Response (10 points)

1. The following experiment was designed to test whether different concentration gradients affect the rate of diffusion. In this experiment, four solutions (0% NaCl, 1% NaCl, 5% NaCl , and 10% NaCl) were tested under identical conditions. Fifteen milliliters (mL) of 0% NaCl were put into a bag formed of dialysis tubing that is permeable to Na^+, Cl^-, and water. The same was done for each NaCl solution. Each bag was submerged in a separate beaker containing 300 mL of distilled water. The concentration of NaCl in mg/L in the water outside each bag was measured at 40-second intervals. The results from the 5% bag are shown in the table below.

CONCENTRATION IN mg/L OF NaCl OUTSIDE THE 5% NaCl BAG

Time (seconds)	NaCl (mg/L)
0	0
40	130
80	220
120	320
160	400

(a) On the axes provided, graph the data for the 5% NaCl solution.

(b) Using the same set of axes, draw and label three additional lines representing the results that you would predict for the 0% NaCl, 1% NaCl, and 10% NaCl solutions. Explain your predictions.

(c) Farmlands located near coastal regions are being threatened by encroaching seawater seeping into the soil. In terms of water movement into or out of plant cells, explain why seawater could decrease crop production. Include a discussion of water potential in your answer.

Scoring Guide Cell Long Free Response

Part A

1 point	correct orientation with dependent variable (concentration) on y (vertical) axis and independent variable (time) on x (horizontal) axis
1 point	correct axes labels with units **and** scaling for 5% line on axes provided
1 point	correct plotting of all data points including zero (0,0); line is not necessary but if drawn must not extend beyond last data point; dashing line beyond last data point is okay; arrow at end of line is okay.

Part B

1 point	correct prediction and legend (or label) for 0%, 1%, and 10% lines (0% line flat, 1% line below 5% line, 10% line above 5% line)
1 point	correct explanation for 0% line (e.g., since there is no NaCl in the bag no Na+Cl- can diffuse into the water in the beaker)
1 point	correct explanation for 1% line — must include a discussion of rate; connects concentration of NaCl with diffusion rate
1 point	correct explanation for 10% line — must include a discussion of rate; connects concentration of NaCl with diffusion rate

Part C

1 point	statement that water will leave the plant and description of effect this has on plant cell (e.g., loss of turgor, plasmolysis, decrease in cell volume, decrease in central vacuole volume)
1 point	concept of osmosis (e.g., movement of water across a selectively permeable membrane (cell or cell membrane) from solution with lower solute concentration (hypotonic) to solution with higher solute concentration (hypertonic)
1 point	explanation that water moves from solution with higher (more positive/less negative) water potential (ψ) to solution with lower (more negative) water potential (ψ)
1 point	explanation of how water loss can cause decreased crop production (e.g., stomates close, transpiration stops, photosynthesis stops, decreased metabolism)