Chapter 11 Biological Membranes and Transport

Multiple Choice Questions

1. **The composition and architecture of membranes**
Page: 370 Difficulty: 2 Ans: C
Which one of the following statements about membranes is true?

A) Most plasma membranes contain more than 70% proteins.
B) Sterol lipids are common in bacterial plasma membranes.
C) Sterol lipids are common in human cell plasma membranes.
D) Sterol lipids are common in plant cell plasma membranes.
E) The plasma membranes of all cell types within a particular organism have basically the same lipid and protein composition.

2. **The composition and architecture of membranes**
Page: 370 Difficulty: 3 Ans: C
The inner (plasma) membrane of *E. coli* is about 75% lipid and 25% protein by weight. How many molecules of membrane lipid are there for each molecule of protein? (Assume that the average protein is M_r 50,000 and the average lipid is 750.)

A) 1
B) 50
C) 200
D) 10,000
E) 50,000

3. **The composition and architecture of membranes**
Page: 370 Difficulty: 2 Ans: A
Which of these statements about the composition of biological membranes is false?

A) In a given eukaryotic cell type (e.g., a hepatocyte), all intracellular membranes have essentially the same complement of lipids and proteins.
B) The carbohydrate found in membranes is virtually all part of either glycolipids or glycoproteins.
C) The plasma membranes of the cells of vertebrate animals contain more cholesterol than the mitochondrial membranes.
D) The ratio of lipid to protein varies widely among cell types in a single organism.
E) Triacylglycerols are not commonly found in membranes

4. **The composition and architecture of membranes**
Page: 370 Difficulty: 1 Ans: C
Which of these statements about the composition of membranes is true?

A) All biological membranes contain cholesterol.
B) Free fatty acids are major components of all membranes.
C) The inner and outer membranes of mitochondria have different protein compositions.
D) The lipid composition of all membranes of eukaryotic cells is essentially the same.
E) The lipid:protein ratio varies from about 1:4 to 4:1

5. **The composition and architecture of membranes**
Pages: 373-376 Difficulty: 1 Ans: E
Membrane proteins:

A) are sometimes covalently attached to lipid moieties.
B) are sometimes covalently attached to carbohydrate moieties.
C) are composed of the same 20 amino acids found in soluble proteins.
D) diffuse laterally in the membrane unless they are anchored
E) have all of the properties listed above.

6. **The composition and architecture of membranes**
Page: 373 Difficulty: 2 Ans: A
Peripheral membrane proteins:

A) are generally noncovalently bound to membrane lipids.
B) are usually denatured when released from membranes.
C) can be released from membranes only by treatment with detergent(s).
D) may have functional units on both sides of the membrane.
E) penetrate deeply into the lipid bilayer.

7. **The composition and architecture of membranes**
Page: 373 Difficulty: 2 Ans: C
An integral membrane protein can be extracted with:

A) a buffer of alkaline or acid pH.
B) a chelating agent that removes divalent cations.
C) a solution containing detergent.
D) a solution of high ionic strength.
E) hot water.

8. **The composition and architecture of membranes**
Page: 377 Difficulty: 2 Ans: B
The shortest α helix segment in a protein that will span a membrane bilayer has about _____ amino acid residues.

A) 5
B) 20
C) 50
D) 100
E) 200

9. **The composition and architecture of membranes**
Page: 377 Difficulty: 2 Ans: E
A hydropathy plot is used to:

A) determine the water-solubility of a protein.
B) deduce the quaternary structure of a membrane protein.
C) determine the water content of a native protein.
D) extrapolate for the true molecular weight of a membrane protein.
E) predict whether a given protein sequence contains membrane-spanning segments.

10. **The composition and architecture of membranes**
Page: 377 Difficulty: 3 Ans: A
Which of these statements is generally true of integral membrane proteins?

A) A hydropathy plot reveals one or more regions with a high hydropathy index.
B) The domains that protrude on the cytoplasmic face of the plasma membrane nearly always have covalently attached oligosaccharides.
C) They are unusually susceptible to degradation by trypsin.
D) They can be removed from the membrane with high salt or mild denaturing agents.
E) They undergo constant rotational motion that moves a given domain from the outer face of a membrane to the inner face and then back to the outer.

11. **Membrane dynamics**
Page: 381 Difficulty: 2 Ans: A
Which of these is a general feature of the lipid bilayer in all biological membranes?

A) Individual lipid molecules are free to diffuse laterally in the surface of the bilayer.
B) Individual lipid molecules in one face (monolayer) of the bilayer readily diffuse (flip-flop) to the other monolayer.
C) Polar, but uncharged, compounds readily diffuse across the bilayer.
D) The bilayer is stabilized by covalent bonds between neighboring phospholipid molecules.
E) The polar head groups face inward toward the inside of the bilayer.

12. **Membrane dynamics**
Page: 381 Difficulty: 2 Ans: A
The type of motion *least* common in biological membranes is:

A) flip-flop diffusion of phospholipid from one monolayer to the other.
B) lateral diffusion of individual lipid molecules within the plane of each monolayer.
C) lateral diffusion of membrane proteins in the bilayer.
D) lateral diffusion of protein molecules in the lipid bilayer
E) random motion of the fatty acyl side chains in the interior of the phospholipid bilayer.

13. **Membrane dynamics**
Page: 381 Difficulty: 2 Ans: C
The fluidity of the lipid side chains in the interior of a bilayer is generally increased by:

A) a decrease in temperature.
B) an increase in fatty acyl chain length.
C) an increase in the number of double bonds in fatty acids.
D) an increase in the percentage of phosphatidyl ethanolamine
E) the binding of water to the fatty acyl side chains.

14. **Membrane dynamics**
Page: 381 Difficulty: 2 Ans: D
The fluidity of a lipid bilayer will be increased by:

F) decreasing the number of unsaturated fatty acids.
C) decreasing the temperature.
G) increasing the length of the alkyl chains.
D) increasing the temperature.
E) substituting 18:0 (stearic acid) in place of 18:2 (linoleic acid).

15. Membrane dynamics
Page: 381 Difficulty: 2 Ans: C
When a bacterium such as *E. coli* is shifted from a warmer growth temperature to a cooler growth temperature, it compensates by:

A) increasing its metabolic rate to generate more heat.
B) putting longer-chain fatty acids into its membranes.
C) putting more unsaturated fatty acids into its membranes.
D) shifting from aerobic to anaerobic metabolism.
E) synthesizing thicker membranes to insulate the cell.

16. Membrane dynamics
Page: 384 Difficulty: 2 Ans: C
When biological membranes are viewed with an electron microscope after freeze-fracturing, particles of various sizes stand out against a smooth background. Which statement below is correct?

A) Freeze-fracturing removes membrane proteins, leaving only the lipid bilayer visible.
B) Freeze-fracturing removes the lipid bilayer leaving only membrane proteins visible.
C) The particles are individual proteins or protein complexes.
D) The particles are the head groups of individual phospholipid molecules.
E) The particles represent only peripheral membrane proteins

17. Membrane dynamics
Page: 386 Difficulty: 2 Ans: C
Integrins are:

A) membrane proteins that are involved in ion transport.
B) membrane proteins that are involved in sugar transport.
C) membrane proteins that mediate cell adhesion.
D) proteins of the extracellular matrix that bind to cell surface proteins.
E) proteins that are found at the membrane-cytoplasm interface.

18. Membrane dynamics
Pages: 387, 393 Difficulty: 1 Ans: C
A process *not* involving the fusion of two membranes or two regions of the same membrane is:

A) endocytosis.
B) entry of enveloped viruses into cells.
C) entry of glucose into cells.
D) exocytosis.
E) reproductive budding in yeast

19. Membrane dynamics
Page: 387 Difficulty: 2 Ans: D
According to the current model for HIV infection, which of the following is *not* involved in the process of membrane fusion?

A) A cell surface co-receptor protein
B) A cell surface receptor protein
C) A viral glycoprotein complex
D) The viral chromosome
E) The viral envelope

20. Solute transport across membranes
Page: 391 Difficulty: 2 Ans: A
Which of these statements about facilitated diffusion across a membrane is true?

A) A specific membrane protein lowers the activation energy for movement of the solute through the membrane.
B) It can increase the size of a transmembrane concentration gradient of the diffusing solute.
C) It is impeded by the solubility of the transported solute in the nonpolar interior of the lipid bilayer.
D) It is responsible for the transport of gases such as O_2, N_2, and CH_4 across biological membranes.
E) The rate is not saturable by the transported substrate

21. Solute transport across membranes
Page: 391 Difficulty: 2 Ans: A
Facilitated diffusion through a biological membrane is:

A) driven by a difference of solute concentration.
B) driven by ATP.
C) endergonic.
D) generally irreversible.
E) not specific with respect to the substrate

22. Solute transport across membranes
Page: 393 Difficulty: 1 Ans: D
Glucose transport into erythrocytes is an example of:

A) active transport.
B) antiport.
C) electrogenic uniport
D) facilitated diffusion.
E) symport.

23. Solute transport across membranes
Page: 394 Difficulty: 2 Ans: B
For the process of solute transport, the constant K_t is:

A) analogous to K_a for ionization of a weak acid.
B) analogous to K_m for an enzyme-catalyzed reaction.
C) analogous to V_{max} for an enzyme reaction
D) proportional to the number of molecules of glucose transporter per cell.
E) the maximum rate of glucose transport.

24. Solute transport across membranes
Page: 397 Difficulty: 2 Ans: D
The type of membrane transport that uses ion gradients as the energy source is:

A) facilitated diffusion
B) passive transport.
C) primary active transport.
D) secondary active transport.
E) simple diffusion.

25. Solute transport across membranes
Page: 398 Difficulty: 3 Ans: B
Consider the transport of glucose into an erythrocyte by facilitated diffusion. When the glucose concentrations are 5 mM on the outside and 0.1 mM on the inside, the free-energy change for glucose uptake into the cell is: (These values may be of use to you: R = 8.315 J/mol·K; T = 298 K; 9 (Faraday constant) = 96,480 J/V; $N = 6.022 \times 10^{23}$/mol.)

A) less than 2 kJ/mol.
B) about 10 kJ/mol.
C) about 30 kJ/mol.
D) about –30 kJoule/mol.
E) impossible to calculate without knowledge of the membrane potential.

26. Solute transport across membranes
Page: 398 Difficulty: 3 Ans: D
Consider the transport of K^+ from the blood (where its concentration is about 4 mM) into an erythrocyte that contains 150 mM K^+. The transmembrane potential is about 60 mV, inside negative relative to outside. The free-energy change for this transport process is: (These values may be of use to you: R = 8.315 J/mol·K; T = 298 K; 9 (Faraday constant) = 96,480 J/V; $N = 6.022 \times 10^{23}$/mol.)

A) about 5 J/mol.
B) about 15 J/mol.
C) about 5 kJ/mol.
D) about 15 kJ/mol.
E) impossible to calculate with the information given.

27. Solute transport across membranes
Page: 398 Difficulty: 3 Ans: E
An electrogenic Na^+ transporter:

A) catalyzes facilitated diffusion of Na^+ from a region of high Na^+ concentration to one of lower Na^+ concentration.
B) must catalyze an electron transfer (oxidation-reduction) reaction simultaneously with Na^+ transport.
C) must transport both Na^+ and a counterion (Cl^-, for example).
D) transports Na^+ against its concentration gradient.
E) transports Na^+ without concurrent transport of any other charged species.

28. Solute transport across membranes
Page: 407 Difficulty: 1 Ans: B
Movement of water across membranes is facilitated by proteins called:

A) annexins.
B) aquaporins.
C) hydropermeases.
D) selectins.
E) transportins.

29. Solute transport across membranes
Page: 409 Difficulty: 2 Ans: A
The specificity of the potassium channel for K^+ over Na^+ is mainly the result of the:

A) differential interaction with the selectivity filter protein.
B) hydrophobicity of the channel.
C) phospholipid composition of the channel.
D) presence of carbohydrates in the channel.
E) presence of cholesterol in the channel.

30. Solute transport across membranes
Page: 411 Difficulty: 2 Ans: C
A ligand-gated ion channel (such as the nicotinic acetylcholine receptor) is:

A) a charged lipid in the membrane bilayer that allows ions to pass through.
B) a membrane protein that permits a ligand to pass through the membrane only when opened by the appropriate ion.
C) a membrane protein that permits an ion to pass through the membrane only when opened by the appropriate ligand.
D) a molecule that binds to the membrane thereby allowing ions to pass through.
E) always requires a second ligand to close the channel once it is opened.

Short Answer Questions

31. The composition and architecture of membranes
Page: 370 Difficulty: 3
The plasma membrane of an animal cell consists of 45% by weight of phospholipid and 55% protein. What is the mole ratio (moles of lipid/moles of protein) if the average molecular weight of phospholipids is 750 and the average molecular weight of membrane proteins is 50,000?

Ans: The ratio of moles lipid/moles protein is about 55. In 100 g of membrane, there are 45 g/750 $g \cdot mol^{-1}$ = 0.06 mol phospholipid, and 55 g/50,000 $g \cdot mol^{-1} = 1.1 \times 10^{-3}$ mol protein. So lipid/protein = 0.06/0.0011 = 55.

32. The composition and architecture of membranes
Page: 370 Difficulty: 2
(a) List the major components of membranes. (b) When a preparation of mitochondrial membranes was treated with high salt (0.5 M NaCl), it was observed that 40% of the total protein in this preparation was solubilized. What kind of membrane proteins are in this soluble extract, and what forces normally hold them to the membrane? (c) What kind of proteins constitute the insoluble 60%, and what forces hold these proteins in the membrane?

Ans: (a) phospholipids, sterols, proteins (integral and peripheral); (b) peripheral membrane proteins, which are associated with the membrane through ionic and hydrogen bonds between their charged and polar side chains and the charged head groups of phospholipids; (c) integral membrane proteins (which are held to the membrane by hydrophobic interactions between their nonpolar side chains and the hydrophobic fatty acyl chains of phospholipids), and those peripheral membrane proteins that are held to the membrane by a covalent lipid anchor.

33. The composition and architecture of membranes
Page: 372 Difficulty: 2
What are the principle features of the fluid mosaic model of membranes?

Ans: The principle features of the fluid mosaic model of membranes include: (1) a lipid bilayer in which individual lipids are free to move laterally but not across the bilayer; (2) integral membrane proteins, which penetrate or span the bilayer, associating with lipid acyl chains by hydrophobic interactions and exhibiting lateral mobility; (3) peripheral membrane proteins, which associate noncovalently with the lipid head groups and protruding domains of integral membrane proteins, and which are sometimes tethered to the membrane by a covalent lipid anchor.

34. The composition and architecture of membranes
Page: 372 Difficulty: 3
Draw the structure of a biological membrane as proposed by the fluid mosaic model. Indicate the positions and orientations of phospholipids, cholesterol, integral and peripheral membrane proteins, and the carbohydrate moieties of glycoproteins and glycolipids.

Ans: Phospholipids and sterols are found in both faces of the lipid bilayer. Integral membrane proteins penetrate or span the lipid bilayer, but peripheral membrane proteins associate at the membrane surface with lipid head groups or integral membrane proteins. The carbohydrate moieties of glycolipids and glycoproteins are invariably on the outside face of the plasma membrane. (See Fig. 11-3, p. 372.)

35. The composition and architecture of membranes
Page: 372 Difficulty: 2
What is an amphipathic compound? Explain how such compounds contribute to the structure of biological membranes.

Ans: An amphipathic compound has one region or domain that is hydrophilic and another that is hydrophobic. When added to water, amphipathic compounds tend to arrange in a way that exposes their hydrophilic regions to the solvent and hides their hydrophobic domains. One structure that accomplishes this is the lipid bilayer, which forms spontaneously with phospholipids in water. (See Fig. 11-4, p. 372)

36. The composition and architecture of membranes
Page: 372 Difficulty: 2
(a) When relatively high concentrations of fatty acids are suspended in water, they form structures known as ________. (b) When relatively high concentrations of membrane phospholipids are dissolved in water, they form structures known as ________. (c) Why are the structures listed in your answers to (a) and (b) above energetically favored?

Ans: (a) micelles. (b) bilayers. (c) Micelles are favored when the polar head group has a greater cross-sectional area than the nonpolar acyl chain, making the molecule wedge-shaped; bilayers are favored when the cross-sectional area of head group and acyl chain(s) are about the same, so that the molecule is cylindrical. (See Fig. 11-4, p. 372.)

37. The composition and architecture of membranes
Page: 372 Difficulty: 3
(a) Define the term *amphipathic*. (b) Diagram two types of assemblies that amphipathic molecules form in water. (c) What are the forces that contribute to the formation of the structures diagrammed in (b)?

Ans: (a) *Amphipathic* means having one region that is polar and another that is nonpolar. (b) The two common structures formed by lipids in water are micelles and bilayers. (See Fig. 11-4, p. 372.) (c) These lipid aggregates in water are stabilized by the energy gain from burying hydrophobic groups out of contact with water. When a hydrophobic chain is surrounded by water, it forces the formation of a cage of immobilized water molecules around it. When several hydrophobic regions cluster, the surface area exposed to water decreases, and the water molecules in the cage are released, with a gain in entropy that drives the formation of the lipid aggregates.

38. The composition and architecture of membranes
Page: 373 Difficulty: 3
(a) Explain why phosphoglycerides are capable of spontaneously assembling into the bilayer structure found in biological membranes but triacylglycerols are not. (b) What are the forces that drive bilayer formation?

Ans: (a): Triacylglycerols have three fatty acyl groups in ester linkage with glycerol; they are very hydrophobic because the carboxyl groups, which are involved in the ester linkages, cannot ionize. Phosphoglycerides have a polar region at their head group, where a phosphate in a phosphodiester linkage bears a full negative charge. The head group itself (serine, ethanolamine, choline, etc.) may also be charged and is polar in any case. Thus, the phospholipid is amphipathic, having both polar and nonpolar regions, and it forms lipid bilayers spontaneously in water. (b) These lipid bilayers are stabilized by the energy gained from burying hydrophobic groups out of contact with water. A hydrophobic chain in water forces the formation of a cage of immobilized water molecules around it.

When several hydrophobic regions cluster in a bilayer, the surface area exposed to water decreases, and the water molecules in the cage are released, accompanied by a gain in entropy that drives the formation of the bilayer.

39. The composition and architecture of membranes
Pages: 373-374 Difficulty: 3
You are presented with a gram of a newly isolated animal virus. Electron microscopy reveals the presence of a typical membrane surrounding the virus, and chemical analysis shows the presence of two membrane lipids, phosphatidylethanolamine and phosphatidylserine, as well as several membrane-associated proteins. Describe briefly a simple experimental approach to answering each of the following questions: (a) Which proteins are exposed at the outer surface and which traverse the membrane, with parts of their structure in the cytoplasm and parts outside the cell? (b) Are the phosphatidylethanolamine and phosphatidylserine symmetrically disposed in the two faces of the bilayer?

Ans: (a) Briefly, two radiolabeled reagents, each of which reacts with primary amines, are used to label proteins in the intact cell. One of the reagents penetrates the plasma membrane readily and is therefore able to label intracellular domains of membrane proteins as well as their extracellular domains. The other reagent is impermeant and can label only domains on the outer face. By carefully assessing which membrane proteins are labeled by which reagent, one can determine which of them has extracellular domains and which has intracellular domains. (b) The same basic procedure can be used to label lipids, such as phosphatidylserine and phosphatidylethanolamine, which contain primary amino groups, and thus to determine their location in the membrane.

40. The composition and architecture of membranes
Pages: 373-374 Difficulty: 3
Reagents A and B both react covalently with primary amino groups such as those of phosphatidylethanolamine. Reagent A permeates erythrocytes, but reagent B is impermeant. Both A and B are available in radioisotopically labeled form. Describe a simple experiment by which you might determine whether the phosphatidylethanolamine of erythrocyte membranes is located in the outside face of the lipid bilayer, the inside face, or in both. Be brief and use diagrams to support your answer.

Ans: Reagent A will label phosphatidylethanolamine head groups in both the outer and the inner monolayer of the membrane; reagent B will label only the phosphatidylethanolamine molecules on the outer face. If phosphatidylethanolamine is equally distributed on both sides of the bilayer, twice as much labeling of phosphatidylethanolamine should be observed with reagent A as with reagent B. Deviations from this ratio indicate asymmetry in the distribution of phosphatidylethanolamine.

41. The composition and architecture of membranes
Pages: 373-374 Difficulty: 1
Explain the differences between integral and peripheral membrane proteins.

Ans: Integral membrane proteins are very firmly associated with the membrane; their hydrophobic domains are associated with the fatty acyl groups in the interior in hydrophobic interactions. Peripheral membrane proteins are more loosely associated and usually do not penetrate the hydrophobic interior of the bilayer. Conditions that reduce ionic interactions and hydrogen bonds commonly release them. (See Fig. 11-6, p. 374.)

42. **The composition and architecture of membranes**
Pages: 373-375 Difficulty: 2
(a) What kinds of forces or bonds anchor an integral membrane protein in a biological membrane? (b) What forces hold a peripheral membrane protein to the membrane? (c) What might one do to solubilize each of the two types of membrane proteins?

Ans: (a) The forces that hold integral membrane proteins in the membrane are hydrophobic interactions between hydrophobic domains of the protein and the fatty acyl chains of the bilayer interior. (b) Peripheral membrane proteins associate with membranes primarily through ionic interactions and hydrogen bonds between charged and polar side chains of the protein and polar head groups of membrane lipids. Some peripheral membrane proteins contain a covalently bound lipid that anchors them to the bilayer. (c) To remove integral membrane proteins, it is generally necessary to use detergents, which convert membranes into "soluble" micelles. Peripheral membrane proteins can often be released by extraction with buffers of high or low salt concentration, high or low pH, or low concentrations of divalent cations.

43. **The composition and architecture of membranes**
Page: 377 Difficulty: 2
A protein is found to extend all the way through the membrane of a cell. Describe this protein in terms of the location of particular types of amino acid side chains in its structure and its ability to move within the membrane.
Ans: This integral membrane protein associates with the lipid bilayer through hydrophobic interactions between domains containing many hydrophobic amino acids and the fatty acyl chains of membrane lipids. Polar and charged residues are located on portions of the protein that protrude out of either face of the membrane. The protein is free to diffuse laterally in the plane of the membrane, but cannot move across the lipid bilayer.

44. **The composition and architecture of membranes**
Page: 377 Difficulty: 2
If the hydrophobic interior of a membrane were about 3 nm thick, what would be the minimum number of amino acids in a stretch of transmembrane α helix?

Ans: The dimensions of an α helix are about 5.4 Å/turn, and there are 3.6 residues/turn, so each residue extends the helix by about 1.5 Å or 0.15 nm. To span 3 nm of lipid bilayer will therefore require a minimum of 20 residues.

45. **Membrane dynamics**
Page: 377 Difficulty: 3
The pitch of an alpha helix is 5.4 A per turn, and there are 3.6 amino acid residues per turn. If the thickness of the lipid bilayer is 30 A, how many amino acid residues are required in an alpha helix that is just long enough to span the lipid bilayer?

Ans. If the pitch is 5.4 A/turn and there are 3.6 residues per turn, then each residue lengthens the helix by 5.4/ 3.6 = 1.5 A/residue. Dividing 30 A by 1.5 A/residue gives a value of 20 residues necessary to span the lipid bilayer.

46. **The composition and architecture of membranes**
Page: 377 Difficulty: 2
Draw a hydropathy plot for a hypothetical integral membrane protein with 3 transmembrane segments and containing 190 amino acids. Be sure to label the x- and y-axes appropriately, including numerical values.

Ans. The plot should have a y-axis that is labeled "hydropathy index" and an x-axis that is labeled "residue number" or "position in the protein." The y-axis should have values from + 3 to – 3; the x-axis should have an integral number that has a range of zero to several hundred. The plot should show three distinct peaks corresponding to the 3 transmembrane segments.

47. The composition and architecture of membranes
Page: 377 Difficulty: 3
What is a hydropathy plot? Sketch if you like, but label the axes.

Ans: A hydropathy plot is a graphical representation of the average "hydropathy" values (tendancy to prefer organic solvents over water) of contiguous groups of amino acid R-groups in a protein. Long hydrophobic sequences are characteristic of integral membrane proteins.

Y-axis: "hydropathy index," values between +3 and –3.
X-axis: residue number, values between 0 and total number of aa's in the protein.

48. The composition and architecture of membranes
Page: 377 Difficulty: 2
Why is a hydropathy plot useful, and what are its limitations?

Ans: Peaks on a hydropathy plot indicate areas of high hydrophobicity, which may signal the presence of transmembrane helices or other integral membrane protein segments. However, because water soluble proteins have hydrophobic interiors, it is possible to get hydrophobic areas for proteins that are not membrane associated.

49. Membrane dynamics
Page: 381 Difficulty: 2
The bacterium *E. coli* can grow at 20 °C or at 40 °C. At which growth temperature would you expect the membrane phospholipids to have a higher ratio of saturated to unsaturated fatty acids, and why?

Ans: At 40 °C, the membranes of *E. coli* will contain more saturated fatty acids than at 20 °C. The cell regulates fatty acid composition to achieve the same fluidity in its membranes, regardless of growth temperature. Saturated fatty acids counterbalance the fluidizing effect of high temperature.

50. Membrane dynamics
Page: 381 Difficulty: 2
Describe two ways a plant can adjust the components of its cell membranes to keep them as fluid as possible on a cold winter morning.

Ans: To compensate for the solidifying effect of low temperature on membrane lipids, it can synthesize and place in the membrane (1) a greater proportion of unsaturated fatty acids and (2) shorter-chain fatty acids. Both increase the fluidity of the lipid bilayer.

51. Membrane dynamics
Page: 381 Difficulty: 2
A plant breeder has developed a new frost-resistant variety of tomato that contains higher levels of unsaturated fatty acids in membrane lipids than those found in standard tomato varieties. However, when temperatures climb above 95 °F, this frost-resistant variety dies, whereas the standard variety continues to grow. Provide a likely explanation of the biochemical basis of increased tolerance to cold and increased susceptibility to heat of this new tomato variety.

Ans: More unsaturated fatty acids will cause an increase in membrane fluidity because unsaturated fatty acids contain "kinks" and cannot pack as tightly as saturated fatty acids. At cold temperatures, the fluidity increase from the extra unsaturated fatty acids counterbalances the tendency of lipids to solidify at low temperature. At high temperatures, the fluidizing effects of the extra unsaturated fatty acids add to the fluidizing effect of higher temperature, and the membrane of the new plant loses its integrity.

52. Membrane dynamics
Page: 381 Difficulty: 2
a) What is meant by the transition temperature of a membrane? List the two characteristics of the fatty acids in a biological membrane that affect the transition temperature. Using ↑ or ↓, show in which direction an increase in these characteristics would change the transition temperature.

Ans. (a) the transition temperature of a membrane is the temperature at which its structure changes from a paracyrstalline solid to a liquid state. (b) The two characteristics of of fatty acids that directly affect T_t are degree of unsaturation (↓) and chain length (↑).

53. Membrane dynamics
Pages: 383-385 Difficulty: 2
Glycosphingolipids and cholesterol cluster together in membrane regions known as "__________". These microdomains are more __________ than the surrounding phospholipid-rich membrane due to a high content of __________ fatty acids. These regions are rich in proteins that are anchored to the membrane by covalently attached __________ and __________ groups and also those anchored by GPI linkage. Proteins aggregated in this fashion are often functionally related. Examples are (1) __________ proteins and (2) __________ proteins.

Ans: "rafts", ordered, saturated, myristoyl, palmitoyl, receptor, signaling.

54. Membrane dynamics
Page: 386 Difficulty: 3
What are the similarities and differences between integrins, cadherins, and selectins?

Ans: All three are families of integral membrane proteins that are involved in cell adhesion. Integrins mediate cell adhesion to proteins of the extracellular matrix. Cadherins and selectins mediate cell-cell adhesion the former by interaction with cadherins on the surface of other cells, the latter by interaction with polysaccharides on the surface of other cells.

55. Solute transport across membranes
Pages: 389-391 Difficulty: 3
Distinguish between simple diffusion (SD), facilitated diffusion (FD), and active transport (AT) across a membrane for the following questions (more than one may be true).

(a) Which processes are energy dependent?
(b) Which processes need some kind of carrier protein(s)?
(c) Which processes can be saturated by substrate?
(d) Which processes can establish a concentration gradient?
(e) How much energy does it take to transport an uncharged substrate in, if its starting inside concentration is 10-fold greater than outside?

Ans: (a) AT only; (b) FD and AT; (c) FD and AT; (d) AT only; (e) 5.7 kJoules/mole

56. Solute transport across membranes
Page: 391 Difficulty: 3
Explain why nonpolar compounds are generally able to diffuse across biological membranes without the aid of a specific transport system.

Ans: A nonpolar compound is more soluble in nonpolar solutes, such as benzene or chloroform, than in polar solvents such as water. They generally pass through biological membranes unaided because it is energetically favorable for them to move from the aqueous solvent into the nonpolar region of the bilayer interior.

57. Solute transport across membranes
Page: 391 Difficulty: 3
Phospholipids are amphipathic molecules. Show how this property accounts for the impermeability of biological membranes to polar compounds and ions.

Ans: Amphipathic molecules, with both hydrophobic and hydrophilic domains, when placed in water tend to arrange themselves in a way that minimizes contact of their hydrophobic domains with water. One structure that accomplishes this is the lipid bilayer where hydrophobic fatty acyl chains point toward the center of the bilayer, forming a hydrophobic layer about 3 nm thick with the polarity of hexane. This lipid bilayer is impermeable to polar and charged compounds because it is energetically costly for these compounds to give up their favorable interactions with the polar solvent water and to dissolve in the lipid bilayer.

58. Solute transport across membranes
Pages: 393-394 Difficulty: 3
Compare the structure and activity of a membrane transport protein that transports a polar substance across a membrane with a typical soluble enzyme. How are transporter and enzyme similar? How are they different?

Ans: Both proteins have domains that specifically recognize and bind to their substrates via weak interactions; they both therefore mediate processes that are stereospecific and saturable. The membrane transporter usually spans the membrane, having one or several hydrophobic domains that interact with the hydrophobic acyl chains of fatty acids in the interior of the lipid bilayer. Soluble enzymes tend to have their hydrophobic residues buried within their interiors, and their hydrophilic residues on the surface, where they interact with water.

59. Solute transport across membranes
Pages: 397-399 Difficulty: 3
Compare and contrast symport and antiport. Which term best describes the transport system mediated by the Na^+K^+ ATPase?

Ans: Symport and antiport are both types of cotransport systems in which two solutes move through the membrane simultaneously. In symport, both move in the same direction; in antiport, one solute goes in one direction, the other in the opposite direction. The Na^+K^+ ATPase of the plasma membrane is an antiport system. It moves K^+ in and Na^+ out in a ratio of 2 K^+ per 3 Na^+. Neither of the two ions can be transported unless the other is present, which is characteristic of cotransport systems. (See Fig. 11-34, p. 397, and Fig. 11-36, p. 399.)

60. Solute transport across membranes
Pages: 398-400, 408-412 Difficulty: 2
What are three differences between ion channels and ion transporters?

Ans: (1) The rate of ion movement through channels is much greater; (2) ion transporters exhibit saturation, whereas ion channels do not; (3) ion channels open and close in response to external stimuli or events such as ligand-binding or changes in electrical potential across the membrane.