Part A

Multiple Choice Questions: (0.5 marks each for a total of 5 marks)

1. Motor proteins play a particularly important role in assembly of the mitotic spindle and anaphase B separation. Which of the following best describes this role?

a. Movement directed toward the positive end of the microtubule only.
b. Movement directed toward the negative end of the microtubule only.
c. Head-to-head association, allowing crosslinking of antiparallel microtubules.
d. Tail-to-tail association, allowing cross-linking of antiparallel microtubules.
e. None of the above is correct.

2. Which of the following is <u>not</u> an example of an adult stem cell?

a. basal cell of sensory epithelium.
b. hemopoietic stem cell.
c. endothelial cell.
d. satellite cell.
e. None of the above is an adult stem cell.

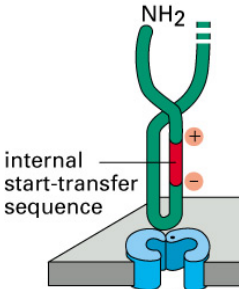
3. Unfolded polypeptide chains are translocated into which of the organelles below?

a. endoplasmic reticulum
b. mitochondrion
c. nucleus
d. a and b are correct
e. none of the above is correct

4. Indicate the following correct order of events for a single cycle of import (translocation) of a protein into the nucleus.

a. NLS with cargo protein binds to import receptor; Ran-GTP binding with receptor releases cargo protein to nucleus; hydrolysis of GTP releases import receptor to cytosol.
b. Hydrolysis of GTP releases import receptor to cytosol; Ran-GTP binding releases cargo protein to nucleus; NLS with cargo protein binds to import receptor.
c. Cargo protein binds directly to import receptor; GTP hydrolysis initiates import of receptor to nucleus; binding of Ran-GDP returns receptor to cytosol.
d. Binding of Ran-GDP returns receptor to cytosol; GTP hydrolysis initiates import of receptor to nucleus; cargo protein binds directly to import receptor.
e. None of the above is correct.

5. A polypeptide chain will be inserted into the ER membrane. In this specific example (see figure), once inserted the orientation of the chain will be:



a. N-terminus facing the lumen; C-terminus facing the cytosol.
b. C-terminus facing the lumen; N-terminus facing the cytosol.
c. Both the C- and N-termini facing the lumen.
d. Both the C- and N-termini facing the cytosol.
e. None of the above is correct.

6. Membrane proteins (and lipids) vital to the structure and function of the plasma membrane are typically delivered to the membrane via:

a. endocytosis
b. exocytosis
c. the constitutive secretory pathway
d. the regulated secretory pathway
e. both a and c

7. SNARE proteins:

a. "catch" chromosomes during formation of the mitotic spindle.
b. are confined to the nucleus.
c. mediate fusion of vesicles with target compartments.
d. are divided into t-SNARES and v-SNARES.
e. both c and d are correct.

8. An unsaturated double bond within the hydrocarbon tail of a plasma membrane phospholipid molecule:

a. is important for the formation of lipid rafts.
b. occurs during apoptosis.
c. elongates the hydrocarbon tail.
d. reduces interaction with adjacent phospholipids and maintains fluidity.
e. c and d are correct.

9. Which of the following ions is buffered at the lowest concentration inside a cell?

a. Ca^{2+}
b. Na^{+}
c. K^{+}
d. Cl^{-}
e. a and b are equal.

10. In most cells, Na^{+} ions will flow *in* through Na^{+} channels. Which of the following choices is/are most consistent with this statement?

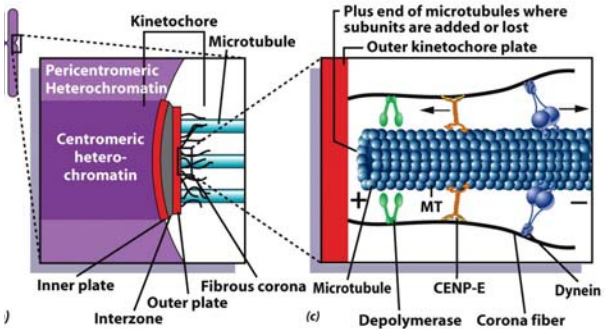
a. Na^{+} channels are voltage gated and open following membrane depolarization.
b. Na^{+} ions will flow down their electrochemical gradient.
c. Na^{+} channels will inactivate at hyperpolarized potentials and prevent further Na^{+} influx.
d. a and b are correct.
e. All of the above are correct.

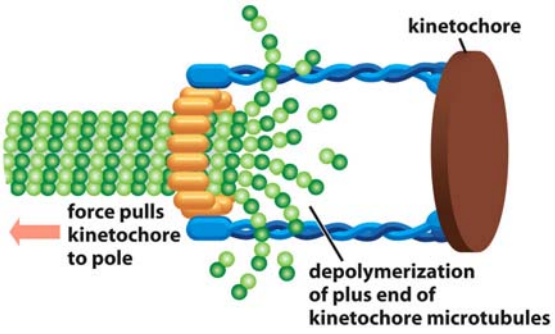
Part B

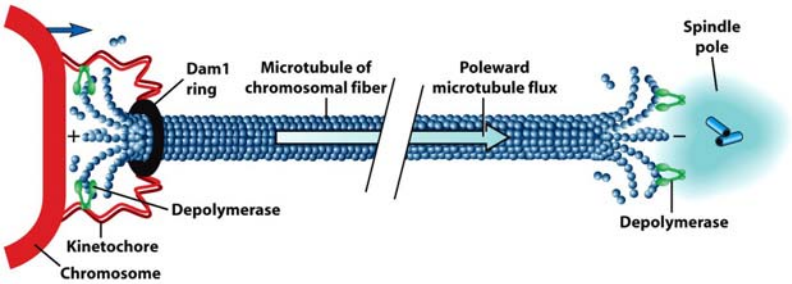
Long Answer Questions (5 marks each for a total of 20 marks).

1. Describe the current theory of how sister chromatids are moved toward the spindle pole during anaphase A separation.

- The kinetochores of chromatids are connected indirectly to kinetochore microtubules (e.g. via corona fibres, molecular motors (i.e. CENP-E, KRP, dynein, dam-1 ring). MTs generally are connected laterally to kinetochores.
- Movement of chromatids, therefore, is believed to occur **primarily** because of the decreased length of MTs in the direction of spindle poles.
- Poleward flux is interrupted by the cessation of subunit addition at the positive (growing) end at the beginning of anaphase A. But since subunit loss continues at the negative (shrinking) end, MTs decrease in length.
- Kinesin-related (motor) proteins (KRPs/catastrophins/depolymerases) destabilize the positive end of MTs at the beginning of anaphase A.
- As the MTs undergo catastrophe (fall apart), this energy is transferred to an assembly of proteins in a ring structure (e.g. dam-1 ring) that attach indirectly to the kinetochore and the chromatid is pulled poleward.
- To a lesser degree, motor proteins are also involved in pulling chromatids (via their indirect attachment to kinetochores) toward the spindle poles. (Note, motor proteins associated with overlap MTs and cell cortex are involved in anaphase B, not A).







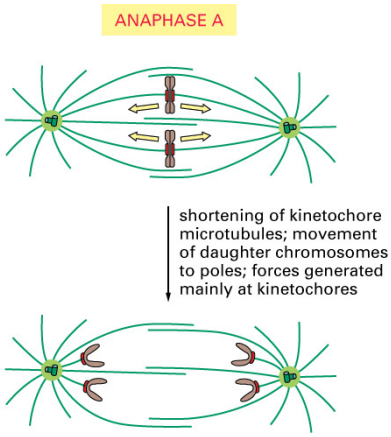
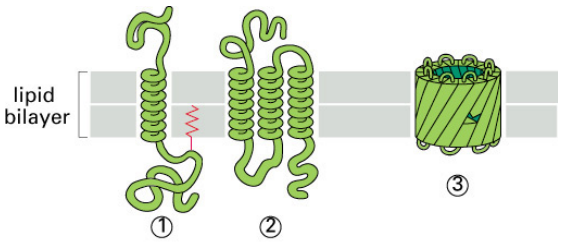


Figure 18–26 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

2. Explain how a transmembrane segment(s) of an integral membrane protein can be stable within the relatively hydrophobic environment of a lipid bilayer. Explain using two structural examples.

- Regions of polypeptide chains that are stabilized within membrane bilayers can be folded (secondary structure) as an α helix, as found in eukaryotes and commonly in the plasma membrane.
- β "sheets" (or barrels) are also formed and are commonly found in prokaryotes and commonly in the mitochondrial membrane.
- Such structures maximize hydrogen (H) bonding interactions between N-H and C-O groups.
- This creates a "shield" of nonpolar amino acid side chains that protects the relatively hydrophilic backbone of the polypeptide chain from the relatively hydrophobic environment of the lipid bilayer.



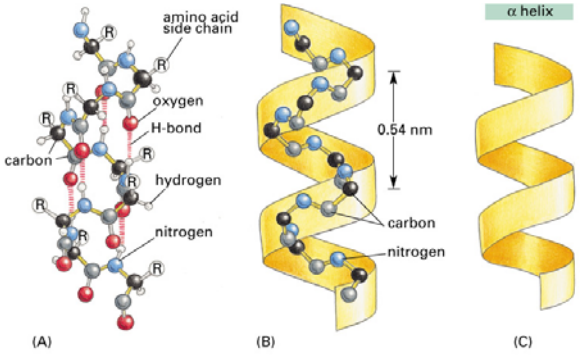


Figure 3–9 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

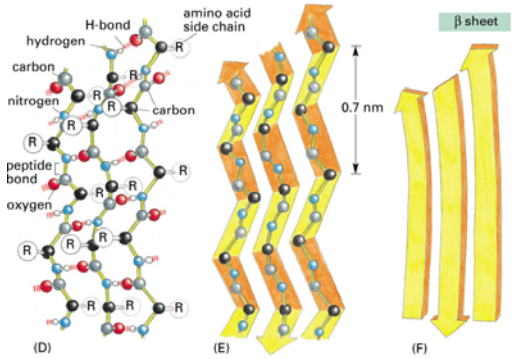
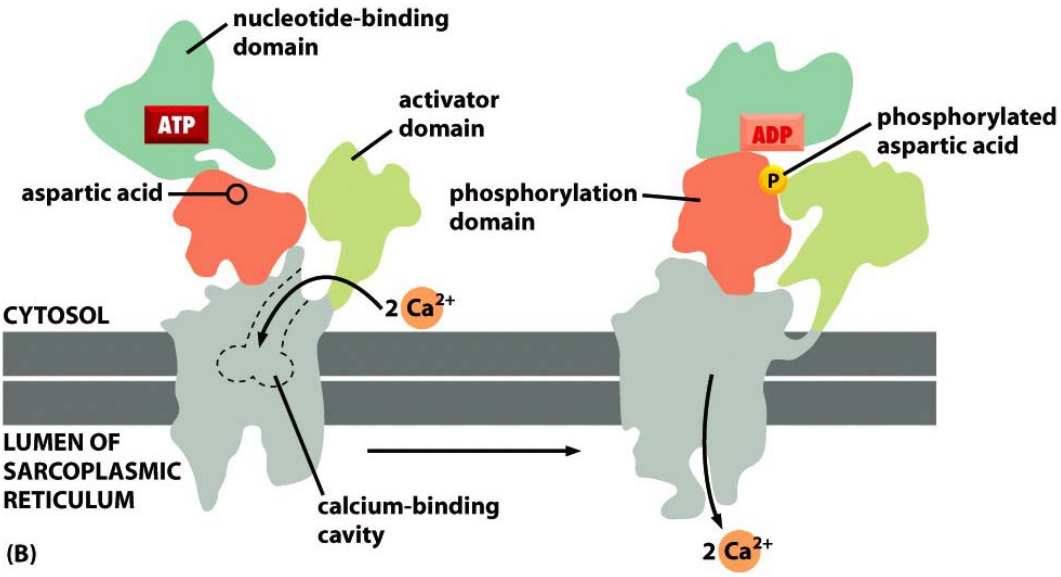


Figure 3–9 part 2 of 2. Molecular Biology of the Cell, 4th Edition.

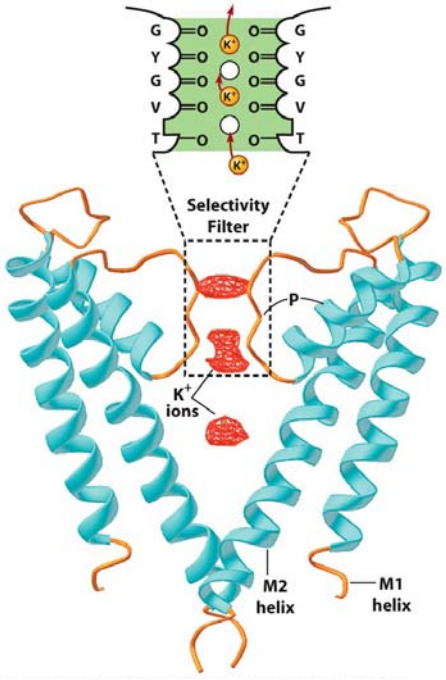
3. Describe how Ca^{2+} is pumped from the cytosol into the sarcoplasmic reticulum of a muscle cell.

- A Ca2+ ATPase is responsible for pumping Ca ions into the SR against its electrochemical gradient, and this occurs in 4 major steps.
- 2 Ca2+ ions bind to α helices on the cytosolic side of the transmembrane protein.
- ATP binds to a nucleotide binding domain. Hydrolysis of ATP and phosphorylation of an aspartic acid occurs.
- A major conformational change of transmembrane helices results.
- Ca2+ ions are then displaced (dissociated) by this conformational change and are released into the SR.



4. Describe the structure of the pore-forming region of a K^+ channel and explain how these channels can be highly selective for K^+ ions compared to Na^+ ions.

- Each of 4 subunits of a K channel contributes an α helix and a non-helical loop, which forms the "pore-forming" region of the channel.
- The non-helical loop is the "selectivity filter" where selection of K ions occurs.
- The filter (or pore-forming region) further consists of 5 rings (each having a diameter of 3 Å) of 4 carbonyl oxygen (O) atoms (i.e. each of 4 subunits contributes an O atom).
- This structure creates 5 spaces (regions of stability) within the pore where K ions are found.
- K ions of the vestibule (entrance) of channel give up hydration shell to interact with O atoms of filter.
- K ions (2.7 Å diameter) are larger than Na ions (1.9 Å diameter) and are, therefore, the correct size to interact with 4 O atoms (of a ring) at the same time. Since Na ions are too small, there is only a small probability (1:1,000) that they will successfully enter the filter.



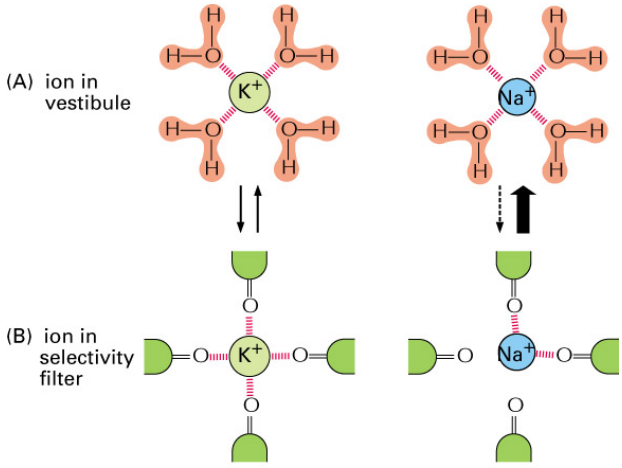


Figure 11–24. Molecular Biology of the Cell, 4th Edition.