1. Phosphatidylethanolamine contains:
   a. glycerol + an unsaturated and saturated fatty acid + phosphate + ethanolamine.
   b. glycerol + two unsaturated fatty acids + phosphate + ethanolamine.
   c. glycerol + two saturated fatty acids + phosphate + ethanolamine.
   d. all of the above.      e. none of the above.

2. Phosphatidylethanolamine has, at pH 7.0, a charge of:
   a. -1.     b. +1.      c. -2.     d. +2.      e. zero.

3. Phosphatidylcholine at pH 12 has a charge of:
   a. -1.     b. +1.      c. -2.     d. +2.      e. zero.

4. Gangloside GM₁ has five sugars attached to:
   a. phosphatidic acid.      b. phosphatidylcholine.    c. ceramide.     d. sphingomyelin.

5. Transverse asymmetry of membrane phospholipids is brought about by:

6. An increase in saturated fatty acids in a membrane will _________ the gel-liquid transition temperature.
   a. increase.     b. decrease.    c. have no effect on.

7. Glycoprotein oligosaccharides are usually linked to the amino acid:
   a. serine.     b. aspartate.     c. arginine.      d. tryptophan.     e. alanine.

8. Which of the following fatty acids is likely to be the most soluble in water?
   a. CH₃(CH₂)₁₈COOH      b. CH₃(CH₂)₂₀COOH       c. CH₃(CH₂)₇CH=CH(CH₂)₇COOH
   d. CH₃(CH₂)₄CH=CHCH₂CH=CH(CH₂)₇COOH    e. None of these are soluble in water.

9. Which of the following lipids is used for energy storage?
   a. glycolipids.    b. glycerophospholipids.    c. sphingolipids      d. triacylglycerols      e. hexane.

10. After the removal of all sugar units from a ganglioside, what molecule remains?
    a. sphingosine.    b. a ceramide.      c. a glycerol.     d. a phosphate.     e. two phosphates.

11. What is the structure of the steroid nucleus found on all sterols?
    a. It consists of five fused rings, four with six carbons and one with five.
    b. It consists of three fused rings, two with six carbons and one with five.
    c. It consists of five fused rings, three with six carbons and two with five.
    d. It consists of four fused rings, three with six carbons and one with five.

12. Which of the following is true about the difference between nucleotides and nucleosides?
    c. Nucleotides lack a phosphate.      d. Nucleosides lack a phosphate.   e None of the above.

13. Deoxyribonucleic acid (DNA) is different from ribonucleic acid (RNA) in that
    a. DNA contains a 3' H, whereas RNA contains a 3' OH.    b. only DNA utilizes the base uracil.
    c. only RNA can be hydrolyzed by alkaline conditions.    d. only DNA contains a pentose sugar.
    e. DNA doesn’t have the same phosphate as RNA.

14. Which of the following is true about the denaturation of double-helical DNA?
a. Denaturation increases with decreasing temperature.  
b. Once denatured, DNA strands cannot anneal.  
c. Denaturation is accompanied by an increase in the absorption of UV light by DNA. 
d. G-C rich DNA melts at lower temperature than A-T rich DNA.  
e. DNA can not be denatured.

15. "Chargaff's rules" about the composition of bases in DNA dictates that 
a. the sum of purine residues must equal the sum of pyrimidine residues. 
b. the sum of A-T base pairs must equal the sum of G-C base pairs.  
c. the base composition of DNA is the same in all species. 
d. DNA specimens isolated from different tissues of the same species vary in base composition. 
e. the sum of ribose equals that of deoxyribose.

16. Which of the following is true about the differences between the structure of B-form DNA (Watson-Crick DNA) and that of A-form or Z-form DNA? 
a. A-form DNA is most stable structure under physiological conditions.  
b. Unlike B-form DNA, the structure of Z-form DNA is a left-handed helix.  
c. Compared to B-form DNA, Z-form DNA has a wider helix and the helical rise is shorter. 
d. The A-form is favored in solutions that are highly hydrated.  
e. none of the above

17. In order to produce radioactive DNA, the deoxynucleotides used for DNA synthesis should contain a radioactive phosphate in which position? 
a. alpha.  
b. beta.  
c. gamma.  
d. delta.  
e. zeta.

18. Which of the following is true about the three major classes of RNAs in the cell: mRNAs, tRNAs, and rRNAs? 
a. mRNAs encode polypeptide chains.  
b. tRNAs are structural components of the ribosome.  
c. rRNAs are adapter molecules that translate the information on an mRNA into a polypeptide sequence. 
d. mRNAs can also encode tRNAs and rRNAs.  
e. tRNAs insert into the nuclear membrane.

19. Evidence that DNA stores the genetic information of the cell was provided by Avery-MacLeod-McCarty experiment in which the transforming principle was: 
a. degraded by a specific enzyme.  
b. shown by mass spectrometry to be DNA.  
c. the idea of the PCR reaction.  
d. chemically synthesized in pure form.  
e. resistant to chymotrypsin.

20. Which of the following is true about DNA structure as proposed by Watson and Crick (B-form DNA)? 
a. DNA forms a left-handed double helix.  
b. The strands of DNA are parallel.  
c. The complementary base pairs are held together in part by hydrogen bonds. 
d. A complete turn of the double helix occurs after every base pair.

21. If a membrane protein in an intact erythrocyte reacts with a membrane-impermeable reagent, what can you conclude about the membrane protein? 
a. It is an integral membrane protein.  
b. It is a peripheral membrane protein.  
c. It interacts best with unsaturated fatty acids.  
d. It is not a plasma membrane protein.  
e. At least one domain of the protein is located on the outer face of the membrane.

22. By what mechanism would a nonpolar molecule move across a membrane if it is moving down its concentration gradient? 
a. facilitated diffusion.  
b. passive transport.  
c. simple diffusion.  
d. active transport  
e. none of these.

23. Which of the following statements is true about active transport? 
a. The transported species always moves against its electrochemical gradient.  
b. It is needed only for the transport of polar molecules.  
c. It is exergonic.  
d. It must be linked to ATP hydrolysis.  
e. Active transport is almost as fast as diffusion.

24. The F-type ATPases of eukaryotes are most likely to be found in membrane of the: 
a. lysosome.  
b. vacuole.  
c. plasma membrane.  
d. mitochondrion.  
e. Golgi.

25. One difference between synport and antiport is that:
a. only antiport requires energy.  b. only synport is reversible.  c only synport is a cotransport system.  
d. only in antiport do two substrates move in opposite directions to each other.  e. none of these.

26. Integral proteins associate with the membrane through:
   a. covalent attachment to lipids.  b. covalent attachment to lipid anchors such as palmitoyl groups. 
c. hydrophobic interactions with lipids.  d. interactions with carbohydrates attached to lipids. 
e. anchoring to glycerol-phospho-lipids using the phosphate group.

27. A hydropathy plot of the amino acid sequence of an erythrocyte membrane protein begins with a region of 
   high negative hydropathy index, followed by three regions of high positive hydropathy index, and ends with a 
   region of high negative hydropathy index. (Each of the regions of high positive and high negative hydropathy 
   index spans more than 20 residues.) What can you predict about the topology of this membrane protein? 
a. It has three transmembrane domains.  b. At least one domain of the protein faces inside the cell.  
c. It is a peripheral membrane protein.  d. It has two domains that span the membrane.  
e. It is pathetic.

28. Peripheral membrane proteins
   a. can be extracted by chelating agents or NaCl.  b. completely span the membrane.  
c. are firmly associated with the membrane.  d. can only be removed with detergents.  
e. all of the above.

29. Which of the following occurs in order for neurotransmitters to be released at synapses?
   a. SNARE proteins transport neurotransmitters out of the cell.  
b. The plasma membrane and vesicle membranes fuse to form an endosome.  
c. Fused vesicle and plasma membranes separate from each other.  
d. v-SNARE and t-SNARE proteins bind to each other.  
e. none of the above.

30. Which of the following is not true about the DNAs from two closely related species?
   a. They are more likely to have similar melting curves than the DNAs from two unrelated species.  
b. They are more likely to form hybrid duplexes than the DNAs from two unrelated species.  
c. They are more likely to have similar base composition than the DNAs from two unrelated species.  
d. They are more likely to have similar purine to pyrimidine ratios than the DNAs from two unrelated species.  
e. I don’t know.

Written Answer Questions:

1. The results of classical Sanger sequencing of a short segment of DNA is show below. What is the 
   sequence of the template strand? Write it correctly from 5' to 3'. (8 points).

   ddATP  ddCTP  ddGTP  ddTTP

2. The human erythrocyte contains $2 \times 10^5$ aquaporin monomers. Water passes through the functional aquaporin
tetramer at a rate of $5 \times 10^8$ molecules/sec. The internal volume of an erythrocyte is $5 \times 10^{-11}$ mL. If this cell is suspended in 2M NaCl, how long would it take for it to lose half of its volume as water? (5 points)

3. Protein digestion begins in the stomach (pepsin) and is finished in the small intestine (many endo and exoproteases). Leucine uptake by small intestine epithelial cells was studied using L-leucine, D-leucine and L-valine to get the following results ($K_T$ in mM, $V_{\text{max}}$ in μmoles/sec):

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Uptake with Na⁺</th>
<th>Uptake without Na⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{\text{max}}$</td>
<td>$K_T$</td>
</tr>
<tr>
<td>D-Leucine</td>
<td>310</td>
<td>4.7</td>
</tr>
<tr>
<td>L-Leucine</td>
<td>420</td>
<td>0.24</td>
</tr>
<tr>
<td>L-Valine</td>
<td>225</td>
<td>0.31</td>
</tr>
</tbody>
</table>

**LIST** the major conclusions (ONLY, NO DISCUSSION) you can draw from this dataset. Do not restate the data (restating the data takes points off). (7 points)