Chapter 5: The Structure and Function of Large Biological Molecules

Concept 5.1 Macromolecules are polymers, built from monomers

1. The large molecules of all living things fall into just four main classes. Name them.

2. Circle the three classes that are called macromolecules. Define macromolecule.

3. Define:
   POLYMER \( \rightarrow \) ______________________________________
   MONOMER \( \rightarrow \) ______________________________________

4. Monomers are put together in what type of reaction? What occurs in this reaction?

5. Large molecules (polymers) are converted to monomers in what type of reaction?

6. The root words of hydrolysis will be used many times to form other words you will learn this year.
   What does each root word mean?
   hydro- ___________________ lysis ___________________

7. Consider the following reaction:
   \( C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + \) _______
   a. The equation is not balanced; it is missing a molecule of water. Write it in on the correct side of the equation.
   b. So, what kind of reaction is this? __________________________
   c. Is \( C_6H_{12}O_6 \) (glucose) a monomer, or a polymer? __________________________
   d. To summarize, when two monomers are joined, a molecule of _______ is removed! always

Also remember that ALL SYNTHESIS REACTIONS REQUIRES ________! ________!
**Concept 5.2 Carbohydrates serve as fuel and building material**

8. Let’s look at carbohydrates, which include sugars and starches. First, what are the monomers of all carbohydrates? __________________________

9. Most monosaccharides are some multiple of (CH₂O). For example, ribose is a 5-carbon sugar with the formula C₅H₁₀O₅. It is a pentose sugar. (From the root *penta*—meaning 5.) What is the formula of a hexose sugar? ______________________

10. Here are the three hexose sugars. Label each of them. Notice that all sugars have the same two functional groups. Name them: C=O ___________ —OH ___________

11. What is the difference between an *aldehyde sugar* and a *ketone sugar*?

12. So, as a quick review, all of these sugars have the same chemical formula: C₆H₁₂O₆. What term did you learn in Chapter 3 for compounds that have the same molecular formulas but different structural formulas? _______________

13. Here is the abbreviated ring structure of glucose. Where are all the carbons?

Pay attention to the numbering system. This will be important as we progress in our study. Circle the number 3 carbon. Put a square around the number 5 carbon.

14. Let’s look at this reaction again:

   \[ C₆H₁₂O₆ + C₆H₁₂O₆ \rightarrow C₁₂H₂₂O₁₁ + H₂O \]

Notice that two monomers are joined to make a polymer. Since the monomers are monosaccharides, the polymer is a *disaccharide*. Three disaccharides are important to us with the formula C₁₂H₂₂O₁₁. Name them below and fill out the chart.

<table>
<thead>
<tr>
<th>Disaccharide</th>
<th>Formed from which two monosaccharides?</th>
<th>Found where?</th>
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</tbody>
</table>
15. Have you noticed that all the sugars end in –ose? This root word means _____.

16. What is a glycosidic linkage?

17. Here is a molecule of starch, which shows 1–4 glycosidic linkages. Translate and explain this terminology in terms of carbon numbering.

18. There are two categories of polysaccharides. Name them and give examples.

<table>
<thead>
<tr>
<th>Type of Polysaccharide</th>
<th>Examples</th>
</tr>
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<tbody>
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<td></td>
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</table>

19. Why can you not digest cellulose? What organisms can?

20. Let’s review some key points about the carbohydrates. Each prompt below describes a unique carbohydrate. Name the correct carbohydrate for each.

   a. Has 1–4 β glucose linkages = _______________________
   b. Is a storage polysaccharide produced by vertebrates; stored in your liver _________
   c. Two monomers of this form maltose = ____________________
   d. Glucose + ____________ form sucrose
   e. Monosaccharide commonly called “fruit sugar” = _____________________
   f. “Milk sugar” = __________________________
   g. Structural polysaccharide that gives cockroaches their “crunch” = ______________
   h. Malt sugar; used to brew beer = __________________
   i. Structural polysaccharide that comprises plant cell walls = ______________

**Concept 5.3 Lipids are a diverse group of hydrophobic molecules**

21. Lipids include fats, waxes, oils, phospholipids, and steroids. What characteristic do all lipids share?
22. What are the building blocks of fats? Label them on this figure.

23. If a fat is composed of 3 fatty acids and 1 glycerol molecule, how many water molecules will be removed to form it? _____________________
   Again, what is this process called? ________________________________

24. On the figure with question 22, label the ester linkages.

25. Draw a fatty acid chain that is 8 carbons long and is unsaturated. Circle the element in your chain that makes it unsaturated, and explain what this means.

26. Name two saturated fats. These fats are __________ at room temperature.

27. Name two unsaturated fats. These fats are ________________ at room temperature.

28. What is a trans fat? Why should you limit them in your diet?

29. List four important functions of fats.
   A. ______________________________________________________________
   B. ______________________________________________________________
   C. ______________________________________________________________
   D. ______________________________________________________________
30. Here is a figure that shows the structure of a phospholipid. Label the sketch to show the phosphate group, the glycerol, and the fatty acid chains. Also indicate the region that is hydrophobic and the region that is hydrophilic.

31. Why is the “tail” hydrophobic?

32. Which of the two fatty acid chains in the figure with question 31 is unsaturated? Label it. How do you know it is unsaturated?

33. To summarize, a phospholipid has a glycerol attached to a phosphate group and two fatty acid chains. The head is hydrophilic, and the tail is hydrophobic. Now, sketch the phospholipid bilayer structure of a plasma membrane. Label the hydrophilic heads, hydrophobic tails, and location of water.

34. Some people refer to this structure as three hexagons and a doghouse. What is it? ________________________________

List 2 functions of this molecule:

35. This molecule is the building block for steroid hormones. Name 3 other steroid hormones.
Concept 5.4 Proteins include a diversity of structures, resulting in a wide range of functions

36. Table 5.1 is loaded with important information. Summarize each type here.

<table>
<thead>
<tr>
<th>Type of Protein</th>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENZYMATIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STORAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HORMONAL</td>
<td></td>
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<tr>
<td>CONTRACTILE</td>
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<tr>
<td>DEFENSIVE</td>
<td></td>
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<tr>
<td>TRANSPORT</td>
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</tr>
<tr>
<td>RECEPTOR</td>
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<tr>
<td>STRUCTURAL</td>
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</tbody>
</table>

37. **Enzymes** are an important type of protein. They will be studied in Chapter 8. For now, use this sketch to review what you know about enzymes. Label the *active site*, the *substrate*, and the *products*.

38. Is this reaction dehydration synthesis or hydrolysis?

39. The monomers of proteins are **amino acids**. Sketch an amino acid here. Label the *alpha* or *central carbon*, *amino group*, *carboxyl group*, and *R group*.

40. What is represented by \( R \)? How many are there?
41. Define these terms:

- dipeptide
- peptide bond
- polypeptide

Label each of these terms on the diagram.

42. There are four levels of protein structure. Refer to Figure 5.20, and summarize each level in the following table.

<table>
<thead>
<tr>
<th>Level of Protein Structure</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary (I°)</td>
<td></td>
</tr>
<tr>
<td>Secondary (2°) Alpha helix</td>
<td></td>
</tr>
<tr>
<td>Beta pleated sheet</td>
<td></td>
</tr>
<tr>
<td>Tertiary (3°)</td>
<td></td>
</tr>
<tr>
<td>Quaternary (4°)</td>
<td></td>
</tr>
</tbody>
</table>

43. Label each of the levels of protein structure on this figure.
44. Enzymes are globular proteins that exhibit at least tertiary structure. On this figure, identify and explain each interaction that folds this portion.

45. Do you remember when, in Chapter 4, we said, “Change the structure, change the function”? Besides mutation, which changes the primary structure of a protein, protein structure can be changed by **denaturation**. Define **denaturation**, and give at least three ways a protein may become denatured.

**Concept 5.5 Nucleic acids store, transmit, and help express hereditary information**

DNA and RNA will be the core topics of Chapter 17. For now, you should just review the general functions and know the components.

46. The flow of genetic information is from DNA → RNA → protein. Use this figure to label where transcription and translation occurs. Label the **nucleus, DNA, mRNA, ribosome, and amino acids.**
The building block of nucleic acids are called ______________________________.

47. The components of these monomers are a sugar, a nitrogenous base, and a phosphate group. Label each on the figure.

48. You may recall that early in this chapter we looked at the numbering system for the carbons of a sugar. Label the end of the strand on the left side of the figure below that has the number 5 sugar 5’ and the other end of the chain 3’.

49. Which 4 nitrogenous bases are found in DNA? __________________
Which 4 four are found in RNA? __________________

50. The sugar found in DNA is __________________.
The sugar found in RNA is __________________.

51. Here is a model of DNA, which was proposed by James Watson and Francis Crick. What is this shape called? __________________
What type of bond holds the two strands together? __________________

52. Why are the strands said to be antiparallel?

53. Write the 2 complementary base pairs that occur in DNA. (Which base bonds with which base?)

54. In a DNA double helix, a region along one DNA strand has this sequence of nitrogenous bases: Write the complementary strand below it.

5’-T A G G C C T-3’

3’ - 5’