**ADVANCED BIOLOGY**
**SUMMER READING QUESTIONS**
**CH 2-5**

Name:

# Chapter 2 Reading Questions

The Chemical Context of Life

## 2.1: Matter consists of chemical elements in pure form and in combinations called compounds

1. Define and give an example of the following terms:

   Matter:

   Element:

   Compound:

2. What four elements make up 96% of all living matter?

3. What is the difference between an *essential element* and a *trace element*?

## 2.2: An element's properties depend on the structure of its atoms

4. Sketch a model of an atom of helium, showing the electrons, protons, neutrons, and atomic nucleus.

5. What is the atomic number of helium? _____ its atomic mass? _____

6. Here are some more terms that you should firmly grasp. Define each term.

   neutron:

   atomic number:

   proton:

   isotope:

   electron:

   electron shells: energy:

   atomic mass:

7. Consider the entry in the periodic table for carbon.
   What is the atomic mass? _____ What is the atomic number? _____

   How many electrons does carbon have? ___ How many neutrons? _____

8. What are *isotopes*? Use carbon as an example.

9. Explain radioactive isotopes and one medical application that uses them.
10. Which is the only subatomic particle that is directly involved in the chemical reactions between atoms?
11. What is *potential energy*?

12. Explain which has more potential energy in each pair:
   a. boy at the top of a slide/boy at the bottom

   b. electron in the first energy shell/electron in the third energy shell

   c. water/glucose

13. What determines the chemical behavior of an atom?

14. Sketch an electron distribution diagram for sodium:

   a. How many valence electrons does it have? _____ Circle the valence electron(s).

   b. How many protons does it have? _____

## 2.3: The formation and function of molecules depend on chemical bonding between atoms

15. Define *molecule*.

16. Now, refer back to your definition of a *compound* and fill in the following chart:

| | Molecule? (y/n) | Compound? (y/n) | Molecular Formula | Structural Formula |
|---|---|---|---|---|
| Water | | | | |
| Carbon Dioxide | | | | |
| Methane | | | | |
| Oxygen | | | | |

17. What type of bond is seen in $O_2$? Explain what this means.

18. What is meant by *electronegativity*?

19. Explain the difference between a *nonpolar covalent bond* and a *polar covalent bond*.

20. Make an electron distribution diagram of water. Which element is most electronegative? Why is water considered a *polar* molecule? Label the regions that are more positive or more negative.

21. Another bond type is the *ionic bond*. Explain what is happening in Figure 2.10.
22. What two elements are involved above?
23. Define *anion* and *cation*. In the preceding example, which is the anion?
24. What is a *hydrogen bond*? Indicate where the hydrogen bond occurs in Figure 2.12.
25. Explain *van der Waals interactions*. Though they represent very weak attractions, when these interactions are numerous they can stick a gecko to the ceiling! .

26. Here is a list of the types of bonds and interactions discussed in this section. Place them in order from the strongest to the weakest: hydrogen bonds, covalent bonds, ionic bonds, van der Waals interactions.
27. Use morphine and endorphins as examples to explain why molecular shape is crucial in biology.

## 2.4: Chemical reactions make and break chemical bonds

28. Write the chemical shorthand equation for photosynthesis. Label the *reactants* and the *products*.

29. For the equation you just wrote,
    How many molecules of carbon dioxide are there? _____
    How many molecules of glucose?_____
    How many elements in glucose? _____

30. What is meant by *dynamic equilibrium*? Does this imply equal concentrations of each reactant and product?

# Chapter 3 Reading Questions

Water and Life

## 3.1: Polar covalent bonds in water molecules result in hydrogen bonding

1. What is a polar molecule? Why is water considered polar?

2. Explain hydrogen bonding. How many hydrogen bonds can a single water molecule form?

## 3.2: Four emergent properties of water contribute to Earth's suitability for life

3. Distinguish between cohesion and adhesion.

4. Which is demonstrated when you see beads of water on a waxed car hood?

5. Which property explains the ability of a water strider to walk on water?

6. The calorie is a unit of heat. Define calorie.

7. Water has high specific heat. What does this mean? How does water's specific heat compare to alcohol's specific heat?

8. Explain how hydrogen bonding contributes to water's high specific heat.

9. Summarize how water's high specific heat contributes to the moderation of temperature. How is this property important to life?

10. Define evaporation. What is heat of vaporization? Explain at least three effects of this property on living organisms.

11. Ice floats! So what? Consider what would happen if ponds and other bodies of water accumulated ice at the bottom. Describe why this property of water is important.

12. Now, explain why ice floats. Why is 4°C the critical temperature?

13. Review and define these terms:

| Term | Definition |
|---|---|
| solvent: | |
| solution: | |
| solute: | |

14. Consider coffee to which you have added sugar. Which of these is the solvent? Which is the solute?

15. Explain why water is such a fine solvent.

16. Distinguish between hydrophobic and hydrophilic substances. Give an example of each.

17. You already know that some materials, such as olive oil, will not dissolve in water. In fact, oil will float on top of water. Explain this property in terms of hydrogen bonding.

18. Now, let's do a little work that will enable you to prepare solutions. Read the section on solute concentrations carefully, and show the calculations here for preparing a 1- molar solution of sucrose. Steps to help you do this follow. The first step is done for you. Fill in the rest.

    Steps to prepare a solution:
    a. Write the molecular formula.

    b. Use the periodic table (on Page B-1, or ptable.com) to calculate the mass of each element. Multiply by the number of atoms of the element. (For example, O has a mass of 16. Therefore, one mole of O has a mass of 16 x 11 = 176 g/mole.)

    c. Add the masses of each element in the molecule

    d. Add this mass of the compound to water to bring it to a volume of 1 liter. This makes 1 liter of a 1 M (1-molar) solution.

19. Can you prepare 1 liter of a 0.5-molar glucose solution? Show your work here.

20. Define molarity.

## 3.3: Acidic and basic conditions affect living organisms

21. What two ions form when water dissociates?

22. What is the concentration of each ion in pure water at 25°C?

23. pH is defined as the negative log of the hydrogen ion concentration [$H^+$]. Explain how water is assigned a pH of 7.

24. To go a step further, the product of $H^+$ and $OH^-$ concentrations is constant at $10^{-14}$. $[H^+]\,[OH^-] = 10^{-14}$

Water, which is neutral with a pH of 7, has an equal number of $H^+$ and $OH^-$ ions.
Now, define

Acid:

Base:

25. Because the pH scale is logarithmic, each numerical change represents a 10X change in ion concentration.

a. How many times more acidic is a pH of 3 compared to a pH of 5?

b. How many times more basic is a pH of 12 compared to a pH of 8?

c. Explain the difference between a pH of 8 and a pH of 12 in terms of $H^+$ concentration.

26. Even a slight change in pH can be harmful! How do buffers moderate pH change?

27. Exercise will result in the production of $CO_2$, which will acidify the blood. Explain the buffering system that minimizes blood pH changes

28. Acid precipitation is increasing. What is the pH of uncontaminated rain?

29. Give two reasons precipitation is more acidic today compared to 1900.

30. What products of fossil fuel burning contribute to acid precipitation?

31. Discuss how CO2 emissions affect marine life and ecosystems.

# Chapter 4 Reading Questions

**Carbon and the Molecular Diversity of Life**

## 4.1: Organic chemistry is the study of carbon compounds

1. Give a brief explanation of Stanley Miller's experiment

## 4.2: Carbon atoms can form diverse molecules by bonding to four other atoms

2. Make an electron distribution diagram of carbon. It is essential that you know the answers to these questions:

   a. How many valence electrons does carbon have? _____

   b. How many bonds can carbon form? _____

   c. What type of bonds does it form with other elements? _____

3. Carbon chains form skeletons. List here the types of skeletons that can be formed.

4. What is a *hydrocarbon*? Name two. Are hydrocarbons hydrophobic or hydrophilic?

## 4.3: A few chemical groups are key to molecular function

5. Define *functional group*.

6. There are seven chemical groups important in biological processes that you should know. Using Figure 4.9 in your text, complete the following chart.

| | **Hydroxyl** | **Carbonyl** | **Carboxyl** | **Amino** | **Sulfhydryl** | **Phosphate** | **Methyl** |
|---|---|---|---|---|---|---|---|
| **Structure** | | | | | | | |
| **Example** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Functional Properties** | | | | | | | |

7. You will need to master the chart and the information in it. Using the functional groups above, see if you can answer the following prompts:

a. —$NH_2$ _____

b. Can form cross-links that stabilize protein structure _____

c. Key component of ATP _____

d. Can affect gene expression _____

e. $CH_3$ _____

f. Is always polar _____

g. Determines the two groups of sugars _____

h. Has acidic properties _____

i. —COOH _____

j. Acts as a base _____

# Chapter 5 Reading Questions

**The Structure and Function of Large Biological Molecules**

## 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* in #8. Define *macromolecule*.

3. What is a *polymer*? What is a *monomer*?

4. Monomers are connected 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.

$$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11}$$

   b. Polymers are assembled and broken down in two types of reactions: *dehydration synthesis* and *hydrolysis*. Which 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 always removed.

## 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 $(CH_2O)$. For example, ribose is a 5-carbon sugar with the formula $C_5H_{10}O_5$. It is a pentose sugar. (From the root *penta–,* meaning five.) What is the formula of a hexose sugar?

10. 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 hexose sugars have the same chemical formula: $C_6H_{12}O_6$. What is the term for compounds that have the same molecular formulas but different structural formulas?

13. Refer to Figure 5.4 (b) in your textbook showing 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.

14. Let's look at our reaction in question 7 again:

$$C_6H_{12}O_6 + C_6H_{12}O_6 \quad C_{12}H_{22}O_{11} + H_2O$$

Notice that two monomers are joined to make a polymer. Since the monomers are monosaccharides, the polymer is a *disaccharide*. Three disaccharides have the formula $C_{12}H_{22}O_{11}$. Name them below and fill out the chart.

| Disaccharide | Formed from Which Two Monosaccharides? | Found Where? |
|---|---|---|
| | | |

| | | |
|---|---|---|
| | | |
| | | |

Have you noticed that all the sugars end in *–ose*? This root word means sugar.

15. What is a *glycosidic linkage*?

16. Refer to Figure 5.5 (a), which shows 1–4 glycosidic linkages. Translate and explain this terminology in terms of carbon numbering.

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

| Type of Polysaccharide | Examples |
|---|---|
| | |
| | |

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

19. 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 B 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 _____

## 5.3: Lipids are a diverse group of hydrophobic molecules

20. Lipids include fats, waxes, oils, phospholipids, and steroids. What characteristic do all lipids share?

21. What are the building blocks of *fats*?

22. If a fat is composed of three fatty acids and one glycerol molecule, how many water molecules will be removed to form it? Again, what is this process called?

23. What are ester linkages?

24. Name two saturated fats.

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

26. Name two unsaturated fats.

27. Why are many unsaturated fats liquid at room temperature?

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

29. List four important functions of fats.

30. Why are the "tails" hydrophobic?

31. Which of the fatty acid chains in Figure 5.10 (b) in your textbook is unsaturated? How do you know it is unsaturated?

32. 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 hydrophilc heads, hydrophobic tails, and location of water.

33. Study your sketch. Why are the tails all located in the interior?

34. Refer to Figure 3.15 in your textbook. Some people refer to this structure as three hexagons and a doghouse. What is it?

35. What are other examples of steroids?

## 5.4: Proteins include a diversity of structures, resulting in a wide range of function

36. Figure 5.13 is an important one! It shows many different functions of proteins. Select any five types of proteins and summarize each type here.

| Type of Protein | Function | Example |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

37. 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*.

38. What is represented by *R*? How many are there?

39. Study Figure 5.14 in your textbook. See if you can understand why some R groups are nonpolar, some polar, and others electrically charged (acidic or basic). If you were given an R group, could you place it in the correct group? Work on the R groups until you can see common elements in each category.

40. Define these terms:

| **Term** | **Definition** |
|---|---|
| **peptide bond** | |
| **dipeptide** | |
| **polypeptide** | |

41. There are four levels of protein structure. Refer to Figure 5.18, and summarize each level in the following table.

| **Level of Protein Structure** | **Explanation** | **Example** |
|---|---|---|
| **Primary** | | |
| **Secondary** | | |
| ***α Helix*** | | |
| ***β Pleated Sheet*** | | |

| | | |
|---|---|---|
| | | |
| **Tertiary** | | |
| **Quaternary** | | |

42. Enzymes are globular proteins that exhibit at least tertiary structure. As you study Figure 5.18 in your text, explain each interaction that folds this protein fragment.

43. Do you remember when we said, "To change the structure, change the function"? Explain how this principle applies to sickle-cell disease. Why is the structure changed?

44. 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.

## 5.5: Nucleic acids store, transmit and help express hereditary information

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

45. The flow of genetic information is from DNA → RNA→ protein. Use Figure 5.22 to explain the process.

46 The components of a nucleic acid are a *sugar*, a *nitrogenous base*, and a *phosphate group*. Make a quick sketch of a nucleotide.

47. Notice that there are five nitrogen bases. Which four are found in DNA?

48. Which four are found in RNA?

49. How do ribose and deoxyribose sugars differ?

50. Here is a model of DNA, which was proposed by James Watson and Francis Crick. What is this shape called?

51. Why are the strands said to be *antiparallel*?

52. What two molecules make up the "uprights"?

53. What molecules make up the "rungs"?

54. In a DNA double helix, a region along one DNA strand has this sequence of nitrogenous bases: 5'-T A G G C C T-3'
Write the complementary strand. Indicate the 5' and 3' ends of the new strand.

## 5.6: Genomics and proteomics have transformed biological inquiry and applications

55. Define the terms genomics and proteomics

56. Given the function of DNA, why would you expect two species with very similar traits to also have very similar genomes?