Chapter 02
The Chemistry of Life

Multiple Choice Questions

Many traits of organisms, such as body form and color, are controlled by specific proteins, in turn controlled by the DNA genetic sequence of nucleotides. The genetic control of color, as in aphids, does not usually shift during the life of an organism. Researchers found that some specific aphid populations shift from an original red coloration to a green coloration. Genetics could be a factor, if some programmed shift could be identified. Environmental conditions of the living and nonliving habitat could be a factor. Either way, the chemistry and observed changes of pigment molecules in the aphids can be studied with the scientific method.

1. What is the link between colored pigment molecules and other organic molecules?
A. Pigment molecules are complex, made up of all four of the other organic molecule groups.
B. The DNA molecule genetic sequence regulates protein molecule function, which can specifically modify pigment structure that affects color.
C. This one group of aphids can easily alter the pigment molecule structure by modifying its DNA nucleotide sequence and building new proteins.
D. In the case of the aphids, the pigment molecules of bacteria are genetically passed on to the DNA of infected aphids.

The DNA genetic control of pigments comes through regulation of which proteins are built in the aphids. The pigment may be a specific protein, or could be dependent on specific proteins built to polymerize the pigment structure. Read sections 2.5 and 2.6 for more information.

Blooms Level: 4. Analyze
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Learning Outcome: 02.06.01 Explain how researchers determined that bacteria induce green pigment production in aphids.
Section: 02.05
Section: 02.06
Topic: Nucleic Acids
Type: Integrative
Type: Investigating Life

2. The initial experiment of Koga and Fugatsu, in testing for any bacterial cause of aphid color change, involved all of these except
A. a group of red aphids was grown as a control group.
B. the specific amounts of red and green pigment molecules were initially measured as dependent variables.
C. a group of aphids infected with *Rickettsiella* bacteria was grown, then killed in order to produce an extract to test on red aphids.
D. a group of red aphids was treated with the independent variable of *Rickettsiella* bacteria infection from green aphids.
E. a group of green aphids was grown, then killed in order to produce an extract to test on red aphids.

Koga and Fugatsu conducted two distinct studies addressing different aspects of the color changing aphids. Read section 2.6 for more information (and review the scientific method in chapter 1).

Blooms Level: 3. Apply
Learning Outcome: 02.06.01 Explain how researchers determined that bacteria induce green pigment production in aphids.
Section: 02.06
Topic: Chemical Bonds
Topic: Nucleic Acids
Type: Investigating Life

3. The observations and research on aphid color changes can most directly be summarized in that
A. species of organisms can be chemically diverse and affect each other, even among similar groups of aphids and bacteria.
B. the method of paper fiber separation of pigment molecules showed that *Ricketsiella* bacteria were the source of the green coloration of aphids.
C. it turned out that the green appearance of aphids was because of the large amount of green *Ricketsiella* bacteria coating their bodies.
D. Koga and Fugatsu proved that the color change from red to green in aphids was ecologically favorable to survival.

Two hardest parts of scientific investigation are determining a research question of what is not yet known, and then drawing useful summary conclusions after research results are analyzed for value. Read section 2.6 for more perspective on this study (and review the scientific method in chapter 1).

Blooms Level: 4. Analyze
Learning Outcome: 02.06.01 Explain how researchers determined that bacteria induce green pigment production in aphids.
Section: 02.06
Topic: Chemical Bonds
Topic: Nucleic Acids
Type: Investigating Life

4. Researchers noted that only few aphids changed color to green from their original red. This is an unusual observation among any animals. What research question came out of the observations?
A. Is the color shift of certain aphids due to genetics or some other factor?
B. The color shift of certain aphids is due to genetics within the species.
C. Do other aphids change colors as they age?
D. Will green aphids change their color to red, or remain green as they age?

The different steps of the scientific method are demonstrated in the Investigating Life section. Hypotheses are statements that serve as individual possible answers to a research question. Read section 2.6 for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.06.01 Explain how researchers determined that bacteria induce green pigment production in aphids.
Section: 02.06
Topic: Nucleic Acids
Type: Investigating Life

5. A conscientious person habitually reads nutrition labels on food packages for weight watching and general health. The main nutritional molecules are made up of
A. trace elements.
B. buffers.
C. bulk elements.
D. isotopes.

Carbohydrates, lipids, and proteins, required in reporting on nutrition labels, are organic molecules composed mainly of carbons, hydrogens, and oxygens. Read sections 2.1.A and 2.5 for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.01.01 Identify the most abundant essential elements in living organisms.
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.01
Section: 02.05
Topic: Carbohydrate
Topic: Lipids
Topic: Nucleic Acids
Topic: Proteins
Type: Integrative

6. In the 1700s, a French scientist, Antoine Lavoisier gained new experimental information about how chemistry works. He isolated chemicals that were reacting, including a metal and an acid. His observation of the results seemed to show that much of the metal had been lost in the chemical reaction. Yet, upon weighing the system, the total amounts of materials had not changed during the reaction. His resulting law of Conservation of Mass also applies to biology, because the materials we are made of are _____ that change forms, but aren't truly lost as we conduct life chemical reactions.
A. energy
B. matter
C. isotopes
D. solutions

Lavoisier showed that chemical reactions rearrange matter, rather than create or destroy atoms that make matter. Read section 2.1 for more information on elements, and also sections 2.2.A and 2.2.B for more information.

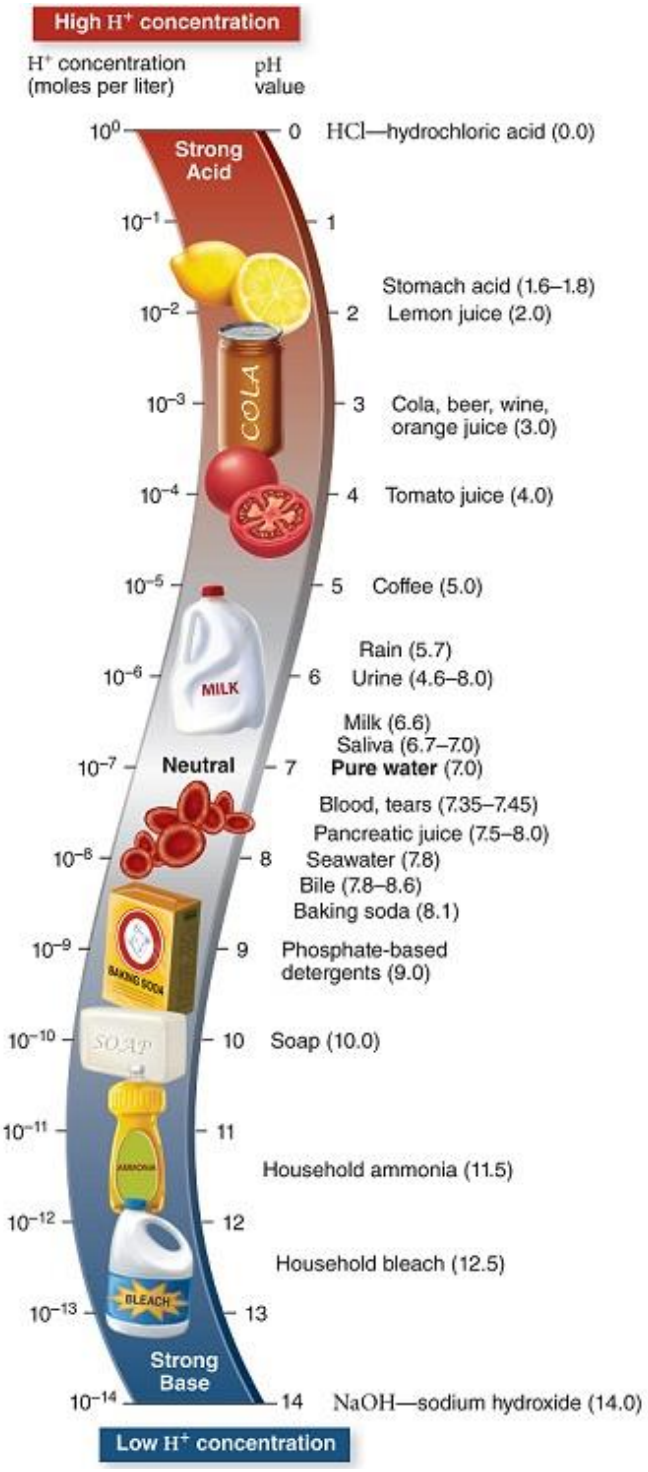
Blooms Level: 2. Understand
Learning Outcome: 02.00.01 Explain the relationship between chemistry and biology.
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Section: 02.01
Topic: Atomic Structure
Type: Integrative

7. The unique properties of water, including its strength as a solvent, its three environmental stages of solid, liquid, and gas, and its temperature regulation, are a result of
A. unbalanced electronegativity of the hydrogens and oxygens as they share electrons.
B. the imbalance in numbers of electrons around hydrogen and oxygen valence shells after they ionically bond.
C. the cohesion and adhesion of water molecules that bond more strongly to each other than other substances.
D. symmetric balance of electronegativity as shared electrons orbit equally around the hydrogens and oxygens.

The same basic properties of water from its covalent bond and resulting electronegativity contribute to the importance of all water properties that benefit life. Read sections 2.2.B and 2.3.A through 2.3.D for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.02.04 Explain the relationship between electronegativity and chemical bond formation.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.02
Section: 02.03
Topic: Properties of Water
Type: Integrative

Refer to this diagram with common examples of substances and their pH.



8. The correct functions of your lungs contribute to the normal pH level of between 7.35 and 7.45. If your lungs do not exchange and remove carbon dioxide from your blood, the blood pH will change. A pH 6.4 reading of your blood indicates
A. a health problem due to the pH value being 2X higher OH^- concentrations than normal in your body.
B. no health risk, as part of normal pH changes in your body that in this case bring it closer to neutral pH.
C. a health problem due to the pH value being 2X higher H^+ concentrations than normal in your body.
D. a health problem due to the pH value being 10X higher H^+ concentrations than normal in your body.
E. a health problem due to the pH value being 10X higher OH^- concentrations than normal in your body.

Because the pH scale is logarithmic, every whole number change represents 10X change in concentrations and reactivity of the solution. Slight changes to the decimal place of pH change can affect your health. Read section 2.4.A for more information.

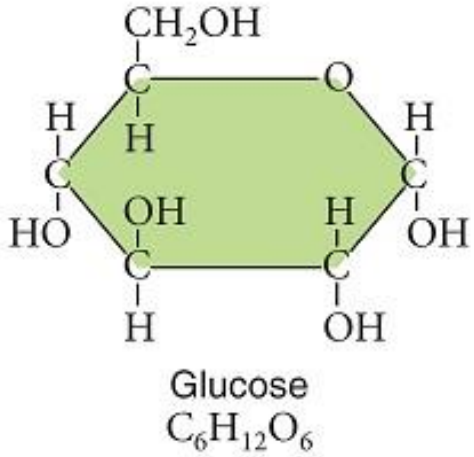
Blooms Level: 3. Apply
Figure: 02.14
Learning Outcome: 02.04.01 Explain how acids and bases affect pH.
Section: 02.04
Topic: Acids and Bases
Topic: Properties of Water

9. Our normal blood pH should be in a fairly narrow range. Imagine you sit down to eat a large meal with cola, tomato-based sauce, and a salad with many citrus fruit slices. Identify the one statement that does not apply as one of the likely outcomes of your meal.
A. Your blood and body fluids will likely become more basic, with higher pH than the normal range.
B. Your blood and body fluids will likely become more acidic, with lower pH than the normal range.
C. The cola, tomato and citrus fruits will add hydrogen (H^+) to your blood and body fluids.
D. Your body will produce buffer molecules to help neutralize acids you ate, so your blood pH doesn't change much.

There are medical terms for having your blood pH out of the very narrow normal range. Your meals can have temporary effects on you, that can affect heart, lungs, and other organ functions, though buffers help in stability. Read sections 2.4.A and 2.4.B for more information.

Blooms Level: 3. Apply
Figure: 02.14
Learning Outcome: 02.00.01 Explain the relationship between chemistry and biology.
Learning Outcome: 02.04.01 Explain how acids and bases affect pH.
Section: 02.04
Topic: Acids and Bases
Topic: Properties of Water
Type: Integrative

Examine this image of the glucose molecule.



Glucose
$C_6H_{12}O_6$

10. This glucose molecule is a(an)
A. disaccharide.
B. carbohydrate.
C. triglyceride.
D. polymer.

The shapes, structures and sizes of organic molecules are specifically linked to vital cell functions. Read section 2.5.A for more information.

Blooms Level: 1. Remember
Figure: 02.17
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate

11. In our diets, this molecule is often covalently bonded with others in the polymer form of
A. a complex carbohydrate.
B. a simple sugar.
C. a fatty acid chain.
D. a triglyceride.

We typically hear of monomers and polymers regarding "plastics," but organic chemists learned about these materials by studying organic molecules from life. Read section 2.5.A for more information.

Blooms Level: 2. Understand
Figure: 02.17
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate

12. Compared with a molecule of glucose, this starch molecule does NOT have which characteristic below?

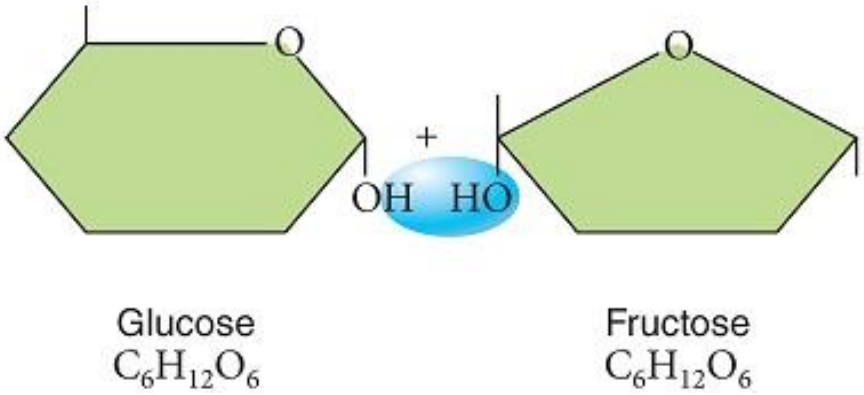
A. This molecule is used by cells for long-term storage and release of energy for cell functions.
B. This molecule is used by cells for quick release of energy for cell functions.
C. This molecule can provide structure for cells that contain it.
D. This molecule is a complex carbohydrate polymer.

Our diets include simple sugars and complex sugars. The uses vary depending on how simple sugars are bonded to each other in chains. Read section 2.5.A for more information.

Blooms Level: 2. Understand
Figure: 02.17
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate

True / False Questions

Examine these two sugars, as shown prior to the chemical reaction that would bond them.



13. These glucose and fructose molecules will bond to form a monosaccharide with the removal of water.
FALSE

Formation of new covalent bonds between monomers results in larger, multiple unit molecules. Read section 2.5 for more information.

Blooms Level: 1. Remember
Figure: 02.17
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate

Multiple Choice Questions

14. The diagram shows glucose and fructose before the chemical reaction called _____ builds a larger polymer from the two monomers.
A. reproduction
B. dehydration synthesis
C. evaporation
D. hydrolysis

Living cells constantly build and tear apart polymers as needed for varying functions. Covalent bonds are formed and broken with the addition or subtraction of components of water. Read sections 2.5 and 2.5.A for more information.

Blooms Level: 2. Understand
Figure: 02.17
Learning Outcome: 02.05.01 Differentiate between dehydration synthesis and hydrolysis.
Section: 02.05
Topic: Carbohydrate
Topic: Chemical Bonds

15. The ring structure of glucose indicates that it is a(an)
A. monosaccharide.
B. disaccharide.
C. fatty acid.
D. nucleotide.
E. amino acid.

The single ring structure and the approximate ratio of carbons:hydrogens:oxygens of 1:2:1 indicates the general type of molecule as a unit. Read section 2.5.A for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate
Topic: Chemical Bonds

16. The primary elements making up living organisms are
A. carbon, hydrogen, oxygen, sulfur, nitrogen, and phosphorus.
B. carbon, hydrogen, iron, sulfur, sodium, and calcium.
C. carbon, oxygen, iron, chlorine, sulfur, and phosphorus.
D. carbon, hydrogen, oxygen, calcium, iron, and iodine.
E. carbon, oxygen, sulfur, calcium, iron, and phosphorus.

Bulk elements are often listed on labels of vitamins and food nutrition labels, enforcing the understanding that they are required for our vital health. They are commonly also needed by other organisms for their health. Read section 2.1.A for more information.

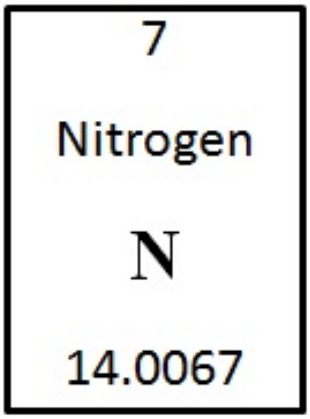
Blooms Level: 1. Remember
Learning Outcome: 02.01.01 Identify the most abundant essential elements in living organisms.
Section: 02.01
Topic: Atomic Structure

17. The atomic number of an element is the number of
A. protons in the orbitals.
B. electrons in the nucleus.
C. neutrons in the orbitals.
D. neutrons in the nucleus.
E. protons in the nucleus.

Each named element has distinct properties associated with their protons and electrons, and the periodic table of the elements organizes elements by these components. Read section 2.1.B for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.01.02 Describe the structure of atoms.
Section: 02.01
Topic: Atomic Structure

18. Given this information from one element in the periodic table of elements, the number of neutrons and protons is



A. 7, which is the atomic number indicated.
B. 14, which is the atomic number indicated.
C. 7, which is the atomic mass indicated.
D. not discernable, because the number of electrons is also needed.
E. 14, which is the atomic mass indicated.

The information about elements is reported in standardized form for reference by all scientists. Read sections 2.1.B and 2.1.C for more information.

Blooms Level: 3. Apply
Learning Outcome: 02.01.02 Describe the structure of atoms.
Section: 02.01
Topic: Atomic Structure

19. The mass number is defined as the total number of _____ of an atom.
A. protons and neutrons
B. protons
C. protons and electrons
D. neutrons and electrons
E. protons, neutrons, and electrons

Mass number is analyzed and reported, because researchers may need to identify if isotopes or radioisotopes are present. Read section 2.1.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.01.02 Describe the structure of atoms.
Section: 02.01
Topic: Atomic Structure

20. An ion is an atom that has
A. a different number of neutrons from the number of protons.
B. a net negative charge.
C. a net negative or positive charge, with number of electrons different from number of protons.
D. the same number of electrons as it does protons.
E. a net positive charge.

The elemental form listed in the periodic table of elements assumes a neutral condition, having electron and proton numbers equal. Read section 2.1.B for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.01.01 Identify the most abundant essential elements in living organisms.
Section: 02.01
Topic: Atomic Structure

21. The first energy shell of an atom contains a maximum of _____ electron(s).
A. eight
B. sixteen
C. four
D. two
E. one

The numbers of electrons that fill the first energy shell is common to all elements. Read section 2.2.A for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.02 Use the number of valence electrons in an atom to predict the number of bonds it will form.
Section: 02.02
Topic: Atomic Structure

22. An element is found to have atoms with eight electrons in its valence shell. The atoms will be ____
A. not chemically stable.
B. highly reactive.
C. highly likely to combine with other atoms.
D. chemically stable.
E. not inert.

The stability, or lack of chemical reactivity, is dependent upon whether the valence shell is full or not, regardless of whether there is a normal atom or an ion. Read sections 2.1.B and 2.2.A for more information.

Blooms Level: 3. Apply
Learning Outcome: 02.01.02 Describe the structure of atoms.
Learning Outcome: 02.02.02 Use the number of valence electrons in an atom to predict the number of bonds it will form.
Section: 02.01
Section: 02.02
Topic: Atomic Structure
Type: Integrative

23. In a covalent bond, atoms
A. share a proton.
B. share electrons.
C. both become highly electronegative.
D. of opposite charges attract each other.

The outer valence shells can be filled by either 'sharing' or complete 'donation' of electrons. Read section 2.2.B for more information.

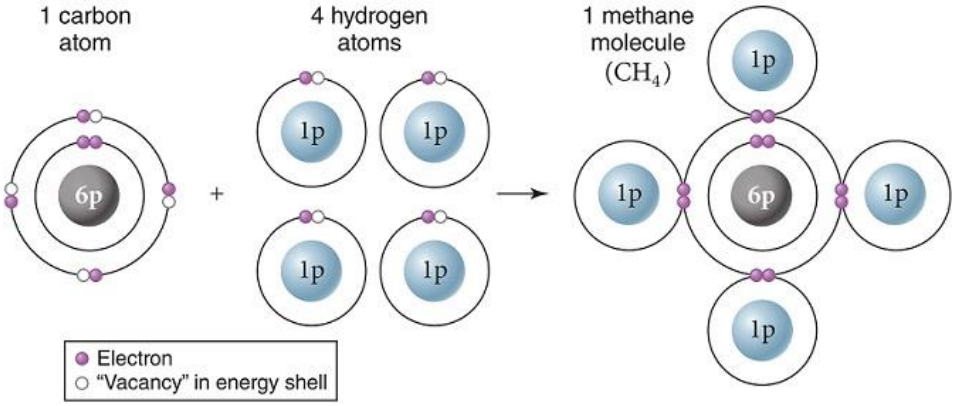
Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Section: 02.02
Topic: Chemical Bonds

24. In an ionic bond,
A. atoms, having gained or lost electrons, attract one another with opposite charges.
B. two atoms are attracted by partial positive and negative charges.
C. atoms attract each other by sharing electrons to fill their valence shells.
D. two atoms both become strongly electronegative and attract each other.

The outer valence shells can be filled by either 'sharing' or complete 'donation' of electrons. The positive and negative charges are due to complete gains or losses of electrons, changing the charge balance with protons. Read section 2.2.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Section: 02.02
Topic: Chemical Bonds

25. Carbon and hydrogen make up many biologically important molecules. Carbon has an electronegativity of 2.55 while hydrogen has an electronegativity of 2.0. On the scale of electronegativity from zero (0) to four (4), the carbon and hydrogens shown here have just formed



A. an ionic bond.
B. a nonpolar covalent bond.
C. a polar covalent bond.
D. a hydrogen bond.

Electronegativity will impact the distribution of where atoms spend most time while shared in covalent bonds. Read section 2.2.B for more information.

Blooms Level: 4. Analyze
Figure: 02.07
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.02.04 Explain the relationship between electronegativity and chemical bond formation.
Section: 02.02
Topic: Chemical Bonds
Type: Integrative

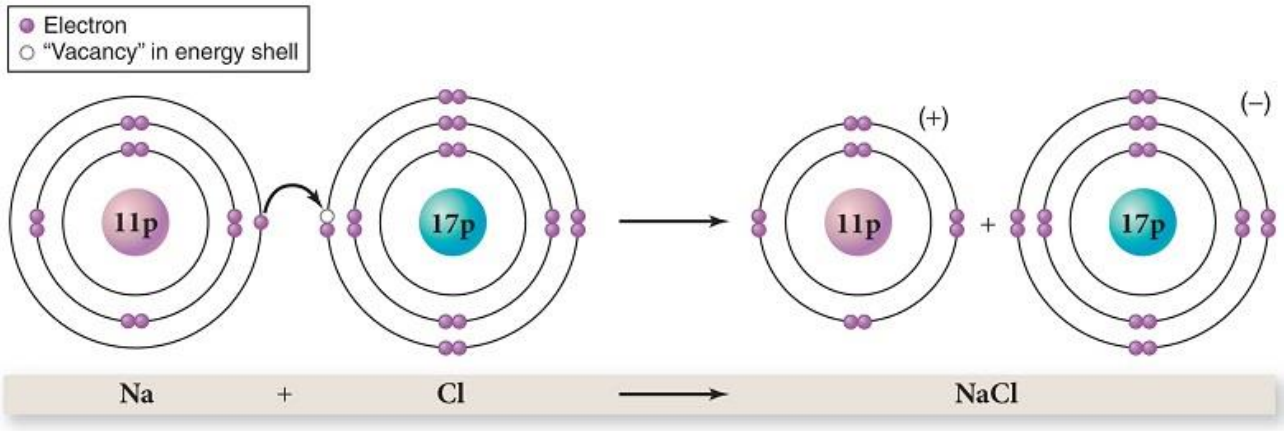
26. Which statement summarizes the distinction between nonpolar and polar covalent bonds?

A. The difference in electronegativity of the atoms in a nonpolar covalent bond is very large.
B. Polar covalent bonds are formed when the atoms gain or lose electrons to bond, and become oppositely charged ions.
C. The electrons are more evenly and symmetrically distributed in orbit among atoms in a nonpolar covalent bond.
D. The electrons are more evenly and symmetrically distributed in orbit among atoms in a polar covalent bond.

Covalent bonds require sharing of electrons, though the time electrons spend in orbit around each atom will vary. Read section 2.2.B for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.02.04 Explain the relationship between electronegativity and chemical bond formation.
Section: 02.02
Topic: Chemical Bonds

27. In the example of ionic bond formation between sodium and chlorine, as shown, which of the following is not a true statement?



A. Sodium donates an electron.
B. Sodium becomes positively charged.
C. The bond that is formed is stronger than a hydrogen bond.
D. Na is the chemical symbol for sodium.
E. Chlorine donates an electron.

The donation, or loss of the electron from sodium (Na) is shown, forming it into an ion. The gain of the electron by chlorine (Cl) forms it into an ion. Read section 2.2.C for more information.

Blooms Level: 1. Remember
Figure: 02.06
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Section: 02.02
Topic: Chemical Bonds

28. The chapter concept map links covalent and ionic bonds as chemical bonds that attract atoms or molecules. What is the chemical bond characteristic that contributes to the numerous important properties of water molecules for living organisms?
A. The covalent bond strengths of water molecules change with pH, temperature, or solute conditions present.
B. The covalent bonds that form water molecules transform to ionic bonds in presence of other molecules, temperature changes, or pH.
C. Hydrogen bonds form between water molecules, not requiring gain, loss, or sharing of electrons.
D. Bonds that form water are of the nonpolar covalent form.

Hydrogen bonds between water molecules provide "flexibility" in distances and angles between the water molecules without gain, loss, or sharing of electrons. This contributes to the numerous important properties of water. Read sections 2.2.D and 2.3 for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.02
Section: 02.03
Topic: Chemical Bonds
Type: Integrative

True / False Questions

29. The property of water demonstrated by this water strider, as it remains on top of the water, is that water is a universal solvent.

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FALSE

Water's partial charges allow it to be cohesive, so that the surface tension among molecules can support this light insect. Read section 2.3.A for more information.

Blooms Level: 1. Remember
Figure: 02.10
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.03
Topic: Chemical Bonds

Multiple Choice Questions

30. You can painlessly wade into a pool, but doing a belly flop off of the high diving board hurts because of
A. water's high boiling point.
B. cohesion in water.
C. water's high density.
D. adhesion in water.
E. water's neutral pH.

Though individually small, water molecules form hydrogen bonds with each other to produce surface conditions we experience differently depending on how we enter the water. Read section 2.3.A for more information.

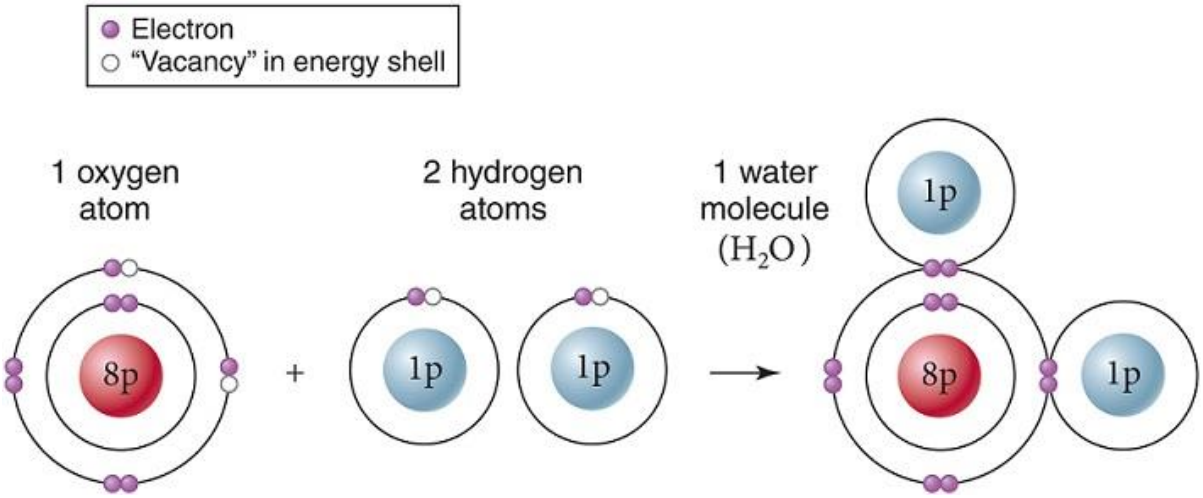
Blooms Level: 3. Apply
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.02
Section: 02.03
Topic: Chemical Bonds
Topic: Properties of Water
Type: Integrative

31. Trees are able to transport water from the roots to the top branches because
A. water acts as a solvent of the tree cells as it moves upwards to the branches.
B. liquid water has a higher density than the air in the plant cells of the roots, trunk and branches.
C. adhesion bonds water molecules to the insides of the plant cells.
D. cohesion bonds water molecules to each other strongly.

The partial hydrogen bond charges between water molecules and the molecules of tree cells help the water move large distances. Read section 2.3.A for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.03
Topic: Chemical Bonds
Topic: Properties of Water

32. Within a single molecule of water, as shown, ____ bonds are formed between oxygen and hydrogen.



A. hydrophobic
B. ionic
C. hydrogen
D. nuclear
E. covalent

As the diagram shows, the oxygen and hydrogens share orbits of electrons in their valence shells. Read section 2.2.B for more information.

Blooms Level: 1. Remember
Figure: 02.07
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Section: 02.02
Topic: Atomic Structure
Topic: Chemical Bonds
Topic: Properties of Water

True / False Questions

33. If a molecule is added to a glass of water, and is easily dissolved by the water, the added molecule is described as hydrophilic.
TRUE

In understanding water's function as a solvent, hydrophilic molecules are paired with polar molecules that can be dissolved easily by the polar water molecule. Read section 2.3.B for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.02
Section: 02.03
Topic: Properties of Water
Type: Integrative

Multiple Choice Questions

34. Evaporation of water is
A. a phase change of water from liquid into a vapor.
B. a phase change of water from solid into a vapor.
C. a phase change of water from vapor into a liquid.
D. a phase change of water from vapor into a solid.
E. All of the answer choices are correct.

Water's hydrogen bonds hold it in different phases of solid, liquid or gas (vapor), and the specific types of phase changes are associated with energy and habitat conditions important to life. Read sections 2.3.B and 2.3.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.03
Topic: Properties of Water

35. You collect and measure samples of ice and surrounding ice water from a stream in the Winter. You find that you collected the same number of water molecules in each form. Water in the ice (solid) form floats in water of the liquid form because
A. in the ice form, the same number of water molecules are found in a solid, more compact volume than the liquid water.
B. in the ice form, the same number of water molecules are found in a crystal form, yet total larger volume than the liquid water.
C. once the water molecules froze into ice, they became hydrophobic, and started repelling from the liquid.
D. the ice is actively melting, since it was surrounded by the liquid water in the stream where it was collected.

Density of molecules changes with most substances at different temperatures, but water is most dense at just above freezing, so the colder, crystalline ice is less dense than surrounding water. Read section 2.3.D for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.03
Topic: Properties of Water

36. In a chemical equation, which components of a chemical reaction is not noted in symbols and abbreviations?
A. Some substance atoms on the left side of the chemical reaction arrow must be destroyed in order to form the substances on the right side.
B. The number of atoms of each element must be the same, balanced on each side of the chemical reaction arrow.
C. Reactants and products are on both sides of the yields arrow.
D. The reactants, or starting substances, are on the left of the chemical reaction arrow.
E. The products, or ending substances, are on the right of the chemical reaction arrow.

Chemical reactions can neither create, nor destroy atoms, so chemical reactions are written in a way that shows balance of all input and output atoms, based on how the substances react. Read section 2.3.E for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.03
Topic: Chemical Reactions

37. An acid
A. has a value above seven on the pH scale.
B. is a chemical that takes hydrogen ions from a solution.
C. has a value of seven on the pH scale.
D. is a chemical that adds hydrogen ions to a solution.
E. All of the answer choices are correct.

The pH values are based on how water molecules break apart into smaller ion components of hydrogen (H^+) and hydroxide (OH^-) components. Read section 2.4 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.04.01 Explain how acids and bases affect pH.
Section: 02.04
Topic: Acids and Bases

38. A base
A. is a chemical that adds hydrogen ions to a solution.
B. has a value below 7 on the pH scale.
C. has a value of 7 on the pH scale.
D. is a chemical that absorbs hydrogen ions from a solution.

The pH values are based on how water molecules break apart into smaller ion components of hydrogen (H^+) and hydroxide (OH^-) components. Read section 2.4 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.04.01 Explain how acids and bases affect pH.
Section: 02.04
Topic: Acids and Bases

39. Algal phytoplankton are single-celled water organisms that can do photosynthesis like plants. In a lake, summer growth of phytoplankton can change the water pH from pH 7.2 to 6.2. This change indicates all of these except
A. the water at pH 6.2 is a stronger acid solution than before the phytoplankton growth.
B. the lake water solution changed from slightly basic to slightly acidic in pH.
C. the water at pH 6.2 has twice the hydrogen (H^+) concentration as before the phytoplankton growth.
D. the water at pH 6.2 has ten times the hydrogen (H^+) concentration as before the phytoplankton growth.

Environmental conditions in which organisms live can be impacted by changes in pH. The pH whole numbers represent ten times more or fewer hydrogen (H^+) in the water solution. Read sections 2.4 and 2.4.A for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.04.01 Explain how acids and bases affect pH.
Section: 02.04
Topic: Acids and Bases

40. Organic molecules are defined as chemical compounds that chiefly contain _____ in fairly distinct ratios and structures.
A. carbon, hydrogen, and nitrogen
B. carbon
C. carbon and oxygen
D. carbon and nitrogen
E. carbon and hydrogen

From the monomer units to the polymer structures, the four main organic molecule groups have distinct properties that repeat in structure. Read all subsections in 2.5 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate
Topic: Chemical Bonds
Topic: Lipids
Topic: Nucleic Acids
Topic: Proteins

41. The four major groups of organic compounds are
A. fats, waxes, carbohydrates, and amino acids.
B. carbohydrates, proteins, amino acids, and nucleic acids.
C. lipids, fats, waxes, and steroids.
D. carbohydrates, lipids, proteins, and nucleic acids.
E. carbohydrates, lipids, steroids, and monosaccharides.

What scientists know about industrial plastics, they initially learned from studying organic molecule structures. Each large organic molecule group has sub-types that must be discerned. Read all sections in 2.5 and examine table 2.5 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate
Topic: Lipids
Topic: Nucleic Acids
Topic: Proteins

42. In living cells, a process by which cells break polymers down into monomers by breaking covalent bonds is
A. hydrolysis.
B. dehydration synthesis.
C. reproduction.
D. All of the answer choices are correct.

Living cells constantly build and tear apart polymers as needed for varying functions. Covalent bonds are formed and broken with the addition or subtraction of components of water. Read section 2.5 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.01 Differentiate between dehydration synthesis and hydrolysis.
Section: 02.05
Topic: Chemical Bonds
Topic: Chemical Reactions

43. Examples of monosaccharides are
A. glucose, maltose, and cellulose.
B. glucose, lactose, and maltose.
C. glucose, ribose, and fructose.
D. glucose, lactose, and cellulose.
E. None of these answers are correct; all options list lipids.

Monosaccharides are single ring structures, usually of four to six carbons. Read section 2.5.A for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate

44. Blood pH is closely maintained at a pH of 7.4. A patient whose blood pH drops below 7.35 is suffering from metabolic acidosis and can go into a coma. What happens to the concentration of H^+ ions in a patient with a blood pH of 6.4?
A. H^+ concentration is decreased 2-fold.
B. H^+ concentration is increased 2-fold.
C. H^+ concentration is increased 10-fold.
D. H^+ concentration is decreased 10-fold.
E. H^+ concentration is decreased 4-fold.

Without proper homeostasis of pH controls by buffers and other body functions, relatively small numerical pH changes can result in potentially deadly consequences. Read section 2.4.A for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.04.01 Explain how acids and bases affect pH.
Section: 02.04
Topic: Acids and Bases

45. Which is not a lipid?
A. a triglyceride
B. a wax
C. a starch
D. a phospholipid
E. a sterol

Fatty acid chains are characteristically attached among the types of lipids. Sterols have distinct clusters of four interconnected rings, differently arranged from chains of rings in carbohydrates. Read section 2.5.B for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Lipids

46. The primary building block (monomer) of proteins is
A. a glucose molecule.
B. a fatty acid.
C. an amino acid.
D. a nucleotide.
E. a group of four interconnected rings.

Proteins are diverse in structure and function, yet are consistently made of chains of linked building blocks, notably including the nitrogen element. Read section 2.5.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Proteins

47. An amino acid contains a structural "backbone" chain of
A. phosphorus atoms.
B. nitrogens.
C. nitrogens and carbons.
D. carbon and phosphorus atoms.
E. carbons.

Amino acid monomers and the resulting protein polymers have a characteristic repeating sequence of the two main elements, in addition to the specialized R groups. Read section 2.5.C for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Proteins

48. The bond that builds amino acid monomers into protein polymers is
A. a primary structural bond.
B. an ionic bond also known as a peptide bond.
C. a denatured hydrogen bond.
D. a covalent bond also known as a peptide bond.

The bond between amino acids is named specifically because it is linking carbon end groups of one monomer to nitrogen end groups of the other. Read section 2.5.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Bonds
Topic: Proteins

49. Many diseases, cancers and even normal human variations can be caused by mutations and variations in the DNA nucleotide sequence. The most likely immediate result of DNA having a different nucleotide sequence is that
A. the protein resulting from the DNA mutation would be denatured and nonfunctional.
B. the peptide bonds in the protein would by hydrolyzed and the protein would fall apart.
C. no direct result of change in the protein molecule would occur if DNA is mutated.
D. the primary structure of R group sequence in a protein would be altered.

This question addresses several properties of the bonds and structures that you need to understand about the precise link between DNA and proteins. Read sections 2.5.C and 2.5.D for more information.

Blooms Level: 3. Apply
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Nucleic Acids
Topic: Proteins
Type: Integrative

50. The primary building block (monomer) of nucleic acids is
A. a nucleotide.
B. an amino acid.
C. a group of four interconnected rings.
D. a fatty acid.
E. a glucose molecule.

The characteristic double helix shape of DNA can be described as a twisted ladder shape, with the monomers forming each "rung" of the structure. Read section 2.5.D for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Nucleic Acids

51. The three major components in a nucleotide are
A. glucose, a nitrogen base, and a phosphate group.
B. a nitrogen base, a six-carbon sugar, and a phosphate group.
C. a carboxyl group, an R group, and an amino group.
D. a nitrogen base, a five-carbon sugar, and a phosphate group.
E. glucose, a fatty acid, and glycerol.

Nucleotides in DNA and RNA have more complex structure, with three smaller subunits making up each nucleotide. Read section 2.6.D for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Nucleic Acids

52. The comparison listed below that is not true in distinguishing DNA from RNA is that
A. DNA is a long two-sided molecule while RNA is a shorter single-sided molecule.
B. DNA and RNA share all nucleotides, except that RNA has Uracil instead of Thymine.
C. DNA is a molecule that stores and regulates our genetics, while RNA is used for cellular energy storage and release for biological functions.
D. DNA has a main function of storing our genetic code, while RNA is used in units to build specific proteins in a cell.

Although DNA and RNA are built of similar nucleotides, they are used by the cell in different ways. DNA stores and regulates genetic information, while RNA is specifically a functional strand used to translate genetic code into proteins for different biological functions. Read section 2.5.D for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Nucleic Acids

53. The four nitrogen bases found in RNA are
A. adenine, thymine, guanine, and uracil.
B. adenine, cytosine, guanine, and uracil.
C. adenine, thymine, cytosine, and uracil.
D. thymine, cytosine, guanine, and uracil.
E. None of the answer choices are correct.

For all known life, there are four nucleotides common in DNA, and the four nucleotides of RNA are similar with one substituted nucleotide. Read section 2.5.D for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Nucleic Acids

54. Sugars $(CH_2O)_n$ dissolve well in water because sugars form ____ bonds with water.
A. hydrogen
B. covalent
C. hydrophobic
D. ionic
E. non-polar

The partial charges that allow water molecules to bond cohesively with each other also allow it to bond adhesively with molecules of other substances. Read section 2.3.B for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.02
Section: 02.03
Topic: Chemical Bonds
Type: Integrative

55. ____ bonds are formed between monomers to form a polymer.
A. Hydrophobic
B. Hydrogen
C. Ionic
D. Nuclear
E. Covalent

It is important to study the monomer units, and the processes of making and breaking the bonds that form larger polymers. Read section 2.5 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.02
Section: 02.05
Topic: Chemical Bonds

56. Saturated fats have long straight tails of fatty acids, and can pack or clump tightly together in cells and animal bodies. Unsaturated fats have kinks in their tails due to double bonds, which prevents them from packing together as tightly. Animals that are ectothermic (their body temperature fluctuates with the environment) need to keep their membranes fluid at cooler temperature and thus use _____ in their membranes.
A. mostly unsaturated fats
B. mostly saturated fats
C. equal amounts of saturated and unsaturated fats
D. carbohydrates
E. proteins

This represents a range of ecological relationships among animals and the temperature in their habitat, and a trait that can vary among species, their habitats, or in seasonal changes. Read section 2.5.B for more information.

Blooms Level: 3. Apply
Learning Outcome: 02.00.01 Explain the relationship between chemistry and biology.
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Bonds
Topic: Lipids
Type: Integrative

57. Saturated fats have long straight tails of fatty acids, while unsaturated fats from vegetables have kinks in their tails due to double bonds. These kinks prevent the fats from packing together as tightly. Hydrogenated vegetable oils, or trans fats, have hydrogens added back to the double bonds and thus behave like
A. carbohydrates.
B. waxes.
C. proteins.
D. unsaturated fats.
E. saturated fats.

Hydrogenation is a technological manipulation that converts less expensive plant oils to forms that taste to us, as economic consumers, more like animal fats. Read section 2.5.B for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Bonds
Topic: Lipids

58. The group of organic molecule polymers with the most complex and diverse three-dimensional structure are
A. proteins.
B. carbohydrates.
C. waxes.
D. saturated fats.
E. unsaturated fats.

Primary, secondary, tertiary, and quaternary structures of proteins demonstrate the different complexity and diversity of the polymers. Read section 2.5.C for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Bonds
Topic: Proteins

True / False Questions

59. Cohesion is a property of water in which water molecules tend to stick together.
TRUE

Cohesion occurs when molecules of any substance attract other molecules of the same substance, and water does this with hydrogen bonds. Read sections 2.2.D and 2.3 for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.02.03 Compare and contrast ionic, covalent, and hydrogen bonds.
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.02
Section: 02.03
Topic: Chemical Bonds
Topic: Properties of Water

60. A peptide bond is a covalent bond formed between the amino group of one amino acid and the R group of another amino acid.
FALSE

Locations of peptide bonds is not random in building the polymers, but must be located in specific positions. Read section 2.5.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Bonds
Topic: Proteins

61. A substance in which other substances dissolve is called a solute.
FALSE

Liquid solutions, such as our blood plasma rely on the solvent and solute components to be balanced for our health. Read section 2.3.B for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.03.01 Explain how the structure of water affects its chemical properties.
Section: 02.03
Topic: Chemical Bonds
Topic: Properties of Water

62. Our general economic source of unsaturated fatty acids is from plants, and composed of at least one pair of double-bonded carbons.
TRUE

The economic understanding of food sources we buy can be important as you note differences among the natural and modified fatty acids. Read section 2.5.B for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Bonds
Topic: Lipids

63. Of the 20 common amino acids in all organisms, essential amino acids are those we must consume in food.
TRUE

There are eight amino acids that humans gain from protein-rich foods. Read section 2.5.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Proteins

Multiple Choice Questions

64. Among numerous functions of common proteins, which of these pairs does not correctly match a protein with its function?
A. Insulin regulates blood glucose levels.
B. Collagen is a structural protein to support hair, skin, and nails.
C. Hemoglobin protein transports oxygen to our cells.
D. DNA polymerase helps synthesize new DNA before our cells divide.
E. Antibodies regulate sweat to keep infections out of our skin pores.

While carbohydrates, lipids, and nucleic acids have relatively few functions, proteins serve many purposes in our bodies. Review table 2.5 for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Chemical Reactions
Topic: Proteins

True / False Questions

65. If a protein is denatured, its structure has been changed enough to make the protein nonfunctional.
TRUE

Normal functions of proteins cease if the 3-dimensional structure is changed by various conditions. Read section 2.5.C for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.01 Differentiate between dehydration synthesis and hydrolysis.
Section: 02.05
Topic: Proteins

66. Proteins store the genetic information of the cell and transmit it to the next generation.
FALSE

Although proteins have many functions, and have structure determined by the DNA genetic code, protein functions do not include storage and inheritance of genetics. Read section 2.5.C for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.01 Differentiate between dehydration synthesis and hydrolysis.
Section: 02.05
Topic: Proteins

Multiple Choice Questions

67. If a carbohydrate polymer is limited to two monomer units, such as sucrose made from glucose and fructose, it is called
A. a polysaccharide.
B. an oligosaccharide.
C. a monosaccharide.
D. a disaccharide.

Whether used for storage or structure, the numbers and arrangement of monomers in the carbohydrates change the properties most, as cells use them. Read section 2.5.A for more information.

Blooms Level: 1. Remember
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate

68. Having the typical ratio of carbon, hydrogen, and oxygen of carbohydrates, the chemical formula for glucose is

A. $C_{12}H_6O_{12}$.
B. $C_6H_6O_6$.
C. $C_{12}H_{22}O_{11}$.
D. $C_6H_{12}O_6$.
E. $C_6H_6O_{12}$.

Through all of the carbohydrates, the C:H:O ratio is relatively consistent. Read section 2.5.A for more information.

Blooms Level: 2. Understand
Learning Outcome: 02.05.02 Compare and contrast the structures and functions of the four main classes of organic molecules.
Section: 02.05
Topic: Carbohydrate