20. An atom has no charge. An ion has a charge because it has either lost or gained electrons. The ion has a full valence shell, while the atom does not.
21. A covalent compound results from non-metallic atoms sharing electrons to form covalent bonds, while an ionic compound results when an ionic bond forms between a positively charged ion and a negatively charged ion.
22. Soil pH and Gardening – gardeners might have to determine the pH of soil to see if certain plants can grow in it; Pools and Hot Tubs – pH of the water has to be tested otherwise algae can grow; Baking – baking involves a series of chemical reactions that require the ingredients to be at a specific pH; Hair – use of hair dyes and shampoos require the correct pH balance to work.
23. Diagram
24. Diagram
25. Water forms beads of water because of attractive cohesive forces between the water molecules are responsible for surface tension.

Chapter 2 Review Questions

1. **d.** a proton has a positive charge; an electron has a negative charge; a neutron has no charge
2. **c.** They both have the same number of protons, but different number of electrons.
3. **d.** a buffer
4. **d.** 1000 times
5. **c.** covalent; hydrogen
6. **b.** Polar, water-loving; Nonpolar, water-fearing
7. **c.** protein and amino acid
8. **c.** the formation of a peptide bond between alanine and lysine
9. **d.** the conversion of monosaccharides into polysaccharides
10. **d.** carbohydrates
11. **d.** they have twice as many hydrogen atoms as oxygen atoms
12. **c.** disaccharide
13. **c.** 3
14. **b.** double bonds
15. **c.** the phosphate group
16. **b.** cholesterol
17. **b.** speeds up chemical reactions
18. **b.** keratin
19. **b.** insulin
20. **b.** a peptide bond
21. **a.** the R group
22. **b.** R group
23. **b.** amino acids
24. **b.** 3
25. **d.** hydrogen bonding
26. **a.** the linear sequence of amino acids
27. **b.** folded differently due to the hydrogen bonding and have a different sequence of amino acids
28. **a.** energy is released
29. **d.** phosphorus
30. **a.** nucleotide
31. **d.** a monosaccharide
32. **b.** RNA
33. **c.** nitrogen
34. **a.** RNA
35. **b.** a phosphate group, a nitrogenous base and a ribose sugar
36. **c.** the pentose sugar
37. **a.** uracil
38. **a.** cytosine and guanine
39. **d.** Safety goggles, juice, Benedict's solution, test tube, test tube tongs, graduated cylinder, hot plate, beaker, water, rubber gloves
40. **a.** 6 (fatty acid), 7 (glycerol)
    b. 3 (amino acid)
    c. 2 (glucose), 8 (maltose), 12 (cellulose), 13 (starch), 14 (glycogen)
    d. 11 (steroid)
    e. 13 (starch)
    f. 6 (fatty acid), 7 (glycerol)
    g. 12 (cellulose)
    h. 2 (glucose)
    i. 5 (water)
    j. 10 (phospholipid)
    k. 9 (ATP)
    l. 3 (amino acid), 4 (dipeptide)
    m. 14 (glycogen)
    n. 1 (triglyceride), 4 (dipeptide), 8 (maltose), 10 (phospholipid), 12 (cellulose), 13 (starch), 14 (glycogen)
    o. 3 (amino acid), 4 (dipeptide)
    p. 5 (water)
41. An atom has the same number of protons and electrons. The positive charges of the protons and the negative charges of the electrons add up to zero, making the atom neutral.
42. The negatively charged oxygen of one water molecule is attracted to the positively charged hydrogen of another water molecule.
43. The pH of the solution will decrease becoming more acidic.
44. Bond X is a hydrogen bond.
45. Bond X forms between the two molecules because the molecules are polar.
46. Three functions of water: 1. acts as a solvent – dissolves substances; 2. acts as a lubricant – lubricates joints; 3. acts as a temperature regulator – regulates body temperature.
47. The unequal sharing of electrons accounts for the polarity.
48. The partially positive and negative charges on the molecule allow water to act as a solvent.
49. The body will store the carbohydrates needed for the race. On the day of the race, glycogen will be converted into glucose so that glucose can be used to produce ATP during cellular respiration.

50. Two hydrogen atoms and one oxygen atom are used to produce a water molecule during the dehydration reaction.

51. The process is a dehydration reaction.

52. Bond X is a peptide bond.

53. A dipeptide (2 amino acids held together by a peptide bond) and a water molecule will form as a result of this reaction.

54. Nine water molecules are produced when 10 amino acids are linked together.

55. Lactose is classified as a disaccharide.

56. A water molecule is required for this reaction to occur.

57. A hydrolysis reaction is illustrated.

58. When nonpolar molecules, such as oil, come into contact with polar molecules, like water, they do not mix. The oil molecules tend to clump together rather than mix with the water. This is because oil molecules are nonpolar and therefore hydrophobic (water-fearing).

59. **a.** DNA codes for the sequence of amino acids in a protein.

b. A nucleotide consists of a nitrogenous base, a sugar and a phosphate group. It is the monomer that makes up a nucleic acid.

c. A monosaccharide consists of one sugar molecule, while a polysaccharide consists of many sugar molecules.

d. A polypeptide is a chain of amino acids held together by peptide bonds.

e. The secondary structure of a protein is determined by the hydrogen bonding between the different amino acids.

f. Due to the unequal sharing of electrons on a water molecule, the water molecule is said to be polar. The negative charge of one water molecule is attracted to the positively charged part of another water molecule. This causes the water molecules to stick together, displaying cohesion.

60. **a.** A glycerol molecule is only composed of a three-carbon chain, while a fatty acid is a long chain of carbons. Both of these molecules make up a triglyceride.

b. A triglyceride has a glycerol molecule attached to three fatty acid chains, while a phospholipid has a glycerol molecule attached to two fatty acid chains and a phosphate group.

c. A peptide bond forms between the carbon of the carboxyl group and the nitrogen of the amino group in a dipeptide. A hydrogen bond forms between different amino acids in the polypeptide chain.

d. Unsaturated fatty acids have double bonds, while saturated fatty acids only have single bonds.

61. **a.** A large amount of molecules can be produced with the same monomer. For example, glucose (a monomer) can form three different polymers (cellulose, starch and glycogen).

b. Hydrolysis breaks down a polymer that is no longer needed and its monomers can be used to produce other polymers through a dehydration reaction.

62. A positive test for Benedict's solution indicates the presence of glucose. Since maltose is made up of two glucose molecules it should test positive like the glucose solution.

63. The phospholipid bilayer forms in an aqueous solution because the polar (hydrophilic) head is soluble in water, while the non-polar (hydrophobic) tails are not. The hydrophilic heads will interact with the water on the outside and inside of the vesicle, while the hydrophobic tails interact with each other.

64. The molecular structure of a phospholipid consists of a hydrophilic head and a hydrophobic tail. The polar hydrophilic head faces outwards toward the watery solutions and the non-polar tails form the hydrophobic interior.

65. The non-polar, hydrophobic tails of the phospholipids are packed tightly together to form the interior of the cell membrane and the hydrophilic heads face outward where they interact with water. The phospholipids bilayer allows only lipid-soluble substances to pass through it. Cellulose is a huge polysaccharide consisting of unbranched chains of glucose molecules. The rigid structure of the plant cell wall owes its physical strength to cellulose.

66 **a.** The purpose of partial hydrogenation is to remove double bonds and to replace them with single bonds in the unsaturated fatty acid. This will add more hydrogen atoms to the unsaturated fatty acid.

b. The content of container would be liquid oil.

67. Starch and glycogen can be broken down into glucose monomers. Glucose can then be used to produce energy for cellular activities through cellular respiration.

68. It is a change in primary structure. The change in amino acid sequence might affect the tertiary structure and quaternary structure because valine now will bond differently with other amino acids in the polypeptide forming different hydrogen bonds, ionic bonds and covalent bonds. The interactions of the different amino acids along the polypeptide chain will affect the 3D globular shape of the polypeptide and now one polypeptide chain will interact with another polypeptide chain.

69. A polymer is a large molecule formed from the joining of smaller unit molecules called monomers. Proteins are made up of repeating units of amino acids, while steroids consist of just one component, a ringed structure.

70. A protein will fold a particular way as hydrogen bonding forms between the different R-groups of the amino acids along the polypeptide chain. In addition to this, non-polar hydrophobic R-groups of amino acids will move toward the interior of the protein's 3D shape. The resulting tertiary structure will determine the function of the protein.

71. Four biological molecules that would have phosphorus in them are ATP, DNA, RNA, and phospholipid.

72. With all the different combinations of amino acids and the different hydrogen bonding that form between the amino acids, thousands of different proteins are possible. With a variety in the amino acid sequence, this will result in different tertiary structures. The functions of proteins are dependent on the protein's 3D structure.

73. The sequence of amino acids along a polypeptide will affect how one amino acid interacts with another amino acid in the polypeptide chain. Hydrogen bonds, covalent bonds, and ionic

bonds will cause the polypeptide to fold into a specific shape based on what amino acids interact with one another along the chain.

74. The difference lies in the hydrogen bonding between the amino acids. The coiling of the chain produces an alpha helix, while the folding of the chain results in a beta pleated sheet.

75. If hydrogen bonding was absent, DNA would not be a double stranded molecule because there would not be complementary base pairing between the bases of the two strands.

76.

Type of Bond	Ionic Bond	Covalent Bond	Hydrogen Bond
Description	- bond that forms in compounds between a positively charged ion and a negatively charged ion - results in the transfer of electrons	- polar bond - bond that forms within molecules are due to sharing of electrons	- bond that forms between the hydrogen of one molecule and a non-metal (eg. oxygen or nitrogen) of another molecule

77.

	Cellulose	Starch	Glycogen
Monomer	glucose	glucose	glucose
Description of Structure	no side chains	some side chains	many side chains
Plant Cell or Animal Cell	plant cell	plant cell	animal cell
Function	structural component of plant cell wall	energy storage in plants	energy storage in animals

78. The absence of side chains in cellulose allows the linear molecules to be side by side, adding strength and rigidity for the plant. Glycogen has many branches and acts as energy storage. The branching of the side chains allows glycogen to be more soluble and it can be synthesized and broken down more quickly for energy.

79.

Characteristic	DNA	RNA	Protein
Is it a polymer?	Yes (consists of nucleotides)	Yes (consists of nucleotides)	Yes (consists of amino acids)
Does it have a three dimensional structure?	Yes	Yes	Yes
Does it contain nitrogen atoms?	Yes (contains nitrogen in the bases)	Yes (contains nitrogen in the bases)	Yes (contains nitrogen in the amino group)
Does it contain phosphorus atoms?	Yes (phosphorus is in the sugar-phosphate backbone)	Yes (phosphorus is in the sugar-phosphate backbone)	No (amino acid does not have phosphorus)
Does it contain hydrogen bonding?	Yes (has hydrogen bonding between A-T and C-G)	Yes (has hydrogen bonding between A-U and C-G)	Yes (has hydrogen bonding between the amino acids)

80. Structural similarities include: they are monosaccharides, hexose, simple sugars; they have the same molecular formula; they occur as ring structures; they have "ose" endings; they provide energy.

81. a. The primary structure of a protein is due to the peptide bonding between the adjacent amino acids.

b. The secondary structure of a protein is due to the hydrogen bonding between the amino acids.

c. The tertiary structure of a protein is due to the covalent bonding between the R-groups of the amino acids.

d. The quarternary structure of a protein is due to the bonding between 2 or more polypeptides.

82. Venn Diagram should have two circles interlocking. Place DNA label above the circle on the left hand side and RNA above the circle on the right hand side. The part where the two circles overlap will list the similarities that these two molecules have. Similarities include: nucleic acid, adenine, guanine, cytosine. In the DNA circle, students should list: double stranded, thymine, double helix, replication. In the RNA circle, students should list: single stranded, uracil, three type of RNA (mRNA, tRNA and rRNA), transcription.

a. A = proteins; B = cellulose; C = amino acids; D = glucose; X = hydrolysis

b. Maltose (a disaccharide) would form if two units of molecule D underwent a dehydration reaction.

c. Two other polymers that would form from glucose are glycogen and starch.

84. Fats produce almost twice the amount of energy for a given gram of protein and carbohydrate.

85. The carbons in fatty acids have more electrons around them. When the fatty acids are oxidized (eg. the electrons are transferred to oxygen), more energy is released than the same process with carbohydrates and proteins.

86. Different types of oils have different percentage of unsaturated and saturated fats. They tend to have the "healthier" unsaturated fats rather than the saturated fats.

87. Unsaturated fats are derived from plants and are liquid at room temperature.

88. Answers may vary – biomechanics, molecular biology, nuclear medicine, biomedical engineering, neuroscience, immunogenetics, microbiology, electrochemistry, geophysics.

For example, biomechanics uses engineering concepts to analyze structure and function in biological systems. Geophysics uses the concepts of physics (eg. electricity and magnetism) to study the Earth.

89. Scientists can inject radioactive material into a patient and trace its movement through the digestive system. They may want to use the radioisotope carbon-14 to track the digestion of starch into maltose, and then into glucose. By analyzing the path that the carbon takes, scientists can determine where carbohydrate digestion takes place in the body. Since nitrogen is found in proteins, scientists can use the radioisotope nitrogen-15 to track the digestion of proteins into peptides, and then into amino acids.

90. **a.** By restricting the consumption of carbohydrates, the body will not convert excess carbohydrates into fat. The body will also start to burn body fat instead of carbohydrates for fuel. This will result in weight loss.

    b. Your body would start to burn fats rather than carbohydrates as fuel.

91. A lack of proteins would not give the body the amino acids it needs to build important proteins for the body (eg. enzymes for metabolic reactions, keratin, collagen, etc.).

92. Diagram

93. Header: Organic Compounds

    First column: Carbohydrates; polysaccharides; dissacharides; monosaccharides

    Second column: Lipids; triglyceride; fatty acids; glycerol

    Third column: Proteins; peptides; amino acids

    Fourth column: Nucleic acids; RNA; DNA; nucleotides

    Fifth column: High-Energy Compounds; ATP; nucleotide; phosphate groups

Chapter 3 Diagnostic Questions

1. **a.** A red blood cell is larger than a virus.
2. **c.** the plasma membrane
3. **b.** to control all of the cell's activities
4. **d.** a cell wall
5. **c.** water + carbon dioxide + sunlight → oxygen + glucose
6. **d.** $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + ATP$
7. **d.** Mitochondria are found in both plant and animal cells, while the chloroplasts are found only in plant cells.
8. **b.** by diffusion
9. A cell is the basic unit of life.
10. **A.** nuclear envelope; **B.** nucleolus; **C.** nuclear pore; **D.** water vacuole; **E.** chloroplast; **F.** mitochondrion; **G.** microtubules; **H.** microfilaments; **I.** plasma membrane; **J.** granum of the chloroplast; **K.** cell membrane (cell membrane); **L.** cytoplasm; **M.** Golgi apparatus; **N.** vesicle; **O.** smooth endoplasmic reticulum; **P.** rough endoplasmic reticulum; **Q.** ribosome
11. **1.** nucleus; **2.** chromosome; **3.** mitochondria; **4.** ribosome; **5.** chloroplast; **6.** vacuole; **7.** endoplasmic reticulum; **8.** plasma membrane; **9.** lysosome
12. Students might say that they could not find everyday examples for every cell structure.
13. DNA and RNA are found in the nucleus.
14. Answers may vary. When you are travelling through a crowded hallway at school into an empty classroom, you are going from an area of high concentration to an area of low concentration.
15. Answers may vary. The diffusion of food aroma molecules comes from the kitchen as someone is cooking.

Chapter 3 Review Questions

1. **a.** The cell is the basic unit of life.
2. **b.** a cell with a surface-area-to-volume of 3:2
3. **d.** cell structure 12
4. **d.** organelle 11
5. **d.** 7
6. **b.** the plasma membrane
7. **c.** cholesterol
8. **c.** diagram of polypeptide chain
9. **d.** it is a double membrane structure that has pores and separates the contents of the cytoplasm from the nucleus
10. **b.** DNA
11. **d.** rough endoplasmic reticulum
12. **c.** rough endoplasmic reticulum
13. **d.** a plastid that has the ability to capture light energy and convert it into organic molecules
14. **b.** peroxisome – fatty acids
15. **d.** mitochondria
16. **c.** membrane-bound vesicles that have hydrolytic enzymes
17. **a.** The secretion of peptidase would not occur.
18. **c.** glucose
19. **d.** cellular respiration
20. **c.** to produce ATP for active transport of calcium ions
21. **a.** cell division
22. **c.** I, II and III only
23. **a.** They both use a carrier protein.
24. **c.** pinocytosis
25. **c.** exocytosis
26. **c.** glycoprotein
27. **d.** the plasma membrane and the nuclear envelope
28. **c.** the number of amino acids entering the cell would decrease
29. **d.** only certain substances can move across it
30. **d.** the excretion of hydrogen ions in the distal convoluted tubule of the kidneys
31. **a.** IV (DNA replication)

    b. V (protein synthesis)

    c. VII (intracellular digestion)

    d. III (rRNA synthesis)

    e. I (photosynthesis)

    f. V (protein synthesis)

    g. II (lipid synthesis)