3. The helical structure allows the DNA molecule more flexibility and the capability of coiling to be stored in a smaller space, the nucleus. This structure also allows the DNA molecule to readily uncoil and be replicated. A linear fibrous structure would give more structural strength, not needed in DNA function, and restrict flexibility.
4. (a) Hydrogen bonding between groups in different sections of the same DNA strand produces the helical or pleated-sheet secondary structure of a single strand of DNA.
   (b) Hydrogen bonding between groups on adjacent strands holds the two strands together, forming a double helix.
5. Changes in DNA sequence alters its structure, and also alters the sequence of the amino acids in proteins it is coded to synthesize in the cell. This leads to synthesis of incorrect proteins or no proteins; if the missing protein or the faulty section of the protein is essential to cell function, the organism cannot function properly.
6. Since the number of A = the number of T, and the number of C = the number of G, one might conclude that A and T are always paired, and C and G are always paired.

Applying Inquiry Skills

7. (Sample answers) If each amino acid is coded by 1 nucleotide: 4 nucleotides can code for only 4 amino acids. If each amino acid is coded by 2 nucleotides, we can have AA, AC, AG, AT; CA, CC, CG, CT; GA, GC, GG, GT; TA, TC, TG, TT: total 16 amino acids. Numerically, $4^2 = 16$ combinations, not enough to code for 20 amino acids. If each amino acid is coded by 3 nucleotides, list all combinations beginning with A: AAA, AAC, AAG, AAT; ACA, ACC, ACG, ACT; AGA, AGC, AGG, AGT; ATA, ATC, ATG, ATT; (total 16 combinations). Repeat list combinations beginning with C, then G, then T. Total: $16 \times 4 = 4^3 = 64$ combinations. Therefore, 3 nucleotides assigned per amino acid can code for at least 20 amino acids.

Making Connections

8. (a) Proteins: amino groups and carboxyl groups (carbonyl and hydroxyl groups). Carbohydrates: hydroxyl groups and carbonyl groups. Nucleic acids: hydroxyl groups, amino groups, carbonyl groups.
   (b) All form hydrogen bonds between the functional groups listed in (a).
   (c) In all the helical structures of these polymers, monomers are linked by strong covalent bonds, giving the polymers stability. Proteins, starch, glycogen, DNA, and RNA are all flexible and mobile in the organism, enabling each polymer to function where needed: proteins such as enzymes where needed, starch and glycogen transported for energy storage or release, and DNA and RNA to replicate or to sites of protein synthesis in the cell.
9. To find out the circuit protected by each fuse, remove the fuses, one at a time, and determine which electrical outlet or electrical appliance no longer functions. (For example, if fuse #1 is removed, and the kitchen outlets and refrigerator are turned off, then fuse #1 must control the circuit for the kitchen and refrigerator.)
10. Minimize time spent in the Sun; wear protective clothing such as hats, long-sleeved shirts, long pants; wear sunscreen; do not use tanning lights.

2.7 FATS AND OILS

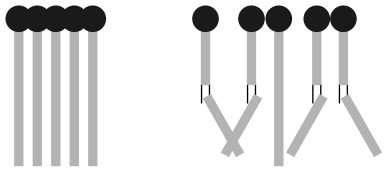
PRACTICE

(Page 136)

Understanding Concepts

1. $CH_3(CH_2)_7CH=CH(CH_2)_7COOCH_2$
   $CH_3(CH_2)_7CH=CH(CH_2)_7COOCH$
   $CH_3(CH_2)_7CH=CH(CH_2)_7COOCH_2$
2. As corn oil is a liquid at room temperature, it is likely to contain unsaturated fatty acids. A hydrogenation process to add hydrogen atoms to the carbon–carbon double bonds may be necessary to change corn oil into a saturated fat with a melting point above that of ordinary room temperature.
3. $CH_3(CH_2)_{16}COO-CH_2$
   $CH_3(CH_2)_{16}COO-CH + 3\,NaOH \rightarrow 3\,CH_3(CH_2)_{16}COONa + \text{glycerol}$
   $CH_3(CH_2)_{16}COO-CH_2$
   sodium stearate
   (soap: Na^+ salt of fatty acid)

4.



saturated fatty acids | unsaturated fatty acids

The presence of double bonds, about which the molecule cannot rotate freely, introduces "bends" into the linear structure. These bends cause the fatty acids to pack less closely together, thus weakening the van der Waals attractions between the fatty acids. The weaker intermolecular attractions account for the lower melting points compared with those of saturated fatty acids.

5. The long hydrocarbon components in fats and oils release large amounts of energy when reacted with oxygen in the cell. The long hydrocarbon chains are bonded as triglycerides, making the melting and boiling points much higher than those of hydrocarbons, and are thus suitable for storage in living systems. The long nonpolar hydrocarbon chains are also insoluble in the aqueous cellular environment, enabling them to be stored undissolved, and mobilized and used as needed.

Applying Inquiry Skills

6. Fats and oils are reacted with a strong base such as NaOH, and heated; the sodium of the fatty acids (soap) and glycerol are produced. Conditions: The fat or oil is heated slowly, with constant stirring, with a concentrated solution of NaOH. The soap formed is precipitated with NaCl and rinsed with a weak acid such as vinegar to remove residual NaOH. Safety precautions include eye protection, a lab apron, no open flames if fat is dissolved in a solvent such as ethanol, and not touching NaOH as it is corrosive to the skin. Take care in handling hot reaction mixture and equipment.

SECTION 2.7 QUESTIONS

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Understanding Concepts

1. Energy storage: e.g., plant oils stored in seeds, animal fat stored under skin. Insulation: animal fat stored under skin serves as insulation for warm-blooded animals such as humans. Solvent: fats and oils act as solvents for fat-soluble vitamins.
2. $$3\ CH_3(CH_2)_{10}COOH + \begin{array}{l} HOCH_2 \\ | \\ HOCH \\ | \\ HOCH_2 \end{array} \rightarrow \begin{array}{l} CH_3(CH_2)_{10}COOCH_2 \\ | \\ CH_3(CH_2)_{10}COOCH \\ | \\ CH_3(CH_2)_{10}COOCH_2 \end{array} + 3\ H_2O$$
3. (Sample answer) $CH_3CH_2CH{=}CH(CH_2)_{11}COOH$
4. (a) Glycerol is 1,2,3-propanetriol, and triglyceride is the ester formed from the reaction of three fatty acids with glycerol.
   (b) Fatty acids are long hydrocarbon chains with a carboxyl group at one end. Fats are triglycerides of fatty acids and glycerol.
   (c) Fats are generally solids at room temperature and oils are liquids. Fats generally contain saturated fatty acids and oils contain unsaturated fatty acids.
   (d) Lipids include fats, oils, waxes, and steroids.
   (e) Esterification is the reaction of an alcohol and a carboxylic acid. Saponification involves the hydrolysis of a fat or oil molecule, forming fatty acids and glycerol. It may be considered the reverse of an esterification reaction.
5. (Sample answer)

$$\begin{array}{l} CH_3(CH_2)_{12}COO{-}CH_2 \\ | \\ CH_3(CH_2)_{12}COO{-}CH \\ | \\ CH_3(CH_2)_{12}COO{-}CH_2 \end{array} + 3\ NaOH \rightarrow 3\ CH_3(CH_2)_{12}COONa + \text{glycerol}$$

6. Intramolecular: covalent bonds. Intermolecular: van der Waals attractions between the long hydrocarbon chains in the fatty acids. In oils, the hydrocarbons contain carbon–carbon double bonds, introducing "bends" in the molecule. These "bends" do not allow the fatty acids to pack together as closely as those in unsaturated fatty acids (found in fats). Thus, the more closely packed fats have higher melting points than those of oils, as a result of stronger van der Waals attractions.
7. The polar functional groups in glycerol (hydroxyl groups) and fatty acids (carboxyl groups: carbonyl and hydroxyl groups) are linked together in the esterification reaction. Thus, only a carbonyl group remains in the ester. The long hydrocarbon groups in triglycerides make the molecules insoluble in water.
8. (a) (Sample answer)

$$\begin{array}{l} CH_3(CH_2)_{10}COO—CH_2 \\ \qquad\qquad\qquad\quad | \\ CH_3(CH_2)_{10}COO—CH \ + \ 3\ NaOH \ \rightarrow \ 3\ CH_3(CH_2)_{10}COONa \ + \ \text{glycerol} \\ \qquad\qquad\qquad\quad | \\ CH_3(CH_2)_{10}COO—CH_2 \end{array}$$

   (b) Soap molecules have both a polar end (Na) which is soluble in water, and a nonpolar end (the long hydrocarbon chain) which is soluble in fats and oils.
9. (Sample answers)

Polymer	Functional groups	Formation	Function
starch	hydroxyl, carbonyl	condensation reactions	energy storage source
cellulose	hydroxyl, carbonyl	condensation reactions	plant cell structure
proteins	carboxyl, amino	condensation reactions	enzymes, muscle tissue
DNA	amino, hydroxyl, carbonyl	condensation reactions	directs sequence in protein synthesis

Applying Inquiry Skills

10. **Experimental Design**

Unknown fats or oils are tested for carbon–carbon double bonds using bromine water or potassium permanganate. A change in colour indicates the presence of double bonds.

Materials

eye protection
lab apron
test tubes and racks
potassium permanganate solution

Procedure

- Add 10 drops of an unknown fat or oil into a clean test tube.
- Add 1 drop of the potassium permanganate solution. Shake gently.
- Dispose of materials in labelled containers.

Analysis

A change in colour of the potassium permanganate solution is evidence of an unsaturated fat or oil.

11. A hydrogenation reaction can convert an unsaturated oil into a saturated fat: margarine. Conditions required include high temperature, high pressure, and a catalyst such as powdered platinum.

$$\begin{array}{lcl} CH_3(CH_2)_7CH=CH(CH_2)_7COO—CH_2 & & CH_3(CH_2)_{16}COO—CH_2 \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad | & & \qquad\qquad\qquad\quad | \\ CH_3(CH_2)_7CH=CH(CH_2)_7COO—CH \ + \ 3\ H_2 & \xrightarrow[\text{Pt}]{\text{heat, pressure}} & CH_3(CH_2)_{16}COO—CH \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad | & & \qquad\qquad\qquad\quad | \\ CH_3(CH_2)_7CH=CH(CH_2)_7COO—CH_2 & & CH_3(CH_2)_{16}COO—CH_2 \end{array}$$

Making Connections

12. The sodium hydroxide saponifies any fats and oils in the clog, producing the sodium salt of the fatty acids, and glycerol. The sodium salt is soluble in water, and is washed away.
13. (a) Chemical composition of linseed oil: linolenic acid (52–60%); linoleic acid (16–18%); oleic acid (18–20%); stearic acid, leuric acid, and palmitic acid (3%).
    (b) Linseed oil is a yellow to dark amber liquid with a paint-like odour. Its melting point is –19°C, and its boiling point 343°C. It oxidizes very easily, is combustible, and reacts violently with chlorine.

(c) Linseed oil has several common uses, including as food (as a dietary source of unsaturated fats); as a health supplement (with claims to strengthen the immune system, reverse arteriosclerosis, inhibit tumour formation, and regulate cholesterol levels); and as a solvent for oil-based paints.
(d) During processing and storage of linseed oil, avoid excess light and exposure to air; store in dark bottles under constant refrigeration. It is too unstable to be used for frying, or spraying on pans for grilling or basting. Rags soaked in linseed oil may spontaneously combust due to gradual exothermic reaction with oxygen.
(e) Linseed oil may be classified as organic (compounds of carbon) as it is made by a plant. It is also natural as it is produced by plants.

14. Olive oil is primarily oleic acid (18 carbons, 1 double bond), which has a melting point of 44.2°C. It is a monosaturated oil, which is the most desirable type of dietary fat, having the effect of lowering LDL cholesterol and total cholesterol levels.

Coconut oil is primarily lauric acid (12 carbons, no double bond), with a melting point of 13.4°C. It is a saturated oil, which is a less desirable type of fat, associated with increased risk of heart disease. It is also thought to increase LDL cholesterol (low-density lipoprotein, or "bad," cholesterol) and total cholesterol levels, so should make up no more than 7% of total calories in any diet.

Cholesterol has long been thought to have an effect on heart health: LDL is the major cholesterol carrier in the blood. Too much LDL cholesterol in the blood results in a buildup on the artery walls, causing formation of plaque that can clog the arteries. A clot that forms near the plaque can block blood flow to the heart muscle (causing a heart attack) or the brain (causing a stroke).

CAREERS IN CHEMISTRY

PRACTICE

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Making Connections

1. (Answers may vary. Sample answer)
Polymer Chemist
Typical projects for a polymer chemist might include research and development of synthetic polymer for specific consumer needs such as fibres for clothing and carpets, and pharmaceutical work. Attractive features of the job include creativity and innovation, nonroutine and stimulating work, and flexible hours. As well, skills are transferable across industries and locations with chemists working in either academic or industrial settings. Polymer chemists require significant training and education—usually a master's or doctoral degree in chemistry or a related field. The job might also entail submitting grant proposals for funding research.

CHAPTER 2 LAB ACTIVITIES

INVESTIGATION 2.1.1 IDENTIFICATION OF PLASTICS

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Evidence

(a) (Sample table)

Sample	Density	Flame colour	Acetone	Melting
1				
2				
3				

Analysis

(b) **Part 1:**
In water: Samples that float may be resin codes 2, 4, or 5 (less dense than water, whose density is 1 g/mL); samples that sink may be resin codes 1, 3, or 6.