# CHAPTER 6

# Lipids: Not Just Fat

## Chapter Outline

The chapter outline provides you with an organizational guide to the topics and ideas presented in this chapter of the text.

**What Are Lipids?**
**Fatty Acids Are Key Building Blocks**
- Chain Length
- Saturation
- *Cis* Versus *Trans*
- Nonessential and Essential Fatty Acids

**Triglycerides**
- Triglyceride Structure
- Triglyceride Functions
- Triglycerides in Food

**Phospholipids**
- Phospholipid Structure
- Phospholipid Functions
- Phospholipids in Food

**Sterols**
- Cholesterol Functions
- Cholesterol Synthesis
- Sterols in Food

**Lipid Digestion and Absorption**
- Digestion of Triglycerides and Phospholipids
- Lipid Absorption
- Digestion and Absorption of Sterols

**Lipids in the Body**
- Chylomicrons
- Very-Low-Density Lipoprotein
- Intermediate-Density Lipoprotein
- Low-Density Lipoprotein
- High-Density Lipoprotein

**Lipids in the Diet**
- Recommended Intakes
- Essential Fatty Acid Requirements
- *Omega*-6 and *Omega*-3 Balance
- Current Dietary Intakes
- Role of Fat Replacers

**Lipids and Health**
- Obesity
- Heart Disease
- Dietary and Lifestyle Factors for Reducing Atherosclerosis Risk
- Metabolic Syndrome
- Putting It All Together
- Cancer

## ◎ Key Terms

Define the following terms.

1. **adipocytes** _____
2. **squalene** _____
3. **diglyceride** _____
4. **subcutaneous fat** _____
5. **cholesterol** _____
6. **visceral fat** _____
7. **metabolic syndrome** _____
8. **hypercholesterolemia** _____
9. **chain length** _____
10. **hydrogenation** _____
11. **lanugo** _____
12. **phytosterols** _____
13. ***omega*-3 fatty acid** _____
14. **micelles** _____
15. **adipose tissue** _____
16. **eicosanoids** _____
17. **very-low-density lipoproteins (VLDL)** _____
18. ***omega*-6 fatty acid** _____
19. **monounsaturated fatty acid** _____
20. **atherosclerosis** _____
21. **intermediate-density lipoproteins (IDL)** _____
22. **sterols** _____
23. **oxidation** _____
24. **phosphate group** _____
25. **polyunsaturated fatty acid** _____
26. **obesity** _____

## ◎ Fill-in-the-Blank

1. The major enzyme responsible for the breakdown of lipoproteins and triglycerides in the blood is _____.
2. _____ is an essential *omega*-3 fatty acid that contains 18 carbon atoms and 3 carbon-carbon double bonds.
3. A term for diseases in which abnormal cells divide without control is _____. These cells can invade nearby tissues and can spread through the bloodstream and lymphatic system to other parts of the body.
4. A _____ is an unsaturated fatty acid with a bent carbon chain. Most naturally occurring unsaturated fatty acids are this type.
5. _____ is the backbone of mono-, di-, and triglycerides; alone, it is a thick, smooth liquid.
6. _____ are fatty acids that the body needs but cannot synthesize and must obtain from the diet.
7. _____ is a fat replacer made from a sucrose backbone with six to eight fatty acids attached. The fatty acid arrangement prevents breakdown by the digestive enzyme lipase, so the fatty acids are not absorbed. It can withstand heat and is stable at frying temperatures. Its trade name is Olean.
8. _____ are compounds containing a long hydrocarbon chain with a carboxyl group (–COOH) at one end and a methyl group ($-CH_3$) at the other end.
9. A fatty acid in which the carbon chain contains one or more double bonds is an _____.
10. _____ are compounds that consist of a glycerol molecule bonded to two fatty acid molecules, and a phosphate group with a nitrogen-containing component. They have both water-soluble and fat-soluble regions, which make them good emulsifiers.
11. The blood lipoproteins that contain high levels of protein and low levels of triglycerides are called _____. Synthesized primarily in the liver and small intestine, these pick up cholesterol released from dying cells and other sources and transfer it to other lipoproteins. They are sometimes called "good cholesterol."

**12.** _____ is a protein released by the body in response to acute injury, infection, or other inflammatory stimuli. It is associated with future cardiovascular events.

**13.** A molecule of glycerol combined with one fatty acid is a _____.

**14.** A general term for all disorders affecting the heart and blood vessels is _____ _____.

**15.** _____ are the cholesterol-rich lipoproteins that result from the breakdown and removal of triglycerides from intermediate-density lipoprotein. Sometimes called "bad cholesterol."

**16.** _____ is a substance that consists of an LDL part plus a protein (apoprotein a) whose exact function is currently unknown.

**17.** A fatty acid completely filled by hydrogen, with all carbons in the chain linked by single bonds, is a _____.

**18.** _____ is an essential *omega*-6 fatty acid that contains 18 carbon atoms and 2 carbon-carbon double bonds (18:2); it is a thin liquid at room temperature.

**19.** _____ are compounds that imitate the functional and sensory properties of fats, but contain less available energy than fats.

**20.** _____ is a nitrogen-containing compound that is part of phosphatidylcholine, a phospholipid. It also is part of the neurotransmitter acetylcholine. The body can synthesize it from the amino acid methionine.

**21.** In the body, _____ is a phospholipid with the nitrogen-containing component choline. In foods, it is a blend of phospholipids with different nitrogen-containing components.

**22.** A _____ is an unsaturated fatty acid with a straighter chain than a *cis* fatty acid, usually as a result of hydrogenation; it is more solid than a *cis* fatty acid.

**23.** A _____ is a large lipoprotein formed in intestinal cells following the absorption of dietary fats. It has a central core of triglycerides and cholesterol surrounded by phospholipids and proteins.

**24.** _____ are fatty acids that your body can make when they are needed. It is not necessary to consume them in the diet.

**25.** A _____ is a complex that transports lipids in the lymph and blood. It consists of a central core of triglycerides and cholesterol surrounded by a shell composed of proteins, cholesterol, and phospholipids. The various types differ in size, composition, and density.

## ◎ Fill-in-the-Blank Summaries

### *Fatty Acids Are Key Building Blocks*

Lipids are a broad range of molecules that dissolve easily in organic solvents, but are much less soluble in _____. They are generally hydrophobic and lipophilic. The three main types of lipids are triglycerides, phospholipids, and sterols. _____ are the largest category of lipids and are stored in the body in _____. _____ are major building blocks of cell membranes. They keep fats suspended in watery fluids. The most famous sterol, cholesterol, is manufactured in the body and is a precursor to the synthesis of sex hormones, _____, and vitamin D. Lipids share many of the same functional properties and transport mechanisms. _____ are common components of triglycerides and phospholipids. There are many types of these substances, which are basically chains of _____ _____ atoms with a carboxyl group on one end and a methyl group at the other end. Short-chain fatty acids have less than _____ carbons; medium chains have 6 to 10; and long chains have _____ or more. The water-soluble property of shorter fatty acids affects their absorption.

A triglyceride is made of _____ fatty acids attached to a glycerol molecule. Triglycerides are esters that form when a hydrogen and an oxygen from the carboxyl group combine with a hydrogen atom from the alcohol's hydroxyl group. A molecule of water is produced, which makes this a _____ reaction.

### *Lipids in the Body*

Lipoprotein carriers transport lipids through the bloodstream. Chylomicrons are formed in the _____ _____. They eventually reach the bloodstream through the _____ _____ in the neck. As they travel through the bloodstream, they gradually give up triglycerides to capillary walls. Lipoprotein lipase breaks them down. After _____ hours little is left of the chylomicron except cholesterol-rich remnants.

Elevated levels of _____ (also referred to as "bad cholesterol") in the blood increase the risk of artery and heart disease.

_____, (also referred to as "good cholesterol") appear to protect against atherosclerosis. They are scavenger lipoproteins, picking up excess _____ released by dying cells and arterial plaques. These plaques are created by LDL degrading over a long period of time.

### *Lipids in the Diet*

The Key Recommendations of the *Dietary Guidelines for Americans, 2010*, with respect to lipid intake, include:

- Consume less than _____ of calories from saturated fatty acids by replacing them with monounsaturated and polyunsaturated fatty acids.
- Consume less than 300 mg per day of _____.
- Keep trans fatty acid consumption as low as possible by limiting foods that contain synthetic sources of trans fats, such as _____, and by limiting other solid fats.

When protein is used as part of a fat substitute, the product cannot be used in cooking because high temperatures cause denaturation. Many products use carbohydrates as fat replacements and bind _____ to further dilute calories. Olestra is a very controversial fat substitute. Because olestra is not absorbed, it may cause symptoms of fat malabsorption such as _____ _____.