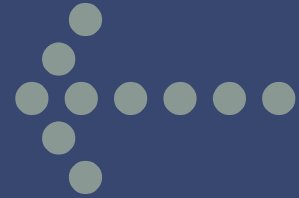


Chap 3 Lipid



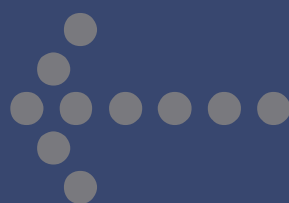


The early 21st century has seen the development of a global epidemic of **obesity**, which is caused by a number of factors including willpower, lifestyle and genetics. The world organization estimates that there are over 300 million clinically obese adults, with 700 million more described as overweight.

Severe obesity can make you dead, it can make you sick, it can make you sad, it can make you alone, it can make you poor.

- Lipids are a diverse group of biomolecules. Lipids are defined as substances from living organisms that **dissolve in nonpolar solvents** such as ether (乙醚), chloroform (氯仿), and acetone but **not appreciably in water**.
- Lipids are ester compounds composed of fatty acids and alcohols.

Main contents

- Biological roles that lipid has
 - Structure and properties of fatty acids (脂肪酸)
 - Classification of lipid
 - Structure of triglyceride/fat(甘油三酯/脂肪)
- 

Section 1 Biological roles

- Energy stores : 9000 cal/g fat; 4100 cal/g protein; 4200 cal/g monosaccharide
- To supply indispensable fatty acids
- Structural components of biological membranes
- To facilitate the absorbance of liposoluble vitamins (脂溶性维生素) by human bodies
- Extracellular and intracellular messengers
- Transporter
- Hormones

Why lipids are used for storage of energy?

- The carbon in lipids (mostly CH_2) is almost **completely reduced** (so its oxidation yields the most energy possible).
- Lipids are **not hydrated** (as mono- and polysaccharides are not), so they can pack more closely in storage tissues

Result: lipids have ~6 more energy of the corresponding amount of proteins or glycogen

体内脂肪含量，男性多还是女性多？

人类身体脂肪有保温功能么？

为什么女生比男生怕冷？



Section 2 Classification of lipid

Lipids may be classified in many different ways. Lipids can be subdivided into the following classes according to the chemical compositions:

Simple lipid: fatty acids
and glycerol



Triacylglycerols; Wax ester

compound lipid



Phospholipids; Sphingolipids;
lipoprotein; glycoprotein

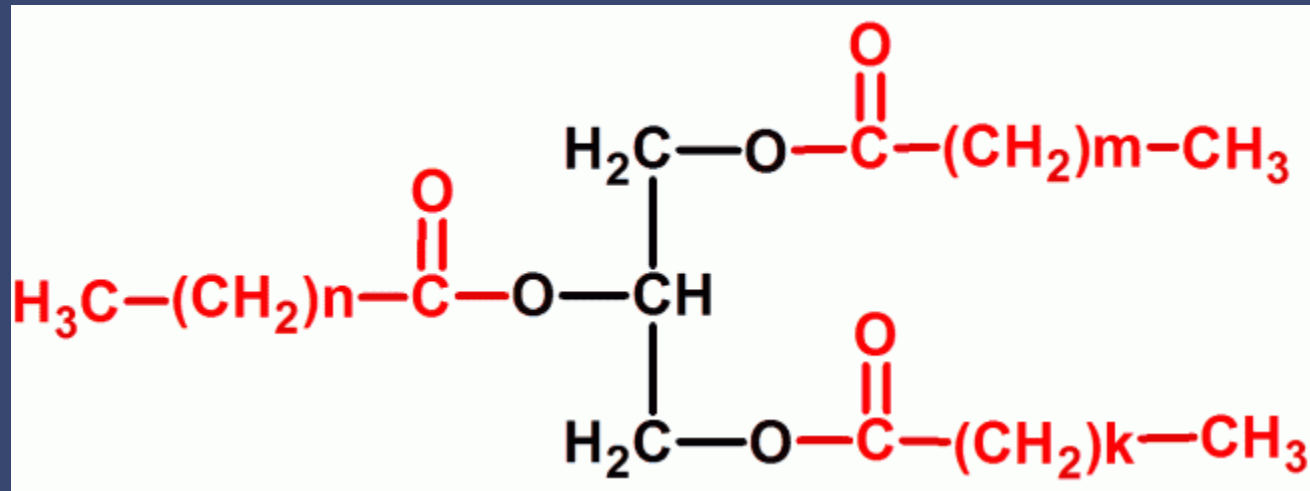
derived lipid



Isoprenoids; steroids

Section 3 Triacylglycerols

- Triacylglycerols are esters of glycerol with three fatty acid molecules.
- Most triacylglycerol molecules contain fatty acids of varying lengths; the fatty acids may be unsaturated, saturated, or combination.
- Depending on their fatty acid compositions, triacylglycerol mixtures are referred to as fats or oils.

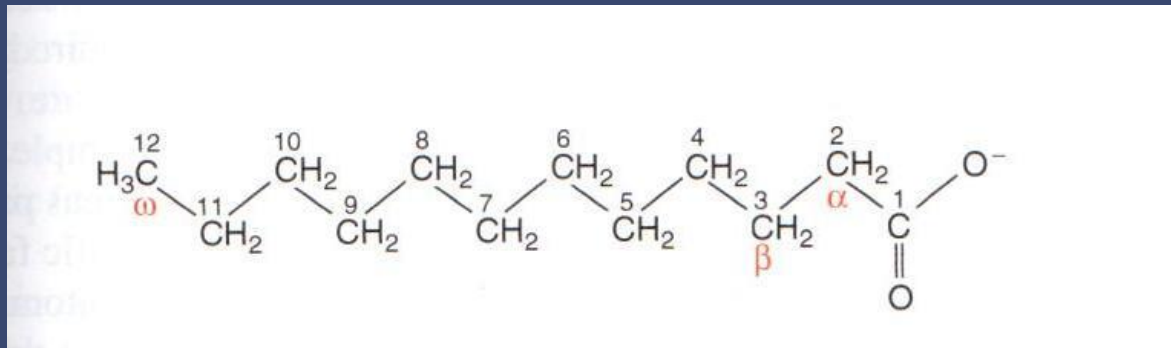


Simple triacylglycerol (单纯甘油酯): **identical fatty acids**

Mixed triacylglycerol (混合甘油酯): **different fatty acids**

Fatty acids

- Fatty acids are monocarboxylic acids (单羧酸) that typically contain hydrocarbon chains (烃链) of variable lengths (between 12 and 20 or more carbons).
- Basic formula: $\text{CH}_3(\text{CH}_2)_n\text{COOH}$
- Fatty acids are numbered from the carboxylate end.
- Greek letters are used to designate certain carbon atoms.

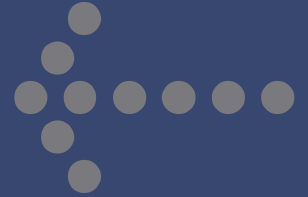


- **Saturated or unsaturated.** Fatty acid chains that contain only carbon-carbon single bonds are referred to as saturated(饱和脂肪酸). Those molecules that contain one or more double bonds are said to be unsaturated (**mono- and polyunsaturated fatty acids**).
- Most naturally occurring fatty acids have an even number of carbon atoms that form an unbranched chain
- The properties of a fatty acid depend on **the chain length and the number of double bonds**.

TABLE 11.1 Examples of Fatty Acids

Common Name	Structure	Abbreviation
Saturated Fatty Acids		
Myristic acid (肉豆蔻酸)	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$	14:0
Palmitic acid (棕榈酸, 软脂酸)	$\text{CH}_3(\text{CH}_2)_{14}\text{CH}_2\text{COOH}$	16:0
Stearic acid (硬脂酸)	$\text{CH}_3(\text{CH}_2)_{16}\text{CH}_2\text{COOH}$	18:0
Arachidic acid (花生酸)	$\text{CH}_3(\text{CH}_2)_{18}\text{CH}_2\text{COOH}$	20:0
Lignoceric acid (二十四酸)	$\text{CH}_3(\text{CH}_2)_{22}\text{CH}_2\text{COOH}$	24:0
Cerotic acid (蜡酸)	$\text{CH}_3(\text{CH}_2)_{26}\text{CH}_2\text{COOH}$	26:0
Unsaturated Fatty Acids		
Palmitoleic acid (棕榈油酸)	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{CH}_3(\text{CH}_2)_5\text{C}=\text{C}(\text{CH}_2)_7\text{COOH} \end{array}$	16:1 ^{Δ9}
Oleic acid (油酸)	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{CH}_3(\text{CH}_2)_7\text{C}=\text{C}(\text{CH}_2)_7\text{COOH} \end{array}$	18:1 ^{Δ9}
Linoleic acid (亚油酸)	$\begin{array}{c} \text{H} \quad \text{H} \quad \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \\ \text{CH}_3(\text{CH}_2)_4\text{C}=\text{C}-\text{CH}_2-\text{C}=\text{C}(\text{CH}_2)_7\text{COOH} \end{array}$	18:2 ^{Δ9,12}
α-Linolenic acid (α-亚麻酸)	$\begin{array}{c} \text{H} \quad \text{H} \quad \quad \text{H} \quad \text{H} \quad \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \quad \quad \\ \text{CH}_3\text{CH}_2\text{C}=\text{C}-\text{CH}_2-\text{C}=\text{C}-\text{CH}_2-\text{C}=\text{C}(\text{CH}_2)_7\text{COOH} \end{array}$	18:3 ^{Δ9,12,13}
γ-Linolenic acid (γ-亚麻酸)	$\text{CH}_3(\text{CH}_2)_3-\left(\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{CH}_2-\text{C}=\text{C} \end{array}\right)_3-(\text{CH}_2)_4-\text{COOH}$	18:3 ^{Δ6,9,12}
Arachidonic acid (花生四烯酸)	$\text{CH}_3(\text{CH}_2)_3-\left(\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{CH}_2-\text{C}=\text{C} \end{array}\right)_4-(\text{CH}_2)_3\text{COOH}$	20:4 ^{Δ5,8,11,14}

Essential fatty acids



- Linoleic acid ($C_{18:2} \Delta^{9,12}$) 亚油酸
- Linolenic acid ($C_{18:3} \Delta^{9,12,15}$) 亚麻酸(DHA,EPA)
- Arachidonic acid ($C_{20:4} \Delta^{5,8,11,14}$) 花生四烯酸

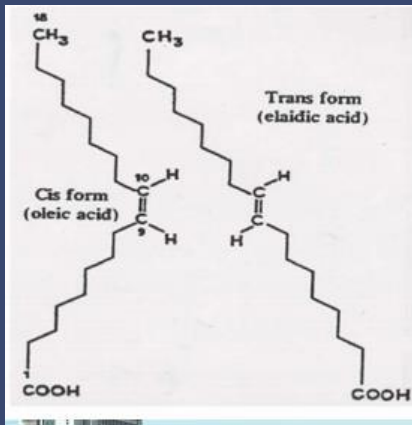
Fatty acids in food: **saturated vs unsaturated**

Source	Lauric/Myristic	Palmitic	Stearic	Oleic	Linoleic
Beef	5	26-32	20-25	37-43	2-3
Milk		25	12	33	3
Coconut	74	10	2	7	
Corn		8-12	3-4	19-24	34-62
Olive		9	2	84	4
Palm		39	4	40	8
Soybean		9	6	20	52
Sunflower		6	1	21	66

Cis/Trans fatty acids

In nearly all naturally occurring unsaturated fatty acids, the double bonds are in the **cis configuration**

Trans-fatty acids are manufactured fats created during a process called **hydrogenation**.



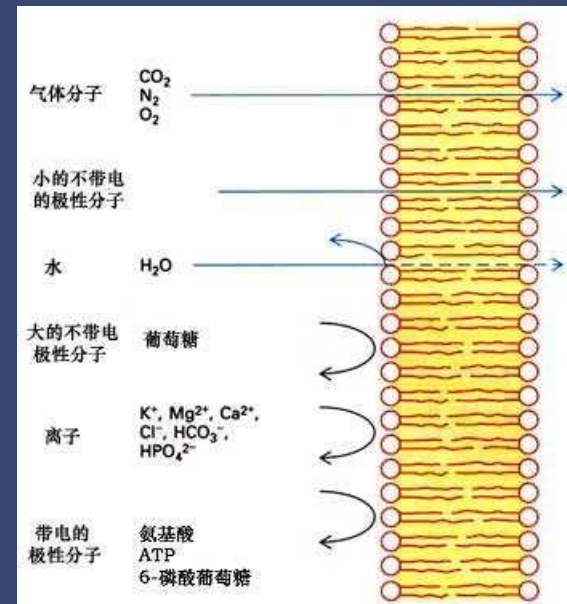
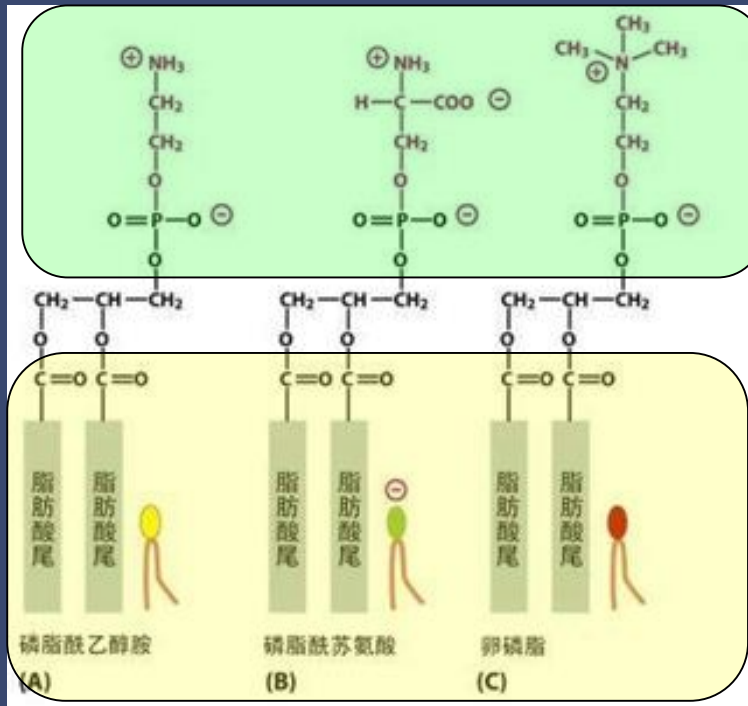
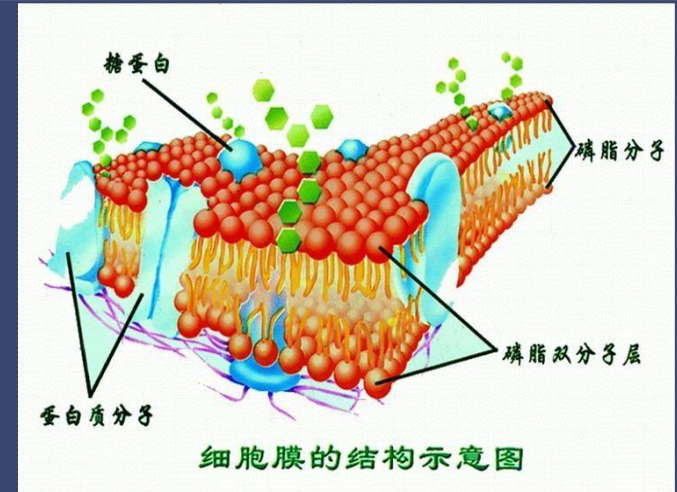
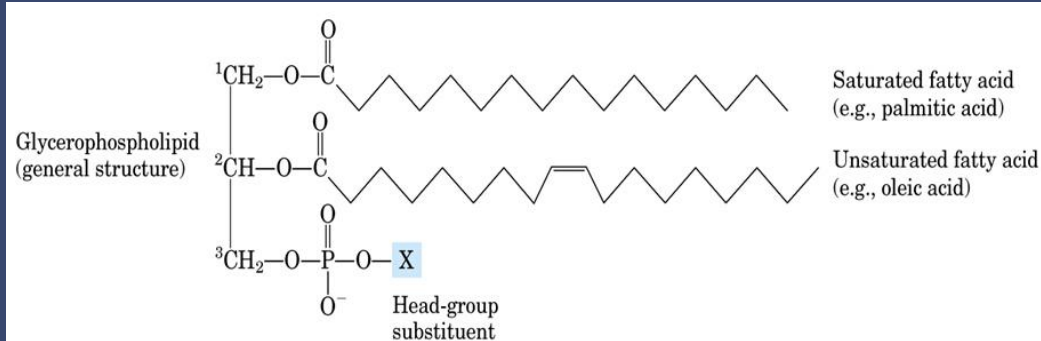
Trans-fatty acids

Trans-fatty acids are found in fried foods, commercial baked goods, processed foods and margarine



Trans (Elaidic acid)	Cis (Oleic acid)	Saturated (Stearic acid)
Elaidic acid is the principal <i>trans</i> unsaturated fatty acid often found in partially hydrogenated vegetable oils. ^[31]	Oleic acid is a <i>cis</i> unsaturated fatty acid that comprises 55–80% of olive oil. ^[32]	Stearic acid is a saturated fatty acid found in animal fats and is the intended product in full hydrogenation. Stearic acid is neither <i>cis</i> nor <i>trans</i> because it has no double bonds.
These fatty acids are geometric isomers (structurally identical except for the arrangement of the double bond).		
Stearic acid contains no double bond and is not isomeric with the previous two.		

Section 4 Phospholipids



生化与健康：“以夷制夷”减肥法

有两种类型的脂肪组织：

白色脂肪组织——只储存脂肪，不燃烧脂肪；

褐色脂肪组织——含有丰富的血管和线粒体，可以将脂肪迅速转变为热能。根据2011年10月发表在cell metabolism上的一篇文章，一种由脑细胞产生的激素——促食素(orexin)能够激活褐色脂肪组织。促食素的缺乏与肥胖有关联，因此，补充促食素将来可能会用来治疗肥胖以及一些与肥胖相关的疾病。这篇论文也解释了一部分人为什么吃得不多却照样长胖——可能天生缺乏激活褐色脂肪组织的促食素。

目前很多减肥药作用的对象是人的食欲，而基于促食素的减肥方法将提供新型抗肥胖的药物，其作用的中心是外周燃烧脂肪的褐色脂肪组织，而不是脑中的食欲中枢。