

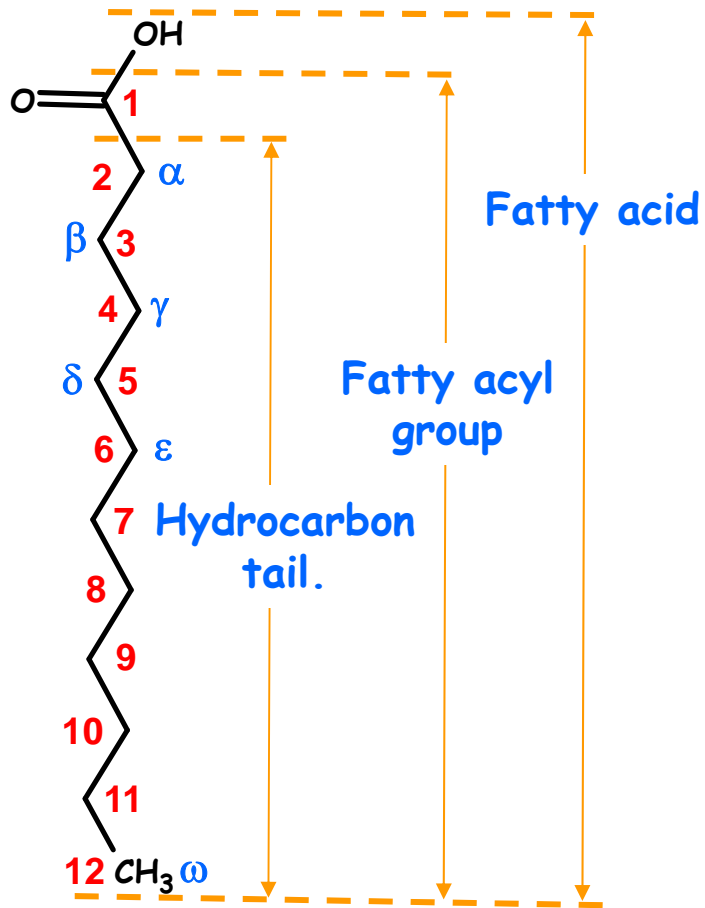
# Chapter 11 - Lipids

Problems: 2-8,10-12,15-17.

- Lipids are essential components of all living organisms
- Lipids are water insoluble organic compounds
- They are hydrophobic (nonpolar) or amphipathic (containing both nonpolar and polar regions)

1. Free fatty acids
2. Triacylglycerols
3. Phospholipids
4. Glycolipids
5. Steroids

# Fatty Acids



Common = lauric acid

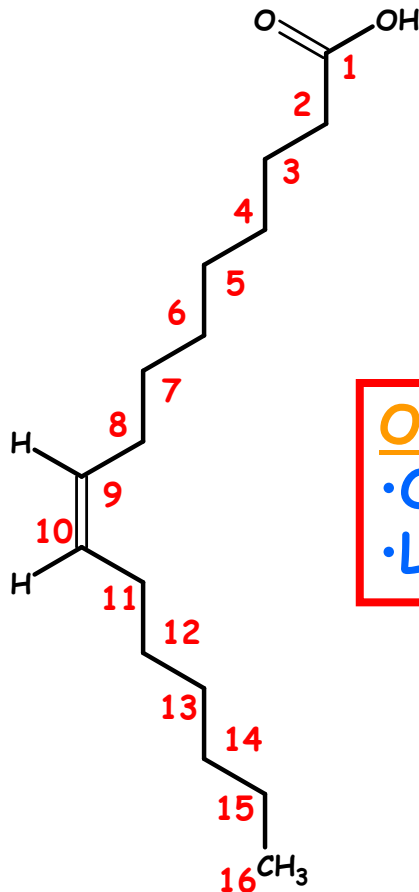
IUPAC = dodecanoic acid

Abbrev. = C12:0

## Other fatty acids (examples)

- Myristic, tetradecanoic, C14:0
- Palmitic, hexadecanoic, C16:0
- Stearic, octadecanoic, C18:0

# Unsaturated Fatty Acids



Common = palmitoleic acid

IUPAC = cis- $\Delta^9$ -hexadecenoic acid

Abbrev. = C16:1<sup>9</sup>

## Other unsaturated fatty acids (examples)

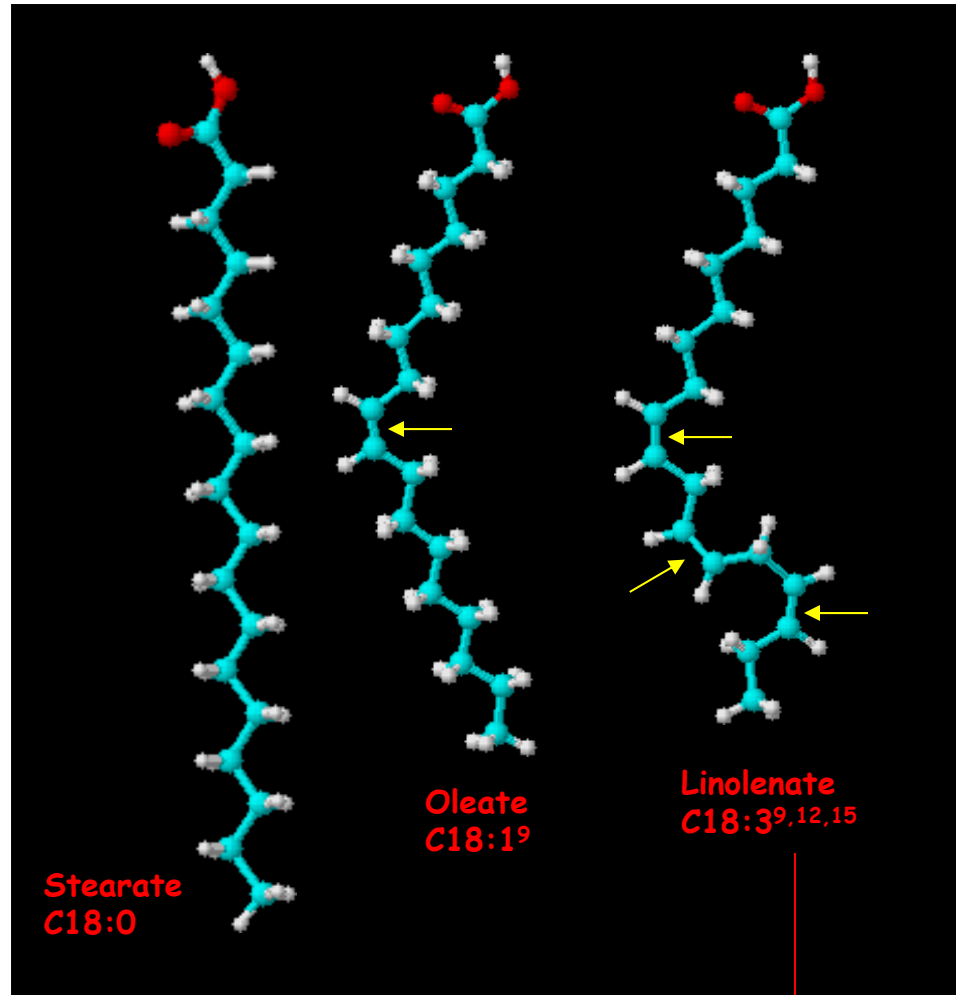
•Oleic, cis- $\Delta^9$ -octadecenoic, C18:1<sup>9</sup>

•Linoleic, cis,cis- $\Delta^{9,12}$ -octadecadienoic, C18:2<sup>9,12</sup>

## Another nomenclature system:

C18:2<sup>9,12</sup> is also known as an  $\omega$ -6 fatty acid (i.e. the last double bond is 6 carbons from the end of the fatty acid chain.)

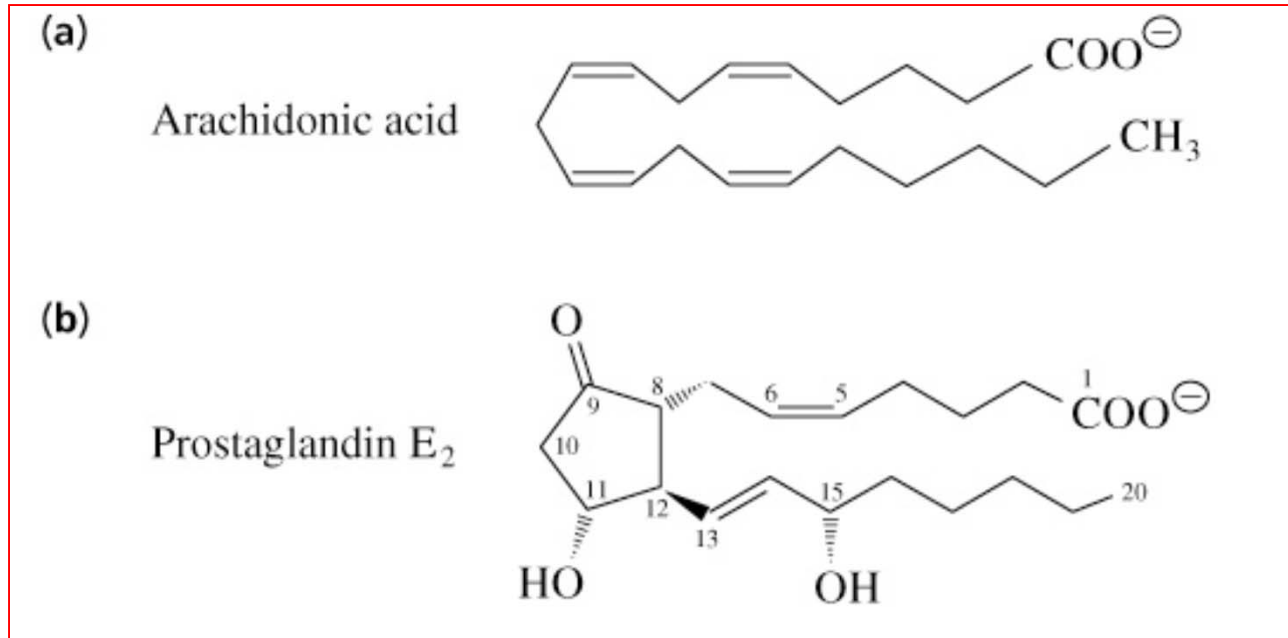
# Unsaturated Fatty Acids



Melting points: 70°C 13°C -17°C

Polyunsaturated

# Eicosanoids

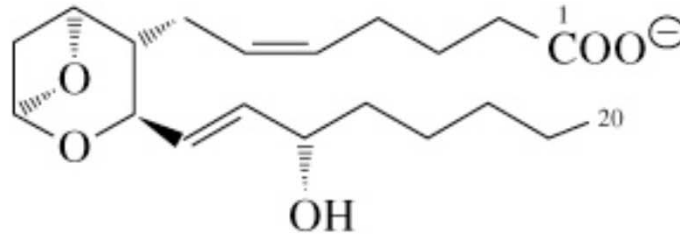


- **Eicosanoids** are oxygenated derivatives of C<sub>20</sub> polyunsaturated fatty acids (e.g. arachidonic acid)
- **Prostaglandins** - eicosanoids having a cyclopentane ring
- Aspirin alleviates pain, fever, and inflammation by inhibiting the synthesis of prostaglandins

# Other Eicosanoids

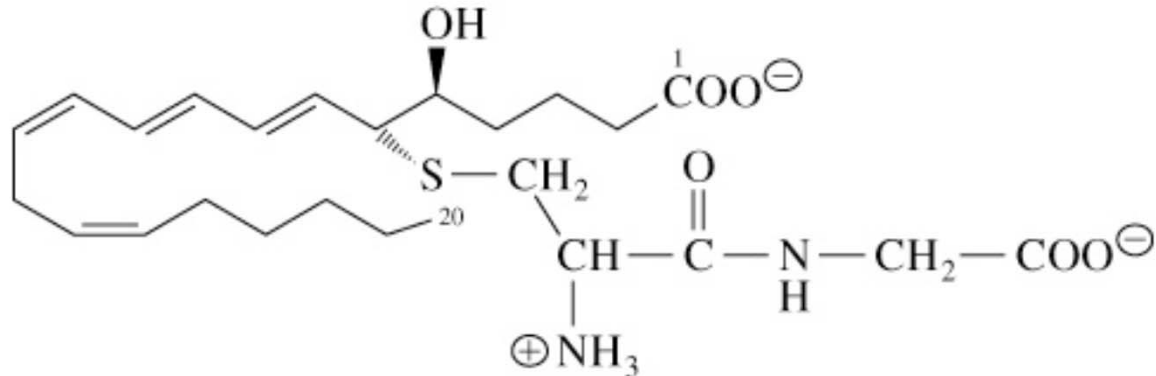
(c)

Thromboxane A<sub>2</sub>



(d)

Leukotriene D<sub>4</sub>



- Prostaglandin E<sub>2</sub> - can cause constriction of blood vessels
- Thromboxane A<sub>2</sub> - involved in blood clot formation
- Leukotriene D<sub>4</sub> - mediator of smooth-muscle contraction and bronchial constriction seen in asthmatics

**Table 11.1** Some naturally occurring fatty acids in animals

Number of carbon atoms	Number of double bonds	Common name	Systematic name	Formula
→ 12	0	Laurate	<i>n</i> -Dodecanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> COO <sup>-</sup>
→ 14	0	Myristate	<i>n</i> -Tetradecanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>12</sub> COO <sup>-</sup>
→ 16	0	Palmitate	<i>n</i> -Hexadecanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO <sup>-</sup>
→ 18	0	Stearate	<i>n</i> -Octadecanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>16</sub> COO <sup>-</sup>
20	0	Arachidate	<i>n</i> -Eicosanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>18</sub> COO <sup>-</sup>
22	0	Behenate	<i>n</i> -Docosanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>20</sub> COO <sup>-</sup>
24	0	Lignocerate	<i>n</i> -Tetracosanoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>22</sub> COO <sup>-</sup>
→ 16	1	Palmitoleate	<i>cis</i> -Δ <sup>9</sup> -Hexadecenoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH=CH(CH <sub>2</sub> ) <sub>7</sub> COO <sup>-</sup>
→ 18	1	Oleate	<i>cis</i> -Δ <sup>9</sup> -Octadecenoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH=CH(CH <sub>2</sub> ) <sub>7</sub> COO <sup>-</sup>
18	2	Linoleate	<i>cis, cis</i> -Δ <sup>9</sup> , Δ <sup>12</sup> -Octadecadienoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> (CH=CHCH <sub>2</sub> ) <sub>2</sub> (CH) <sub>6</sub> COO <sup>-</sup>
18	3	Linolenate	<i>all-cis</i> -Δ <sup>9</sup> , Δ <sup>12</sup> , Δ <sup>15</sup> -Octadecatrienoate	CH <sub>3</sub> CH <sub>2</sub> (CH=CHCH <sub>2</sub> ) <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> COO <sup>-</sup>
20	4	Arachidonate	<i>all-cis</i> Δ <sup>5</sup> , Δ <sup>8</sup> , Δ <sup>11</sup> , Δ <sup>14</sup> -Eicosatetraenoate	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> (CH=CHCH <sub>2</sub> ) <sub>4</sub> (CH <sub>2</sub> ) <sub>2</sub> COO <sup>-</sup>

**Table 11.1**

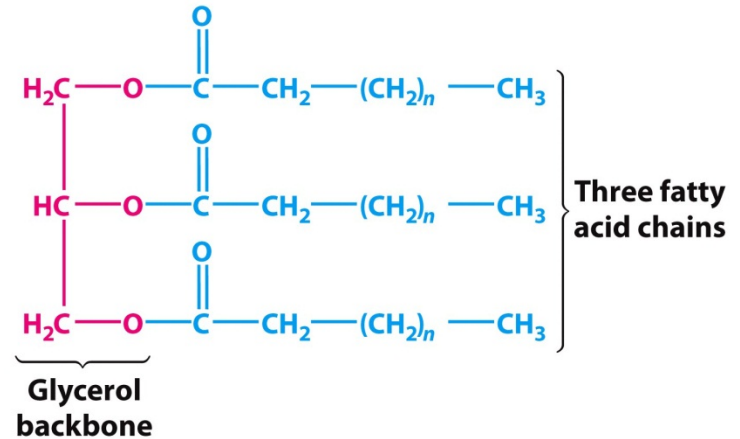
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# Triacylglycerol

- Fatty acids are **important metabolic fuels** (2-3 times the energy of proteins or carbohydrates)
- Fatty acids are **stored as neutral lipids** called **triacylglycerols (TGs)**
- TGs are composed of **3 fatty acyl residues esterified to a glycerol** (3-carbon sugar alcohol)
- TGs are very **hydrophobic**, and are **stored in cells in an anhydrous form** (e.g. in fat droplets)

TGs are **catabolized by lipases**.  
**Digestion** requires **bile salts** (solubilize TGs).  
**Transport** of TGs is accomplished through **lipoproteins**.



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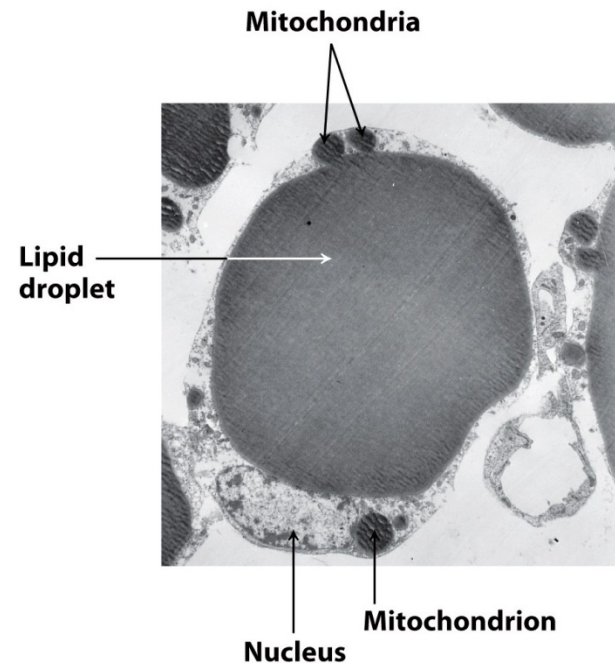
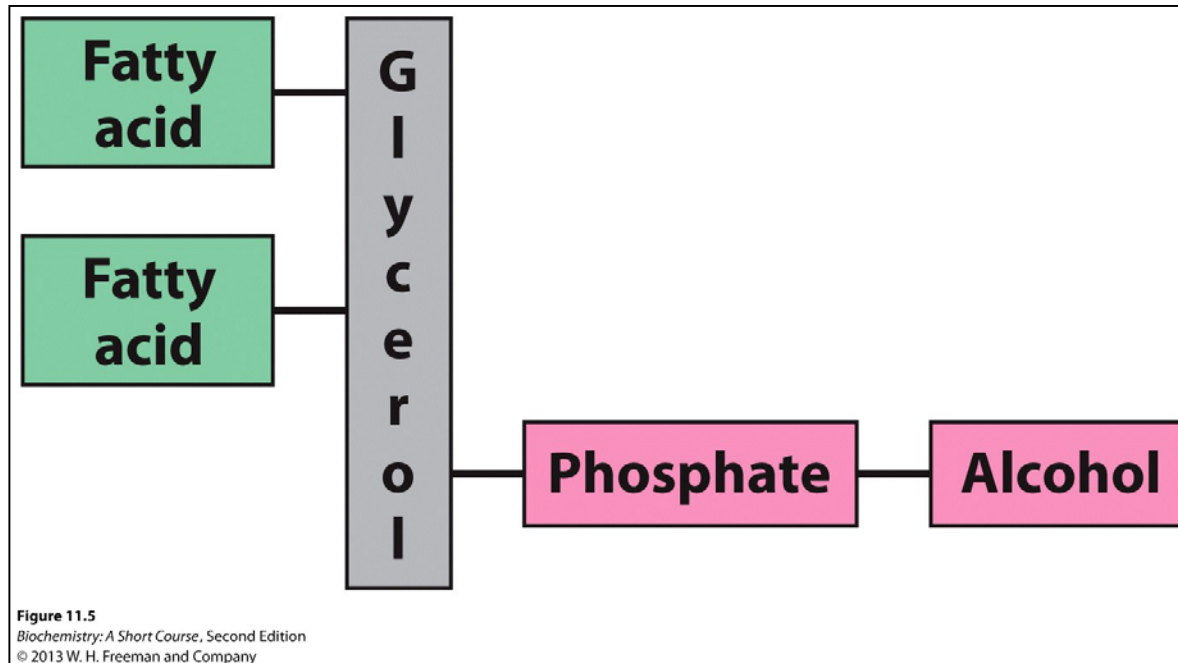


Figure 11.3  
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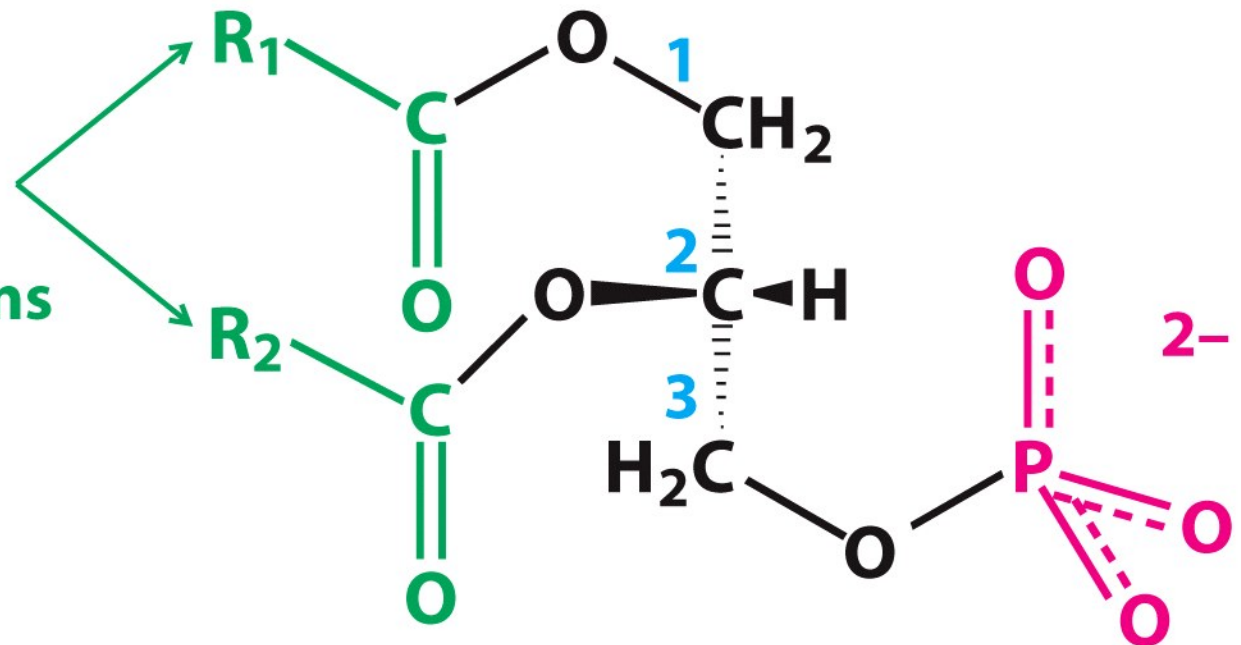


# Phospholipids



- The most abundant lipids in membranes
- Possess a glycerol backbone
- A **phosphate** is esterified to both glycerol and another compound bearing an -OH group
- Phosphatidates are glycerophospholipids with **two fatty acid groups** esterified to C-1 and C-2 of glycerol 3-phosphate

Acyl groups  
with fatty acid  
hydrocarbon chains



## Phosphatidate (Diacylglycerol 3-phosphate)

Figure 11.6

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# Types of phospholipids

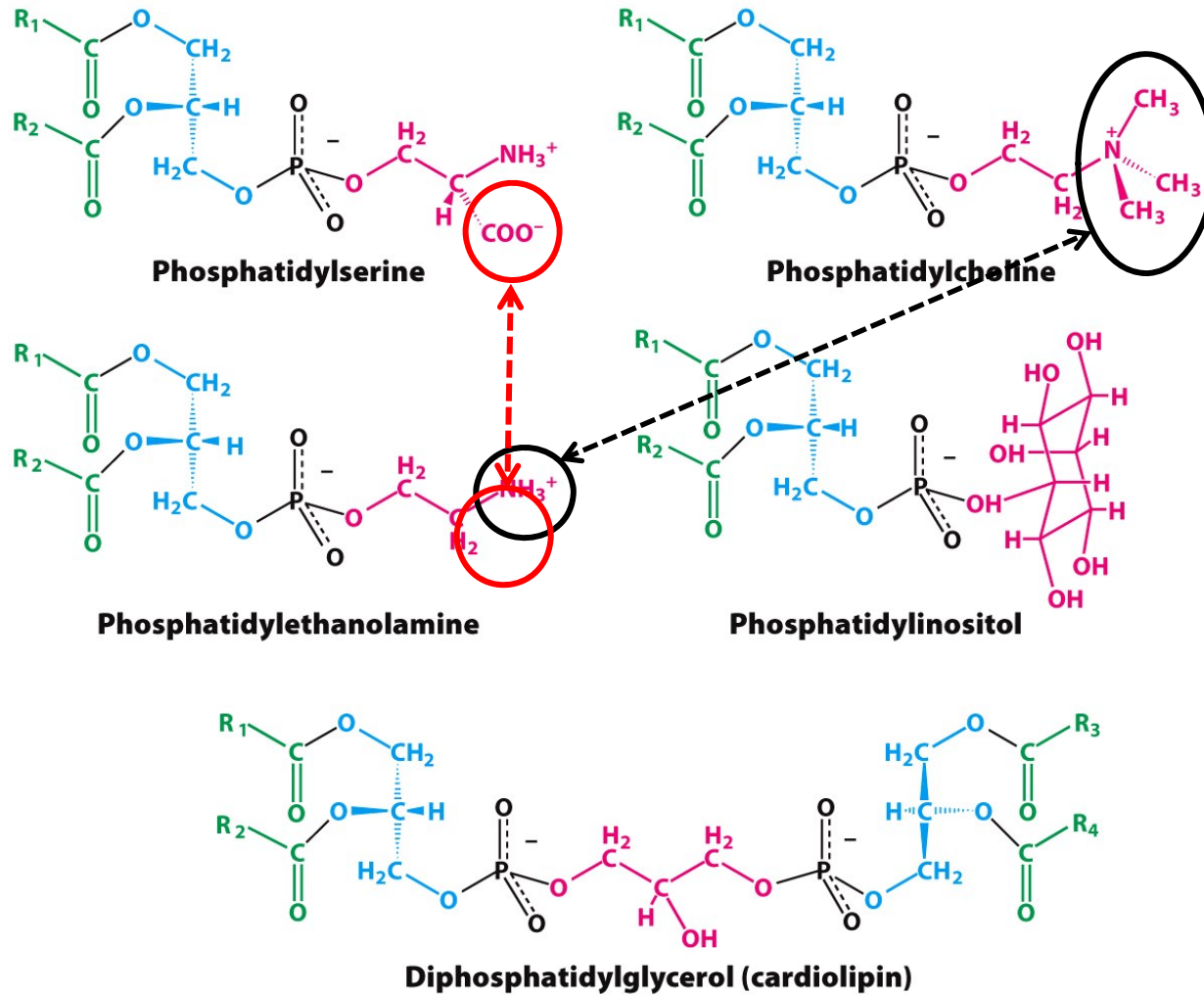
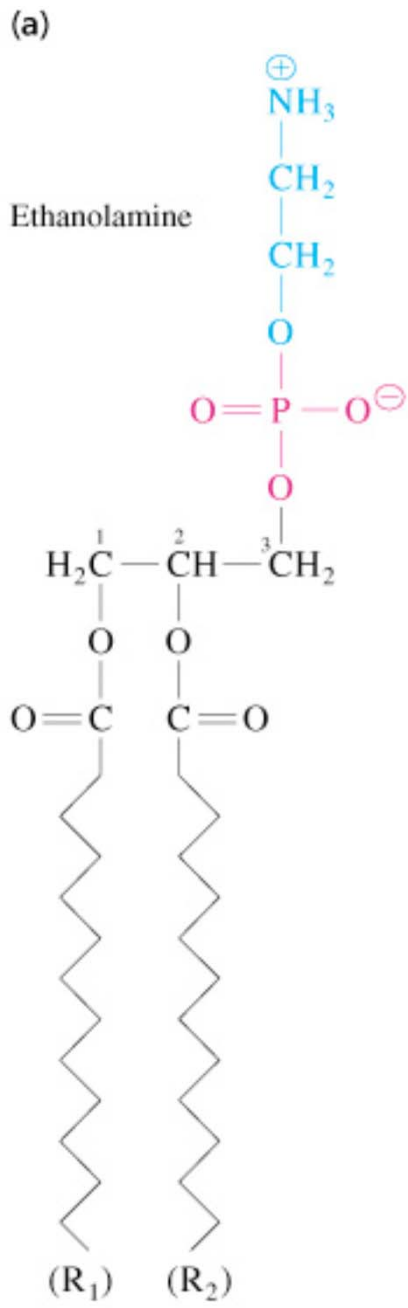
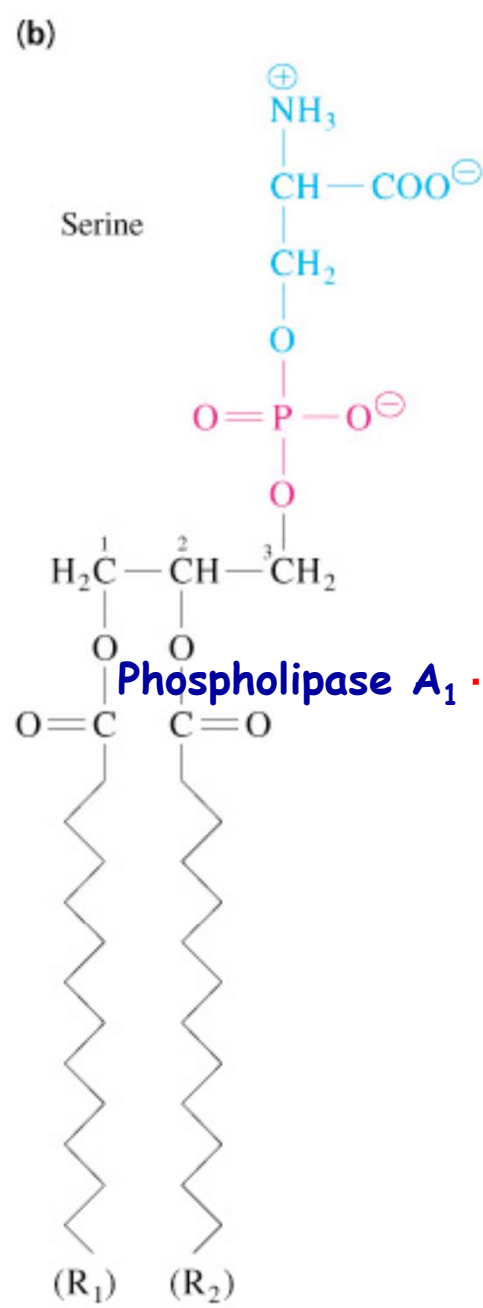


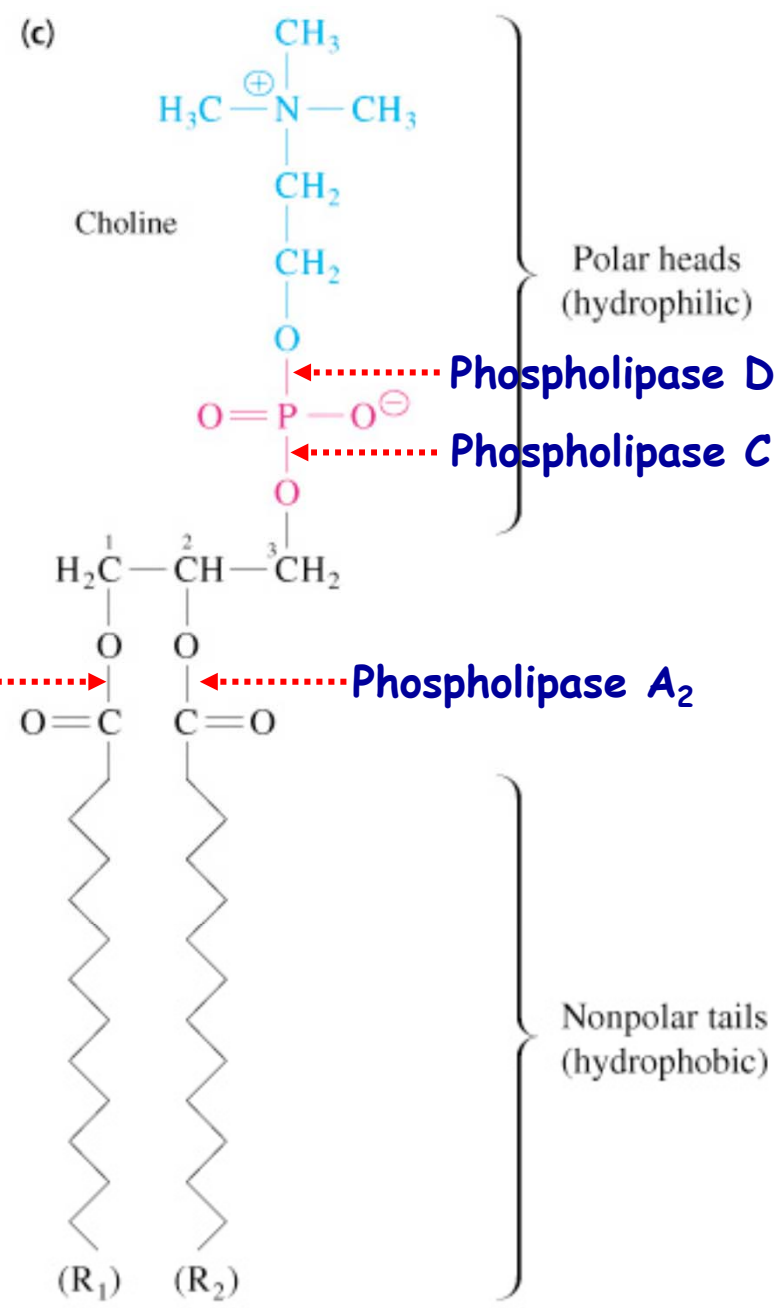
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Phosphatidylethanolamine



Phosphatidylserine



Phosphatidylcholine

Polar heads  
(hydrophilic)

Phospholipase D

Phospholipase C

Phospholipase A<sub>1</sub>

Phospholipase A<sub>2</sub>

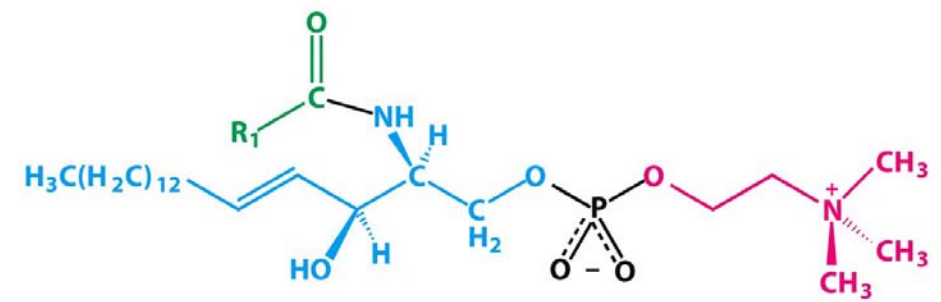
Nonpolar tails  
(hydrophobic)



# Sphingolipids

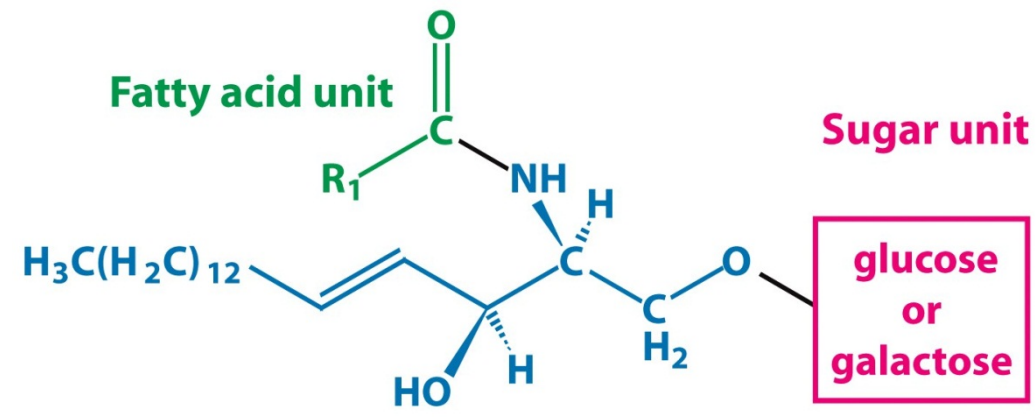


**Sphingosine**



**Sphingomyelin**

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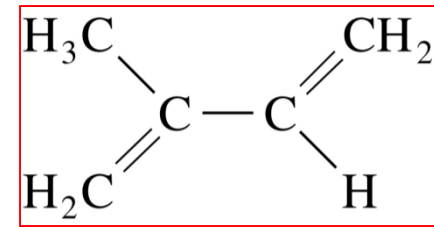


**Cerebroside  
(a glycolipid)**

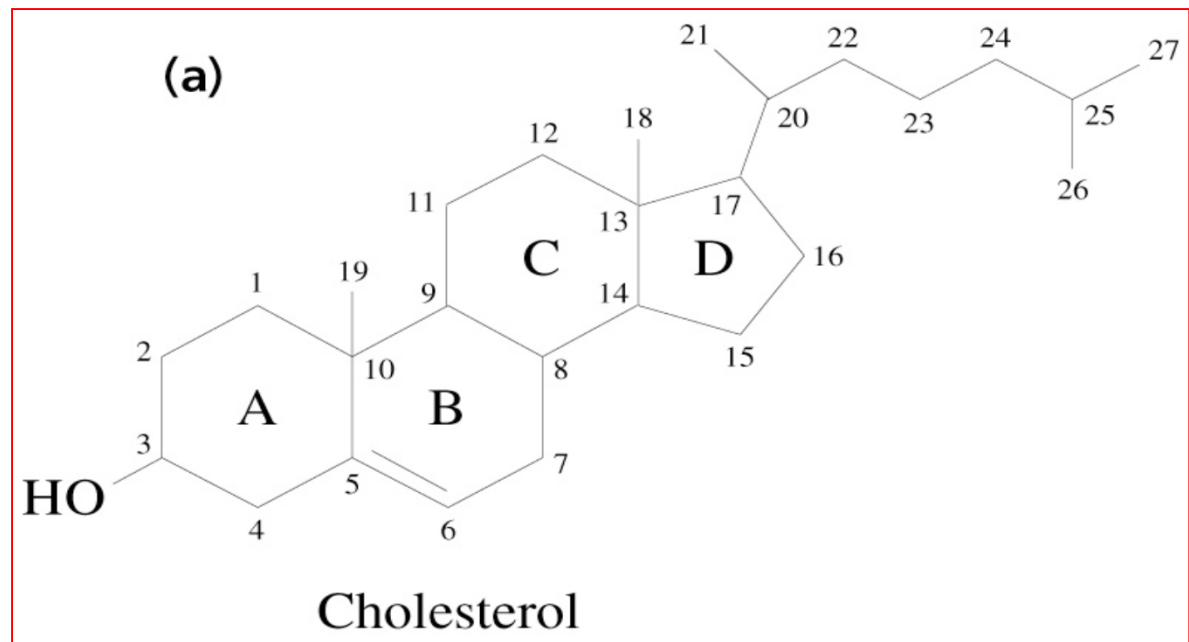
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# Steroids

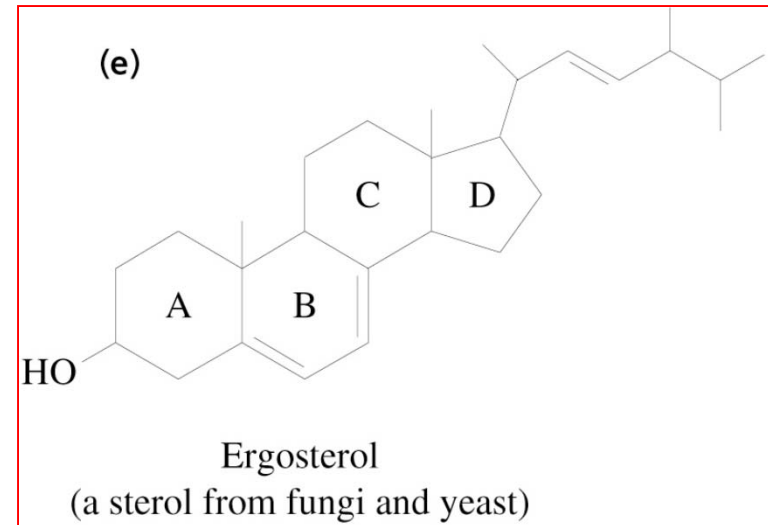
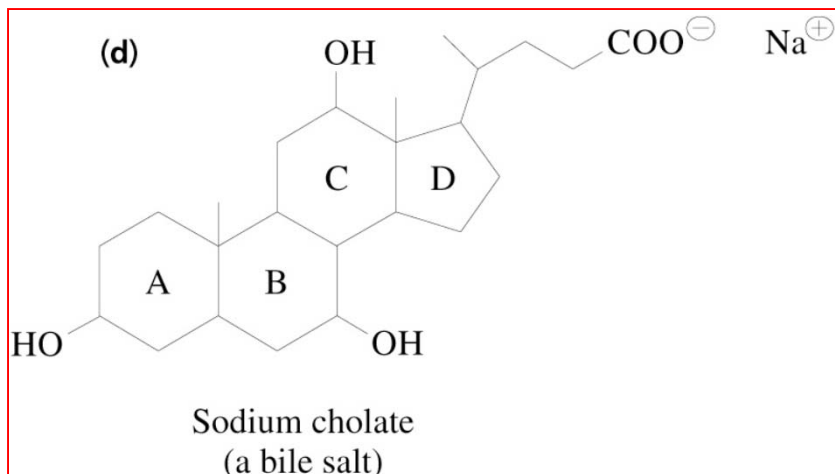
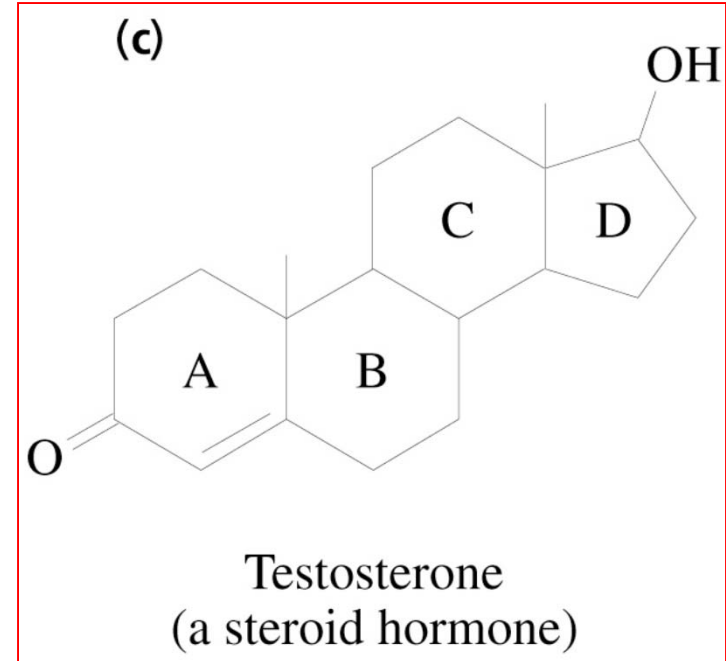
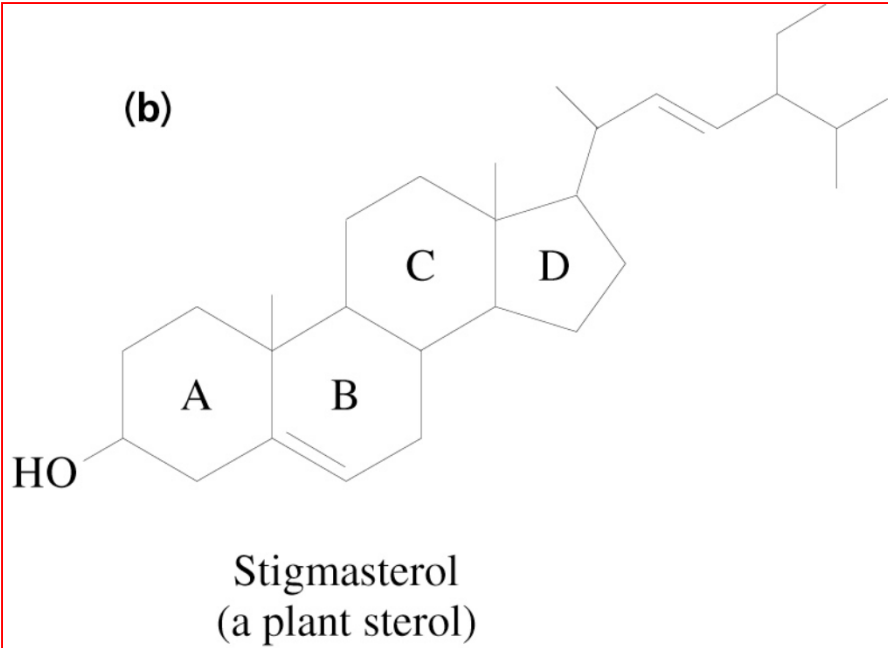
- Classified as **isoprenoids** - related to 5-carbon isoprene (found in membranes of eukaryotes)
- Steroids contain **four fused ring systems**: 3-six carbon rings (A,B,C) and a 5-carbon D ring
- Ring system is nearly **planar**
- **Substituents point either down (a) or up (b)**



-OH = "ol"  
-C=O = "one"  
-COOH = "ate"



# Some Other Steroids



# Functions and Properties of Cholesterol

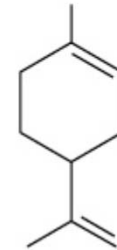
- Cholesterol modulates the fluidity of mammalian cell membranes
- It is also a precursor of the steroid hormones and bile salts
- It is a sterol (has hydroxyl group at C-3)
- The fused ring system makes cholesterol less flexible than most other lipids
- Cholesterol is converted to cholesteryl esters for cell storage or transport in blood
- Fatty acid is esterified to C-3 OH of cholesterol
- Cholesterol esters are very water insoluble and must be complexed with phospholipids or amphipathic proteins for transport



# Some Other Isoprenoids

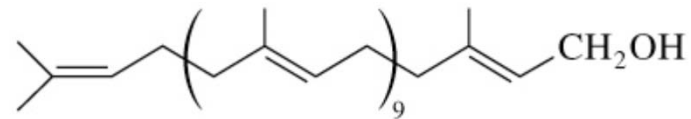
- Lipid vitamins (A, D, E, and K) are isoprenoid derivatives

(a)



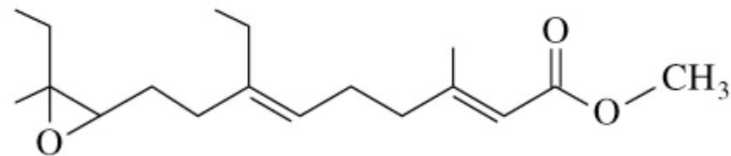
Limonene

(b)



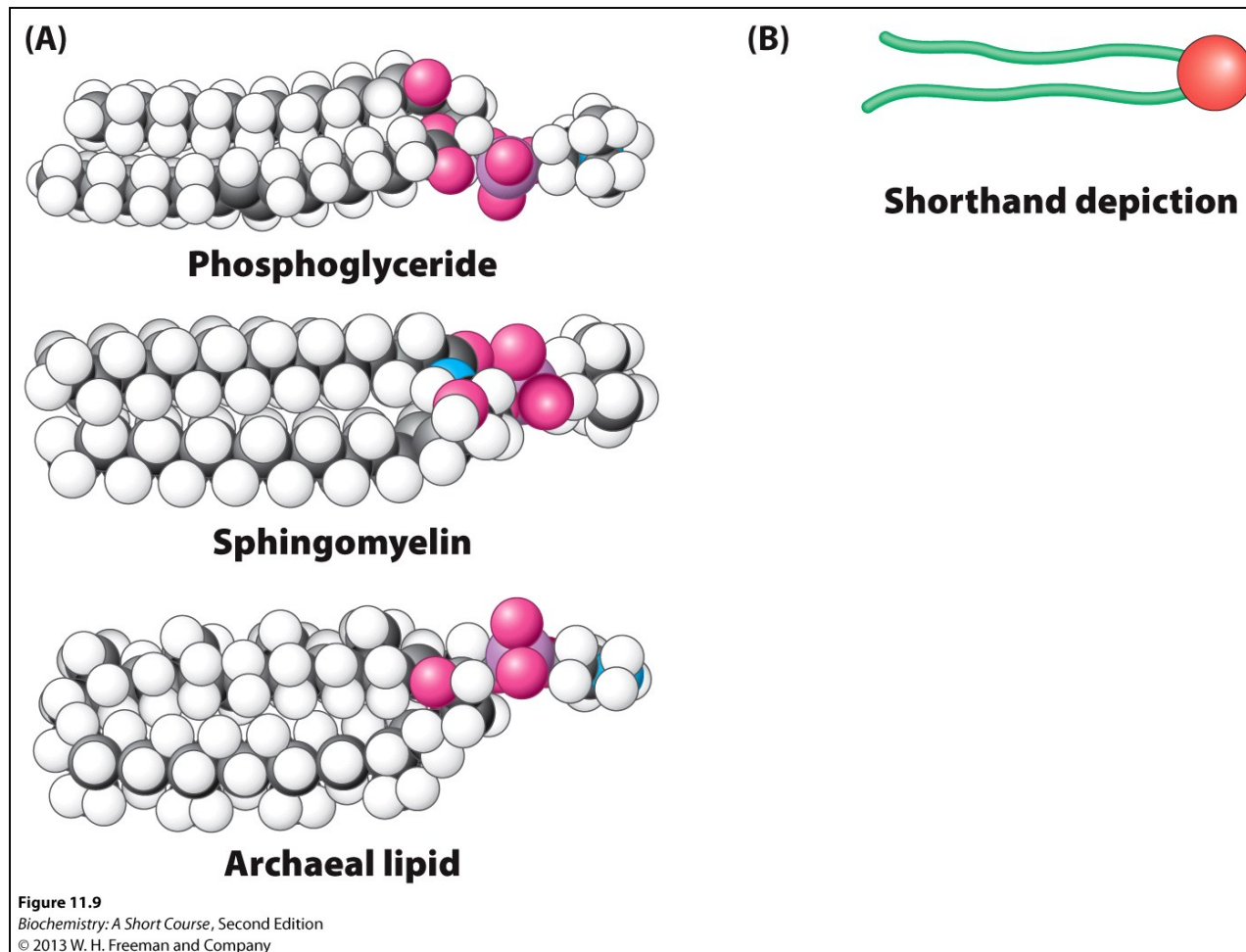
Bactoprenol  
(Undecaprenyl alcohol)

(c)



Juvenile hormone I

# Membrane Lipids are Amphipathic



# Some Membrane Proteins are Lipid Anchored

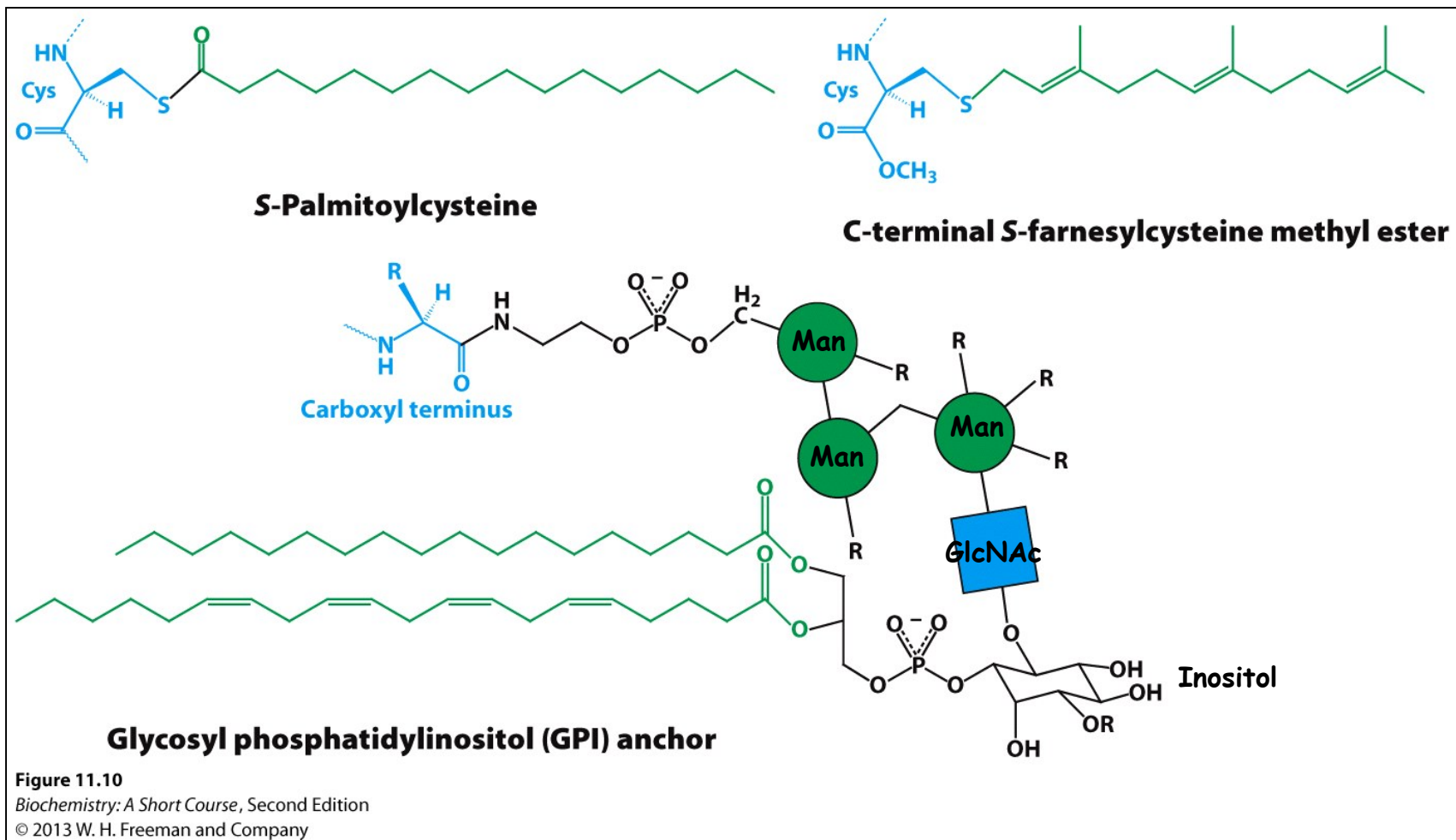


Figure 11.10

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