Lipids: Membrane Structure

- Role of lipids
- Fatty acid structure and nomenclature
- Types of membrane lipids
- Structure of membrane
- Membrane fluidity
Role of lipids

- Energy
- Energy Storage
- Hormones
- Vitamins
- Digestion
- Insulation
- Membrane structure: Hydrophobic properties
Lipids

**Diagram**

```
LIPIDS
  ├── Fatty acids
  │    ├── Eicosanoids
  │    └── Triacylglycerols
  │        ├── Waxes
  │        └── Sphingolipids
  │            └── Sphingomyelins
  │                ├── Ceramides
  │                └── Other phospholipids
  │                    ├── Phosphatidylethanolamines
  │                    │    ├── Plasmalogens
  │                    │    └── Phosphatidylserines
  │                    │        └── Phosphatidylcholines
  │                    │                        └── Phosphatidylinositol
  │                    │                                            ├── Other glycosphingolipids
  │                    │                                            └── Glycosphingolipids
  │                        └── Cerebrosides
  │                                        ├── Gangliosides
  │                                        └── Other glycosphingolipids
  ├── Steroids
  └── Lipid vitamins
      └── Terpenes
```

Figure 9.1
# Fatty acid nomenclature

<table>
<thead>
<tr>
<th>Number of carbons</th>
<th>Number of double bonds</th>
<th>Common name</th>
<th>Systematic name</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0</td>
<td>Laurate</td>
<td>n-Dodecanoate</td>
<td>CH₃(CH₂)₁₀COO⁻</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>Myristate</td>
<td>n-Tetradecanoate</td>
<td>CH₃(CH₂)₁₂COO⁻</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>Palmitate</td>
<td>n-Hexadecanoate</td>
<td>CH₃(CH₂)₁₄COO⁻</td>
</tr>
<tr>
<td>18</td>
<td>0</td>
<td>Stearate</td>
<td>n-Octadecanoate</td>
<td>CH₃(CH₂)₁₆COO⁻</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>Arachidate</td>
<td>n-Eicosanoate</td>
<td>CH₃(CH₂)₁₈COO⁻</td>
</tr>
<tr>
<td>22</td>
<td>0</td>
<td>Behenate</td>
<td>n-Docosanoate</td>
<td>CH₃(CH₂)₂₀COO⁻</td>
</tr>
<tr>
<td>24</td>
<td>0</td>
<td>Lignocerate</td>
<td>n-Tetracosanoate</td>
<td>CH₃(CH₂)₂₂COO⁻</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>Palmitoleate</td>
<td>cis-Δ⁹-Hexadecenoate</td>
<td>CH₃(CH₂)₇CH═CH(CH₂)₇COO⁻</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>Oleate</td>
<td>cis-Δ⁹-Octadecenoate</td>
<td>CH₃(CH₂)₇CH═CH(CH₂)₇COO⁻</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>Linoleate</td>
<td>cis,cis-Δ⁹, Δ¹₂- Octadecadienoate</td>
<td>CH₃(CH₂)₄(CH═CHCH₂)₂(CH₂)₆COO⁻</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>Linolenate</td>
<td>all-cis-Δ⁹,Δ¹₂, Δ¹⁵- Octadecatrienoate</td>
<td>CH₃(CH₂)₇CH═CH(CH₂)₃(CH₂)₆COO⁻</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>Arachidonate</td>
<td>all-cis Δ⁵,Δ⁸,Δ¹¹, -Δ¹⁴ Eicosatetraenoate</td>
<td>CH₃(CH₂)₄(CH═CHCH₂)₄(CH₂)₂COO⁻</td>
</tr>
</tbody>
</table>

Table 12-1
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Fatty acid Structure

- Long hydrocarbon chains
- Various lengths
- Saturated Fatty acids
- No double bond
Unsaturated Fatty acids

- One or more double bonds
- Cis: $\text{cis-} \Delta^9$, double bond between 9 and 10 carbon
- Trans: $\text{trans-} \Delta^2$, double bond between 2 and 3 carbon
- $\omega$-3 counting from the distal end.

An $\omega$-3 fatty acid
Types of membrane lipids

- Phospholipids
- Glycolipids
- Cholesterol
Phospholipids

- Glycerol backbone
- 2 fatty acids usually one saturated and one unsaturated
- C-3 carbon has phosphoric acid group
Types of phospholipids

- Phosphatidylserine
- Phosphatidylcholine
- Phosphatidylethanolamine
- Phosphatidylinositol
- Diphosphatidylglycerol (cardiolipin)

Figure 12-5
Biochemistry, Sixth Edition
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Sphingomyelin: amino alcohol

Sphingosine

Sphingomyelin
Glycolipids: sugar containing lipids

- Cerbroside
- Gangliosides: branched chain of sugars
- Extracellular side of membrane
- Receptors

![Cerbroside structure](image)
Cholesterol
Structure of membrane

- Membrane bilayer
- Lipids are amphipathic: hydrophillic and hydrophobic
- Contains phospholipids, glycolipids, cholesterol, and proteins
- Membranes are asymmetric
- Membranes are fluid
- Proteins mediate most functions
Membrane bilayer
Lipid bilayers

- Nanometers to millimeters in thickness, usually 6-10 nm
- Self assembly: entropy
- Impermeable to ions and most polar molecules to form boundaries
- Create a charge difference
Membrane proteins

- Protein ratio in membranes can vary from 1:4 to 4:1 depending on function
- Integral proteins
- Peripheral proteins
Membrane fluidity

- Phospholipids can diffuse laterally
- Rotations from one face to the other is very slow
Control of membrane fluidity

- Processes require some fluidity
- $T_m =$ melting temperature depends on length of fatty acid chain
- Double bonds increase fluidity
- Cholesterol inserts into bilayers and disrupts interactions; moderates fluidity
Fatty acid composition

- Bacteria can vary number of double bonds to regulate fluidity
- Eukaryotic cells (and bacteria) can change fatty acid composition with ratio of saturated to unsaturated fatty acids and chain length

<table>
<thead>
<tr>
<th>Major fatty acids</th>
<th>Cauliflower bud</th>
<th>Turnip root</th>
<th>Pea shoot</th>
<th>Bean shoot</th>
<th>Sweet potato</th>
<th>Maize shoot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmitic (16:0)</td>
<td>21.3</td>
<td>19.0</td>
<td>12.8</td>
<td>24.0</td>
<td>24.0</td>
<td>28.3</td>
</tr>
<tr>
<td>Stearic (18:0)</td>
<td>1.9</td>
<td>1.1</td>
<td>2.9</td>
<td>2.2</td>
<td>2.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Oleic (18:1)</td>
<td>7.0</td>
<td>12.2</td>
<td>3.1</td>
<td>3.8</td>
<td>6.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Linoleic (18:2)</td>
<td>16.4</td>
<td>20.6</td>
<td>61.9</td>
<td>43.6</td>
<td>50.8</td>
<td>54.6</td>
</tr>
<tr>
<td>Linolenic (18:3)</td>
<td>49.4</td>
<td>44.9</td>
<td>13.2</td>
<td>24.3</td>
<td>10.6</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Ratio of unsaturated to saturated fatty acids

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*Shown in parentheses are the number of carbon atoms in the fatty acid chain and the number of double bonds. Source: After Lyons et al. 1964.*