Membranes: a ________________________________ of living organisms

- ________________________________
- ________________________________
- ________________________________
- serve to separate ________________________________

Make-up:
- ________________________________
- ________________________________
- ________________________________
Lipids

Lipid - broadly defined as a ___________________________ that is at best, __________________________ but readily soluble in __________________________ such as chloroform or acetone.

- __________ and their derivatives, and substances related __________________________ to these compounds.

Types of lipids:

- fatty acids
- triacylglycerols
- phospholipids
- waxes
- sphingolipids
- glycolipids
- sterols/steroids

Two categories

1. ___________________________ with polar head groups and _______________
   ___________________________

2. ___________________________
Fatty Acids

amphipathic lipid - carboxyl group ______________ (hydrophilic)
- hydrocarbon chain ______________ (hydrophobic)

- _______ carbon atoms
- hydrocarbon chain ______________
- saturated: ____________
- unsaturated: ____________
- double bonds ____________

Palmitic acid
Stearic acid
Oleic acid
Linoleic acid
α-Linolenic acid
Arachidonic acid
Fatty Acids

unsaturations

- cis double bond puts ________
  the hydrocarbon tail

- no conjugated double bonds

conjugated:

Notation:

18:0

18:1 - Δ⁹
Fatty Acids
unsaturations

Unsaturations reduce _________________________________

Table 8.1

Typical Naturally Occurring Saturated Fatty Acids

<table>
<thead>
<tr>
<th>Acid</th>
<th>Number of Carbon Atoms</th>
<th>Formula</th>
<th>Melting Point (^\circ)C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lauric</td>
<td>12</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{10}\text{CO}_2\text{H})</td>
<td>44</td>
</tr>
<tr>
<td>Myristic</td>
<td>14</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{12}\text{CO}_2\text{H})</td>
<td>58</td>
</tr>
<tr>
<td>Palmitic</td>
<td>16</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{14}\text{CO}_2\text{H})</td>
<td>63</td>
</tr>
<tr>
<td>Stearic</td>
<td>18</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{16}\text{CO}_2\text{H})</td>
<td>71</td>
</tr>
<tr>
<td>Arachidic</td>
<td>20</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{18}\text{CO}_2\text{H})</td>
<td>77</td>
</tr>
</tbody>
</table>

Saturated F.A.’s are generally _________________________________

Highly unsaturated F.A.’s are _________________________________

F.A.’s rarely found free in nature

Table 8.2

Typical Naturally Occurring Unsaturated Fatty Acids

<table>
<thead>
<tr>
<th>Acid</th>
<th>Number of Carbon Atoms</th>
<th>Degree of Unsaturation</th>
<th>Formula</th>
<th>Melting Point (^\circ)C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmitoleic</td>
<td>16</td>
<td>16:1—(\Delta^9)</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{5}\text{CH}═\text{CH}(\text{CH}<em>2)</em>{7}\text{CO}_2\text{H})</td>
<td>-0.5</td>
</tr>
<tr>
<td>Oleic</td>
<td>18</td>
<td>18:1—(\Delta^9)</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{7}\text{CH}═\text{CH}(\text{CH}<em>2)</em>{7}\text{CO}_2\text{H})</td>
<td>16</td>
</tr>
<tr>
<td>Linoleic</td>
<td>18</td>
<td>18:2—(\Delta^9,12)</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{4}\text{CH}═\text{CH}(\text{CH}_2)\text{CH}═\text{CH}(\text{CH}<em>2)</em>{7}\text{CO}_2\text{H})</td>
<td>-5</td>
</tr>
<tr>
<td>Linolenic</td>
<td>18</td>
<td>18:3—(\Delta^9,12,15)</td>
<td>(\text{CH}_3(\text{CH}_2)\text{CH}═\text{CH}(\text{CH}<em>2)</em>{5}\text{CH}═\text{CH}(\text{CH}<em>2)</em>{7}\text{CO}_2\text{H})</td>
<td>-11</td>
</tr>
<tr>
<td>Arachidonic</td>
<td>20</td>
<td>20:4—(\Delta^5,8,11,14)</td>
<td>(\text{CH}_3(\text{CH}<em>2)</em>{4}\text{CH}═\text{CHCH}<em>2)</em>{4}(\text{CH}<em>2)</em>{2}\text{CO}_2\text{H})</td>
<td>-50</td>
</tr>
</tbody>
</table>

\{plant F.A.’s
Omega (ω)-3 Fatty Acids

**FIG. 1 OMEGA-3 AND OMEGA-6 FATTY ACIDS**

- **C=C numbering begins at ____________, opposite end from carboxyl group.**
- Highly ______________.
- Humans cannot make ω-3 fatty acids.
- essential, must be obtained ____________.
- ______________ of some plants high in ω-3s.

**Reported health benefits:**
- __________ blood circulation
- Lower ______________
  - Anti-________ activity
  - Anti-________ activity

- Alpha-linolenic acid (ALA, C18:3, omega-3)
- Eicosapentaenoic acid (EPA, C20:5, omega-3)
- Docosahexaenoic acid (DHA, C22:6, omega-3)
- Linoleic acid (LA, C18:2, omega-6)
- Arachidonic acid (AA, C20:4, omega-6)
Triacylglycerols (triglycerides)

Triacylglycerols - _______________ of a fatty acid to each _______________

Generally, same F.A. ___________________________ on glycerol

Not found in membranes but act to store F.A.’s _______________________

Tristearin (a simple triacylglycerol)
Phosphoacetylgllycerols (phospholipids)

Phosphoacetylgllycerols - ester linkage of ___________ and one ________________ group to glycerol.
- PO₄ can be esterified to additional alcohol containing compound

Phosphatidic acid - phosphoacetylgllycerol with no __________________________.

Phosphatidyl ester - phosphoacetylgllycerol with an___________________________.

F.A. can vary
C(1) - ___________
C(2) - ___________

Phosphatidic acid

Phosphatidyl ester
Phosphoacylglycerols (phospholipids)

Phosphatidyl esters
Phosphoacylglycerols (phospholipids)

**Phosphatidyl esters** - have highly __________________________

- have long __________________________

- main components (lipids) in ____________________

![Phosphatidylinositol](image)

Hydrophilic surfaces

Hydrophobic tails

Hydrophilic surfaces
Steroids - lipids consisting _________________________
- 3 six membered rings
- 1 five membered ring

- function mostly _____________________
Steroids/Sterols

Sterols - a steroid with a ____________
- cholesterol is major component of ____________
- cholesterol is ______________
- sterols rarely found in prokaryotes

- ______________ little cholesterol
- major sterols β-sitosterol and stigmasterol
- have additional ____________ at C-24

- ____________ main sterol is ergosterol
Membranes

Membranes - separate cells from the ________________
- separate ________________ from rest of cell.
- controls transport of ____________ in and out of cell
- have embedded ________________

Membrane characteristics are determined by the ________________
__________________________________________________________.

How are all of these lipids put together to form membrane?

- hydrophobic tails of phospholipids will interact with each other __________
  ________________.
- hydrophobic tails __________
  ________________.
- hydrophilic heads on ________
  ____________________________
Membranes

Differences between inner and outer layer of lipid-bilayer

Phospholipids in outer layer are ______ hydrophilic heads and hydrophobic tails, more room

Phospholipids in inner layer are ______ hydrophilic heads and hydrophobic tails, less room

Can distinguish inner and outer layer experimentally ________________________.
Membranes

Membrane fluidity:
- __________________ in phospholipids
- amount of ______________
- ________________________

- Unsaturated F.A.’s in phospholipids
__________________________.
- Increases ________________.
Membranes

Membrane fluidity: cholesterol

Cholesterol - OH associates with ________________
- rigid ring structure associates with ________________
- makes membrane ________________
Membranes

**Membrane fluidity**: temperature

- at low temperatures hydrocarbon tails of phospholipids
  ________________________________

- increase in heat reduces _______________________
  ________________________________

- surface area _________________________

- \( T_m \): temperature at which membrane changes from __________
  ________________________________

- thickness decreases

- cholesterol will decrease mobility of _______________________
  ________________________________

![Diagram of membrane structure](image)

**Gel** → **Heat** → **Liquid crystal**
Membranes

Phospholipid transition within the bilayer

- Lateral movement

- “sea of phospholipids”

- “flip-flop” of phospholipids from one layer of bilayer to another

- Why would this not happen spontaneously?
Membranes

Proteins Associated with membranes

1, 2, 4: __________________________
_______________________________

3: _____________________________
_______________________________

Integral membrane proteins __________________________

Peripheral membrane proteins are loosely associated with _________
______________________________ through polar and/or electrostatic interactions
Membranes

Proteins Associated with membranes

α-helix or β-sheet of integral membrane proteins associates with hydrophobic phospholipid tails.

- polar peptide backbone ________________

- hydrophobic side chains on ________________

Membrane anchoring of proteins

Palmitic acid: 16:0

Myristic acid: 14:0
Fluid-mosaic Model

**Fluid:** - In order for membrane proteins to function ________________

- composition of F.A.’s on phospholipids (saturated/unsaturated, chain length), amount of ________________ in response to temperature, ________________.

**Mosaic:** - made up of many different compounds, proteins, phospholipids, etc.

- lots of ________________

- proteins “float” in a ________________
Transport Across Membranes

**Passive transport:**
- movement of substance

__________________
-from ________________
-does not require ________

**simple diffusion:**
small uncharged molecules
(O₂, N₂, H₂O, CO₂)
pass __________
______________.

**facilitated diffusion:**
carrier protein used to move ________
__________ through memb.

outside cell

inside cell

conformational change
Transport Across Membranes

**Passive transport:**
- movement of substance  
  ____________________________
- from _______________________  
- does not require ____________

**Simple diffusion:**
- small uncharged molecules  
  \( \text{O}_2, \text{N}_2, \text{H}_2\text{O}, \text{CO}_2 \)
- pass ___________ ____________

**Facilitated diffusion:**
- carrier protein used to move ____________  
  __________ through memb.

**Active transport:**
- movement of substance _________
  ____________________________
- from ________________________
- requires ________________
Transport Across Membranes

Passive transport is spontaneous (-\(\Delta G\))

\[ \Delta G = RT \ln \left( \frac{[C_{in}]}{[C_{out}]} \right) \]

= RT \ln \left( \frac{[\ ]}{[\ ]} \right)

= RT \ln (______)

= RT (_______)

R always ______

As T move towards negative?
As T increases?
As \([C_{in}]\) moves toward \([C_{out}]\)?
As \([C_{in}]\) surpasses \([C_{out}]\)?
Transport Across Membranes

Facilitated diffusion of glucose into red blood cells

Glucose permease

[Image: Glucose in blood, conc. ≈ 5 mM → Facilitated diffusion → Intracellular glucose conc. < 5 mM]
Transport Across Membranes

How do integral membrane proteins make “holes” in membranes for facilitated transport

Location of ______________________

Location of ______________________

(b) β-sheet

α-helix

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Transport Across Membranes

**Active transport:**
- movement of substance ____________________________ gradient.
- from ________________
- requires ____________

Where does energy come from?

\[ \Delta G = RT \ln \left( \frac{[\text{outside cell}]}{[\text{inside cell}]} \right) \]

\[ = RT \ln \left( \frac{[\text{inside cell}]}{[\text{outside cell}]} \right) \]

\[ = RT \ln ( ) \]

\[ = RT ( ) \]

Primary active transport - ________________________________
Transport Across Membranes

**Active transport**: sodium-potassium ion pump (Na\(^+\)/K\(^+\) pump)

Normal condition of cell:

\[ [K^+_{\text{inside}}] > [K^+_{\text{outside}}] \]

\[ [Na^+_{\text{inside}}] < [Na^+_{\text{outside}}] \]

Uses energy from _____________ to transport ______ from inside cell to outside and ______ from outside cell to inside

**Na\(^+\)-K\(^+\) pump**

http://www.youtube.com/watch?v=yz7EHJFDEJs
Transport Across Membranes

**Active transport:** bacterial lactose permease (galactoside permease)

Gradients of protons (H$^+$) __________________________
____________________, i.e. free energy, -ΔG

Energy in H$^+$ gradient __________
________________________

**Secondary active transport** - use of free energy in
________________________
________________________