

#### Chapter 8: Lipids



# **Functions of Lipids**

#### - Storage

Fats are long term energy (9 kcal/g) while carbohydrates are quick energy (4 kcal/g).

#### - Membrane Components

Lipid barriers keep water out.

#### - Messengers

Hormones process signals.







### Classifications



# **Structure of Lipids**

Fatty Acids: long-chain carboxylic acids



oleic acid: cis-octadecanoic acid, C<sub>18</sub>H<sub>34</sub>O<sub>2</sub>





palmitic acid: hexadecanoic acid, C<sub>16</sub>H<sub>32</sub>O<sub>2</sub>

Always in even numbers.



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#### Micelles

#### <u>Micelle</u>: spherical cluster of molecules



casein in milk





drug carriers

# **Saturation and Unsaturation**

<u>saturated</u>: maximum number of hydrogens

- labeled "fats"
- considered "less" healthy
- higher m.p.

<u>unsaturated</u>: fewer than the maximum number of hydrogens

- labeled "oils"
- considered "more" healthy
- lower m.p.





### Fats and Oils

At room temperature, animal fats are typically solids while oils are liquids.

Polyunsaturated fat: more than one double bond per fatty acid





In general, melting point increases with:

- saturation
- increasing molecular weight



# Triglycerides

<u>Triglyceride</u>: triesters of glycerol (alcohol) and fatty acids (carboxylic acid)



1,2,3-propanetriol, "glycerol"

triglyceride

Some monoglycerides and diglycerides exist.





# **Physical Properties**

Triglycerides are hydrophobic, making them insoluble in water.



Left: Immiscible lipid and water mixture. Right: Adding bile salts (ionic compounds) allows them to dissolve in water.



# Hydrolysis

# <u>Hydrolysis (lipolysis)</u>: addition of water to split an ester in acidic conditions

Opposite of esterification



triglyceride

Takes place during:

- digestion
- breakdown after storage



## Saponification

#### Saponification: splitting esters in basic conditions NOT the opposite of esterification.



Base must be added in stoichiometric amounts. Reaction is *irreversible*.



#### Soaps



#### hard soap: made with NaOH, sodium carboxylates

<u>soft soap</u>: made with KOH, potassium carboxylates

# Hydrogenation

<u>Hydrogenation</u>: adding H<sub>2</sub> with a metal catalyst



Hydrogenation increases a fat's solidity.



Partial hydrogenation changes the consistency to softer, malleable solids but also produces trans fats.



#### Waxes

#### wax: ester of fatty acids and long-chain alcohols



#### Waxes are:

- insoluble in water
- not easily hydrolyzed
- used as protective coatings

### Classifications



# Lipid Bilayer

#### lipid bilayer: outer membrane





**Hydrophilic** ends point *outward*. **Hydrophobic** ends point *inward*.



Saturated lipids only



Mixed saturated and unsaturated





Monounsaturated

### Fluid Mosaic Model

<u>fluid mosaic model</u>: Free, lateral motion of the bilayers makes membranes "liquid-like" to allow transport through it



# Phosphoglycerides

<u>phosphoglycerides</u>: triester of glycerol with two fatty acids and one phosphoric acid linked to an aminoalcohol



The aminoalcohol can be:

- choline (lecithins)
- ethanolamine (cephalins)
- serine (cephalins)



# Sphingolipids

sphingolipids: contain sphingosine instead of glycerol



### Classifications



### **Steroids**

<u>steroid</u>: Contain 3 cyclohexane (phenathrene) and 1 cyclopentane fused together



 $C_{17}H_{28}$ , cyclopentaphenanthrene

gonane: simplest steroid, contains only core structure

Steroids differ by the number of methyl and functional groups attached to the core structure.





## Cholesterol

<u>cholesterol</u>: most abundant steroid in the human body, builds and maintains membranes

In a day, 1000-mg cholesterol is made to keep a total body <sub>+</sub> content of 35-g.

Typical daily cholesterol intake is 200-300 mg.



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### HDL vs. LDL

HDL has a high ratio of protein to cholesterol. It moves cholesterol to the liver and is considered "good".

LDL has a low ratio of protein to cholesterol. It moves cholesterol to artery walls and is considered "bad".





## HDL vs. LDL

#### Recommended levels of HDL, LDL, and total cholesterol

HDL Good Cholesterol	LDL Bad Cholesterol	<b>Total</b> Cholesterol
Below 40	Above 160	Above 240
41 - 59	130 - 159	200 - 239
Above 60	Below 129	Below 200
mg/dl	mg/dl	mg/dl
	HDL Good Cholesterol Below 40 41 - 59 Above 60 mg/dl	HDL Good CholesterolLDL Bad CholesterolBelow 40Above 16041 - 59130 - 159Above 60Below 129mg/dlmg/dl

High LDL and low LDL are considered "desirable".

#### **Heart Disease**



#### Hormones



#### Progesterone



Progesterone is produced in the ovaries, adrenal glands, and the placenta as one of the "female" sex hormones.

It has been commercially synthesized from diosgenin.







# <u>estradiol</u>: female sex hormone generated from the aromatization of the A ring in testosterone.



#### Testosterone

<u>testosterone</u>: promotes maturation of male characteristics



Testosterone promotes *anabolic effects*, including growth of muscle mass, increased bone density, and stimulation of linear growth and bone maturation.

Anabolic steroids cause muscle fibers to become larger and repair more quickly than normal



### Glutocorticoids

<u>glucocorticoids</u>: control carbohydrate metabolism and control inflammation and the immune system.

<u>cortisol</u>: released due to stress to increase blood sugar levels by converting fatty acids and amino acids in the liver to glucose.

<u>cortisone</u>: oxidized ketone derivative of cortisol



### Classifications



# Prostaglandins

<u>prostaglandin</u>: fatty acid synthesized from arachidonic acid

Induce labor, lower blood pressure, relaxes muscles, inflames tissue around injuries.





<u>thromboxane</u>: ring is a cyclic acetal
Induces platelet aggregation to start blood clotting.

<u>leukotriene</u>: oxidized arachdionic acid, without ring closure

Occur mainly in white blood cells to produce long-lasting muscle contractions, inflammation, and fever.



