Lipids - Definition

Definition:
- Water insoluble
- No common structure – (though generally large R-groups)

Water Solubility (Hydrophilic)

What makes molecules water soluble (hydrophilic)?

- Like dissolves like
- Small
- Similar IMF's – Polar/H-bonds
- Functional Groups that are generally water soluble:

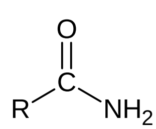
Alcohols

R-OH

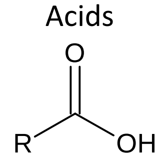
Amines

$R\text{-}NH_2$

Amides



Carboxylic Acids



Water Insoluble (Hydrophobic)

What makes molecules water insoluble (hydrophobic)?

- Large molecules (R-groups)
- Different IMF's – Nonpolar
- Functional Groups that are generally water insoluble:

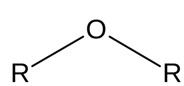
Alkane/ene/yne

$R\text{-}CH_3$

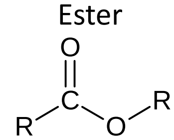
$R{-}CH{=}CH_2$

$R{-}C{\equiv}CH$

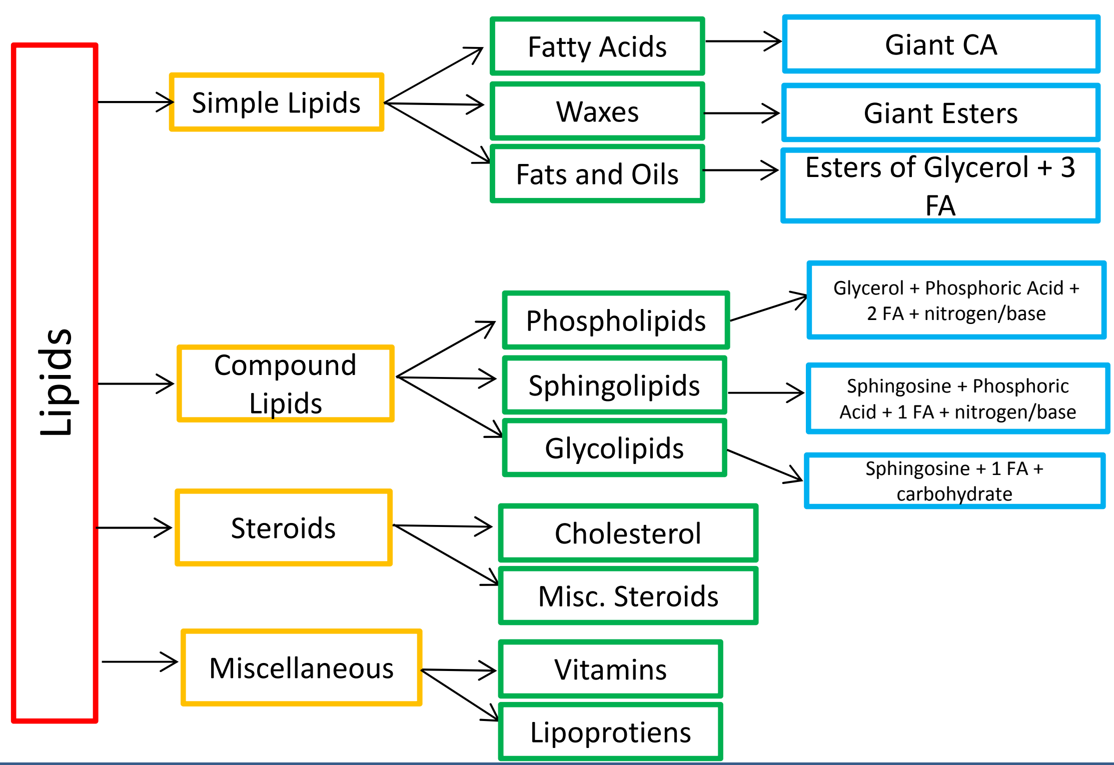
Ether



Ester



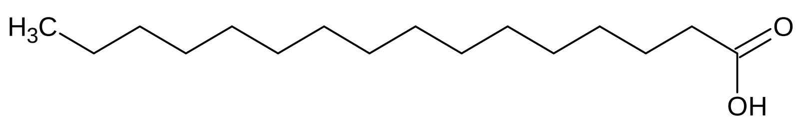
Classification of Lipids



Fatty Acids

Fatty Acids:

- Giant Carboxylic Acids
- Straight (unbranched) chains
- Even number of carbons
- Saturated vs. Unsaturated
- Cis vs. Trans isomers
- Essential FA
- ω-3 vs. ω-6
- Eicosands –
    - arachidonic acid, linolenic acid, linoleic acid
    - thromboxane, prostaglandin, prostacyclin, leukotriene



Saturated
vs.
Unsaturated

Saturated FA

Physical

- No C=C
- Mostly animals
  (and higher plant cells)
- Higher MP (solids)
- Long shelf life
- Linear → LDF →Pack better
- Replace cholesterol in LDL/HDL
- Only used for Energy

Biological

- Excess → atherosclerosis
  heart diseases
- Increase LDL (bad)
- Decrease HDL (good)

- Can block arteries easier

Unsaturated FA

Physical

- Contain C=C
- Plants
- Lower MP (liquids)
- Spoil quickly
- Cis/Trans Isomers

Biological

- Good (better than Sat.)
- Increase HDL (good)
- Decrease LDL (bad)

Bonus Reaction: Use of Br_2 to detect presence.

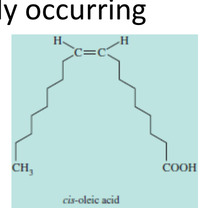
Saturated vs. Unsaturated

	Saturated Fats	Unsaturated Fats
Recommended consumption:	Not more than 10% of total calories per day.	Not more than 30% of total calories per day
Health Effect:	Excessive consumption is not good because of their association with atherosclerosis and heart diseases.	Unsaturated fats are considered good to eat if you are watching your cholesterol.
Life:	These are long lasting and do not get spoiled quickly	These get spoiled quickly
Commonly found in:	Butter, coconut oil, whole milk, meat,peanut butter,margarine,cheese,vegetable oil or fish oil	Avocado, soybean oil, canola oil, olive oil
Cholesterol:	Saturated fats increase LDL (badcholesterol) and decrease the HDL	Unsaturated fats increase high-density lipoprotein (HDL or good cholesterol) and decrease LDL (bad cholesterol)
Melting Point:	High	Low
Physical state at room temperature:	Solid	Liquid
Type of bonds:	Consist of SINGLE bond	Consist of at least 1 DOUBLE bond

Cis vs. Trans Isomers

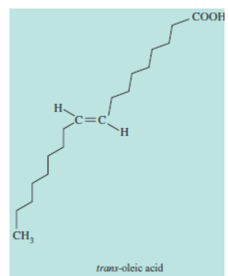
Cis-Isomer

Physical
- Contain C=C
- Naturally occurring



Biological
- GOOD
- Decrease LDL (bad)
- Increase HDL (good)

Trans-Isomer

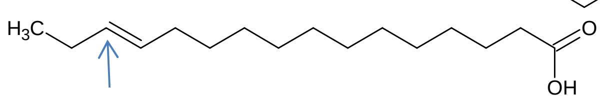


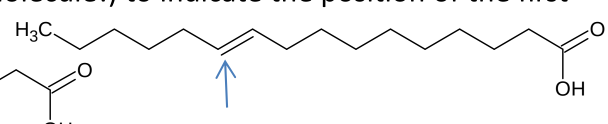
Physical
- Contain C=C
- Rare in a nature
- Man made through Hydrogenation Reaction
- Linear → Packs tightly → High MP

Biological
- BAD
- Increase LDL (bad)
- Decrease HDL (good)
- Increase risk of Heart Attack

ω-3 vs. ω-6 Fatty Acids

Greek letter Omega (ω) is the last letter in the Greek alphabet. It is used by biologist (counting from the wrong end of the molecule!) to indicate the position of the first C=C in an unsaturated fat.



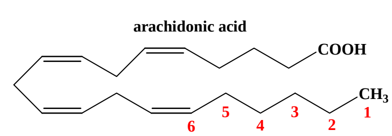


ω-3 Fatty Acids

Biological
- GOOD
- Precursor to molecules that produce useful (less harmful) effects
- Ex: Linolenic acid

ω-6 Fatty Acids

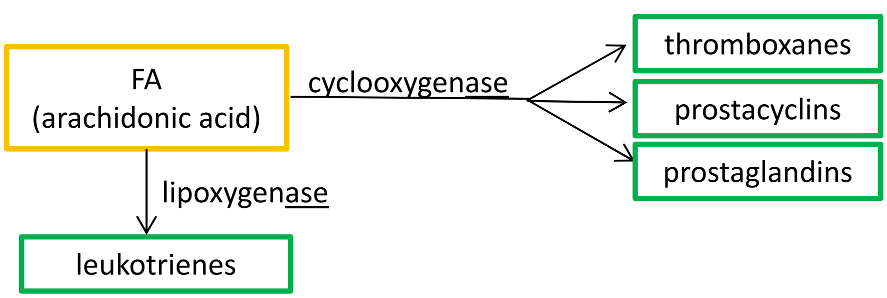
Biological
- BAD
- Precursor to molecules that produce harmful (exaggerated) effects
- Ex: Arachidonic acid → Trigger for Heart Attacks



Eicosanoids

Eicosanoids:

- Example of FA Biological Pathway
- Parent molecule → Daughter molecules (Enzyme (-ase))
- Local Hormones – short lived
- Coordinate immune system response, blood clotting
  - attract WBC, vasodilation/restriction, body temperature, mucous etc.
  - Ratio of ω-3 vs. ω-6 ratio important
- Drugs – used to control biochemical pathway
  - NSAIDS – inhibit cyclooxygenase (side-effect: stomach ulcers)
  - COX-2 – inhibit cyclooxygenase (side-effect: increased heart attacks)

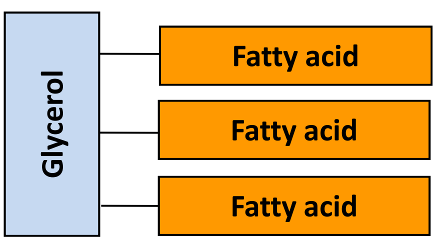


Biological Pathways

Biological Pathways:

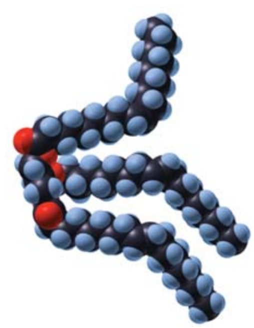
- Precursor Molecules
- Parent molecule $\xrightarrow[\text{Enzyme (-ase)}]{}$ Daughter molecules
- Examples:
  - Eicosanoids (FA)
  - Steroids
  - Atherosclerosis
- Control mechanisms for biological pathways

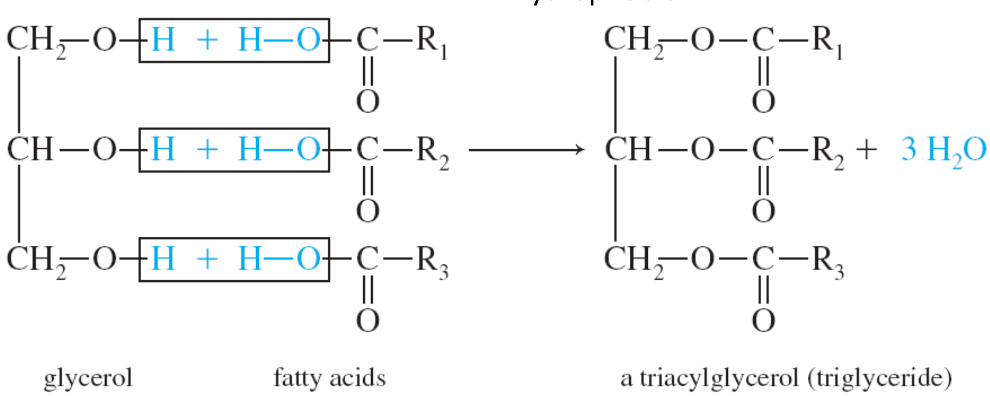
Fats and Oils Structure



Fats and Oils:

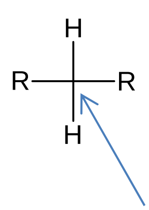
- Glycerol + 3 FA
- Giant Esters
- Dehydration Reaction
- Amide Bonds
- Triacylglycerol or Triglycerides
- Hydrophobic





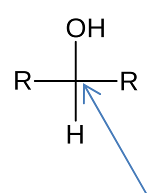
Fats and Oils
Biological Properties

Fats:
- 9.5 kcal/g or 40 kJ/g
- Average FA is 75% Carbon
- More Reduced



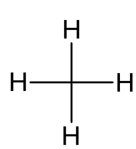
Ox: -2

Carbohydrates:
- 4.5 kcal/g or 20 kJ/g
- Average FA is 40% Carbon
- More oxidized

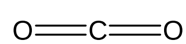


Ox: 0

Oxidation Number: Charge an atom would have if it were in an ionic compound
- H = +1
- O = -2
- C = calculate



Ox: -4

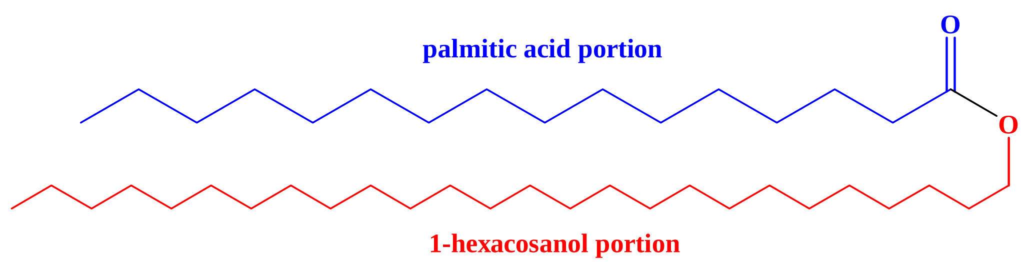


Ox: +4

Waxes

Waxes:

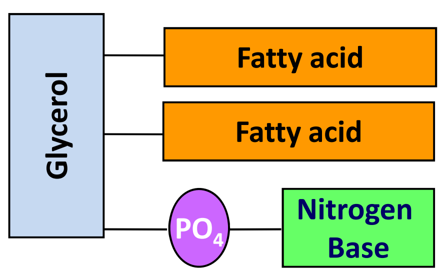
- Giant Ester (20-30 Carbons)
- Very hydrophobic
- Used as protective layer on plant leaves, animal feathers, fur, cars, floors



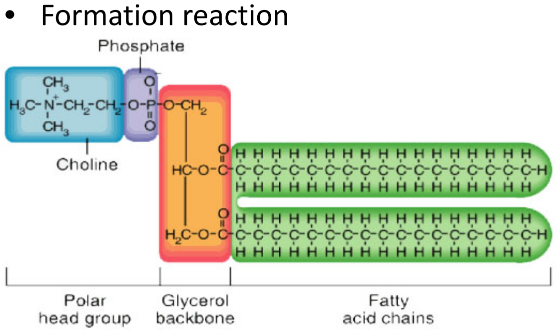
Phospholipids

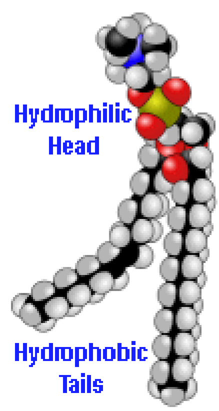
Phospholipids:

- Structure:
  - Glycerol
  - 2 - FA
  - 1 - Phosphoric Acid
  - Amino-alcohol



- Nerve tissue, brain matter, cell membranes (10-20%)
- Used in foods as an emulsifier for chocolates and margarine
- Hydrophobic vs. Hydrophilic parts
- Formation reaction

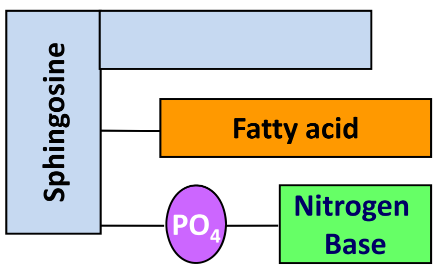


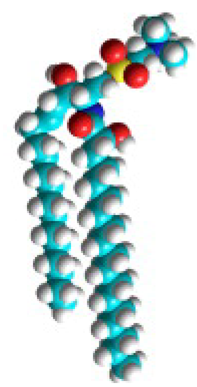


Sphingolipids

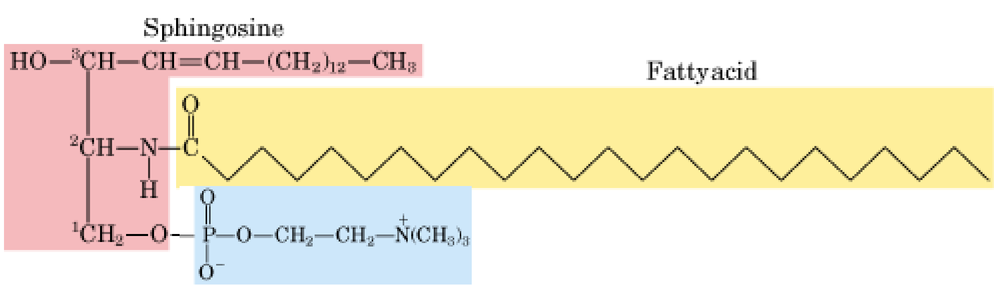
Sphingolipids:

- Structure:
  - Sphingosine
  - 1 - FA
  - 1 - Phosphoric Acid
  - Amino-alcohol





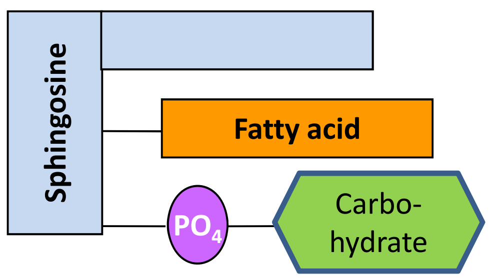
- Membrane components, nerve sheath
- Hydrophobic vs. Hydrophilic parts
- Formation reaction
- Amide bond



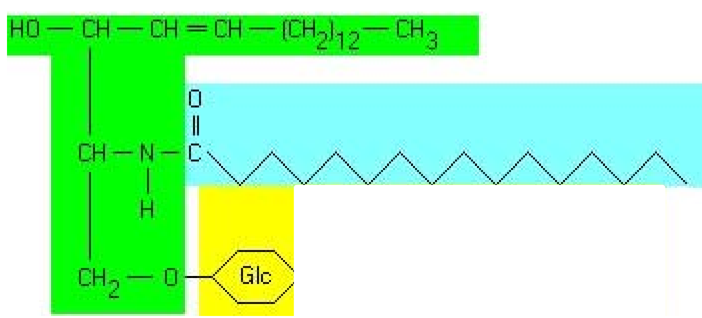
Glycolipids

Glycolipids:

- Structure:
  - Sphingosine
  - 1 - FA
  - 1 - Phosphoric Acid
  - Carbohydrate



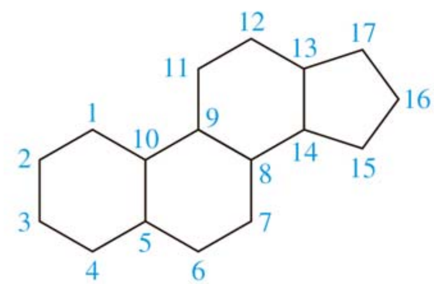
- Cerebrosides and gangliosides – cell membranes of nerve and brain tissue
- Hydrophobic vs. Hydrophilic parts
- Formation reaction
- Amide bond



Steroids

Steroids:

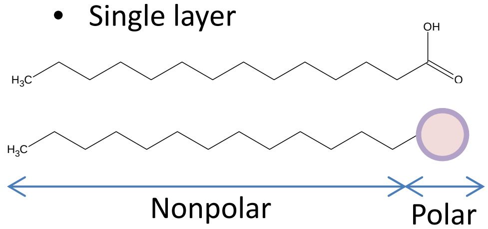
- Parent Molecule → Daughter Molecules
- Vary widely in function
  1. Cholesterol - membrane component
  2. Bile salts – digestion of fats
  3. Ergosterol → Vitamin D
  4. Digitalis – heart drug
  5. Adrenal cortex hormones – metabolism
  6. Sex hormones – characteristics and reproduction
- Figure 28.5

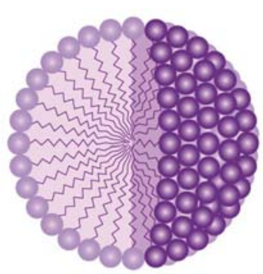


steroid ring nucleus

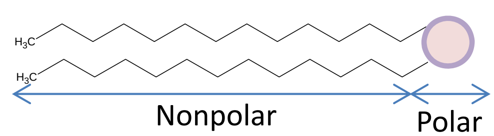
Micelles and Liposomes

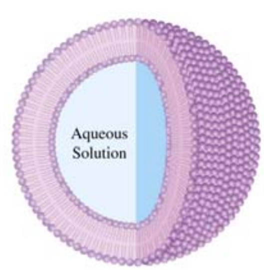
Micelles:
- Formed from FA
- Polar head
- 1 Non-Polar Tail
- Single layer





Liposomes:
- Formed from phospholipids etc.
- Polar head
- 2 Non-polar tails
- Double layer

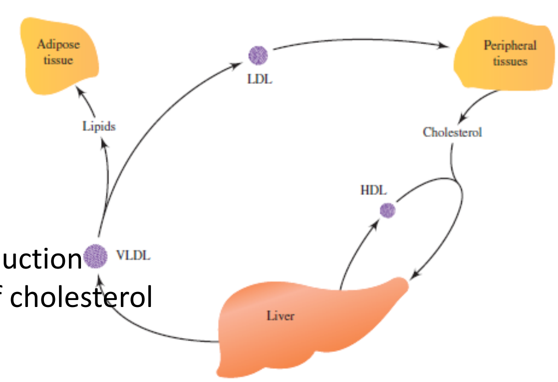




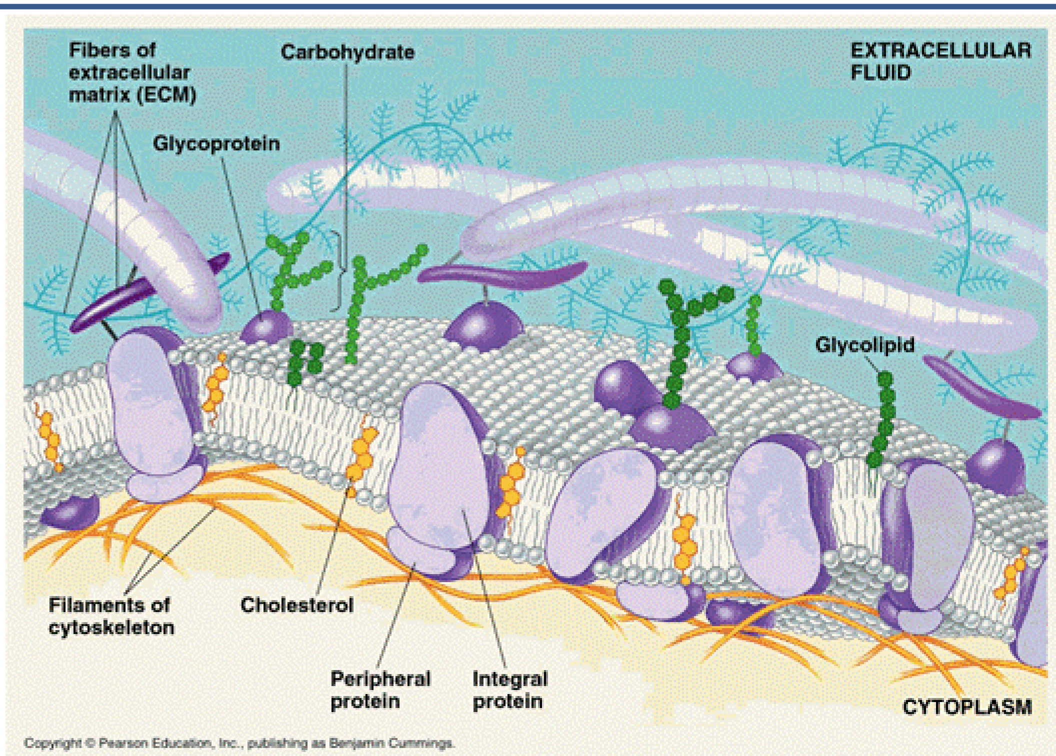
Atherosclerosis

Atherosclerosis:

- Metabolic disease → deposits of lipids on artery walls → heart attack
- Lipids naturally aggregate (hydrophobic)
    1. Lipids trapped in artery walls (oxidized)
    2. White cells (macrophages) scavenge lipids → bloated
    3. Foam cells are stuck to arteries
- Improper transport of lipids
- Lipid "cycle"
    1. VLDL = Good – deliver lipids
    2. Adipose = Storage
    3. LDL = BAD
    4. Peripheral = Energy
    5. HDL = GOOD – recycle
- Drugs/Treatment
    1. Low cholesterol diet
    2. Decrease Triacylglycerol production
    3. Inhibit metabolic synthesis of cholesterol
    4. Increase excretion
    5. Decrease absorption



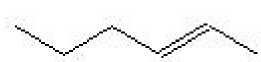
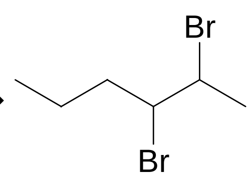
Cell Membranes



Reaction – Br_2

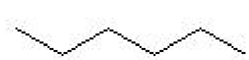
Reaction: General test for saturation.

- C=C react quickly with Br_2
- Addition Reaction

 + Br_2 → 

(Fast)

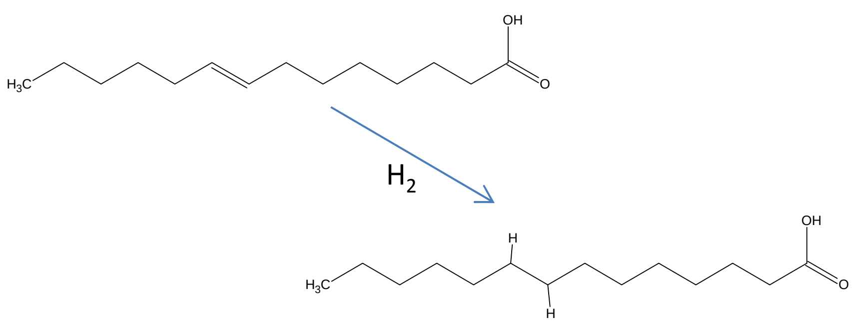
Orange → Clear

 + Br_2 → Slow (Requires UV light)

Orange → NR

Reaction - Hydrogenation

Reaction:
- Unsaturated FA → Saturated FA
- Addition reaction



Reaction – Dehydration

Dehydration reactions are how most molecules in this chapter are formed

- Glycerol + 3 FA → Fats and Oils
- CA + Alcohol → Waxes
- Glycerol + 2 FA + Phosphate + Amino-alcohol → Phospholipid
- Etc…