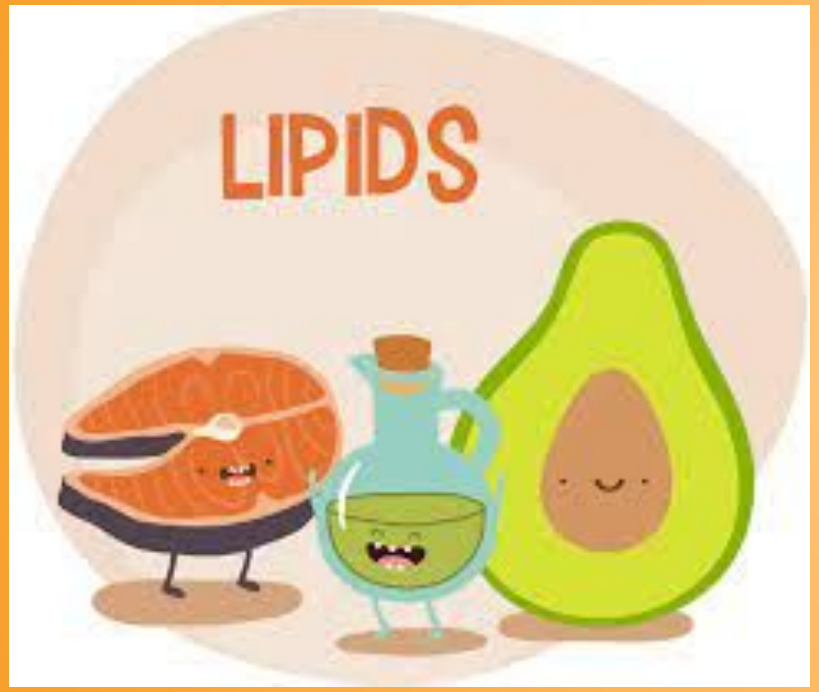


Lecture 5 - The lipids:

Fats, oils, phospholipids, and sterols

Lipids/Fats

- **Lipid** – not soluble in water; an organic compound
- **Fat** – a solid lipid (at room temperature) – in this course used interchangeably with the term lipid unless specified
- **Oil** – a liquid lipid (at room temperature)
- 3 Main categories of dietary lipids:
  - **Triglyceride:** ~ 95% of lipids in human body
  - **Phospholipid:** soluble in water and fat. Used as an emulsifier (mixes fat and water – eg. Lecithin). Present in all cell membranes.
  - **Sterol:** example: cholesterol
  - https://youtu.be/69-eGO7XDfU

1. Three Types of Lipids

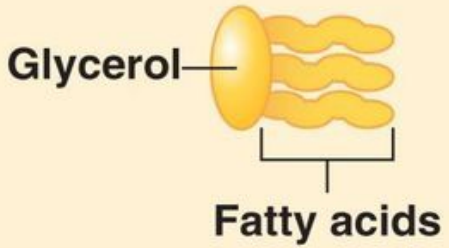
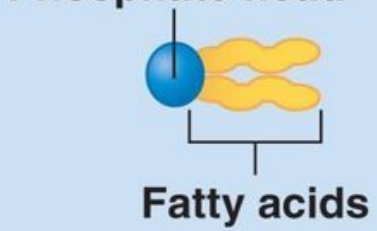
Lipid	Structure	Examples
Triglycerides		Saturated fat Unsaturated fat Trans fat
Phospholipids		Lecithin
Sterols		Cholesterol

Figure 5.9

Usefulness of fats in the body

- **Why is glucose is not the body's major form of stored energy?**

- Glucose is stored as **glycogen** – we have limited quantities stored in our liver & muscles. Enough for 1 – 48 hrs depending on activity level
- Glucose attracts water, so our weight would double if we stored the same amount of energy as glycogen rather than fat.

- **Fat cells/Adipocytes:** specialize in fat storage (fat tissue secretes hormones that regulate appetite and influence other body functions) Fats pack tightly together without water and can store much more energy in a small space
- Gram for gram: fats provide more than twice energy of carbs

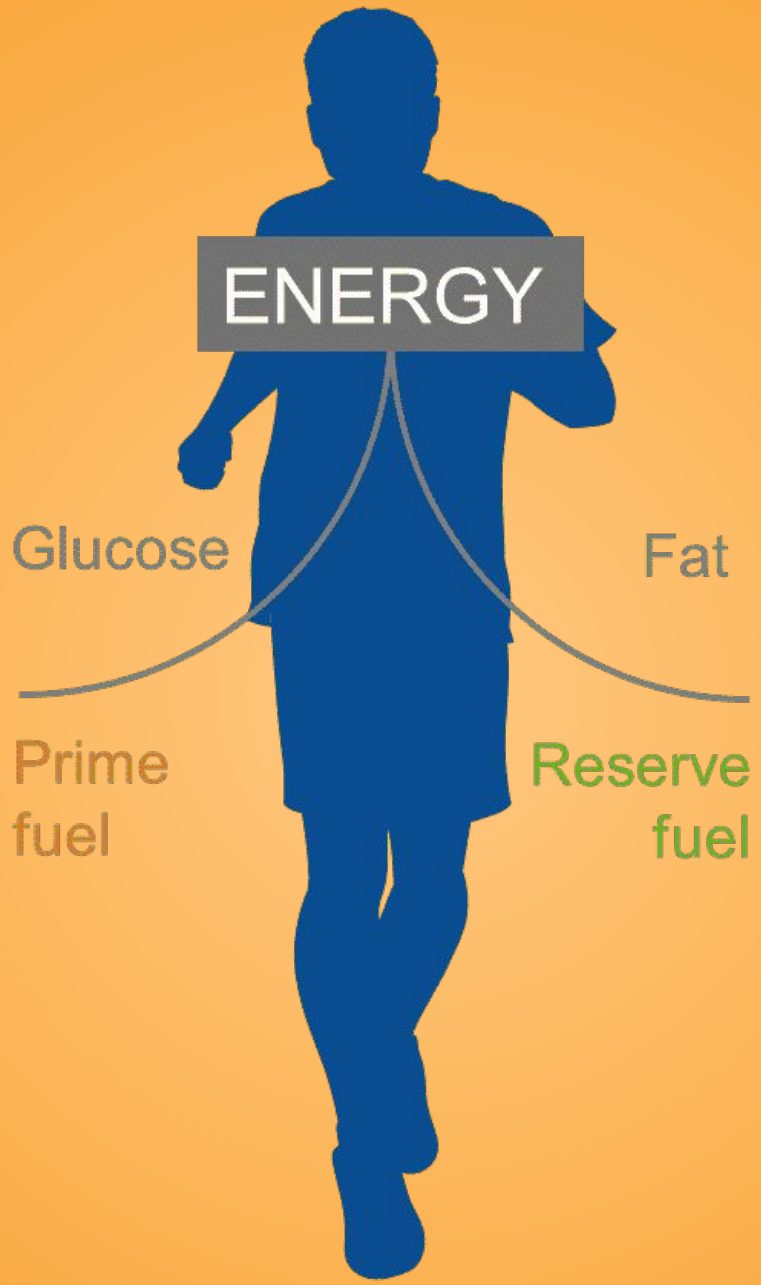
Lipids serve as energy reserves

Can produce ATP energy through **Beta-oxidation**

Carbohydrate

- Fast energy supply
- Limited source

Glycogen stores
Depletion of carb fuel limits endurance
(= exhaustion)

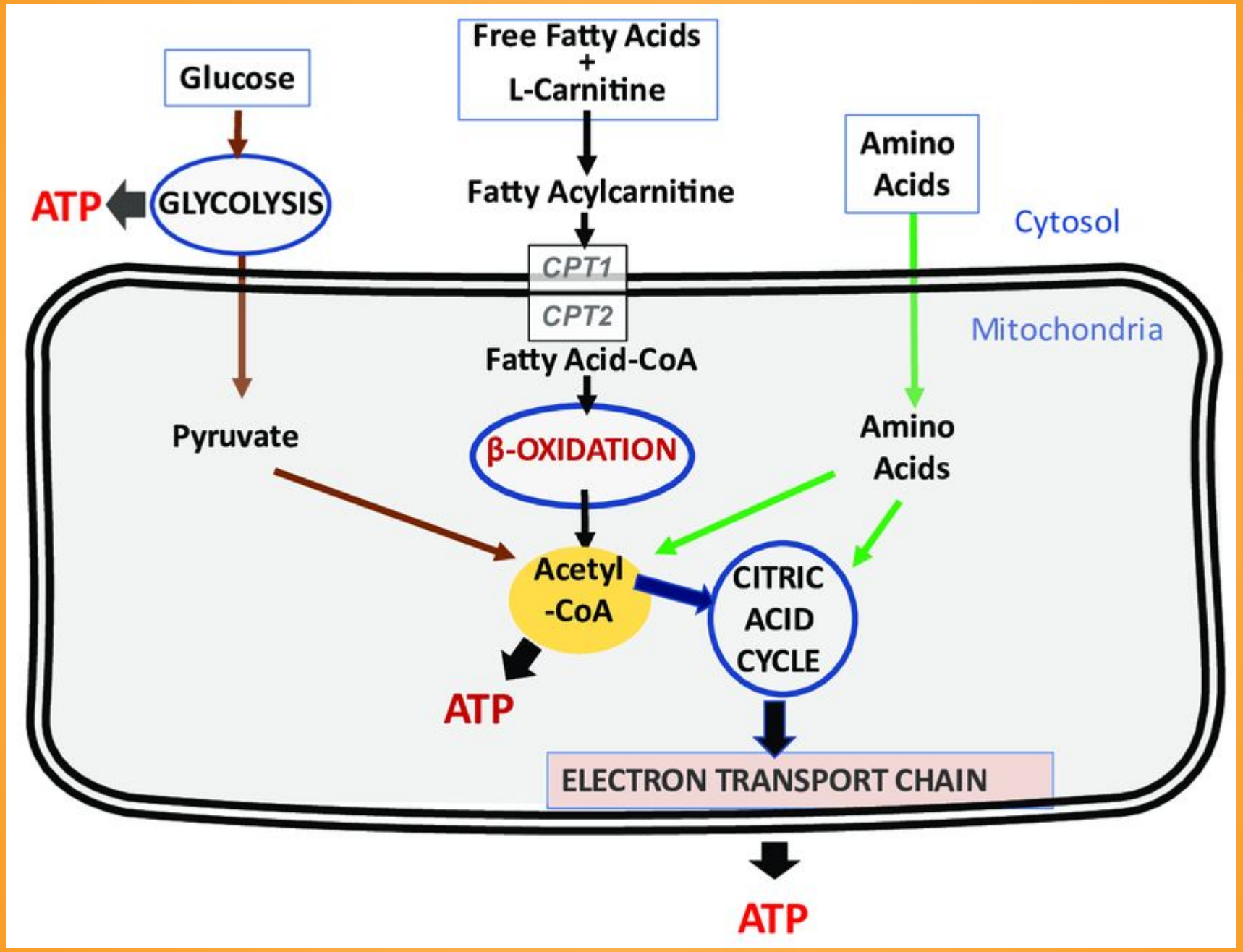


Fat

- Slower energy supply
- Unlimited sources

Fat stores

FYI


Glucose
Free Fatty Acids
+
L-Carnitine
Amino
Acids
ATP
GLYCOLYSIS
Fatty Acylcarnitine
Cytosol
CPT1
CPT2
Mitochondria
Fatty Acid-CoA
Pyruvate
β-OXIDATION
Amino
Acids
Acetyl
-CoA
CITRIC
ACID
CYCLE
ATP
ELECTRON TRANSPORT CHAIN
ATP

the 2 energy sources:

carbs

- quick & short energy
- big effect on blood sugar & insulin
- think of them like **kindling** on a fire
- need to eat often

fats

- long lasting energy
- little to no effect on blood sugar & insulin
- think of them like a **log** on a fire
- satiated for hours

carbs

fats

@daniellehamiltonhealth

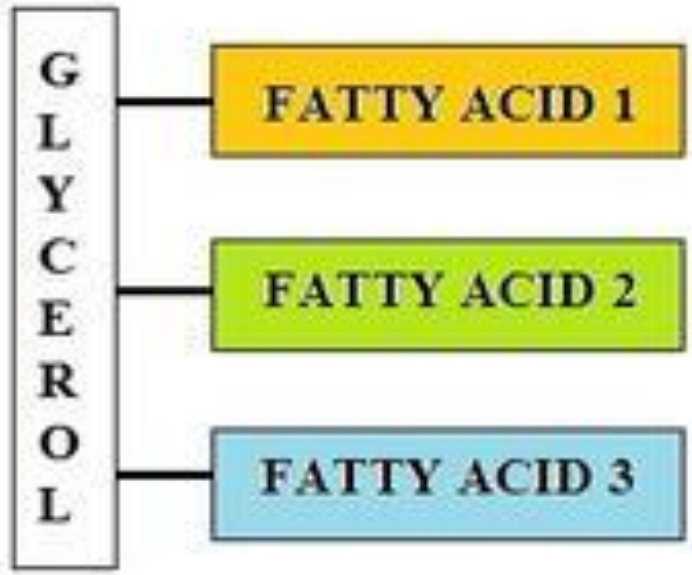
Usefulness of fats

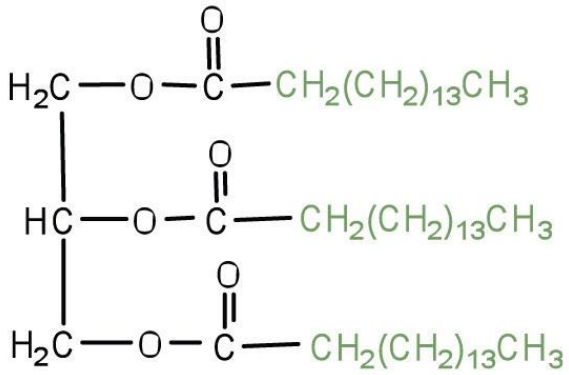
- **Fats in food:** provide nutrition, provide energy, transport fat soluble vitamins, contribute to taste and mouthfeel of foods, feelings of satiety

Fats in the body:

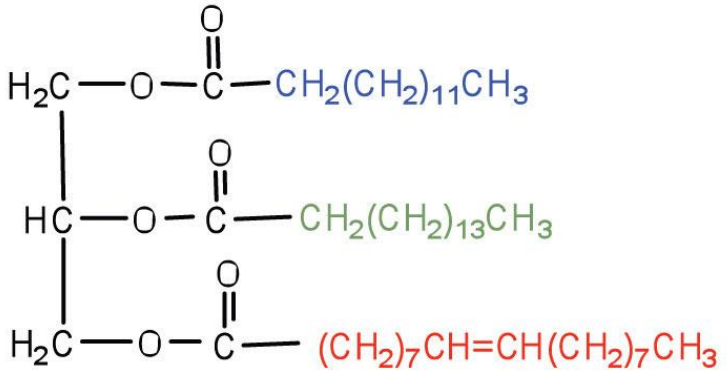
- They also cushion vital organs
- Insulate body from temperature extremes,
- Carry fat-soluble vitamins (A, D, E, K)
- Essential fatty acids are raw materials necessary for making other molecules - steroid hormones, bile, Vit D
- **Phospholipids**: present in all cell membranes
- **Sterols**: Cholesterol forms the basis of steroid hormones & myelin sheaths

Triglycerides: storage of fat





Tristearin
a simple triglyceride



a mixed triglyceride

Biochemistry of Fats

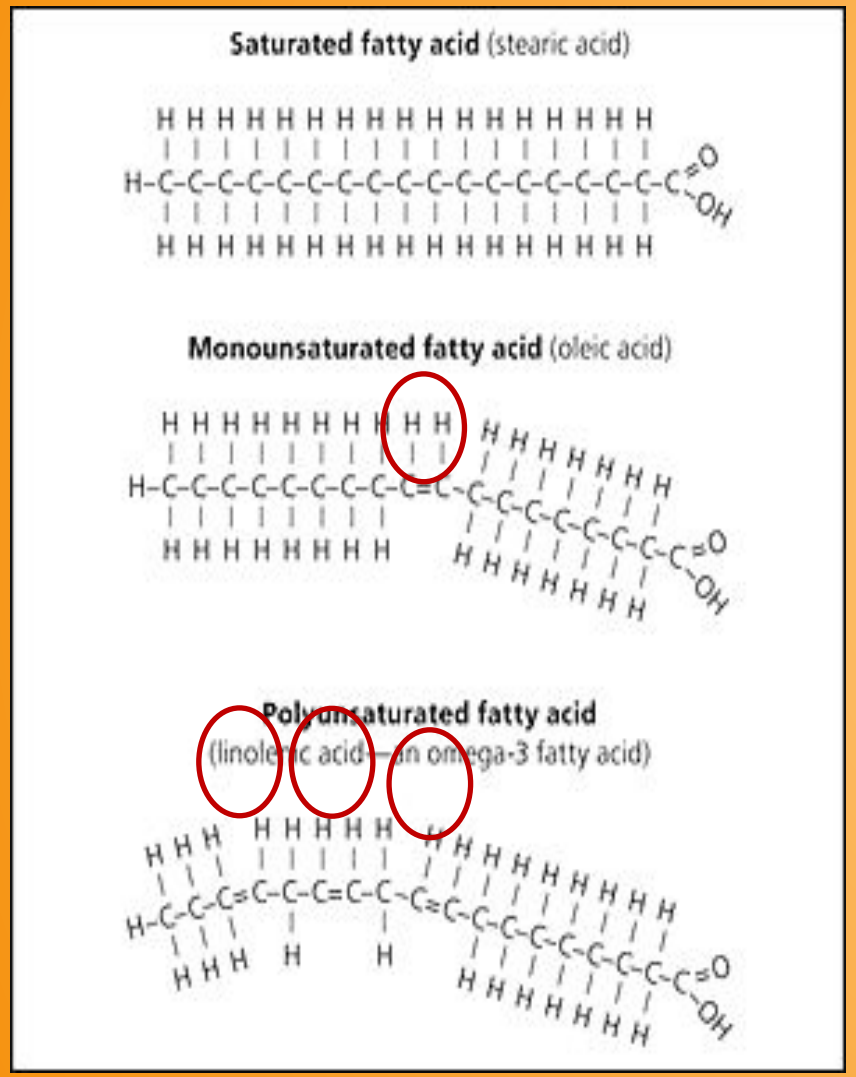
Fats and oils are composed of **triglycerides** - a ***Glycerol*** backbone with ***three fatty acids attached***

Fatty acids can be: ***Short chain*** (2 - 5 Carbons)
Medium Chain (6 -12 Carbons) or
Long chain (13 or more Carbons)

Fatty Acids may also be **Saturated, Monounsaturated or Polyunsaturated** (see next slide)

Fats Osmosis

Saturated vs. unsaturated Fatty Acids (filled with H or not)



Saturation refers to whether a fatty acid chain is holding all of the hydrogen (H) atoms it can hold. If every available bond from the carbons (C) is holding an H, the chain forms a **saturated fatty acid (filled to capacity with H**)

Unsaturated fatty acid contains one or more points of unsaturation.

One point of unsaturation is a **Monounsaturated fatty acid.**

With 2 or more points of unsaturation, it is a **polyunsaturated fatty acid**.

Point of unsaturation: the chain has a place where H are missing (an "empty spot")

Degree of saturation of fatty acids in a fat affects temperature at which the fat melts (it determines the fat's softness or hardness)

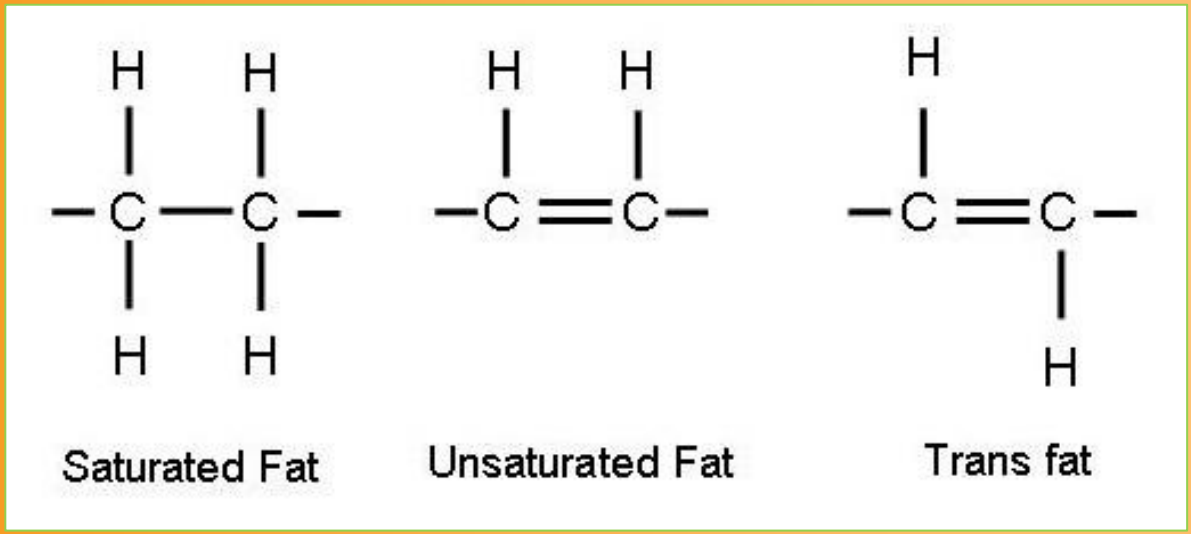
In general, animal fats tend to be saturated, while plant fats are likely unsaturated. Ted Ed

Effects of processing on unsaturated fats

- What is “hydrogenated vegetable oil”?
- https://youtu.be/brs2nMubr84
- **Hydrogenation** of fats makes them stay fresher longer and also changes their physical properties
- Hydrogenated fats resist rancidity better, are firmer textured, have a higher smoking point (for frying) than unsaturated oils
- BUT Hydrogenated fats also lose health benefits of unsaturated oils
- PARTLY HYDROGENATED OILS = TRANS FATS

Trans fatty acids –are they harmful?

- Through partial hydrogenation, some of the unsaturated oils end up changing their shapes instead of becoming saturated



- Trans fats raise LDL and lower HDL, as well as promote inflammation
- Trans fats act somewhat like saturated fats in the body

Lipid Review:
https://youtu.be/BVxeeiR7JB0

Essential polyunsaturated fatty acids

- Recall that *Essential* means we must get these fatty acids through the diet
- **Linoleic acid and linolenic acid: they must be supplied by diet** (essential nutrients)
- Raw materials necessary to make **eicosanoids**: hormone-like, affect wide range of diverse body functions, such as muscle relaxation and contraction; blood vessel dilation and constriction, blood clot formation, blood lipid regulation, immune responses, inflammation, pain
- Aspirin (NSAIDs) relieves fever, inflammation and pain by slowing synthesis of eicosanoids such as prostaglandins & thyroxine

  Whats Up Dude Fatty Acids

Omega-6 and Omega-3 fatty acid families

- **Linoleic acid:** parent member of the **omega-6 fatty acid; example of omega-6 is arachidonic acid** (necessary to make eicosanoids).

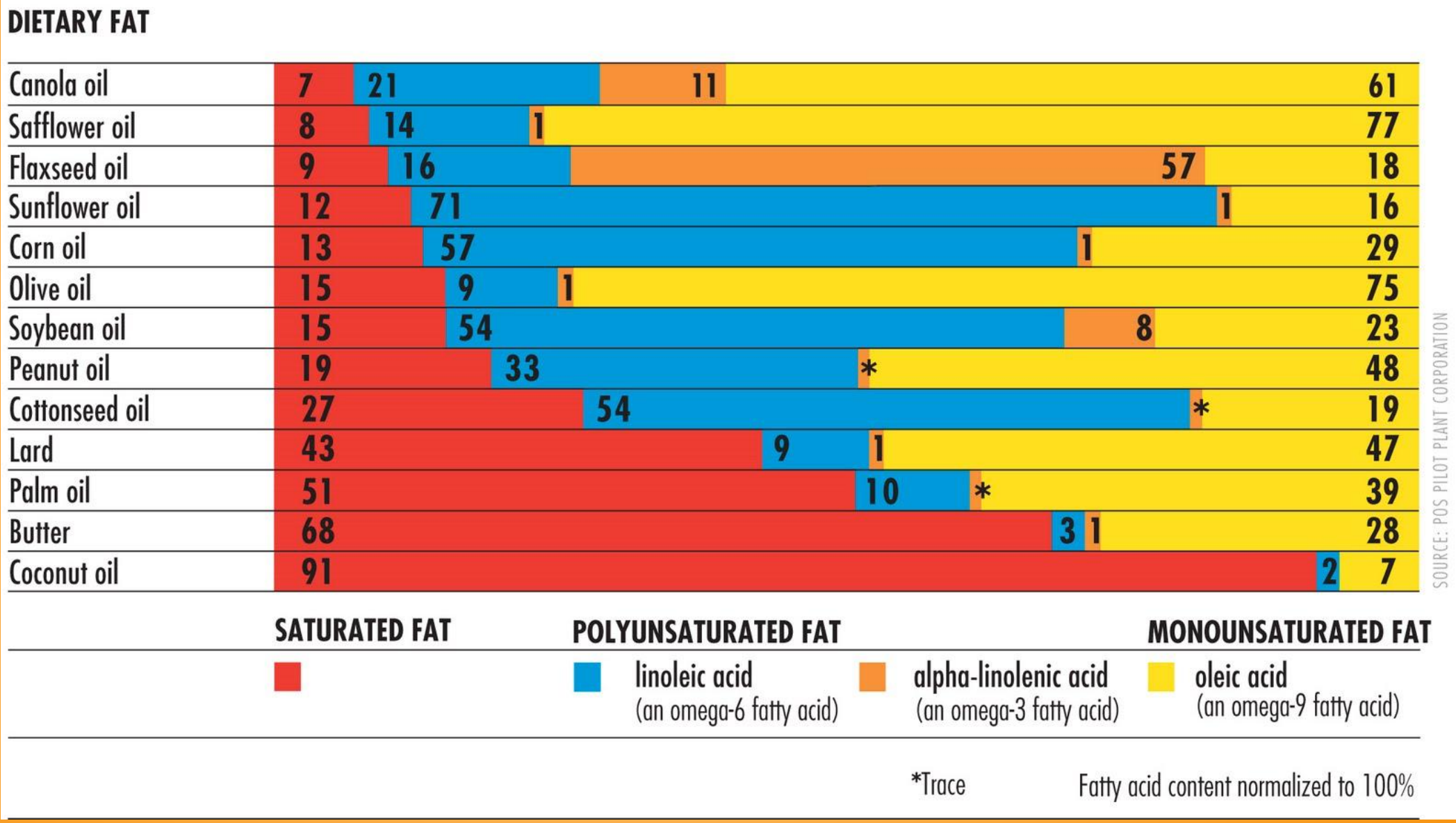
- **LinoleNic acid:** parent member of the **omega-3 fatty acid** family; examples: **EPA and DHA** (abundant in oils of certain fish, lower risk of heart disease).

- Native peoples of Greenland and Alaska: diet high in fat but abundant in fish and fish oils, they have very low rate of death by heart disease.

- Omega-3s are also beneficial to immune system, joint health, skin health and protective against some cancers

- https://youtu.be/ZnvOSs7sODo

Comparison of Dietary Fats



How to choose which oil to use?

- Use fresh oils -within 30 - 60 days after opening. Oils will begin to oxidize & form free radicals
- Choose glass bottles for max freshness
- **Choose an oil with the correct smoke point**- heating an oil beyond its smoke point will cause free radical formation.
- High smoke point oils are: Avocado, Camellia, Almond, Ghee (clarified butter) & canola.
- Olive oil, coconut oil & sesame oil are medium heat oil (sauteing, baking)

- Avoid chemical extractants - choose cold-pressed oils instead of expeller pressed or refined oils

The Problems With Most Cooking Oils

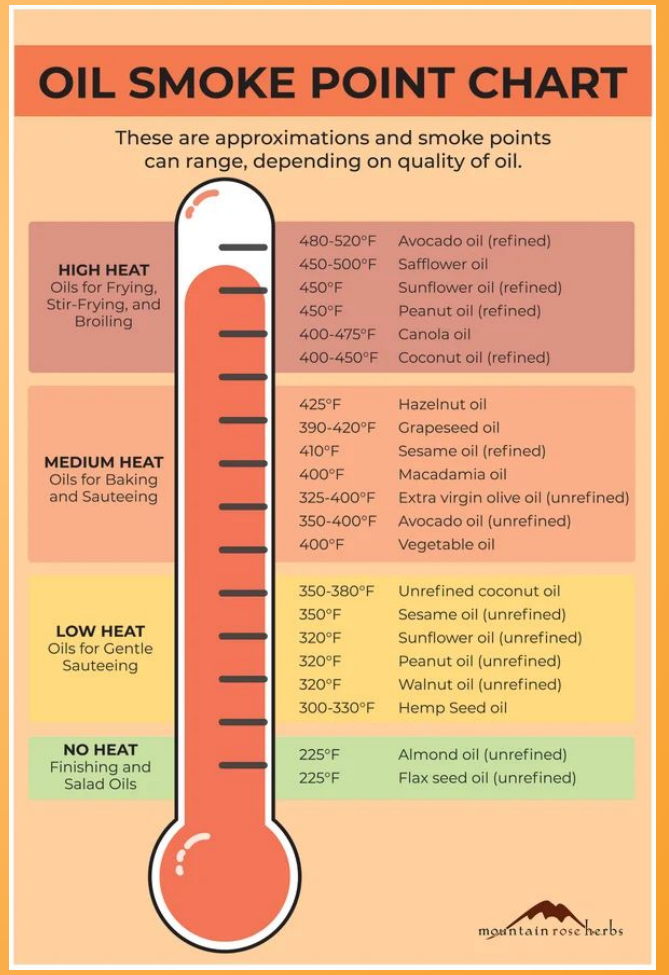
- Most vegetable oils have a low smoke point.
- Vegetable oils and seed oils are high in inflammatory omega-6 linoleic acid.
- They break down during storage and cooking, resulting in a stale or rancid flavor.
- Vegetable oils drive deforestation and are unsustainable.

Better Cooking Oil Options

- For high heat cooking: Avocado oil.
- Coconut oil and avocado oil are lower in linoleic acid compared to seed oils.
- Olive oil, coconut oil, and avocado are better choices for fresh, tasty recipes.
- Currently, any oil crop is environmentally unfriendly, but you can buy certified oils to reduce rainforest harm.

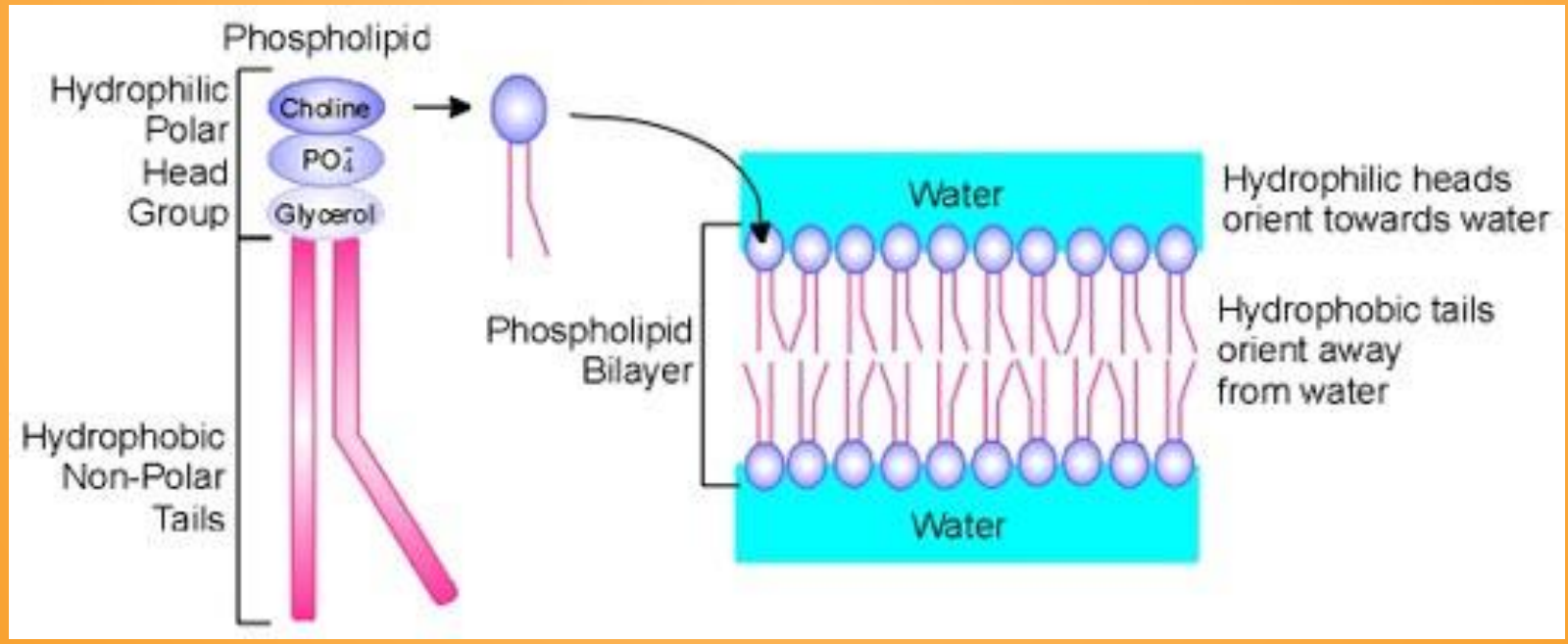
Zero Acre

FYI - Smoke points of Oils and Fats



Phospholipids

Phospholipid: also formed of a molecule of **glycerol** with fatty acids attached but 2 rather than 3 fatty acids In place of the third is a molecule containing **phosphorus**, which makes the phospholipid soluble in water (while its fatty acid makes it soluble in fat)

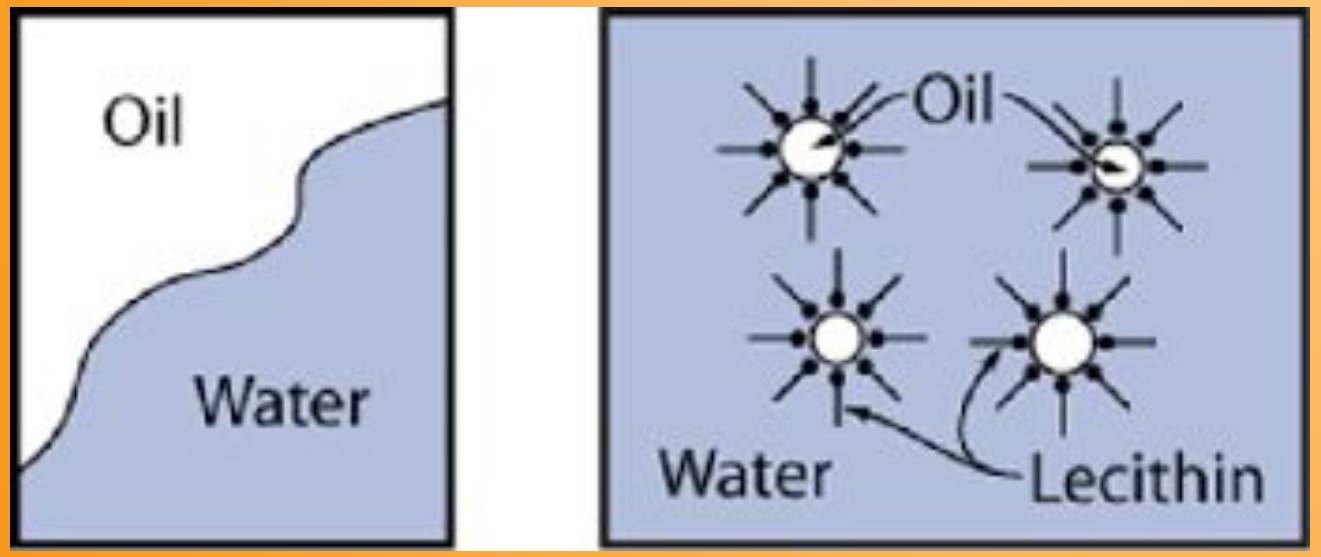


Phospholipids: water-loving and fat-loving characteristics

Emulsifier: a substance that mixes with both fat and water and permanently disperses fat in water, forming an **emulsion.**

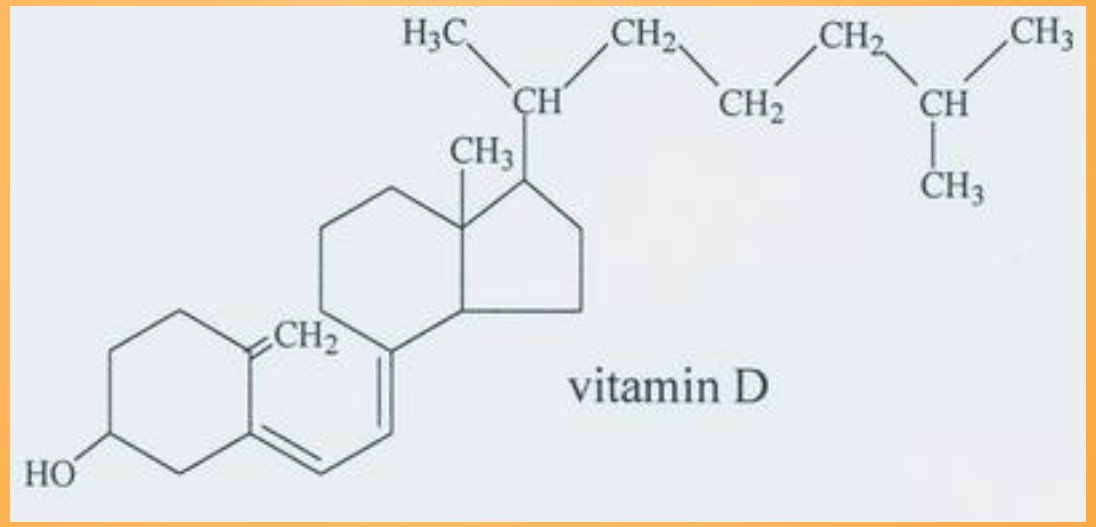
Bile: emulsifier made by liver. Bile doesn't digest fat as enzymes do but **emulsifies** it so enzymes in watery fluids may contact it and split the fatty acids from glycerol for absorption

https://youtu.be/TNG-RRzwBVU



Sterols

- Such as cholesterol are large, complicated molecules in the shape of rings of C with side chains of C, H and O



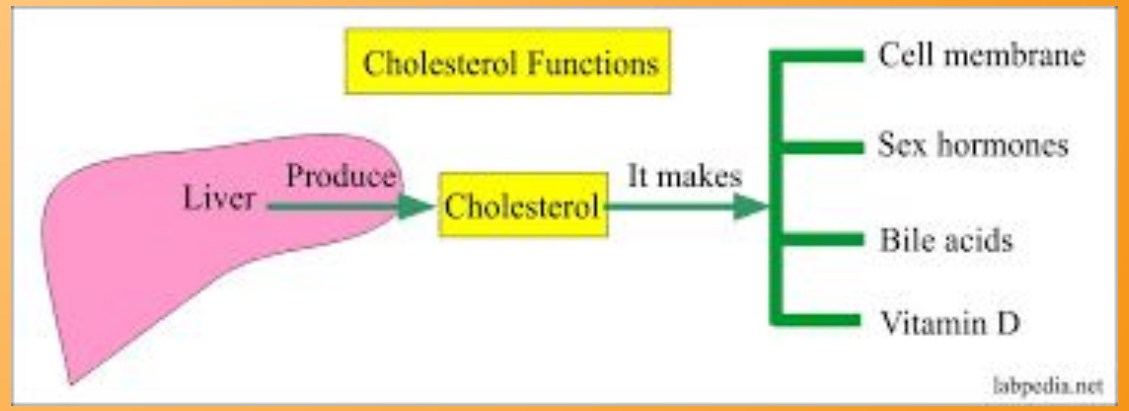
vitamin D

Sterols -examples

- **Cholesterol** is an emulsifier – the key emulsifier in bile (secreted by the gallbladder)
- **Vitamin D** is also an important sterol made from cholesterol in the body
- **Steroid hormones**, including cortisol and sex hormones such as testosterone and estrogen are also made from cholesterol

Cholesterol:

- Forms cell membranes and it is necessary for body's functioning
- It is not an essential nutrient
- It is a major component of plaques that narrow arteries in atherosclerosis



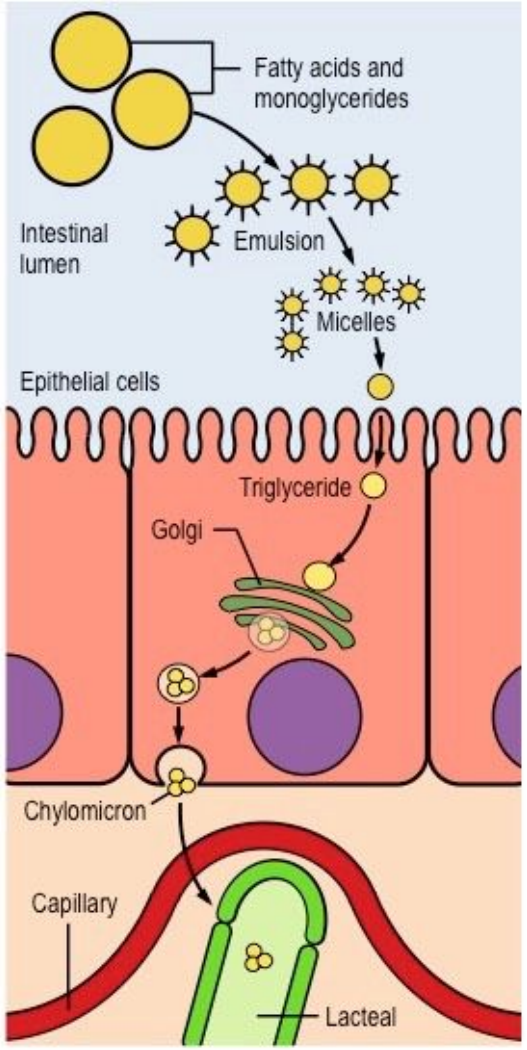
Digestion of Lipids

- Fat does not mix well with saliva or stomach acid
- Stomach – gastric lipase begins to digest triglycerides into fatty acids
- Gallbladder secretes bile – emulsifies fats and helps them to dissolve in the small intestine
- Pancreatic enzymes – pancreatic lipase breaks lipids into smaller particles for digestion (triglycerides → fatty acids, monoglycerides)

- https://www.youtube.com/watch?v=TZOCQko8iDg (1:52 min)

Digestion of Lipids (cont.)

- Once intestine's contents are emulsified, fat-splitting enzymes act on triglycerides to split fatty acids from glycerol backbones
- Free fatty acids, glycerol and monoglycerides cling together in spherical particles (micelles) surrounded by bile
- Bile shuttles lipids across watery mucus layer to absorptive cells of intestinal villi
- Cells extract lipids
- Bile may be absorbed and reused by body, or it may exit with feces (gives brown colour)
- **Digestive tract absorbs triglycerides from a meal with up to 98% efficiency (little fat is excreted by a healthy system)**



Fatty acids and monoglycerides are emulsified by bile salts to form micelles

Fatty acids enter the epithelial cells and link to form triglycerides

Triglycerides combine with proteins inside the Golgi body to form chylomicrons

Chylomicrons enter the lacteal and are transported away from the intestine

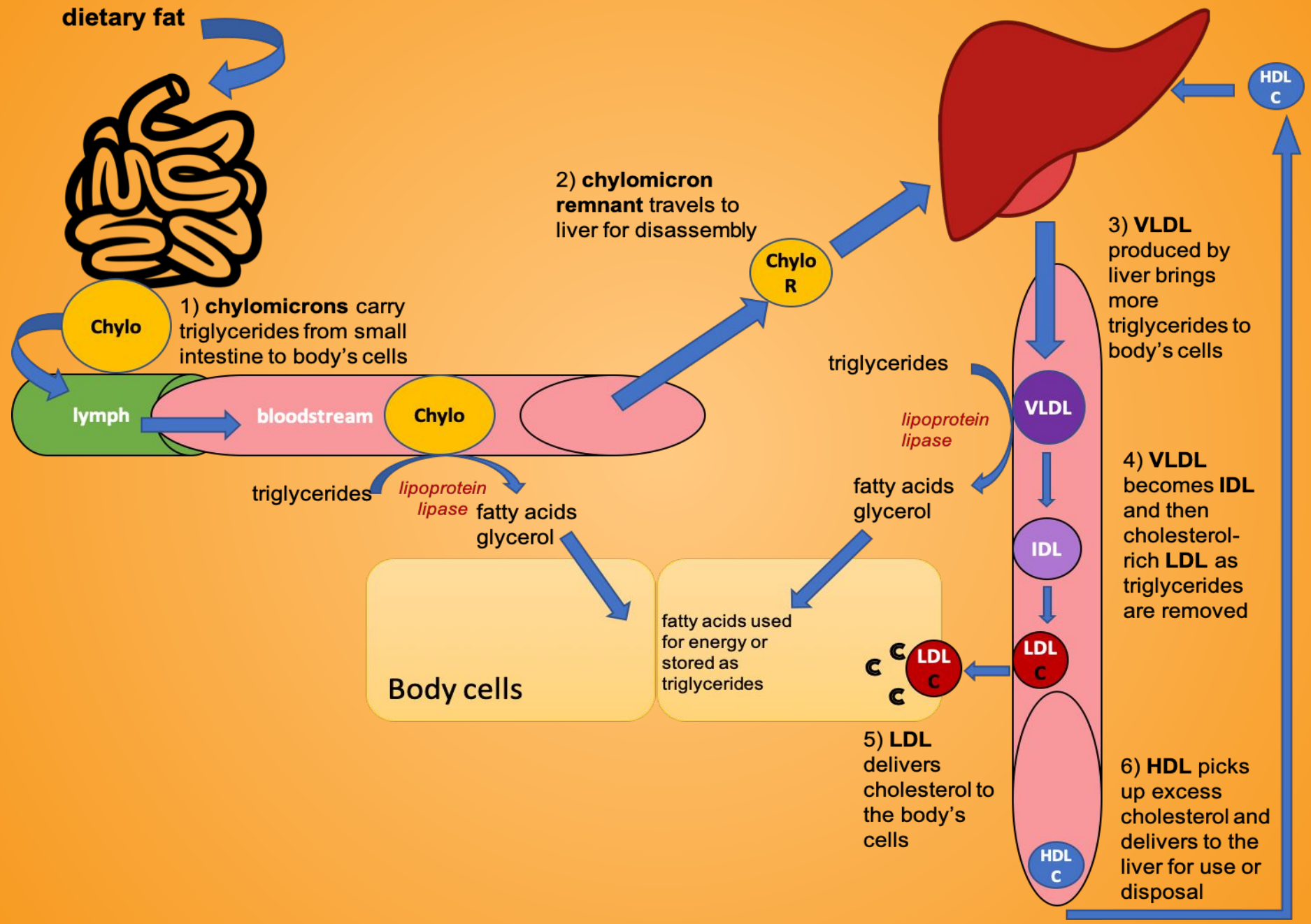
Absorption and transport of fats

- Smaller products of lipid digestion (glycerol, short chain fatty acids) pass directly to blood, travelling unassisted to the liver
- Larger lipids (monoglycerides and long chain fatty acids) would float in water: instead they are transported as ***"passengers" in lipoproteins*** (assembled packages of lipids + proteins) before being released into **lymph** lthat leads to blood
- Inside intestinal cells, they cluster with proteins and phospholipids to form **chylomicrons**
- Tissues of body can extract fat from chylomicrons passing by in the blood. Remnants are picked up by liver, which dismantles and reuses its parts

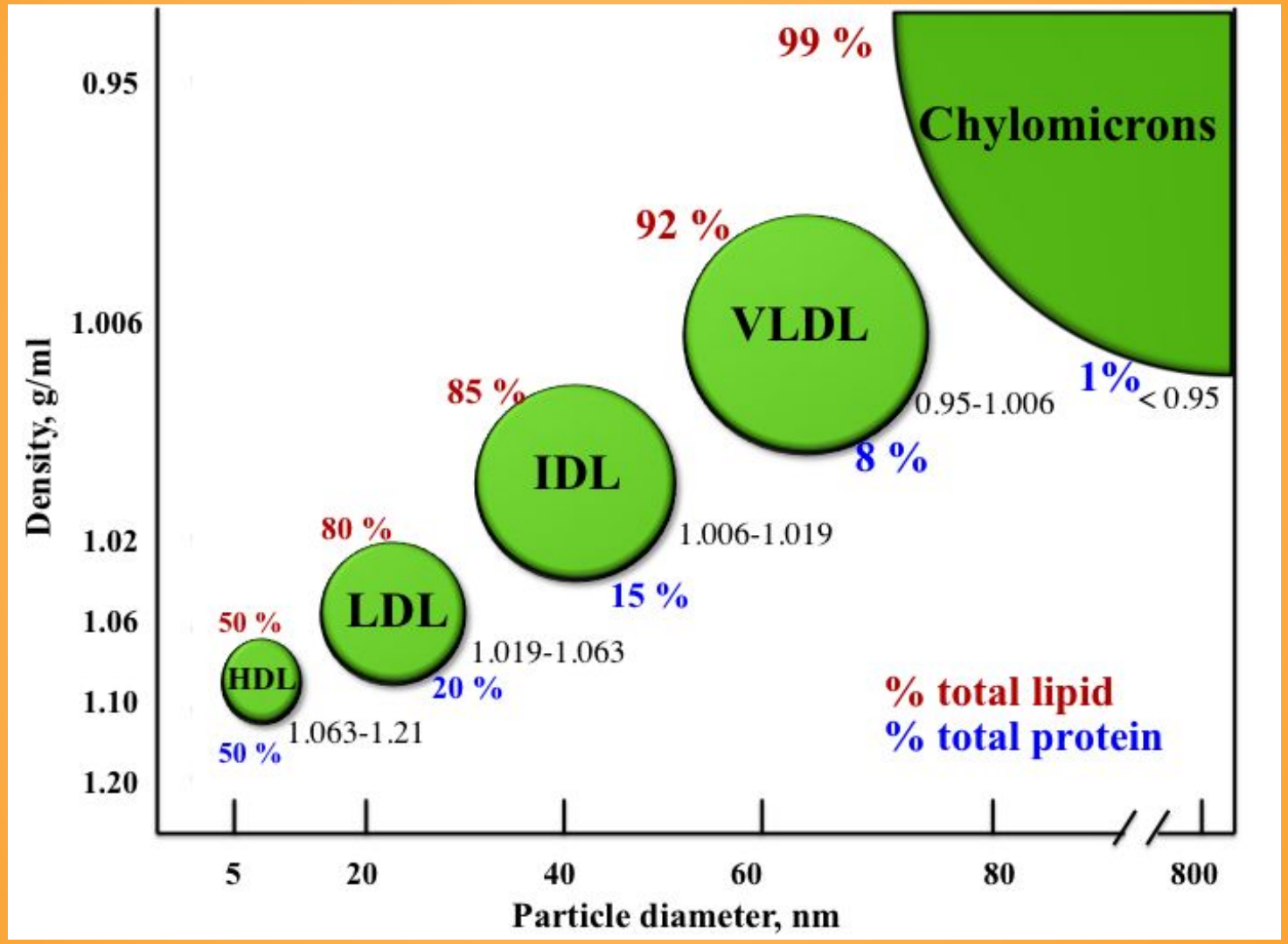
- https://www.youtube.com/watch?v=i0kHf_5s3J8 (10:07 min)

Major Lipoproteins: VLDL, LDL, HDL

- In addition to chylomicrons, the body uses 4 other types of lipoproteins to carry fats:
- **Very low-density lipoproteins (VLDL):** carry triglycerides made in liver to body cells for their use
- **Intermediate -density lipoproteins (IDL),** similar to LDL, can contribute to atherosclerosis
- **Low-density lipoproteins (LDL), aka "bad" cholesterol** transport cholesterol and other lipids to tissues. LDL are made from VLDL after they have donated many of their triglycerides to body cells
- **High-density lipoproteins (HDL): aka "good" cholesterol -** critical for carrying cholesterol away from body cells to liver for disposal
- **LDL and HDL difference**: in proportions of lipids they contain and tasks they perform (**not** in type of cholesterol they carry)


dietary fat
Chylo
1) **chylomicrons** carry triglycerides from small intestine to body's cells
lymph
bloodstream
Chylo
triglycerides
lipoprotein lipase
fatty acids
glycerol
Body cells
2) **chylomicron remnant** travels to liver for disassembly
Chylo R
triglycerides
lipoprotein lipase
fatty acids
glycerol
fatty acids used for energy or stored as triglycerides
HDL C
3) **VLDL** produced by liver brings more triglycerides to body's cells
VLDL
4) **VLDL** becomes **IDL** and then cholesterol-rich **LDL** as triglycerides are removed
IDL
LDL C
LDL C
5) **LDL** delivers cholesterol to the body's cells
HDL C
6) **HDL** picks up excess cholesterol and delivers to the liver for use or disposal

Lipoproteins

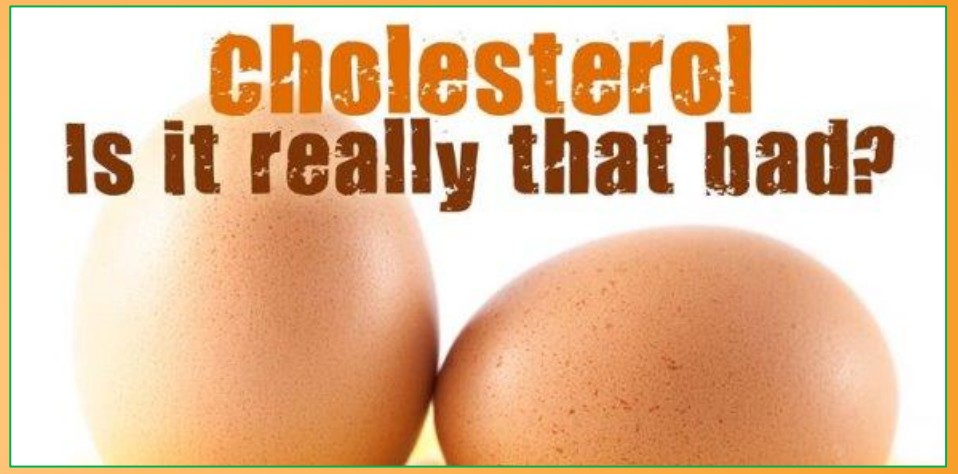


Cholesterol theory:
“Cholesterol is the major cause behind heart disease”

Cholesterol Levels

Total Cholesterol	*Canada (mmol/L)*	*USA (mg/dL)*
Ideal	< 5.2	< 200
High	5.2 - 6.1	201 - 239
Very High	> 6.2	> 240
LDL Cholesterol	*Canada (mmol/L)*	*USA (mg/dL)*
Ideal	< 2.6	< 100
Middle Range	2.7 - 4.1	100 - 159
High	4.2 - 4.9	160 - 189
Very High	> 4.9 / 5.0	> 190
HDL Cholesterol	*Canada (mmol/L)*	*USA (mg/dL)*
Low	< 1.0	< 40
High	> 1.6	> 60

lornahealth.com



https://youtu.be/YGSbs-Wri1A

General Recommendations for Lipids

- **20 – 35% of the diet; 44 – 78g based on a 2000 cal diet**
- Focus on getting more PUFAs, less saturated fats, trans fats as low as possible (WHO)
- PUFAs -

DRI Linoleic acid (omega 6) (5-10% total Calories) 17g/day young men, 12 g/day young women

DRI Linolenic acid (omega 3) (0.6% - 1.2% tot Cal) 1.6g/day for men & 1.1g/day women

- Ensure healthy ratio omega 6 to Omega 3 fats
- Many studies have shown that humans evolved eating a diet that had equal amounts of omega 6 & Omega 3 fats. However, the standard Western diet often s closer to a 16 to 1 ratio of omega 6s to 3s. DRI recommendations are at a ratio of approx. 10 to 1. Many studies have tried lower ratios such as 5:1 or 3:1 & found benefits in many kinds of inflammatory diseases. Research is ongoing.
- **Special diets**:
- Keto diets recommend ~70-80% of your calories should come from fats
- Low fat diets 15 – 20% calories; popularly recommended for CVD & weight loss in the 80s to 2000s; less common now

Which of the following is not one of the ways fats are useful in foods?

a. Fats contribute to the taste and smells of foods
b. Fats carry fat-soluble vitamins
c. Fats provide a low-calorie source of energy compared to carbohydrates
d. Fats provide essential fatty acids

Generally speaking, vegetable and fish oils are rich in which of these?

a. Polyunsaturated fat
b. Saturated fat
c. Cholesterol
d. Trans fatty acids

A benefit to health is seen when _____is used in place of _____in the diet

a. saturated fat; monounsaturated fat
b. saturated fat; polyunsaturated fat
c. monounsaturated fat; saturated fat
d. polyunsaturated fat; saturated and trans fats

Chylomicrons, a class of lipoproteins, are produced in the

a. Gallbladder
b. Small intestinal cells
c. Large intestinal cells
d. Liver

The roles of the essential fatty acids include

a. Form part of cell membranes
b. Support infant growth and vision development
c. Support immune function
d. All of the above

LDL deliver triglycerides and cholesterol from the liver to the body's tissues

a. T

b. F

Consuming large amounts of trans fatty acids lowers LDL cholesterol and thus lowers the risk of heart disease and heart attack

a. T

b. F