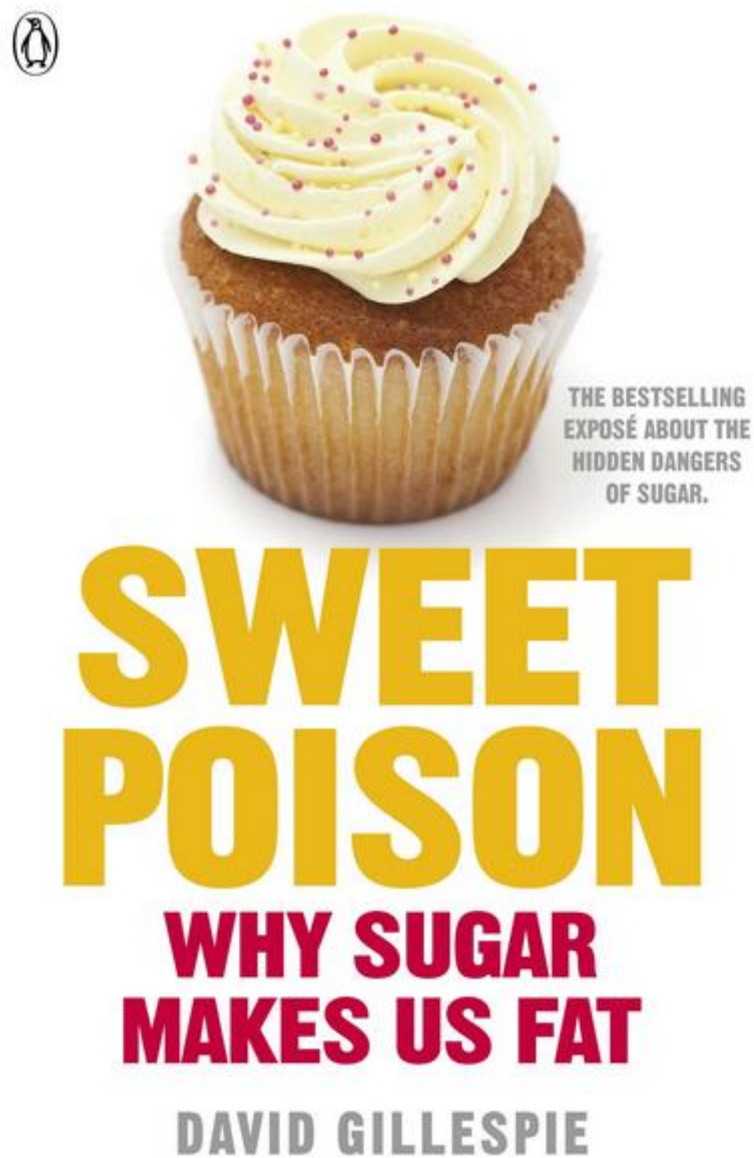
Some Interesting Nutritional Biochemistry of Sugars

The Fructose Paradox: "Sweet Poison"



Very sweet sugar

Cheap to produce
(high fructose corn syrup)

Low Glycemic Index

….but, it's a nutritional nightmare!

The Glycemic Index (GI)

Some sugars are good at stimulating a physiological response in blood sugars, others are not

Glycemic Index is a measure of this:
High GI = sharp spike in blood glucose levels
Low GI = slow effect on blood glucose levels

Why is this important? Fairly complex, but basically, blood sugar is the body's main supply of energy.

High blood glucose levels → increased insulin production (a hormone produced by your pancreas)
If high levels of insulin are maintained, insulin resistance will develop.
Welcome to **Type 2 Diabetes**.

Low GI foods result in a slow and sustained increase in blood glucose → lower demands on insulin production.

Forms of Carbohydrates

Monosaccharides

- The simplest form of sugars
- Found in small amounts in fruit – more abundant in ripe fruit
- The 'sweetest' form of sugar

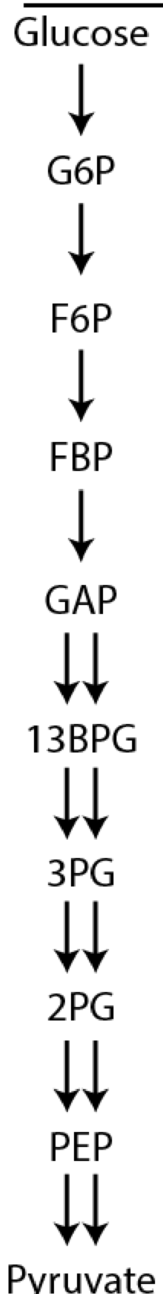
Disaccharides

- Two sugar units linked together
- Common form of sugar in a lot of food.
- Examples are cane sugar (sucrose) and dairy sugar (lactose)

Oligosaccharides and Polysaccharides (mid to low GI)

- Long chains of sugars
- Starch and fiber are good examples

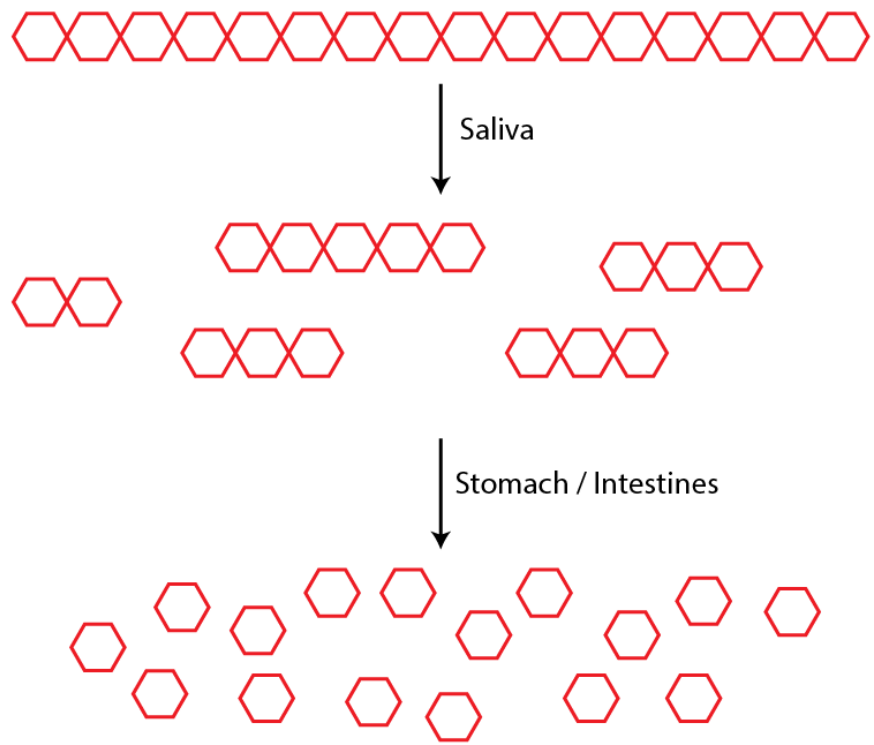
Sugar Metabolism



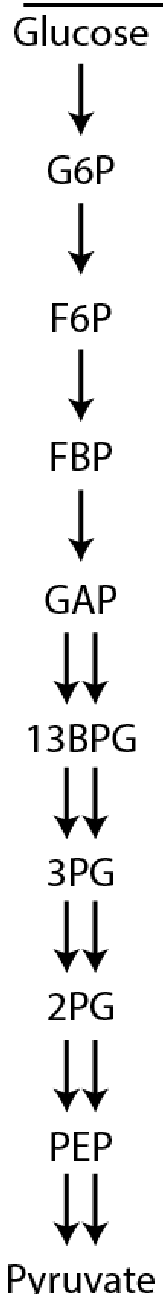
Goal: Get to Glucose or one of the intermediates

Digestion Bottleneck

Dietary sugar can ONLY be transported into our blood as monosaccharides!



Sugar Metabolism – the role of gut bacteria



Not all oligosaccharides are easily metabolized!

Enter your gut microbiota – These bacteria play an absolutely essential function in health

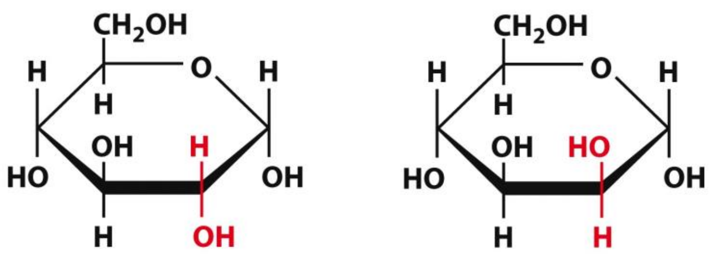
- Digest foods that the stomach and intestine have not been able to
- Helps with the production of vitamins (B and K)
- Prevents aggressive and dangerous bacteria from colonizing in your stomach
- Plays an important role in the immune system (barrier effect)

Prebiotics: foods that are fermentable by your gut bacteria (fiber)

Metabolism of Mannose (part of glycoproteins)

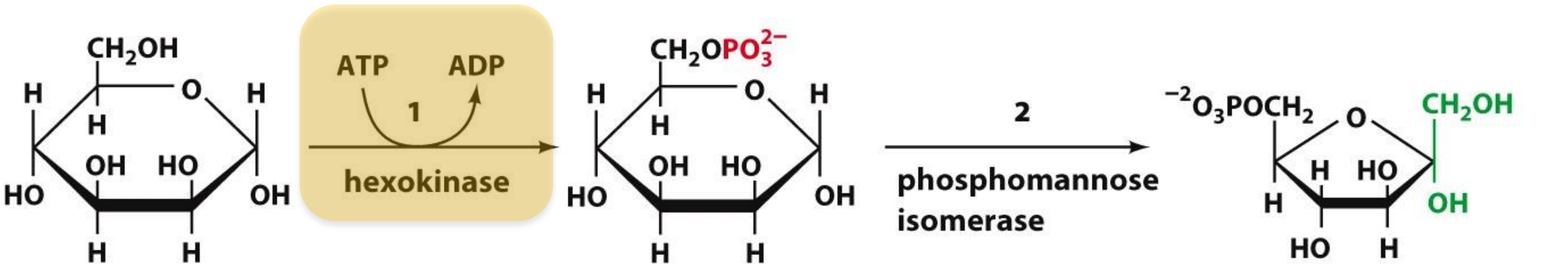
Glucose
↓
G6P
↓
F6P
↓
FBP
↓
GAP
↓↓
13BPG
↓↓
3PG
↓↓
2PG
↓↓
PEP
↓↓
Pyruvate

Mannose is a C2 epimer of Glucose



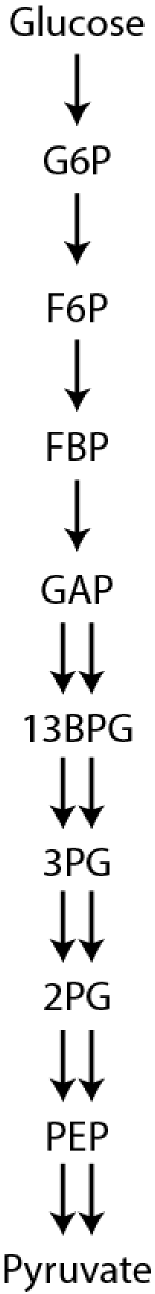
α-D-Glucose α-D-Mannose

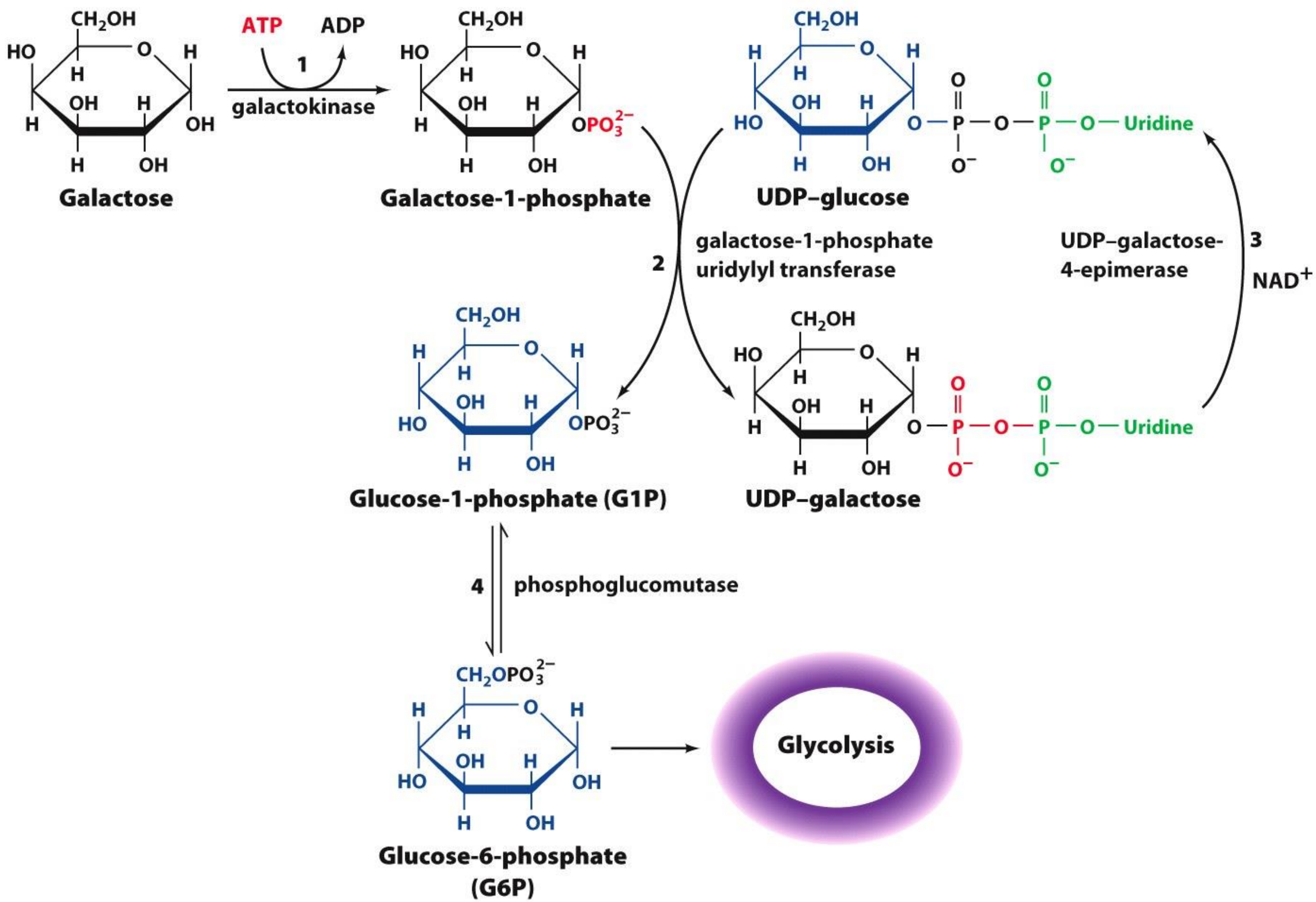
Hexokinase has flexibility in substrate specificity



Mannose **Mannose-6-phosphate** **Fructose-6-phosphate (F6P)**

Metabolism of Galactose

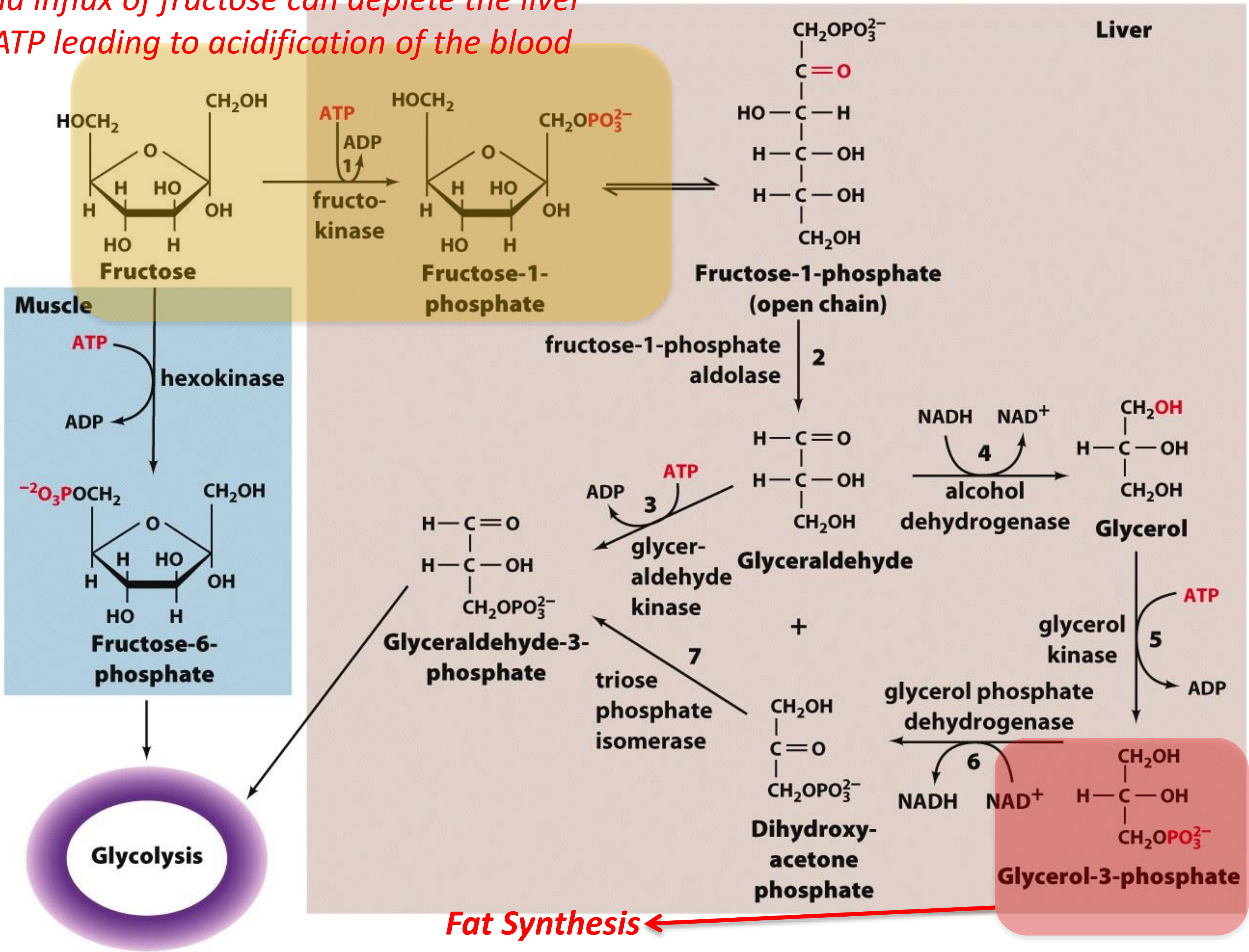




Metabolism of Fructose

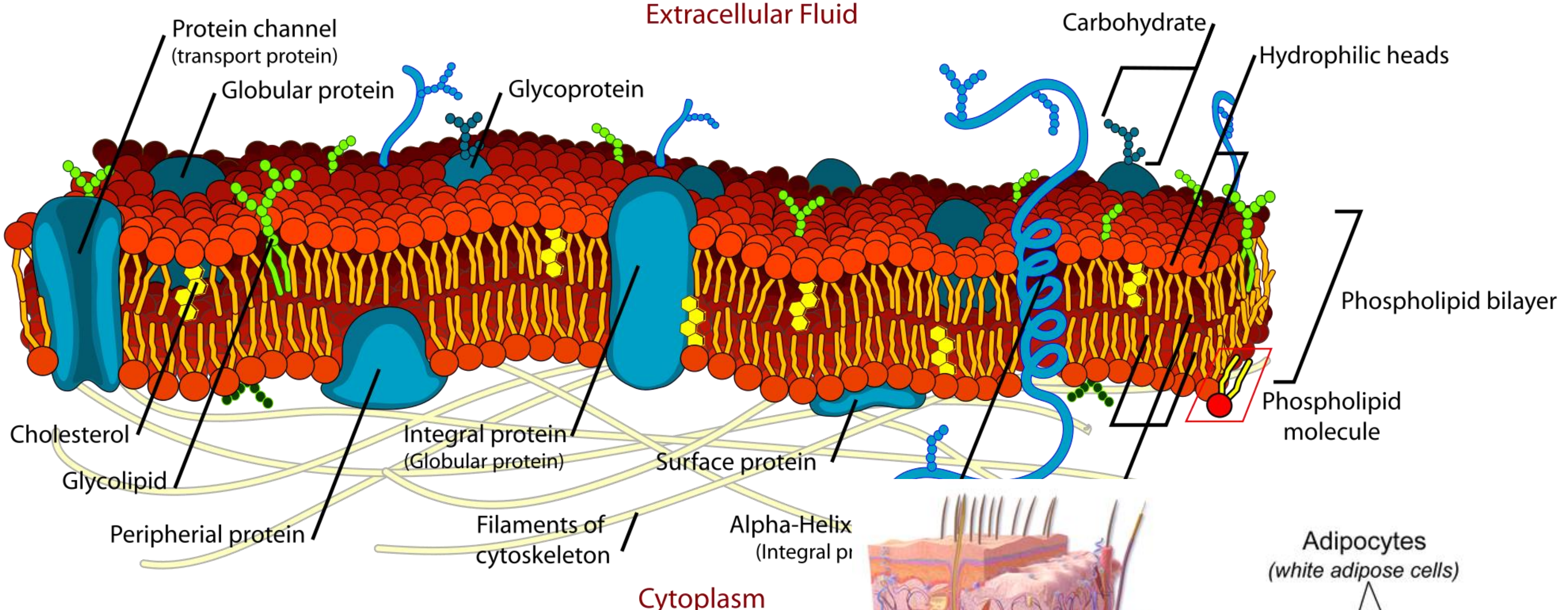
Rapid influx of fructose can deplete the liver of ATP leading to acidification of the blood

Glucose
↓
G6P
↓
F6P
↓
FBP
↓
GAP
↓↓
13BPG
↓↓
3PG
↓↓
2PG
↓↓
PEP
↓↓
Pyruvate

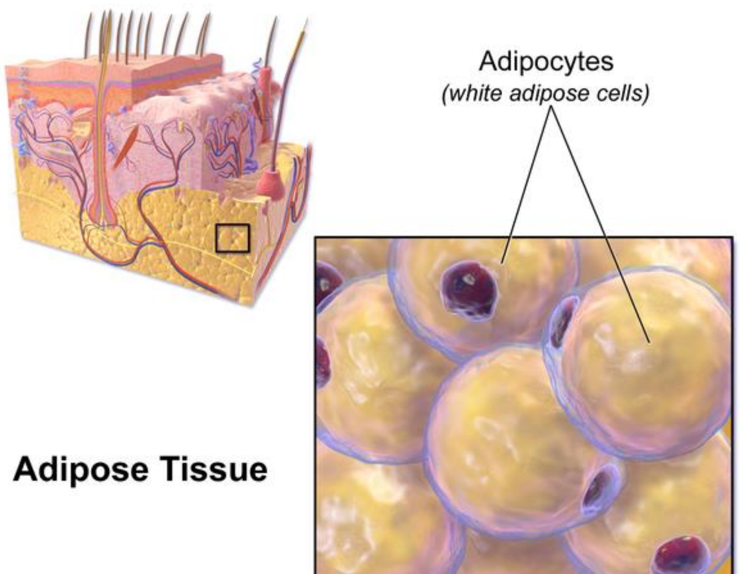


The Role of Fats and Cholesterol

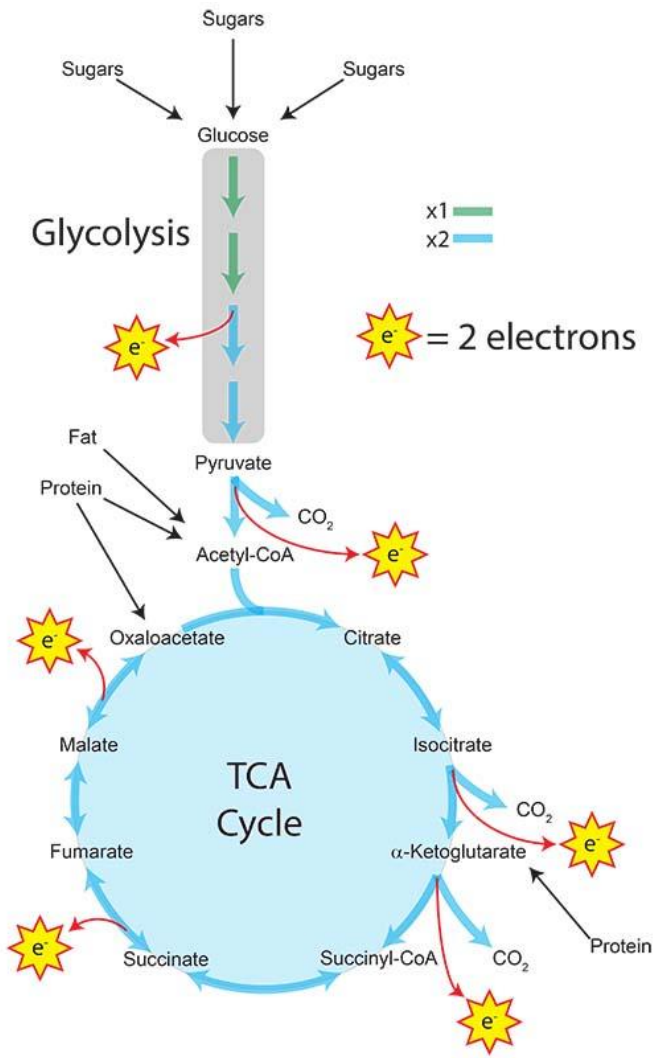
1. Biological Membranes



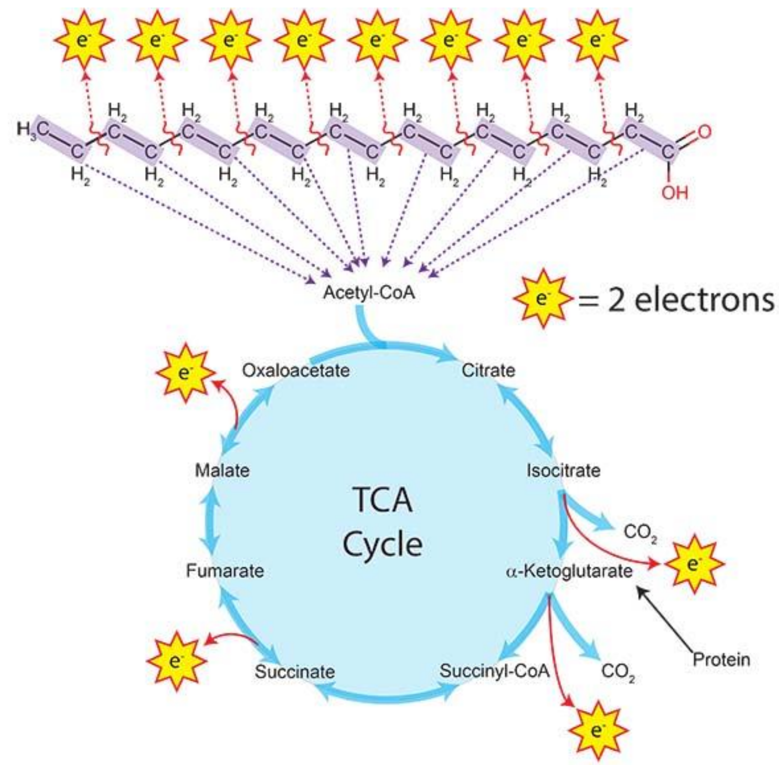
2. Energy Storage



"Burning" Fats for Energy



$$3\ ADP + 4\ H^+ + O_2 \xrightarrow{2\,e^-} 2\ H_2O + 3\ ATP$$



$$3\ ADP + 4\ H^+ + O_2 \xrightarrow{2\,e^-} 2\ H_2O + \sim 3\ ATP$$

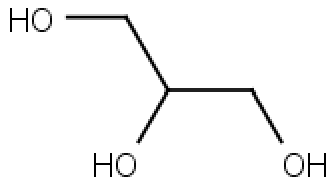
Types of Fats

Lipids – biological origin – sparingly soluble in water

Main classes of lipids

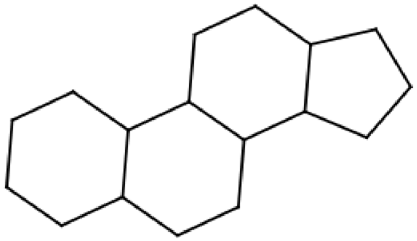
Fatty Acids – long hydrocarbon chains with a carboxylic acid on one end

Triacylglycerols – fatty acid derivatives of glycerol



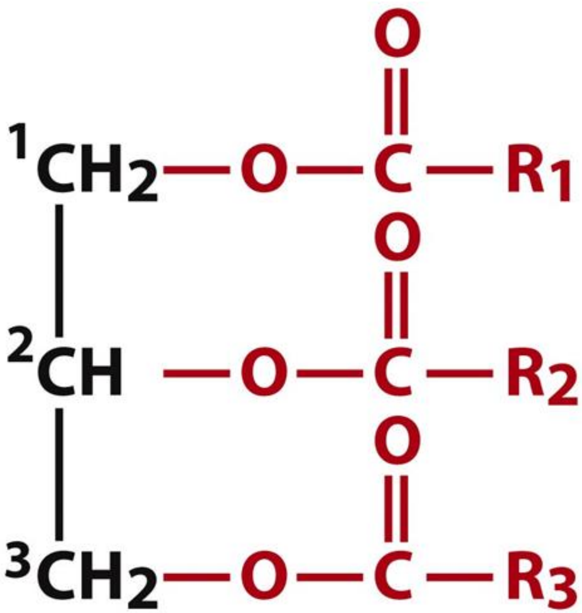
Phosphoacylglycerol–phosphate substituted diacylglycerols

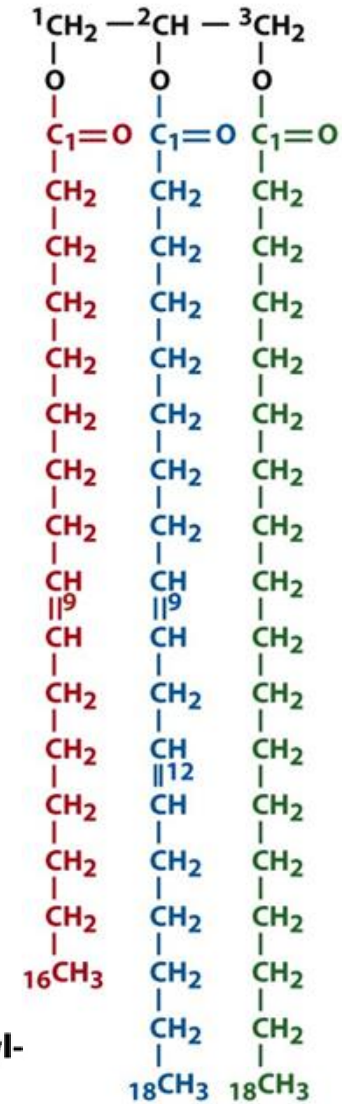
Cholesterol – 4 ring system with a single polar group



Triacylglycerol (ide)

Triacylglycerols – fatty acid derivatives of glycerol





1-Palmitoleoyl-2-linoleoyl-3-stearoyl-glycerol

Fatty Acids

Saturated – single bonds all the way down the chain

Saturated fatty acids				
12:0	Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$	44.2
14:0	Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$	52
16:0	Palmitic acid	Hexadecanoic acid	$CH_3(CH_2)_{14}COOH$	63.1
18:0	Stearic acid	Octadecanoic acid	$CH_3(CH_2)_{16}COOH$	69.6
20:0	Arachidic acid	Eicosanoic acid	$CH_3(CH_2)_{18}COOH$	75.4
22:0	Behenic acid	Docosanoic acid	$CH_3(CH_2)_{20}COOH$	81
24:0	Lignoceric acid	Tetracosanoic acid	$CH_3(CH_2)_{22}COOH$	84.2

C > 20 or C < 14 are very uncommon

Most chains have an even number

Fatty Acids

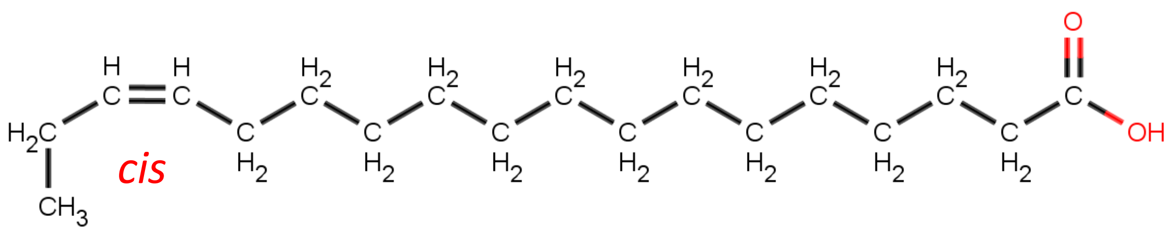
Unsaturated – single bonds all the way down the chain

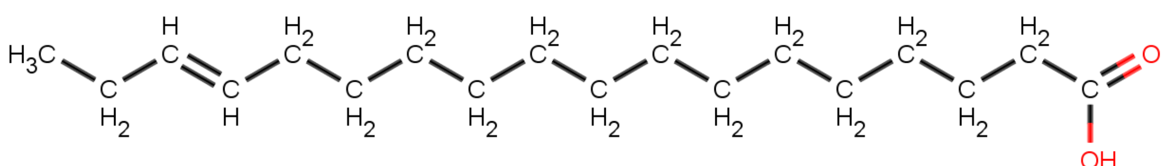
16:1*n*–7	**Palmitoleic acid**	**9-Hexadecenoic acid**	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	**−0.5**
18:1*n*–9	**Oleic acid**	**9-Octadecenoic acid**	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	**13.4**
18:2*n*–6	**Linoleic acid**	**9,12-Octadecadienoic acid**	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	**−9**
18:3*n*–3	**α-Linolenic acid**	**9,12,15-Octadecatrienoic acid**	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	**−17**
18:3*n*–6	**γ-Linolenic acid**	**6,9,12-Octadecatrienoic acid**	$CH_3(CH_2)_4(CH{=}CHCH_2)_3(CH_2)_3COOH$	
20:4*n*–4	**Arachidonic acid**	**5,8,11,14-Eicosatetraenoic acid**	$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COOH$	**−49.5**
20:5*n*–3	**EPA**	**5,8,11,14,17-Eicosapentaenoic acid**	$CH_3CH_2(CH{=}CHCH_2)_5(CH_2)_2COOH$	**−54**
22:6*n*–3	**DHA**	**4,7,10,13,16,19-Docosahexenoic acid**	$CH_3CH_2(CH{=}CHCH)_6CH_2COOH$	
24:1*n*–9	**Nervonic acid**	**15-Tetracosenoic acid**	$CH_3(CH_2)_7CH{=}CH(CH_2)_{13}COOH$	**39**

Chain length : number of double bonds - position of 1st double bond from CH_3 terminal

All double bonds are *cis*

Double bonds tend to form every 3 carbons

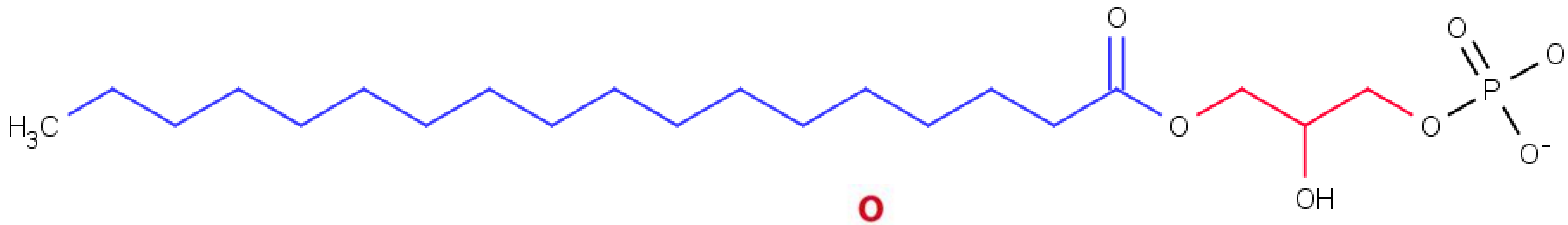




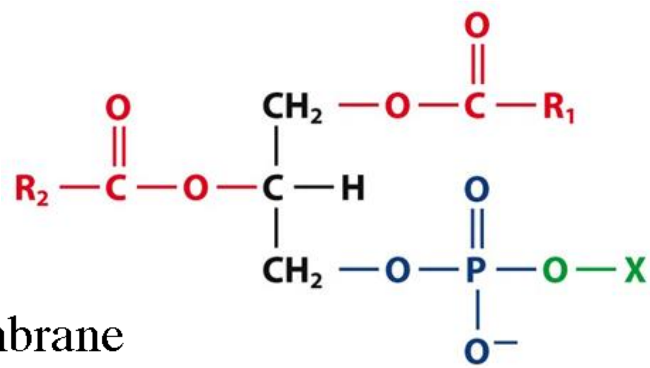
trans

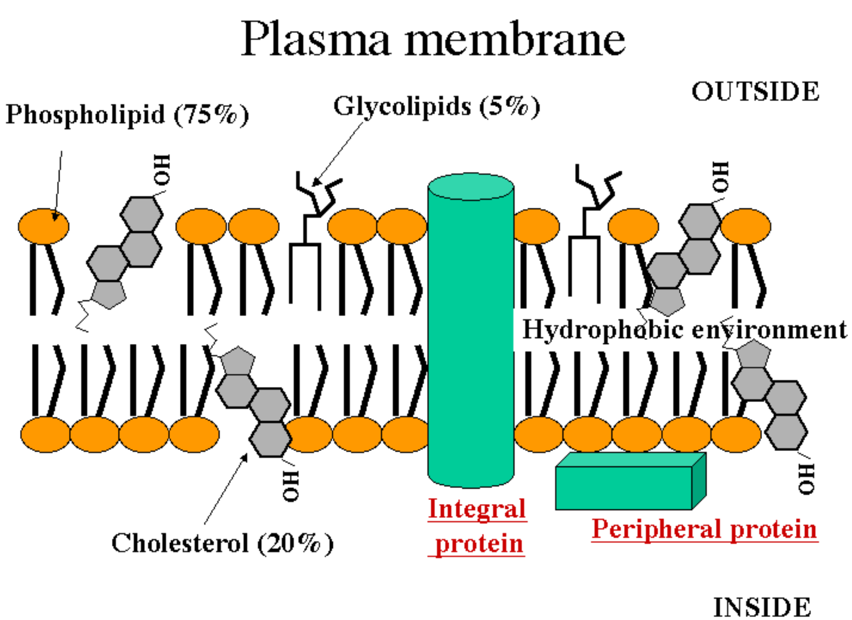
Phosphoglycerides

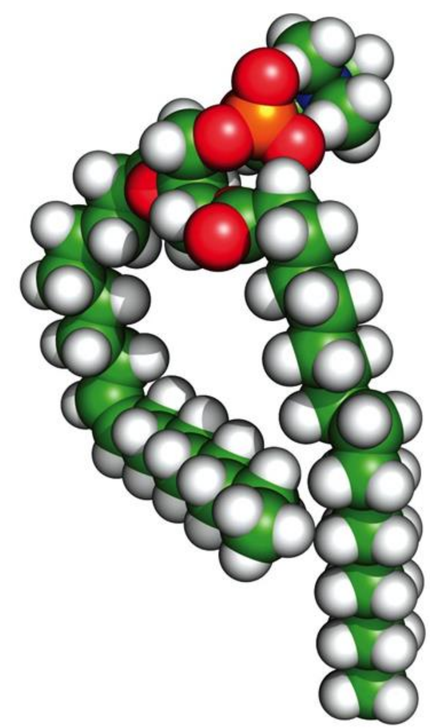
Phosphoglycerides–phosphate substituted acylglycerols



Most common lipid component in biological membranes

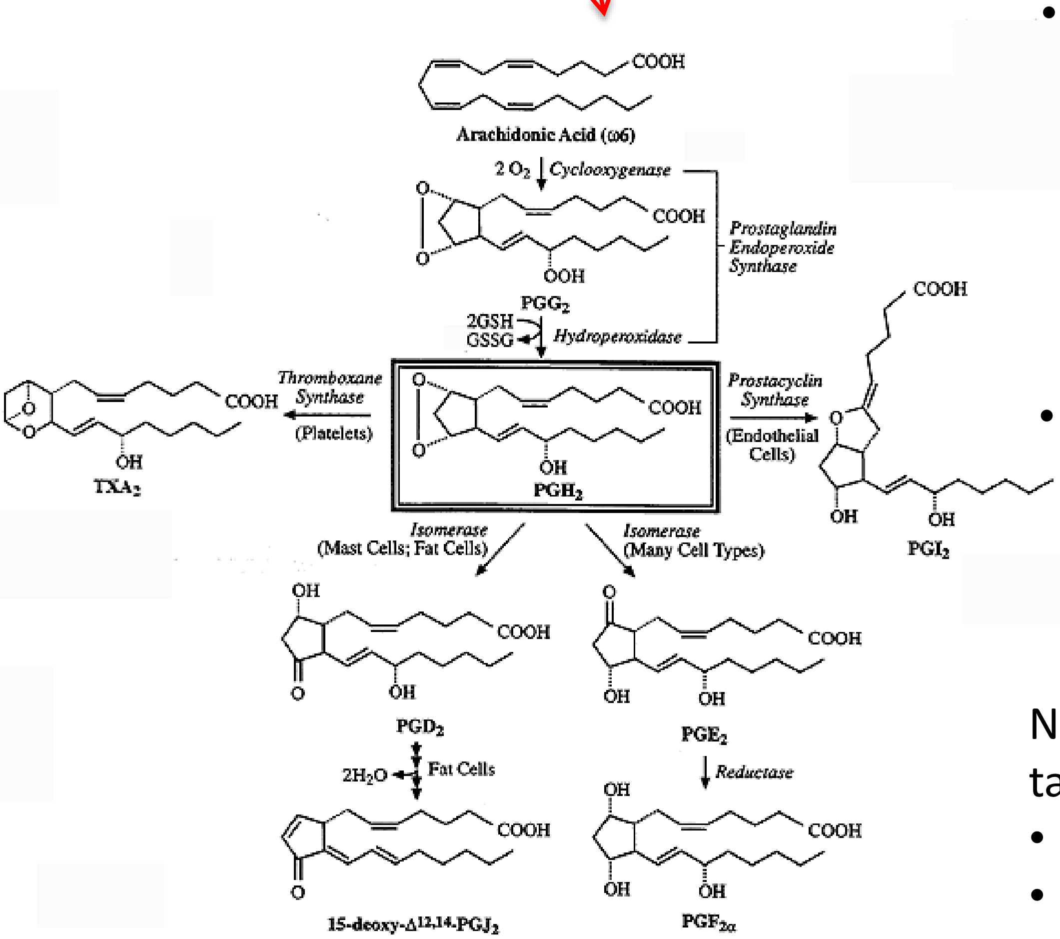






Omega 6's and Prostaglandin Hormones

Synthesized in your body from Linoleic Acid



Some of the physiological effects of Prostaglandins:

- The inflammatory response (rheumatoid arthritis).
- The production of pain and fever.
- The regulation of blood pressure.
- The induction of blood clotting.
- The control of several reproductive functions such as the induction of labor.
- The regulation of the sleep / wake cycle.

Notable: Cyclooxygenase (COX-2) is the target of many anti-inflammatory drugs

- Aspirin
- Naproxen (Aleve)
- Ibuprofen (Motrin, Advil)

The importance of omega-3 FA

•**Blood fat (triglycerides).** Fish oil supplements can lower elevated triglyceride levels. Having high levels of this blood fat puts you at risk for heart disease. DHA alone has also been shown to lower triglycerides.

•**Rheumatoid arthritis.** Fish oil supplements (EPA+DHA) can curb stiffness and joint pain. Omega-3 supplements also seem to boost the effectiveness of anti-inflammatory drugs.

•**Depression.** Some researchers have found that cultures that eat foods with high levels of omega-3s have lower levels of depression. Fish oil also seems to boost the effects of antidepressants and may help the depressive symptoms of bipolar disorder.
•**Baby development.** DHA appears to be important for visual and neurological development in infants.

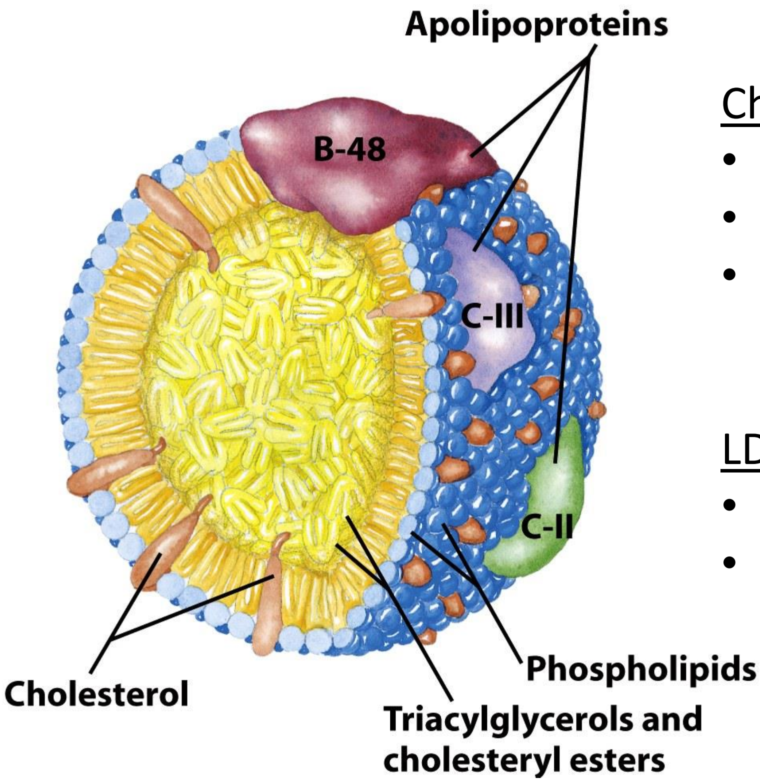
•**Asthma.** A diet high in omega-3s lowers inflammation, a key component in asthma. But more studies are needed to show if fish oil supplements improve lung function or cut the amount of medication a person needs to control the condition.

•**ADHD.** Some studies show that fish oil can reduce the symptoms of ADHD in some children and improve their mental skills, like thinking, remembering, and learning. But more research is needed in this area, and omega-3 supplements should not be used as a primary treatment.

•**Alzheimer's disease and dementia.** Some research suggests that omega-3s may help protect against Alzheimer's disease and dementia, and have a positive effect on gradual memory loss linked to aging. But that's not certain yet.

Source: WebMD

The Good, the Bad and the Ugly



Chlyomicrons

- Dietary fat/cholesterol transport to cells
- Originate in intestinal mucosa cells
- 1-2% protein, 85-88% triglycerides, ~8% phospholipids, ~3% cholesteryl esters and ~1% cholesterol

LDL (Low Density Lipoprotein) – "Bad" Cholestrol

- Cholesterol transport from liver to cells
- One of the lipoproteins (B-100) is recognized by LDL receptors. This triggers encapsulation of LDL and release of cholesterol to be used in the plasma membrane
- 20-22% protein, 10-15% triglycerides, 20-28% phospholipids, 37-48% cholesteryl esters, and 8-10% cholesterol

HDL (High Density Lipoprotein)

- Cholesterol transport to liver for degradation (or recycling)
- Cholesterol "scavenger"
- 55% protein, 3-15% triglycerides, 26-46% phospholipids, 15-30% cholesteryl esters, and 2-10% cholesterol