Lipid Metabolism

Dr Sairindhri Tripathy

What is a Lipid?

- These are nonpolar organic compounds
- Generally insoluble to water, but soluble t
  nonpolar solvent like;
  - chloroform
  - acetone
  - ether
  - benzene
- It contains a carbonyl group (-COOH)

What are the functions of lipids?

- As membrane structural component.
- As intracellular storage depot of metabolic fue
- As transport form of metabolic fuel.
- As protective form of the cells of many bacteri leaves of higher plants, exoskeleton of insect and the skin of vertebrates.
- A regulatory substances.
- As transport form of some neurotransmitters.
- As receptors in nerve ending membranes.
- As determinants of immunological specificity.
- Enzyme co-factors

Types of Lipids

- The four main groups of lipids include:

1. Fatty acids (saturated and unsaturated)

2. Glycerides (glycerol-containing lipids)

3. Nonglyceride lipids (sphingolipids, steroids, waxes)

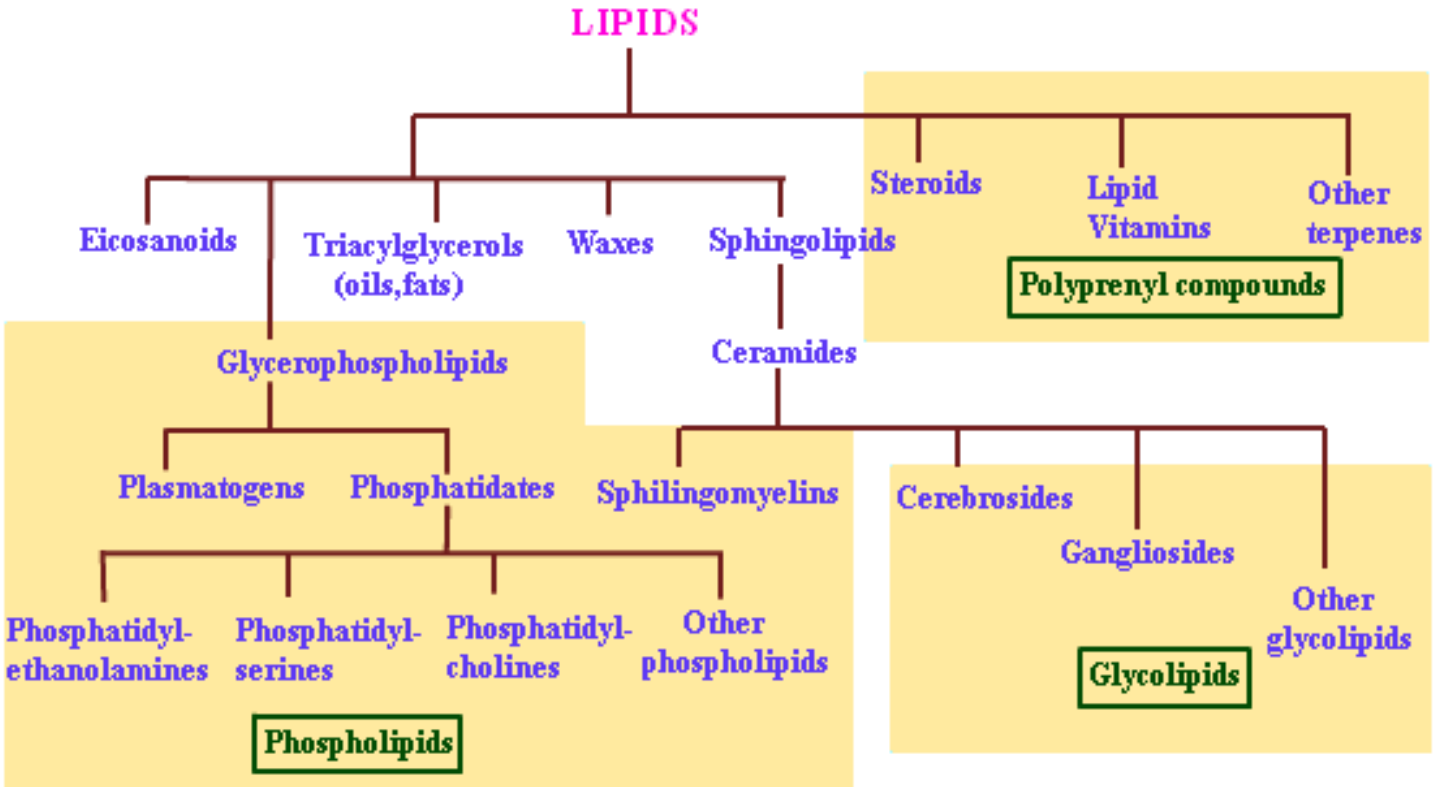
4. Complex lipids (lipoproteins, glycolipids)

Different Types of Lipids

The classification of lipids can be structural based or based on their functions. **Mainly lipids are classified in five types.**

- Fatty acyl (FA)
- Glycerolipids (GL)
- Glycerophospholipids (GP)
- Sterol lipids (ST)
- Sphengolipids (SP)

The relation between different types of lipids is as follows.



Lipid Catabolism

- **Catabolism** – refers to several reactions that produce energy

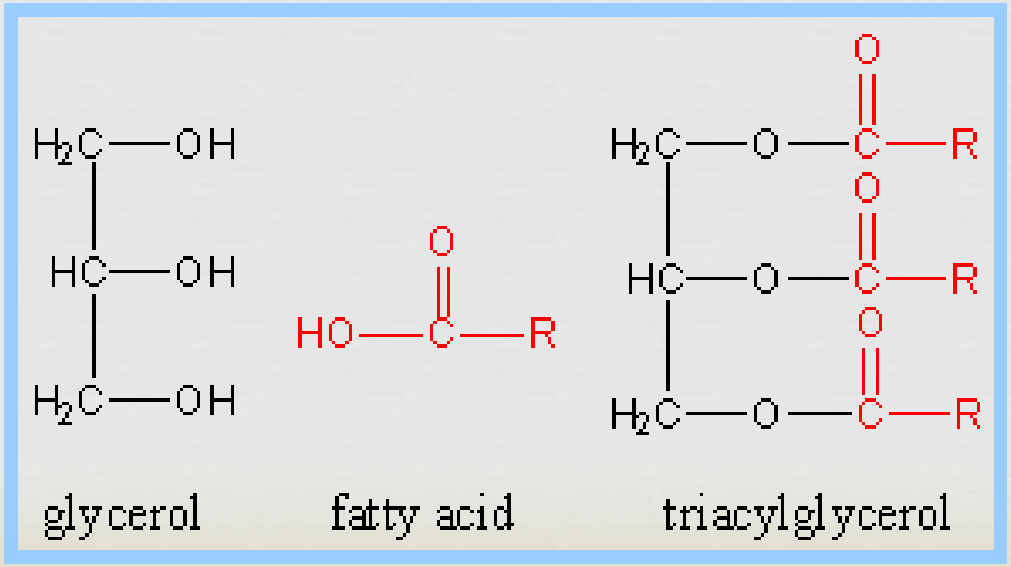
  - it is a breakdown of complex organic compounds into a simpler compounds.

- It is related to carbohydrate metabolism becau the carbohydrates will turn into fats. The glycerol will participate is glycolysis.
- It is important process because the produced Fatty acids will participate in fatty acid oxidation.
- Energy is produced through a process called lipogenesis

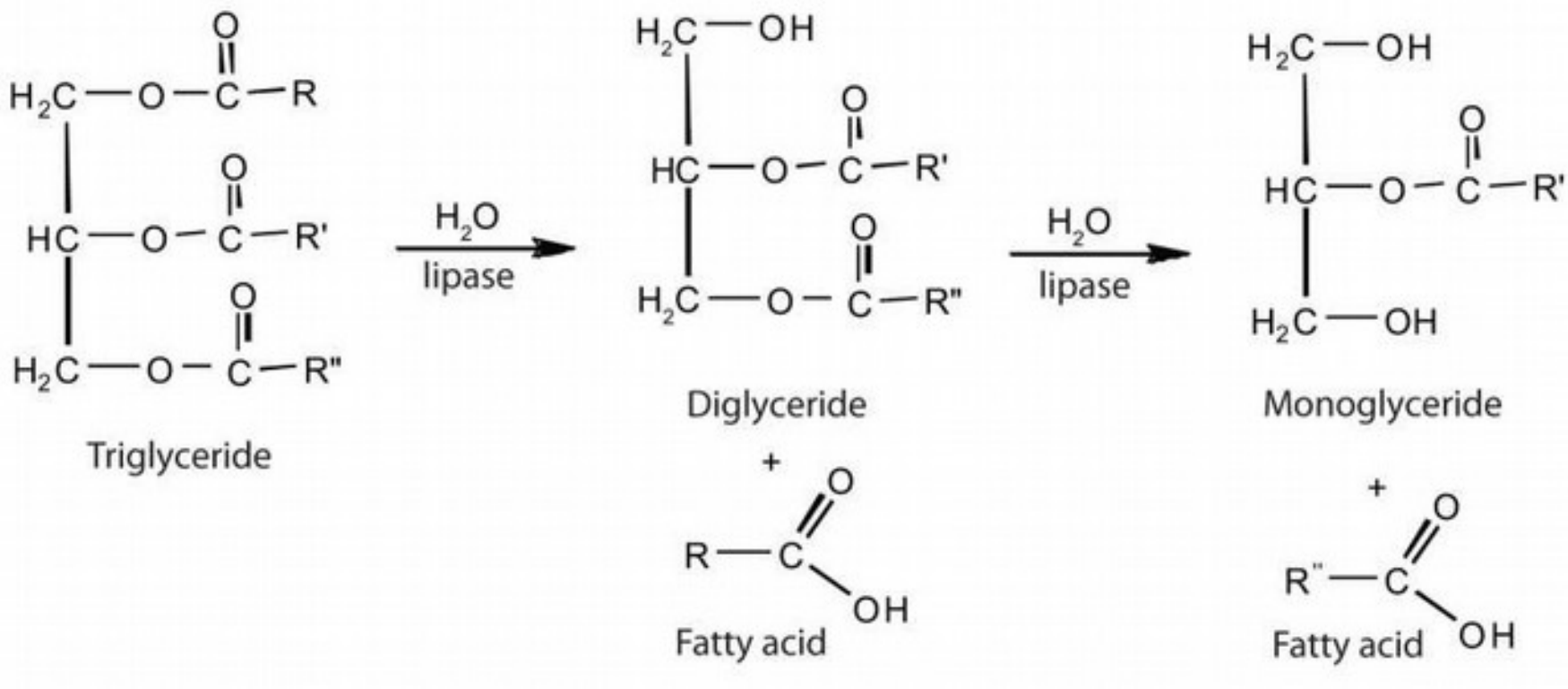
1. Lipolysis- splitting of fat, stimulated by : epinephrine, norepinephrine and cortisol

- **Triacylglycerols** (triglycerides) are the most abundan dietary lipids

- Each triacylglycerol has a **glycerol** backbone to which are esterified **3 fatty acids**. Most triacylglycerols "mixed." The three fatty acids differ in chain length and number of double bonds



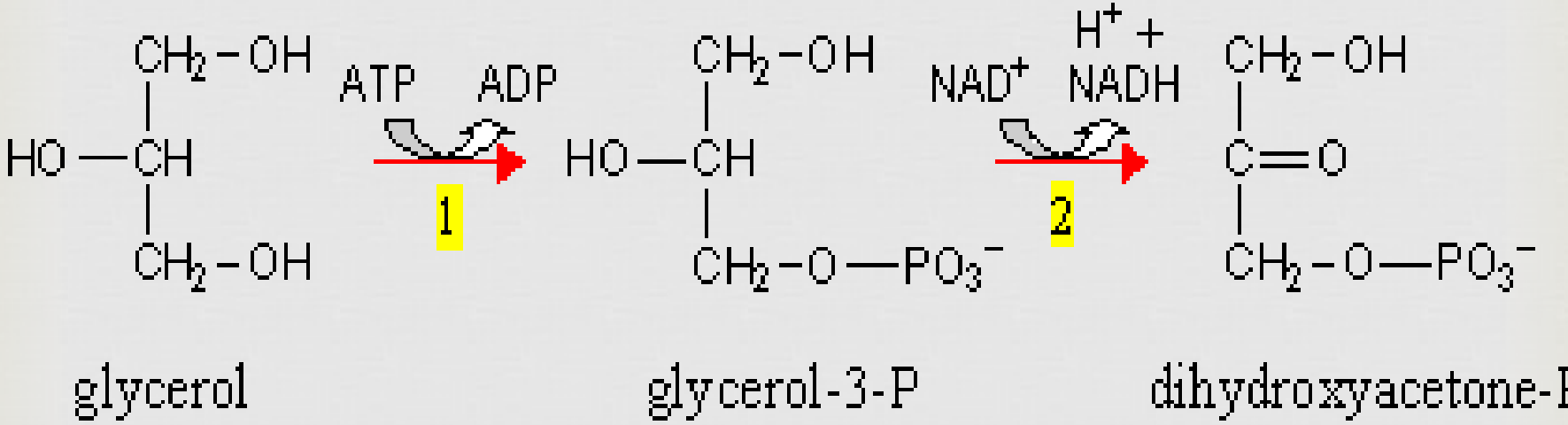
Stage 1. Lipid catabolism (Lipolysis)

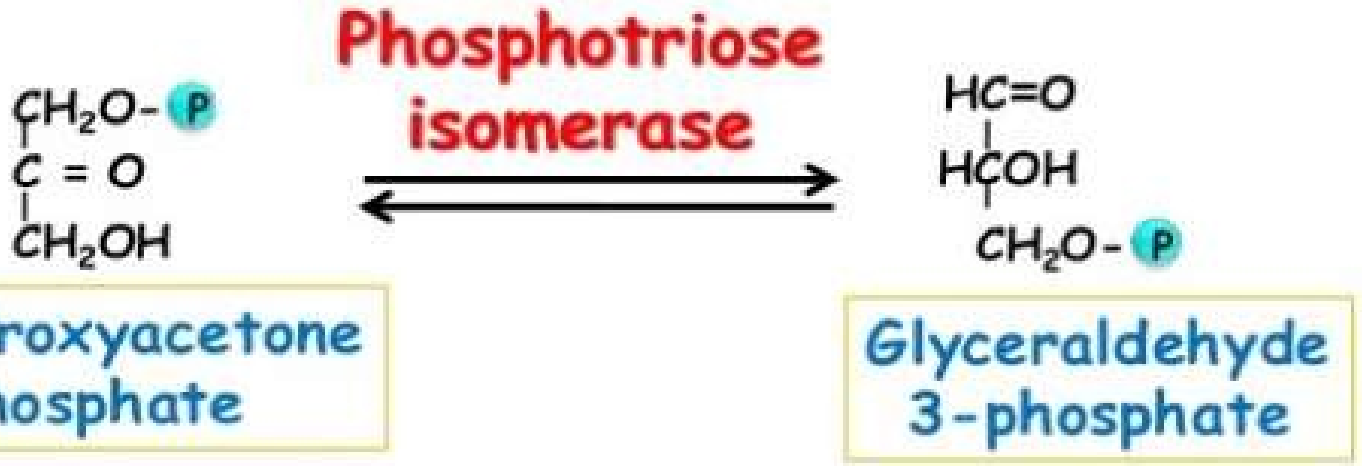


Lipases hydrolyze triacylglycerols, releasing one fatty acid at a time, producing diacylglycerols, and eventually glycerol. .

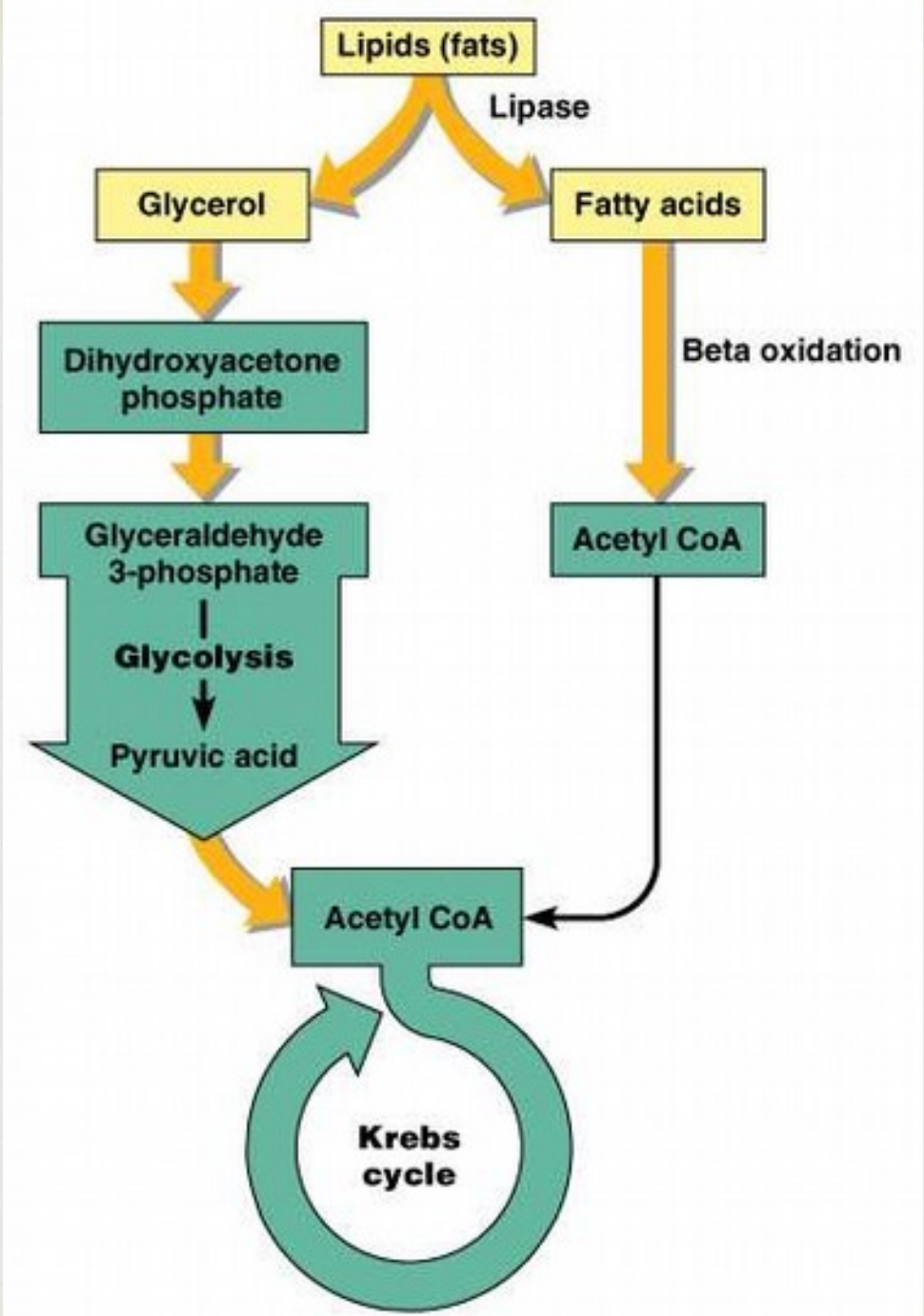
The end of the process 3 fatty acids and 1 glycerol.

- **Glycerol** arising from hydrolysis of triacylglycerols is converted to the Glycolysis intermediate **dihydroxyacetone phosphate**, by reactions catalyzed by:
  (1) Glycerol Kinase
  (2) Glycerol Phosphate Dehydrogenase.



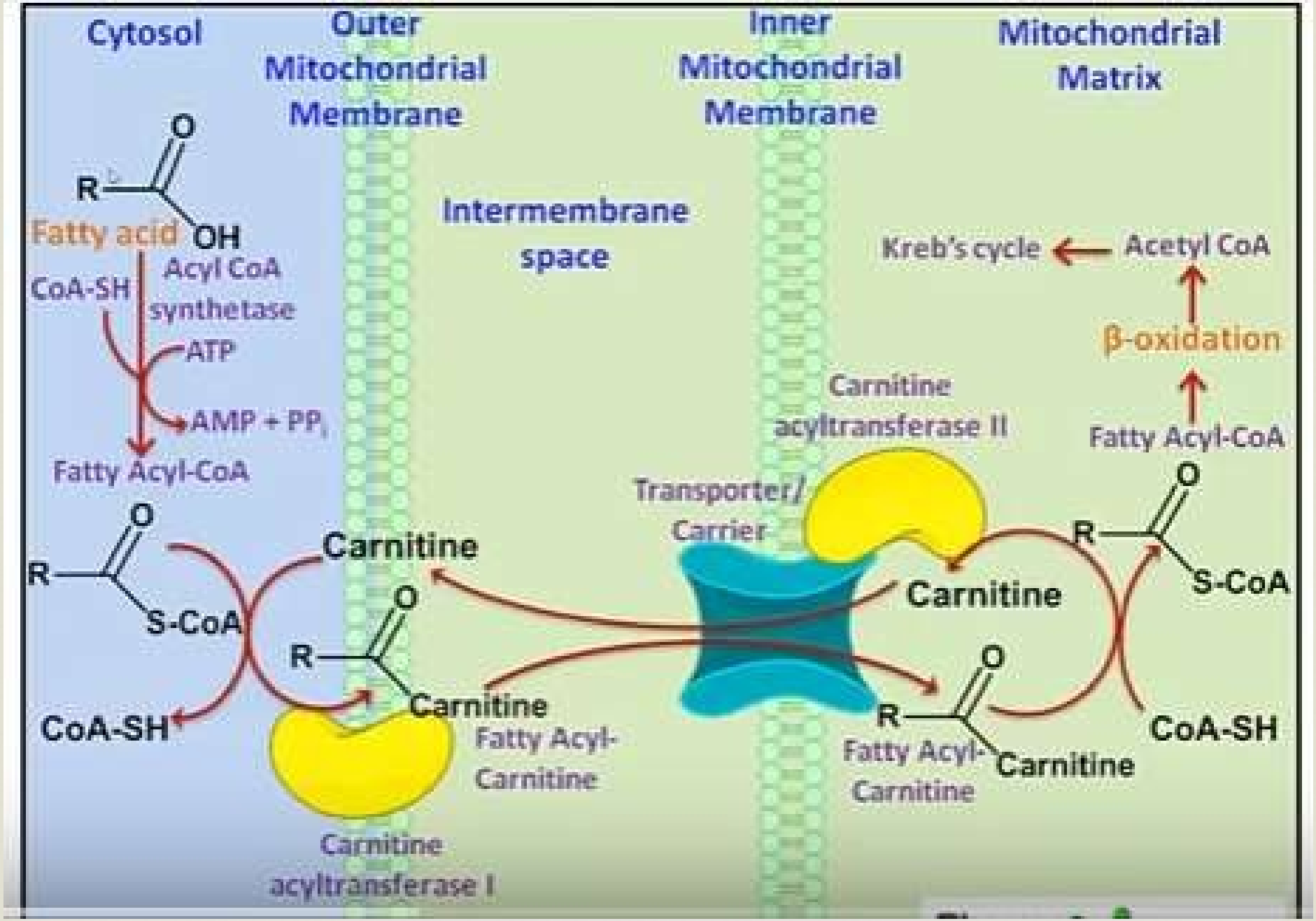


- Dihydroxyacetone phosphate is isomerised to glyceraldehyde 3-phosphate by the enzyme Phosphotriose isomerase.
- In this reaction, 2 molecules of glyceraldehyde 3-phosphate are formed.
- Glyceraldehyde 3-phosphate can also be synthesized from glycerol (fats) by phosphorylation.
- This is reversible reaction.



Beta Fatty Acid Oxidation

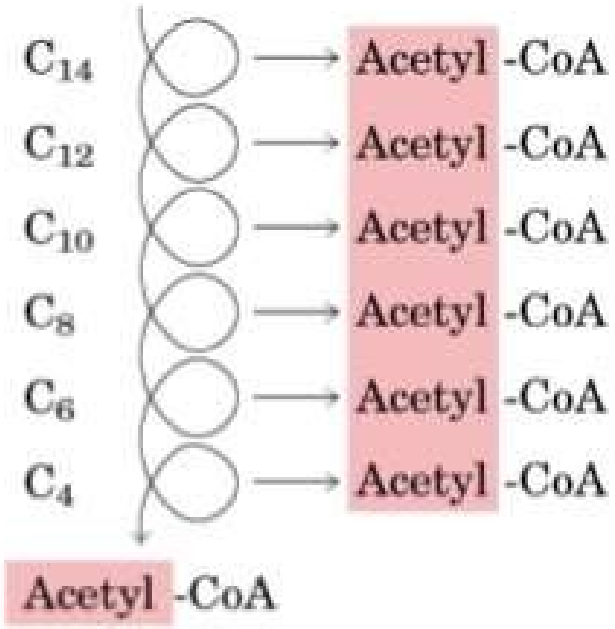
- The end product of each cycle is the **fatty acid** shorter by 2 carbons and acetyl CoA.
- The series of reactions is also **known as** the **beta-oxidation** pathway because the major reaction site is the **beta**-carbon or #3 carbon from the thioester carbo
- Happens in the mitochondrial membrane
- The fatty acids must be activated and turned into ace CoA


Cytosol
Outer Mitochondrial Membrane
Inner Mitochondrial Membrane
Mitochondrial Matrix
Intermembrane space
Fatty acid
CoA-SH
Acyl CoA synthetase
ATP
AMP + PPi
Fatty Acyl-CoA
Kreb's cycle
Acetyl CoA
β-oxidation
Fatty Acyl-CoA
Carnitine acyltransferase II
Transporter/ Carrier
Carnitine
S-CoA
CoA-SH
Fatty Acyl-Carnitine
Carnitine acyltransferase I

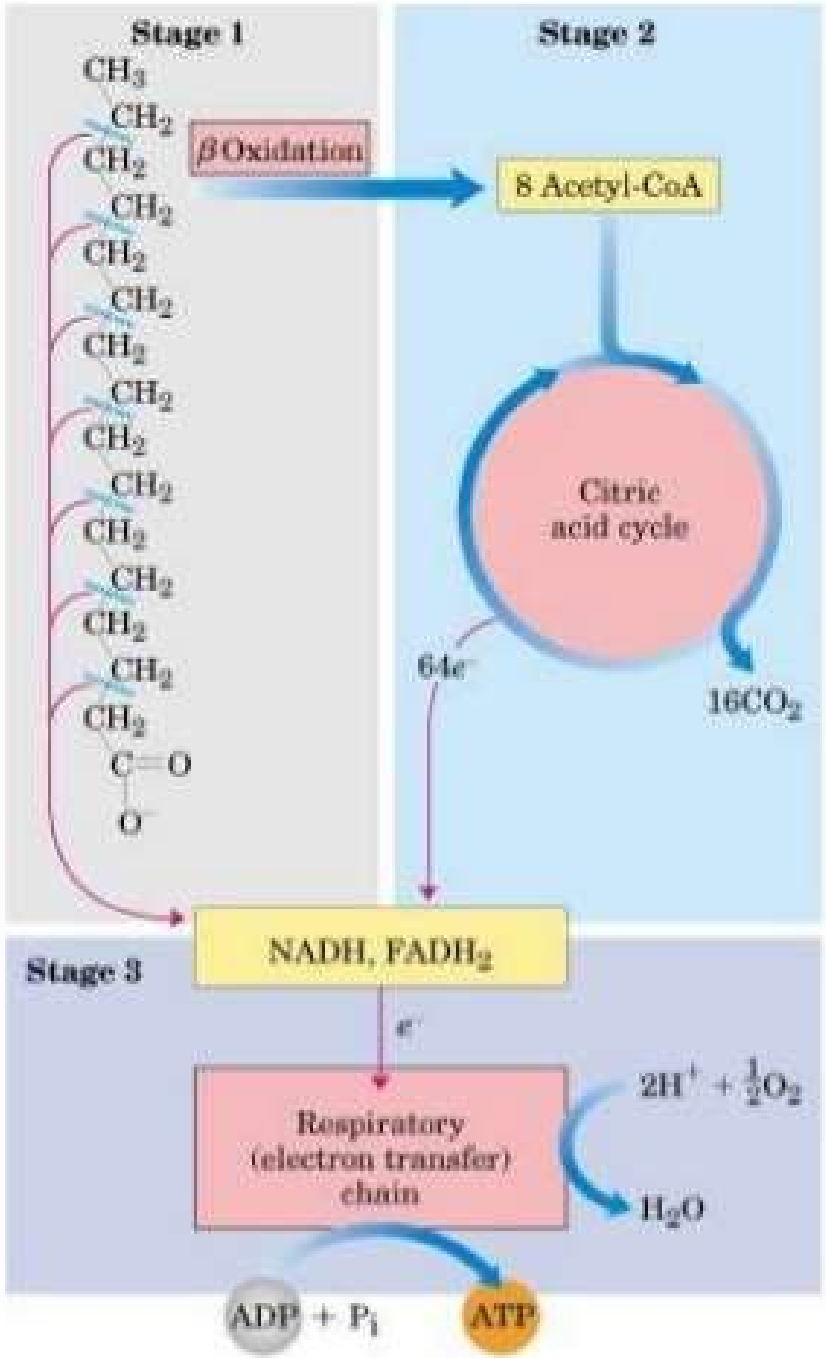
Activation and Transported to Mitochondria

- FA + CoA + ATP → fatty acyl-CoA+ AMP + $2P_i$
- Coupled to the cleavage of ATP
- **AcylCoASynthetase**– a family of isozymes specific for short, medium and long chain FA that catalyze production of fatty acyl-CoA
- Transported through inner mitochondrial membrane via **carnitine**
  - uses specific acylcarnitine transporter

β-oxidation – first of three stages of fatty acid oxidation



(b)



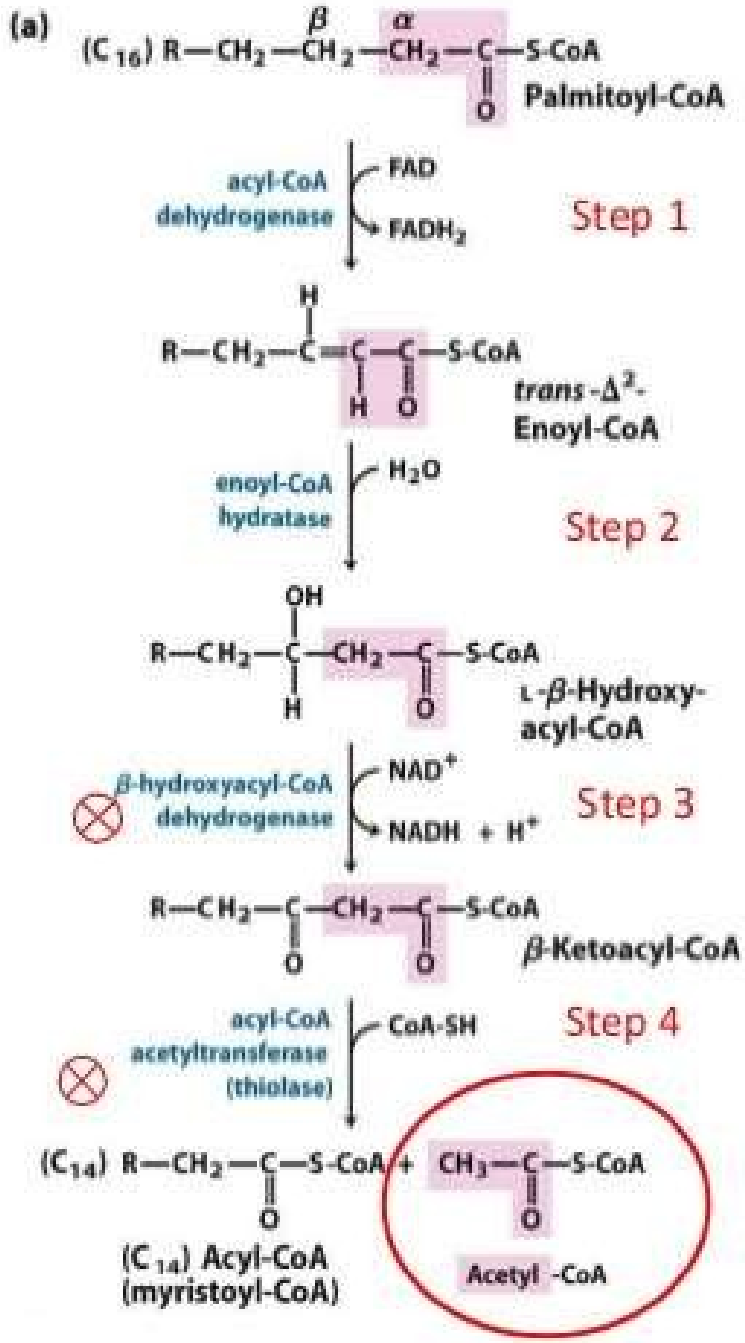
4 Steps of β-oxidation

1. Dehydrogenation of the fatty acyl-CoA to make a trans double bond between α and β carbon.
   - Short, medium, and long chain acyl-CoAdehydrogenases
   - e^- removed transferred to FAD
2. Hydration of the double bond

1. Dehydrogenation of the β-hydroxyl group to a ketone

   - e^- removed transferred to NAD^+

1. Acylation – addition of CoA and production of acetyl-CoA



Energy Yield from β-Oxidation

- Yield of ATP per mole of stearic acid (C_{18}).

Step	Chemical Step	Happens	ATP
1	Activation (stearic acid -> stearyl CoA)	Once	-2
2	Oxidation (acyl CoA -> trans-enoyl CoA) produces $FADH_2$	8 times	16
4	Oxidation (hydroxy-acyl CoA to ketoacyl CoA) produces $NADH + H^+$	8 times	24
	Oxidation of acetyl CoA by the common metabolic pathway, etc.	9 times	108
		TOTAL	146