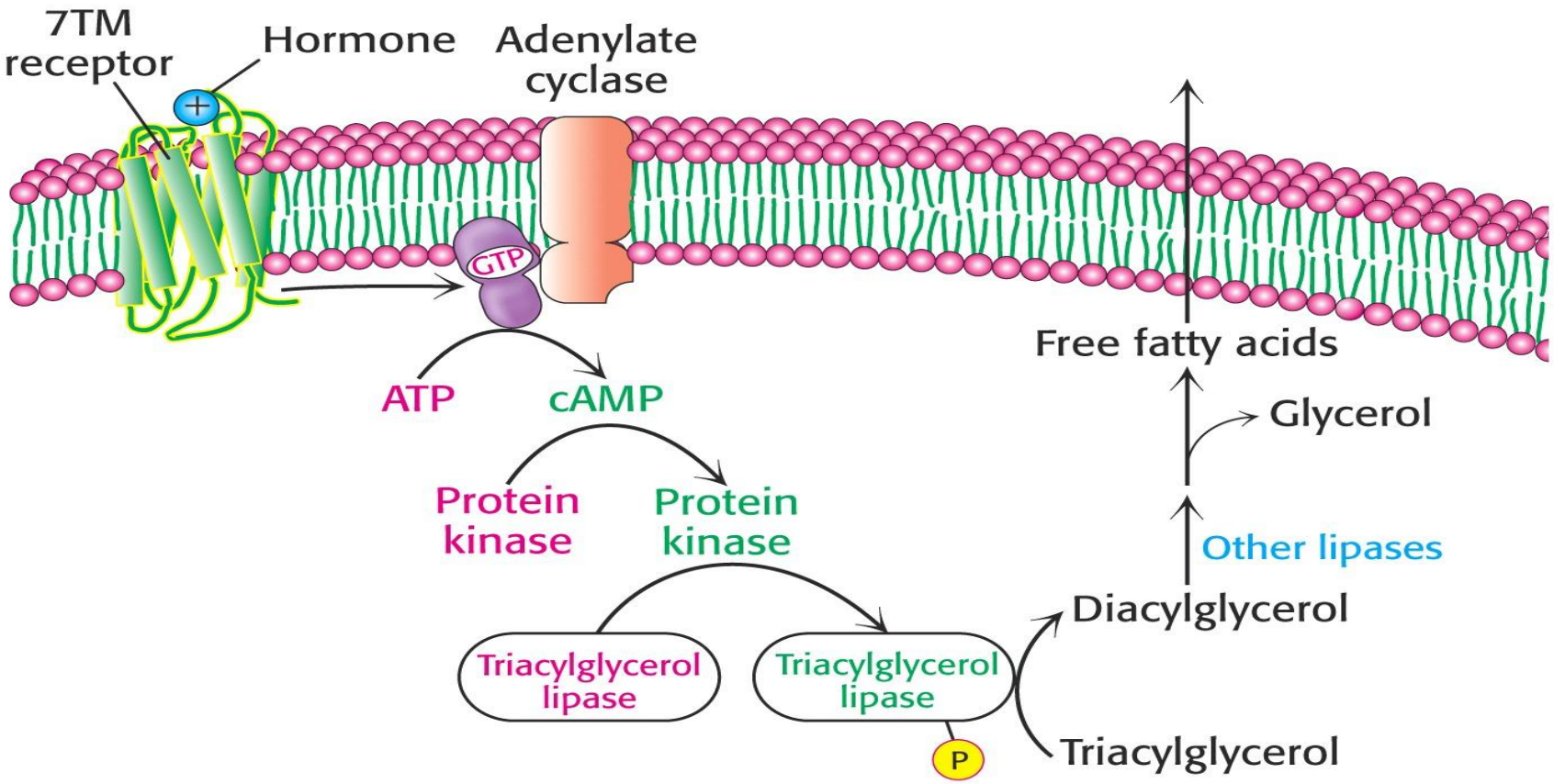
Fatty Acid Metabolism

- The breakdown of triglycerides by lipases
  - is under hormonal control.

– hormones lipolysis in adipose tissue
  - epinephrine, glucagon , promote breakdown of fat (lipolysis)
  - insulin inhibits lipolysis

– released fatty acids insoluble in plasma
  - must be attached to serum albumin for transport

Fatty Acid Metabolism



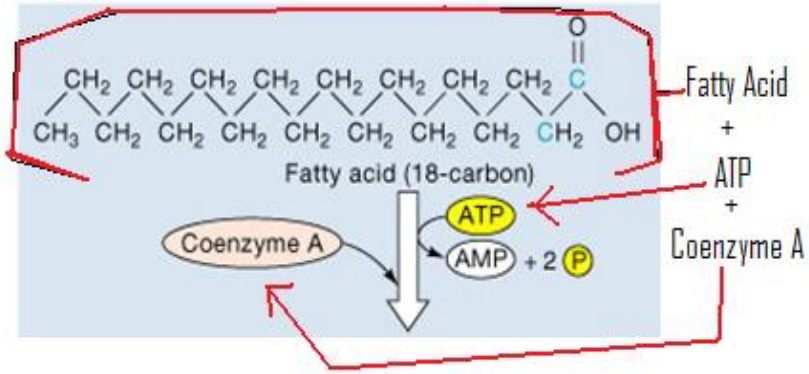
Fatty acids can also be broken down for energy.

- **Beta-oxidation takes place in mitochondria**
  - **Breakdown of fatty acid molecules into 2-carbon fragments**
- **Lipids and energy production**
  - **Used when glucose reserves are limited**
  - **Fatty acid oxidation is a major source of cell ATP**

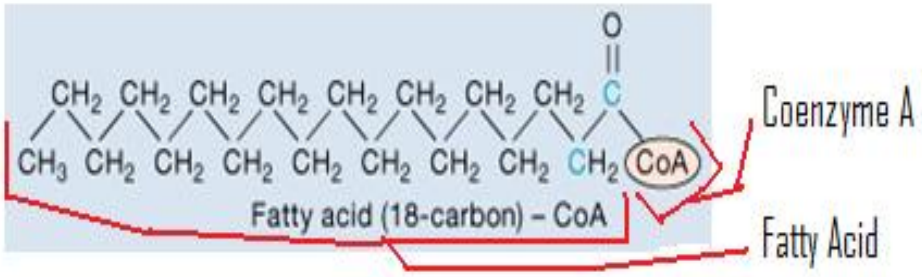
- **In beta oxidation long chain of fatty acids are broken down into fragments of two carbons. Say we have a fatty acid chain that is 18 carbon long. During beta oxidation fragments of two carbon will be removed from the chain of fatty acid. So after the first round of reaction (as shown in the figure) a fatty acid chain that is 16 carbon long will remain, after the second round of reactions a fatty acid chain that 14 carbon long will remain**
- **For each round of reaction two carbon will be removed from the chain. As two carbons are removed from the chain, NADH, FADH2 and Acetyl CoA will be generated.**

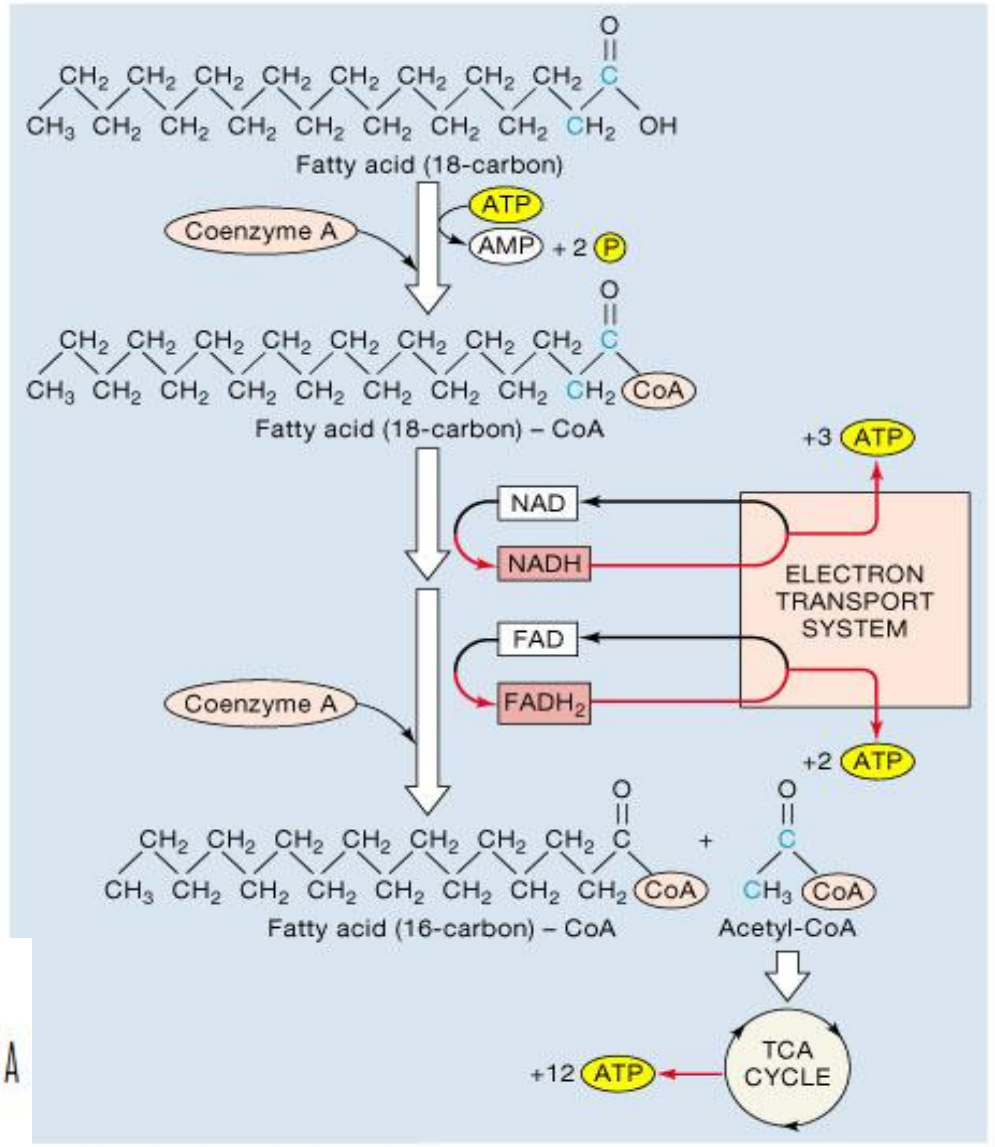
Beta Oxidation

- **The steps in beta oxidation:**
  1) **Coenzyme A bind to fatty acid. This step requires one ATP**

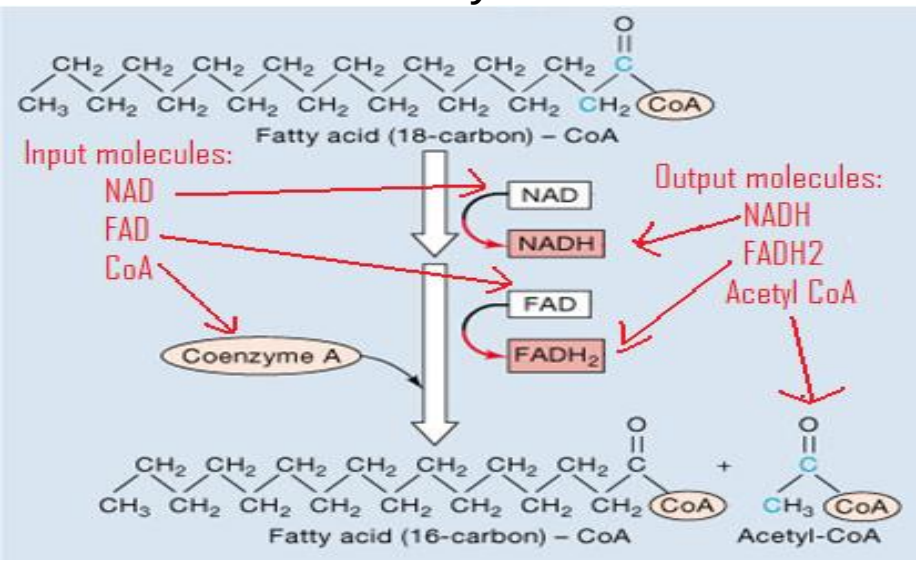


  2) **This reaction will prepare fatty acid for beta oxidation and generate a fatty acid attached to CoA**

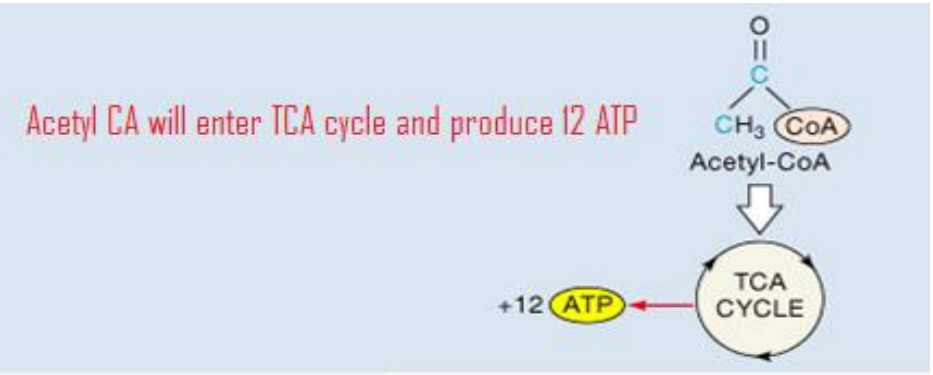


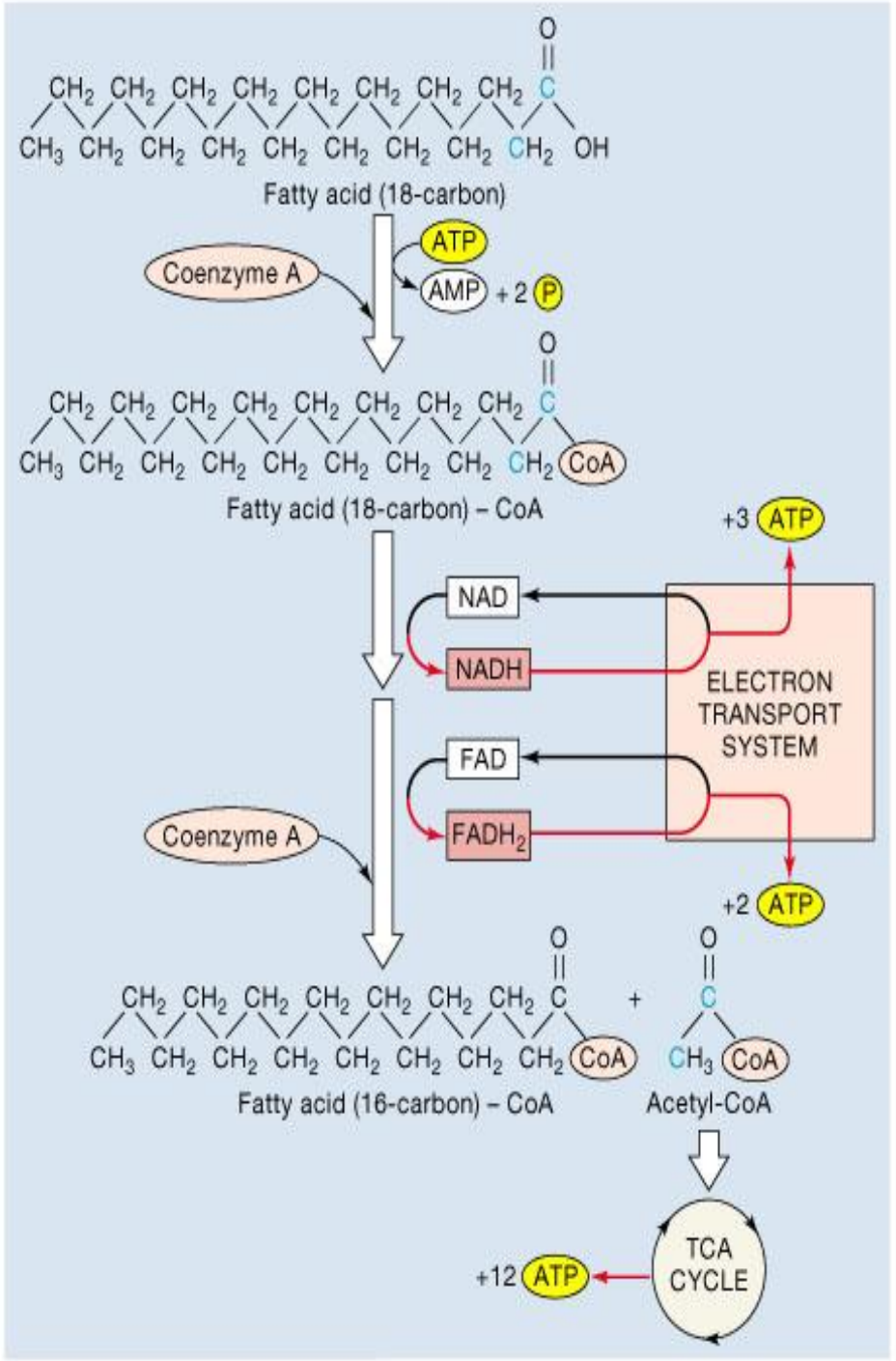


3) The first round of beta oxidation will generate one NADH, one FADH2 and one Acetyl CoA



4) Acetyl CoA will enter TCA cycle and generate 3NADH, 1FADH and 1GTP. 3NADH = 9ATP, 1FADH2 = 2ATP, and GTP = 1ATP.



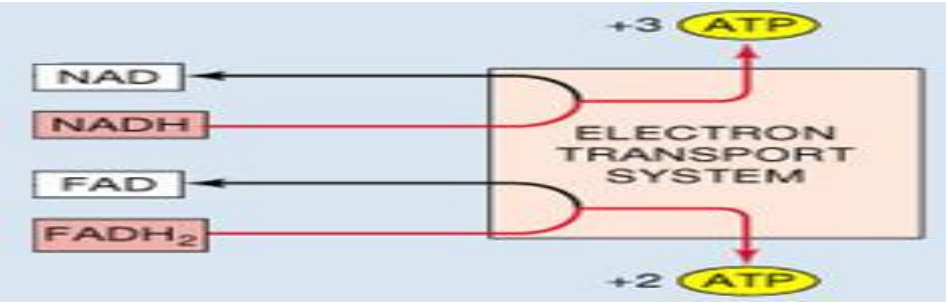


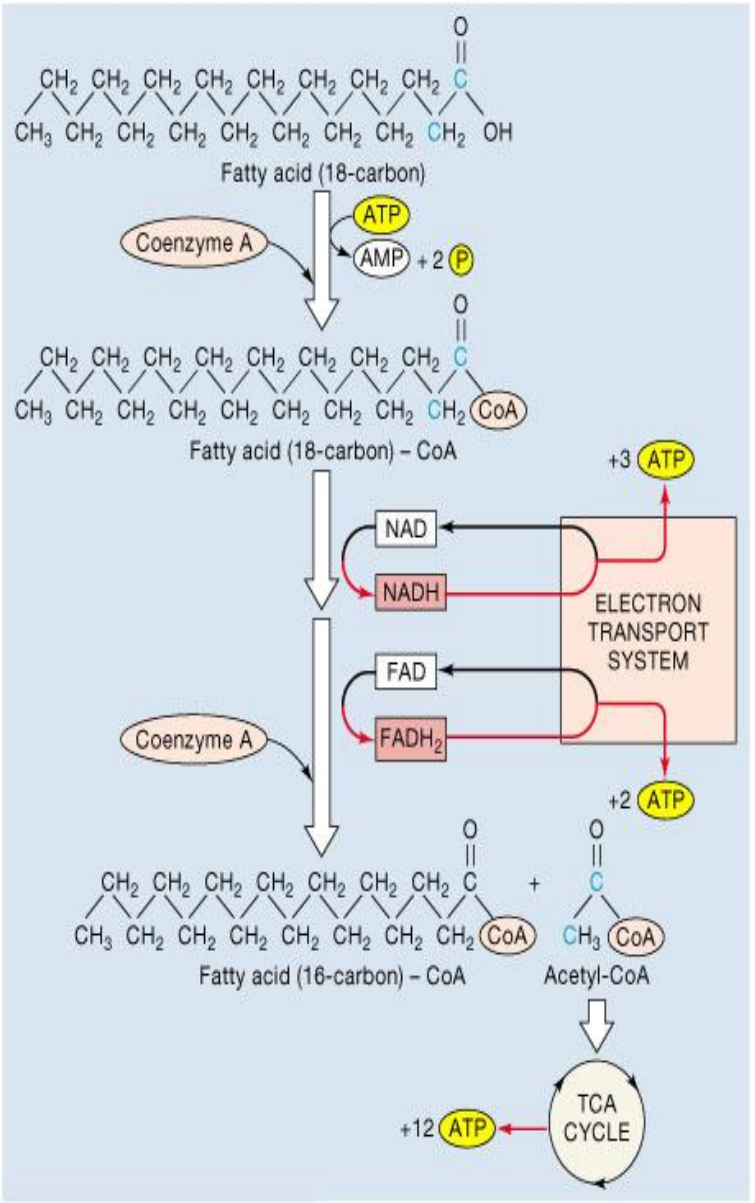
Beta Oxidation

5) NADH and FADH2 will enter the ETS and generate ATP

1NADH = 3ATP

1FADH2 = 2ATP





Summary :

one round of beta oxidation will generate :

NADH = 3ATP

FADH2 = 2ATP

Acetyl CoA = 12ATP

So if each round of beta oxidation produces 17ATP, then one molecule of fat will produce a lot more ATP (energy) than one molecule of glucose. Remember that glucose produced 2ATP in glycolysis and 34/36ATP via TCA and ETS

Calculations

Carbons in Fatty Acid	Acetyl CoA C/2	β-oxidation cycles (C/2) -1
12	6	5
14	7	6
16	8	7
18	9	8

Note: In each round of β-oxidation *one molecule* of $FADH_2$ and *one molecule* of $NADH+H^+$ are produced which generates 2 and 3 ATP molecules, respectively

Example: **Energy of palmitoyl ~Co A (16 C) oxidation**

- Number of cycles= n/2 -1 = 7 cycles
- Number of acetyl ~Co A = n/2 =8

→ So, 7 NADH, each provide 3 ATP when oxidized in the ETC 7X3=21 ATP

→ 7 $FADH_2$ each provide 2 ATP when oxidized in the ETC 7x 2=14 ATP

→ 8 acetyl ~Co A , each provides 12 ATP when converted to CO_2& H_2O by the TCA cycle 8x12= 96 ATP

So total energy yield of oxidation of palmitoyl ~Co A = 21 + 14 + 96 = 131 ATP

- As 2 molecules of ATP are used in the activation of a molecule of fatty acid →Therefore, there is a net yield of **129 molecules of ATP**

Type of Lipids

- **Saturated fat**
  - **Animal oil like, meat, milk, butter**
  - **Vegetable oil like, coconut oil**
- **Polyunsaturated fat**
  - **Plant source like, corn, cottonseed, sunflower oil and soybean oil**
- **Monounsaturated fat**
  - **Plant and animal product like, olive oil, canola oil, avocado and peanut oil**

Lipids Functions

- **Excellent energy reserves**
- **Structure of cell membranes**
- **Organ padding**
- **Body thermal insulation**
- **Essential fatty acids (EFA)**
- **Hormone synthesis**

Cholesterol

- **Cholesterol is needed to make bile, sex hormones, steroids and vitamin D.**
- **It is the constituent of cell membrane structure**
- **Dietary recommendation - <300 mg/dl**
- **Sources – egg yolks, liver, shellfish, organic foods**

Lipoproteins

- Lipoproteins are lipid-protein complex that contains large glycerides and cholesterol
- 5 types of lipoprotein
    1) Chylomicrons
        - Largest lipoproteins composed primarily of triglycerides
        - Delivers lipids from digestive tract (intestine) to liver
    2) Very low-density lipoproteins (VLDLs)
        - Contain triglycerides, phospholipids and cholesterol
        - Delivers triglycerides to the cells
        - Lipoprotein lipase (enzyme) in the capillaries break the triglyceride into monoglyceride and fatty acid for use by the cell

Lipoproteins

3) Intermediate-density lipoproteins (IDLs)
   - Contain smaller amounts of triglycerides
   - Return remaining triglycerides back to the liver
   - When the IDL arrives into the liver, the livers adds cholesterol to IDL. Once cholesterol is added to the IDL, it would be called LDL

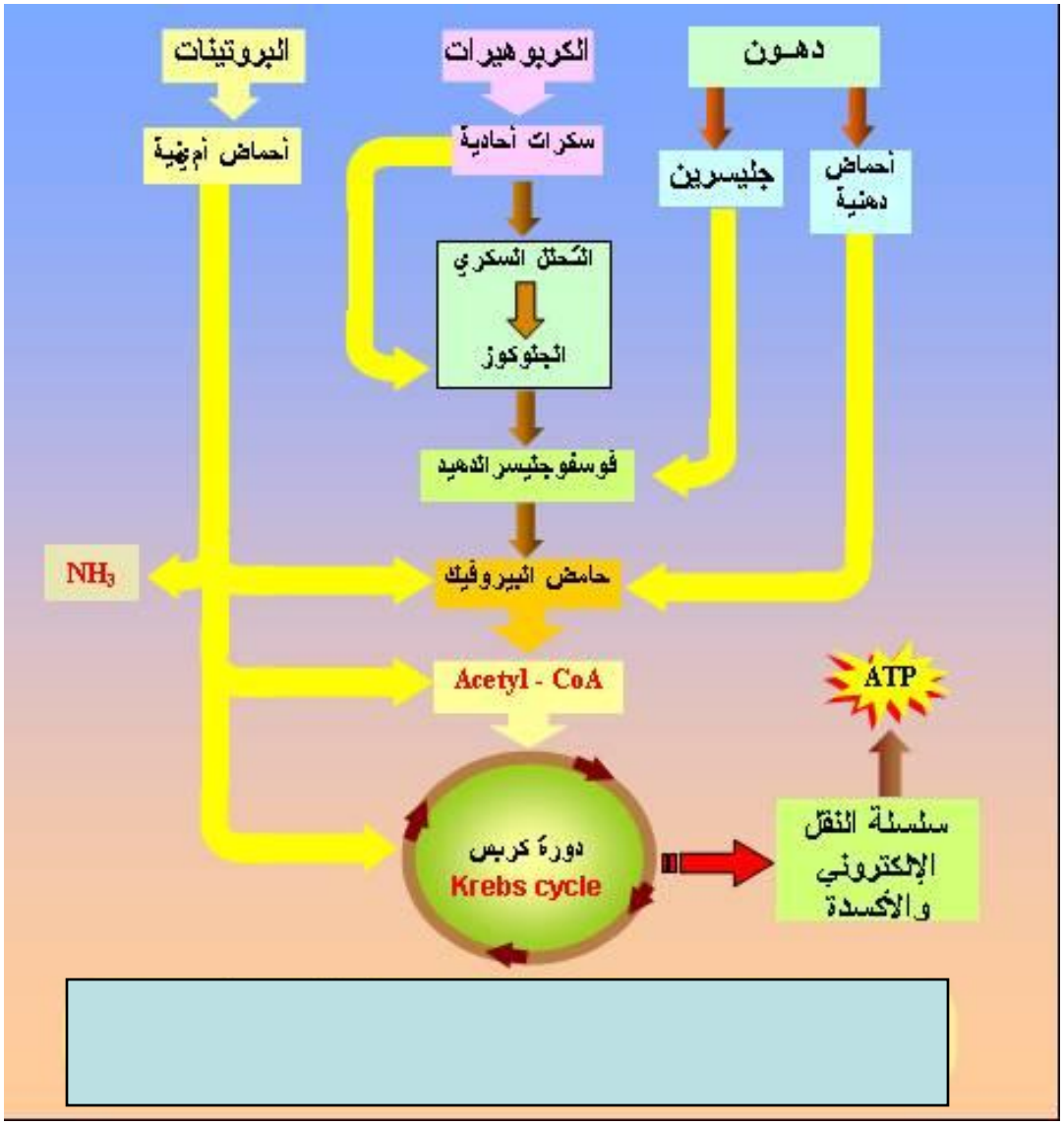
4) Low-density lipoproteins (LDLs) – also called the bad cholesterol
   - Contain mostly cholesterol
   - LDL is released into the blood stream by the liver
   - LDL delivers cholesterol to the cells
   - The cell uses the cholesterol for synthesis of membrane, hormones and other material
   - Any excess cholesterol that is not used by the cell will diffuse out of cell back into capillaries (circulation)

5) High-density lipoproteins (HDLs) also called the good cholesterol
   - HDL collects the extra cholesterol that diffuses out of the cell and delivers them back to the liver
   - The liver reuses the cholesterol to make LDL, and excretes any excess cholesterol with bile

Blood levels for Lipids

- **Total Cholesterol:**
  - **<200 mg/dl = desirable**
  - **200-239 mg/dl = borderline hyperlipidemia**
  - **>240 mg/dl = hyperlipidemia**
- **LDL < 130 mg/dl is favorable**
- **HDL > 35 mg/dl is favorable**

1. الخلايا الحية تستخدم مختلف المواد العضوية كوقود للتنفس
2. مختلف المواد العضوية تتحول عبر سلاسل ايضية جانبية الى Acetyl Coenzyme A



Carnitine

كمادة ناقلة للاحماض الدهنية للميتوكوندريا