

SNS COLLEGE OF ALLIED HEALTH SCIENCE
Affiliated to The Tamil Nadu Dr M.G.R Medical University, Chennai



DEPARTMENT OF OPERATION THEATRE AND ANAESTHESIA

TECHNOLOGY

COURSE NAME: BIOCHEMISTRY

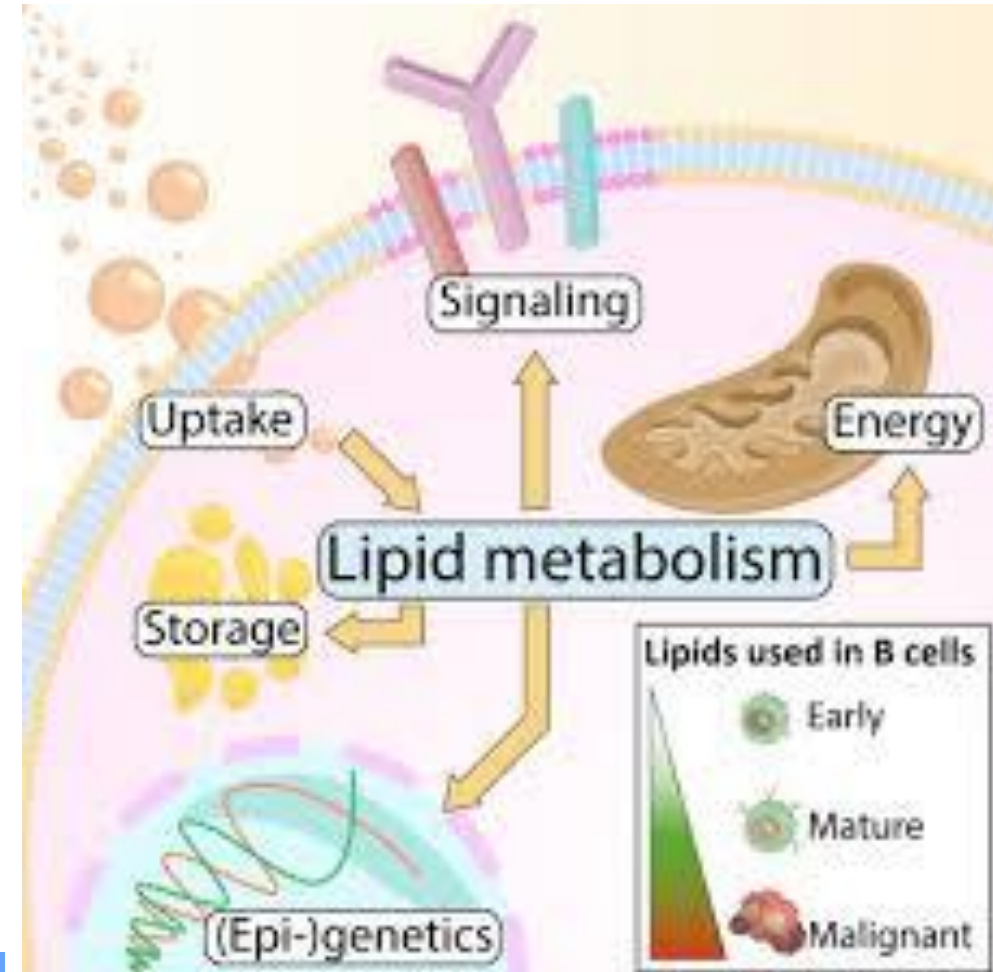
UNIT : 3

TOPIC : LIPIDS – METABOLISM

FACULTY NAME: MITHRA V

LIPID METABOLISM

- Processes of **synthesis** (**Anabolism**) and **breakdown** (**Catabolism**) of lipids
- Includes **energy storage** as fats, breakdown for energy, and synthesis of structural lipids
- **Key roles:** Energy production, cell membranes, hormones, signaling
- Synthesized in **liver/adipose tissue**



LIPID METABOLISM PATHWAYS

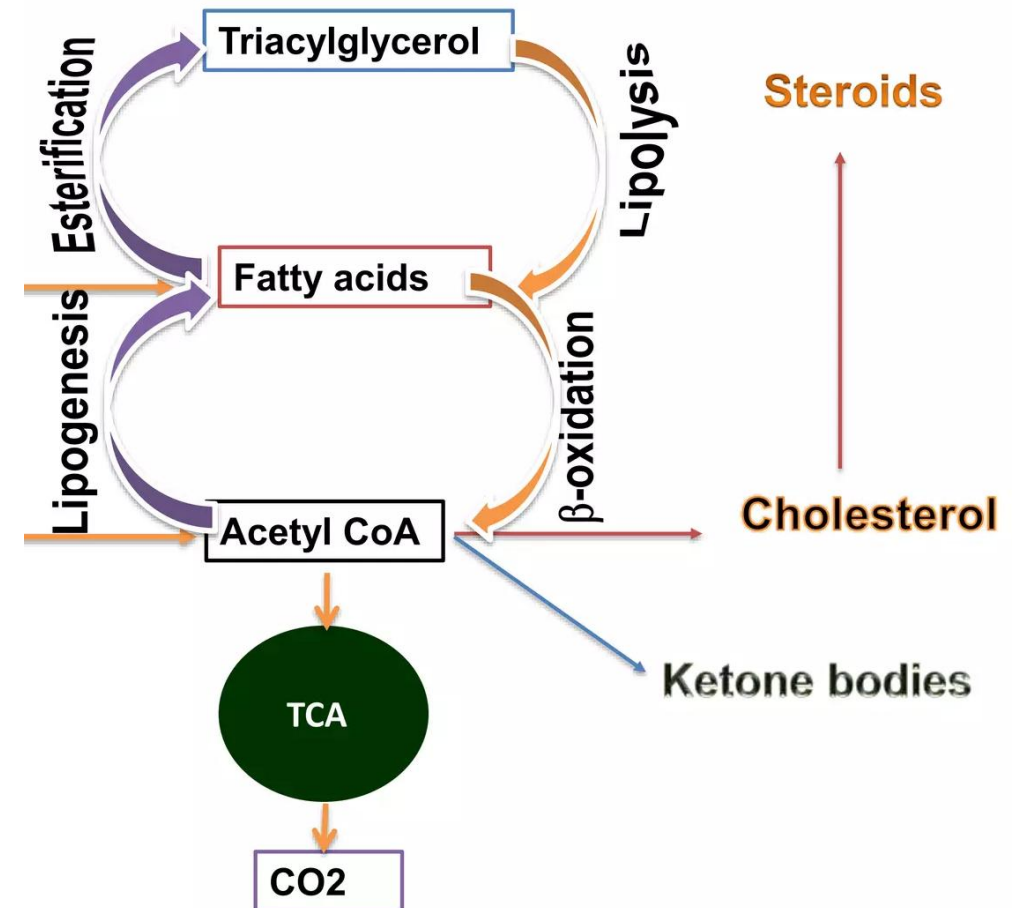
1. Lipolysis (Triglyceride Breakdown)

2. Fatty Acid Oxidation (Beta-Oxidation)

3. De Novo Lipogenesis (Fatty Acid & Triglyceride Synthesis)

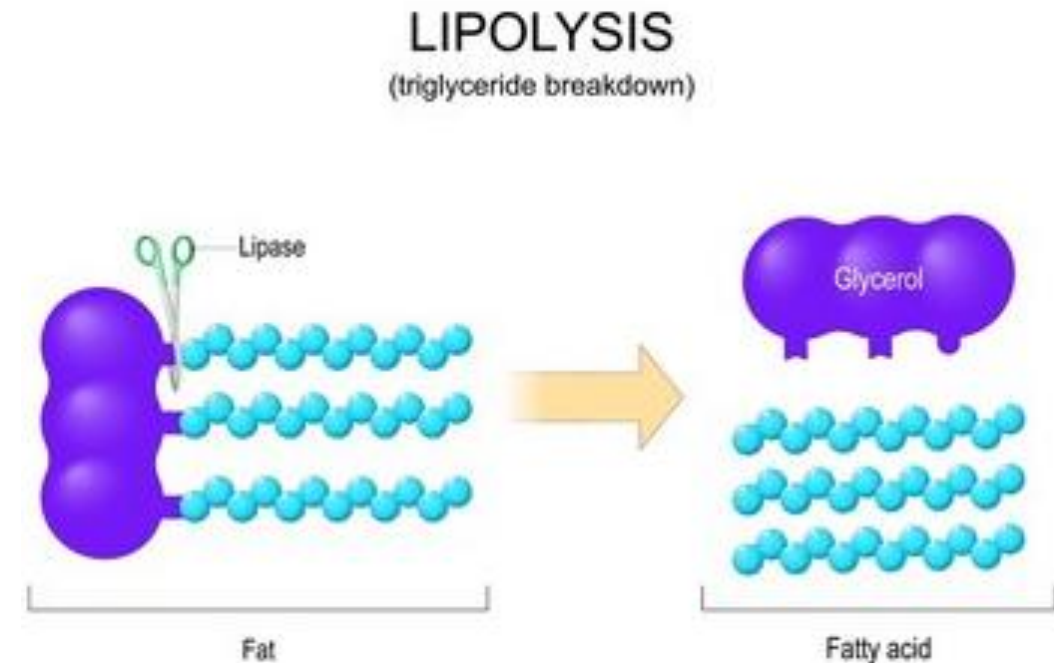
4. Ketogenesis (Ketone Body Synthesis)

5. Cholesterol Synthesis



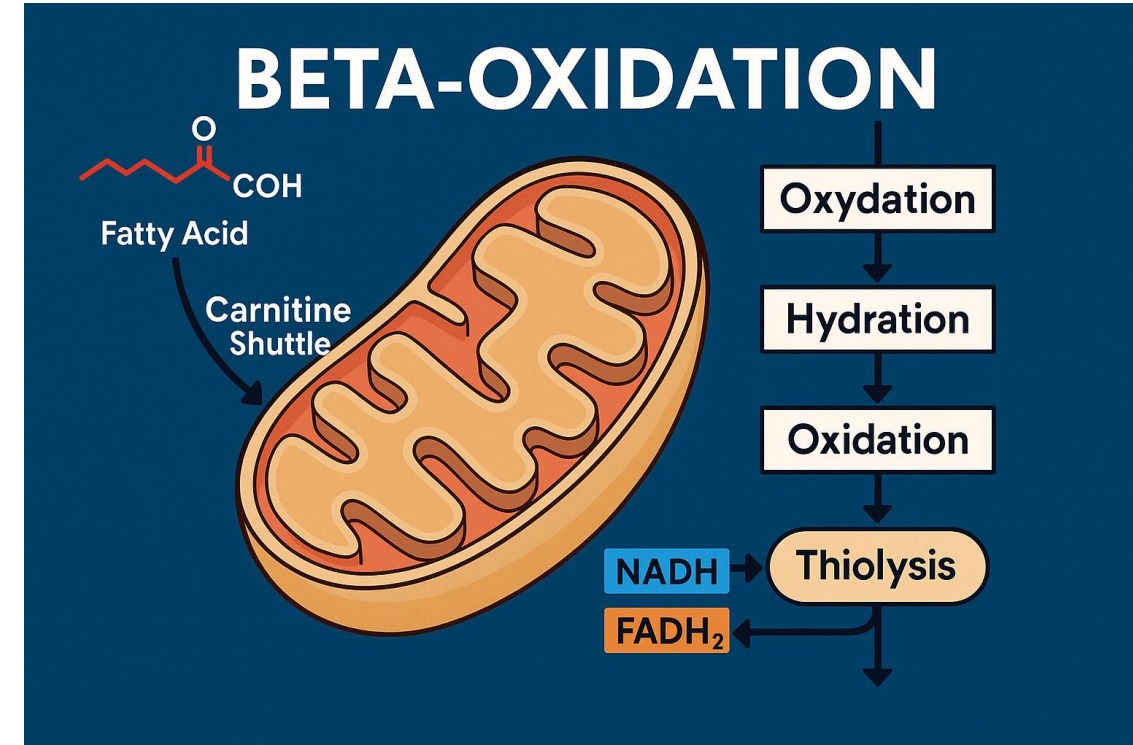
LIPOLYSIS (TRIGLYCERIDE BREAKDOWN)

- Hydrolysis of triglycerides into **glycerol + 3 free fatty acids**
- **Location:** Adipose tissue
- Triggered by hormones (e.g., epinephrine, glucagon) during fasting/energy need
- **Key enzymes:**
 - Lipoprotein lipase (LPL)
 - Hormone-sensitive lipase (HSL)



FATTY ACID OXIDATION (BETA-OXIDATION)

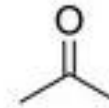
- Breakdown of **fatty acids to acetyl-CoA**
- **Location:** Mitochondria
- Fatty acids activated to acyl-CoA.
- Shortens chain by 2 carbons per cycle
- **Produces:**
 - **Acetyl-CoA, NADH, FADH₂** (for ATP)



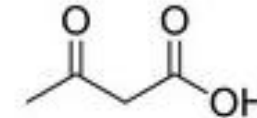
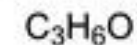
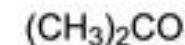
KETOGENESIS (KETONE BODY SYNTHESIS)

- **Synthesis of ketone bodies** from acetyl-CoA
- **Location:** Liver Mitochondria
- Exported as **alternative fuel** for **brain/muscle**
- During **low glucose availability** (e.g., starvation, low-carb diets),
- Liver produces ketone bodies from acetyl-CoA (mainly from fatty acid oxidation).

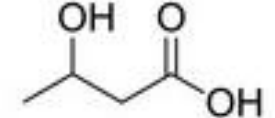
Ketone bodies



Acetone



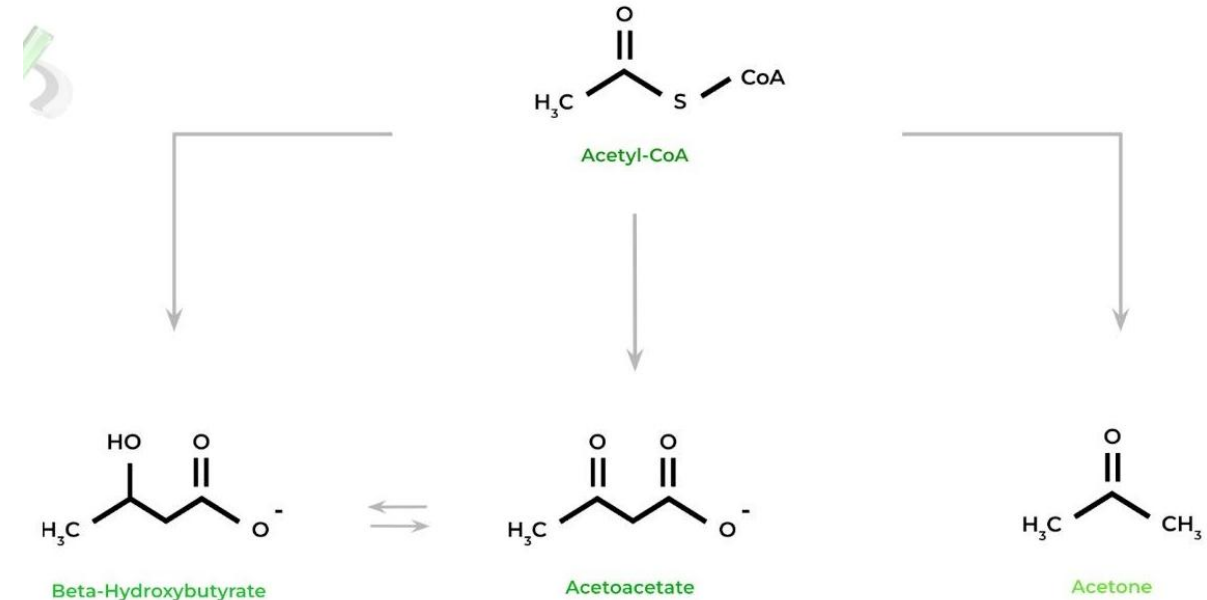
Acetoacetic acid



β -Hydroxybutyric acid

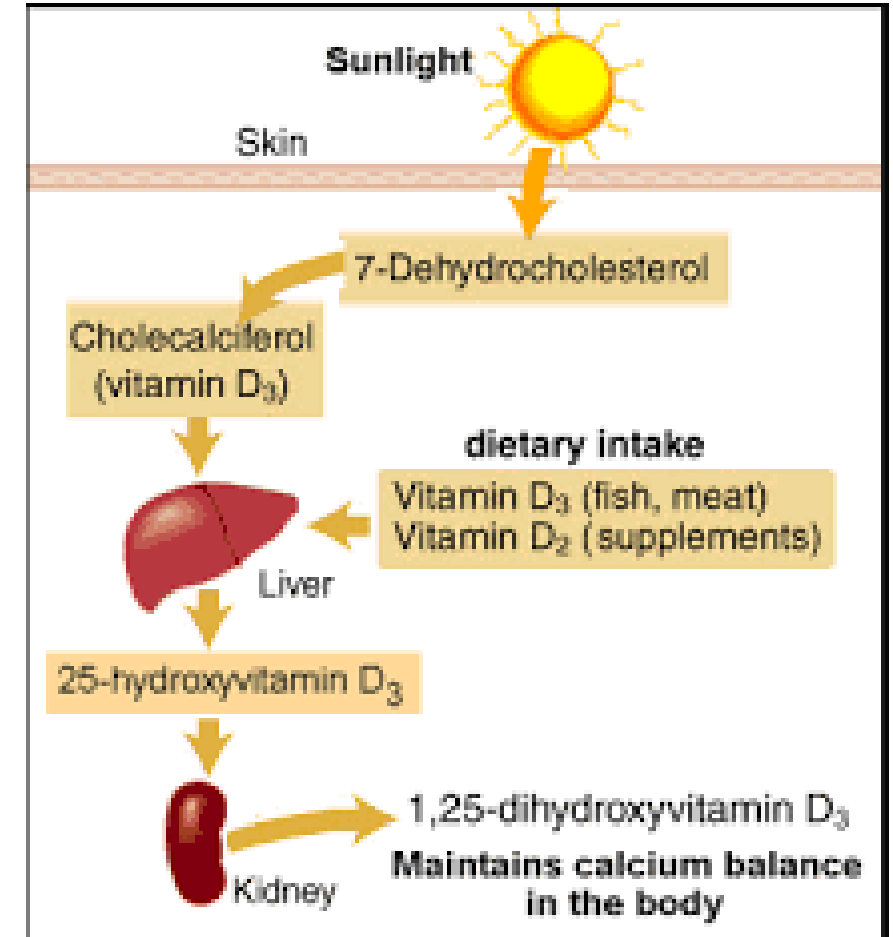


- Ketones are released into blood and used by tissues (especially brain) as alternative fuel
- Converted back to **acetyl-CoA** → TCA cycle → **ATP**.
- High ketone levels → **Ketosis, uncontrolled diabetes** → **Ketoacidosis**
- **Symptom of high ketones:** Fruity/acetone breath (from exhaled acetone).



CHOLESTEROL SYNTHESIS

- De novo synthesis mainly in liver
- Via **mevalonate pathway** from acetyl-CoA
- **Key steps:**
- Acetyl-CoA → HMG-CoA → mevalonate
- Used for membranes, hormones, bile acids, **vitamin D**

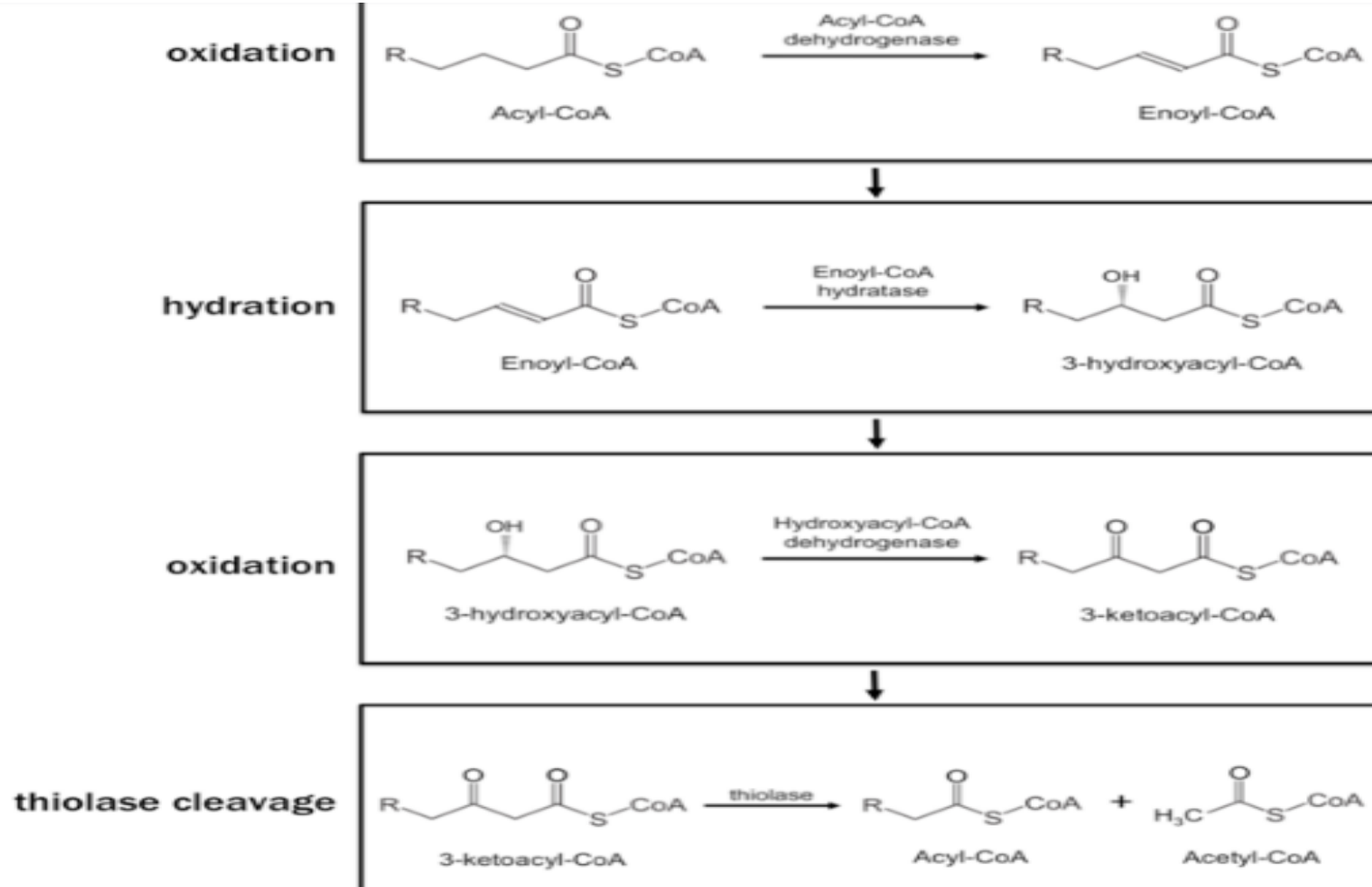


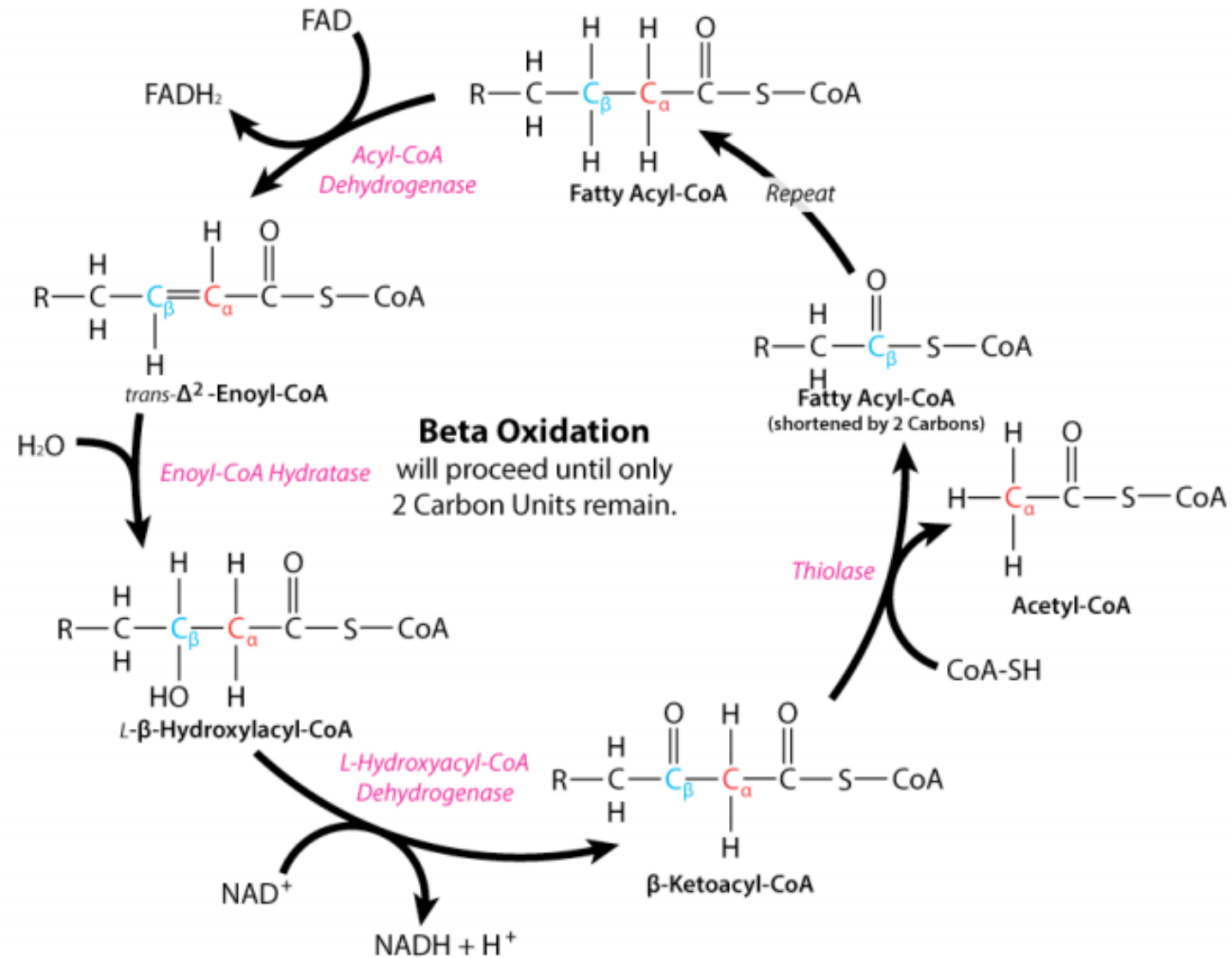
BETA-OXIDATION OF FATTY ACIDS (PALMITIC ACID)



- **Activation:** Palmitic acid + CoA + ATP $\rightarrow$ Palmitoyl-CoA + AMP + PPi (costs 2 ATP equivalents).
- **Dehydrogenation:** Palmitoyl-CoA $\rightarrow$ Trans-2-enoyl-CoA + FADH₂ (Acyl-CoA dehydrogenase).
- **Hydration:** Trans-2-enoyl-CoA $\rightarrow$ L- β -hydroxyacyl-CoA (Enoyl-CoA hydratase).
- **Oxidation:** L- β -hydroxyacyl-CoA $\rightarrow$ β -ketoacyl-CoA + NADH (β -hydroxyacyl-CoA dehydrogenase).
- **Thiolysis:** β -ketoacyl-CoA + CoA $\rightarrow$ Acetyl-CoA + Shortened acyl-CoA (β -ketothiolase).
- **Steps (per cycle, repeated 7 times for palmitic acid, C16:0):**

FATTY ACID OXIDATION (BETA-OXIDATION)





ATP YIELD FROM COMPLETE OXIDATION OF PALMITIC ACID



- Each **NADH** → ~**2.5 ATP**
- Each **FADH₂** → ~**1.5 ATP**
- Each **acetyl-CoA** (fully oxidized in the TCA/citric acid cycle) → ~**10 ATP**
- (3 NADH × 2.5 = 7.5 ATP + 1 FADH₂ × 1.5 = 1.5 ATP + 1 GTP/ATP = total 10 ATP)
- Palmitic acid (16 carbons) undergoes **7 cycles** of beta-oxidation, producing:
 - 8 acetyl-CoA
 - 7 NADH
 - 7 FADH₂

- **Activation: -2 ATP**
- To start beta-oxidation, palmitic acid must be activated to palmitoyl-CoA - uses 1 ATP
- Since hydrolyzing PPi costs the equivalent of another ATP, the net cost is **2 ATP equivalents**.
This is subtracted at the end.
- **From the 7 cycles of beta-oxidation:**
 - $7 \text{ NADH} \times 2.5 \text{ ATP/NADH} = \mathbf{17.5 \text{ ATP}}$
 - $7 \text{ FADH}_2 \times 1.5 \text{ ATP/FADH}_2 = \mathbf{10.5 \text{ ATP}}$
 - Total from beta-oxidation reducing equivalents: **28 ATP**

From the 8 acetyl-CoA (via TCA cycle):

8 acetyl-CoA $\times$ 10 ATP/acetyl-CoA = 80 ATP

Gross total ATP (before subtracting activation cost): 28 + 80 = 108 ATP

Net total ATP: 108 - 2 = ~106 ATP

The shortened acyl-CoA re-enters the cycle.

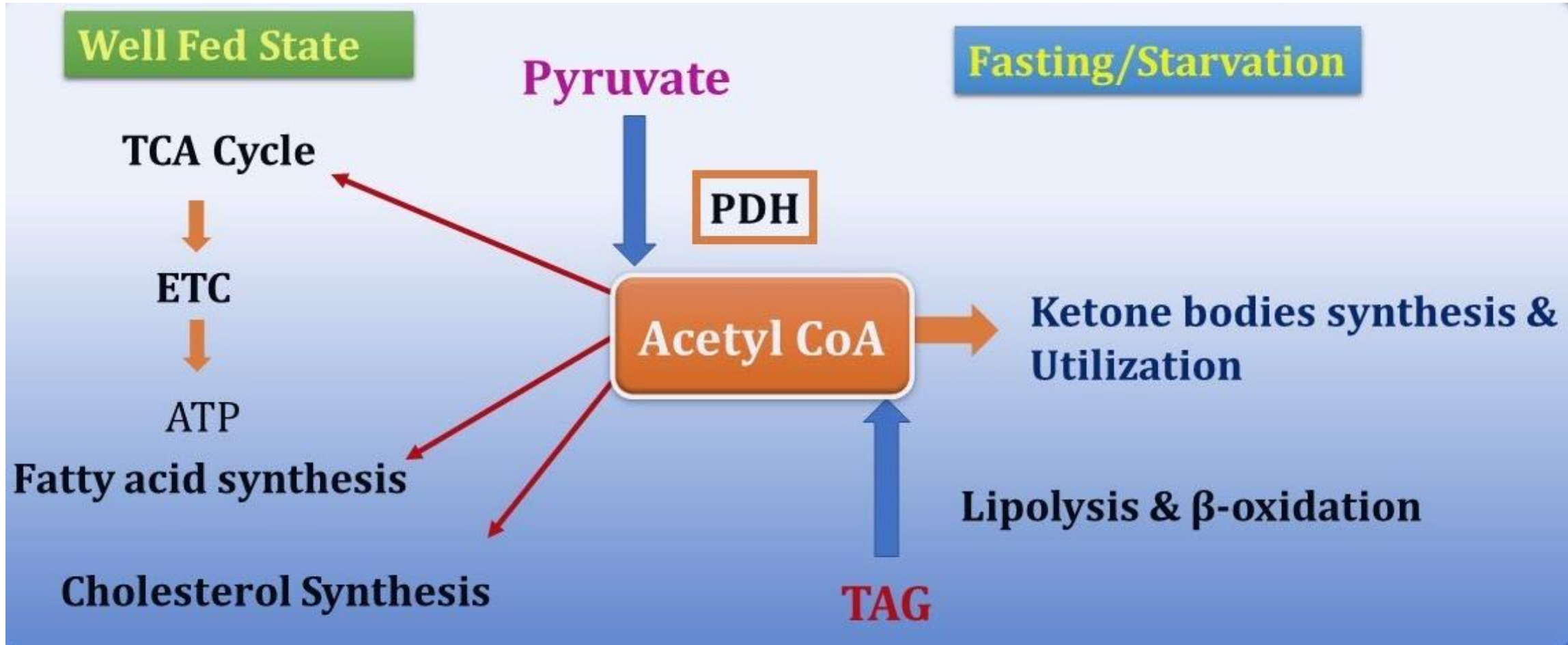
After 7 cycles: 8 acetyl-CoA, 7 NADH, 7 FADH₂.

Net Reaction

Palmitic acid (C₁₆H₃₂O₂) + 23 O₂ + 108 ADP + 108 Pi $\rightarrow$ 16 CO₂ + 16 H₂O + 108 ATP

This provides high energy efficiency compared to glucose oxidation

SUMMARY



REFERENCES



- **Lehninger Principles of Biochemistry** - David L. Nelson, Michael M. Cox, Aaron A. Hoskins Edition: 8th Edition (2021)
- **Harper's Illustrated Biochemistry** - Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil Edition: 32nd Edition (2023)
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- <https://teachmephysiology.com/gastrointestinal-system/liver/protein-and-ammonia-metabolism-in-the-liver/>
- https://www.osmosis.org/notes/Protein_Metabolism

THANK YOU