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

DEPARTMENT OF PHYSICIAN ASSISTANT

COURSE NAME: BIOCHEMISTRY

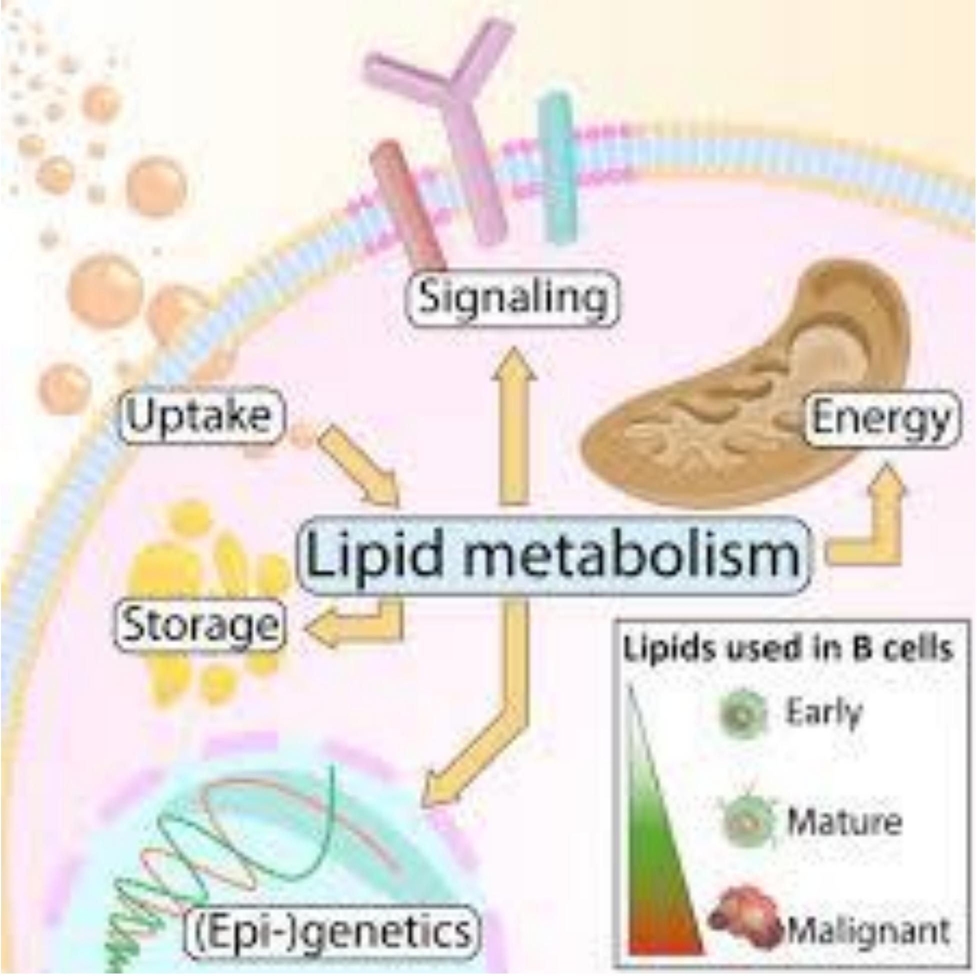
UNIT : 2

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

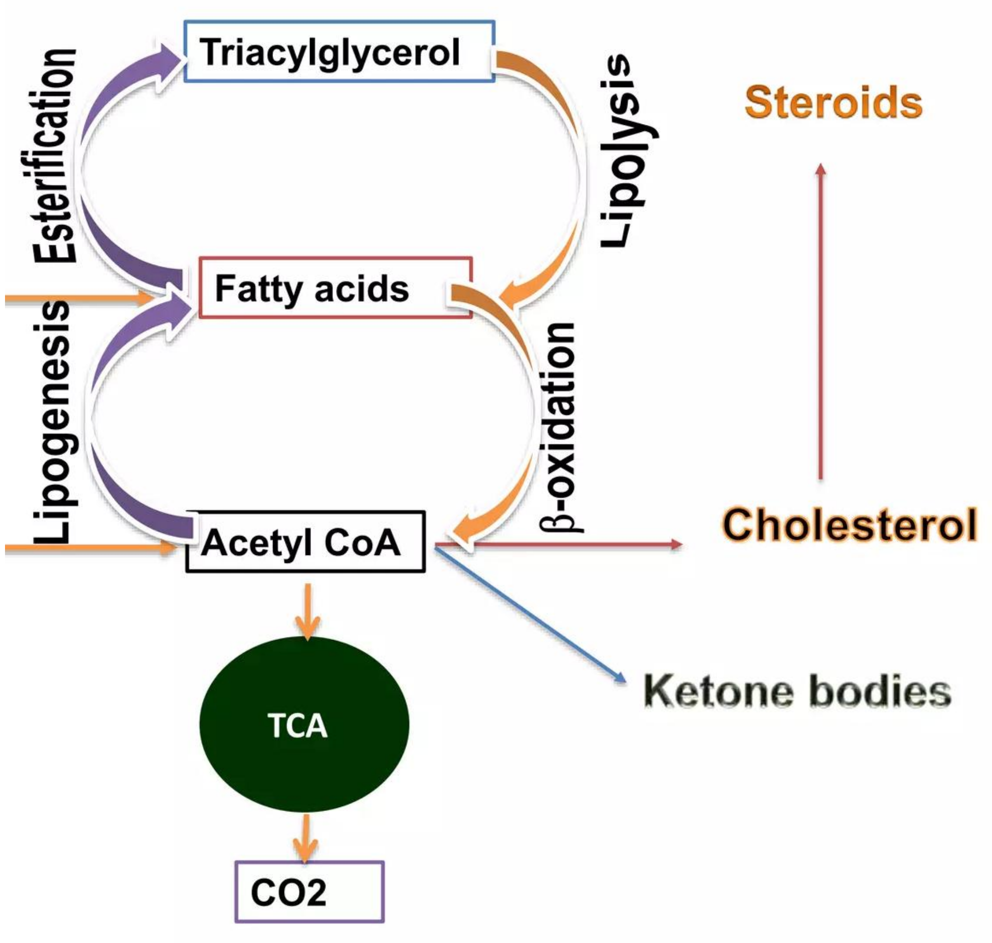
1. Lipolysis (Triglyceride Breakdown)

2. Fatty Acid Oxidation (Beta-Oxidation)

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

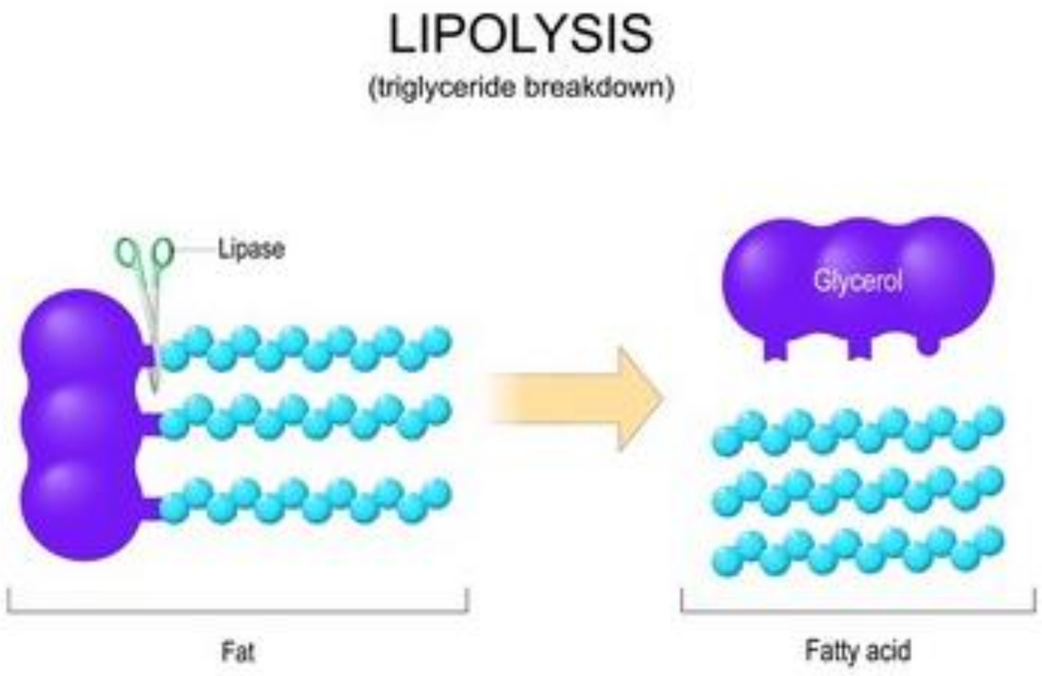
4. Ketogenesis (Ketone Body Synthesis)

5. Cholesterol Synthesis



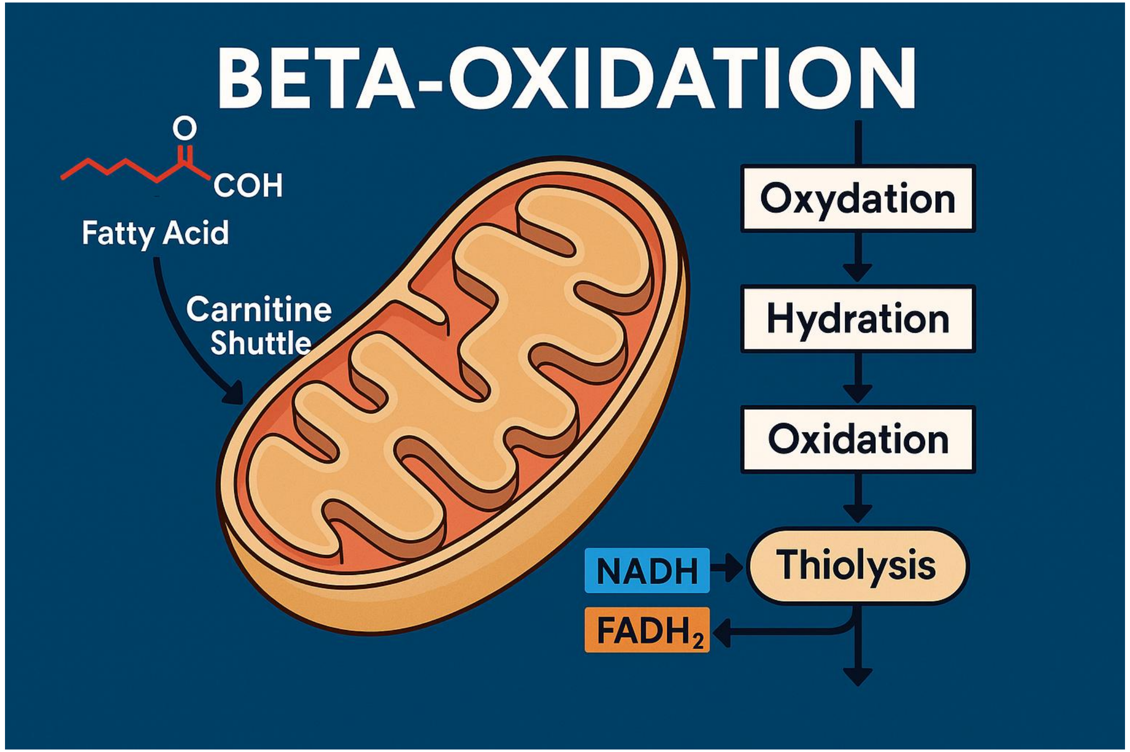
LIPOLYSIS (TRIGLYCERIDE BREAKDOWN)

- 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)



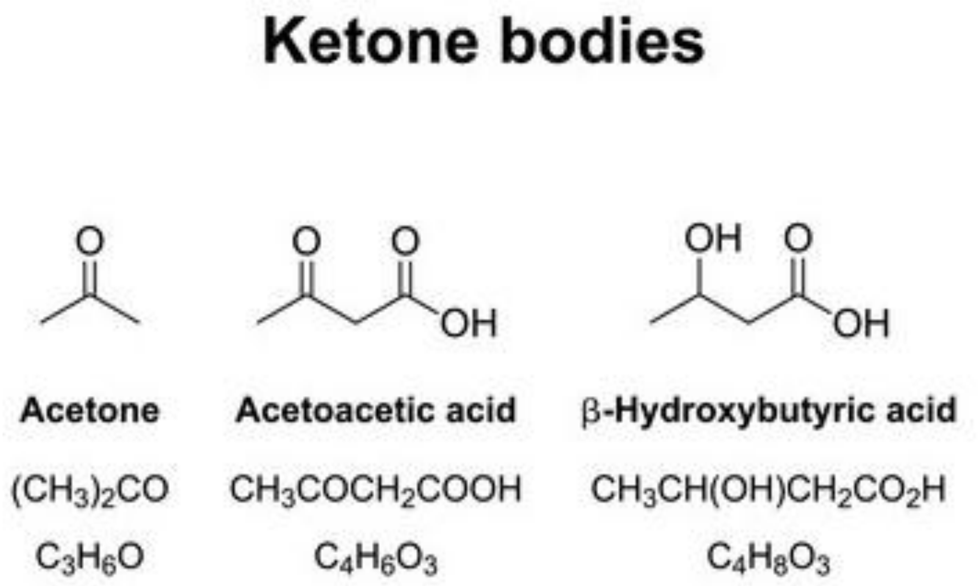
FATTY ACID OXIDATION (BETA-OXIDATION)

- 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, $FADH_2$ (for ATP)

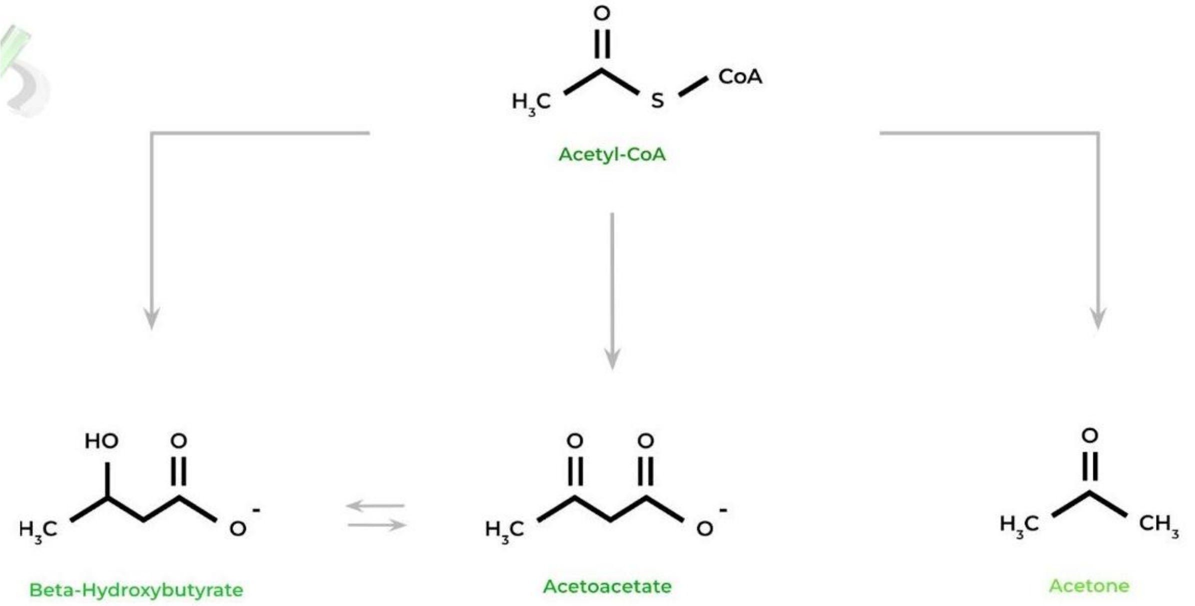


KETOGENESIS (KETONE BODY SYNTHESIS)

- 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).

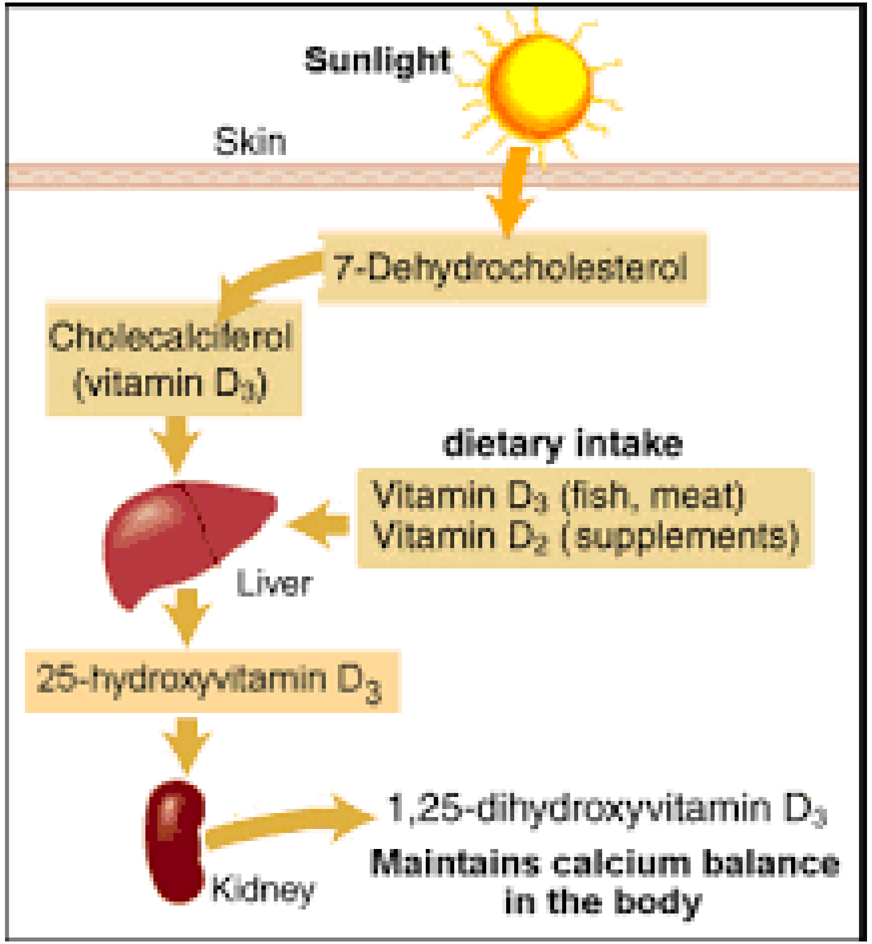


- Ketones are released into blood and used by tissues (especially brain) as alternative fuel
- Converted back to acetyl-CoA → TCA cycle → ATP.
- High ketone levels → Ketosis, uncontrolled diabetes → Ketoacidosis
- **Symptom of high ketones**: Fruity/acetone breath (from exhaled acetone).



CHOLESTEROL SYNTHESIS

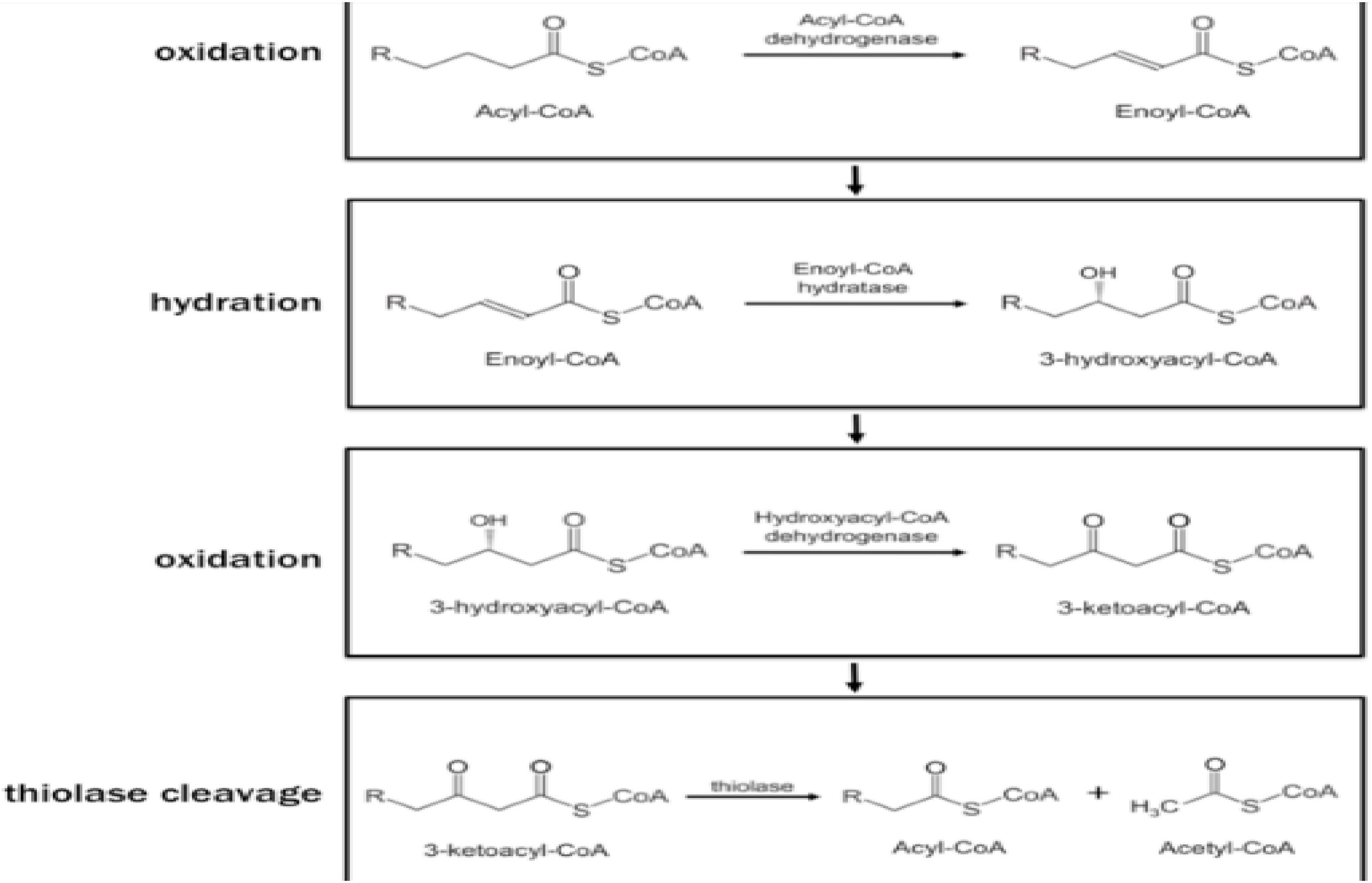
- De novo synthesis mainly in liver
- Via mevalonate pathway from acetyl-CoA
- **Key steps:**
- Acetyl-CoA → HMG-CoA → mevalonate
- Used for membranes, hormones, bile acids, vitamin D

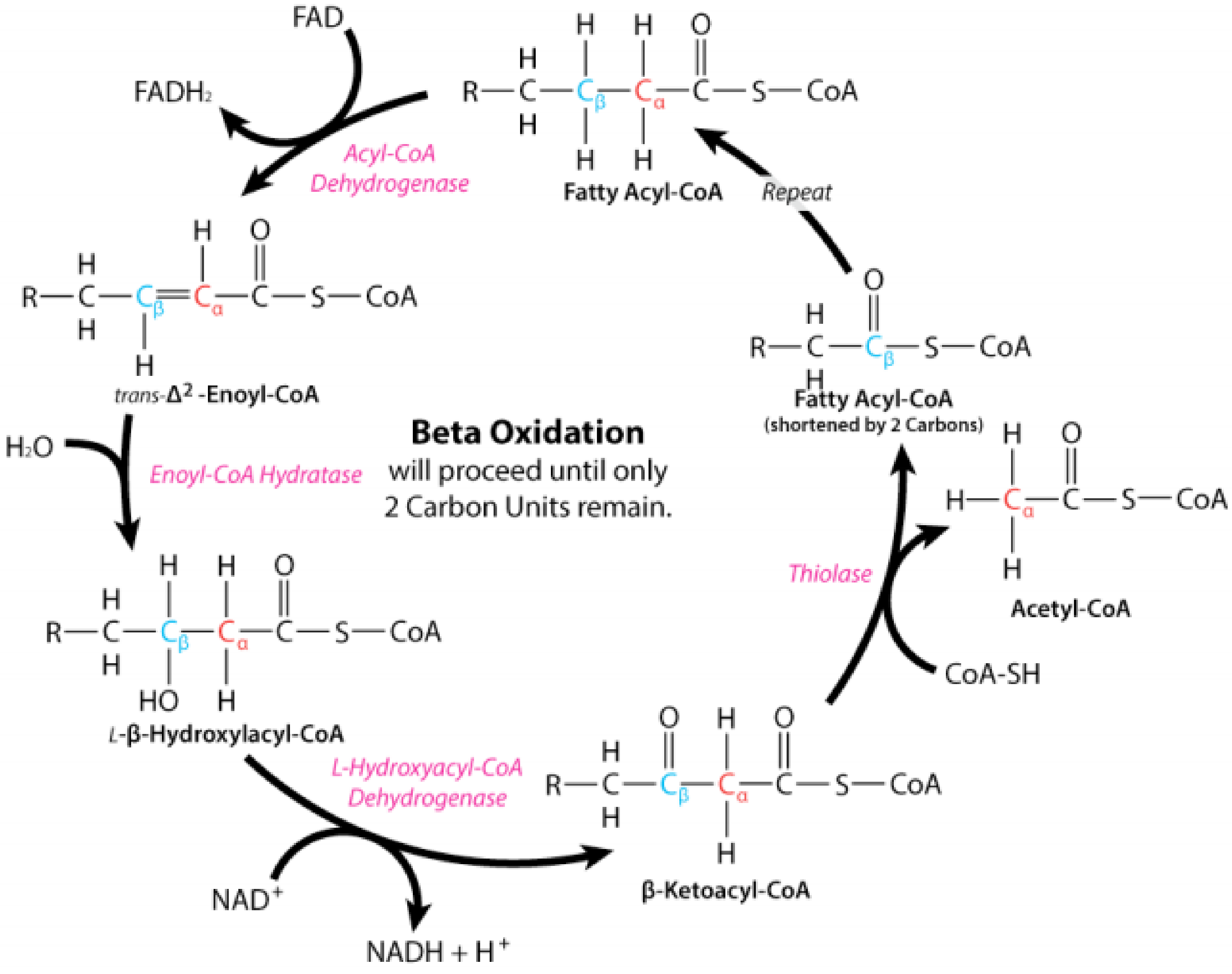


BETA-OXIDATION OF FATTY ACIDS (PALMITIC ACID)

- **Activation**: Palmitic acid + CoA + ATP → Palmitoyl-CoA + AMP + PPi (costs 2 ATP equivalents).
- **Dehydrogenation**: Palmitoyl-CoA → Trans-2-enoyl-CoA + $FADH_2$ (Acyl-CoA dehydrogenase).
- **Hydration**: Trans-2-enoyl-CoA → L-β-hydroxyacyl-CoA (Enoyl-CoA hydratase).
- **Oxidation**: L-β-hydroxyacyl-CoA → β-ketoacyl-CoA + NADH (β-hydroxyacyl-CoA dehydrogenase).
- **Thiolysis**: β-ketoacyl-CoA + CoA → Acetyl-CoA + Shortened acyl-CoA (β-ketothiolase).
- **Steps (per cycle, repeated 7 times for palmitic acid, C16:0)**:

FATTY ACID OXIDATION (BETA-OXIDATION)




FAD
FADH₂
Acyl-CoA
Dehydrogenase
Fatty Acyl-CoA
Repeat
trans-Δ2 -Enoyl-CoA
H₂O
Enoyl-CoA Hydratase
Beta Oxidation
will proceed until only
2 Carbon Units remain.
Fatty Acyl-CoA
(shortened by 2 Carbons)
Acetyl-CoA
Thiolase
CoA-SH
L-β-Hydroxylacyl-CoA
L-Hydroxyacyl-CoA
Dehydrogenase
β-Ketoacyl-CoA
NAD+
NADH + H+

ATP YIELD FROM COMPLETE OXIDATION OF PALMITIC ACID

- Each NADH → ~2.5 ATP
- Each $FADH_2$ → ~1.5 ATP
- Each acetyl-CoA (fully oxidized in the TCA/citric acid cycle) → ~10 ATP
- (3 NADH × 2.5 = 7.5 ATP + 1 $FADH_2$ × 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 $FADH_2$

- **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 NADH × 2.5 ATP/NADH = **17.5 ATP**
  - 7 $FADH_2$ × 1.5 ATP/$FADH_2$ = **10.5 ATP**
  - Total from beta-oxidation reducing equivalents: **28 ATP**

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

8 acetyl-CoA × 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.

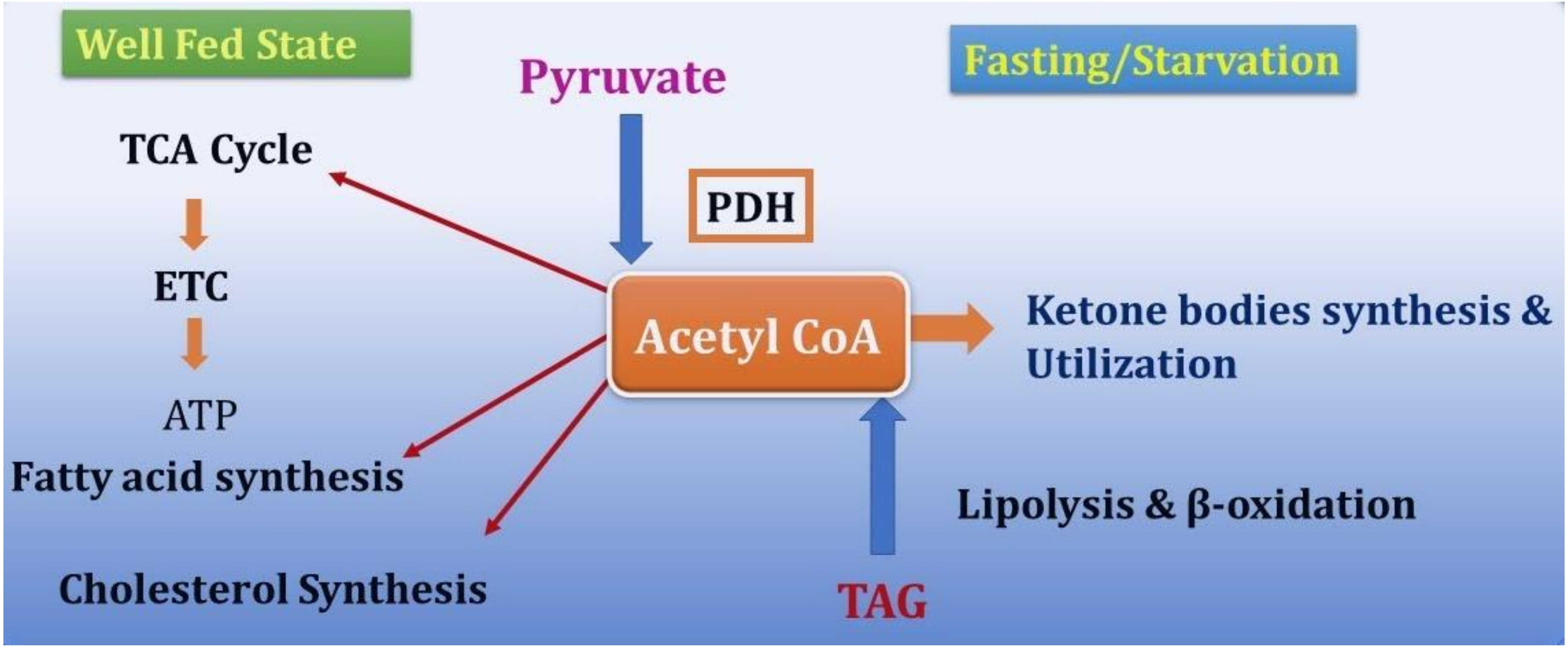
After 7 cycles: 8 acetyl-CoA, 7 NADH, 7 $FADH_2$.

Net Reaction

Palmitic acid ($C_{16}H_{32}O_2$) + 23 O_2 + 108 ADP + 108 Pi → 16 CO_2 + 16 H_2O + 108 ATP

This provides high energy efficiency compared to glucose oxidation

SUMMARY


Well Fed State
Pyruvate
Fasting/Starvation
TCA Cycle
PDH
ETC
Acetyl CoA
Ketone bodies synthesis &
Utilization
ATP
Fatty acid synthesis
Lipolysis & β-oxidation
Cholesterol Synthesis
TAG

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)
- **Textbook of Biochemistry for Medical Students** - DM Vasudevan, Sreekumari S, Kannan Vaidyanathan Edition: 10th Edition (2023)
- https://teachmephysiology.com/gastrointestinal-system/liver/protein-and-ammonia-metabolism-in-the-liver/
- https://www.osmosis.org/notes/Protein_Metabolism

THANK YOU