Biochemistry Wave

Concepts in Biochemistry Simplified with Illustrations

Features

Solving the Biochemistry Puzzle!

- Bullet points and figures for quicker learning and better understanding
- Concepts explained with examples
- Biochemical cycles simplified
- Recent advances in biochemistry covered
- Related points from Medicine (Harrison) and Pharmacology covered
- Quick review of exam based questions from AIPGMEE, DNB-CET, AIIMS and PGI

About the Author

Dr. Soumya Kurup completed her MBBS from Govt. Medical College, Thrissur. She was a topper in AIPGMEE and DNB-CET 2014 and is pursuing MD in Pediatrics from Govt. Medical College, Calicut, Kerala. Her keen interest in Biochemistry and her passion for the subject has lead to the genesis of Biochemistry Wave.

This book has been written by Dr. Soumya Kurup with the intention of making concepts in Biochemistry clear to students and to give readers an extra edge in competitive exams.

Recommended by Toppers and Faculty

"Biochemistry is an important subject for NEET pattern. But we often tend to skip important topics or concepts due to lack of time. Biochemistry Wave offers a solution to this problem by breaking down the theory to points and presenting in a manner that can be understood better, read faster and more importantly can be revised towards the end. It will be useful to all PG aspirants. Good luck!"

Dr. Nimitha P
JR in Dermatology, AIIMS, New Delhi
Rank 33, AIPGMEE 2015 | Rank 55, AIIMS November 2014

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Biochemistry Wave

SOUMYA KURUP

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Biochemistry Wave

Concepts in Biochemistry Simplified with Illustrations

- First Full Color Book for Biochemistry to Crack AIPGMEE/DNB-CET/AIIMS/PGI and All Other PGMEE Exams
- Comprehensively and Concisely Compiled Based on Harper's 30/e, Lippincott's 6/e, Goodman & Gilman's 12/e, Harrison's 19/e and Nelson's 20/e
- Includes Quick Review of High Yield MCQs for Each Chapter

Soumya Kurup

Foreword by Dr. Sreekumari S
Author of D M Vasudevan & Sreekumari S, Textbook of Biochemistry

LETTERWAVE BOOKS

Biochemistry Wave

First Edition

Dr. Soumya Kurup

Contents

EDULANCHE PREVIEW

1 CHAPTER

Contents

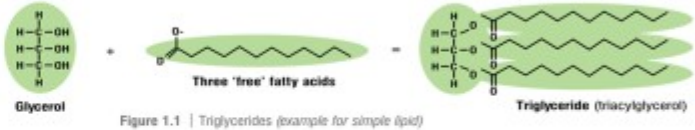


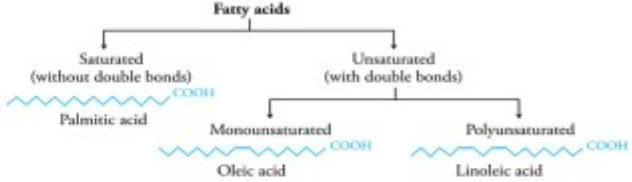
Figure 1.1 | Triglycerides *(example for simple lipid)*

Neutral lipids

- Triglycerides, Cholesterol and Cholesteryl esters are also called neutral lipids as they are uncharged.
- They are uncharged as they do not carry charged (ionisable) groups like phosphates or amino groups.

Fatty Acids

- Fatty acids are *aliphatic carboxylic acids*
- Occur in body mainly as esters in neutral fats and oils; also in unesterified form as free fatty acids in plasma
- Those occurring in natural fats usually contain even number of carbon atoms
- The aliphatic chain may contain double bonds. Accordingly fatty acids are classified into,
  i. Saturated fatty acids: Without double bond and
  ii. Unsaturated fatty acids: With double bond(s)



Saturated fatty acids

	Name	No. of carbon atoms	Present in
SCFA *(Short chain fatty acids)*	Acetic	2	Milk, butter
	Propionic	3	
	Butyric	4	
	Caproic	6	
MCFA *(Medium chain fatty acids)*	Caprylic	8	Coconut oil
	Capric	10	
	Lauric	12	
	Myristic	14	
LCFA *(Long chain fatty acids)*	Palmitic	16	Animal & plant fats
	Stearic	18	

- Cherry red spot is seen in: Tay Sachs, Sandhoffs, GM_1 gangliosidosis, Niemann Pick's, Aryl sulfatase A deficiency, Farber's disease and Gaucher's (rare)
- Cherry red spot is NOT seen in: Fabry's disease, Gaucher type I
- Exaggerated startle (hyperacusis) is seen in: Tay Sachs, Sandhoff
- No hepatosplenomegaly: Tay Sachs, Fabry's
- No mental retardation: Gaucher's type I, Fabry's
- Pulmonary infiltrates are seen in: Niemann Picks

WOLMAN'S DISEASE
- Autosomal recessive inheritance
- Deficiency of lysosomal acid lipase enzyme
- Accumulation of cholesterol esters and triglycerides in histiocytic foam cells of most visceral organs
- Calcification of adrenal glands is pathognomonic

LIPID METABOLISM

Products of digestion of dietary carbohydrate, lipid and protein, i.e., glucose, fatty acids + glycerol and amino acids respectively are metabolized to a common product, acetyl-CoA, which is then oxidised by the citric acid cycle to generate ATP.

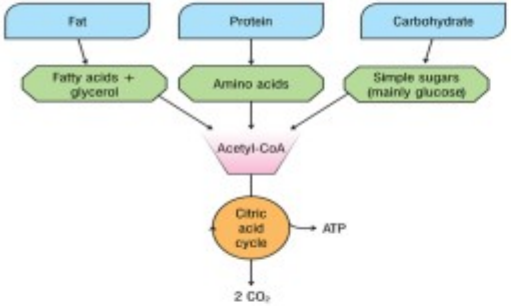


Figure 1.4 Outline of the pathways for the catabolism of fats, proteins & carbohydrates

- Dietary lipid or denovo synthesis (from acetyl CoA derived from metabolism of carbohydrates or amino acids) is the source of long-chain fatty acids.
- Fatty acids may be oxidised to acetyl-CoA (β-oxidation) or undergo esterification with glycerol to form triacylglycerol (fat) which is the main fuel reserve.

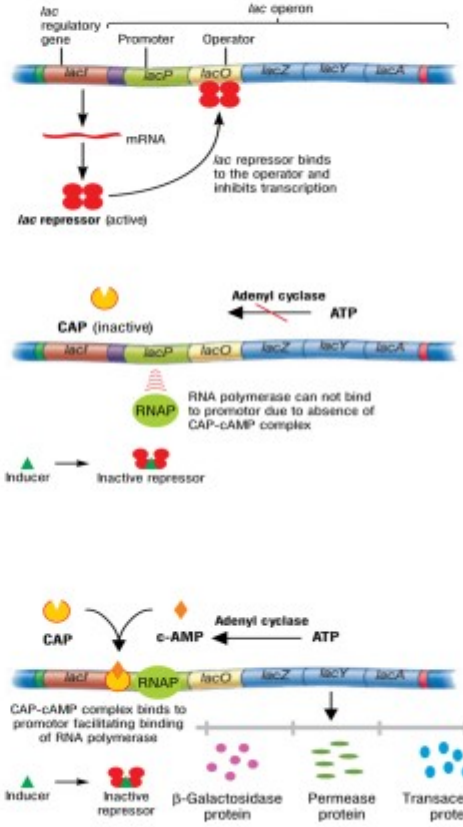
OXIDATION OF FATTY ACIDS

- Longer chain free fatty acids are transported in plasma combined with albumin

β-oxidation is the major pathway by which the long chain of fatty acid molecule is cut from one end, to release two carbon molecule acetyl CoA, one at a time. The process continues till the whole chain is cut. As the chain is broken between α and β carbon it is called β-oxidation.

Beta oxidation

- It is the main oxidative pathway and involves 3 major steps:
  1. Activation of fatty acid
  2. Transport to mitochondria
  3. Beta oxidation in mitochondria



No inducer
(Lactose - - - Glucose + + +)

When there is no inducer, the products synthesized by lacI gene forms a repressor molecule that binds to the operator. This inhibits binding of RNA polymerase and prevents transcription of lacZ, lacY and lacA structural genes into mRNA.

With inducer and glucose
(Lactose + + + Glucose + + +)

- Repressor molecules are conformationally altered by the inducer (lactose) → cannot bind efficiently to the operator locus.
- CAP inactive due to absence of cAMP (glucose inhibits adenylyl cyclase which converts ATP to cAMP)
- So eventhough repressor is inactive, RNA polymerase cannot bind efficiently to promoter due to absence of CAP-cAMP complex
- Hence lac operon is off, structural genes are not transcribed.

With inducer and no glucose
(Lactose + + + Glucose - - -)

- Lactose binds to repressor molecule causing conformational change in it which can no longer bind to operator locus
- Adenylyl cyclise activated in the absence of glucose: cAMP produced
- CAP-cAMP complex binds to promoter facilitating binding of RNA polymerase
- Hence lac operon is on, structural genes are transcribed

Figure 8.16 Lac operon expression according to availability of lactose and glucose.

Activation of fatty acid

- Fatty acid —Acyl CoA synthetase (ligase)→ Acyl CoA
- Requires 2 high energy bonds (*Only step in β oxidation that requires energy from ATP*)
- Occurs in endoplasmic reticulum, peroxisomes and on the outer membrane of mitochondria

Transport of acyl CoA to Mitochondria

- Long chain fatty acids cannot penetrate inner mitochondrial membrane; so they are transported with the help of Carnitine
- *Short chain & medium chain fatty acids do not require carnitine for transport*
- Carnitine palmitoyl transferase I (CPT I) in outer mitochondrial membrane converts acyl CoA to acyl carnitine
- Acyl carnitine is transported across inner mitochondrial membrane by carnitine-acyl carnitine translocase
- Carnitine palmitoyl transferase II (CPT II) in inner mitochondrial membrane converts acyl carnitine back to acyl CoA; carnitine is released
- Carnitine is transported back to outer membrane by carnitine-acyl carnitine translocase

β-oxidation in Mitochondria

- Acyl CoA that enters mitochondria undergoes β oxidation as follows:

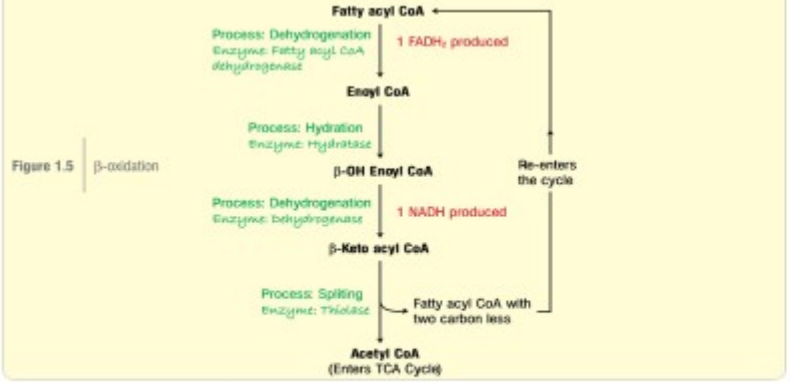
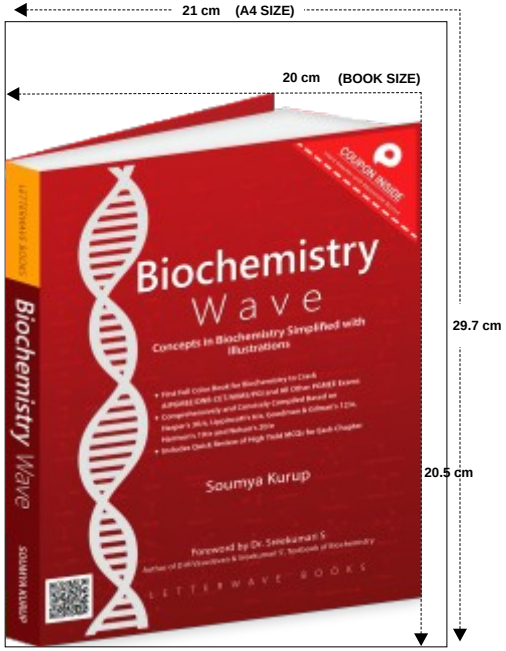


Figure 1.5 β-oxidation

- Acetyl CoA formed via β-oxidation can have three fates,
  i. It is oxidised to CO_2 + H_2O via citric acid (TCA) cycle
  ii. Act as precursor for synthesis of cholesterol and other steroids
  iii. Form ketone bodies (acetoacetate and 3 hydroxybutyrate) in the liver

QUICK REVIEW OF QUESTIONS

1. The fatty acid found exclusively in breast milk among the following is:
   Linoleate
2. Main transporter of cholesterol to peripheral tissues is:
   LDL
3. **Chylomicrons:** Carry exogenous dietary triglycerides to peripheral tissues
4. **VLDL:** Carry endogenous triglycerides from liver to peripheral tissue
5. **HDL:** Esterified cholesterol is carried to the liver where HDL is degraded and cholesterol is removed
6. Liver and RBCs are not able to utilise ketone bodies for energy
7. GPI (Glycosylphosphatidyl inositol) is seen in association with:
   Membrane raft
8. In well fed state the activity of CPT-I in outer mitochondrial membrane is inhibited by:
   Malonyl CoA
9. Which receptor/s are present in the liver for uptake of LDL?
   Apo E and apo B100
10. Enzyme deficient in Refsum's disease is:
    Phytanic alpha oxidase
11. **About LDL receptor:** Liver and many extrahepatic tissues express LDL receptor. Present on cell surface in pits that are coated on the cytosolic side of cell membrane with a protein called clathrin. It is taken into the cells by endocytosis. Increased cellular cholesterol down regulates the synthesis of LDL receptors
12. Glycosphingolipid is made up of:
    Glucose, sphingosine, fatty acids
13. Organelles of hepatocyte where elongation of long chain fatty acids take place:
    ER and mitochondria
14. Gangliosides consist of:
    Long chain fatty acids (usually c18-24), alcohol sphingosine, a carbohydrate moiety which contains
    1. glucose or galactose,



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