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Lipids

Biochemistry

Definition, classification and functions of lipids, fatty acids, triglycerides, phospholipids, cholesterol, digestion, absorption and lipid metabolism.

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CHAPTER 04

Lipids

Fatty acids, triglycerides, phospholipids, cholesterol and digestion

1. Definition and classification

Lipids are a diverse group of hydrophobic or amphipathic biomolecules that are poorly soluble in water and soluble in appropriate organic solvents. They are important for energy storage and cell structure.

Traditional class	Examples
Simple lipids	Triacylglycerols (fats and oils), waxes
Complex lipids	Phospholipids, glycolipids, lipoprotein complexes
Derived lipids	Fatty acids, sterols, lipid-derived signalling compounds

2. Fatty acids

Fatty acids contain a carboxyl group and a hydrocarbon chain. Saturated fatty acids have no carbon-carbon double bonds; monounsaturated have one; polyunsaturated have more than one. Cis double bonds introduce bends; trans configurations are straighter. Essential fatty acids are linoleic acid (omega-6) and alpha-linolenic acid (omega-3). EPA and DHA are long-chain omega-3 fatty acids; endogenous conversion from alpha-linolenic acid is limited.

3. Major lipid types

Lipid	Structure / function
Triglyceride	Glycerol + three fatty acids; major energy storage form
Phospholipid	Amphipathic head and hydrophobic tails; membrane bilayer
Glycolipid	Lipid with carbohydrate group; cell recognition and nervous tissue
Cholesterol	Sterol; membrane fluidity and precursor of bile acids, steroid hormones and vitamin D
Eicosanoids	Lipid-derived local mediators; inflammation, vascular tone and platelet regulation

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4. Functions

Lipids provide approximately 9 kcal/g, store energy in adipose tissue, protect organs and help insulate the body. Membrane lipids maintain cellular barriers and participate in signalling. Dietary fat supports absorption of vitamins A, D, E and K. Essential fatty acids are required for normal membrane and signalling functions.

5. Digestion and absorption

- Lingual and gastric lipases initiate some fat digestion; the small intestine is the main site in adults.
- Bile salts emulsify fat droplets. They are not enzymes.
- Pancreatic lipase with colipase converts triglycerides mainly into free fatty acids and 2-monoacylglycerol. Other enzymes digest phospholipids and cholesterol esters.
- Mixed micelles deliver lipid products to enterocyte surfaces. Long-chain fatty acids are re-esterified and packaged with apolipoproteins into chylomicrons.
- Chylomicrons move through lymphatic lacteals to systemic blood. Shorter-chain fatty acids can enter portal blood more directly.

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- Most bile acids are reabsorbed in the terminal ileum and recycled via the enterohepatic circulation.

6. Overview of lipid metabolism

Lipolysis mobilizes stored triglycerides; fatty acids undergo beta-oxidation to produce acetyl-CoA, NADH and FADH2. In the fed state excess energy may support triglyceride synthesis. The liver makes ketone bodies during prolonged fasting or insulin deficiency. Lipoproteins transport lipids in blood (see Chapter 10).

7. Saturation, configuration and nutritional importance

Saturated fatty acids have no carbon-carbon double bonds; monounsaturated fatty acids have one and polyunsaturated fatty acids have two or more. Naturally occurring unsaturated fatty acids are commonly cis, producing bends that influence membrane fluidity. Industrial trans fats increase cardiovascular risk. Linoleic acid (omega-6) and alpha-linolenic acid (omega-3) are essential fatty acids.

8. Structure of major lipids

Lipid	Structural features	Function
Triacylglycerol	Glycerol esterified with three fatty acids	Concentrated energy reserve
Glycerophospholipid	Glycerol, two fatty acids, phosphate-containing head	Membrane bilayer and signalling
Sphingolipid	Sphingoid backbone; variable head group	Membranes and neural tissue
Cholesterol	Four fused rings and hydroxyl group	Membrane fluidity and precursor for steroids, bile acids and vitamin D
Glycolipid	Lipid with carbohydrate group	Cell recognition and membrane structure

Cell membrane

Phospholipids are amphipathic: they contain a water-attracting head and water-avoiding region. In aqueous environments they form bilayers. Cholesterol modifies membrane properties; membrane proteins mediate transport, receptors and cell adhesion.

9. Lipid digestion: sequence

Dietary fat -> emulsification by bile salts -> enzyme digestion -> mixed micelles -> enterocyte uptake -> re-esterification -> chylomicron secretion -> lymph -> blood. Micelles assist delivery to enterocytes but are not absorbed intact as chylomicrons.

10. Clinical importance and nursing applications

Steatorrhoea (greasy stools) may result from fat malabsorption due to pancreatic, biliary or intestinal disease. Dyslipidaemia increases cardiovascular risk; severe hypertriglyceridaemia can increase pancreatitis risk. Cholestasis may impair absorption of fat-soluble vitamins. Assess diet, stool characteristics and weight; support prescribed dietary and lipid monitoring plans.

11. Important Examination Questions

Long Answer Questions

1. 1. Classify lipids and explain their digestion and absorption.
2. 2. Describe fatty acids, triglycerides, phospholipids and cholesterol.
3. 3. Explain the clinical significance of fat malabsorption and lipid transport.

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Short Answer Questions

1. 1. Write a short note on Essential fatty acids.
2. 2. Write a short note on cholesterol functions.
3. 3. Write a short note on phospholipids.

Very Short Answer Questions

1. 1. Which two fatty acids are essential? - Linoleic and alpha-linolenic acids.
2. 2. Name the main dietary lipid storage form. - Triacylglycerol.
3. 3. What is steatorrhoea? - Excess fat in stool, often causing greasy stools.
4. 4. What is a micelle? - An aggregate that helps solubilize lipid digestion products.

Additional objective question

What emulsifies fat? - Bile salts.

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12. Quick Revision

- Lipids supply about 9 kcal/g.
- Bile salts aid emulsification; pancreatic lipase hydrolyses triglycerides.
- Long-chain dietary lipids generally leave the intestine in chylomicrons.
- Phospholipids and cholesterol are important membrane constituents.

Conclusion

Lipid chemistry explains energy storage, membrane structure, lipid absorption and clinically important disorders of fat transport and metabolism.

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Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. Which substance emulsifies dietary fats without acting as an enzyme?

A. Pancreatic lipase
B. Pepsin
C. Trypsin
D. Bile salts

2. Which particles carry long-chain dietary lipids from enterocytes through lymphatic lacteals?

A. LDL
B. Chylomicrons
C. HDL
D. VLDL

3. Which lipid is a precursor of bile acids, steroid hormones and vitamin D?

A. Cholesterol
B. Triglyceride
C. Glycerophospholipid
D. Sphingolipid

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Answer key and explanations

1. D - Bile salts

Bile salts emulsify droplets but are not enzymes.

2. B - Chylomicrons

Chylomicrons move from the intestine through lymphatic lacteals into blood.

3. A - Cholesterol

Cholesterol is a sterol with these precursor functions.

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