King Saud University
College of Sciences
Biochemistry Department

الأيض (١)
Metabolism (1)
BCH 340

Lecture 13: Biosynthesis of triglyceride

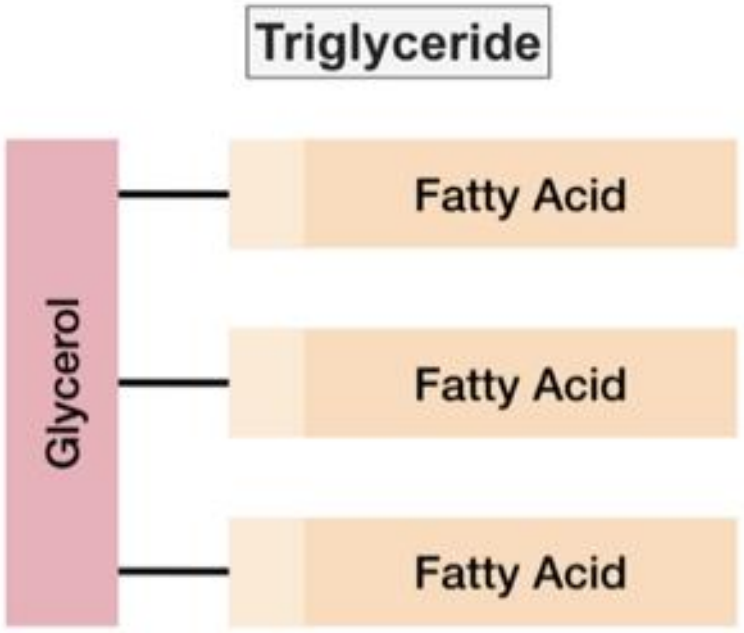
Intended learning outcomes (ILOs)

By the end of this lecture, students will be able to:

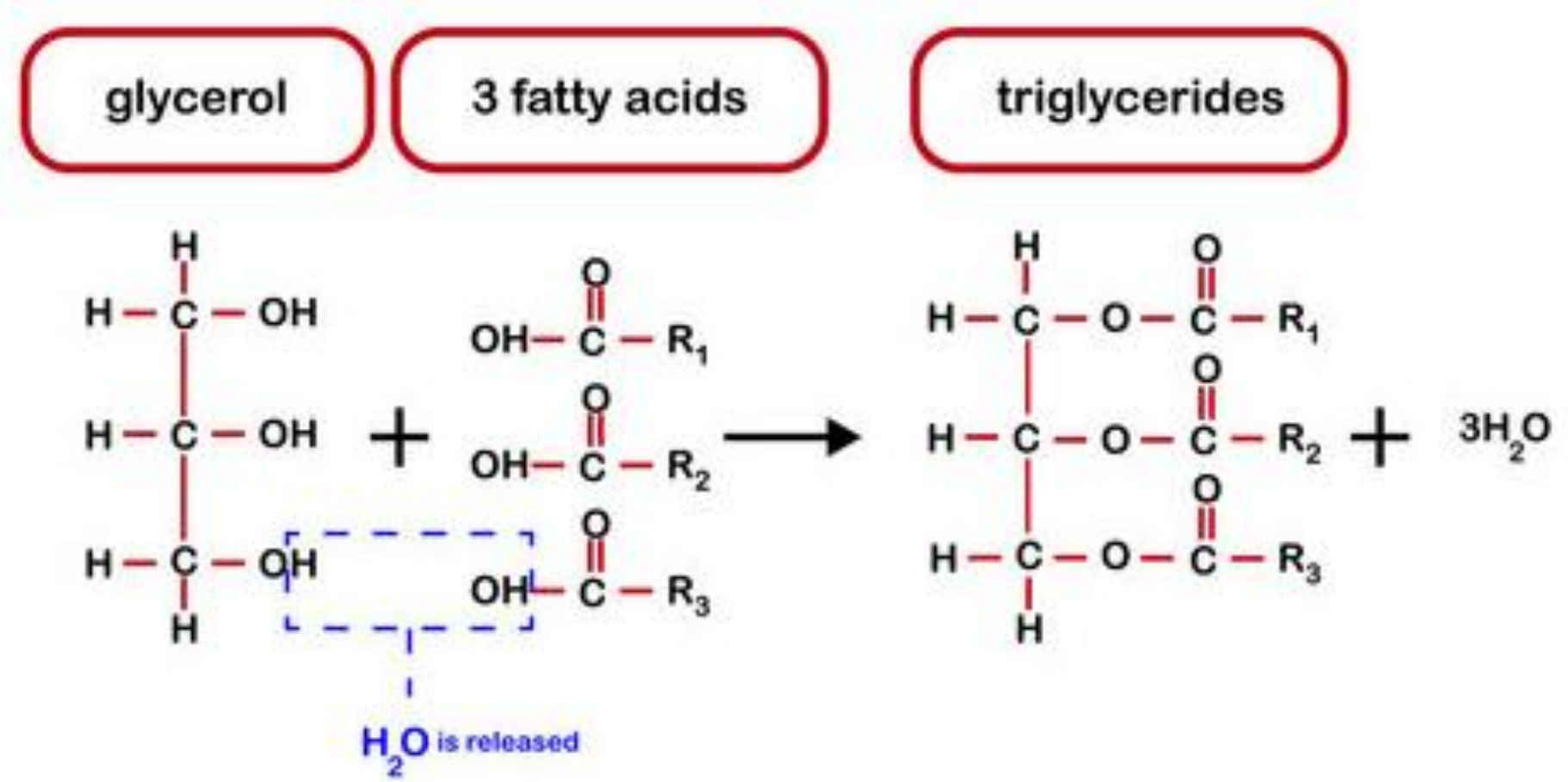
- Understand the biochemical pathways involved in the biosynthesis of triglycerides.
- Explain the role of glycolysis in providing precursor molecules for triglyceride synthesis.
- Identify the key enzymes involved in triglyceride biosynthesis.

Triglyceride (triacylglycerols)

- Triglycerides (commonly known as neutral fats) are the most common type of fat in the body and serve a crucial role in the storage of metabolic energy.
  - With a high energy content of approximately 38 kJ/g, they are primarily stored in adipose tissue throughout the body.
- Triglycerides are composed of three fatty acid molecules esterified to a glycerol backbone.



Formation of triglyceride



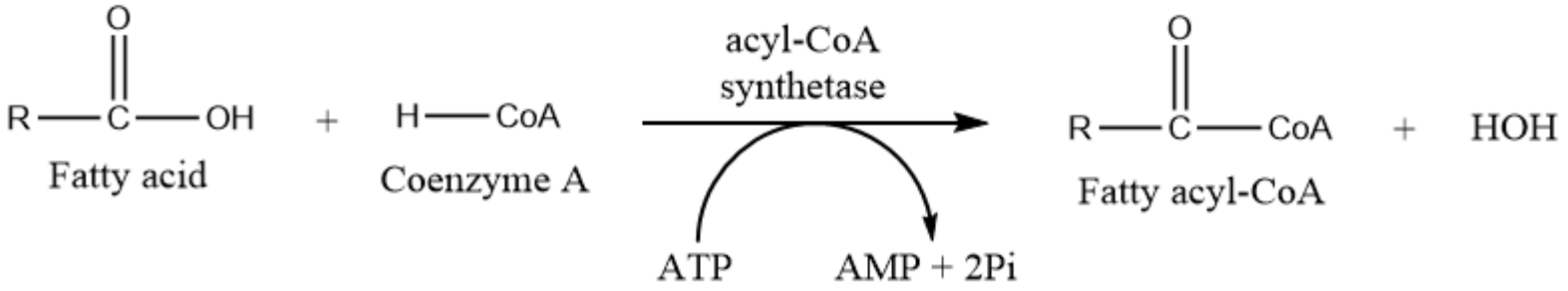
Biosynthesis of triglyceride

- The biosynthesis of triglycerides primarily occurs in the liver and adipose tissue. It involves two main precursors:
  - Glycerol 3-phosphate
  - Fatty acyl-CoA molecules
- During synthesis, these precursors undergo a series of enzymatic reactions, leading to the formation of a phosphatidic acid intermediate.
  - This intermediate serves as a key step in the synthesis pathway of triglycerides.

Biosynthesis of triglyceride (cont.)

Fatty acid activation:

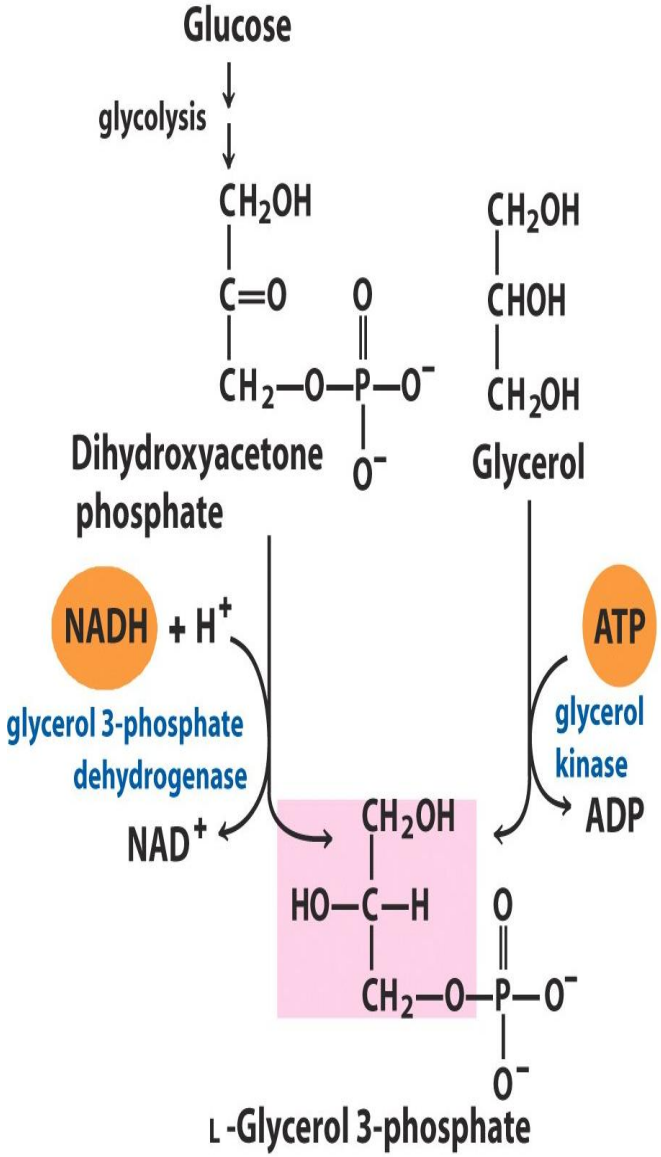
- Before incorporation into triglycerides, fatty acids must be activated. This occurs in the cytoplasm, where fatty acids are attached to coenzyme A (CoA) to form fatty acyl-CoA molecules.
- This step requires ATP and is catalyzed by fatty acyl-CoA synthetase.



Biosynthesis of triglyceride (cont.)

Formation of Glycerol-3-phosphate:

- Glycerol-3-phosphate is a precursor for the glycerol backbone of triglycerides. It can be derived from:
  - Glucose through glycolysis (mainly in adipose tissue).
  - Glycerol through glycerol kinase (active in liver, kidney, intestine and mammary gland).



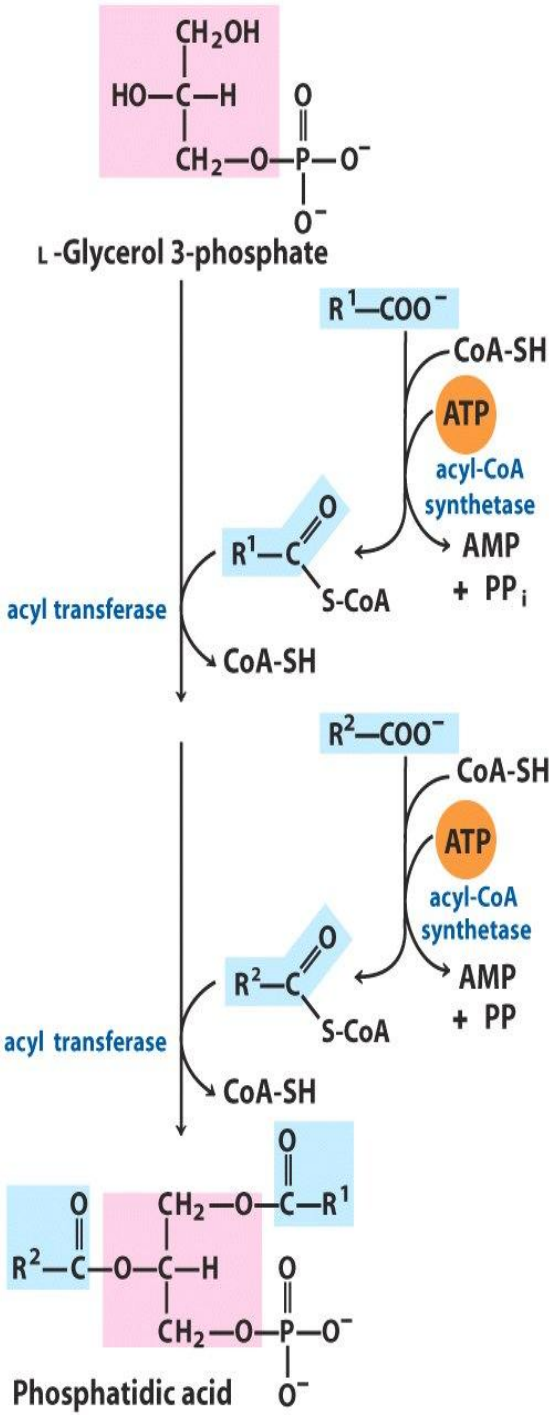
Biosynthesis of triglyceride

Acylation of glycerol-3-phosphate:

- The acylation of glycerol-3-phosphate (by the action of acyl transferase) involves the addition of two fatty acyl-CoA molecules to form phosphatidic acid (also known as diacylglycerol phosphate).

- In many cases, the fatty acid chain attached to C1 of the glycerol backbone is saturated, while the fatty acid chain attached to C2 is unsaturated, containing one or more double bonds.

    - This structural arrangement contributes to the fluidity and flexibility of cell membranes (where phosphatidates are abundant).



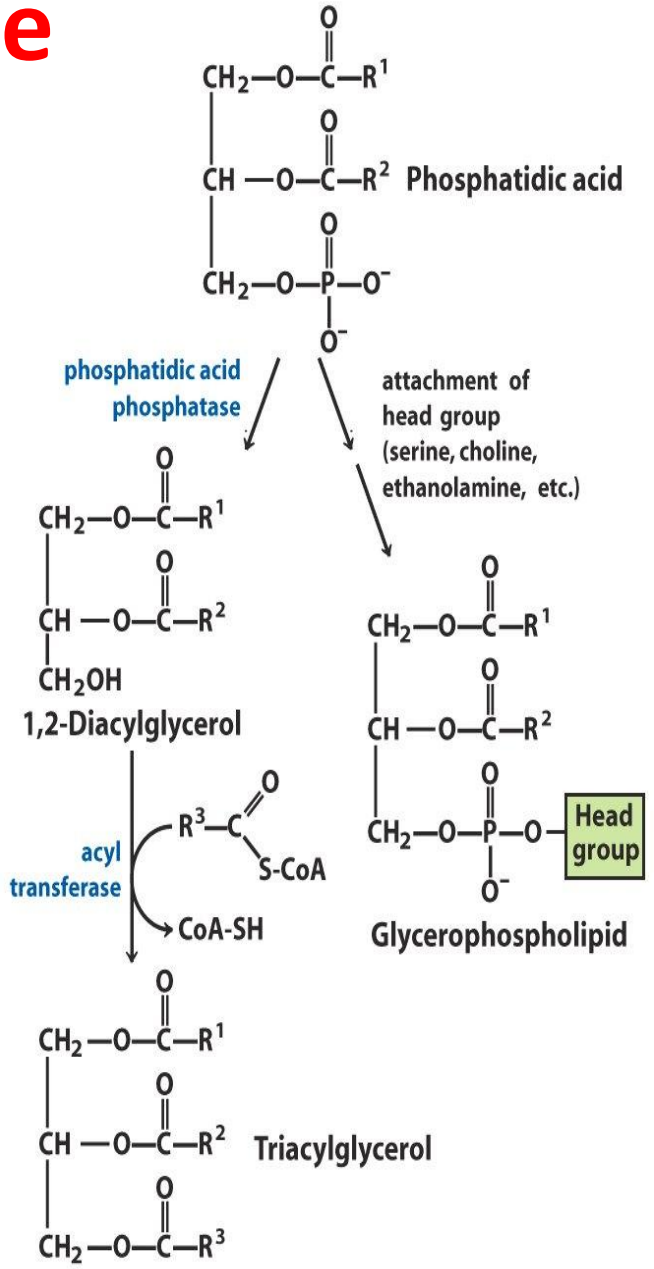
Biosynthesis of triglyceride

Dephosphorylation of phosphatidic acid:

- Phosphatidic acid is dephosphorylated by phosphatidate phosphatase, resulting in the release of a phosphate group.
  - This step yields diacylglycerol, which serves as a precursor for triglyceride synthesis.

Acylation of diacylglycerol:

- Finally, the third fatty acyl-CoA molecule is added to diacylglycerol, catalyzed by diacylglycerol acyltransferase. This forms the triglyceride molecule.

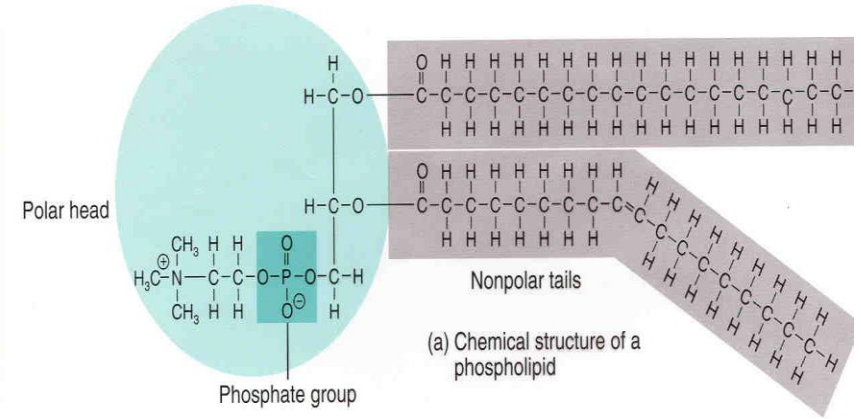


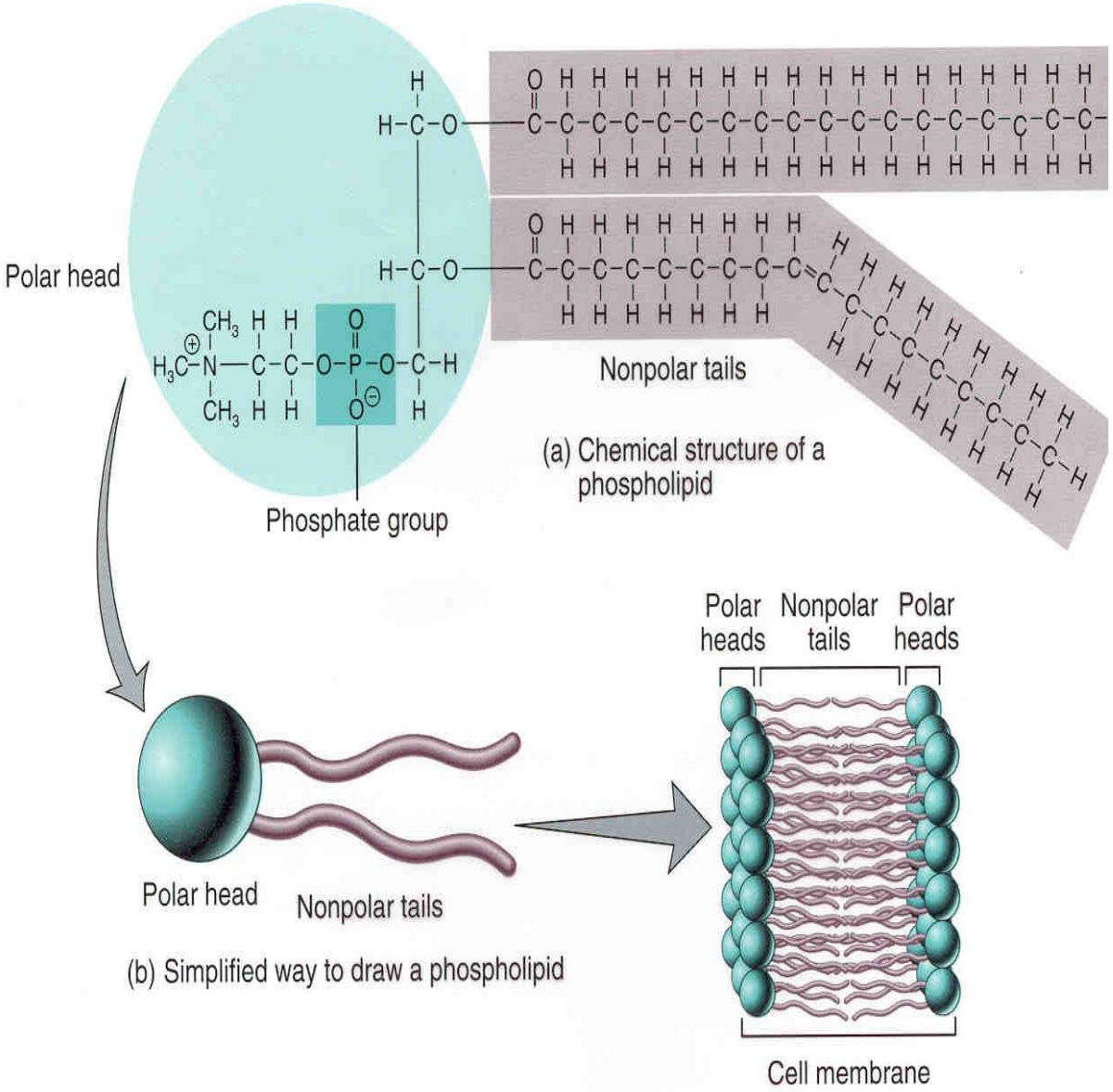
Phospholipids

- Phospholipids are a major component of cell membranes. They consist of a glycerol backbone, two fatty acid chains, a phosphate group, and a polar head group.
- Phospholipids have a saturated fatty acid on C-1 and an unsaturated fatty acid on C-2 of the glycerol backbone.

Note:

- In phospholipids, the phosphate group replaces the fatty acid attached to C3 on the glycerol molecule.



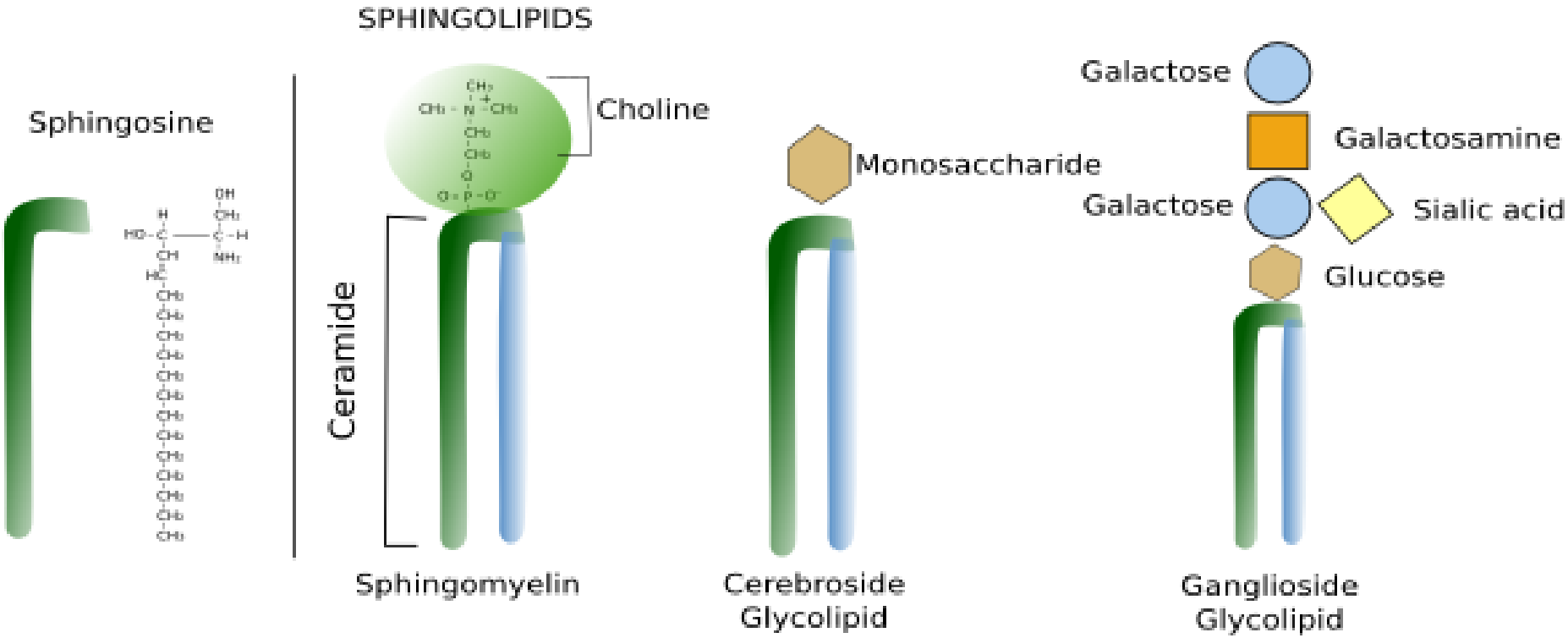

Polar head
Phosphate group
Nonpolar tails
(a) Chemical structure of a phospholipid
Polar heads
Nonpolar tails
Polar heads
Polar head
Nonpolar tails
(b) Simplified way to draw a phospholipid
Cell membrane

Glycolipids

- Glycolipids are a type of lipid molecule that consists of a lipid (fatty acid) tail linked to a carbohydrate moiety.
- They are found predominantly in cell membranes and play important roles in cell recognition and signaling.
- Glycolipids are synthesized in the endoplasmic reticulum (ER) and Golgi apparatus through complex enzymatic pathways involving lipid and carbohydrate metabolism.
  - In the ER, the initial steps of glycolipid synthesis occur, including the assembly of the lipid portion of the molecule.
  - Then, these precursor molecules are transported to the Golgi apparatus, where further modifications take place, such as the addition of carbohydrates to form the final glycolipid structure.

Molecular structure of some abundant sphingolipids in eukaryotic membranes

- Most membrane glycolipids in animal cell membranes are sphingolipids.



Thank you