

Advanced Cell Biology. Lecture 5

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Outline

Polysaccharides

Fatty acids and lipids

- Storage lipids: oils and fats

- Membrane lipids

- Signal lipids: sterols and others

- Lipid vitamins

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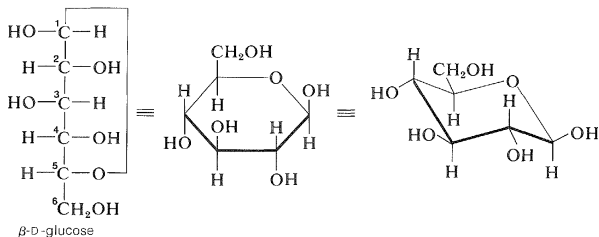
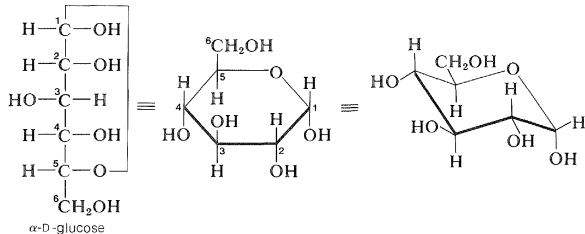
Previous final question: the answer

What is the difference between α - and β - glucose?

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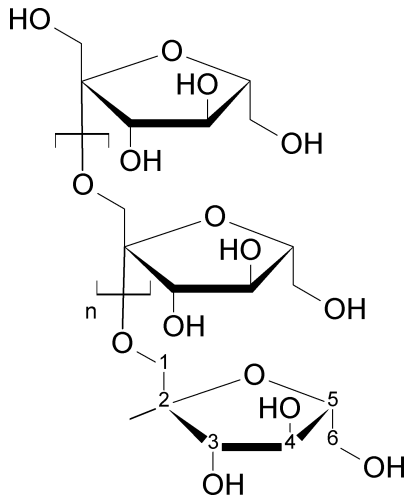
Orientation of rightmost -OH group

α - and β - glucose (again)

Inulin

- ▶ Polymer of fructose, often has a fibrous structure
- ▶ Typically, occurs in many plants of sunflower family (e.g., *chicory*, *dandelion* or *Jerusalem artichoke*)

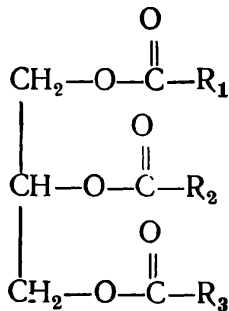
Inulin structure



Storage lipids: oils and fats

- ▶ Fatty acids are massive ($C > 15$) hydrocarbon acids
- ▶ Oils and fats are esters (complex ethers) of glycerol and (often different) fatty acids: **triacylglycerols**, or **triglycerides**
- ▶ Stable, hydrophobic and high-energetic molecules

Triacylglycerols (triglycerides)



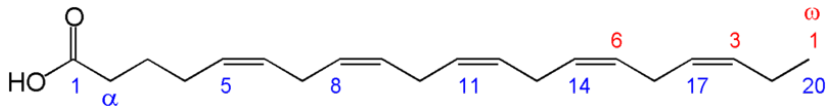
Diversity of fatty acids

- ▶ Saturated: contain only single bonds between carbons
- ▶ Unsaturated: contain also double bonds
- ▶ Unsaturated typically have bend chain, and much lower melting temperature
- ▶ Trans fats contain hydrogenated unsaturated oils

Examples of fatty acids

- ▶ *Palmitic* acid (C_{15}): from animal fats
- ▶ *Stearic* acid (C_{17}): from animal fats
- ▶ *Oleic* acid ($C_9 = C_8$): from olive
- ▶ *Linoleic* acid ($C_6 = C_3 = C_8$): from flax
- ▶ *Omega-3* fatty acids are considered now as important health factors

EPA, eicosapentaenoic acid

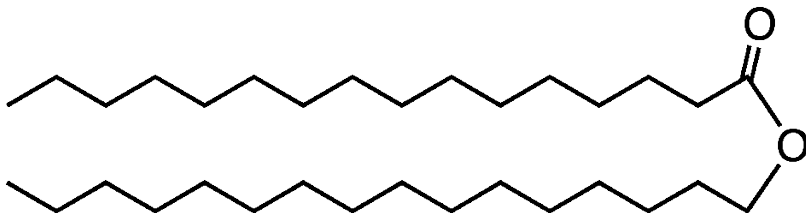


Produces statistically insignificant decrease in human depression

Waxes

- ▶ Waxes are esters of fatty acids and fatty alcohols (alcohols with long chains)
- ▶ Have high melting temperatures
- ▶ Use as structural and protective molecules, both in animals and plants

Cetyl palmitate wax

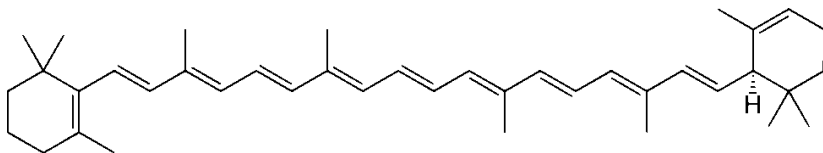


Primary constituent of spermaceti, the wax found in the skull of sperm whales

Plant lipids: isoprenoids

- ▶ Derivatives of isoprene, $\text{CH}_2=\text{CH}(\text{CH}_3)=\text{CH}_2$
- ▶ Simple polyisoprenoids (*terpenes*) form some aroma compounds
- ▶ Complex polyisoprenoids (*terpenoids*) are carotenes and other plant pigments, and also components of latex

α -carotene



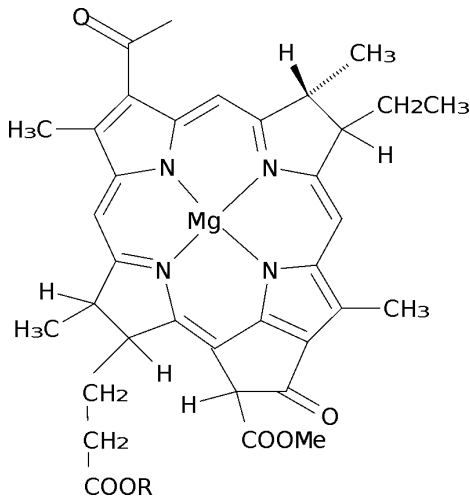
Porphyrins

- ▶ Occur in plants and animals
- ▶ Easily form complexes with metals and gases
- ▶ *Chlorophyll* and *heme* (red blood pigment) are examples of porphyrins

└ Fatty acids and lipids

└ Storage lipids: oils and fats

Bacteriochlorophyll *a*



Membrane lipids

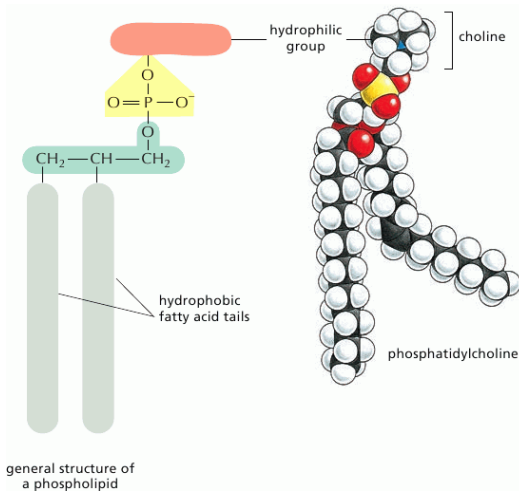
- ▶ Membrane lipids are structural units of membrane double layer
- ▶ Their chemical structure is similar to triacylglyceroles (fats) but one of fatty acids is replaced with other molecule

Phospholipids

- ▶ Phospholipids are esters of glycerol (or sphingoside), fatty acids and phosphorous acid
- ▶ Head + two tails structure
- ▶ Glycerol + phosphate head is hydrophilic whereas fatty acid tail is hydrophobic

- └ Fatty acids and lipids
 - └ Membrane lipids

Phospholipids

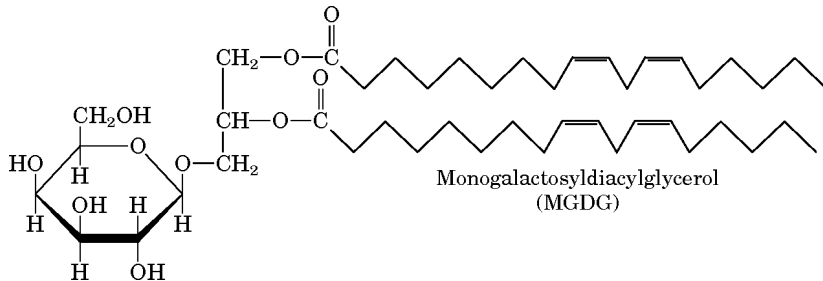


Glycolipids

- ▶ Glycolipids have two hydrocarbon tails and sugar head
- ▶ Often occur in plant cells, especially in chloroplasts

- └ Fatty acids and lipids
 - └ Membrane lipids

Glycolipids

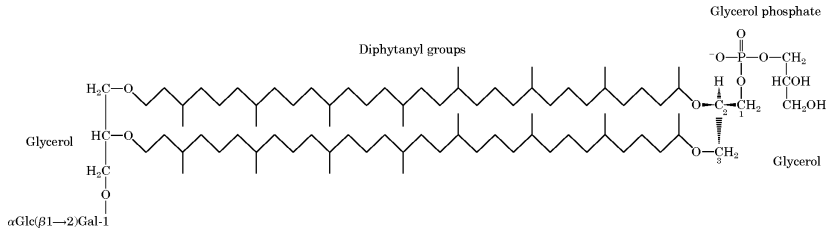


Archaea membrane lipids

- ▶ Archaea (or archebacteria) have highly specific biochemistry
- ▶ Their membranes contain glycerol dialkyl glycerol tetraethers (GDGTs) which are double esters (have glycerol from both ends) and span the whole membrane
- ▶ These membranes are much more stable to high temperatures and low pH

- └ Fatty acids and lipids
- └ Membrane lipids

Glycerol dialkyl glycerol tetraethers (GDGTs)

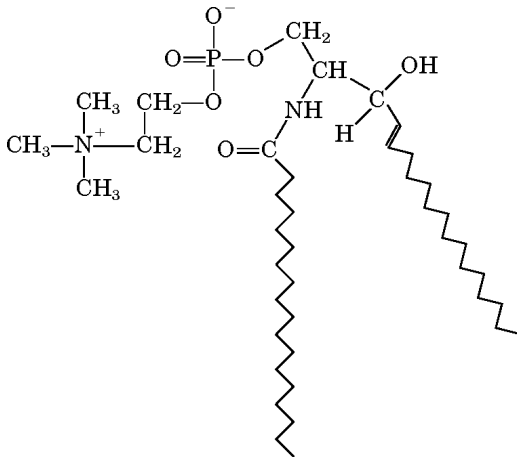


Sphingolipids

- ▶ Sphingolipids are composed of one *sphingosine* (long chain amino-alcohol), one polar head and one fatty acid
- ▶ Again, head + two tails structure
- ▶ Sphingolipids in the membrane are important sites of biological recognition; nervous cells are especially rich of sphingolipids

- └ Fatty acids and lipids
- └ Membrane lipids

Sphingomyelin



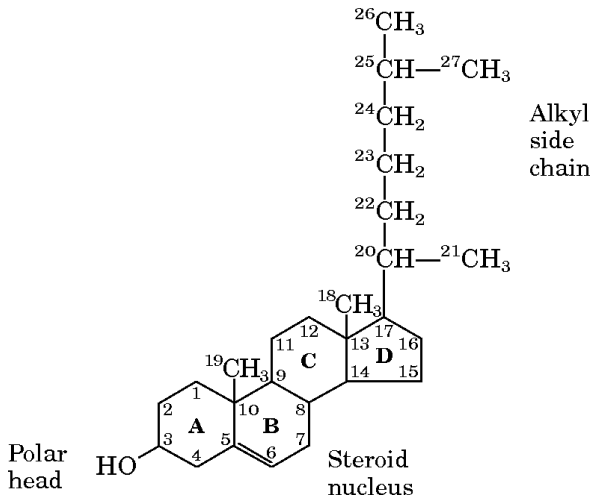
Sphingomyelin

Cholesterol

- ▶ Cholesterol is a *sterol*: molecule with four fused carbon rings
- ▶ One of main components of membrane, and also precursor to steroid hormones and other molecules
- ▶ Coronary disease is directly connected with cholesterol metabolism

- └ Fatty acids and lipids
- └ Membrane lipids

Cholesterol

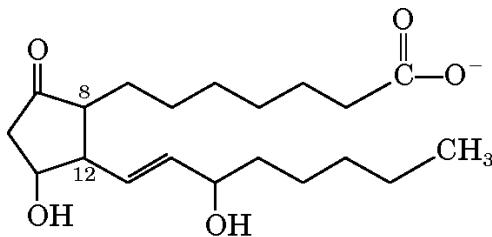


Eicosanoids: derivatives of fatty acids

- ▶ *Eicosanoids* are hormones—biochemical signals
- ▶ They are structurally similar to membrane lipids
- ▶ Some of them, e.g., *prostaglandins*, play important physiological roles

- └ Fatty acids and lipids
 - └ Signal lipids: sterols and others

Prostaglandin, one of eicosanoids



Prostaglandin E₁
(PGE₁)

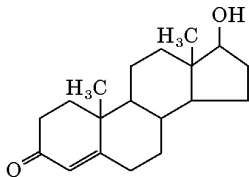
- └ Fatty acids and lipids
- └ Signal lipids: sterols and others

Steroids

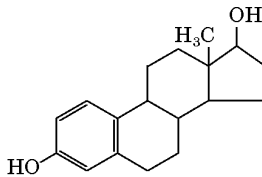
- ▶ *Steroids* are derivatives of *sterols* (mostly cholesterol)
- ▶ Occur both in plants and animals
- ▶ Have high specificity to receptors and therefore are produced in small quantities
- ▶ In vertebrates, play a role of sex hormones

- └ Fatty acids and lipids
- └ Signal lipids: sterols and others

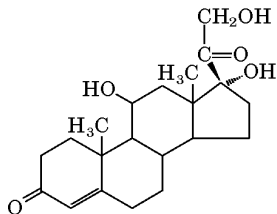
Steroids



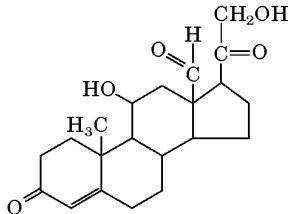
Testosterone



Estradiol



Cortisol



Aldosterone

Lipid vitamins

- ▶ Vitamin **D** (close to sterols) transforms into hormone regulating calcium uptake
- ▶ Vitamin **A** (retinol) transforms into retinal which is a main light response pigment of eye
- ▶ Vitamin **E** (tokoferol) assists in numerous biosynthetic processes

CC1(C)C(C)C(C)C(C)C1C2C(C)C(C)C(C)C2C3C(C)C(C)C(C)C3C4C(C)C(C)C(C)C4C5C(C)C(C)C(C)C5C6C(C)C(C)C(C)C6C7C(C)C(C)C(C)C7C8C(C)C(C)C(C)C8C9C(C)C(C)C(C)C9C10C(C)C(C)C(C)C10C11C(C)C(C)C(C)C11C12C(C)C(C)C(C)C12C13C(C)C(C)C(C)C13C14C(C)C(C)C(C)C14C15C(C)C(C)C(C)C15C16C(C)C(C)C(C)C16C17C(C)C(C)C(C)C17C18C(C)C(C)C(C)C18C19C(C)C(C)C(C)C19C20C(C)C(C)C(C)C20C21C(C)C(C)C(C)C21C22C(C)C(C)C(C)C22C23C(C)C(C)C(C)C23C24C(C)C(C)C(C)C24C25C(C)C(C)C(C)C25C26C(C)C(C)C(C)C26C27C(C)C(C)C(C)C27C28C(C)C(C)C(C)C28C29C(C)C(C)C(C)C29C30C(C)C(C)C(C)C30C31C(C)C(C)C(C)C31C32C(C)C(C)C(C)C32C33C(C)C(C)C(C)C33C34C(C)C(C)C(C)C34C35C(C)C(C)C(C)C35C36C(C)C(C)C(C)C36C37C(C)C(C)C(C)C37C38C(C)C(C)C(C)C38C39C(C)C(C)C(C)C39C40C(C)C(C)C(C)C40C41C(C)C(C)C(C)C41C42C(C)C(C)C(C)C42C43C(C)C(C)C(C)C43C44C(C)C(C)C(C)C44C45C(C)C(C)C(C)C45C46C(C)C(C)C(C)C46C47C(C)C(C)C(C)C47C48C(C)C(C)C(C)C48C49C(C)C(C)C(C)C49C50C(C)C(C)C(C)C50C51C(C)C(C)C(C)C51C52C(C)C(C)C(C)C52C53C(C)C(C)C(C)C53C54C(C)C(C)C(C)C54C55C(C)C(C)C(C)C55C56C(C)C(C)C(C)C56C57C(C)C(C)C(C)C57C58C(C)C(C)C(C)C58C59C(C)C(C)C(C)C59C60C(C)C(C)C(C)C60C61C(C)C(C)C(C)C61C62C(C)C(C)C(C)C62C63C(C)C(C)C(C)C63C64C(C)C(C)C(C)C64C65C(C)C(C)C(C)C65C66C(C)C(C)C(C)C66C67C(C)C(C)C(C)C67C68C(C)C(C)C(C)C68C69C(C)C(C)C(C)C69C70C(C)C(C)C(C)C70C71C(C)C(C)C(C)C71C72C(C)C(C)C(C)C72C73C(C)C(C)C(C)C73C74C(C)C(C)C(C)C74C75C(C)C(C)C(C)C75C76C(C)C(C)C(C)C76C77C(C)C(C)C(C)C77C78C(C)C(C)C(C)C78C79C(C)C(C)C(C)C79C80C(C)C(C)C(C)C80C81C(C)C(C)C(C)C81C82C(C)C(C)C(C)C82C83C(C)C(C)C(C)C83C84C(C)C(C)C(C)C84C85C(C)C(C)C(C)C85C86C(C)C(C)C(C)C86C87C(C)C(C)C(C)C87C88C(C)C(C)C(C)C88C89C(C)C(C)C(C)C89C90C(C)C(C)C(C)C90C91C(C)C(C)C(C)C91C92C(C)C(C)C(C)C92C93C(C)C(C)C(C)C93C94C(C)C(C)C(C)C94C95C(C)C(C)C(C)C95C96C(C)C(C)C(C)C96C97C(C)C(C)C(C)C97C98C(C)C(C)C(C)C98C99C(C)C(C)C(C)C99C100C(C)C(C)C(C)C100C101C(C)C(C)C(C)C101C102C(C)C(C)C(C)C102C103C(C)C(C)C(C)C103C104C(C)C(C)C(C)C104C105C(C)C(C)C(C)C105C106C(C)C(C)C(C)C106C107C(C)C(C)C(C)C107C108C(C)C(C)C(C)C108C109C(C)C(C)C(C)C109C110C(C)C(C)C(C)C110C111C(C)C(C)C(C)C111C112C(C)C(C)C(C)C112C113C(C)C(C)C(C)C113C114C(C)C(C)C(C)C114C115C(C)C(C)C(C)C115C116C(C)C(C)C(C)C116C117C(C)C(C)C(C)C117C118C(C)C(C)C(C)C118C119C(C)C(C)C(C)C119C120C(C)C(C)C(C)C120C121C(C)C(C)C(C)C121C122C(C)C(C)C(C)C122C123C(C)C(C)C(C)C123C124C(C)C(C)C(C)C124C125C(C)C(C)C(C)C125C126C(C)C(C)C(C)C126C127C(C)C(C)C(C)C127C128C(C)C(C)C(C)C128C129C(C)C(C)C(C)C129C130C(C)C(C)C(C)C130C131C(C)C(C)C(C)C131C132C(C)C(C)C(C)C132C133C(C)C(C)C(C)C133C134C(C)C(C)C(C)C134C135C(C)C(C)C(C)C135C136C(C)C(C)C(C)C136C137C(C)C(C)C(C)C137C138C(C)C(C)C(C)C138C139C(C)C(C)C(C)C139C140C(C)C(C)C(C)C140C141C(C)C(C)C(C)C141C142C(C)C(C)C(C)C142C143C(C)C(C)C(C)C143C144C(C)C(C)C(C)C144C145C(C)C(C)C(C)C145C146C(C)C(C)C(C)C146C147C(C)C(C)C(C)C147C148C(C)C(C)C(C)C148C149C(C)C(C)C(C)C149C150C(C)C(C)C(C)C150C151C(C)C(C)C(C)C151C152C(C)C(C)C(C)C152C153C(C)C(C)C(C)C153C154C(C)C(C)C(C)C154C155C(C)C(C)C(C)C155C156C(C)C(C)C(C)C156C157C(C)C(C)C(C)C157C158C(C)C(C)C(C)C158C159C(C)C(C)C(C)C159C160C(C)C(C)C(C)C160C161C(C)C(C)C(C)C161C162C(C)C(C)C(C)C162C163C(C)C(C)C(C)C163C164C(C)C(C)C(C)C164C165C(C)C(C)C(C)C165C166C(C)C(C)C(C)C166C167C(C)C(C)C(C)C167C168C(C)C(C)C(C)C168C169C(C)C(C)C(C)C169C170C(C)C(C)C(C)C170C171C(C)C(C)C(C)C171C172C(C)C(C)C(C)C172C173C(C)C(C)C(C)C173C174C(C)C(C)C(C)C174C175C(C)C(C)C(C)C175C176C(C)C(C)C(C)C176C177C(C)C(C)C(C)C177C178C(C)C(C)C(C)C178C179C(C)C(C)C(C)C179C180C(C)C(C)C(C)C180C181C(C)C(C)C(C)C181C182C(C)C(C)C(C)C182C183C(C)C(C)C(C)C183C184C(C)C(C)C(C)C184C185C(C)C(C)C(C)C185C186C(C)C(C)C(C)C186C187C(C)C(C)C(C)C187C188C(C)C(C)C(C)C188C189C(C)C(C)C(C)C189C190C(C)C(C)C(C)C190C191C(C)C(C)C(C)C191C192C(C)C(C)C(C)C192C193C(C)C(C)C(C)C193C194C(C)C(C)C(C)C194C195C(C)C(C)C(C)C195C196C(C)C(C)C(C)C196C197C(C)C(C)C(C)C197C198C(C)C(C)C(C)C198C199C(C)C(C)C(C)C199C200C(C)C(C)C(C)C200C201C(C)C(C)C(C)C201C202C(C)C(C)C(C)C202C203C(C)C(C)C(C)C203C204C(C)C(C)C(C)C204C205C(C)C(C)C(C)C205C206C(C)C(C)C(C)C206C207C(C)C(C)C(C)C207C208C(C)C(C)C(C)C208C209C(C)C(C)C(C)C209C210C(C)C(C)C(C)C210C211C(C)C(C)C(C)C211C212C(C)C(C)C(C)C212C213C(C)C(C)C(C)C213C214C(C)C(C)C(C)C214C215C(C)C(C)C(C)C215C216C(C)C(C)C(C)C216C217C(C)C(C)C(C)C217C218C(C)C(C)C(C)C218C219C(C)C(C)C(C)C219C220C(C)C(C)C(C)C220C221C(C)C(C)C(C)C221C222C(C)C(C)C(C)C222C223C(C)C(C)C(C)C223C224C(C)C(C)C(C)C224C225C(C)C(C)C(C)C225C226C(C)C(C)C(C)C226C227C(C)C(C)C(C)C227C228C(C)C(C)C(C)C228C229C(C)C(C)C(C)C229C230C(C)C(C)C(C)C230C231C(C)C(C)C(C)C231C232C(C)C(C)C(C)C232C233C(C)C(C)C(C)C233C234C(C)C(C)C(C)C234C235C(C)C(C)C(C)C235C236C(C)C(C)C(C)C236C237C(C)C(C)C(C)C237C238C(C)C(C)C(C)C238C239C(C)C(C)C(C)C239C240C(C)C(C)C(C)C240C241C(C)C(C)C(C)C241C242C(C)C(C)C(C)C242C243C(C)C(C)C(C)C243C244C(C)C(C)C(C)C244C245C(C)C(C)C(C)C245C246C(C)C(C)C(C)C246C247C(C)C(C)C(C)C247C248C(C)C(C)C(C)C248C249C(C)C(C)C(C)C249C250C(C)C(C)C(C)C250C251C(C)C(C)C(C)C251C252C(C)C(C)C(C)C252C253C(C)C(C)C(C)C253C254C(C

Final question (2 points)

- └ Fatty acids and lipids
- └ Lipid vitamins

Final question (2 points)

Which role in the cell lipids do NOT play?

Summary

- ▶ Lipids are extremely diverse; the only character uniting them is their hydrophobic behavior

For Further Reading



A. Shipunov.

Advanced Cell Biology [Electronic resource].

2011—onwards.

Mode of access: [http:](http://)

[//ashipunov.info/shipunov/school/biol_250](http://ashipunov.info/shipunov/school/biol_250)



B. Alberts et al.

Essential Cell Biology. 3rd edition.

Garland Science, 2009.

Chapter 2: Molecules in cells, Panel 2-4.