



BIOCHEMISTRY

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LIPIDS



Lipids => broad group of naturally occurring molecules => include

- **fats,**
- **waxes,**
- **sterols,**
- **fat soluble vitamins,**
- **monoacylglycerols,**
- **diacylglycerols,**
- **phospholipids and**
- **others.**

- compounds => generally
 - **soluble in organic solvents** and
 - largely **insoluble in water.**

- main **biological functions** of lipids :
 - **energy storage,**
 - **structural components of cell membranes,**
 - **vitamins,**
 - **hormones** and
 - **important signaling molecules.**

- **Lipid** is sometimes used as a **synonym** for **fats**.
- **fats** are a subgroup of lipids called **triacyl glycerols**.
- **Lipids** also encompass molecules , such as -
- **fatty acids and their derivatives** (including tri-, di- and monoacylglycerols and phospholipids), as well as other
- **sterol-containing metabolites** such as **cholesterol**.
- Humans use **various biosynthetic pathways** => both **degrade and synthesize lipids**
- **some essential lipids** cannot be made this way => must be obtained from the **diet**.

Lipid Classification (7 groups):

- • **Fatty Acids**
- • **Acyl glycerols**
- • **Glycerophospholipids**
- • **Sphingolipids**
- • **Sterols**
- • **Prenol lipids**
- • **Saccharo lipids**

1. Fatty acids

- consists of :
 - **hydrocarbon chain** and
 - a terminal **carboxylic acid group**.
- This arrangement confers the molecule with a **polar, hydrophilic end** and a **nonpolar, hydrophobic end => insoluble in water.**
- fatty acid structure => the most **fundamental categories of biological lipids** => commonly used as a **building block** => more structurally complex lipids.

- **carbon chain** (4 to 24 carbons) => may be **saturated** or **unsaturated**.
- **saturated fatty acid** => all the carbon atoms => **saturated** with hydrogen atoms with general formula $\text{CH}_3(\text{CH}_2)_n\text{COOH}$ where => **n is an even number**.
- **Mono-unsaturated fatty acids** => one double bond in their structure.
- **polyunsaturated fatty acids** => two or more double bonds.
- double bonds in polyunsaturated fatty acids are generally separated by at least **one methylene group**.

- double bond => there is the possibility of => either a **cis or trans geometric isomerism** => significantly affects => molecule's **molecular configuration**.
- **Cis-double bonds** => cause the fatty acid **chain to bend** => an effect that is **more pronounced** when **more double bonds** are there in a chain.
- plays important role => **structure and function of cell membranes**.

- Naturally occurring fatty acids => **cis** configuration, although **trans** form => **natural and partially hydrogenated** fats and oils.
- **Shorter the chain => lower is the melting temperature**
- **Unsaturated fatty acids => lower melting temperatures** than saturated fatty acids of same chain length.

2. Glycerolipids

- Glycerolipids are composed mainly of
- **mono-, di- and tri-substituted glycerols**, the most well-known **triacylglycerols / triglycerides / fats**.
- In these compounds => **all three hydroxyl groups of glycerol => esterified => different fatty acids (Mixed Lipids)**.



There are different triglycerides, depending on the side chains.

- They **function** => **food store**.
- these lipids comprise => **bulk of storage fat** in **animal tissue** and **oil seeds**.
- TG or fats may be => **solid** or **liquid** at room temperature => their **structure and composition**.

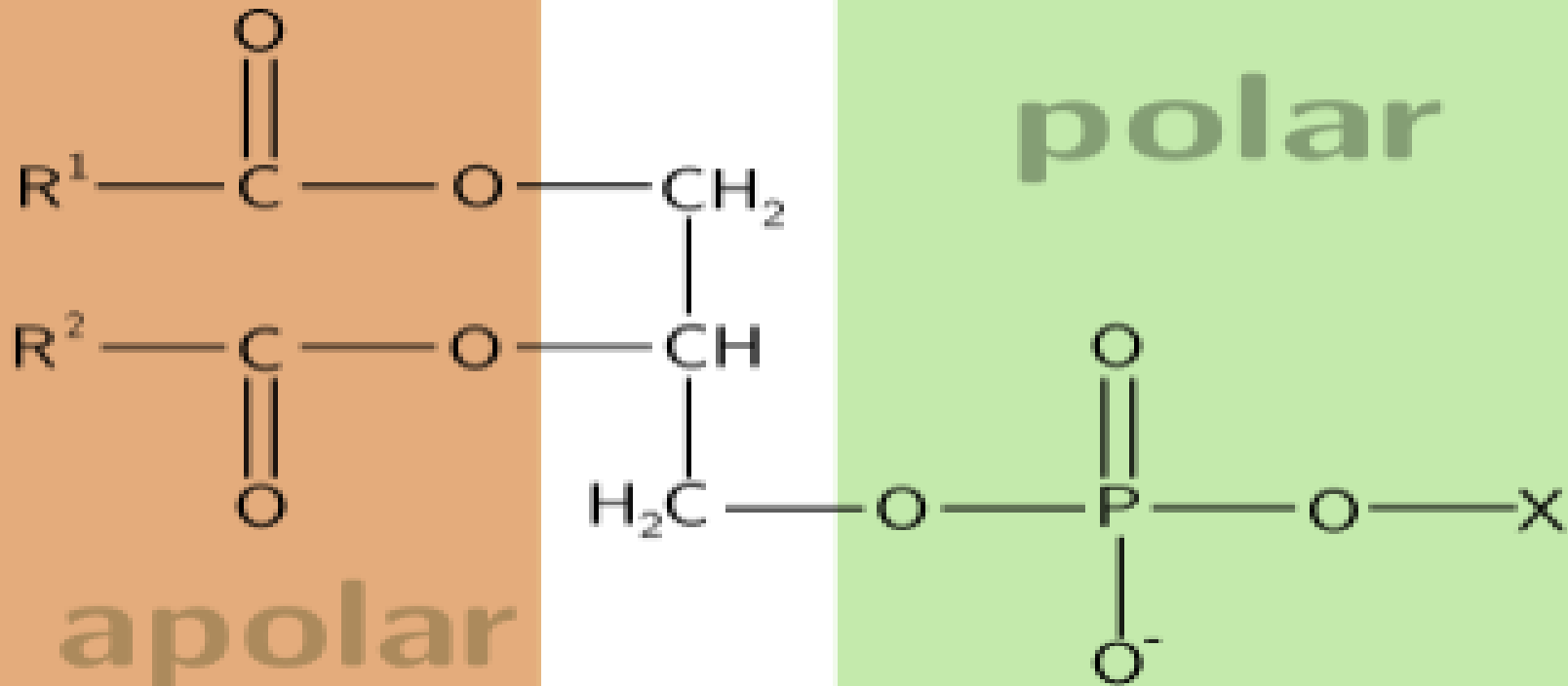
- **“Oils”** => used to refer to fats => **liquids** at normal room temperature.
- **“fats”** => used to refer to fats => **solids** at normal room temperature.
- **“Lipids”** => used to refer to => **both liquid and solid fats**, along with **other related substances**.

3. Glycerophospholipids

- **phospholipids** :
- key components of the **lipid bilayer of cells**
- involved in **metabolism** and
- **cell signaling**.

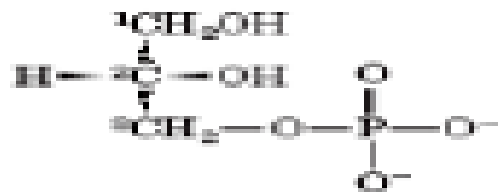
- **Neural tissue** (including **brain**) contains relatively high amounts
=> **glycerophospholipids** and
- alterations in **their composition** has been implicated in => various
neurological disorders.

- PL found in **biological membranes** :
- **Phosphatidyl choline** (PC or lecithin)
- **phosphatidyl ethanolamine** (PE) and
- **Phosphatidyl serine** (PS).
- **Plasmalogens** => a type of glycerolipids contain => **fatty alcohol** at C-1 of Sn glycerol with double bond instead of a fatty acid.



Glycerophospholipids have three components: fatty acid lipid groups (orange), glycerol (white), and phosphate ester (green)





L-Glycerol 3-phosphate



Amphiphilic

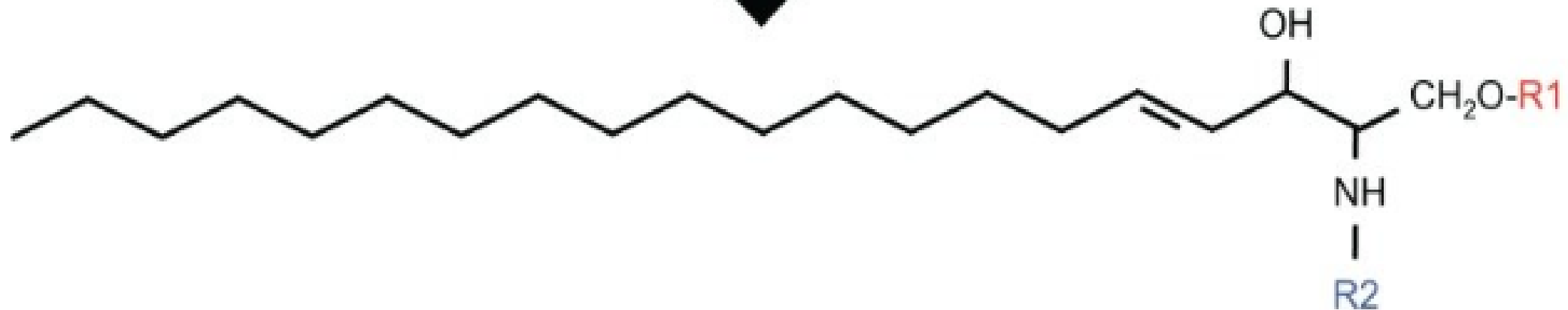
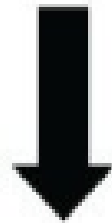
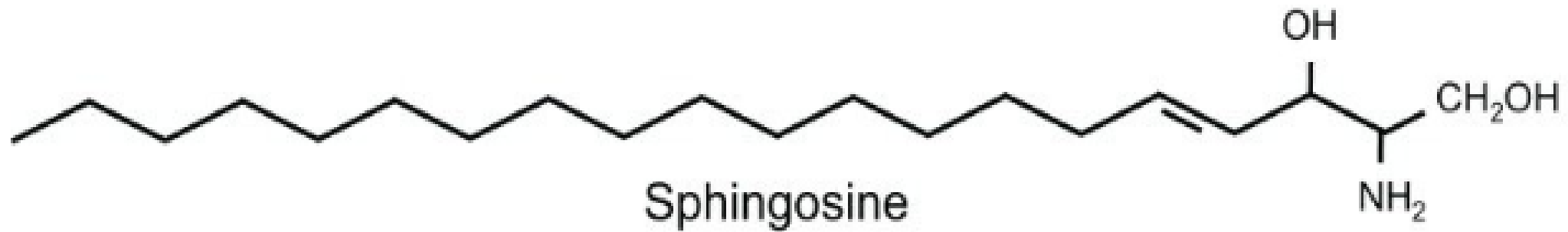
Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	—H	-1
Phosphatidylethanolamine	Ethanolamine	—CH ₂ —CH ₂ —NH ₂	0
Phosphatidylcholine	Choline	—CH ₂ —CH ₂ —N(CH ₂) ₃	0
Phosphatidylserine	Serine	—CH ₂ —CH(NH ₂)—COO ⁻	-1
Phosphatidylglycerol	Glycerol	—CH ₂ —CH(OH)—CH ₂ —OH	-1
Phosphatidylinositol 4,5-bisphosphate	myo-Inositol 4,5-bisphosphate		-4
Cardiolipin	Phosphatidylglycerol		-2

Glycerophospholipids

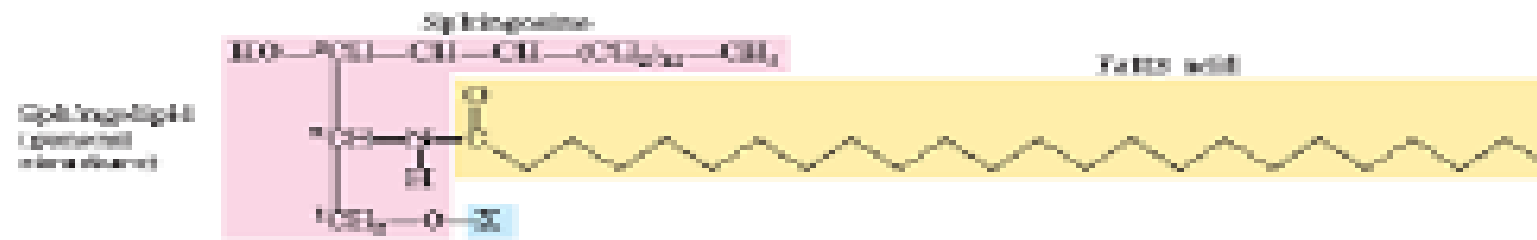
4. Sphingolipids

- complex family of compounds that share => common structural feature => **a sphingoid base backbone** (synthesized de novo from the amino acid **serine** and a long- chain fatty acyl CoA) => then converted into =>
- **ceramides,**
- **phosphosphingolipids,**
- **glycosphingolipids and**
- **other compounds.**

- major **sphingoid base** of mammals is commonly referred to as => **sphingosine**.
- **Ceramides** (N-acylsphingoid bases) are a **major subclass** of sphingoid base derivatives with an amide-linked fatty acid.
- The fatty acids are typically **saturated** or **mono-unsaturated** with chain lengths from **16 to 26** carbon atoms.



Structure of sphingolipids. In sphingolipids, the hydrophobic region consists of a longchain sphingoid base with generally 18 carbons, such as sphingosine, which is linked to the acyl group of a fatty acid via an amide bond (R₂). The hydrophilic region (R₁) consists in the simplest case of a hydroxyl group in the case of ceramide.



Name of sphingolipid	Name of X	Formula of X
Ceramide	—	—H
Sphingomyelin	Phosphocholine	O $\text{P}-\text{O}-\text{CH}_2-\text{CH}_2-\text{N}(\text{CH}_3)_3$ O^-
Neutral glycolipid Glucosylceramide	Glucose	
Lactosylceramide (a globoside)	Dis-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

Sphingolipids

➤ **Functions of mammalian sphingolipids**

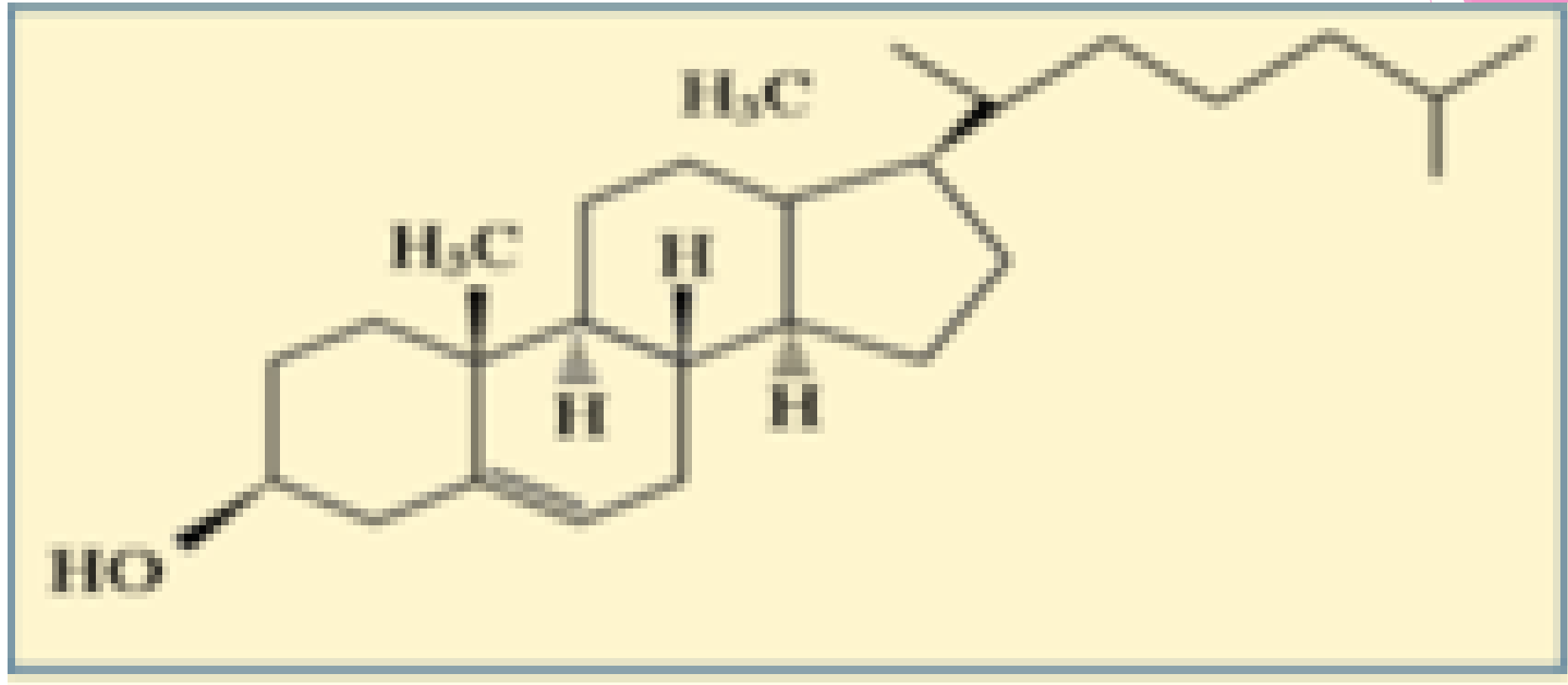
- Sphingolipids => protect the cell surface against harmful environmental factors by forming a mechanically stable and chemically resistant outer leaflet of the plasma membrane lipid bilayer.
- Certain complex glycosphingolipids => involved in specific functions => cell recognition and signaling.
- **Cell recognition** depends => on physical properties of sphingolipids
- **signaling** involves specific interactions of the glycan structures of glycosphingolipids with similar lipids present on neighboring cells or with proteins.

5. Sterols

- Sterol lipids => **cholesterol** and its derivatives => important component of **membrane lipids**, along with the **glycerophospholipids** and **sphingomyelins**.
- Steroids => derived from the same **fused four-ring core structure** => have different biological roles as **hormones** and **signaling molecules**.
- eighteen-carbon(**C18**) steroids => include **the estrogen family**
- **C19** steroids => comprise the **androgens** such as -
- **testosterone** and **androsterone**.

- **C21 subclass** => includes the **progestogens** as well as **glucocorticoids** and **mineralocorticoids**.
- **secosteroids** => comprising various forms of vitamin D => are characterized by cleavage of the B ring of the core structure.
- Other examples of sterols => **bile salt** and their **conjugates**, which in mammals are => oxidized derivatives of **cholesterol** and are **synthesized in the liver**.

cholesterol

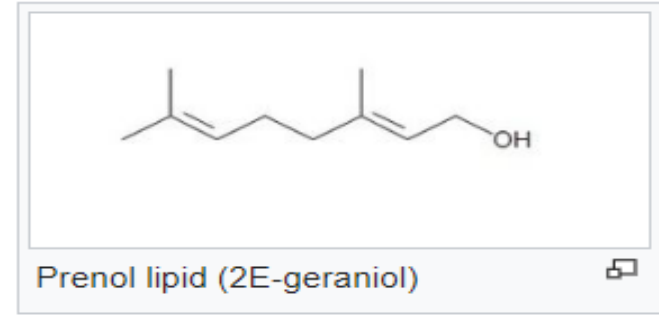


Sterols are steroids in which one of the hydrogen atoms is substituted with a hydroxyl group in the carbon chain. They have in common with steroids the same fused four-ring core structure.

6. Prenol lipids

➤ Prenol (3-methyl-2-buten-1-ol) => **natural alcohol**.

➤ one of the simplest **terpenes**.



➤ Prenol lipids => synthesized from => **5-carbon precursors isopentenyl diphosphate** and **dimethylallyl diphosphate** => produced mainly via => mevalonic acid (MVA) pathway.

➤ simple **isoprenoids** (linear alcohols, diphosphates) are formed by => successive addition of C5 units and => are classified according to **number of these terpene units**.

- Structures containing **> than 40 carbons** are known as **polyterpenes**.
- **Carotenoids** are important simple **isoprenoids** => function as **antioxidants** and as **precursors of vitamin A**.
- Another biologically important class of molecules is exemplified by the **quinones and hydroquinones** => contain an **isoprenoid tail** attached to a quinonoid core of **non-isoprenoid origin**.
- **Vitamin E, vitamin K** and **ubiquinones** => examples of this class.

7. Saccharolipids

- compounds in which **fatty acids** are directly linked to **sugar backbone** => forming structures => compatible with **membrane bilayers**.
- In saccharolipids => **a monosaccharide** substitutes for the **glycerol backbone** present in **glycerolipids** and **glycerophospholipids**.
- most familiar **saccharolipids** => **acylated glucosamine** precursors of the Lipid A component of the **lipopolysaccharides** =>
- **Gram-negative bacteria**

Common Fatty Acids

Chemical Names and Descriptions of some Common Fatty Acids				
Common Name	Carbon Atoms	Double Bonds	Scientific Name	Sources
Butyric acid	4	0	butanoic acid	butterfat
Caproic Acid	6	0	hexanoic acid	butterfat
Caprylic Acid	8	0	octanoic acid	coconut oil
Capric Acid	10	0	decanoic acid	coconut oil
Lauric Acid	12	0	dodecanoic acid	coconut oil
Myristic Acid	14	0	tetradecanoic acid	palm kernel oil
Palmitic Acid	16	0	hexadecanoic acid	palm oil
Palmitoleic Acid	16	1	9-hexadecenoic acid	animal fats
Stearic Acid	18	0	octadecanoic acid	animal fats
Oleic Acid	18	1	9-octadecenoic acid	olive oil
Vaccenic Acid	18	1	11-octadecenoic acid	butterfat
Linoleic Acid	18	2	9,12-octadecadienoic acid	grape seed oil
Alpha-Linolenic Acid (ALA)	18	3	9,12,15-octadecatrienoic acid	flaxseed (linseed) oil
Gamma-Linolenic Acid (GLA)	18	3	6,9,12-octadecatrienoic acid	borage oil
Arachidic Acid	20	0	eicosanoic acid	peanut oil, fish oil
Arachidonic Acid (AA)	20	4	5,8,11,14-eicosatetraenoic acid	liver fats
EPA	20	5	5,8,11,14,17-eicosapentaenoic acid	fish oil

THANKS

The background features abstract, overlapping geometric shapes in various shades of pink and purple, creating a modern, layered effect. The shapes are primarily triangles and polygons, some with soft gradients and others with solid colors. The overall composition is clean and contemporary.