

LIPID MAPS

Lipid complexity

Classification

Nomenclature

Matthew Conroy

Senior Biocurator

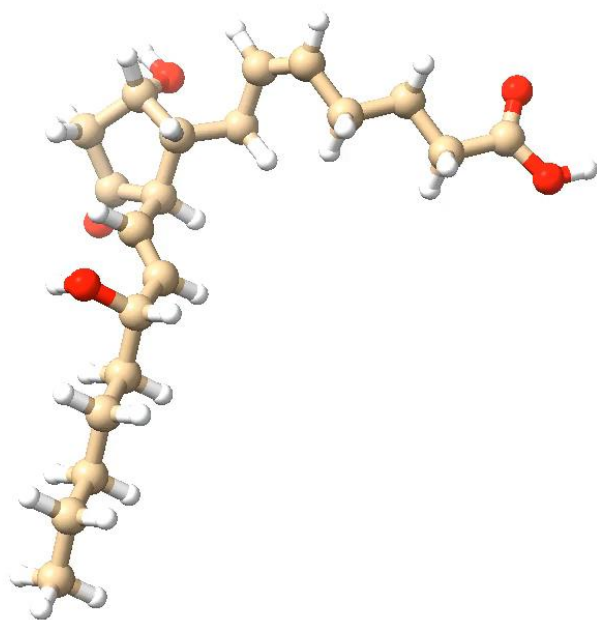
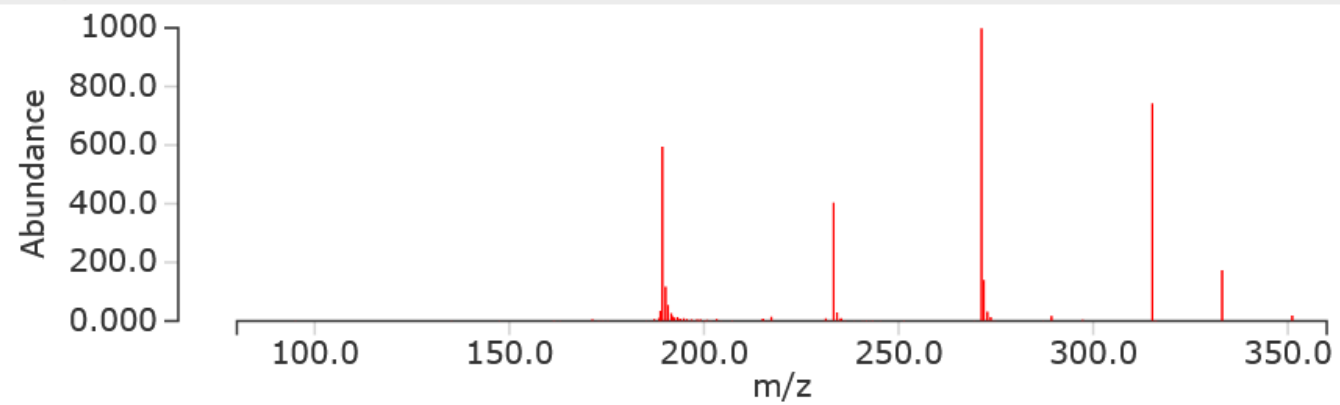


UC San Diego

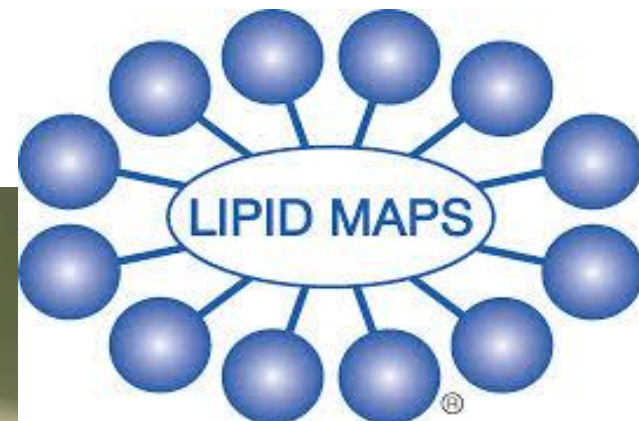


PGD2; LC-ESI-QIT; MS2; CE:20 V; [M-H]-

Mass Spectrum



LIPID MAPS



LIPID MAPS®

A [No Title] free, open access lipidomics resource

MS Data Bulk Search

MS Analysis

LMSD Database

Lipid Analysis Software

Structure Drawing Tools

Webinars & Podcasts

BioPAN Software

Statistical Analysis Tools

Classification & Nomenclature

lipidmaps.org

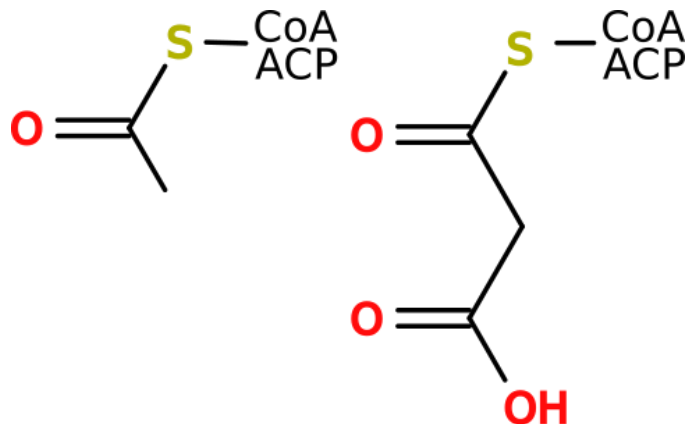
Databases and tools to aid lipidomics research

What is a lipid? LIPID MAPS Definition

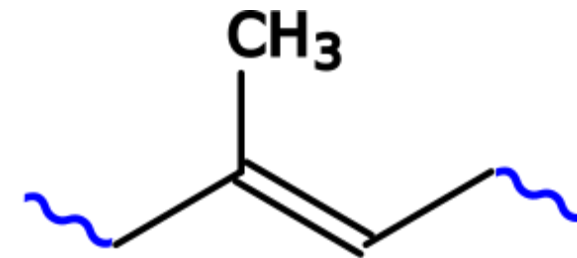
(Fahy et al. *J. Lipid Res*, 2009)

- Hydrophobic or amphipathic small molecules
- Originate entirely or in part by carbanion-based condensations of:

- Thioesters



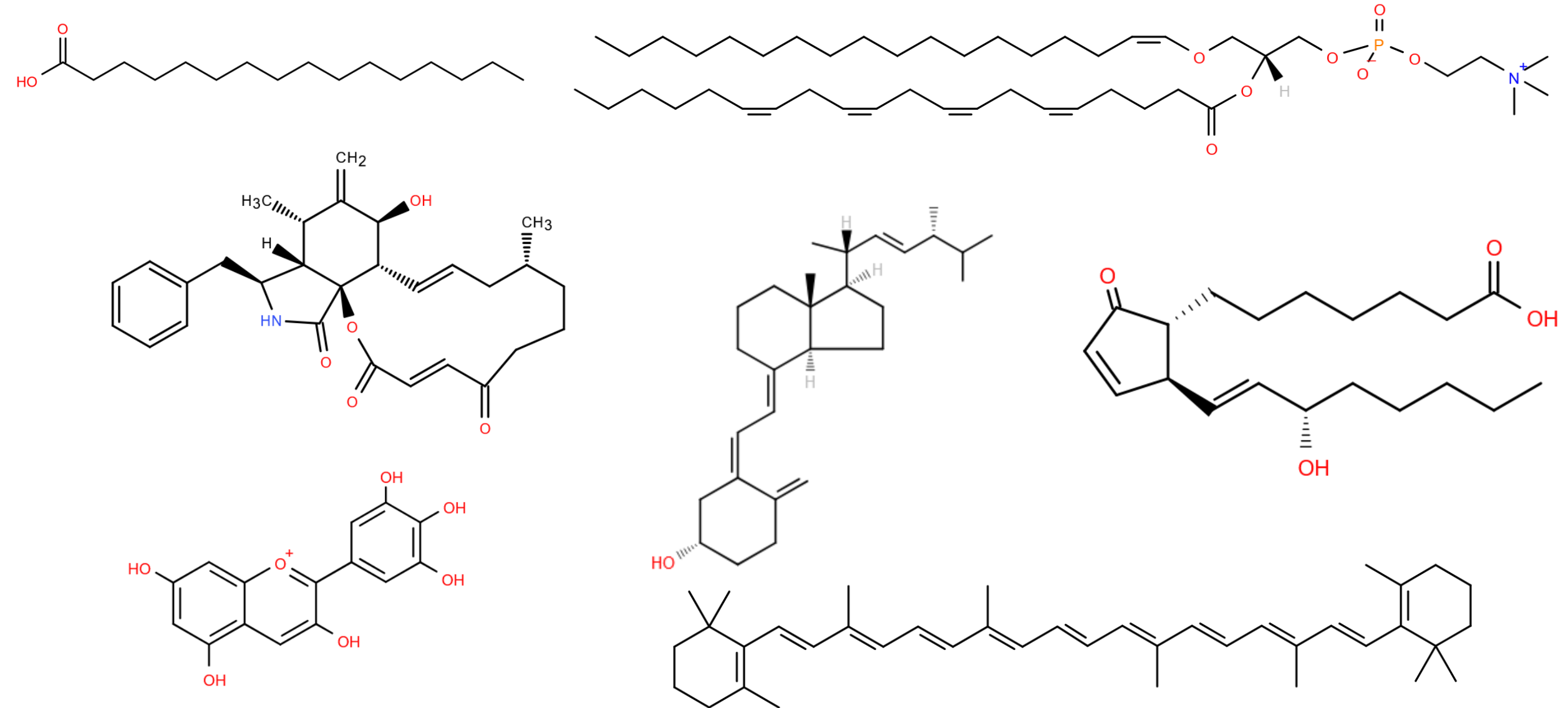
- Isoprene units



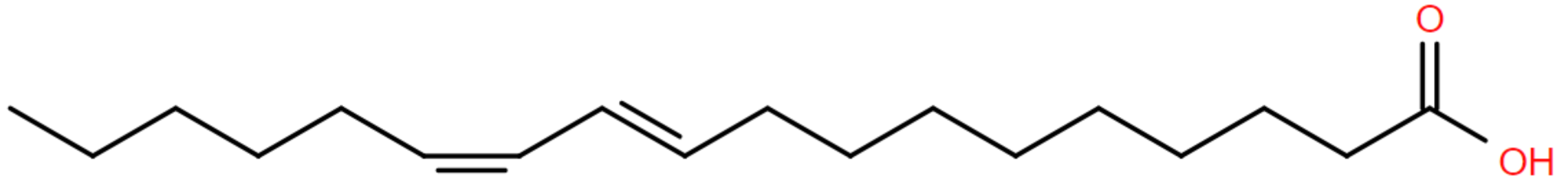
- Prenols

- Fatty acids, Polyketides

Enormous diversity of lipids



Diversity even in the 'simplest' lipids



How many ~18-32 C fatty acids are there?

MAPS Structure database?

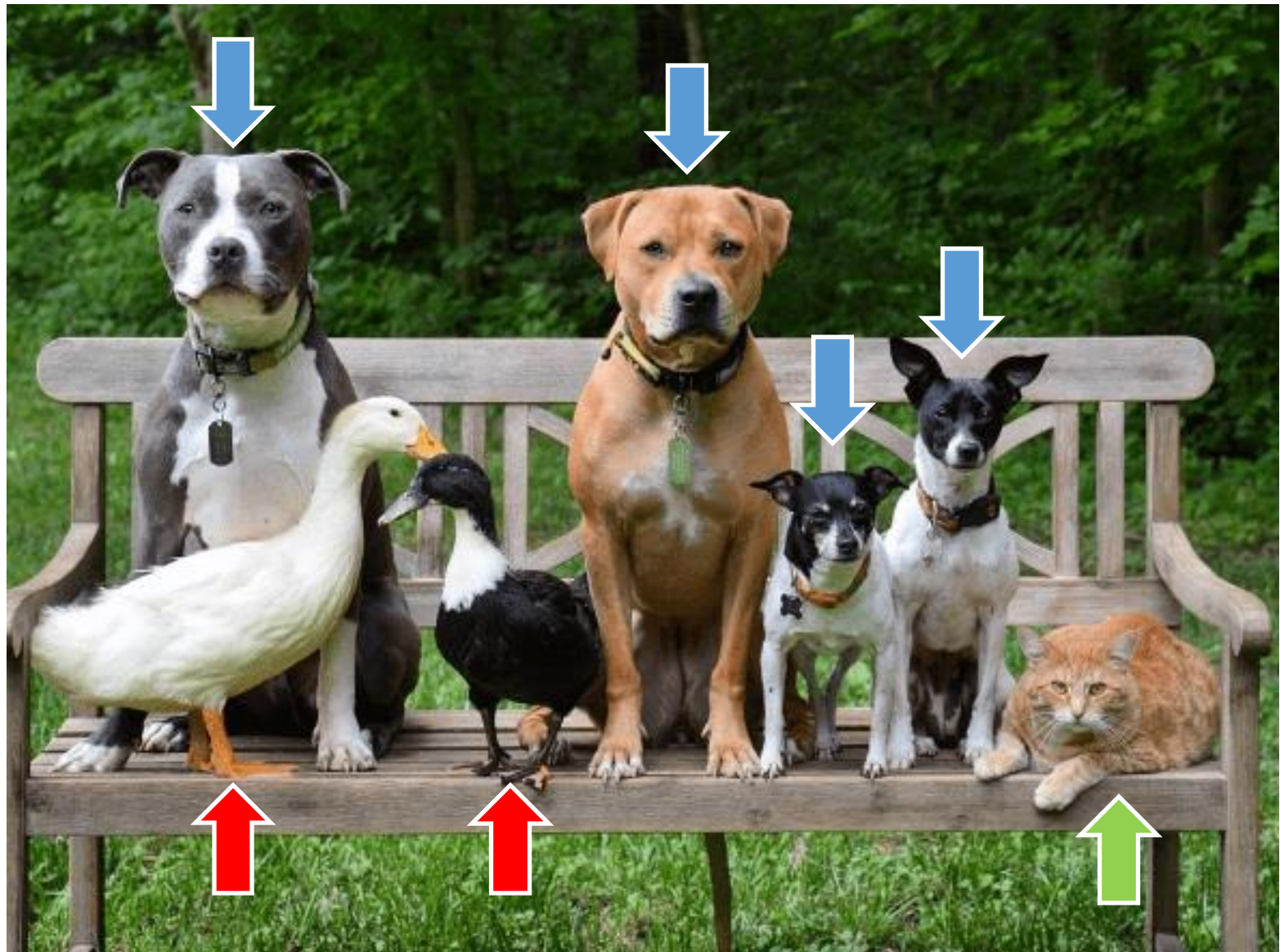
ie 18 carbons and 2 double bond
(equivalents)?

103

Lipid Classification

**Humans are natural
classifiers**

**We have an innate
desire to categorise
things**





Henri Braconnot

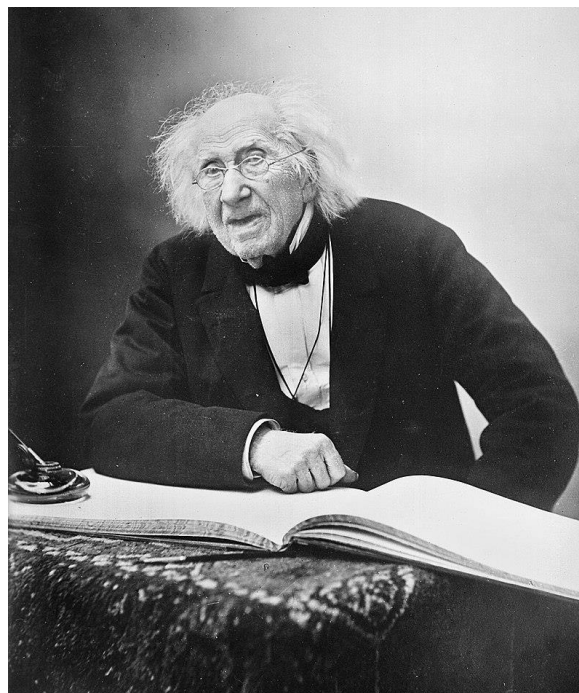
1815 Lipids (*graisses*)

- *suifs* -solids
- *huiles* -fluids

Michel Eugène Chevreul

1823

- oils
- greases
- tallow
- waxes
- resins
- balsams
- volatile oils



RECHERCHES CHIMIQUES
SUR
LES CORPS GRAS
D'ORIGINE ANIMALE,
PAR M. E. CHEVREUL.

On doit tendre avec effort à l'infailibilité sans y prétendre.
M. LAVERGNE.



A PARIS,
CHEZ F. G. LEVRAULT, LIBRAIRE-ÉDITEUR,
RUE DE M. LE PRINCE, n° 31;
ET A STRASBOURG, RUE DES JUIFS, n° 33.

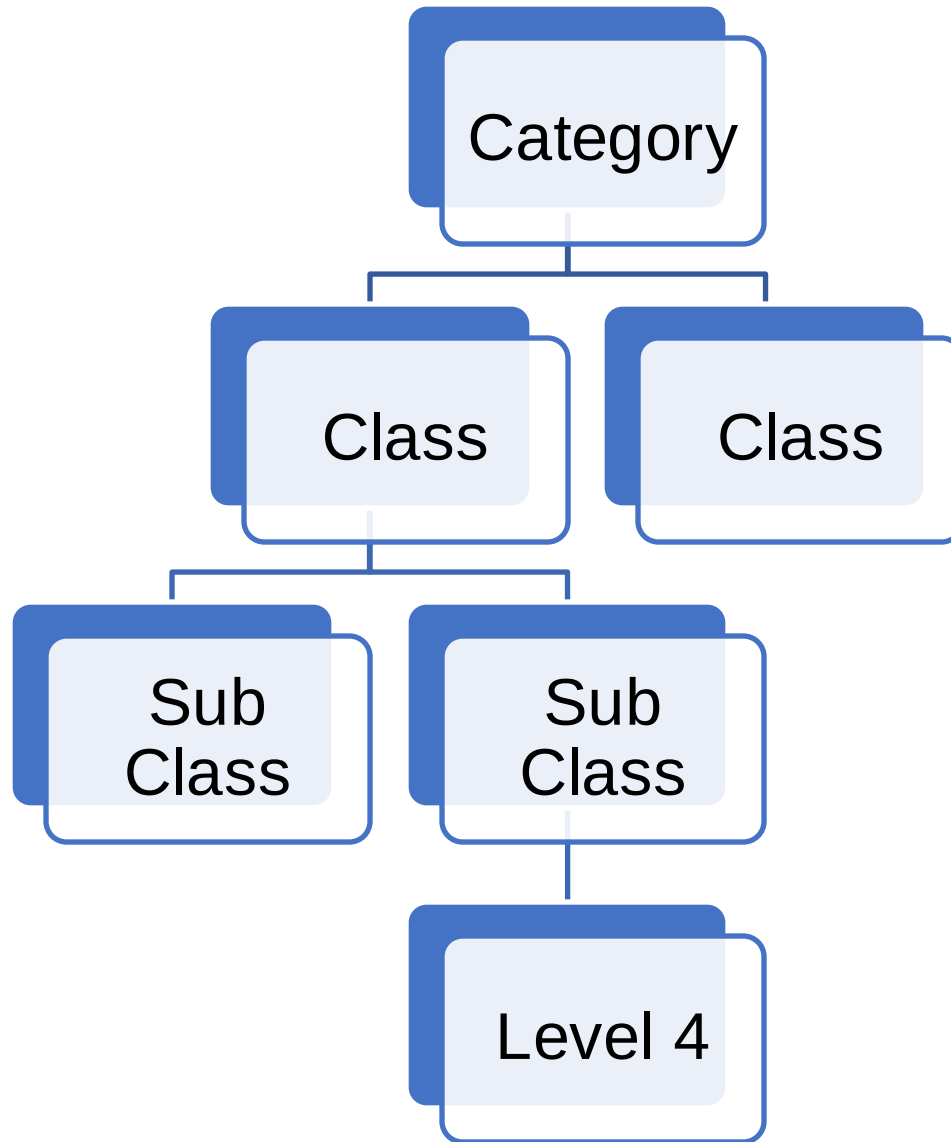
1823.

The Eight LIPID MAPS lipid categories

Category		Number in LMSD
Fatty acyls	FA	10783
Glycerolipids	GL	7745
Glycerophospholipids	GP	10093
Sphingolipids	SP	4990
Saccharolipids	SL	1345
Polyketides	PK	7183
Sterol Lipids	ST	3957
Prenol Lipids	PR	2505

<https://lipidmaps.org/databases/lmsd/overview>

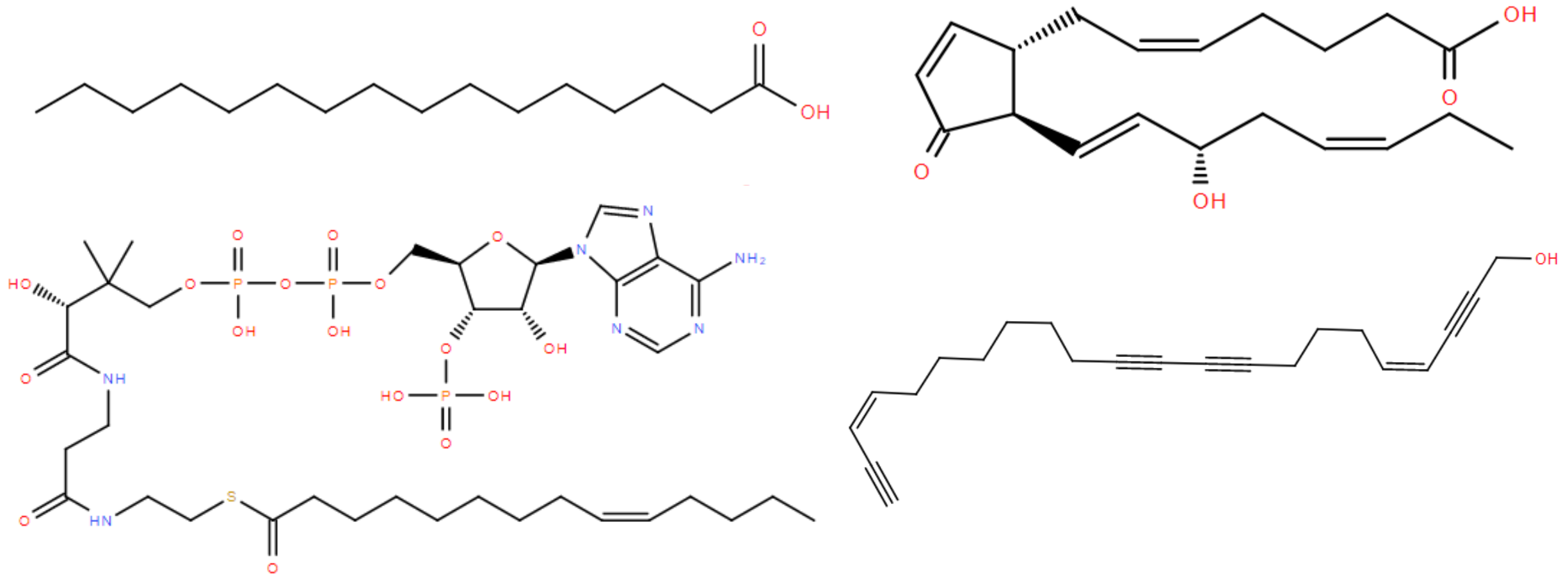
Categories subdivided into 3 further levels



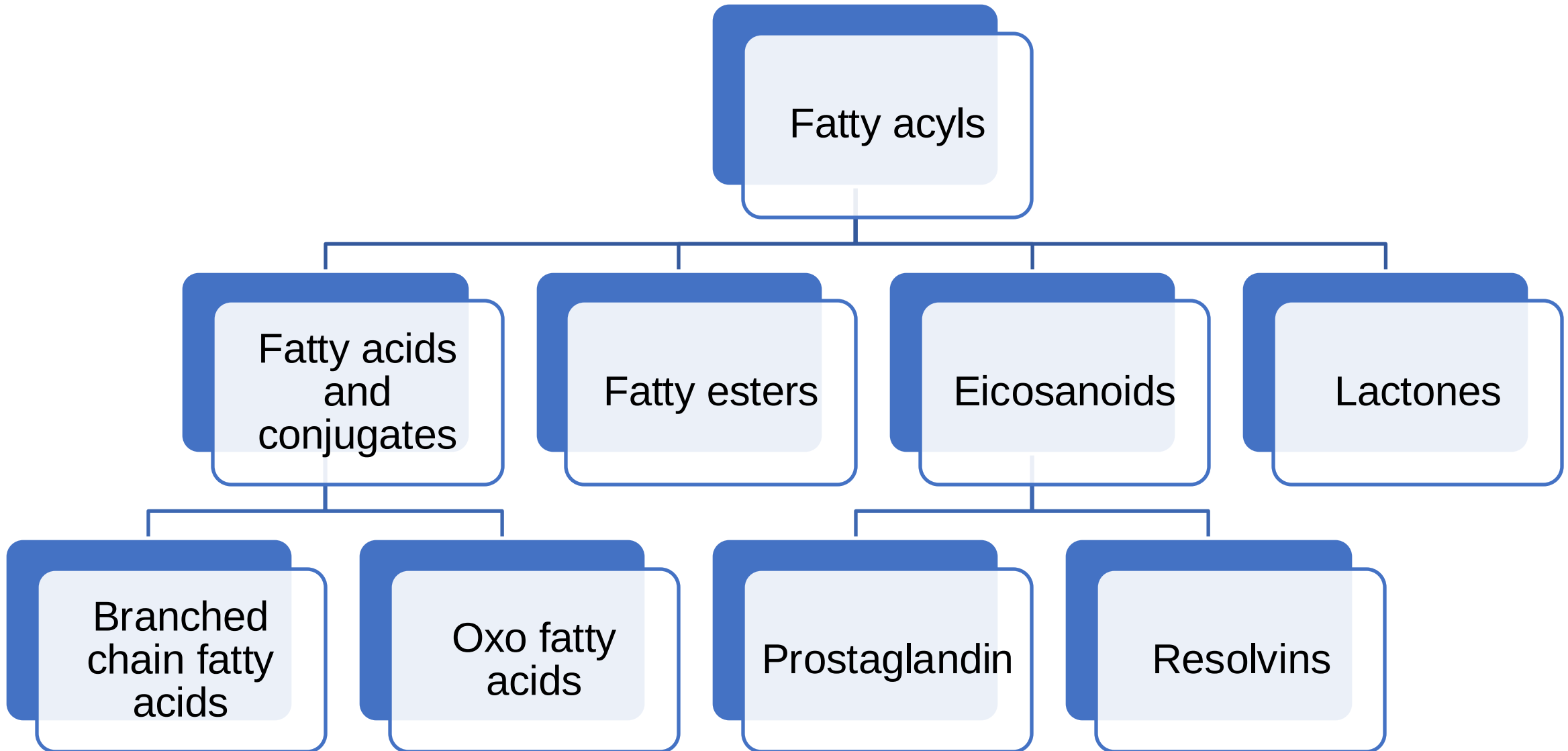
Unique to C₁₀ - C₃₀ isoprenoids
in Prenol category

Fatty Acyls - FA

- A diverse set of molecules derived from fatty acids

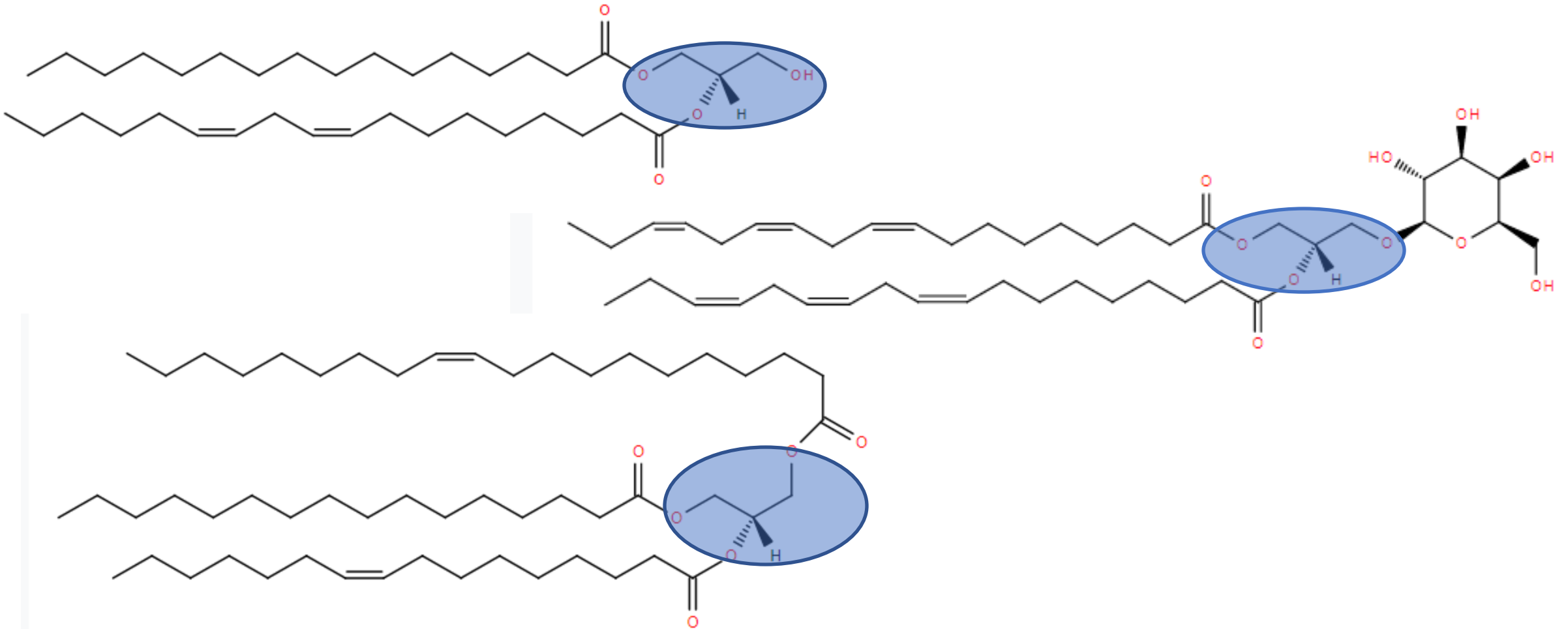


Fatty Acyls

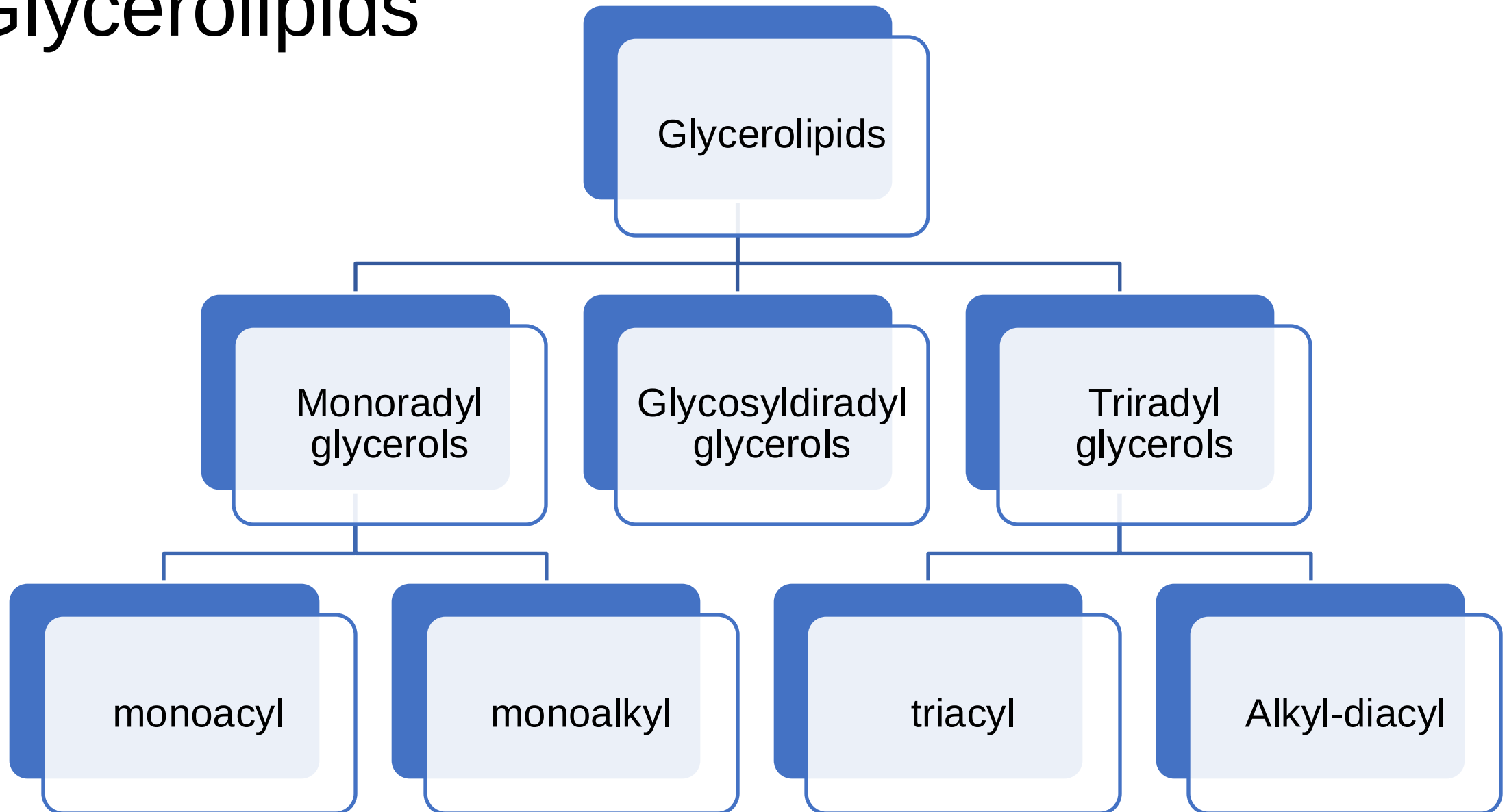


Glycerolipids - GL

- One or more fatty acids esterified to a glycerol

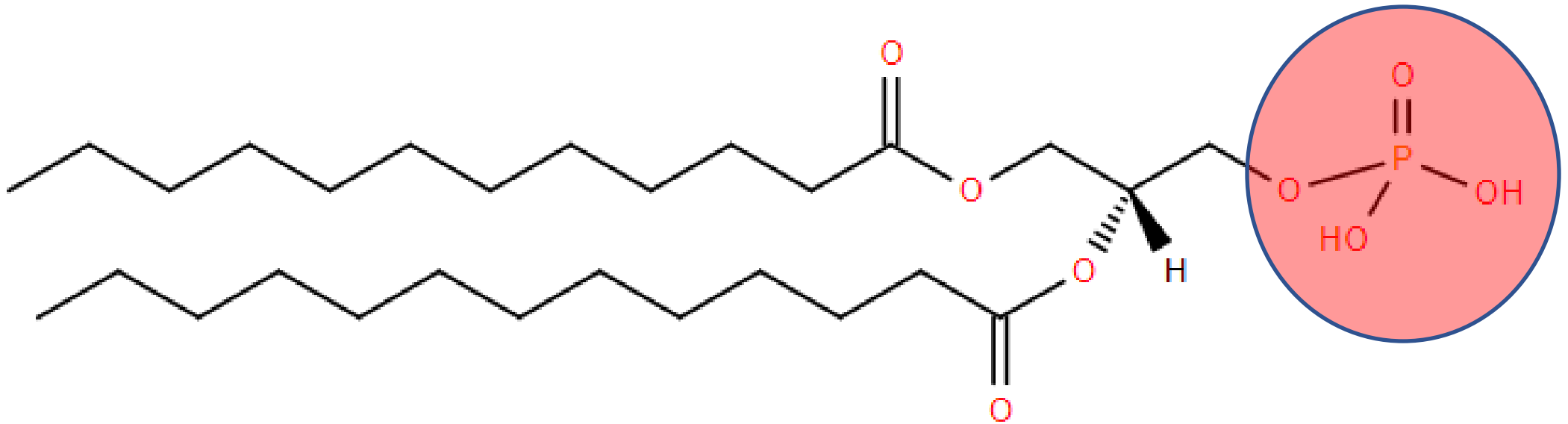


Glycerolipids

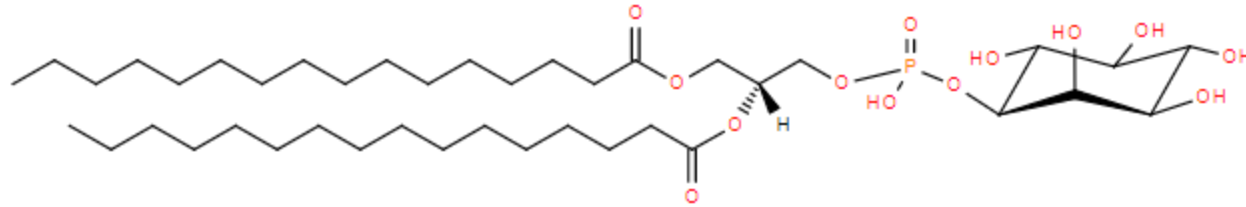


Glycerophospholipids - GP

- A special case of glycerolipid involving a phosphate group at (usually) *sn*3

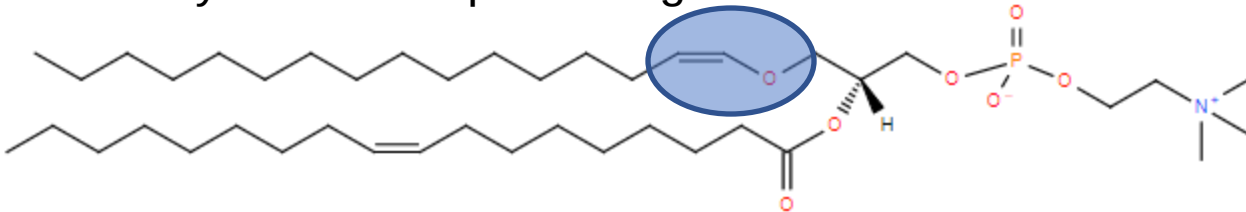


The phosphate can be further modified

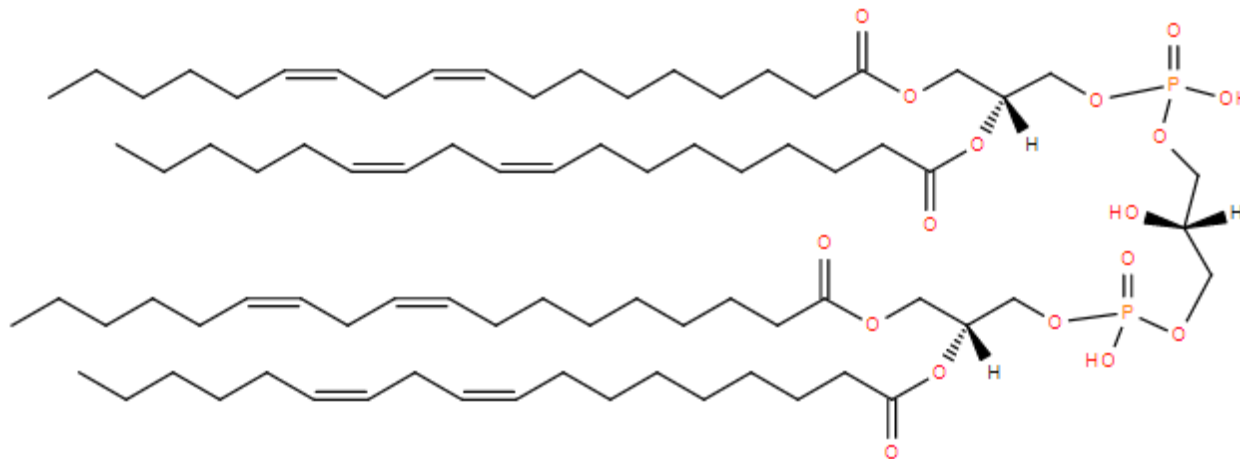


Phosphatidyl inositol

Vinyl ether link- plasmalogen



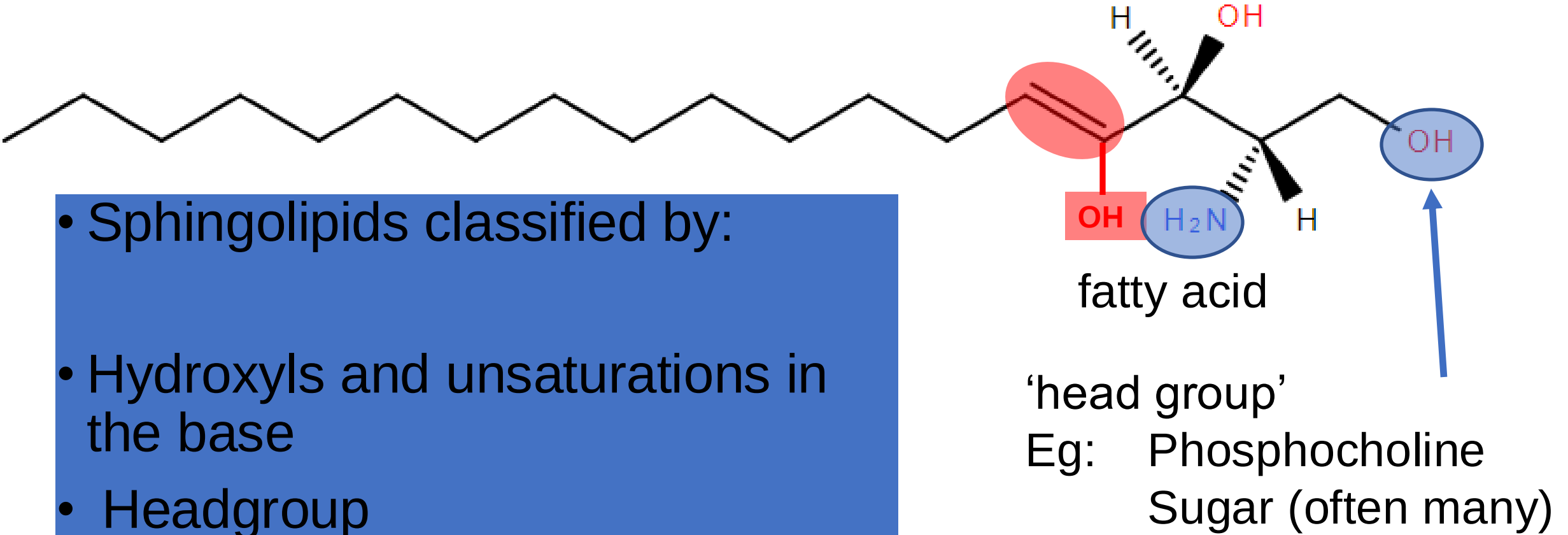
Phosphatidyl choline



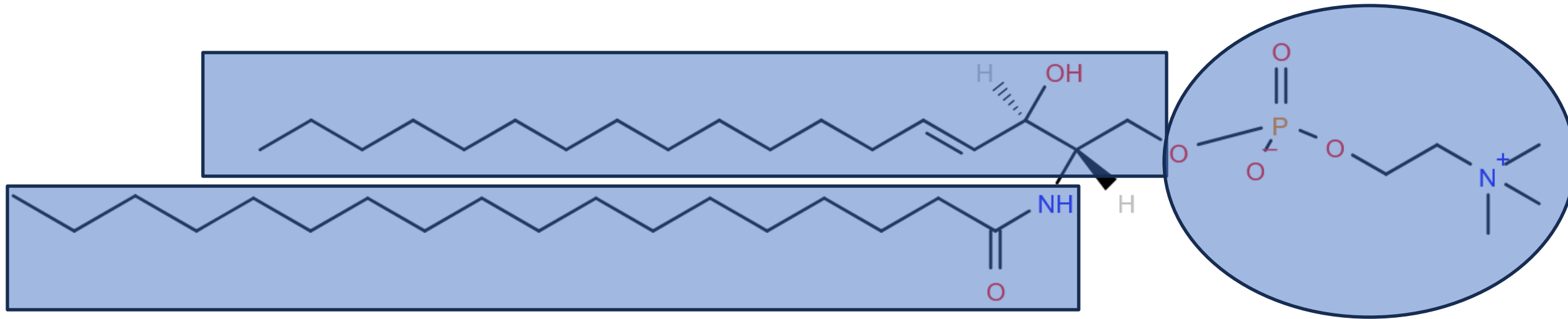
Cardiolipin

Sphingolipids - SP

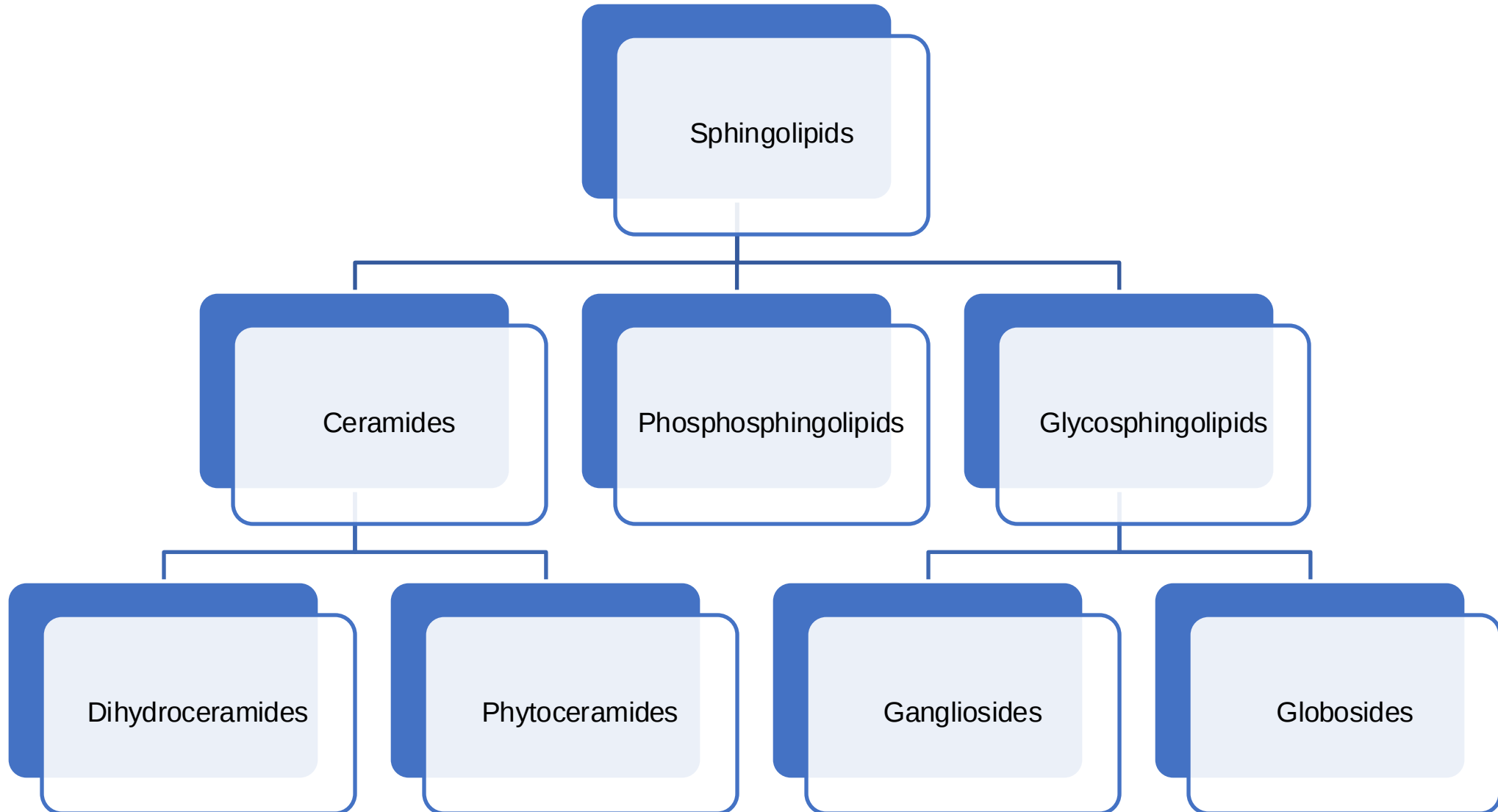
- Built from a 'sphingoid base'



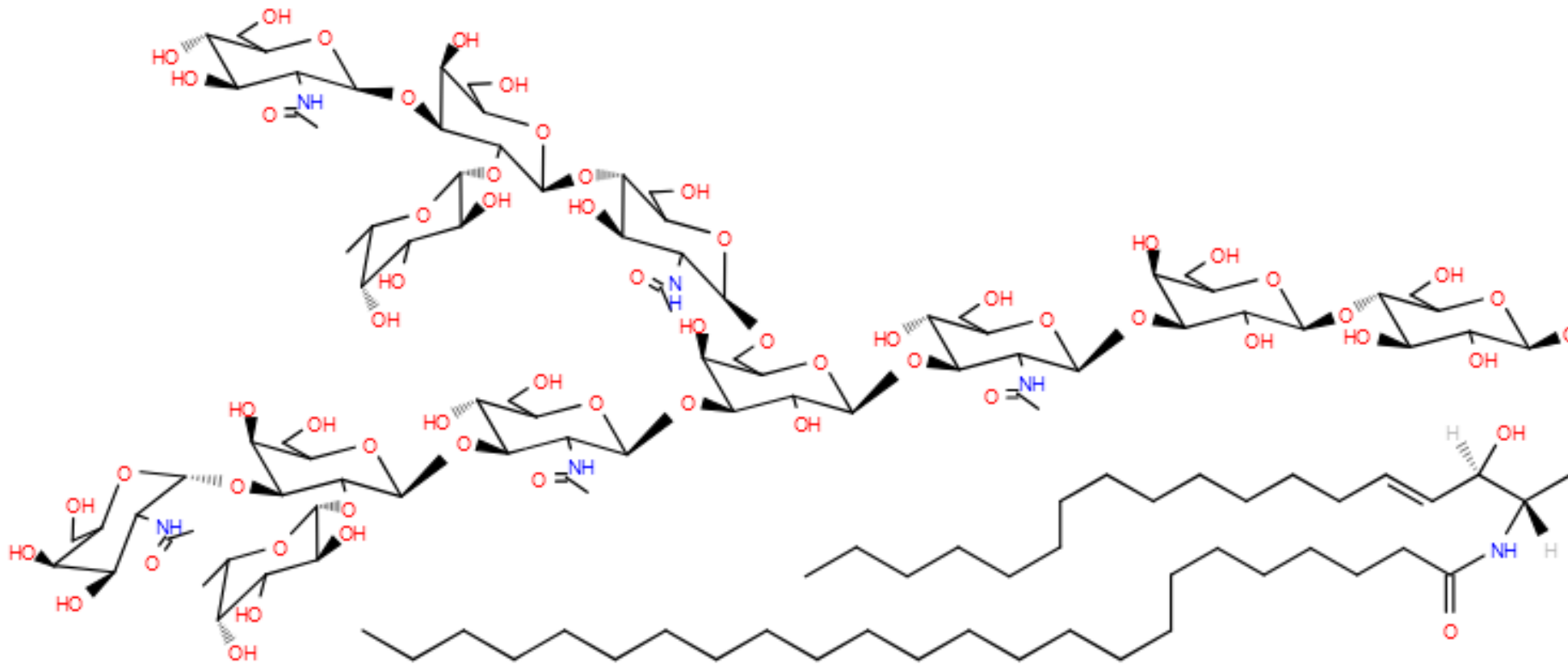
Sphingomyelin



Sphingolipids

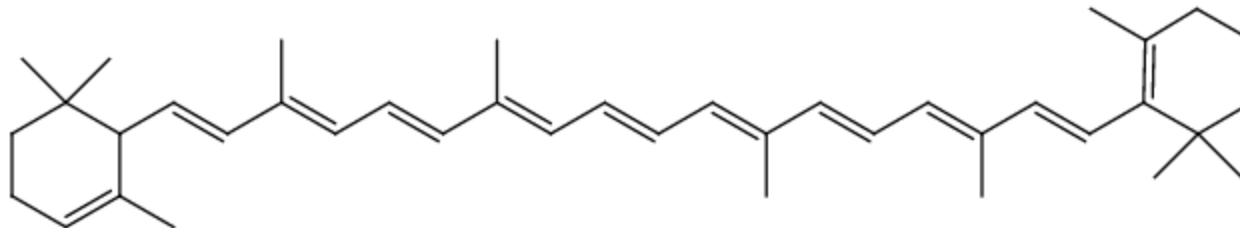
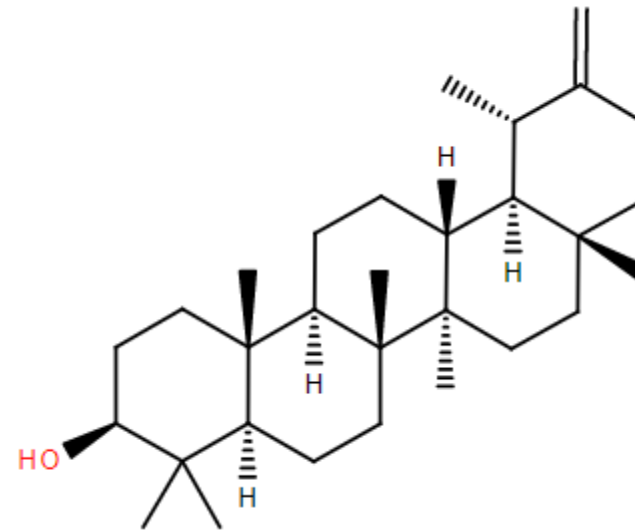
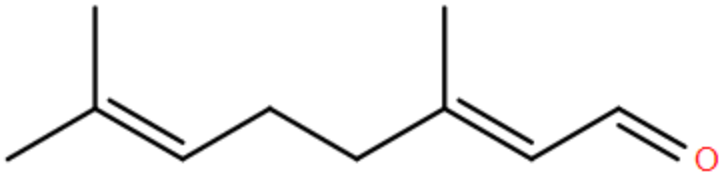


Glycosphingolipids (gangliosides) can be very complex

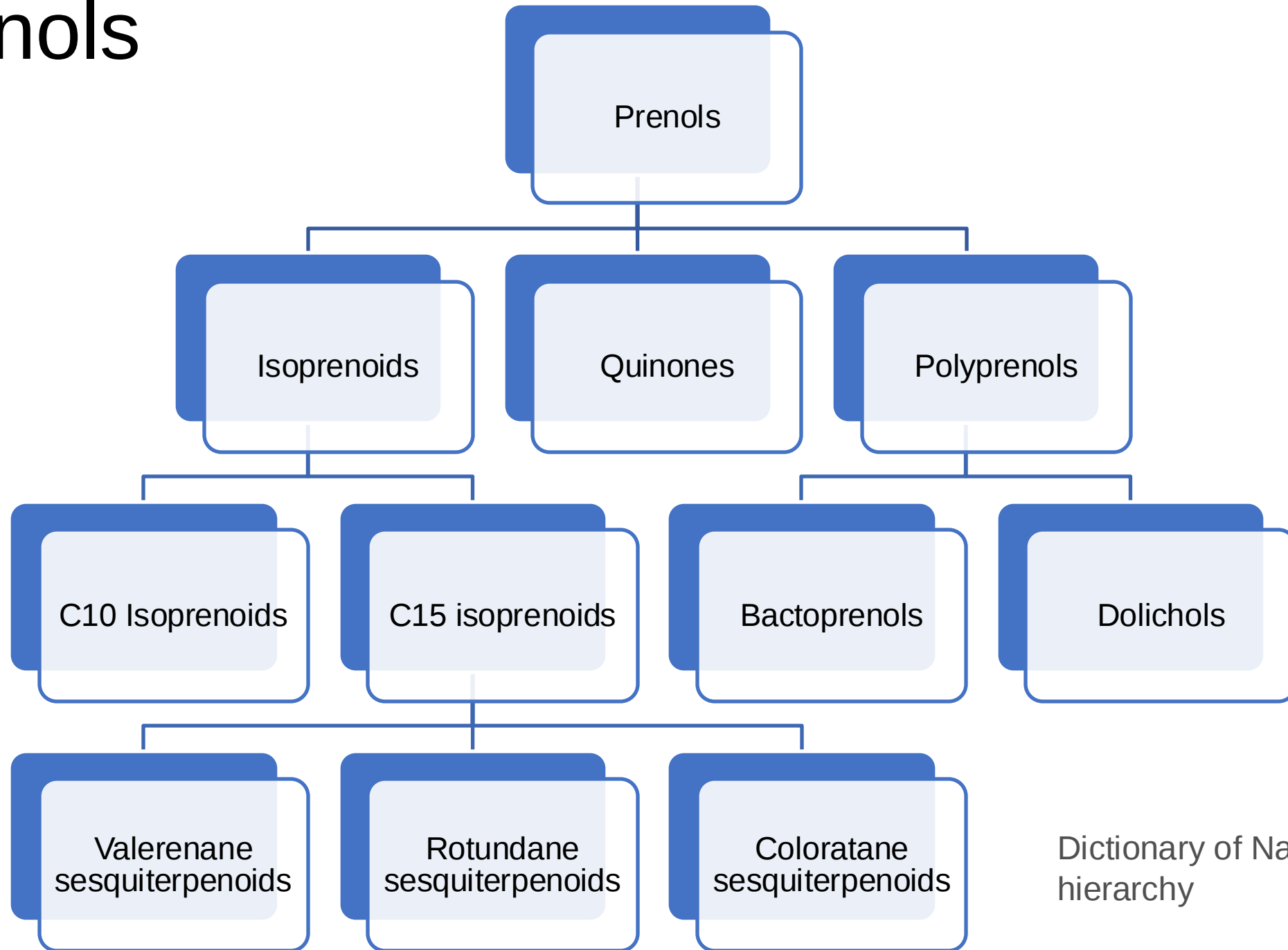


Prenols

- Built up from 5-carbon isoprene units
- Linear or cyclised



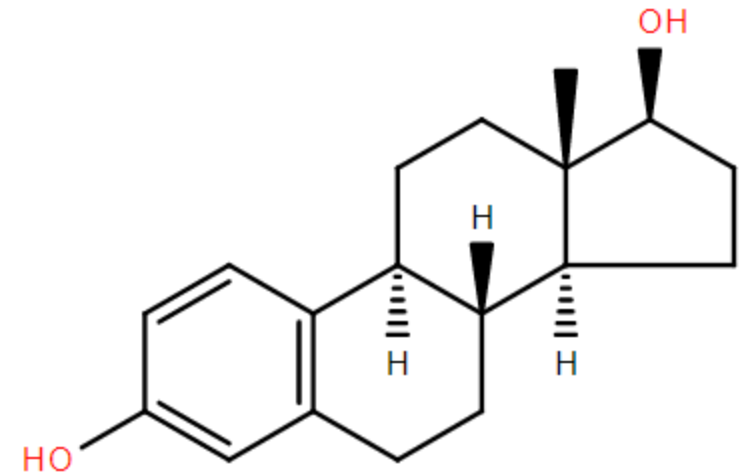
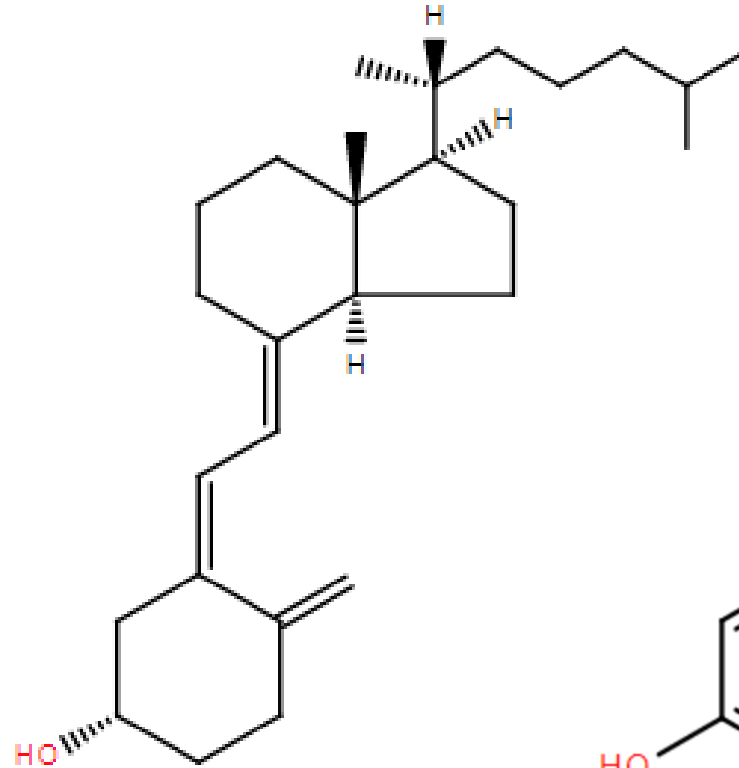
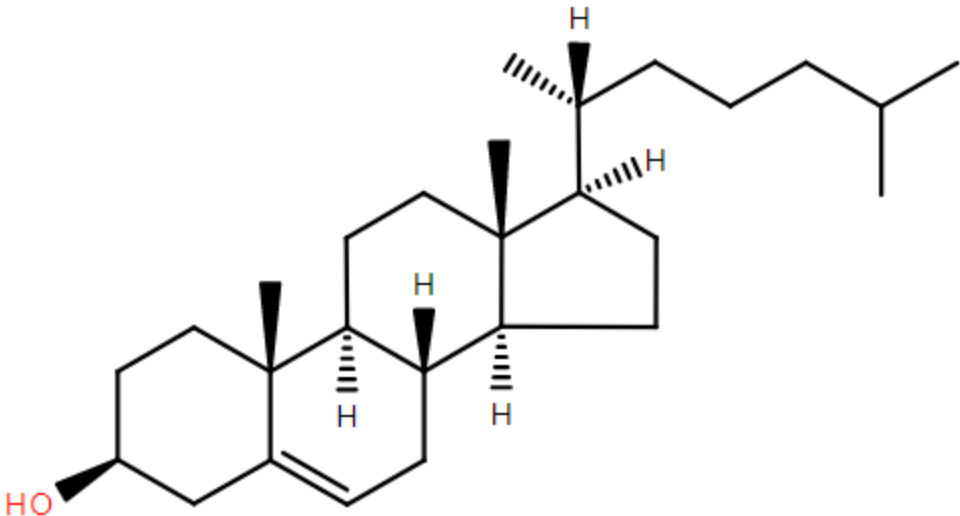
Prenols



Dictionary of Natural Products
hierarchy

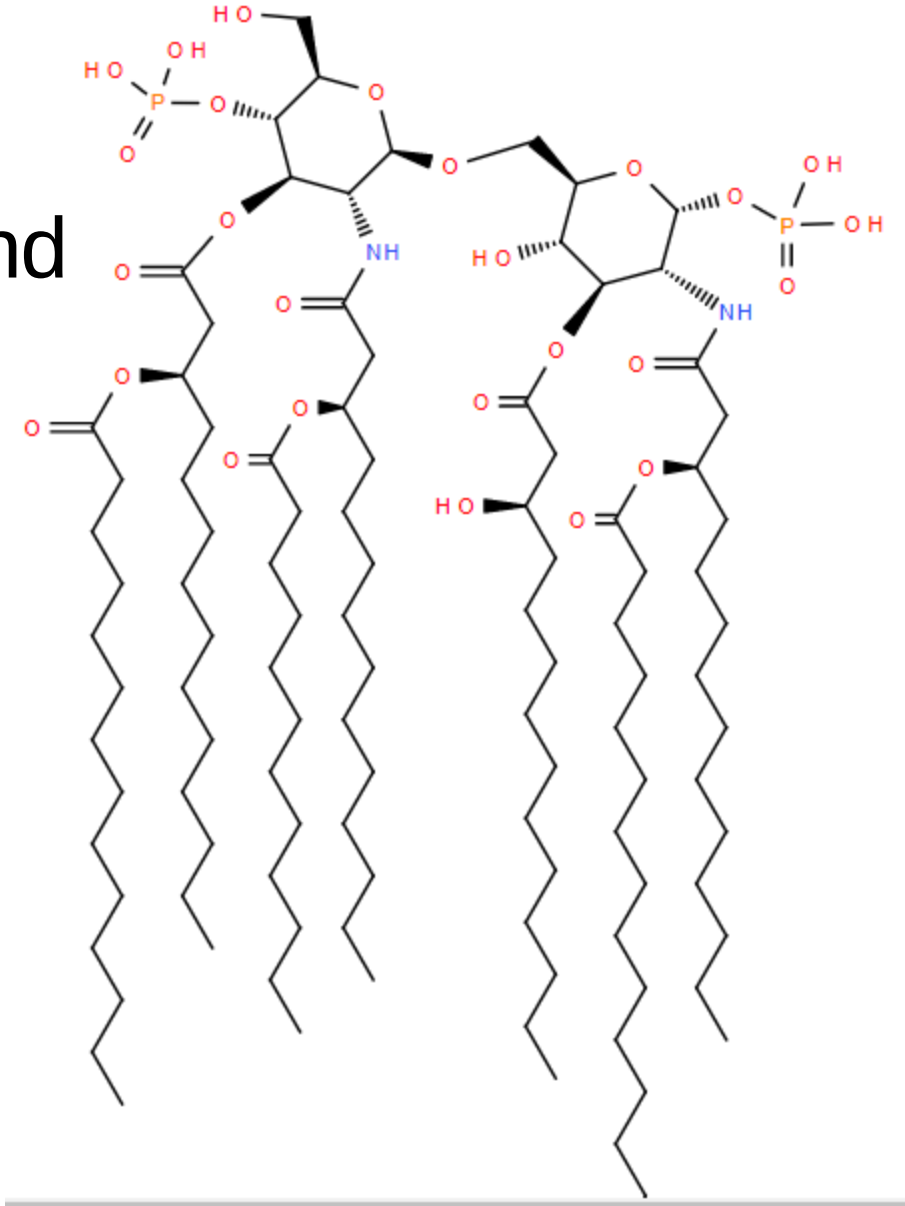
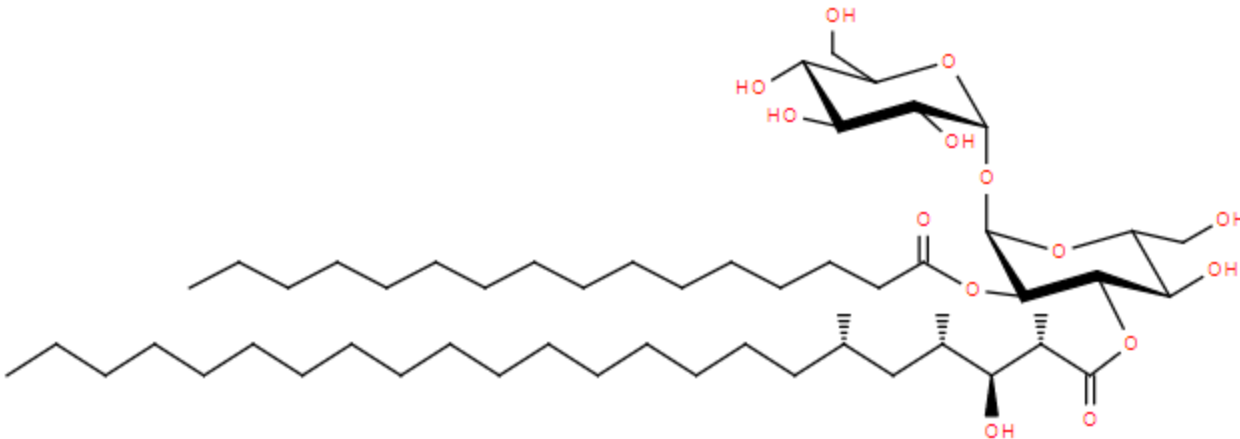
Sterols: A special case of C30 isoprenols

Including
steroid hormones,
bile acids,
Vitamin Ds



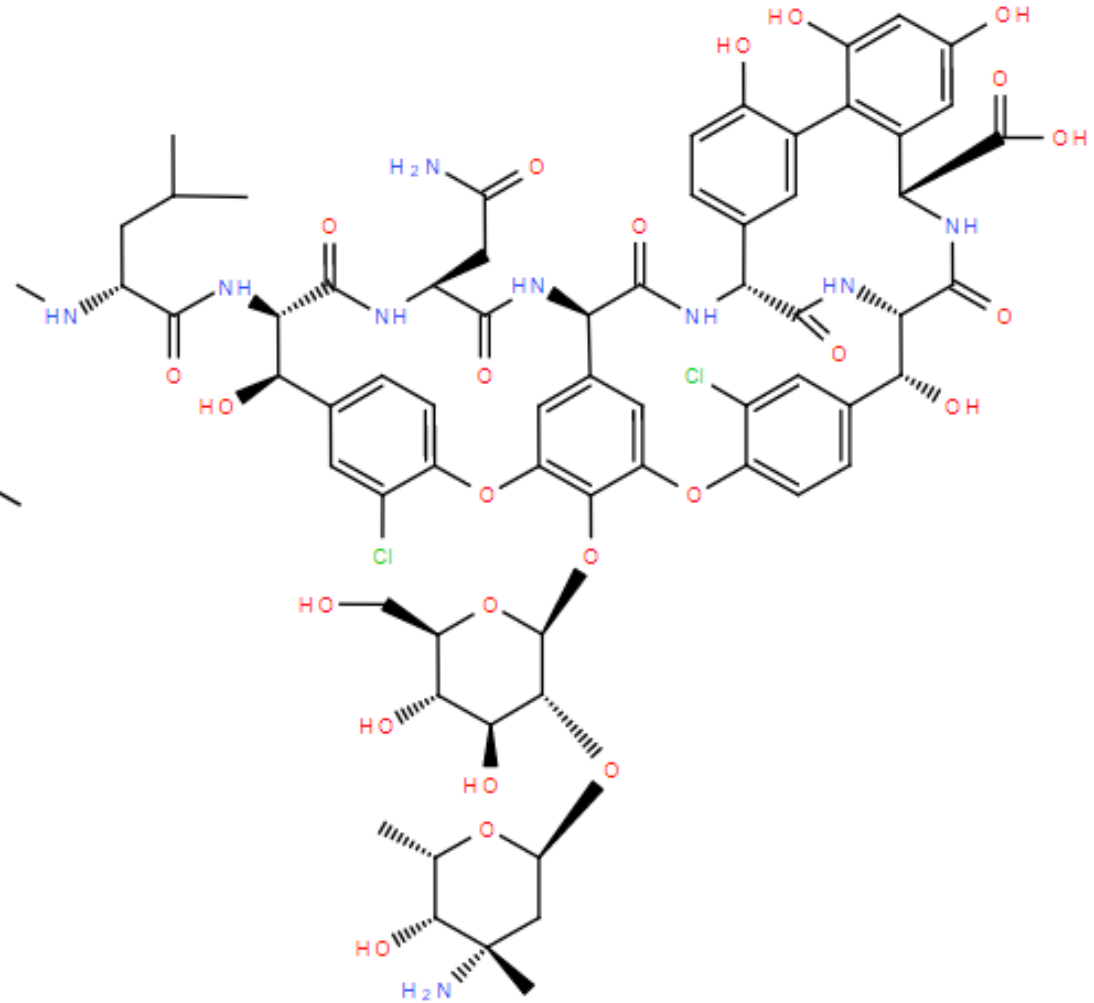
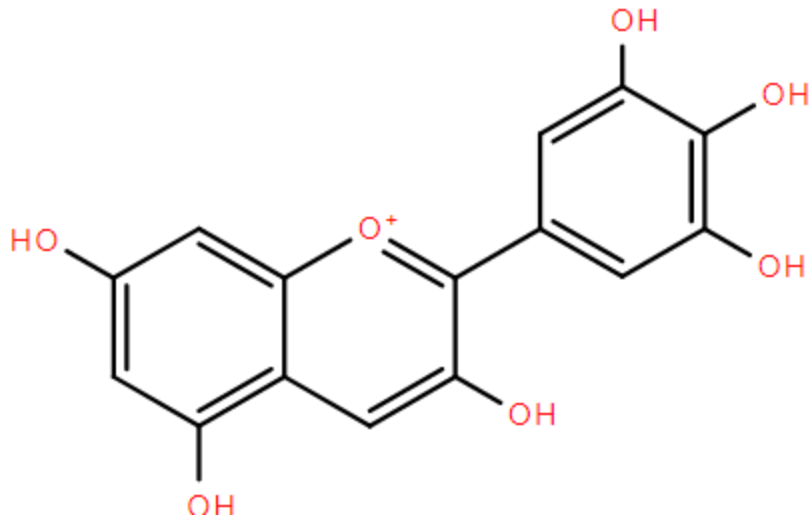
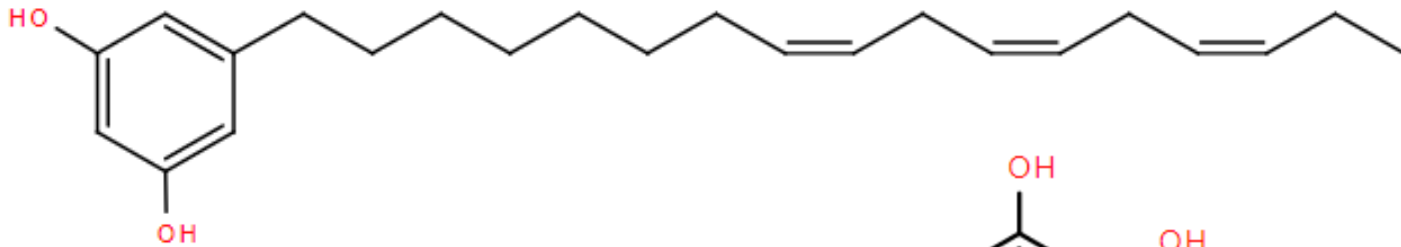
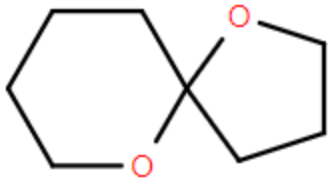
Saccharolipids- SL

- NOT a Glycolipid
- Sugar linkage is not via glycosidic bond
- SL are mostly bacterial in origin



Polyketides- PK

- Diverse plant & microbial metabolites

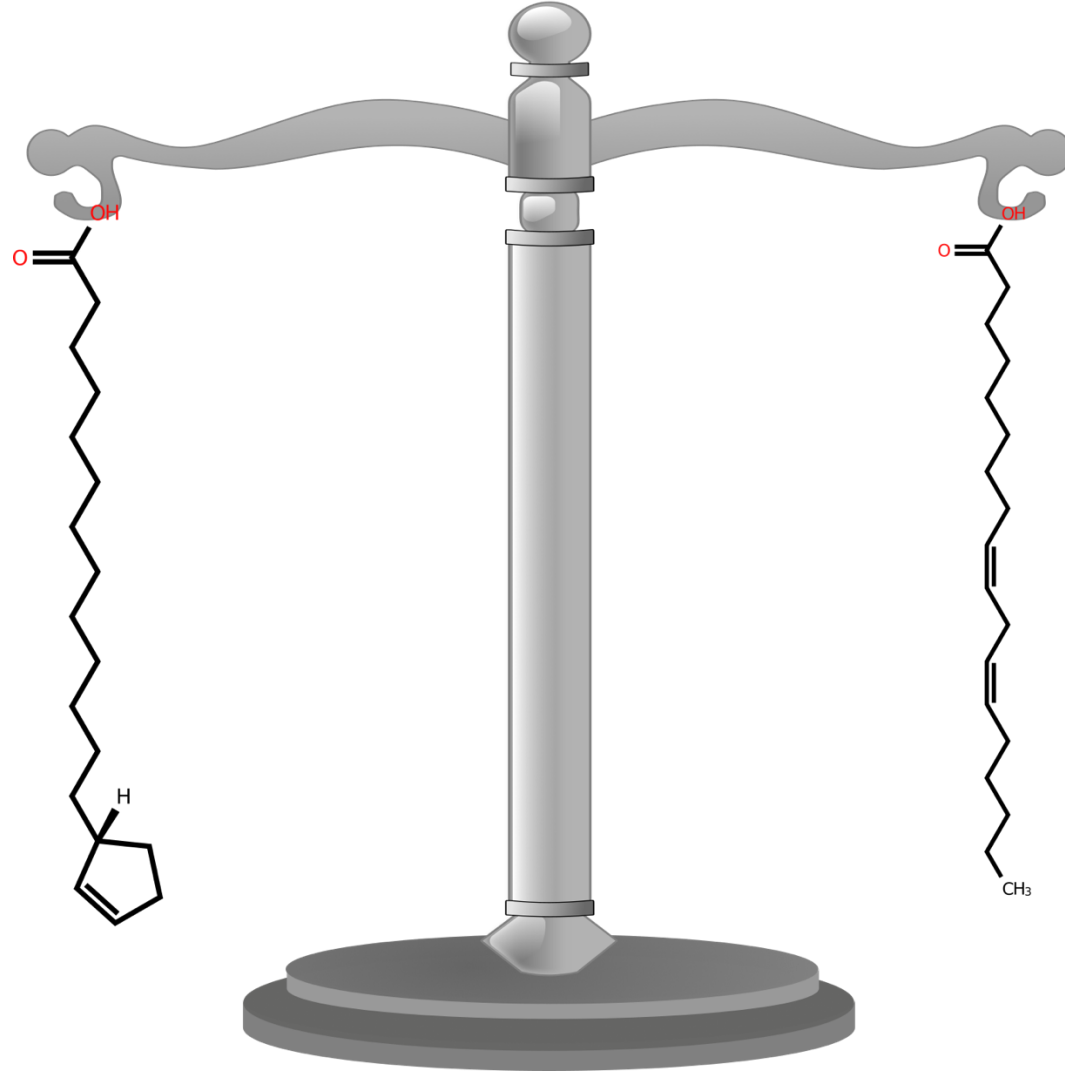


Shorthand Nomenclature

What it is, and why we need it

https://lipidmaps.org/lipid_nomenclature

You cannot identify a substance simply by weighing it



You cannot identify a substance
simply by weighing it



1 kilo

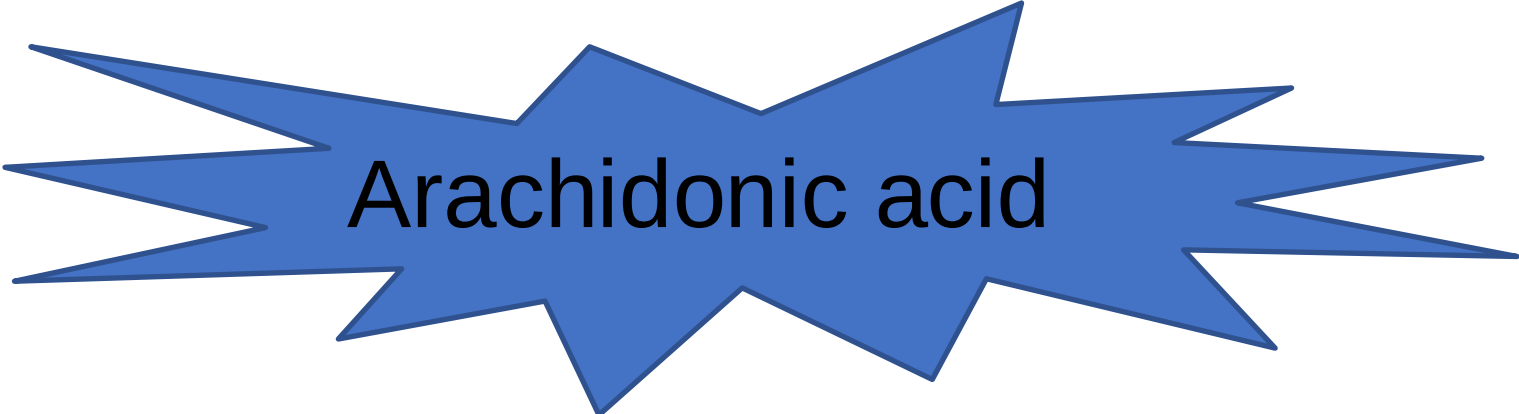
≠



1 kilo

Report only a level of detail you actually have

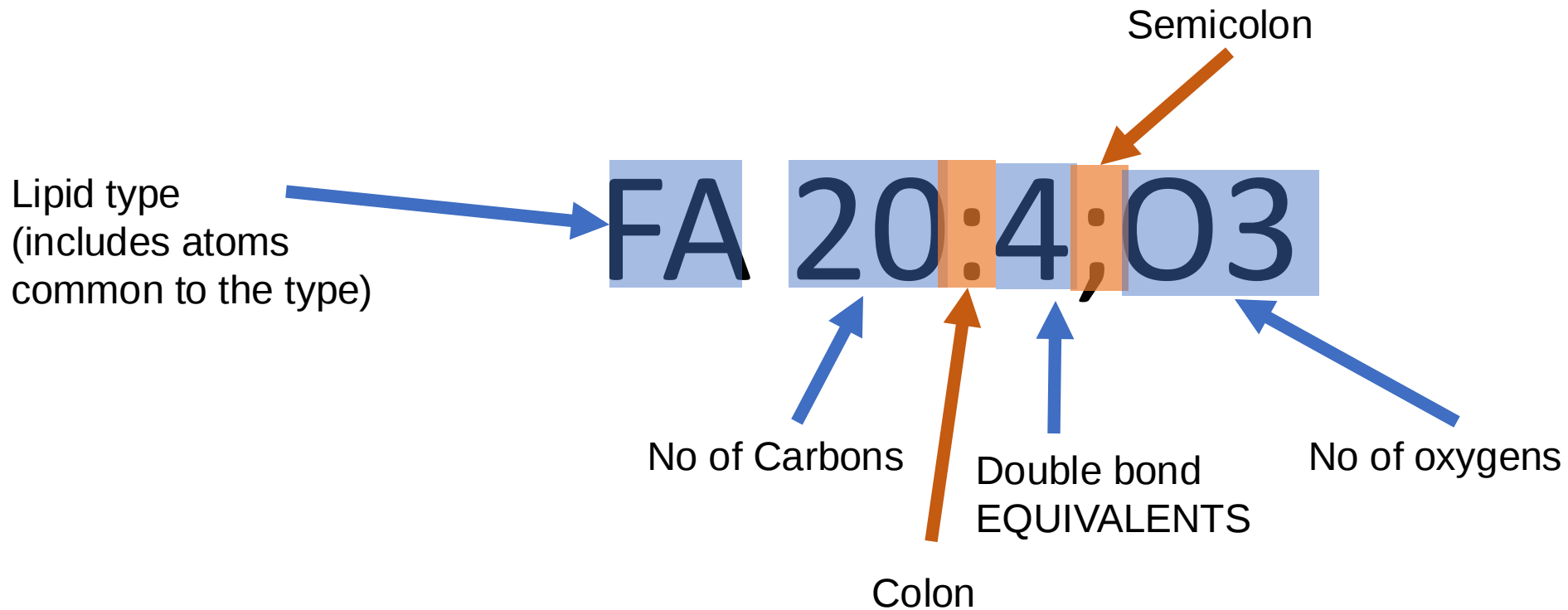
- Shorthand nomenclature describes lipids at different levels of characterization
- Only certain classes are amenable to this notation
- A fatty acid with 20 carbons and 4 double bonds
- Double bonds are at C 5, 8, 11, 14
- Double bonds are all Z (cis) stereochemistry



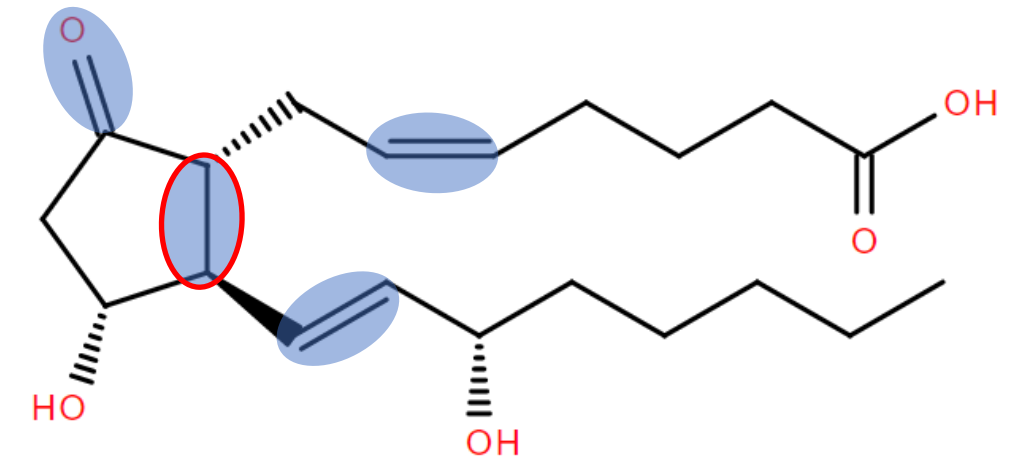
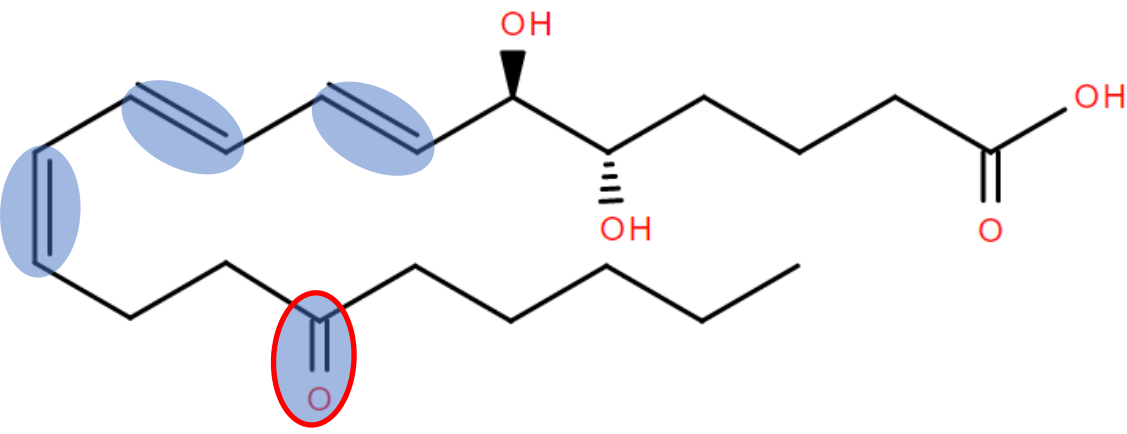
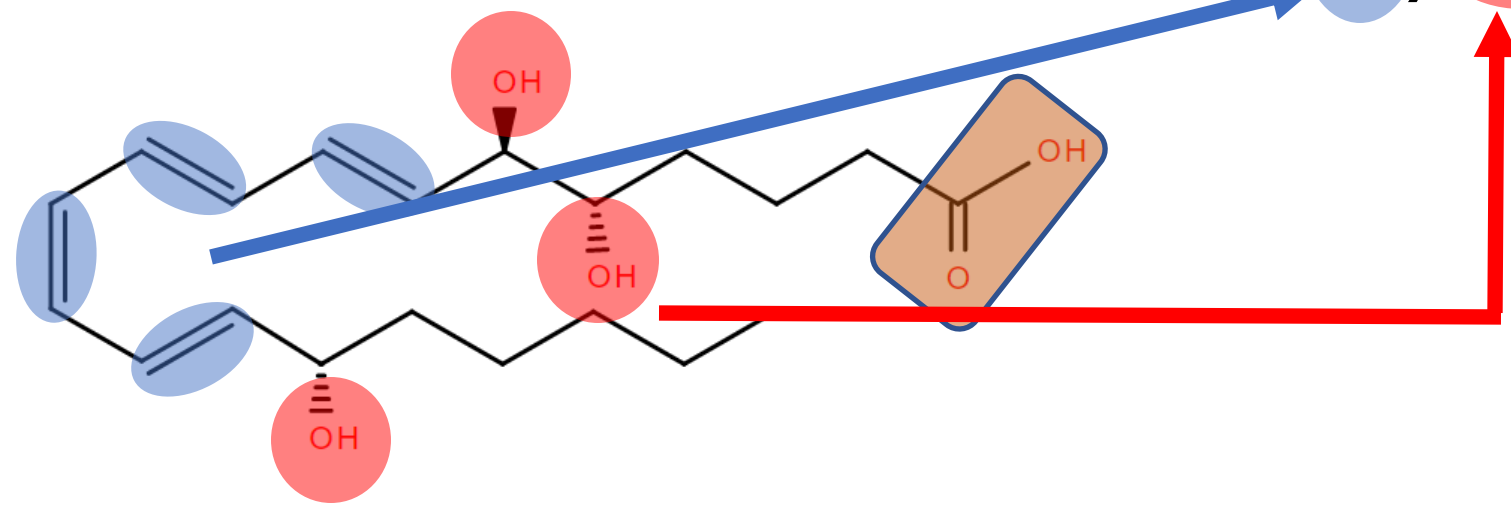
Arachidonic acid

Shorthand Nomenclature

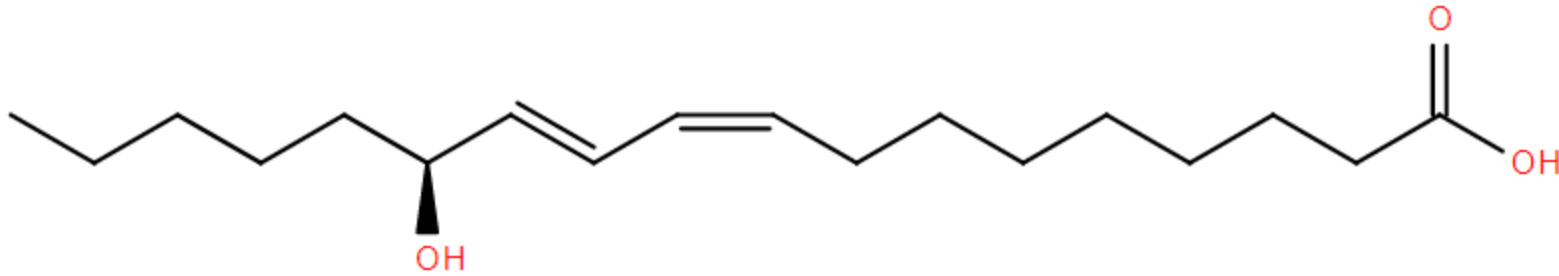
- Describe lipids at different levels of characterisation
- Species level- the least detail



FA 20:4;O3



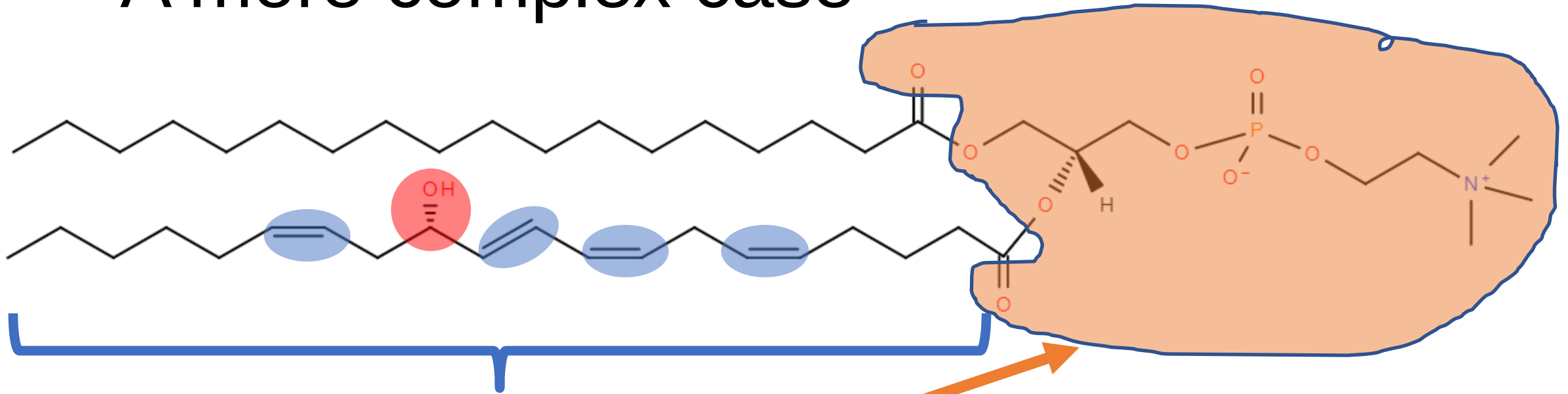
Hierarchy of shorthand nomenclature



• 13S-hydroxy-9Z,11E-octadecadienoic acid

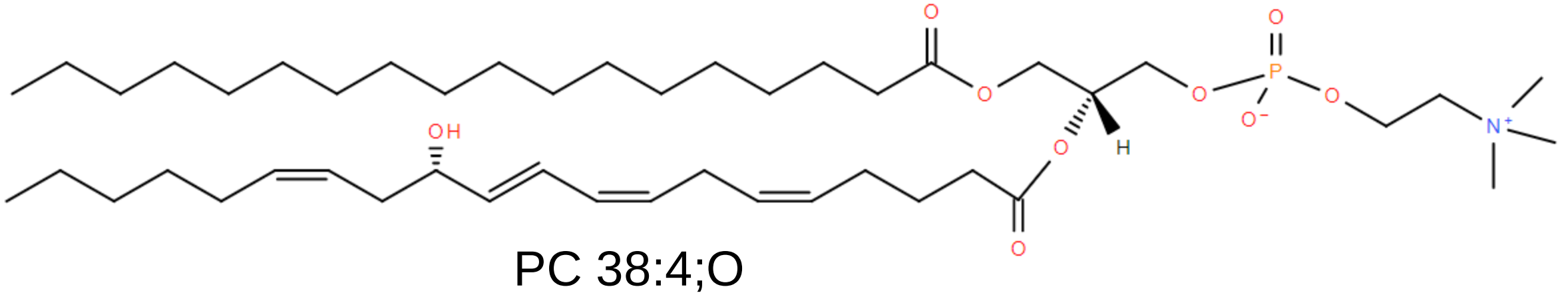
- FA 18:2;O
- FA 18:2 (9, 11);O
- FA 18:2;OH
- FA 18:2(9Z,11E);13OH
- FA 18:2(9Z,11E);13OH[S]

A more complex case



PC 38:4;O

More detailed information



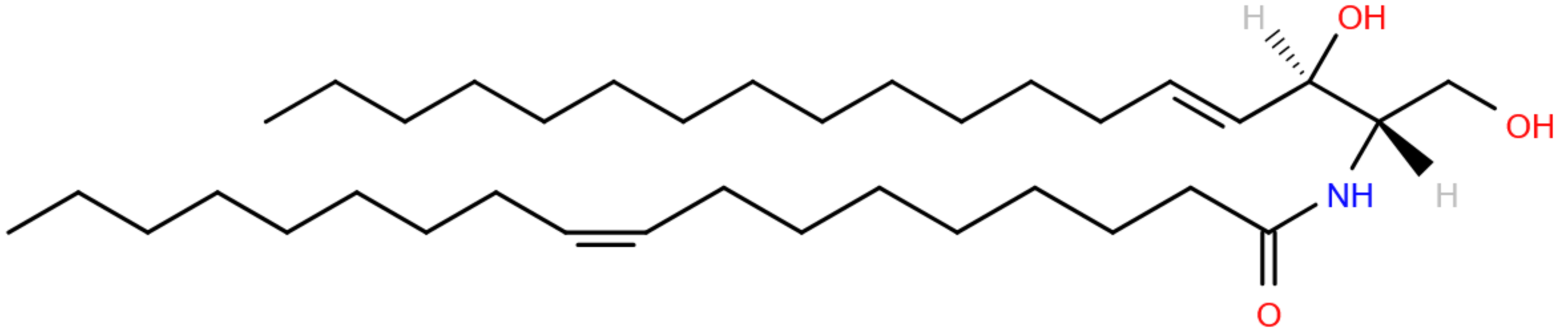
PC 18:0_20:4;O

PC 18:0/20:4;O

— unknown acyl chain position

/ known positions sn1/sn2
sn1/sn2/sn3 for triacylglycerols

Sphingolipids

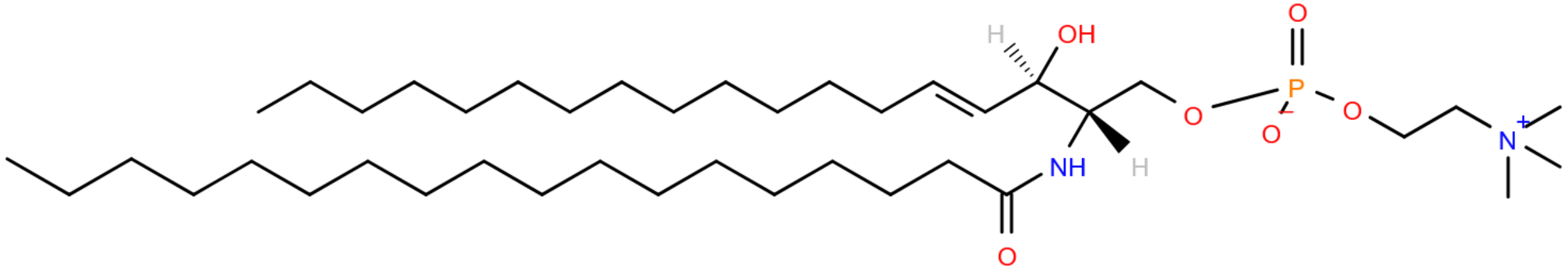


Cer 36:2;O2

Cer 18:1;O2/18:1

Old form: Cer d18:1/18:0

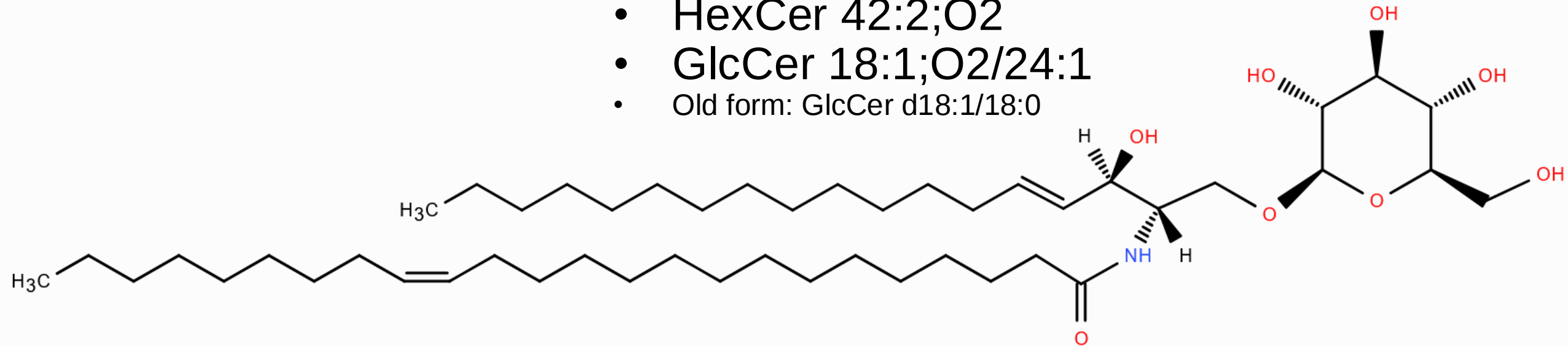
Sphingolipids



SM 36:1;O2

SM 18:1;O2/18:0

- HexCer 42:2;O2
- GlcCer 18:1;O2/24:1
- Old form: GlcCer d18:1/18:0



Take home message

You can't infer complete chemistry from a mass

Report using the **appropriate** level of detail
using shorthand nomenclature

Lipids on the skin of pregnant/non-pregnant women

m/z	Formula	Description	Anova (p)	Highest mean	Adducts
559.517	C18H33NO	Linoleamide	0.000	Control	M + Na
603.534	C39H70O4	1-(14-methyl-pentadecanoyl)-2-(8-[3]-ladderane-octanyl)-sn-glycerol	0.000	Control	M + H
647.558	C41H74O5	DG(18:3(9Z,12Z,15Z)/20:0/0:0)[iso2]	0.000	Control	M + H
684.193	C30H35O18+	Petunidin 3-glucoside-5-(6"-acetylglucoside)	0.004	Pregnant	M + H
794.497	C43H72NO10P	PS(20:5(5Z,8Z,11Z,14Z,17Z)/17:1(9Z))	0.000	Pregnant	M + H
808.506	C42H76NO10P	PS(18:3(9Z,12Z,15Z)/18:0)	0.001	Pregnant	2 M + H
852.556	C50H78NO8P	PC(20:5(5Z,8Z,11Z,14Z,17Z)/22:6(4Z,7Z,10Z,13Z,16Z,19Z))	0.000	Pregnant	M + Na
855.741	C55H98O6	TG(16:1(9Z)/18:0/18:3(9Z,12Z,15Z))[iso6]	0.000	Control	M + Na
862.539	C49H78NO8P	PE(22:6(4Z,7Z,10Z,13Z,16Z,19Z)/22:4(7Z,10Z,13Z,16Z))	0.000	Pregnant	M + Na
866.567	C49H82NO8P	PE(22:6(4Z,7Z,10Z,13Z,16Z,19Z)/22:2(13Z,16Z))	0.002	Pregnant	M + H
874.785	C54H97D5O6	TG(17:0/17:1(10Z)/17:0) (d5)	0.000	Control	M + H
877.726	C57H96O6	TG(14:1(9Z)/18:0/22:6(4Z,7Z,10Z,13Z,16Z,19Z))[iso6]	0.000	Control	M + Na
878.565	C52H80NO8P	PC(22:6(4Z,7Z,10Z,13Z,16Z,19Z)/22:6(4Z,7Z,10Z,13Z,16Z,19Z))	0.000	Pregnant	M + H
878.565	C50H82NO8P	PC(20:5(5Z,8Z,11Z,14Z,17Z)/22:4(7Z,10Z,13Z,16Z))	0.000	Pregnant	M + H
879.741	C57H98O6	TG(16:1(9Z)/18:0/20:5(5Z,8Z,11Z,14Z,17Z))[iso6]	0.000	Control	M + H

Further Information

- Fahy E *et al* **A comprehensive classification system for lipids**

J. Lipid Res. 2005 PubMed ID: [15722563](#)

- Fahy E *et al* **Update of the LIPID MAPS® comprehensive classification system for lipids**

J. Lipid Res. 2009 PubMed ID: [19098281](#)

- Liebisch G *et al* **Shorthand notation for lipid structures derived from mass spectrometry**

J Lipid Res. 2013 PubMed ID: [23549332](#)

- Liebisch G *et al.* **Update on LIPID MAPS classification, nomenclature, and shorthand notation for MS-derived lipid structures**

J. Lipid Res. 2020 PubMed ID: [33037133](#)