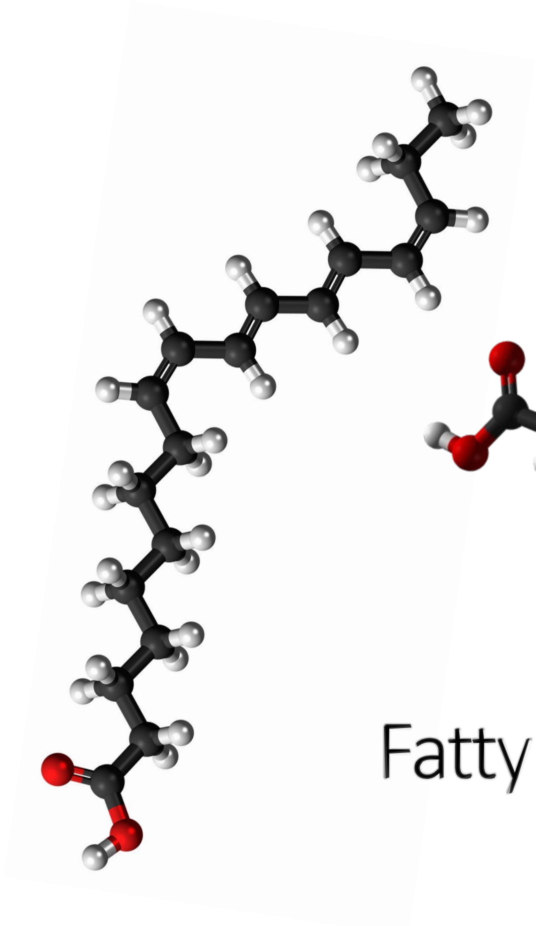
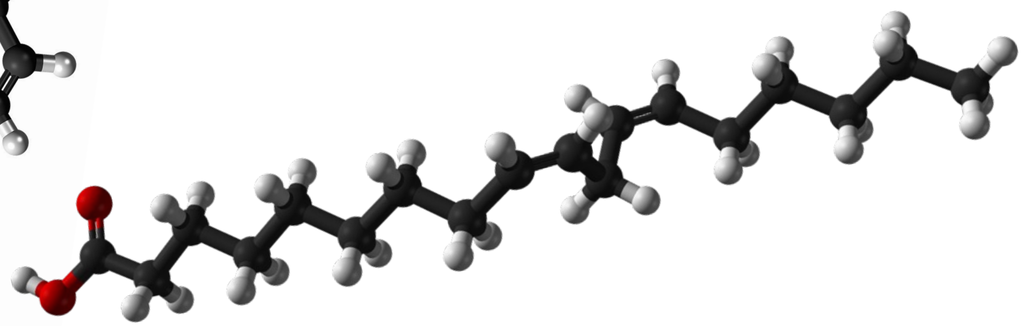
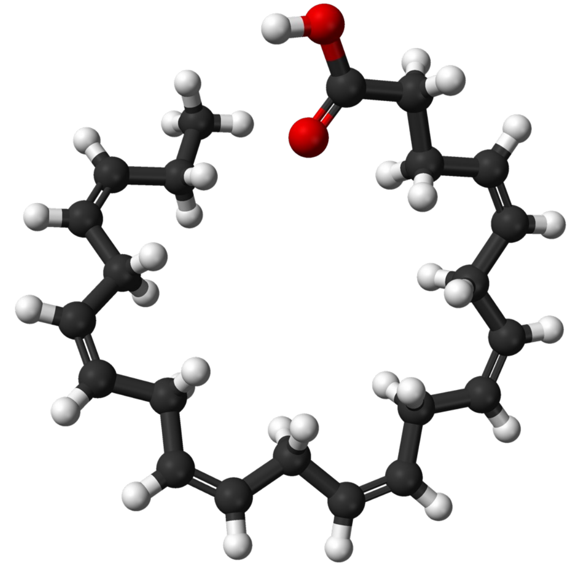
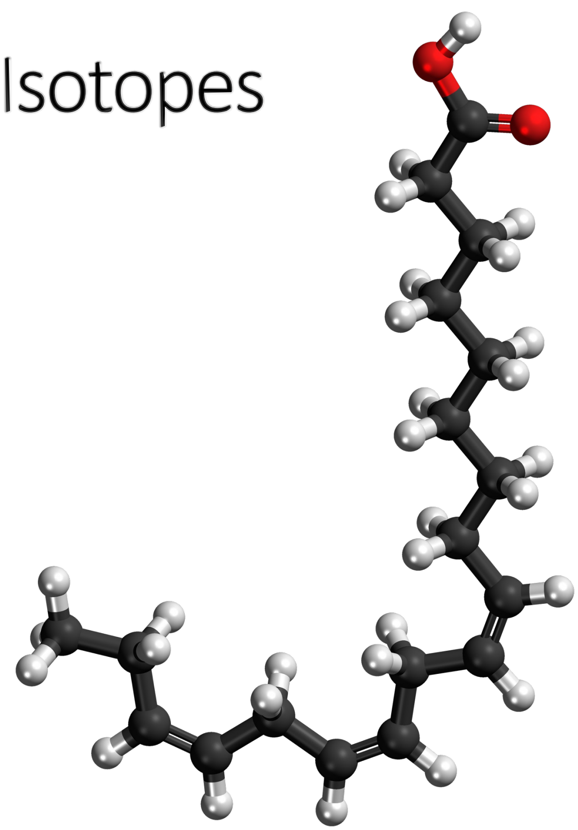
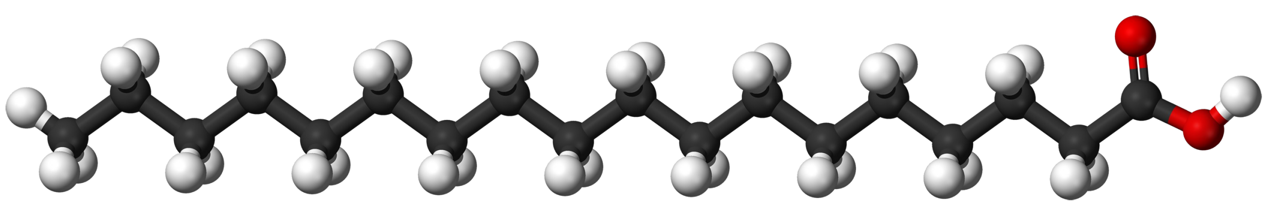






Fatty Acid Carbon and Hydrogen Isotopes





Back to Biochemistry Basics: Lipids

Lipids: hydrophobic or amphipathic organic substances
examples: fatty acids, waxes, steroids, phospholipids

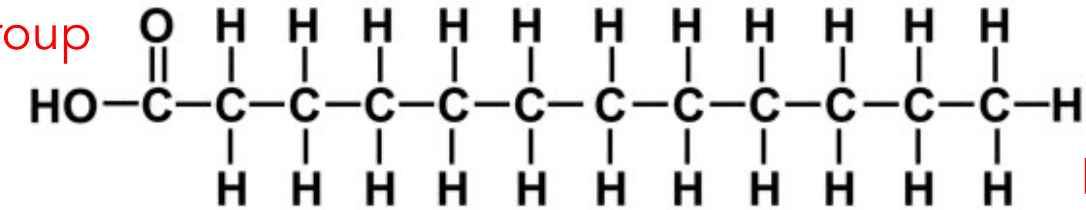
Hydrocarbons: nonpolar molecules constructed of carbon and hydrogen
example: isoprenoids

Three Types of Lipids Found in Cells:

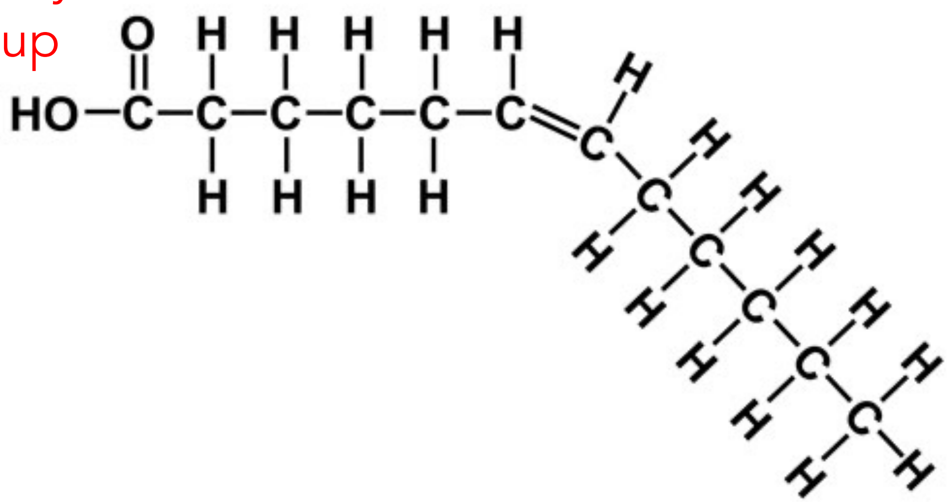
Triglycerides or Fats (energy storage in adipose tissue)
Phospholipids (main component of plasma membranes)
Steroids (estrogen, testosterone, cholesterol)

Back to Biochemistry Basics: Fatty Acid Structure

Saturated Fatty Acid

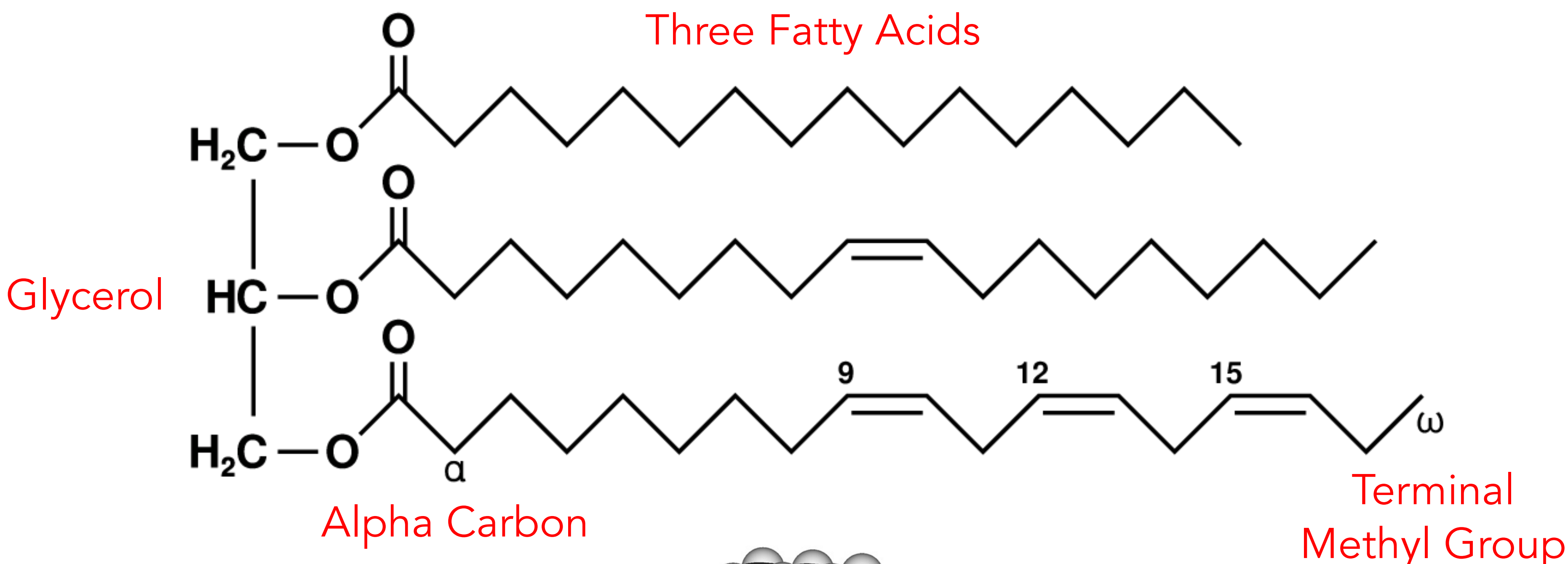


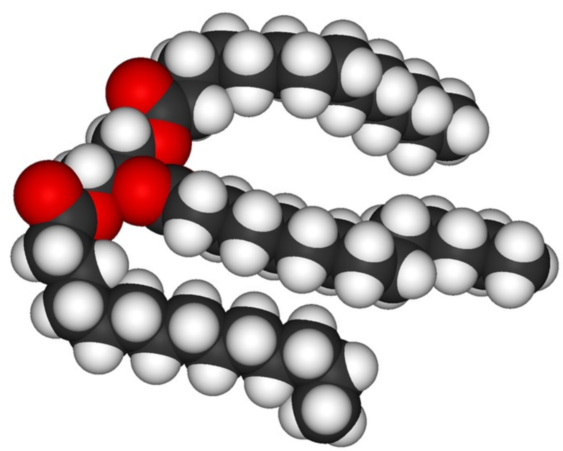
Unsaturated Fatty Acid



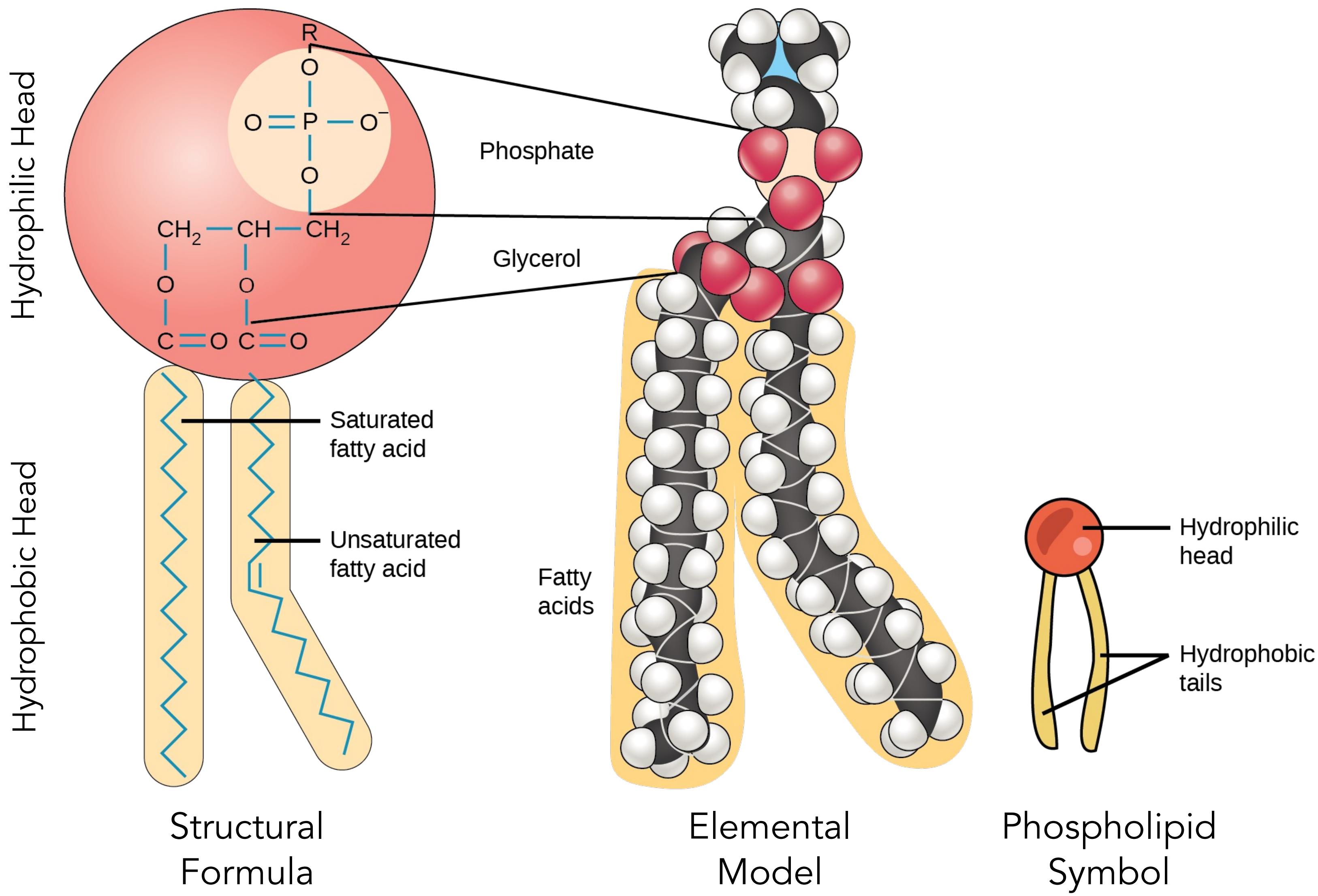
Double bonds between carbon atoms create kinks in the structure.

Back to Biochemistry Basics: Triglyceride Structure



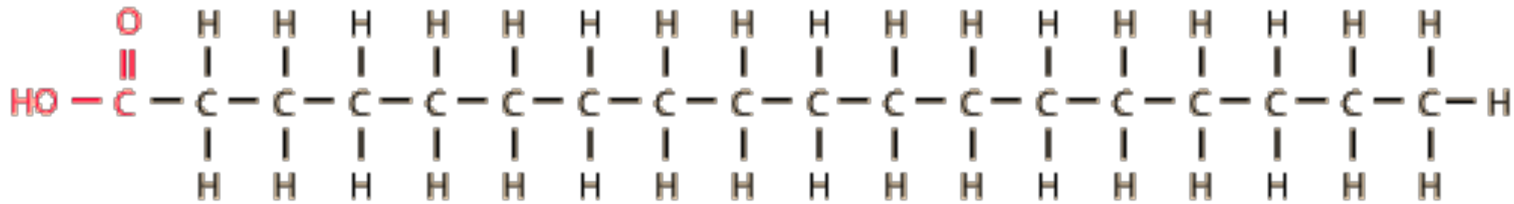


Back to Biochemistry Basics: Phospholipid Structure



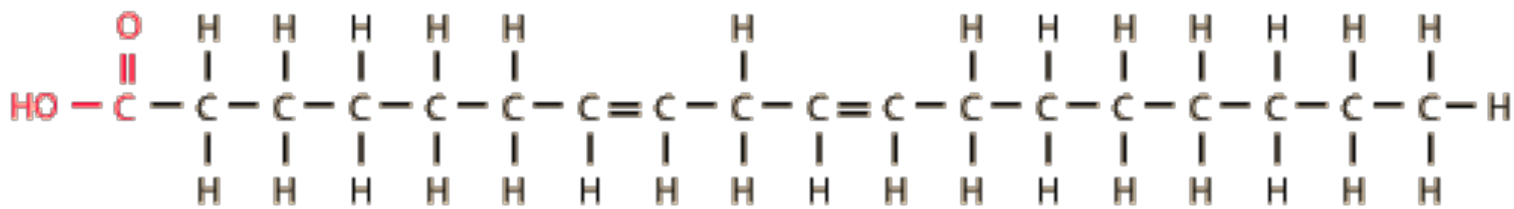
Fatty Acids: Saturated versus Unsaturated

18:0



Stearic Acid: Saturated Fatty Acid

18:2(n-6)



Linoleic Acid: Unsaturated Fatty Acid

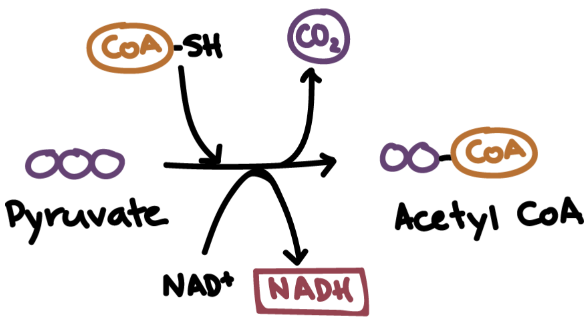
\# of C atoms → **A:B(n-x)** ← position of last double bond

↑

\# of double bonds

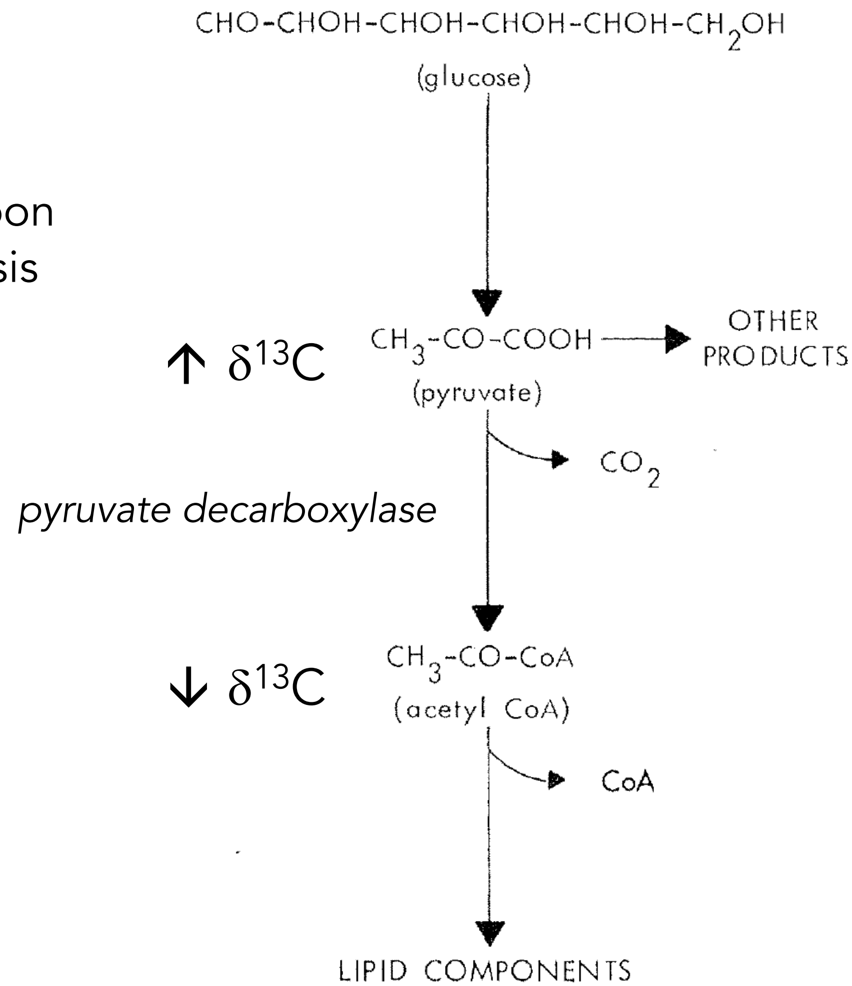
Isotopic Fractionation During Lipid Synthesis

Decarboxylation



main source of carbon for lipid biosynthesis

Carbon source	δ¹³C (per mil)	
	Carbon source	Lipid
Glucose	−9.5	−15.7
		−16.3
Sodium pyruvate	−20.5	−28.9
		−28.9
Sodium acetate	−20.1	−21.5
		−20.7

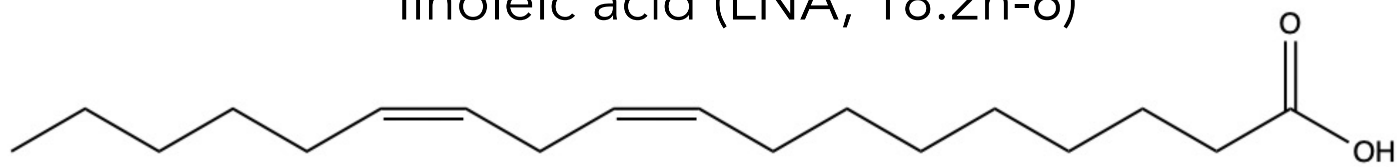


DeNiro and Epstein 1977

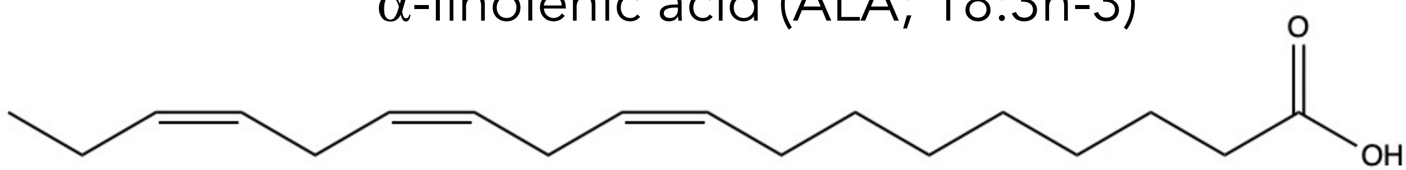
Essential Fatty Acids (PUFAs)

Animals do not have the enzymes needed to create double bonds in fatty acids closer than the 7th carbon atom (n-7 or ω7) from the methyl group.

linoleic acid (LNA; 18:2n-6)



α-linolenic acid (ALA; 18:3n-3)

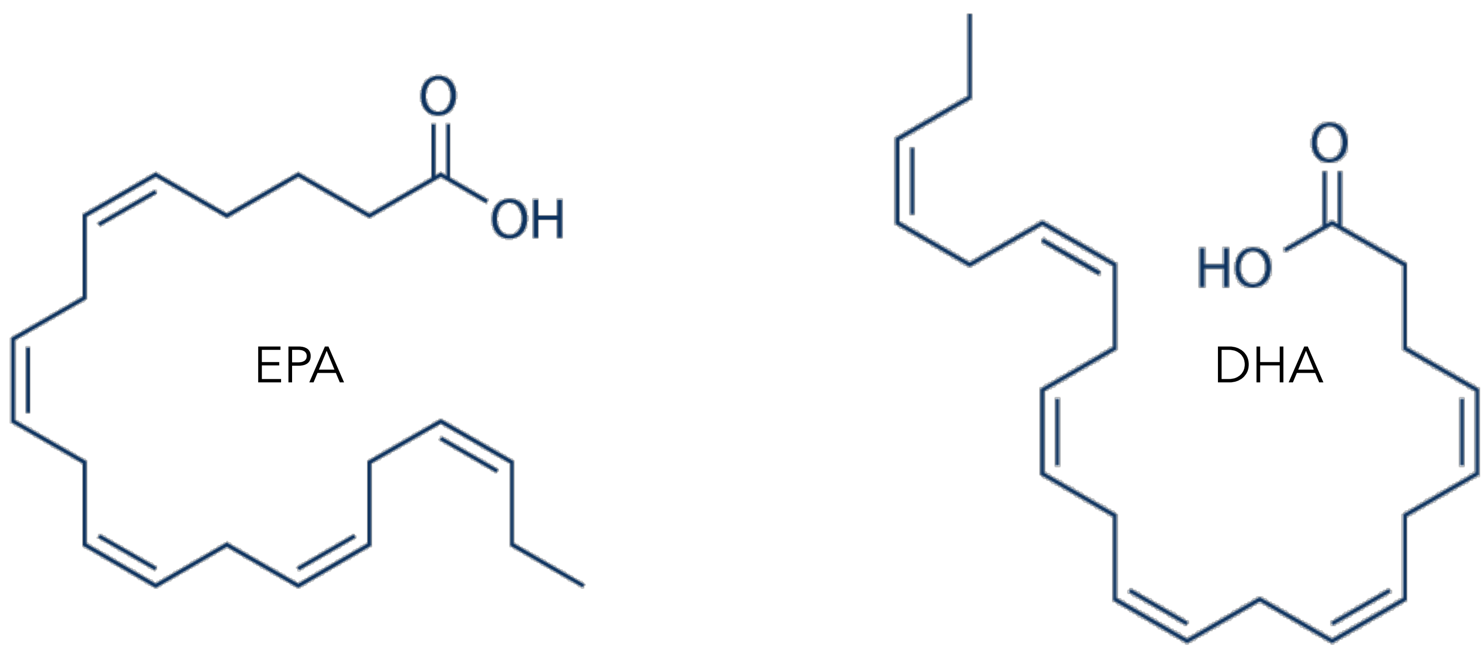


These are also considered polyunsaturated fatty acids (PUFAs)
LNA is an omega-6 FA
ALA is an omega-3 FA

Highly Unsaturated Fatty Acids (HUFAs)

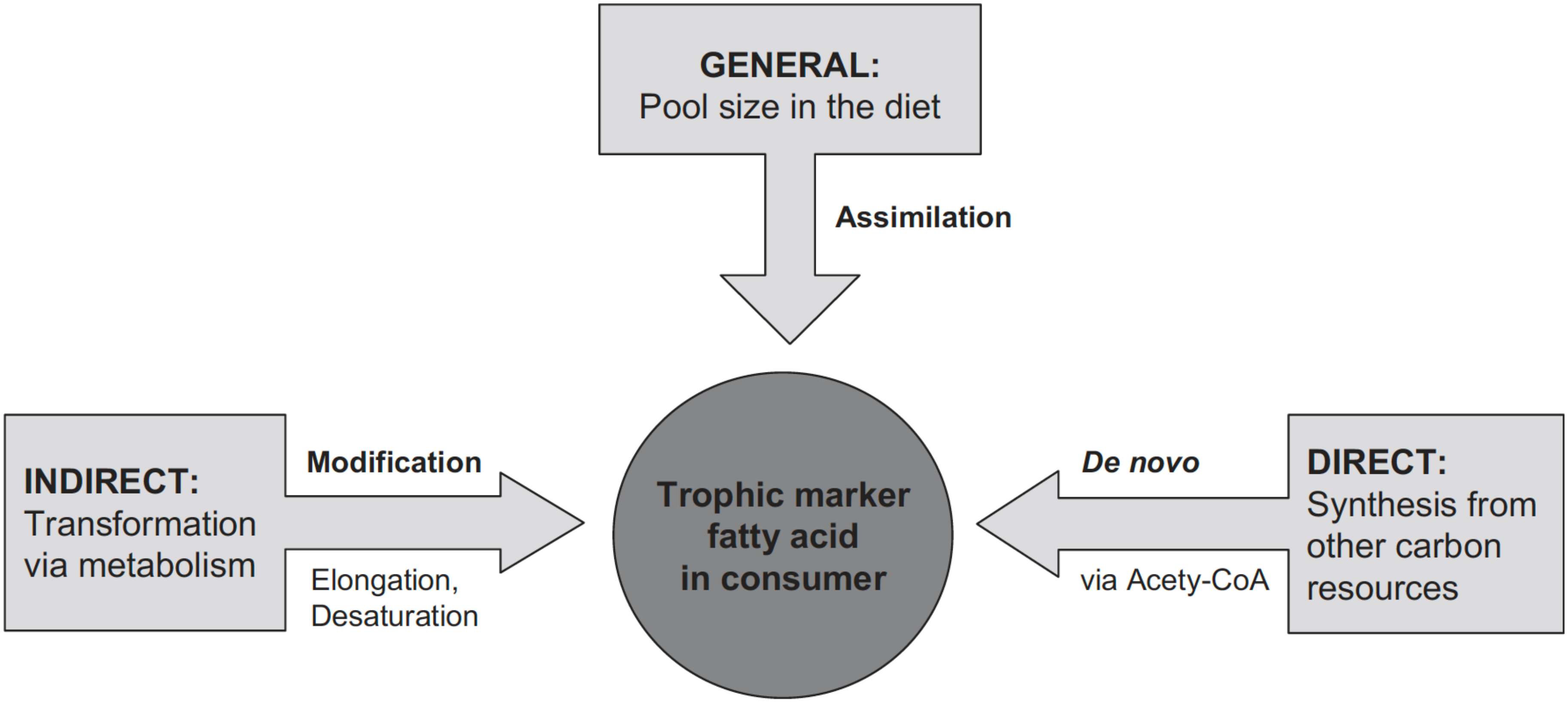
Animals can desaturate and elongate α-linolenic acid (18:3n-3) to the HUFAs eicosapentaenoic acid (20:5n-3) and docosahexaenoic acid (22:6n-3), but they may not be able to do this quickly enough to meet their metabolic demands.

Thus, these HUFAs can be conditionally essential.
Directly routing them from diet is energetically advantageous.



EPA and DHA are omega-3 fatty acids

Assimilation vs Modification vs Synthesis

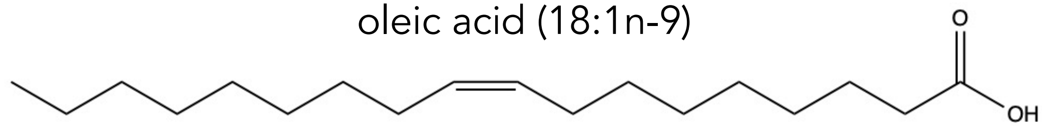


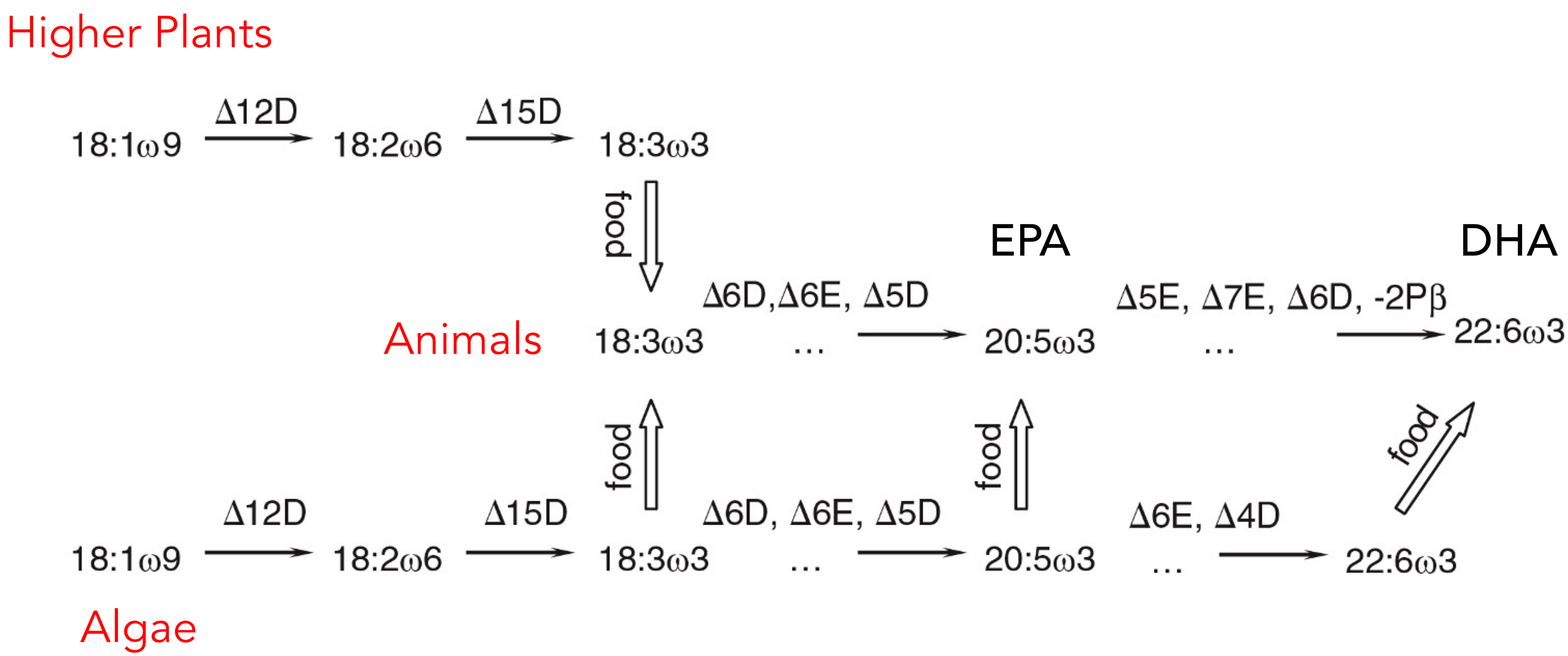
Organismal lipid composition is not as conserved as protein composition.
Environmental and physiological conditions (including growth state, nutritional status, and stress) can dramatically alter lipid composition.

Ruess and Chamberlain 2010

Aquatic Primary Producers Are Rich in HUFA

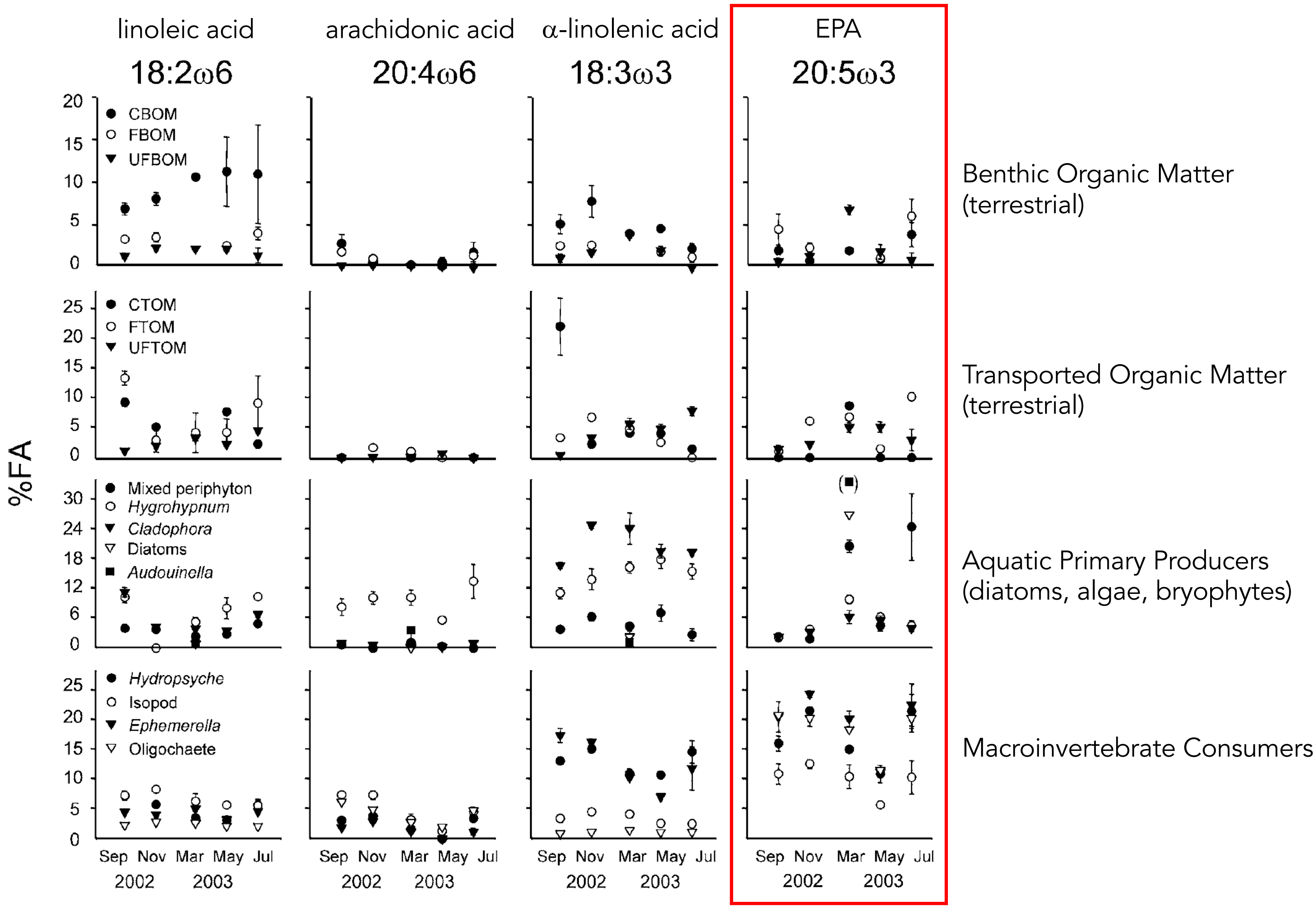
oleic acid (18:1n-9)





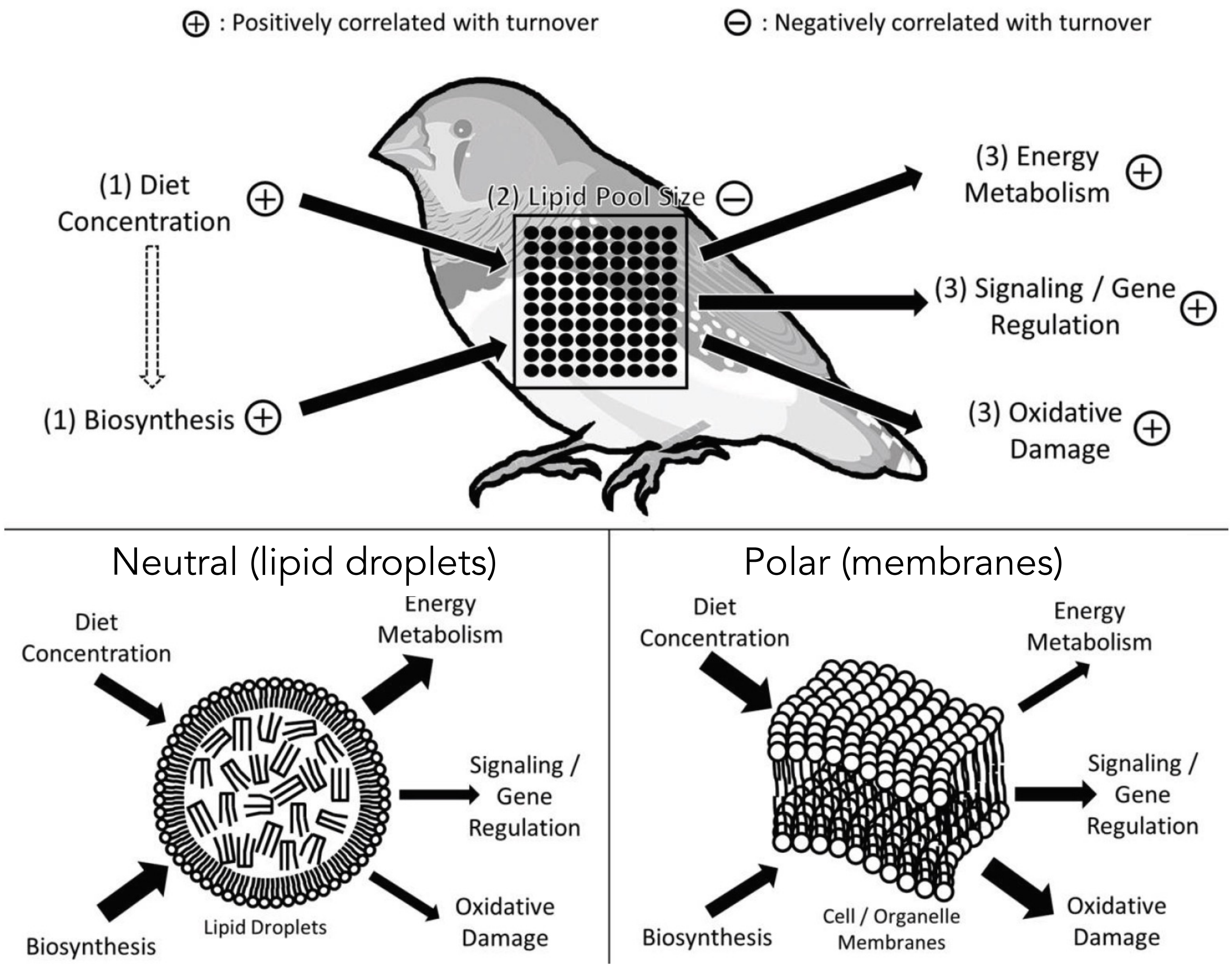
Gladyshev et al. 2009

Aquatic Primary Producers Are Rich in HUFA



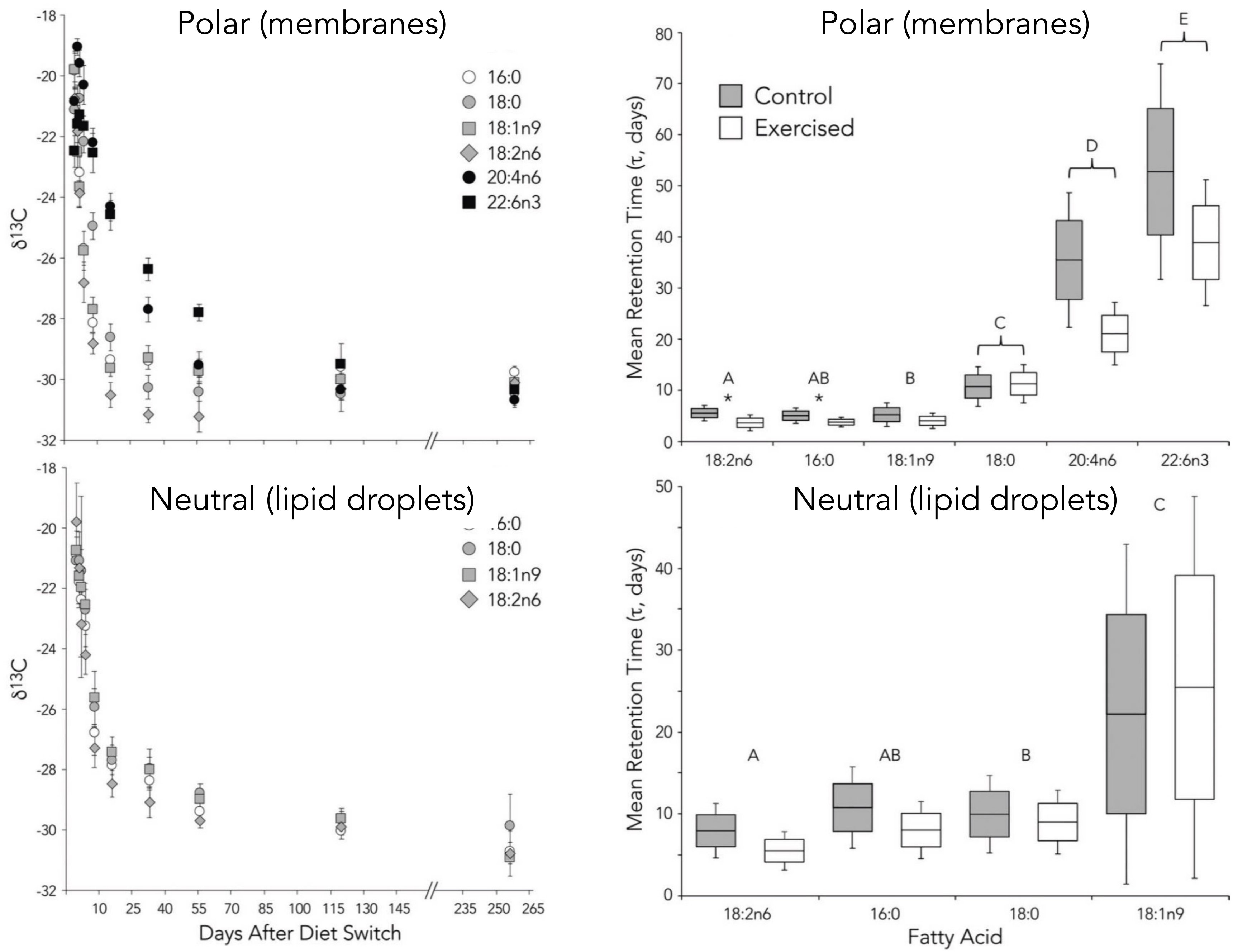
Torres-Ruiz et al. 2007

Fatty Acid Turnover Rate?



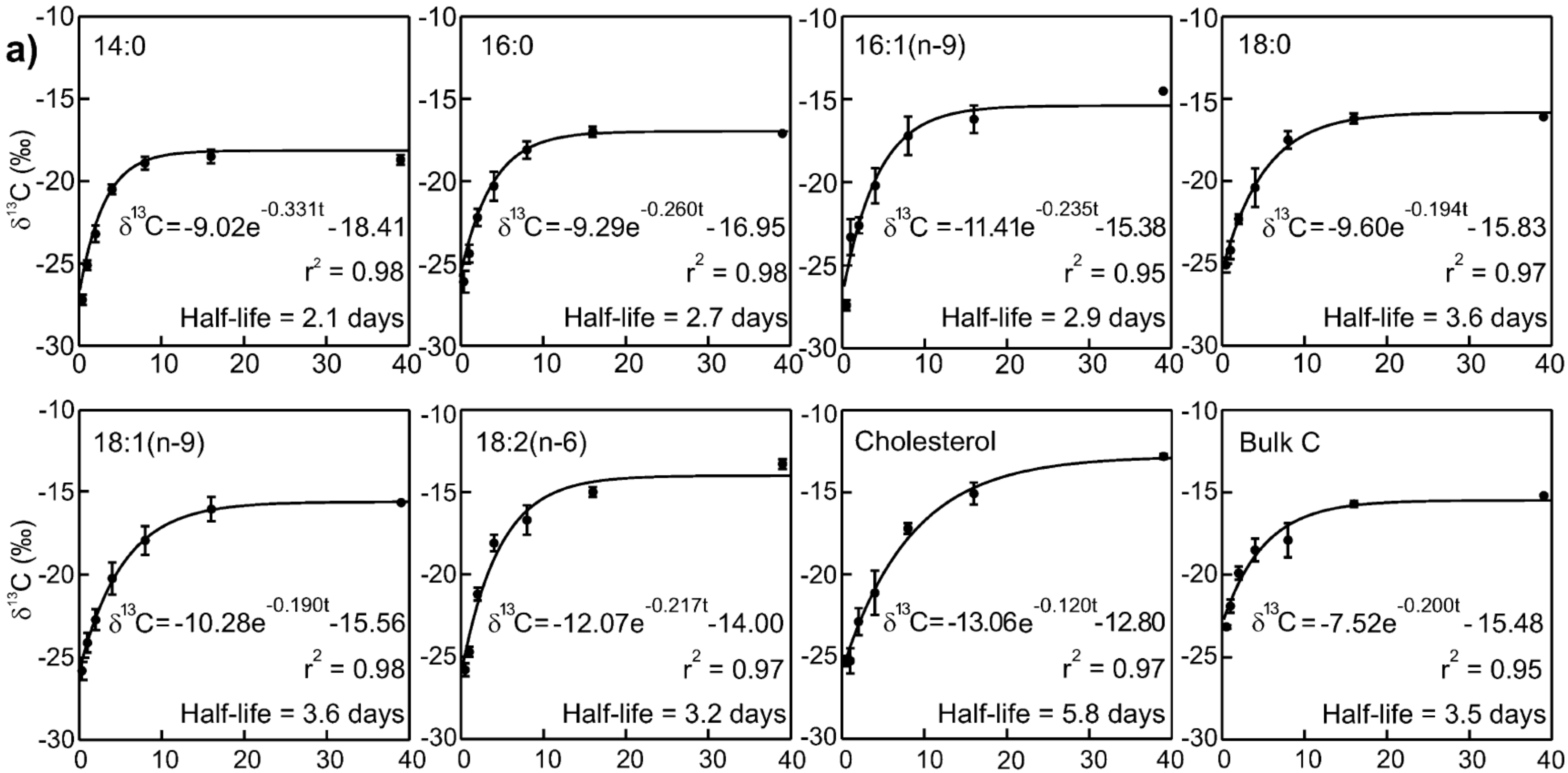
Carter et al. 2019

Fatty Acid Turnover Rate?



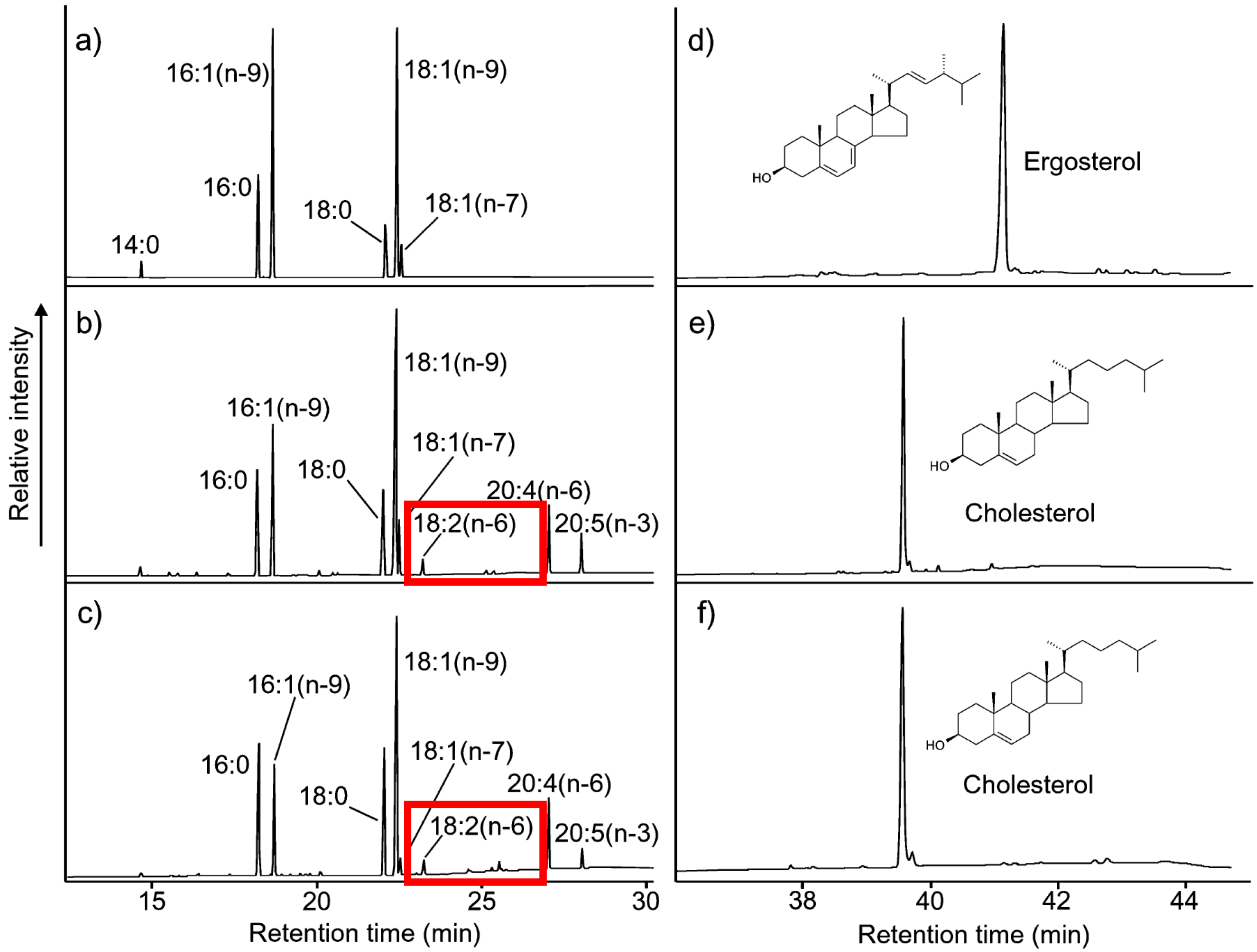
Carter et al. 2019

Fatty Acid Turnover Rate: Collembola



Chamberlain et al. 2004

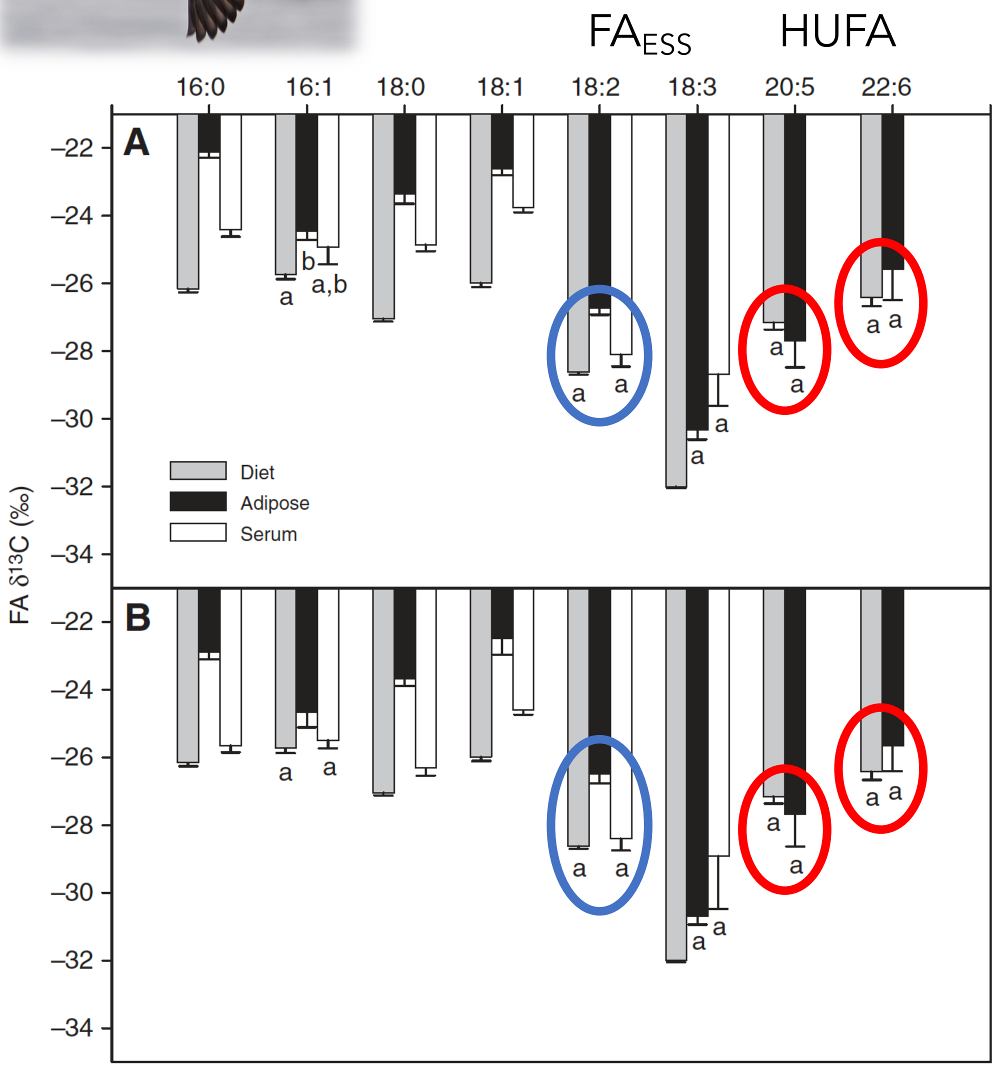
Collembola Can Synthesize Essential Fatty Acids

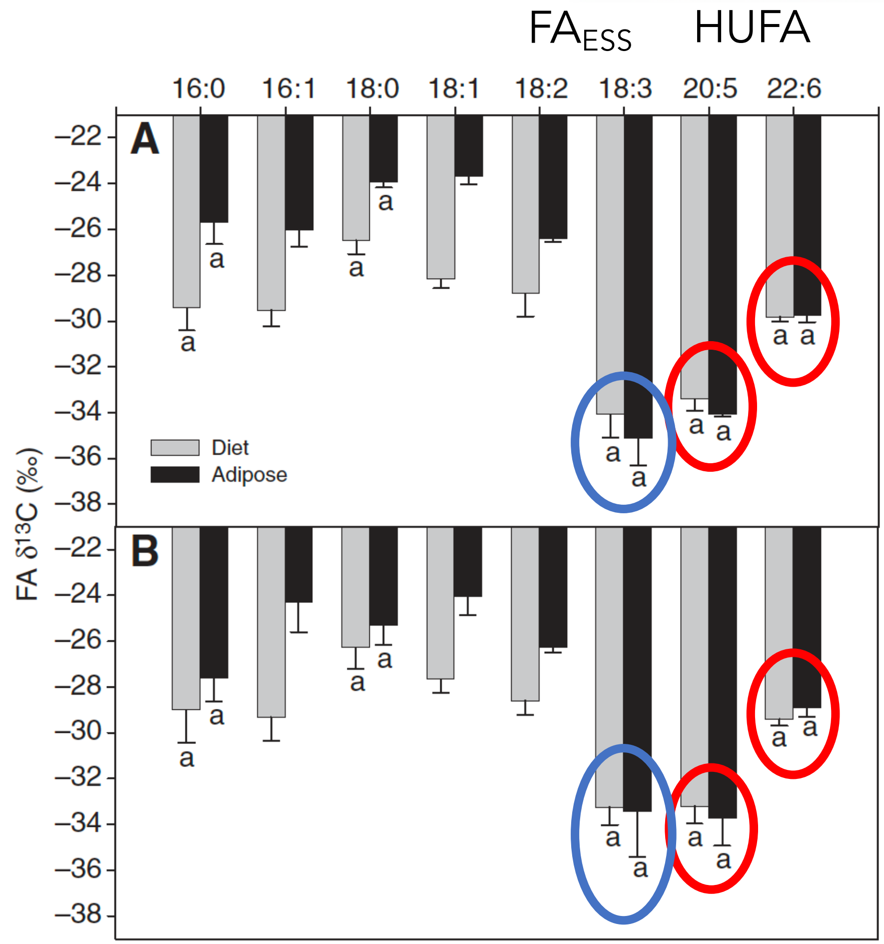


The diet items did not contain PUFAs, so Collembola synthesized them *de novo*.

Chamberlain et al. 2004

Essential Fatty Acids as Energy Sources?





If supplied in excess, FA$_{ESS}$ may be catabolized for energy and may have higher δ^{13}C values in consumer tissues as compared to diet.

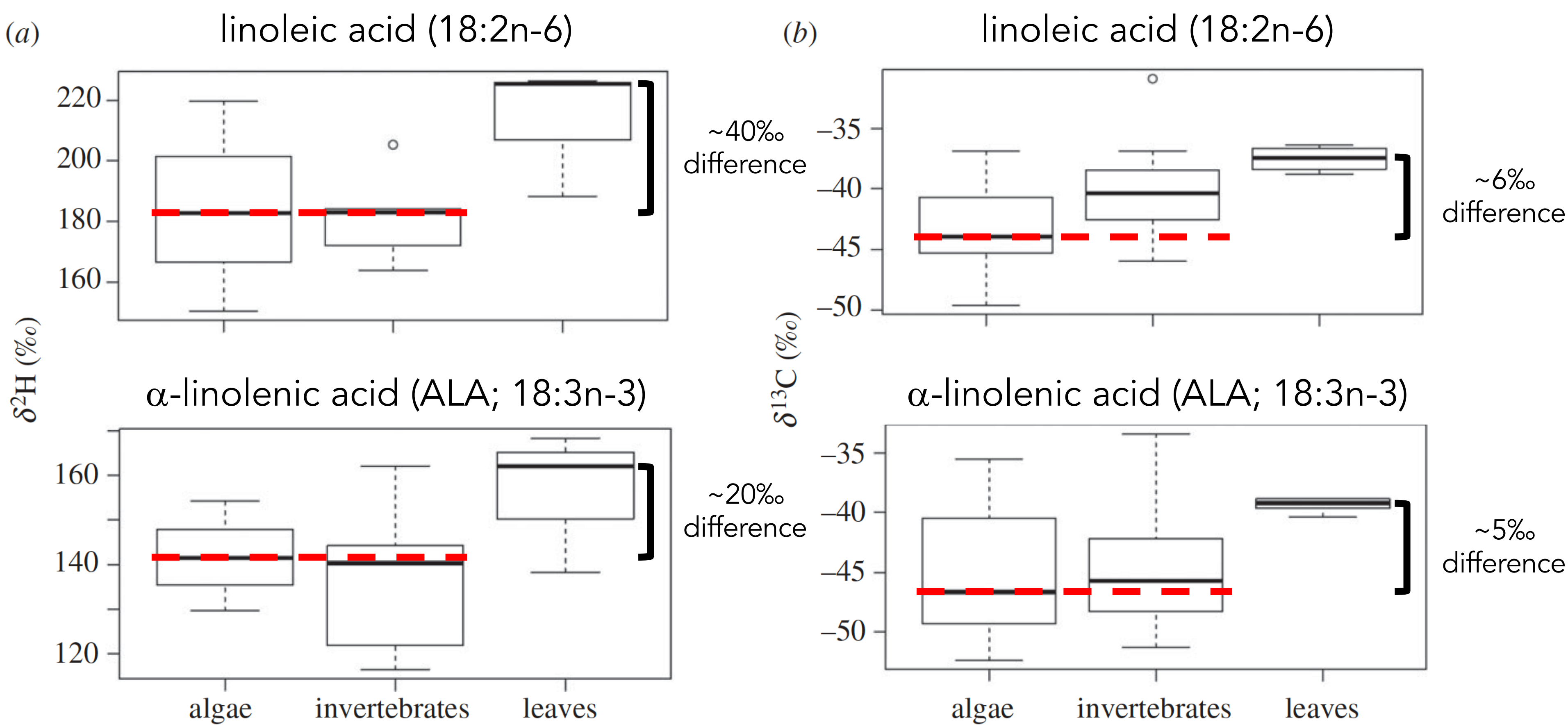
Budge et al. 2011

Essential Fatty Acids as Energy Sources?

Calculated	Discrimination factors (Δ_{A-D}) Steller's eider	Spectacled eider
16:0	4.04±0.20	3.26±0.24
16:1	1.28±0.30	1.06±0.46
18:0	3.69±0.31	3.36±0.23
18:1	3.38±0.23	3.51±0.50
FA_{ESS} 18:2n-6 linoleic acid	1.90±0.21	2.13±0.29
18:3n-3 α-linolenic acid	1.69±0.30	1.32±0.26
20:5n-3	–0.53±0.82	–0.52±0.98
22:6n-3	0.84±0.93	0.77±0.80
Mean	NA	NA
Mean 18:2 and 18:3 only	NA	NA
Assumed		
20:5n-3	0	0
22:6n-3	0	0

Budge et al. 2011

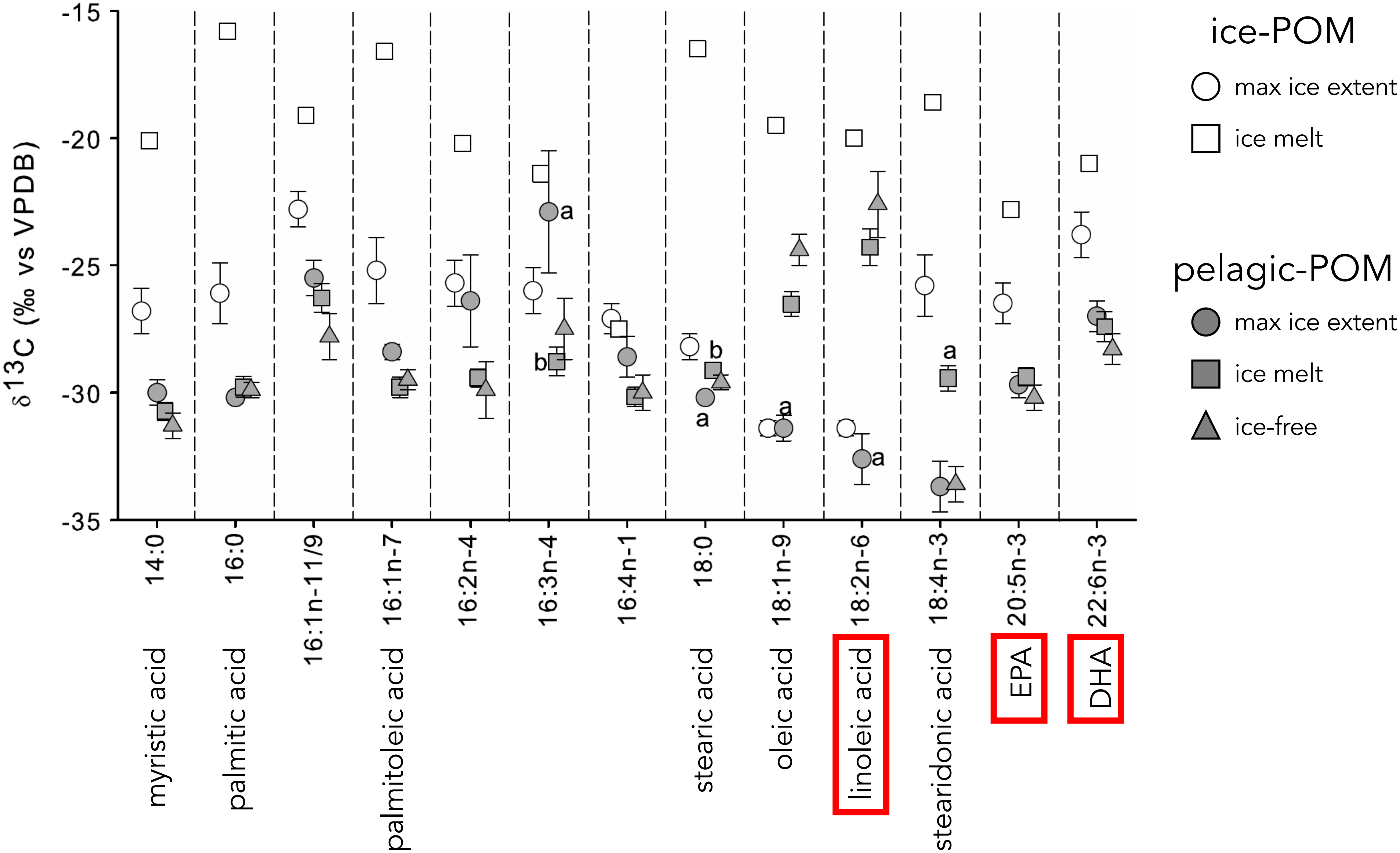
Terrestrial versus Aquatic Resource Use



δ^2H and $\delta^{13}C$ data indicate invertebrates likely obtain more FA_{ESS} from algae than terrestrial leaves.

Twining et al. 2020

Fatty Acids Vary Among Ice-Associated and Pelagic Phytoplankton



Wang et al. 2014

Esterification to Fatty Acid Methyl Esters (FAMEs)

Lipid Extraction (2:1 chloroform:methanol)

Separation of neutral and polar Fractions

Esterification:
1M acetyl chloride in methanol heated at 90°C for 2 hours