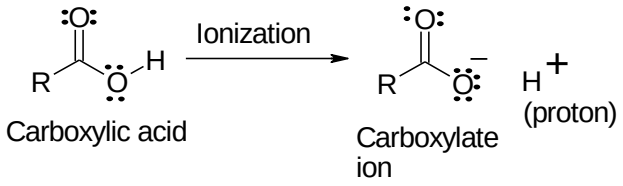
Carboxylic acids



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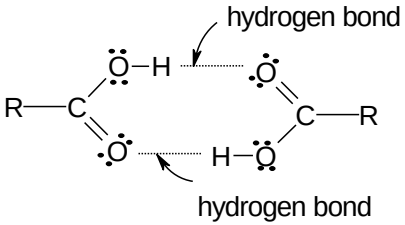
Physical properties

- Carboxylic acids are polar, and form hydrogen bonds with each other.
- At high temperatures, in vapour phase, carboxylic acids usually exist as dimeric pairs.



2

- Lower carboxylic acids (1 to 4 carbons) are miscible with water, whereas higher carboxylic acids are very much less-soluble due to the increasing hydrophobic (hydrophilic is water loving group) nature of the alkyl chain.
- They tend to be rather soluble in less-polar solvents such as ethers and alcohols.

3

Boiling points of Carboxylic Acids

Formula	IUPAC Name	Boiling Point
HCO_2H	methanoic acid	101 °C
CH_3CO_2H	ethanoic acid	118 °C
$CH_3CH_2CO_2H$	propanoic acid	141 °C
$CH_3(CH_2)_2CO_2H$	butanoic acid	164 °C
$CH_3(CH_2)_3CO_2H$	pentanoic acid	186 °C
$CH_3(CH_2)_4CO_2H$	hexanoic acid	205 °C
$CH_3(CH_2)_5CO_2H$	heptanoic acid	223 °C
$CH_3(CH_2)_6CO_2H$	octanoic acid	239 °C
$CH_3(CH_2)_7CO_2H$	nonanoic acid	253 °C
$CH_3(CH_2)_8CO_2H$	decanoic acid	269 °C

4

Nomenclature of Carboxylic Acids

Carbon atoms	Common name	IUPAC name	Chemical formula	Common location or use
1	Formic acid	Methanoic acid	HCOOH	Ants, Insect stings
2	Acetic acid	Ethanoic acid	CH_3COOH	Vinegar
3	Propionic acid	Propanoic acid	CH_3CH_2COOH	Milk
4	Butyric acid	Butanoic acid	$CH_3(CH_2)_2COOH$	Rancid butter
5	Valeric acid	Pentanoic acid	$CH_3(CH_2)_3COOH$	Valerian
6	Caproic acid	Hexanoic acid	$CH_3(CH_2)_4COOH$	Goat fat
7	Enanthic acid	Heptanoic acid	$CH_3(CH_2)_5COOH$	Vines
8	Caprylic acid	Octanoic acid	$CH_3(CH_2)_6COOH$	Coconuts and breast milk

5

Nomenclature of Carboxylic Acids

Carbon atoms	Common name	IUPAC name	Chemical formula	Common location or use
9	Pelargonic acid	Nonanoic acid	$CH_3(CH_2)_7COOH$	Pelargonium (a herb)
10	Capric acid	Decanoic acid	$CH_3(CH_2)_8COOH$	Goat fat
12	Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$	Coconut oil and hand wash soaps.
14	Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$	Nutmeg
16	Palmitic acid	Hexadecanoic acid	$CH_3(CH_2)_{14}COOH$	Palm oil
18	Stearic acid	Octadecanoic acid	$CH_3(CH_2)_{16}COOH$	Chocolate, waxes, soaps, and oils
20	Arachidic acid	Eicosanoic acid	$CH_3(CH_2)_{18}COOH$	Peanut oil

6

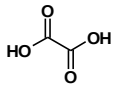
Dicarboxylic acids

- The organic acids with double acid groups or containing other substituents are usually known by their trivial names

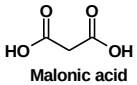
Compound	IUPAC Name	Trivial (Common) Name
HOOCCOOH	2-Ethanedioic Acid	Oxalic Acid
$HOOCCH_2COOH$	3-Propanedioic Acid	Malonic Acid
$HOOC(CH_2)_2COOH$	4-Butanedioic Acid	Succinic Acid
$HOOC(CH_2)_3COOH$	5-Pentanedioic Acid	Glutamic Acid
$HOOC(CH_2)_4COOH$	6-Hexanedioic Acid	Adipic Acid
HOOCCH=CHCOOH	cis-butenedioic Acid	Maleic Acid
HOOCCH=CHCOOH	trans-butenedioic Acid	Fumaric Acid

7

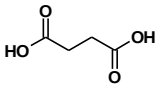
Dicarboxylic acids



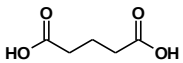
Oxalic acid



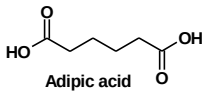
Malonic acid



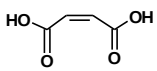
Succinic acid



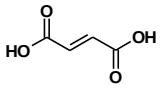
Glutamic acid



Adipic acid



cis Butenedioic acid



Trans Butenedioic acid

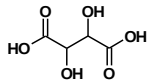
8

Some Carboxylic acids in nature

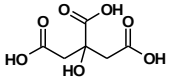
Compound	Systematic Name	Trivial (Common) Name
HOOCCH(OH)CH(OH)COOH	2,3-Dihydroxybutanedioic Acid	Tartaric Acid
HOOC-CH_2-C(OH)(COOH)-CH_2-COOH	3-Hydroxy-3-carboxylpentanedioic Acid	Citric Acid
$HOCH_2CH_2COOH$	1-Hydroxypropanoic Acid	Lactic Acid
$C_6H_5CH{=}CHCOOH$	3-Benzyl-2-propanoic Acid	Cinnamic Acid
C_6H_5COOH	1-Carboxyl-1,3,5-cyclohexatriene	Benzoic Acid
$H_3CCOCOOH$	2-Ketopropanoic Acid	Pyruvic Acid

9

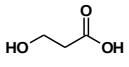
Some Carboxylic acids in nature



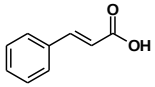
Tartaric acid



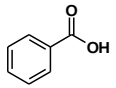
Citric acid



Lactic acid



Cinnamic acid



Benzoic acid

Pyruvic Acid

10

Useful Carboxylic acids: Methanoic (Formic) acid

- It smells very strong and is corrosive.
- The boiling point is 101 degrees celcius.
- The name formic acid is comes from the Latin, formica which means ant.
- This acid was discovered by the distillation of ants.
- A bite of an ant can be painful due to the presence of this acid.
- It is the most simple and strongest carboxylic acid.

11

Useful Carboxylic acids: Ethanoic (Acetic) acid

- This acid also smells strong and is corrosive, but less so than methanoic acid.
- Ethanoic acid is commonly called acetic acid.
- A 5% solution of ethanoic acid (acetic acid) and water is known as vinegar. Vinegar (Fr. Vin, wine + Egar, sour) means sour wine.
- The boiling point of ethanoic acid is 118 degrees celcius.

12

Ethanoic (Acetic) acid

- Ethanoic acid originates when ethanol (grain alcohol) is oxidized (reacts with oxygen).
- Ethanol + Oxygen ⟶ Ethanoic Acid + Water
- Ethanoic acid often originates in wine by means of the above reaction causing the wine to become sour.
- Acetic acid in the form of vinegar is used as a preserving agent and in the textile industry.

13

Benzoic acid:

- Benzoic acid occurs naturally free and bound as benzoic acid esters in many plant and animal species. Appreciable amounts have been found in most berries (around 0.05%). For humans, the World Health Organization's International Programme on Chemical Safety (IPCS) suggests a provisional tolerable intake would be 5 mg/kg body weight per day.
- Benzoic acid and its salts are used as a food preservatives. Typical levels of use for benzoic acid as a preservative in food are between 0.05–0.1%. Benzoic acid inhibits the growth of mold, yeast and some bacteria.

14

Citric acid

- It is a natural preservative/conservative and is also used to add an acidic, or sour, taste to foods and soft drinks. At room temperature, citric acid is a white crystalline powder.
- The concentrations of citric acid in citrus fruits range from 0.005 mol/L for oranges and grapefruits to 0.30 mol/L in lemons and limes.
- As its ester (Citrate), it is a critical component of bone, helping to regulate the size of calcium crystals.
- Citric acid is also used to remove fatty acids in blood vessels and to lower blood pressure.
- Citric acid can be added to e.g. ice cream as an emulsifying agent to keep fats from separating, to caramels to prevent sucrose crystallization, or to recipes in place of fresh lemon juice

15

Tartaric acid

- It is a white crystalline diprotic organic acid.
- It occurs naturally in many plants, particularly grapes, bananas, and tamarinds; is commonly combined with baking soda to function as a leavening agent in recipes, and is one of the main acids found in wine.
- It is added to other foods to give a sour taste, and is used as an antioxidant.
- Salts of tartaric acid are known as tartrates. It is a dihydroxyl derivative of succinic acid.

16

Carboxylic Acids in Natural Products

- Carboxylic acids are widespread in nature, often combined with other functional groups.
- Simple alkyl carboxylic acids, composed of four to ten carbon atoms, are liquids or low melting solids having very unpleasant odors. The **fatty acids** are important components of the biomolecules known as **lipids**, especially fats and oils.

17

Intro to Fatty acids

- **fatty acid** is a carboxylic acid with a long aliphatic tail (chain), which is either saturated or unsaturated.
- Most naturally occurring fatty acids have a chain of an even number of carbon atoms, from 4 to 28. The length of carbon atoms in most natural fatty acids are C4 to C22, with C18 most common.
- Fatty acids are the main constituents of oils and fats found in nature.
- When they are not attached to other molecules, they are known as "free" fatty acids.
- Fatty acids that have double bonds are known as unsaturated. Fatty acids without double bonds are known as saturated.

18

Long Chain Fatty acids

- The fatty acids we shall study are known as Long Chain Fatty acids (LCFA) .
- LCFAs are fatty acids with aliphatic tails longer than 12 carbons (up to 22 carbons).
- The melting point increases with chain length and decreases with increased unsaturation

19

Fatty Acids in Natural Products

- Interestingly, the molecules of most natural fatty acids have an **even number of carbon atoms**.
- Analogous compounds composed of odd numbers of carbon atoms are perfectly stable and have been made synthetically.

20

Saturated Fatty acids

- They have commonly straight chains and even carbon number (4-30). They have the general formula: $CH_3(CH_2)_nCOOH$
- They are named from from the saturated hydrocarbon with the same number of carbon atoms, the final -e is changed to **-oic**. For example, the fatty acid with 18 carbon atoms is correctly termed octadecanoic acid but it has also a trivial name (as several common fatty acids), i.e. stearic acid. This compound may be defined also 18:0.

21

Saturated Fatty acids

- Up to 6 (or 4) carbon atoms, organic acids are considered "short-chain organic acids", they have substantial solubility in water. Furthermore, they do not behave physiologically like other fatty acids since they are more rapidly digested and absorbed in the intestinal tract and have unique properties in regulating sodium and water absorption through the mucosal epithelium. Biochemically, they are more closely related to carbohydrates than to fats.
- From 8 (or 6) to 10 (or 12) carbon atoms, fatty acids are said to have a medium chain.
- Fatty acids which have 14 (or 12) and more carbon atoms are considered as long-chain fatty acids.

22

Saturated Fatty acids

- Fatty acids with 4 to 12 carbon atoms are found mainly in milk fats (mainly butyric acid in cow and decanoic acid in sheep) but those with 10 and 12 carbon atoms are found also in certain seed oils such as coconut and other kernel fats of the palm family.

23

List of the most common saturated fatty acids

Systematic name	Trivial name	Shorthand designation	Molecular wt.	Melting point (°C)
butanoic	butyric	4:0	88.1	-7.9
pentanoic	valeric	5:0		
hexanoic	caproic	6:0	116.1	-3.4
octanoic	caprylic	8:0	144.2	16.7
nonanoic	pelargonic	9:0	158.2	12.5
decanoic	capric	10:0	172.3	31.6
dodecanoic	lauric	12:0	200.3	44.2
tetradecanoic	myristic	14:0	228.4	53.9
hexadecanoic	palmitic	16:0	256.4	63.1
heptadecanoic	margaric (daturic)	17:0	270.4	61.3
octadecanoic	stearic	18:0	284.4	69.6
eicosanoic	arachidic	20:0	312.5	75.3
docosanoic	behenic	22:0	340.5	79.9
tetracosanoic	lignoceric	24:0	368.6	84.2

24

Common LC Saturated FATTY ACIDS

Formula	Common Name	Melting Point
$CH_3(CH_2)_{10}CO_2H$	lauric acid	45 ºC
$CH_3(CH_2)_{12}CO_2H$	myristic acid	55 ºC
$CH_3(CH_2)_{14}CO_2H$	palmitic acid	63 ºC
$CH_3(CH_2)_{16}CO_2H$	stearic acid	69 ºC
$CH_3(CH_2)_{18}CO_2H$	arachidic acid	76 ºC
$CH_3(CH_2)_{20}CO_2H$	behenic acid	79.9 ºC
$CH_3(CH_2)_{22}CO_2H$	lignoceric acid	84.2 ºC

25

Lauric Acid

- **Lauric acid** (12:0) is one of the three most widely distributed saturated fatty acids found in nature (14:0, 16:0, and 18:0).
- It occurs extensively in *Lauraceae* seeds (*Laurus nobilis*) where it was discovered (*Marsson T Ann in 1842*).
- It is dominant in cinnamon oil (80-90%), coconut oil (40-60% as trilaurin) and is found also in *Cuphea* species (*Umbelliferae*) whose production was initiated in Germany.
- The recent uses of lauric acid are in the manufacture of flavourings, cocoa butter, margarine, alkyd resins, soaps, shampoos and other surface active agents, including special lubricants. Lauric acid as monoglyceride is known to the pharmaceutical industry for its good antimicrobial properties.
- The major sources of lauric acid for human food are palm kernel, coconut and palm.

26

Myristic acid

- **Myristic acid** (14:0) is present in major amounts in seeds of the family *Myristicaceae* (nutmeg oil - or oil of mace - from *Myristica fragrans* contains about 60-70% of trimyristin) where it was first discovered (*documented in 1841*).
- Nutmeg is found in Moluccas and spice islands of Indonesia.
- Coconut and palm kernel are also convenient sources of 14:0 (trimyristine) which may be isolated in a pure form by distillation. It is also present in milk fats (8-12%) and in the head oil of the sperm whale (15%).
- An excess of myristic acid in the diet induces a rise in plasma cholesterol in animals and human being .
- Among saturated fatty acids, only myristic acid is able to make an amide link with some cellular proteins (myristoylation), modification which regulates their biological activities.

27

Palmitic acid

- **Palmitic acid** (16:0) is the commonest saturated fatty acids in plant and animal lipids.
- It was purified first by **Chevreul** in his researches on butter and tallow, but was first characterized by Fremy E (*in 1840*), who prepared it in pure form from palm oil, from which he named it.
- Despite its wide distribution, it is generally not present in fats in very large proportions.
- It usually forms less than 5% of the total fatty acids, sometimes as much as 10% in common vegetal oils (peanut, soybean, corn, coconut) and in marine-animal oils.
- Lard, tallow, cocoa butter palm oil contain 25 to 40% of this component.

28

Stearic acid

- **Stearic acid** (18:0) was described by **Chevreul** (1823) in the course of his researches on fats.
- It is the highest molecular weight saturated fatty acid occurring abundantly in fats and oils.
- It occurs in small quantities in seed and marine oils. Milk fats (5-15%), lard (10%), tallow (15-30%), cocoa and shea butters ((30-35%) are the richest sources of stearic acid.
- It is the principal constituent of hydrogenated fats and oils (about 90%).

29

Other Long Chain Saturated Fatty Acids

- **Arachidic acid** (20:0) occurs in appreciable quantities in groundnut (*Arachis hypogea)* oil (3%) where it was discovered in 1854 by Gössmann. Larger amounts are found in seeds of *Sapindaceae* (up to 20%). It is also found in the depot fat of some animals and in milk fats.
- **Behenic acid** (22:0) was first reported as a constituent of ben (behen) oil (seeds of *Moringa oleifera*). Except for the seed oils of the *Crucifereae* (between 0.5 and 3.4%), this fatty chain does not occur in the principal oils. Large amounts are found in hydrogenated animal and vegetal oils (8-57%).
- **Lignoceric acid** (24:0) is present at trace levels in plant oils except in groundnut oil (about 1%) and notably in a Leguminous seed oil (*Adenanthera pavonina*) where it may amount to about 25%. It is the principal fatty acid present in carnauba wax (30% of the normal fatty acids). A major source is rice-wax bran (about 40%).

30

Saturated fat profile of common foods

Food	Lauric acid	Myristic acid	Palmitic acid	Stearic acid
Butter	3%	11%	29%	13%
Ground beef	0%	4%	26%	15%
Dark chocolate	0%	1%	34%	43%
Salmon	0%	1%	29%	3%
Eggs	0%	0.3%	27%	10%
Cashews	2%	1%	10%	7%
Soybean oil	0%	0%	11%	4%

Source: http://en.wikipedia.org/wiki/Saturated_fat

31

Saturated fatty acids in rocks

- Saturated fatty acids with straight chain have been found in a number of sediments ranging in age from Precambrian to Recent.
- In most sediments, fatty acids with even-carbon chain are more abundant than those with odd-carbon chain. All fatty acids from C_8 to C_{28} have been found in sediments (*Kvenvolden in 1967*).
- Experiments suggest that normal paraffins in petroleum may be produced from normal fatty acids of longer chain lengths by decarboxylation (removal of carbon dioxide from chain) or other chemical reactions.

32

Association of Saturated Fatty Acids with diseases

- Fats that are high in saturated fatty acids (including meat fats, milk fat, butter, lard, coconut oil, palm oil, and palm kernel oil) are commonly considered to be potentially less healthy than fats with a lower proportion of saturated fatty acids and higher proportions of unsaturated fatty acids like olive oil, peanut oil, canola oil, avocados, safflower, corn, sunflower, soy, and cottonseed oils.

33

Unsaturated Fatty acids

- Unsaturated fatty acids have one or more double bonds between carbon atoms.
- The two carbon atoms in the chain that are bound next to either side of the double bond can occur in a *cis* or *trans* configuration.
- In naturally occurring unsaturated fatty acids, all double bonds are cis bonds.
- Most fatty acids in the *trans* configuration (trans fats) are not found in nature and are the result of human processing (e.g., hydrogenation).

34

Unsaturated Fatty acids

- The presence of cis-double bonds markedly lowers the melting point, the bent chains packing less well.
- Trans-acids have melting points much closer to those of the corresponding saturates.

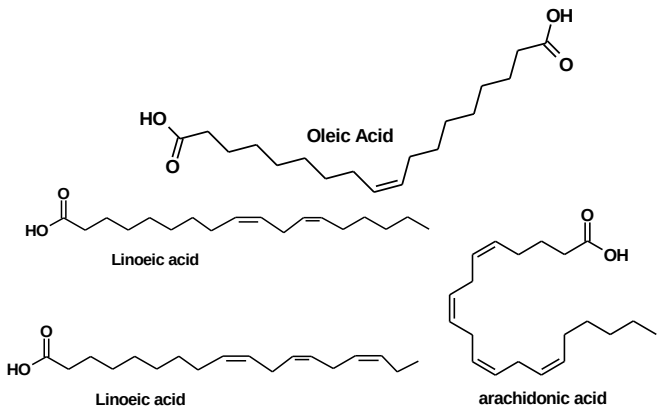
35

Carboxylic Acids in Natural Products: Unsaturated fatty acids

Formula	Common Name	Melting Point
$CH_3(CH_2)_5CH{=}CH(CH_2)_7CO_2H$	palmitoleic acid	0 ºC
$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$	oleic acid	13 ºC
$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH{-}(CH_2)_7CO_2H$	linoleic acid	-5 ºC
$CH_3CH_2CH{=}CHCH_2CH{=}CH{-}CH_2CH{=}CH(CH_2)_7CO_2H$	linolenic acid	-11 ºC
$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2CO_2H$	arachidonic acid	-49 ºC

36

Unsaturated fatty acids



37

Naming Unsaturated Fatty acids

- For unsaturated fatty acids found in nature, simple nomenclature has been developed.
- Usually, the double bonds are in *cis or Z configuration,* and double bonds in di- or polyunsaturated fatty acids are interrupted by a methylene (-CH_2-) group.
- Thus, generally, unsaturated fatty acids can be expressed by (i) number of carbons, (ii) number of double bonds and (iii) the position at which the first double bond from the *ω-position (= methyl group) appears.*

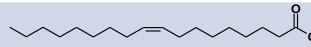
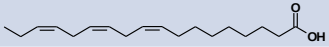
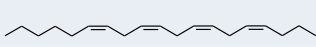
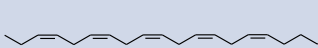
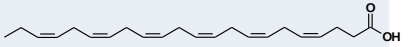
38

Naming Unsaturated Fatty acids

- The fatty acids have two ends—the acid (COOH) end and the methyl (CH_3) end. The carbon next to the carboxylate is known as α, the next carbon β, and so forth. Since biological fatty acids can be of different lengths, the last position is labelled as a "ω", the last letter in the Greek alphabet. The location of the first double bond is counted from the methyl end, which is also known as the omega (ω) end or the n end.
- Fatty acids are straight chain hydrocarbons possessing a carboxyl (COOH) group at one end.
- For example, an expression "18:2 *ω-6 for linoleic acid" indicates "a fatty acid with 18 carbons, with 2 double bonds* starting at the 6th carbon from the methyl end".
- The unsaturated fatty acids are divided into families according to the position of the first double bond appears, (like *ω-3 family, ω-6 family and ω-9 family).*

39

Examples of naming unsaturated fatty acids

Trivial Name	Symbolic expression	Chemical Structure
oleic acid	18:1 *ω-9*	
linoleic acid	18:2 *ω-6*	
α-linolenic acid	18:3 *ω-3*	
arachidonic acid	20:4 *ω-6*	
eicosapentaenoic Acid *(no trivial name)*	20:5 *ω-3*	
docosahexaenoic acid *(no trivial name)*	22:6 *ω-3*	

40

Sources on Unsaturated Fatty acids

- Monounsaturated fats are found in natural foods such as red meat, whole milk products, nuts and high fat fruits such as olives and avocados. Olive oil is about 75% monounsaturated fat. Canola oil and Cashews are both about 58% monounsaturated fat. Tallow (beef fat) is about 50% monounsaturated fat and lard is about 40% monounsaturated fat.
- Other sources include macadamia nut oil, grapeseed oil, groundnut oil (peanut oil), sesame oil, corn oil, popcorn, whole grain wheat, cereal, oatmeal, safflower oil, sunflower oil, tea-oil Camellia, and avocado oil.
- Polyunsaturated fat can be found mostly in Nuts, Seeds, Fish, Algae and Leafy Greens. Whole food sources are always best, as processing and heating may damage polyunsaturated fats.

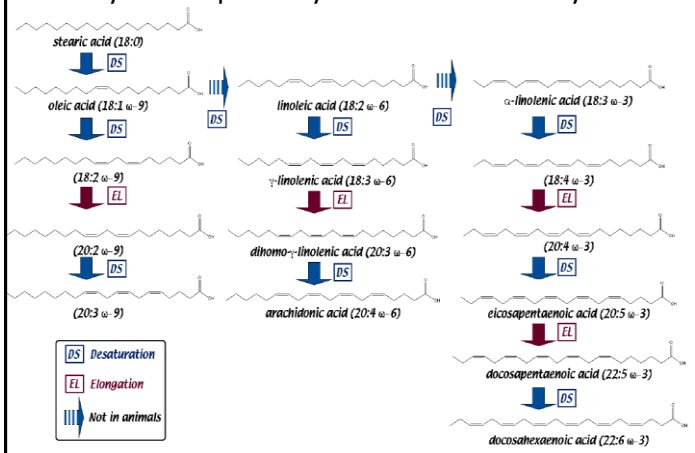
41

Essential fatty acids (EFAs)

- The unsaturated fatty acids are divided into families according to the position of the first double bond appears, (like *ω-3 family, ω-6 family and ω-9 family).*
- The acids within the same family are biosynthetically related, being interconverted by enzymatic processes of desaturation and chain elongation.
- Animals can neither convert oleic acid (*ω-9 family) to linoleic acid* (*ω-6 family) nor linoleic acid to α-linolenic acid (ω-3 family). In other words, animals can* not self-synthesize linoleic acid and *α-linolenic acid. Therefore, animals should take these* fatty acids from their diet.
- This is why these fatty acids are called "**essential fatty acids**".
- Only two EFAs are known for humans:
  - α-Linolenic acid (the shortest chain omega-3 fatty acid)
  - Linoleic acid (the shortest chain omega-6 fatty acid)

42

Biosynthetic pathway of unsaturated fatty acids



Omega-3 (*n*–3) fatty acids

- Omega−3 fatty acids (popularly referred to as ω−3 fatty acids or n-3 fatty acids) are fats commonly found in marine and plant oils. They are polyunsaturated fatty acids with a double bond (C=C) starting after the third carbon atom from the end of the carbon chain.
- N-3 fatty acids have many health benefits and are considered essential fatty acids, meaning that they cannot be synthesized by the human body but are vital for normal metabolism.
- Though mammals cannot synthesize n−3 fatty acids, they have a limited ability to form the long-chain n−3 fatty acids including eicosapentaenoic acid (EPA, 20 carbons and 5 double bonds), docosahexaenoic acid (DHA, 22 carbons and 6 double bonds) and α-linolenic acid (ALA, 18 carbons and 3 double bonds).
- Common sources of n–3 fatty acids include fish oils, algal oil, squid oil and some plant oils such flaxseed oil.

44

List of *n*−3 fatty acids

Common name	Symbolic expression	Chemical name
Hexadecatrienoic acid (HTA)	16:3 (*n*−3)	*all-cis*-7,10,13-hexadecatrienoic acid
α-Linolenic acid (ALA)	18:3 (*n*−3)	*all-cis*-9,12,15-octadecatrienoic acid
Stearidonic acid (SDA)	18:4 (*n*−3)	*all-cis*-6,9,12,15-octadecatetraenoic acid
Eicosatrienoic acid (ETE)	20:3 (*n*−3)	*all-cis*-11,14,17-eicosatrienoic acid
Eicosatetraenoic acid (ETA)	20:4 (*n*−3)	*all-cis*-8,11,14,17-eicosatetraenoic acid
Eicosapentaenoic acid (EPA)	20:5 (*n*−3)	*all-cis*-5,8,11,14,17-eicosapentaenoic acid
Heneicosapentaenoic acid (HPA)	21:5 (*n*−3)	*all-cis*-6,9,12,15,18-heneicosapentaenoic acid
Docosapentaenoic acid (DPA), Clupanodonic acid	22:5 (*n*−3)	*all-cis*-7,10,13,16,19-docosapentaenoic acid
Docosahexaenoic acid (DHA)	22:6 (*n*−3)	*all-cis*-4,7,10,13,16,19-docosahexaenoic acid
Tetracosapentaenoic acid	24:5 (*n*−3)	*all-cis*-9,12,15,18,21-tetracosapentaenoic acid
Tetracosahexaenoic acid (Nisinic acid)	24:6 (*n*−3)	*all-cis*-6,9,12,15,18,21-tetracosahexaenoic acid

45

Omega-6 (n-6) fatty acids

- ***n*−6 fatty acids** (popularly referred to as **ω−6 fatty acids** or **omega-6 fatty acids**) are a family of unsaturated fatty acids that have in common a final carbon–carbon double bond in the *n*−6 position, that is, the sixth bond, counting from the methyl end.
- The biological effects of the *n*−6 fatty acids are largely mediated by their conversion to *n*-6 eicosanoids (signaling molecules made by oxidation of twenty-carbon essential fatty acids) that bind to diverse receptors found in every tissue of the body.
- There are four families of eicosanoids—the prostaglandins, prostacyclins, the thromboxanes and the leukotrienes.

46

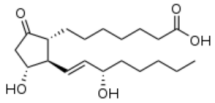
List of *n*−6 fatty acids

Common name	Symbolic expression	Chemical name
Linoleic acid (LA)	18:2 (*n*−6)	*all-cis*-9,12-octadecadienoic acid
Gamma-linolenic acid (GLA)	18:3 (*n*−6)	*all-cis*-6,9,12-octadecatrienoic acid
Eicosadienoic acid	20:2 (*n*−6)	*all-cis*-11,14-eicosadienoic acid
Dihomo-gamma-linolenic acid (DGLA)	20:3 (*n*−6)	*all-cis*-8,11,14-eicosatrienoic acid
Arachidonic acid (AA)	20:4 (*n*−6)	*all-cis*-5,8,11,14-eicosatetraenoic acid
Docosadienoic acid	22:2 (*n*−6)	*all-cis*-13,16-docosadienoic acid
Adrenic acid	22:4 (*n*−6)	*all-cis*-7,10,13,16-docosatetraenoic acid
Docosapentaenoic acid	22:5 (*n*−6)	*all-cis*-4,7,10,13,16-docosapentaenoic acid
Tetracosatetraenoic acid	24:4 (*n*−6)	*all-cis*-9,12,15,18-tetracosatetraenoic acid
Tetracosapentaenoic acid	24:5 (*n*−6)	*all-cis*-6,9,12,15,18-tetracosapentaenoic acid
Calendic acid	18:3 (*n*−6)	8E,10E,12Z-octadecatrienoic acid

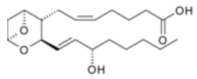
47

Omega-6 (n-6) fatty acids

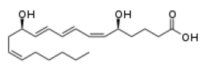
- Structures of selected eicosoids



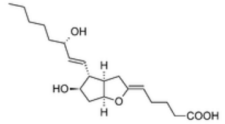
Prostaglandin E_1. The 5-member ring is characteristic of the class.



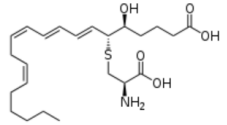
Thromboxane A_2. Oxygens have moved into the ring.



Leukotriene B_4. Note the 3 conjugated double bonds.



Prostacyclin I_2. The second ring distinguishes it from the prostaglandins.



Leukotriene E_4, an example of a cysteinyl leukotriene.

48

Omega-9 (ω-9 or n-9) fatty acids

- ω-9 fatty acids are not essential in humans, because humans generally possess all the enzymes required for their synthesis

49

Negative health effects of n-6 fats

- Some medical research suggests that excessive levels of certain *n*−6 fatty acids, relative to certain *n*−3 (Omega-3) fatty acids, may increase the probability of a number of diseases. The optimal ratio is thought to be 4 to 1 or lower.
- Excess *n*−6 fats interfere with the health benefits of *n*−3 fats, in part because they compete for the same rate-limiting enzymes. A high proportion of *n*−6 to *n*−3 fat in the diet shifts the physiological state in the tissues toward the pathogenesis of many diseases: prothrombotic, proinflammatory and proconstrictive.

50