

ANSC 619
PHYSIOLOGICAL CHEMISTRY OF LIVESTOCK SPECIES
Lipid Chemistry

I. Common Saturated Fatty Acids

NO. OF CARBONS	COMMON NAME	GENEVA NAME	STRUCTURE
4	Butyric	Tetranoic	$\text{CH}_3(\text{CH}_2)_2\text{COOH}$
6	Caproic	Hexanoic	$\text{CH}_3(\text{CH}_2)_4\text{COOH}$
8	Caprylic	Octanoic	$\text{CH}_3(\text{CH}_2)_6\text{COOH}$
10	Capric	Decanoic	$\text{CH}_3(\text{CH}_2)_8\text{COOH}$
12	Lauric	Dodecanoic	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$
14	Myristic	Tetradecanoic	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$
16	Palmitic	Hexadecanoic	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
18	Stearic	Octadecanoic	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
20	Arachidic	Eicosanoic	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$

You will need to know the common names for fatty acids in bold face.

II. Common Nonessential Fatty Acids

No Double Bonds

16C

Palmitic acid

Hexadecanoic



One Double Bond

18C

Oleic acid

cis-9-Octadecenoic



18C

Conjugated linoleic acid *cis-9,trans-11-Octadecadienoic*

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III. Essential Fatty Acids

Two Double Bonds

18C

Linoleic acid

cis-9,12-Octadecadienoic



Three Double Bonds

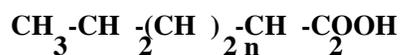
18C

α -Linolenic acid

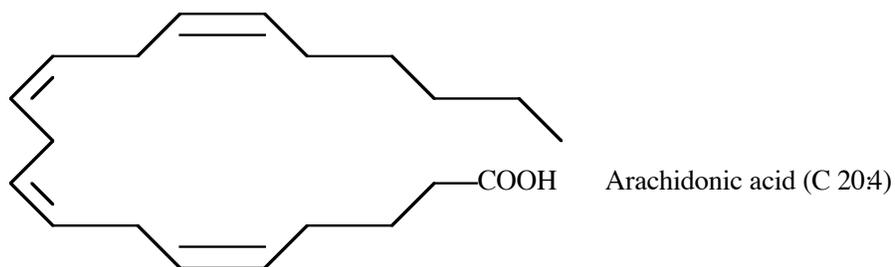
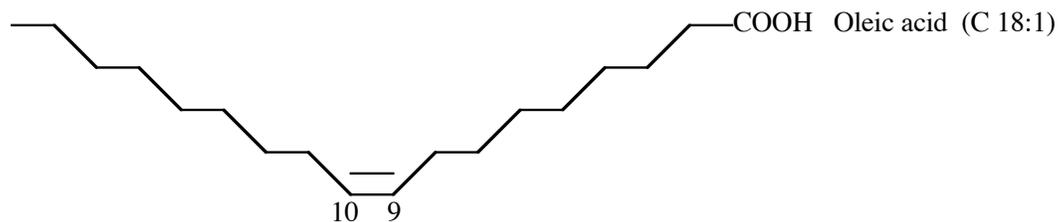
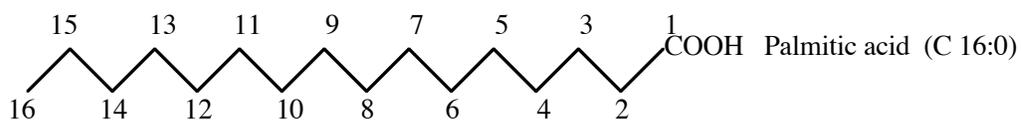
cis-9,12,15-Octadecatrienoic



IV. Some important structures



Fatty acid (general)



V. Derivation of Trivial Names

A. Latin

1. Capro = goat. So, capric = anything smelling like goats (eventually used to indicate a group of fatty acids).
2. Palm = from the *Palmaceae* (palm oil) family
3. Olea = olive. So, oleum = oil
4. Linum = flax. So, linoleum (or linoleic) = flax oil, which is high in both 18:2 and 18:3.

B. Greek

1. Stear = animal fat.

C. Japanese

1. Abura = oil
2. Shiboo = animal fat

油

Abura (oil)

脂肪

Shiboo (animal fat)

IV. Nomenclature Systems

A. Delta system

1. Numbers from the carboxyl end (standard biochemical technique) to the first unsaturated carbon
2. *Example:* α -Linolenic acid – 18:3 $\Delta^{9,12,15}$

B. "N minus" system

1. Numbers from the terminal methyl carbon to the first unsaturated carbon, "subtracts" those carbons, and places these numbers in parentheses.
2. *Example:* α -Linolenic acid – 18:3(*n*-3)
3. Position of other double bonds deduced by 1,4-diene rule.

C. Omega system

1. Numbers from the terminal methyl carbon to the first unsaturated carbon
2. *Example:* α -Linolenic acid – 18:3 ω 3.

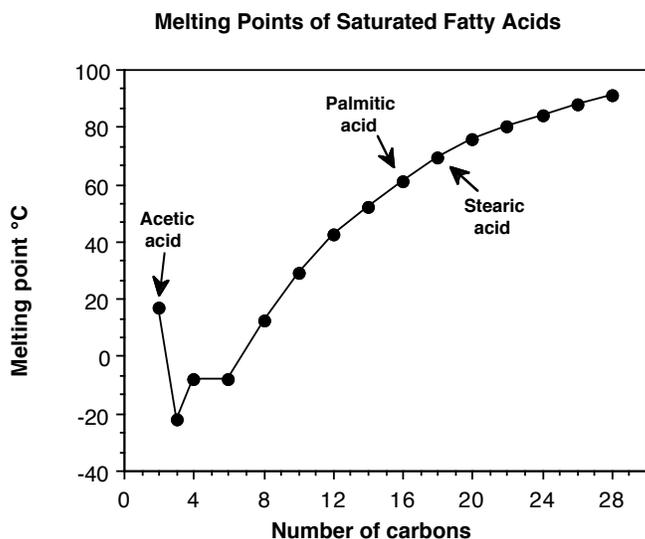
3. Position of other double bonds deduced by 1,4-diene rule.

D. Trivial names and Geneva system (see above table)

V. Melting Points and Fatty Acid Composition

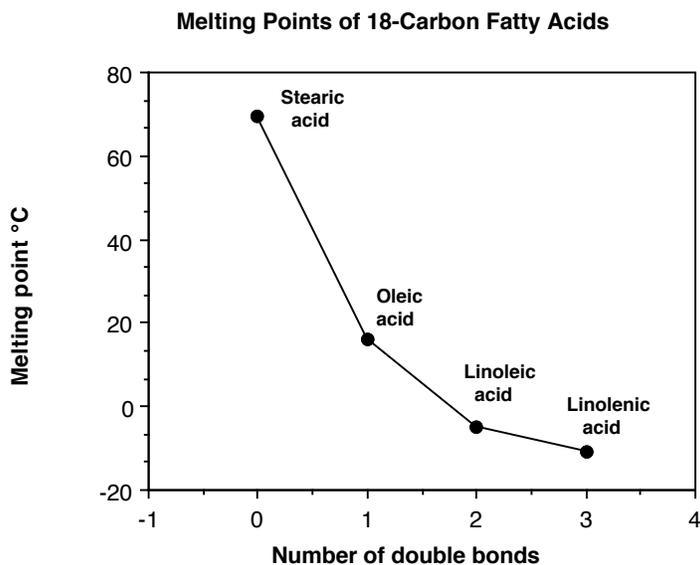
A. Carbon length and melting point

1. Increasing the number of carbons increases the melting point.
2. Exception: acetic acid has a melting point higher than predicted by carbon number.



B. Number of double bonds and melting point

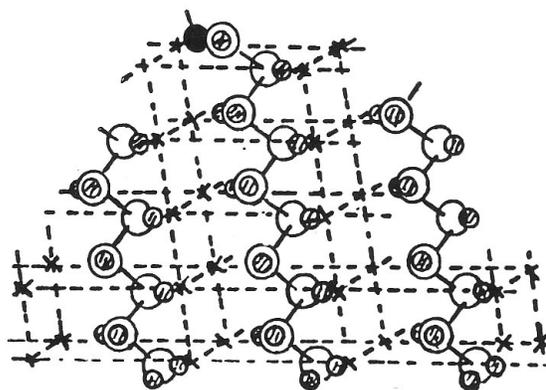
1. Increasing the number of double bonds decreases the melting point.
2. All saturated fatty acids in beef (14, 16, and 18-carbon) are solids at room temperature.
3. All polyunsaturated fatty acids are liquids at room temperature.



B. Biochemical basis for melting point of lipids

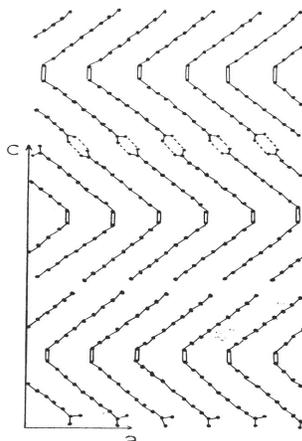
1. Fatty acid subcells

- Fatty acids form crystals with ordered structure.
- The crystals typically display subcells between portions of the molecules (usually two carbons in length).
- Subcells are established by hydrophobic bonds across methylene carbons.



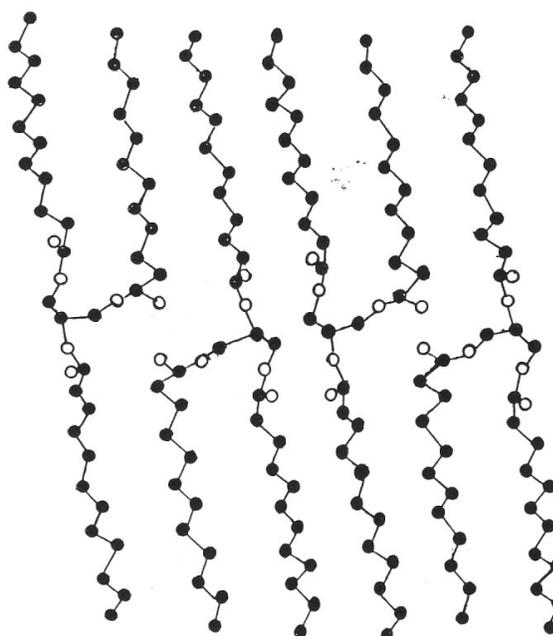
2. Fatty acid crystals

- Crystals of oleic acid (**at right**) have a highly ordered structure.
- The *cis* double bonds are tilted in opposite directions to the plane of the molecules.
- This configuration provides maximum van der Waals forces.



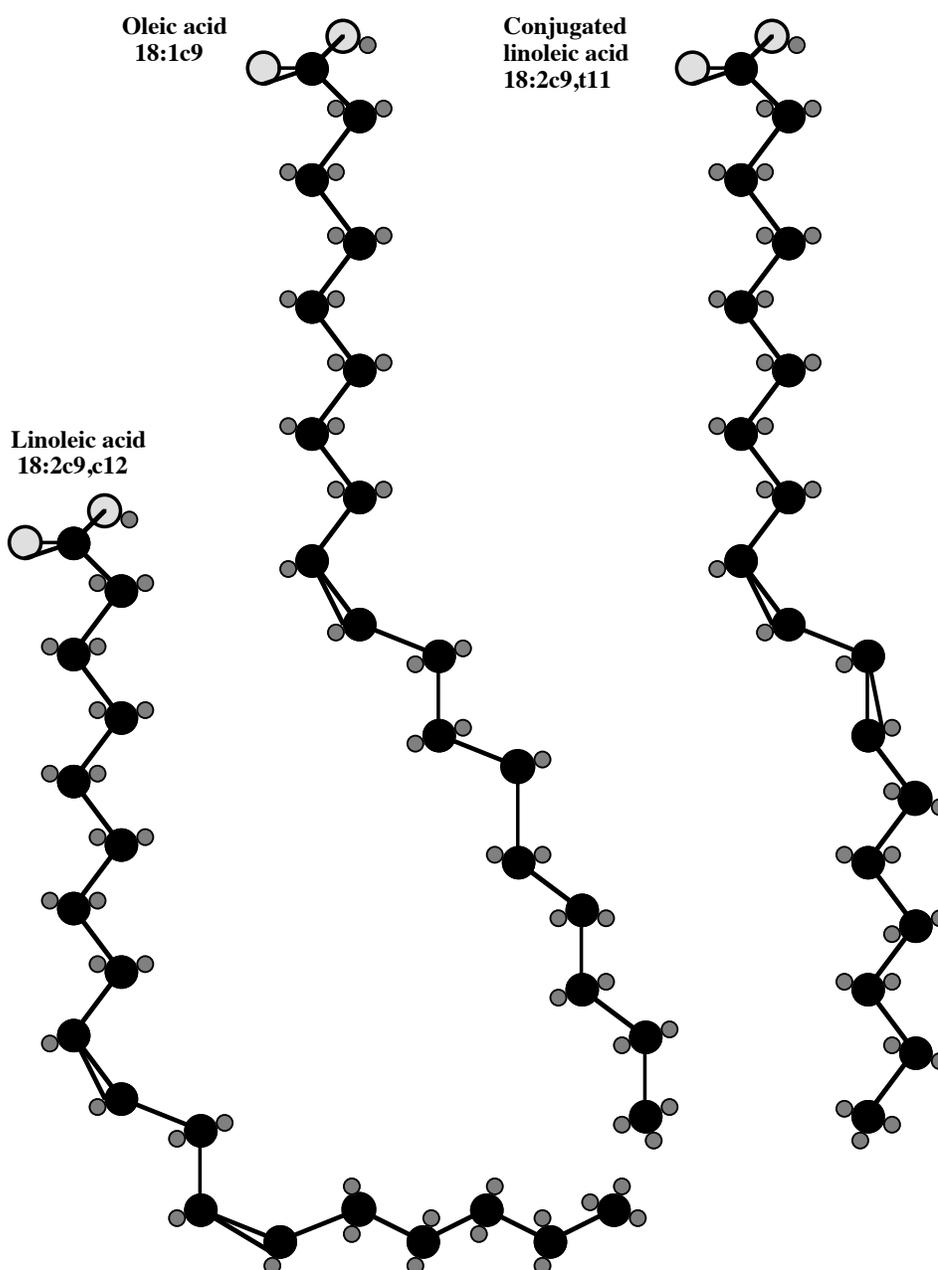
3. Triacylglycerol crystals

- Crystals of TAG (such as trilaurin, **right**) are highly ordered.
- Hydrophobic side chains associate with each other.
- More polar glycerol backbones also associate with one another.
- Increasing the number of carbons of a saturated fatty acids increases the melting point.



4. Double bonds and fatty acid crystals

- a. *cis*-Double bonds introduce bends in the fatty acids.
 - 1) Subcells cannot form as readily.
 - 2) Hydrophobic forces among subcells are weaker.
- b. *trans*-Double bonds do not cause a bend in the fatty acid.
 - 1) Subcells form readily.
 - 2) Melting points are similar to saturated or monounsaturated fatty acids.



VI. Triacylglycerol composition and structure

A. Dietary animal lipids

1. Typically higher in saturated fatty acids than plant oils.
2. Composition is influenced by endogenous synthesis and dietary fatty acids.

Table 3.1 The fatty acid composition of some animal storage fats* (g per 100 g total fatty acids)

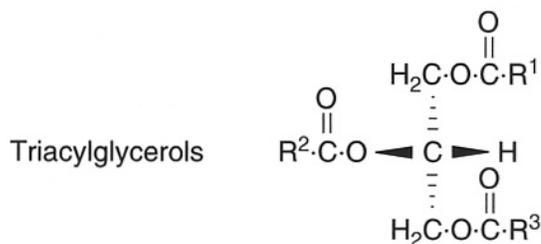
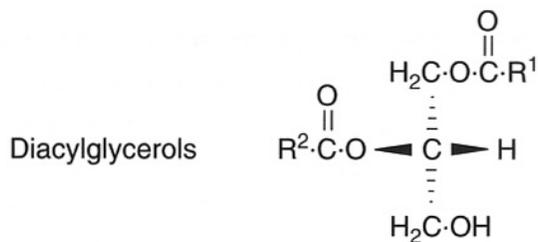
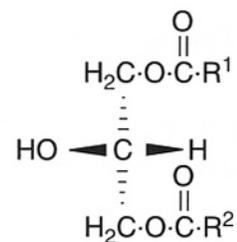
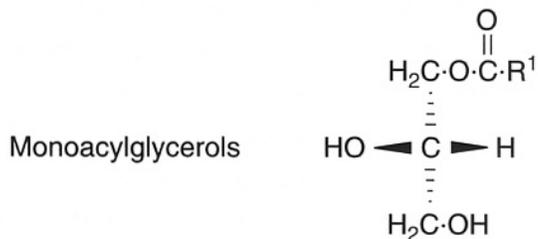
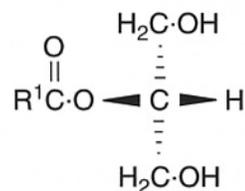
	4:0- 12:0	14:0	16:0	16:1	18:0	18:1	18:2 <i>n</i> -6	20:1+ 22:1	20:5 <i>n</i> -3	22:6 <i>n</i> -3	total
<i>Adipose tissue</i>											
Cow		3	26	9	8	45	2				93
Human (1)		2	19	7	3	48	13				92
Human (2)		2	20	4	5	39	24				94
Lamb		3	21	4	20	41	5				94
Pig (1)		1	29	3	14	43	9				99
Pig (2)		1	21	3	12	46	16				99
Poultry		1	27	9	7	45	11				94
<i>Milk</i>											
Cow	10	12	26	3	11	29	2				93
Goat	20	11	26	3	10	26	2				98
<i>Egg yolk</i>											
Hen			29	4	9	43	11				96
<i>Fish oils</i>											
Cod (liver)		6	8	10	3	17	3	25	10	11	93
Mackerel (flesh)		8	16	9	2	13	1	26	8	8	91
Herring (flesh)		9	15	8	1	17	1	39	3	3	96
Sardine (flesh)		8	18	10	1	13	1	7	18	9	85

B. Dietary plant lipids

- a. Contain *n*-6 and *n*-3 fatty acids.
- b. Stearic acid is especially low, but oleic acid can be abundant.

C. Structure of acylglycerols

1. Fatty acids are distributed within triacylglycerols (TAG) with some specificity.
2. This specificity depends on both the species and the tissue site within the species in which the TAG was synthesized.
3. The stereospecific number (sn) indicates the position of the fatty acid on the glycerol backbone.

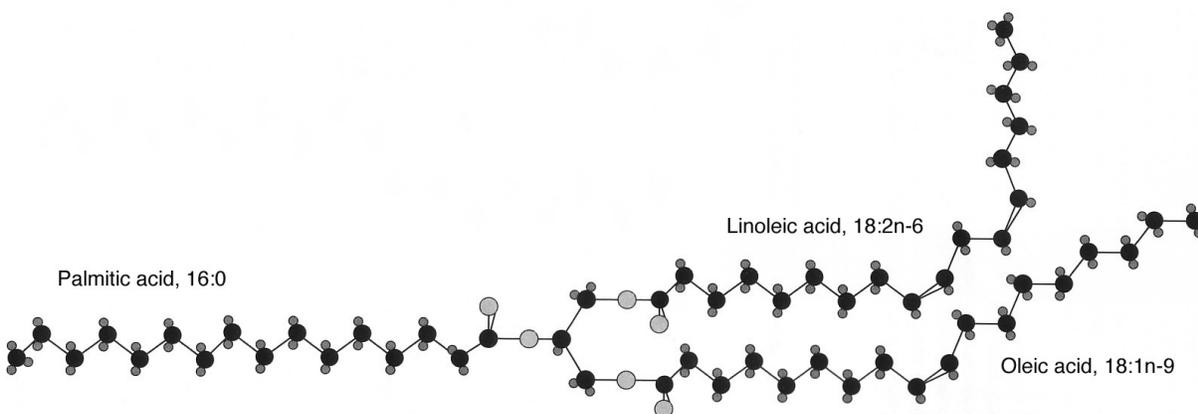
(a) 1, 2, 3-Triacyl-*sn*-glycerols(b) 1, 2-Diacyl-*sn*-glycerols(c) 1, 3-Diacyl-*sn*-glycerols(d) 1-Monoacyl-*sn*-glycerols(e) 2-Monoacyl-*sn*-glycerols

D. Heterogeneity of triacylglycerols

1. TAG can exist in pure form (i.e., containing only one fatty acid).
2. More often, TAG exist as combinations of fatty acids (as indicated in the table below).

E. Common fatty acid distributions in TAG

1. Animal fats usually have saturated fatty acids at the *sn*-1 position (exception: pig lard has 16:0 at *sn*-2. Human milk fat is the same.).
2. Animal fats usually have unsaturated fatty acids at *sn*-2 position.
3. Milk has short-chain fatty acids at the *sn*-3 position.

**TABLE 4** Positional Distribution of Individual Fatty Acids in Triacylglycerols of Some Natural Fats

Source	Position	Fatty acid (mol%)										
		4:0	6:0	8:0	10:0	12:0	14:0	16:0	18:0	18:1	18:2	18:3
Cow's milk	1	5	3	1	3	3	11	36	15	21	1	
	2	3	5	2	6	6	20	33	6	14	3	
	3	43	11	2	4	3	7	10	4	15	0.5	
Coconut	1		1	4	4	39	29	16	3	4		
	2		0.3	2	5	78	8	1	0.5	3	2	
	3		3	32	13	38	8	1	0.5	3	2	
Cocoa butter	1							34	50	12	1	
	2							2	2	87	9	
	3							37	53	9		
Corn	1							18	3	28	50	
	2							2		27	70	
	3							14	31	52	1	
Soybean	1							14	6	23	48	9
	2							1		22	70	7
	3							13	6	28	45	8
Olive	1							13	3	72	10	0.6
	2							1		83	14	0.8
	3							17	4	74	5	1
Peanut	1							14	5	59	19	
	2							2		59	39	
	3							11	5	57	10	
Beef (depot)	1						4	41	17	20	4	1
	2						9	17	9	41	5	1
	3						1	22	24	37	5	1
Pig (outer back)	1						1	10	30	51	6	
	2						4	72	2	13	3	
	3								7	73	18	