

**ANSC 689**  
**PHYSIOLOGICAL CHEMISTRY OF LIVESTOCK SPECIDS**  
**General Chemistry of Fatty Acids and Triacylglycerols**

### 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	$\text{CH}_3(\text{CH}_2)_8\text{COOH}$
<b>12</b>	<b>Lauric</b>	Dodecanoic	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$
<b>14</b>	<b>Myristic</b>	Tetradecanoic	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$
<b>16</b>	<b>Palmitic</b>	Hexadecanoic	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
<b>18</b>	<b>Stearic</b>	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*

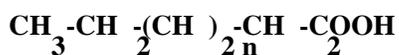
18C

**$\alpha$ -Linolenic acid**

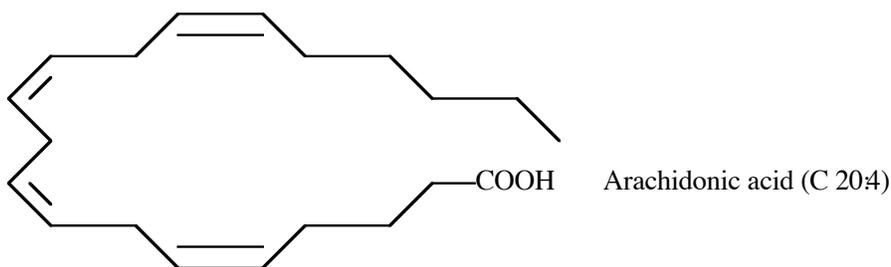
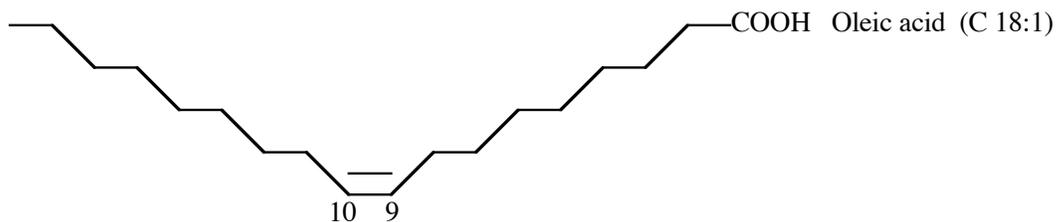
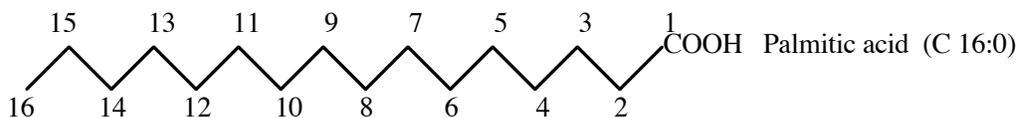
*cis*-9,12,15-Octadecatrienoic



### 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:*  $\alpha$ -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:*  $\alpha$ -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:*  $\alpha$ -Linolenic acid – 18:3 $\omega$ 3.

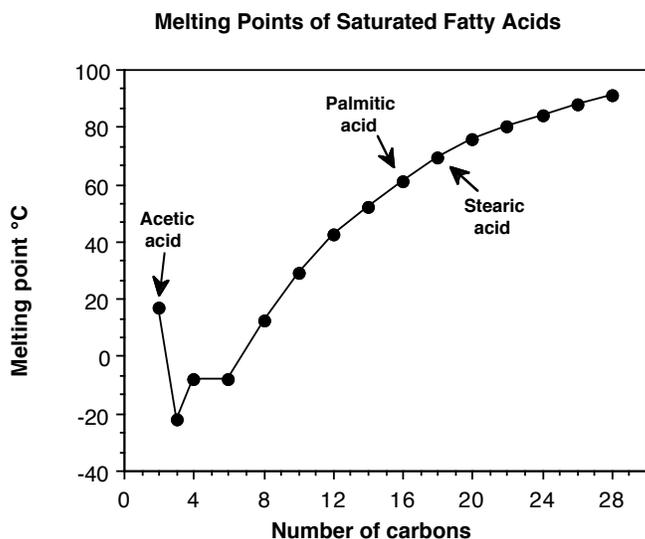
3. Position of other double bonds deduced by 1,4-diene rule.

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

## VI. Melting Points and Fatty Acid Composition

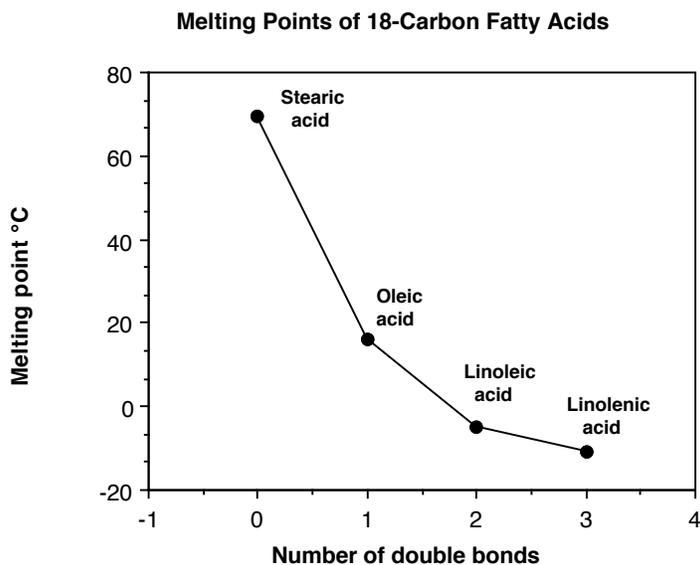
### A. Carbon length and melting point

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

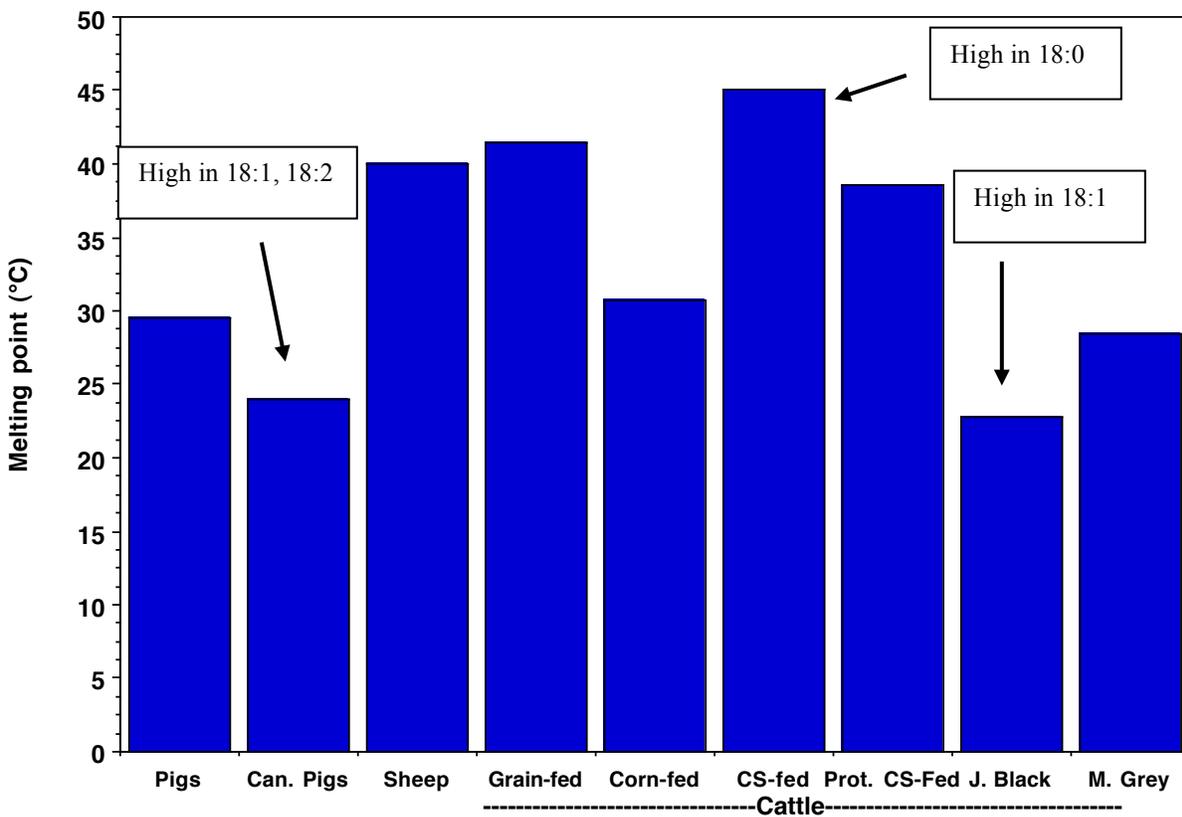
1. Increasing the number of double bonds decreases the melting point.
2. All saturated fatty acids in beef (14, 16, and 18-carbon) are solids at room temperature.
3. All polyunsaturated fatty acids are liquids at room temperature.



## VII. Melting points of animal lipids

### A. Differences among species/diets

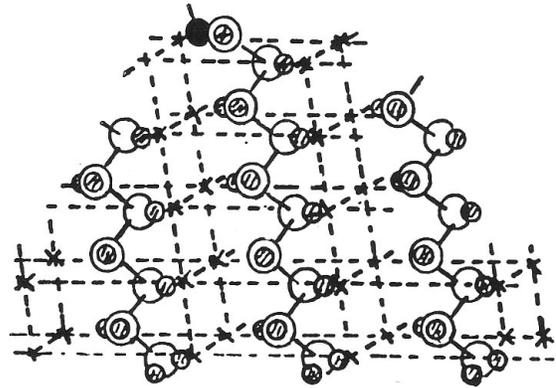
1. For most animals, melting points of lipids are between 22 and 40°C.
2. Melting point is determined by fatty acid composition.
3. Fatty acid composition is determined by *diet* and *genetics*.
  - a. Lipids of tissues from monogastrics fed unsaturated fatty acids closely resemble fatty acid composition of the diet.
  - b. Composition of lipids of tissues from ruminants are determined by diet (limited effect) and activity of tissue desaturases.



## B. Biochemical basis for melting point of lipids

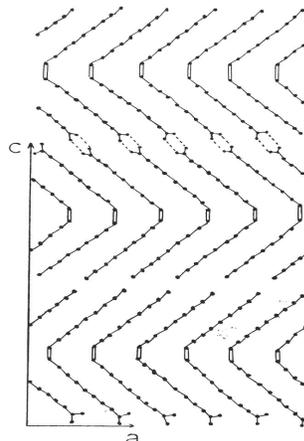
### 1. Fatty acid subcells

- 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.



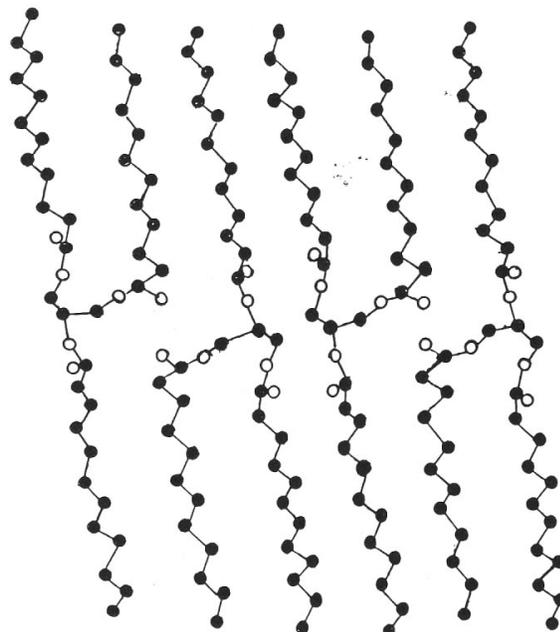
### 2. Fatty acid crystals

- 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.



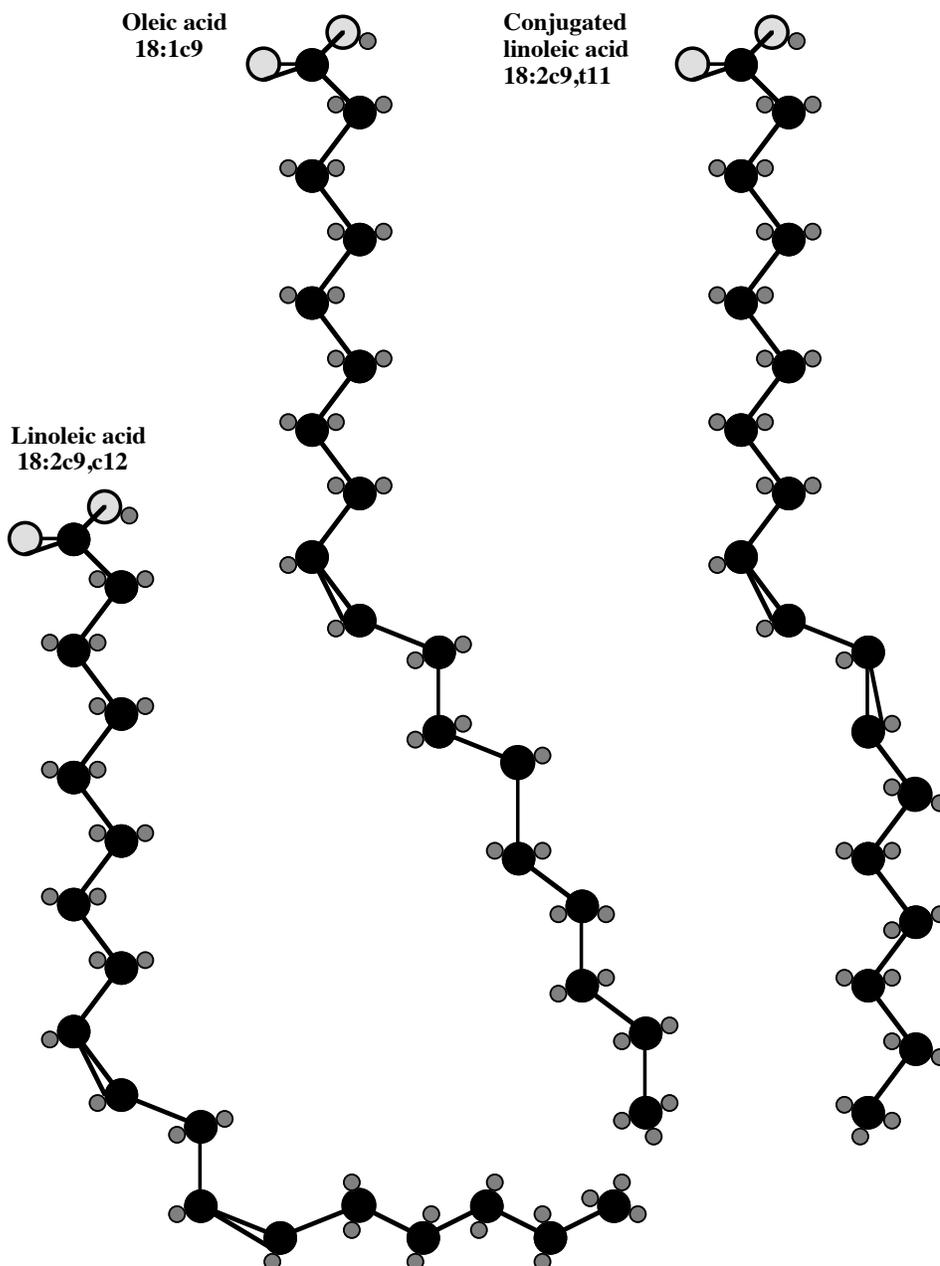
### 3. Triacylglycerol crystals

- 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.

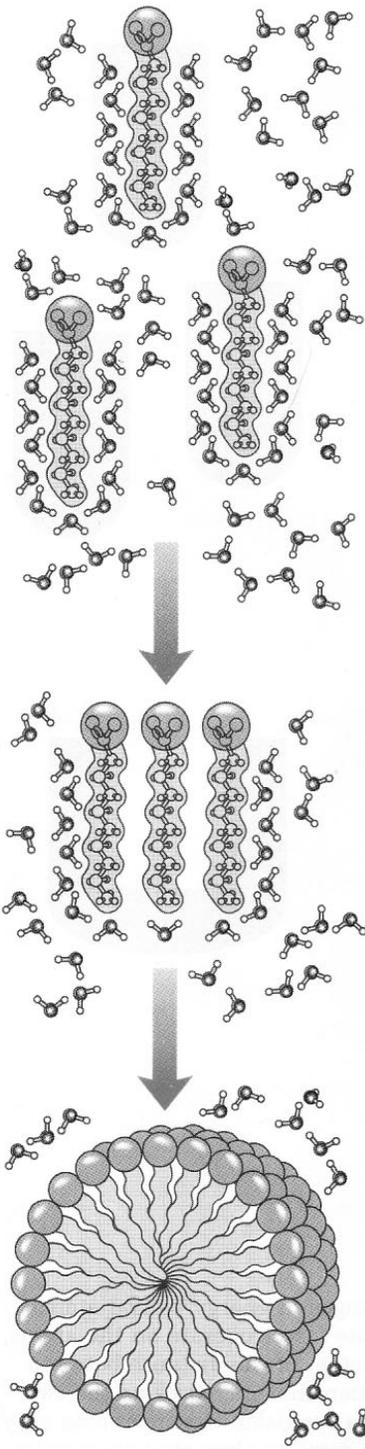


#### 4. Double bonds and fatty acid crystals

- 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.



### VIII. Hydrophobic interactions

 <p><b>Dispersion of lipids in H<sub>2</sub>O</b> Each lipid molecule forces surrounding H<sub>2</sub>O molecules to become highly ordered.</p> <p><b>Clusters of lipid molecules</b> Only lipid portions at the edge of the cluster force the ordering of water. Fewer H<sub>2</sub>O molecules are ordered, and entropy is increased.</p> <p><b>Micelles</b> All hydrophobic groups are sequestered from water; no highly ordered shell of H<sub>2</sub>O molecules is present, and entropy is increased.</p> <p>(b)</p>	<p><b>A. Description</b></p> <ol style="list-style-type: none"> <li>Hydrophobic interactions are <i>not</i> chemical bonds.</li> <li>Represent the most stable state when nonpolar molecules are surrounded by water molecules.</li> </ol> <p><b>B. Characteristics</b></p> <ol style="list-style-type: none"> <li>Hydrophobic portions of nonpolar or amphipathic (polar plus nonpolar) molecules become surrounded by water molecules.</li> <li>The layer of water molecules causes a decrease in entropy.</li> <li>To reach a more stable state (higher entropy), the nonpolar molecules aggregate.</li> <li>In the case of amphipathic molecules, micelles can form.</li> </ol>
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