

# FOOD

**Purpose of food**

**energy**

**water**

**building blocks**

**essential molecules the body does not make**

**Macronutrients**

**fats**

**carbohydrates**

**proteins**

**Micronutrients**

**vitamins**

**minerals**

H																	
													C	N	O		
Na	Mg												P	S	Cl		
K	Ca																

Chemistry in Context 6<sup>th</sup> Edition, ACS, McGraw-Hill

Element	Symbol	g/100g body mass	Relative abundance of atoms
Oxygen	O	64.6	2.7
Carbon	C	18	1
Hydrogen	H	10	6.7
Nitrogen	N	3.1	0.14
Calcium	Ca	1.9	0.033
Phosphorous	P	1.1	0.023
Potassium	K	0.36	0.0061
Sulfur	S	0.25	0.0052
Sodium	Na	0.11	0.0032
Magnesium	Mg	0.03	0.0014

PERIODIC TABLE Atomic Properties of the Elements

NIST National Institute of Standards and Technology Technology Administration, U.S. Department of Commerce

Frequently used fundamental physical constants

For the most accurate values of these and other constants, visit [physics.nist.gov/constants](http://physics.nist.gov/constants)

$1$  electron =  $9.10938356 \times 10^{-31}$  kg (reduced mass corresponds to the isotopes)

Bohr radius =  $5.291772109 \times 10^{-11}$  m

$c$  speed of light in vacuum =  $299\,792\,458$  m s<sup>-1</sup> (exact)

$\alpha$  fine structure constant =  $7.2973525693 \times 10^{-8}$  (exact)

$k_B$  Boltzmann constant =  $1.3806504 \times 10^{-23}$  J K<sup>-1</sup>

$\mu_B$  Bohr magneton =  $9.274009153 \times 10^{-24}$  J T<sup>-1</sup>

$a_0$  elementary charge =  $1.602176487 \times 10^{-19}$  C

$m_p$  proton mass =  $1.67262171 \times 10^{-27}$  kg

$m_n$  neutron mass =  $1.674927211 \times 10^{-27}$  kg

$\hbar$  Planck constant =  $1.054571817 \times 10^{-34}$  J s (exact)

$R$  Rydberg constant =  $1.097373156816 \times 10^7$  m<sup>-1</sup>

$\mu_0$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 c$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 e^2$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 c^2$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 c^3$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 c^4$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 c^5$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

$\mu_0 c^6$  permeability of free space =  $1.2566370614 \times 10^{-6}$  N A<sup>-2</sup>

Legend: Solids, Liquids, Gases, Artificially Prepared

# Composition of Food

**Table 11.1**

**Percentage of Water, Fats, Carbohydrates, and Proteins**

<b>Food</b>	<b>Water</b>	<b>Fats</b>	<b>Carbohydrates</b>	<b>Proteins</b>
White bread	37	4	48	8
2% Milk	89	2	5	3
Chocolate chip cookies	3	23	69	4
Peanut butter	1	50	19	25
Sirloin steak	57	15	0	28
Tuna fish	63	2	0	30
Black beans (cooked)	66	<1	23	9

Source: U.S. Department of Agriculture, Agricultural Research Service, *Home and Garden Bulletin 72*.

# Nutrition facts

Sample label for  
Macaroni & Cheese

① **Start Here** →

② **Check Calories**

③ **Limit these  
Nutrients**

④ **Get Enough  
of these  
Nutrients**

⑤ **Footnote**

<b>Nutrition Facts</b>	
Serving Size 1 cup (228g) Servings Per Container 2	
<b>Amount Per Serving</b>	
<b>Calories</b> 250	Calories from Fat 110
	<b>% Daily Value*</b>
<b>Total Fat</b> 12g	<b>18%</b>
Saturated Fat 3g	<b>15%</b>
Trans Fat 3g	
<b>Cholesterol</b> 30mg	<b>10%</b>
<b>Sodium</b> 470mg	<b>20%</b>
<b>Total Carbohydrate</b> 31g	<b>10%</b>
Dietary Fiber 0g	<b>0%</b>
Sugars 5g	
<b>Protein</b> 5g	
Vitamin A	4%
Vitamin C	2%
Calcium	20%
Iron	4%
* Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs.	
	Calories    2,000    2,500
Total Fat	Less than 65g    80g
Sat Fat	Less than 20g    25g
Cholesterol	Less than 300mg    300mg
Sodium	Less than 2,400mg    2,400mg
Total Carbohydrate	300g    375g
Dietary Fiber	25g    30g

⑥ **Quick Guide  
to % DV**

• **5% or less  
is Low**

• **20% or more  
is High**

*wikipedia*  
**Source: US FDA**

We need water, starches, fats, proteins, minerals as food input

Carbohydrates	45-65%	kcal/g	= 4
Protein	20-35%		= 4
Fat	10-35%		= 9
alcohol			= 7

So per **100g of steak** there are 50g water, 15 g protein, 35 g fat:  
=  $(15 \times 4) + (35 \times 9)$  kcals = **375 kcal**

8oz = 227g = 825 kcal

12oz = 1240 kcal

16oz = 1650 kcal

**Note: 1 kcal = 1 CAL (food cal)**

1 cal raises temp of 1 gram water by 1°C

## How much food do we need?

- Depends on size
- Depends on age
- Depends on gender

**Table 11.6**

**Estimated Calorie Requirements (United States)**

Gender by Age (yr)	Activity Level		
	Sedentary <sup>a</sup>	Moderately Active <sup>b</sup>	Active <sup>c</sup>
<i>Females</i>			
14–18	1800	2000	2400
19–30	2000 ←	2000–2200	2400
31–50	1800	2000	2200
51+	1600	1800	2000–2200
<i>Males</i>			
14–18	2200	2400–2800	2800–3200
19–30	2400 ←	2600–2800	3000
31–50	2200	2400–2600	2800–3000
51+	2000	2200–2400	2400–2800

*Chemistry in Context 6<sup>th</sup> Edition, ACS, McGraw-Hill*

# How do we spend energy?

- Living – basal metabolism rate (BMR)  
= 1 Cal/kg•h
- Light activity, e.g. slow walking, shopping, golf  
= 2-4 Cal/kg•h
- Moderate, e.g. fast walking, cycling, tennis, gardening  
= 4-6 Cal/kg•h
- Heavy, e.g. vigorous work, swimming, running  
= 6-10 Cal/kg•h

**BODY MASS INDEX** = BMI = [MASS in kg] / [Height in m]<sup>2</sup>  
<20 = underweight; 20-25 ok; 25-29 to overweight; > 30 obese

**Waist/Height** ratio is a more accurate predictor of 'health issues':  
> ca. 0.55 signals increased risk of neg. health effects

REFINED SUGAR HAS NO NUTRITIONAL VALUE.



0 VITAMINS  
0 MINERALS  
0 ENZYMES  
0 FIBER

## REFINED SUGAR IS LINKED TO:

OBESITY



NERVOUS TENSION

HYPERTENSION

ACHING LIMBS

HIGH BLOOD PRESSURE



DIABETES



HYPOGLYCEMIA

ACNE

DEPRESSION

SKIN IRRITATION

HEADACHES

STIFFENING OF ARTERIES

FATIGUE

VIOLENT BEHAVIOR

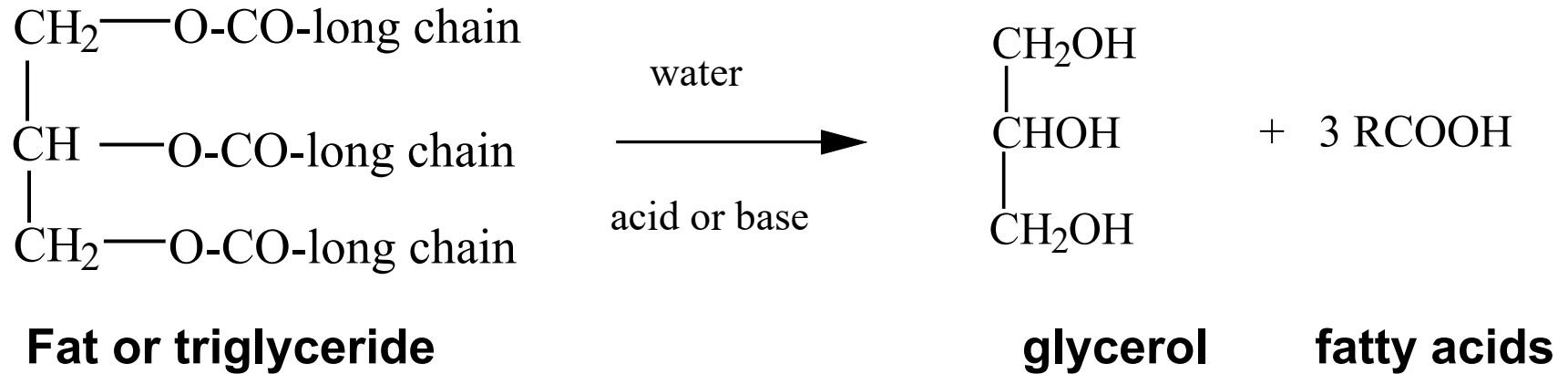
From  
[www.skinnychef.com](http://www.skinnychef.com)

Refined sugar is **pure sucrose** so it **SHOULDN'T** have any of these!

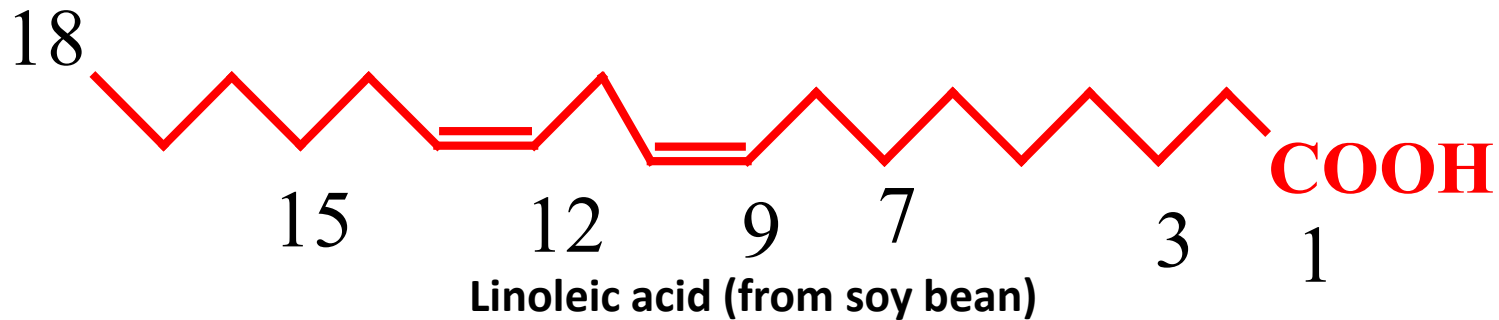
**Average North American consumes 50-60 kg/y**

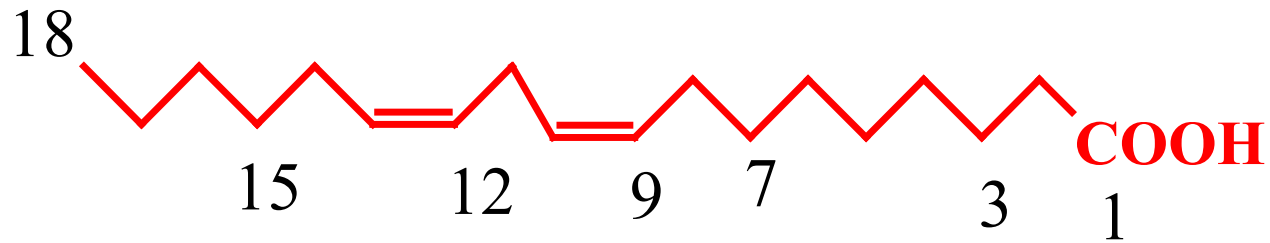


**FATS:** triesters of glycerol with the fatty acids: hence triglycerides



**FATTY ACIDS** (natural ones have even numbers of C's and are cis)

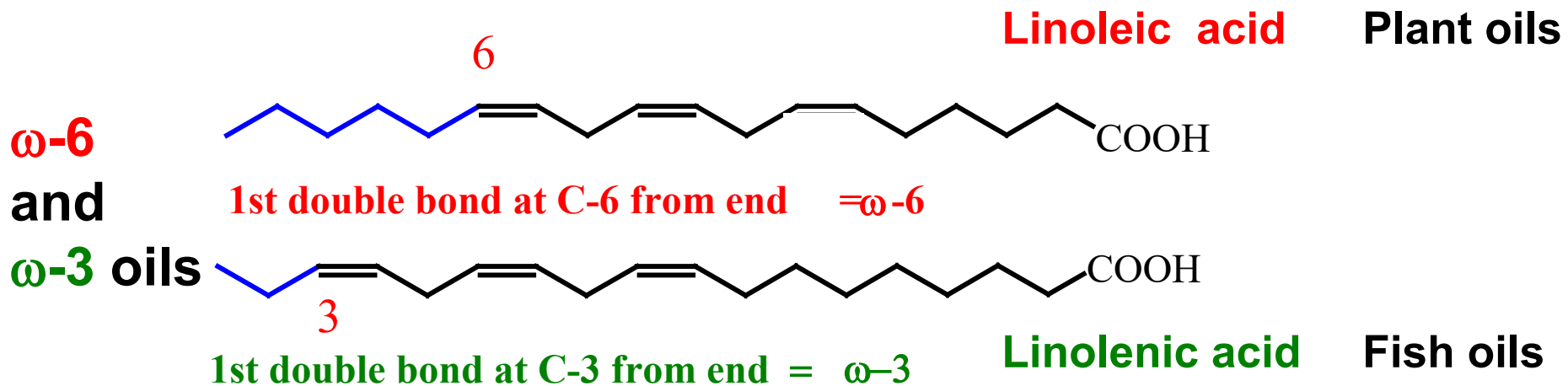




#C'S	# DB'S	POSITIONS	NAME	SOURCE
4/6	0		Butyric/caproic	Butter
8/10	0		Caprylic/capric	Coconut
12/14/16	0		Lauric/myristic/palmitic	Palm
18	0		Stearic	Beef fat
18	1	9(-10)	Oleic	Olive Oil
<b>18</b>	<b>2</b>	<b>9;12</b>	<b>Linoleic</b>	<b>Soy Bean</b>
18	3	9;12;15	Linolenic	Fish/Liver
20	0		Arachidic	Peanut
20	4	5;8;11;14	Arachidonic	Fish/Liver
22	0		Behenic	Canola (Rapeseed)

Humans **can synthesize** most fats from different starting materials, i.e. **we do not have to eat fat as fat**

The exceptions are **linoleic** and **linolenic** acids



Modern diet: 10:1  **$\omega$ -6/ $\omega$ -3** vs. Ancient diet: 1:1  **$\omega$ -6/ $\omega$ -3**

Current theory is that  $\omega$ -3 gives **lower blood triglyceride** levels

PLUS 1g of  $\omega$ -3 per day has been shown to give a **20% reduction in heart-related deaths**

**Lack of  $\omega$ -3 leads to heart disease, thrombosis, atherosclerosis**

**Modern Canola** has about **11%  $\omega$ -3** while decreasing **Erucic acid C22-1(13-14)** to **<1%** (implicated in heart lesions and found in rapeseed oil)

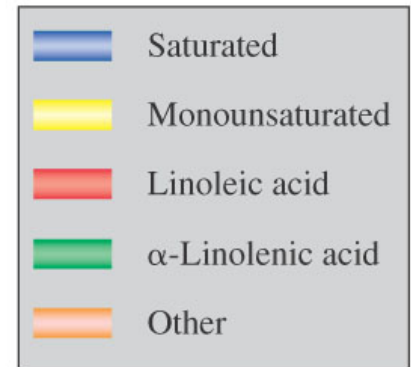
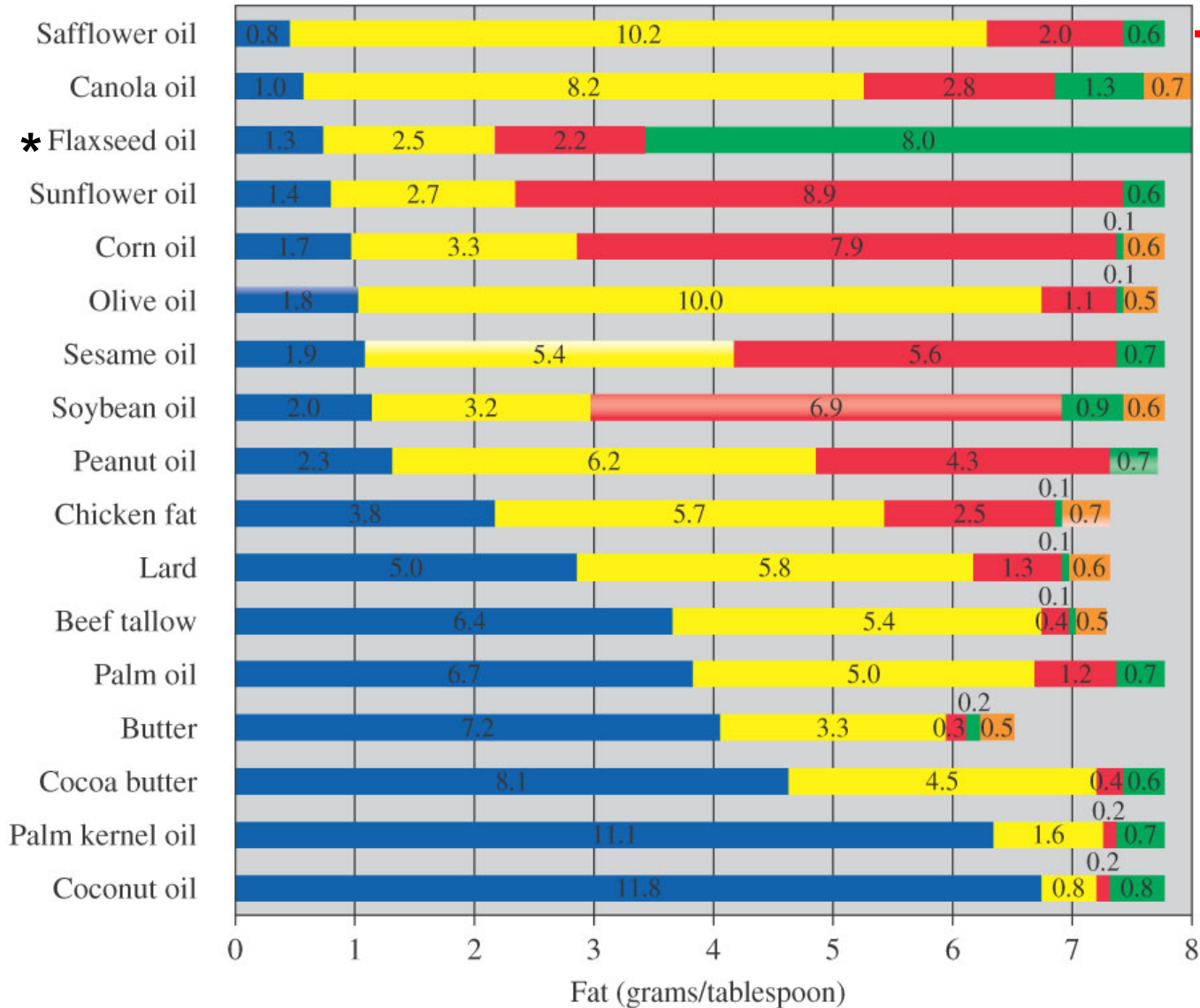
Omega-3 fatty acids are found in oily fish like salmon and flaxseed and canola oils



#ADAM

# Foods have different compositions of fats

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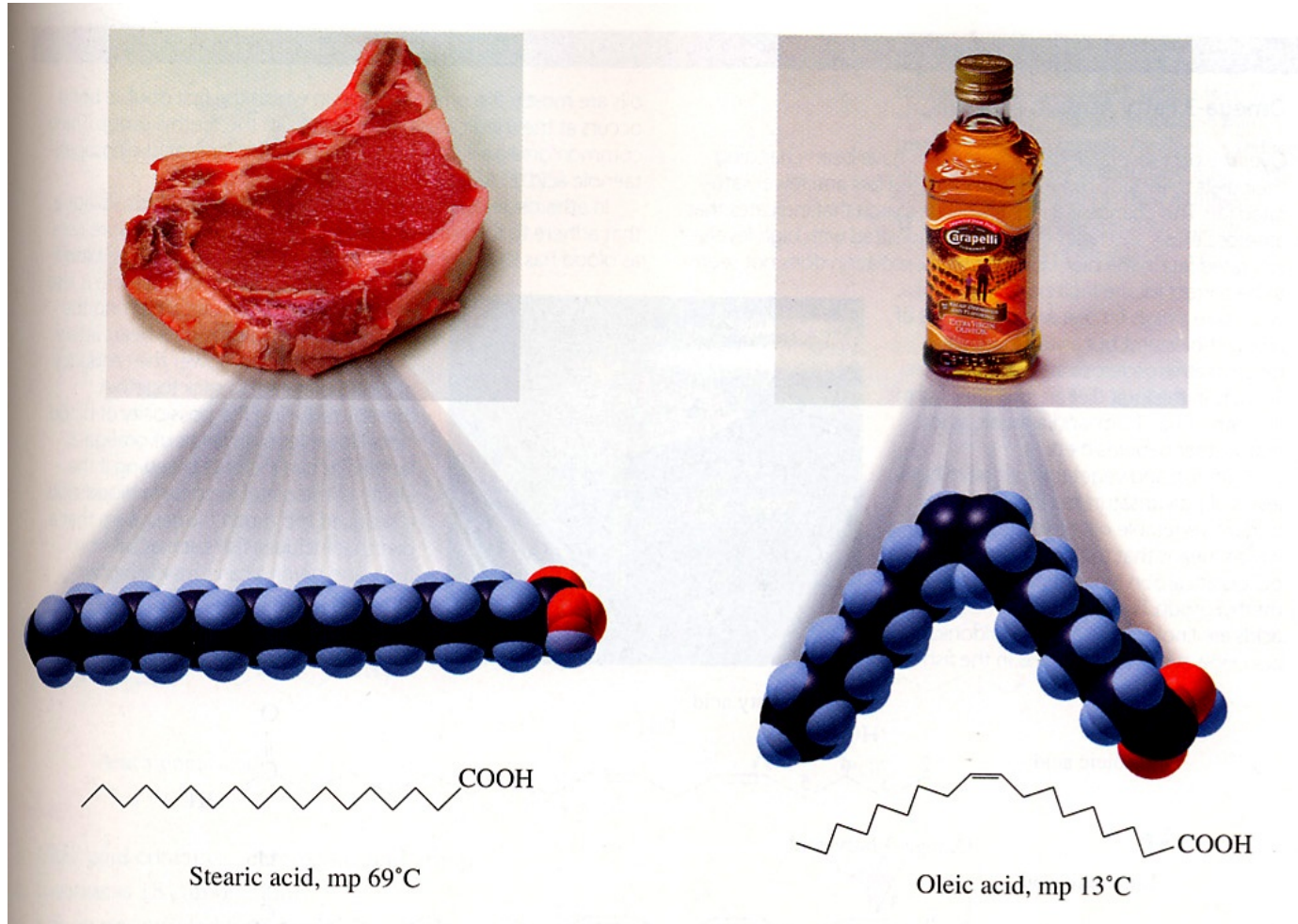


*Chemistry in Context 6<sup>th</sup> Edition, ACS, McGraw-Hill*

*\* aka 'Linseed oil'*

**Natural fatty acids are cis** but can be **isomerized to trans**  
**trans-** are **higher melting** than **cis-** : **solid fats** vs. **oils**

**Saturated fats** (no d.b.): pack better,  $> M_p =$  **SOLIDS**



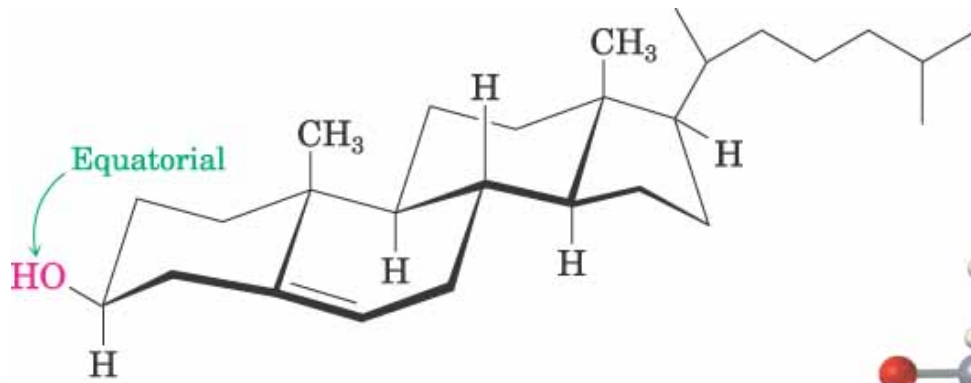
## **Saturated fats: increased risk of heart disease, stroke and some forms of cancer...maybe?**

*Medical studies mixed but generally support an increased risk - virtually all major health agencies recommend decreasing intake.*

## **Trans-fats (US and CAN require labelling)**

**Modern margarine has some cis-bonds isomerized to trans to increase 'solidity':**

<b>Hard margarine</b>	<b>~12% trans-fats</b>
<b>Soft margarine</b>	<b>~5% trans-fats</b>
<b>Becel</b>	<b>0% trans-fat but still ~12% satd fat</b>



**Cholesterol**

©2004 Thomson - Brooks/Cole



**HDL = high-density lipoprotein (carries cholesterol to liver)**

**LDL = low-density lipoprotein (carries cholesterol from liver)**

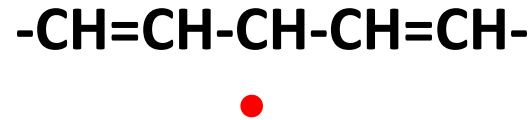
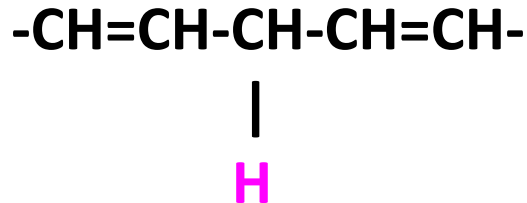
**Excess LDL's seem to accumulate in artery walls,**

**and become oxidized; contents provoke inflammatory response and plaque buildup. HDL's help interfere with this oxidation**

**Hence HDL's are GOOD and LDL's are BAD**



## DISADVANTAGES of unsaturated fats: easier to oxidise



**Allylic hydrogen** is easily oxidised to a **free radical** which further reacts with oxygen to cleave the chain and produce **SMELLY** short chain fatty acids (under-arm sweat and rancid butter smell)

Rags soaked in linseed oil (mostly  $\omega$ -3 acid: linolenic acid) can spontaneously combust:

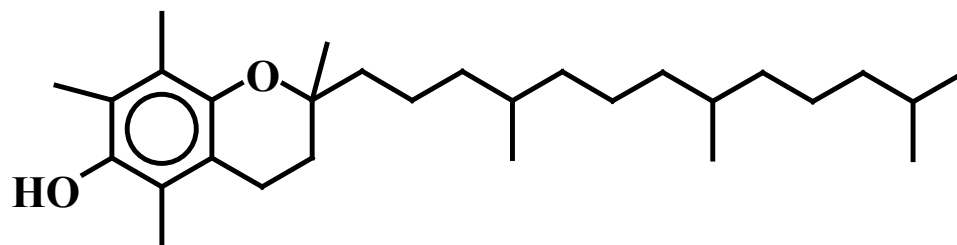
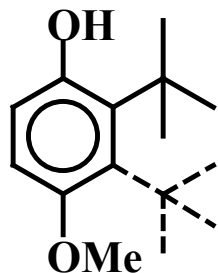
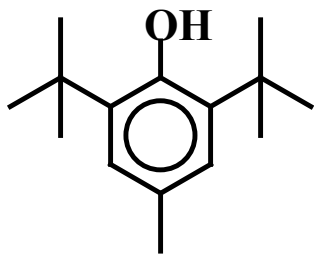
[https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB0QtwlwAA&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3D9yq6VW-c2Ts&ei=fHHiVLSFD9GsogTKzIDQAw&usq=AFQjCNFQEcXcuevn6ssyR4zWNaWFKzVBNw&sig2=X3Hy7DUBRTvU\\_dRJCQXEzq](https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB0QtwlwAA&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3D9yq6VW-c2Ts&ei=fHHiVLSFD9GsogTKzIDQAw&usq=AFQjCNFQEcXcuevn6ssyR4zWNaWFKzVBNw&sig2=X3Hy7DUBRTvU_dRJCQXEzq)

**ANTIOXIDANT** (usually  $\text{ArOH}$ ) can supply a  $\text{H}\cdot$  back to this **free radical** and reform the fat, before it has had time to react with oxygen

**NOTE:** **Butylated hydroxytoluene (BHT)** is 2-t-butyl-4-methylphenol and it is commonly added to cereals for the same reasons (next page)



## Hence need to protect fats with antioxidants:



**BHT**

butylated-  
hydroxytoluene

**BHA**

butylated-  
hydroxyanisole

**VITAMIN E**

a-tocopherol

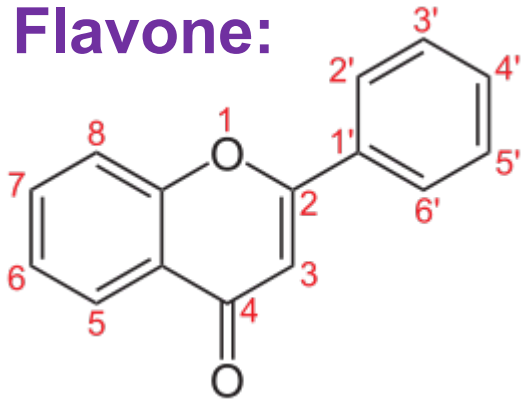
allowed at 0.01-0.02%

*too expensive for food*

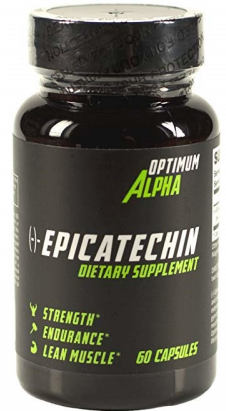
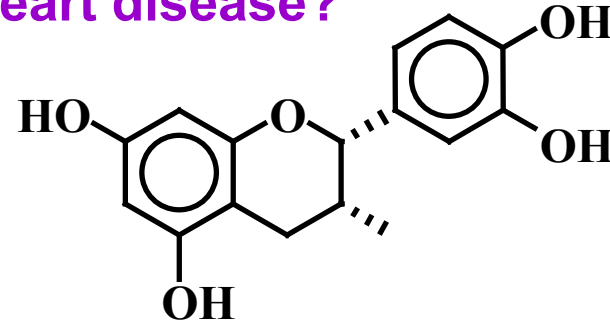
**Note:** in these the  $\text{ArO}\cdot$  is highly crowded which makes it less reactive

# FLAVONOIDS

## Flavone:



e.g. **epicatechin** are found in green and black teas, red wines, dark chocolate and also have antioxidant properties:  
**reduced heart disease?**



**Proponents of dark chocolate also claim:**

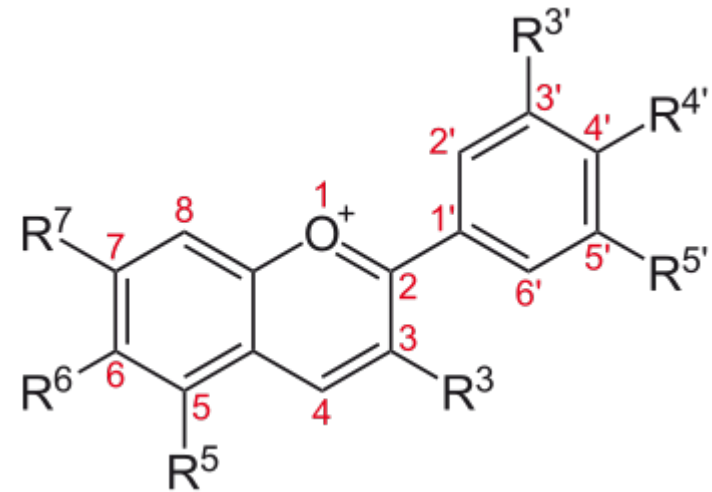
- 1) Helps weight loss**
- 2) Lowers blood pressure**
- 3) Decreases risk of Alzheimer's**
- 4) Protects brain from stroke effects**
- 5) Decreases risk of diabetes, etc.**

***Your results may vary...***

# ANTHOCYANIDINS

R3, R5, R7 virtually always OH  
and other R groups may be OH

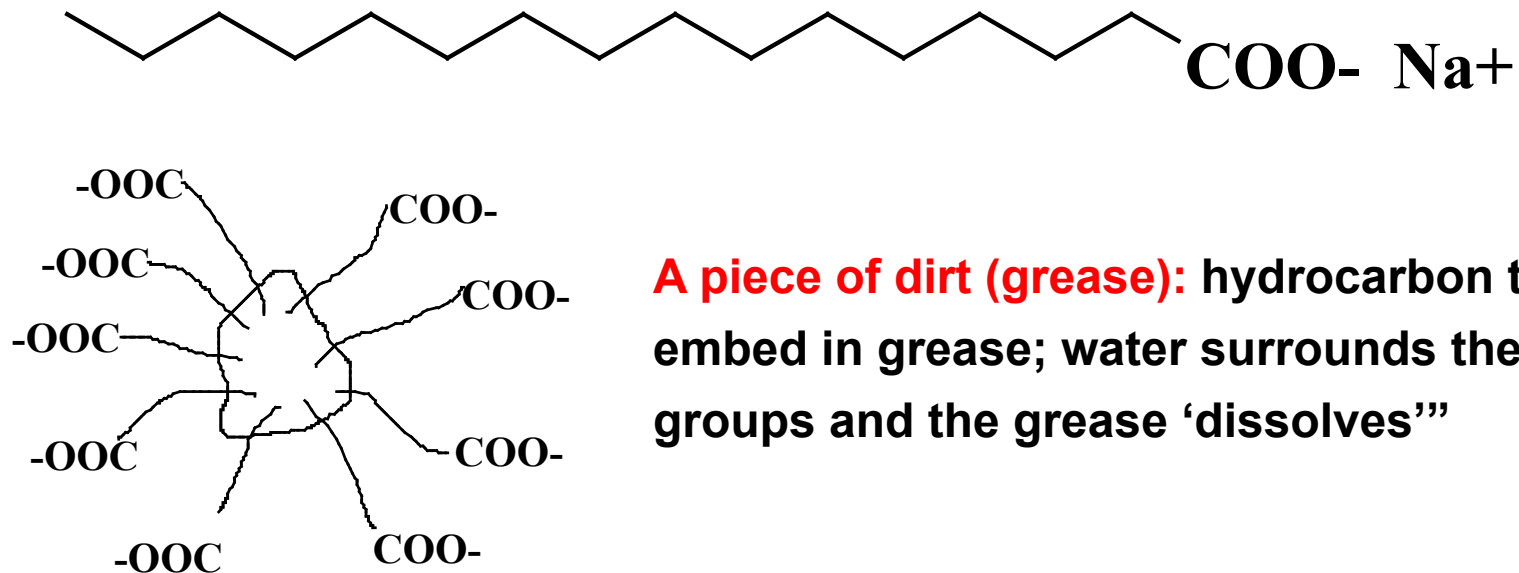
**Powerful anti-oxidants** found  
as **pigments** in berries, flowers,  
vegetables, outer skins:  
blueberries, blood oranges, jalapeno peppers, purple onions,  
red apple skins, many others



**OILS: Vegetable oil production** 80-100 Mtons/y mostly as Soy, Palm, Canola (about ~20% each) plus minor amounts of coconut and peanut oils

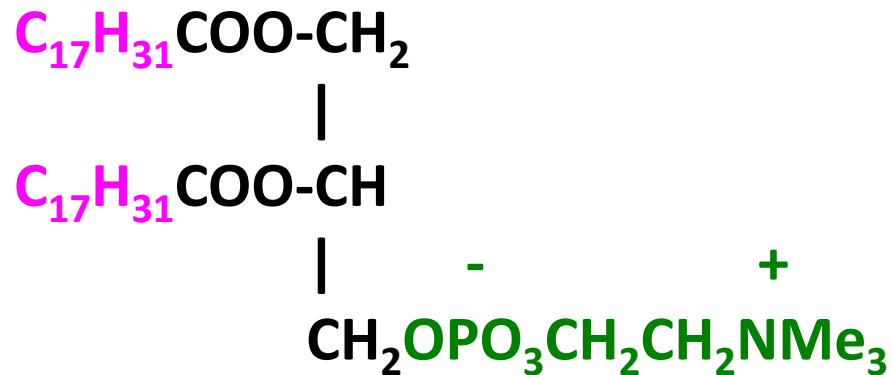
<b>Soft margarine</b> has	<b>80% fat</b>	<b>16% water</b>
<b>Low fat soft margarine</b> has	<b>40%fat</b>	<b>56% water!!!</b>

**Fats don't dissolve in water, so have to emulsify them**



**A piece of dirt (grease):** hydrocarbon tails embed in grease; water surrounds the  $\text{-COO}^-$  groups and the grease ‘dissolves’”

For fats, can use **phospholipids**: *eg.* **Lethicin** (egg yolks)

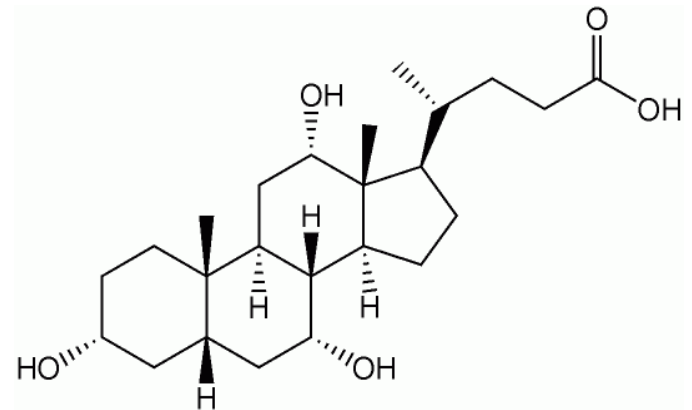


greasy end binds fat

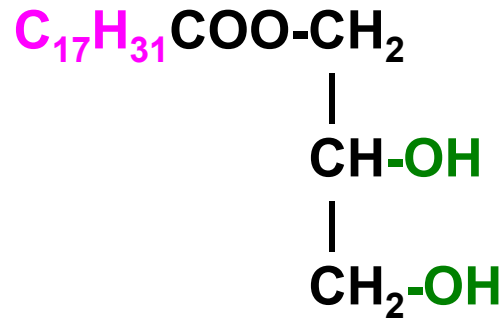
ionic end binds water

bile acids transport fats  
thru the intestine for use

**Cholic acid:**



Similarly **mono- or diglycerides** bind fats to sugars:



**greasy end binds fat** **this H-bonds to sugar -OH's**

so used in ***shortenings, cakes and cookies***: can get up to 40% sugar in a cake without it being 'crunchy'; fats make cookies more 'crumbly'

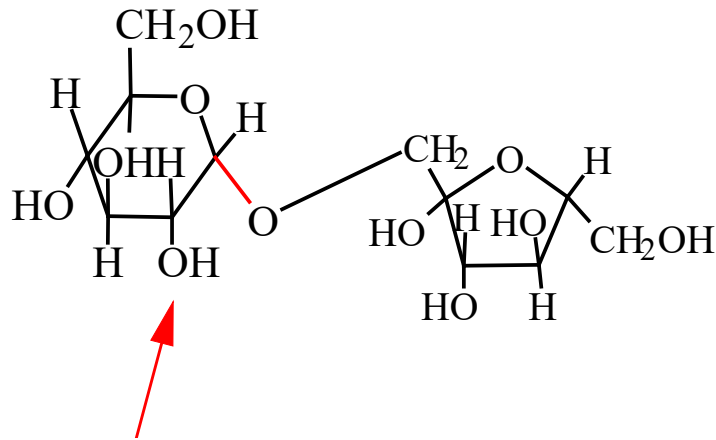




# FAT SUBSTITUTES

Some are '**modified**' *starches*, have the texture of fat but 4 kcal/g rather than 9 kcal/g

## OLESTRA



each **-OH** of sucrose is converted to a **-OCO(CH<sub>2</sub>)<sub>6,7,8</sub>CH<sub>3</sub>**

the resulting molecule **cannot pass through the intestine**, so is not absorbed: because it is so '**greasy**' it can lubricate the intestines too much so '**anal leakage**' (!! ) can occur carrying with it some fat soluble vitamins

**Natural Waxes** are **long chain acid** / **long chain alcohol** esters:



**Carnauba wax** (used for car polish and coatings on 'no-mess' candies like Smarties, M+M's) contains some pendant HO~~~~COOH that polymerize and give it its hardness

**CANNOT DIGEST THESE**

**Jojoba oil** is an unsaturated 'wax' that is not metabolised: under study as a frying oil and diesel fuel; moisturizer in cosmetics

