

FOOD

Purpose of food

energy

water

building blocks

essential molecules the body does not make

Macronutrients

fats

carbohydrates

proteins

Micronutrients

vitamins

minerals

H																					
Na	Mg																				
K	Ca																				

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PERIODIC TABLE
Atomic Properties of the Elements

Frequently used fundamental physical constants

For the most accurate values of these and other constants, visit physics.nist.gov/constants

1 electron $e = 1.602176565(35) \times 10^{-19}$ C (exact)
 Planck constant $h = 6.62607015 \times 10^{-34}$ J s (exact)
 Speed of light in vacuum $c = 299\,792\,458$ m s⁻¹ (exact)
 Elementary charge $e = 1.602176634 \times 10^{-19}$ C (exact)
 Atomic mass constant $m_u = 1.66053906860(50) \times 10^{-27}$ kg (exact)
 Proton mass $m_p = 1.67262192369(51) \times 10^{-27}$ kg
 Neutron mass $m_n = 1.674927471(63) \times 10^{-27}$ kg
 Fine-structure constant $\alpha = 7.2973525693(11) \times 10^{-3}$
 Rydberg constant $R_\infty = 10973731.568160(21) \text{ m}^{-1}$
 Boltzmann constant $k_B = 1.38065837(44) \times 10^{-23}$ J K⁻¹

States: Solids (blue), Liquids (green), Gases (yellow), Artificially Prepared (pink)

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
Chlorine	Cl	0.40	0.0060
Potassium	K	0.36	0.0061
Sulfur	S	0.25	0.0052
Sodium	Na	0.11	0.0032
Magnesium	Mg	0.03	0.0014

Composition of Food

Table 11.1

Percentage of Water, Fats, Carbohydrates, and Proteins

Food	Water	Fats	Carbohydrates	Proteins
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*.

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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**

Nutrition Facts			
Serving Size 1 cup (228g)			
Servings Per Container 2			
Amount Per Serving			
Calories 250		Calories from Fat 110	
			% Daily Value*
Total Fat 12g			18%
Saturated Fat 3g			15%
Trans Fat 3g			
Cholesterol 30mg			10%
Sodium 470mg			20%
Total Carbohydrate 31g			10%
Dietary Fiber 0g			0%
Sugars 5g			
Protein 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	65%	kcal/g	= 4
Protein	20%		= 4
Fat	10%		= 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

Gender by Age (yr)	Activity Level		
	Sedentary ^a	Moderately Active ^b	Active ^c
<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

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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]²
<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:

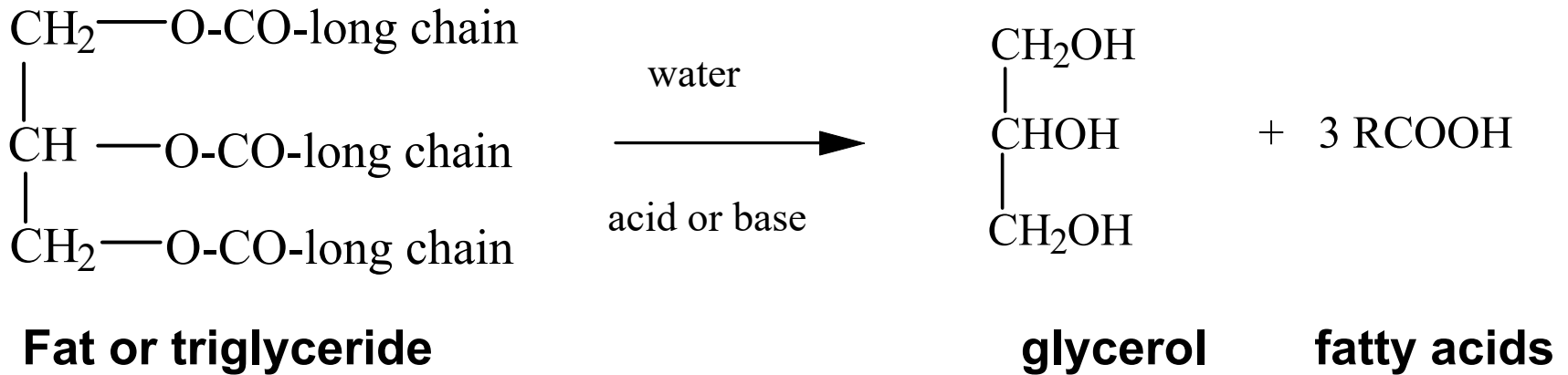
OBESITY ★	NERVOUS TENSION
HYPERTENSION	ACHING LIMBS
HIGH BLOOD PRESSURE ★	DIABETES ★
HYPOGLYCEMIA	ACNE
DEPRESSION	SKIN IRRITATION
HEADACHES	STIFFENING OF ARTERIES
FATIGUE	VIOLENT BEHAVIOR

From
www.skinnychef.com

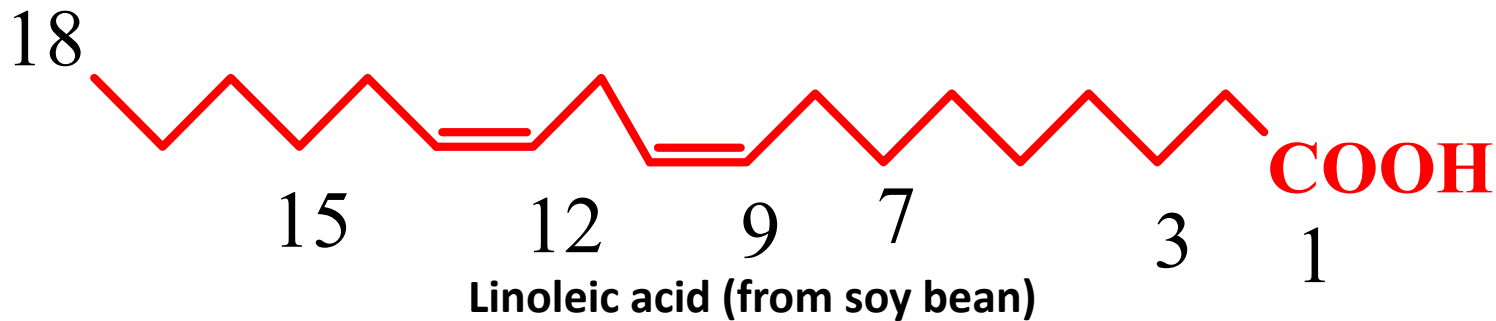
Refined sugar is **pure sucrose** so it **SHOULDN'T** have any of these!

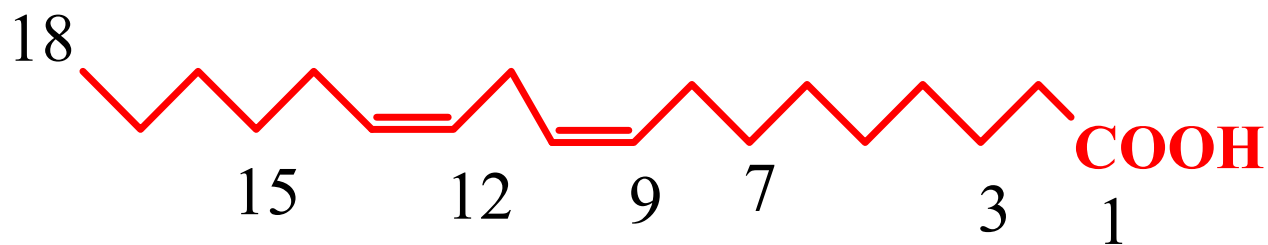
Average North American consumes 50-60 kg/y

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



FATTY ACIDS (natural ones have even numbers of C's, formed from acetyl-CoA = $\text{CH}_3\text{CO---}$ CoA and are **cis**)

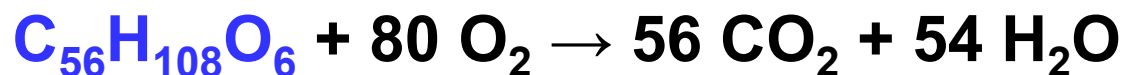




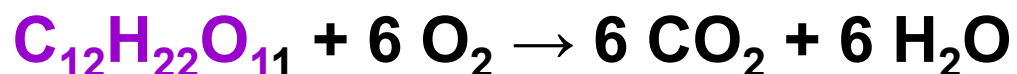
#C'S	# DB'S	POSITIONS	NAME	SOURCE
4/6	0		Butyric/caproic	Butter
8/10	0		Caprylic/capric	Coconut
12/14/16	0		Lauric/myristic/palmitic	Palm
18	0		Stearic	Beef fat
18	1	9(-10)	Oleic	Olive Oil
18	2	9;12	Linoleic	Soy Bean
18	3	9;12;15	Linolenic	Fish/Liver
20	0		Arachidic	Peanut
20	4	5;8;11;14	Arachidonic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

Energy from Fats

Typical **heavy fat**: **more 'reduced' than a sugar**, hence more energy released during oxidation



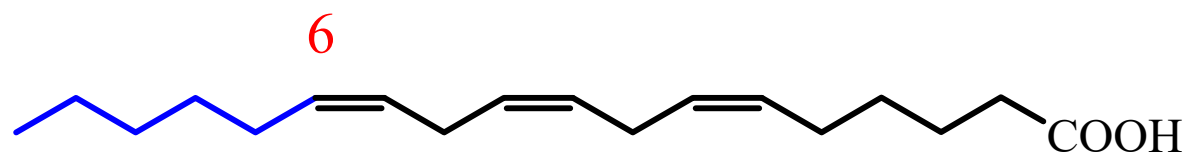
vs. **sucrose**:



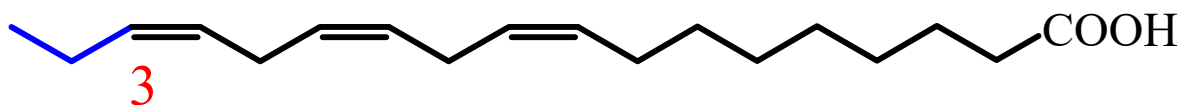
Humans **can synthesize** most fats from different starting materials, i.e. **we do not have to eat fat as fat**

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

ω -6 and ω -3 oils



1st double bond at C-6 from end = ω -6



1st double bond at C-3 from end = ω -3

ω -6	FATTY ACID	Linoleic acid	Plant oils
ω -3	FATTY ACID	Linolenic acid	Fish oils

Modern diet: 10:1 ω -6/ ω -3 vs. Ancient diet: 1:1 ω -6/ ω -3

Current theory is that ω -3 gives **lower blood triglyceride** levels

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

Lack of ω -3 leads to heart disease, thrombosis, atherosclerosis

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

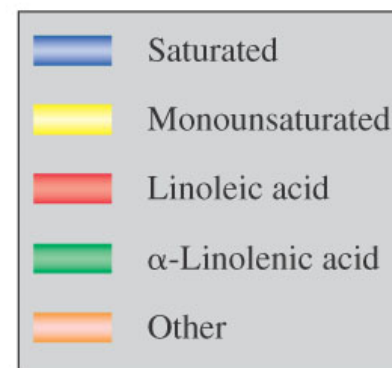
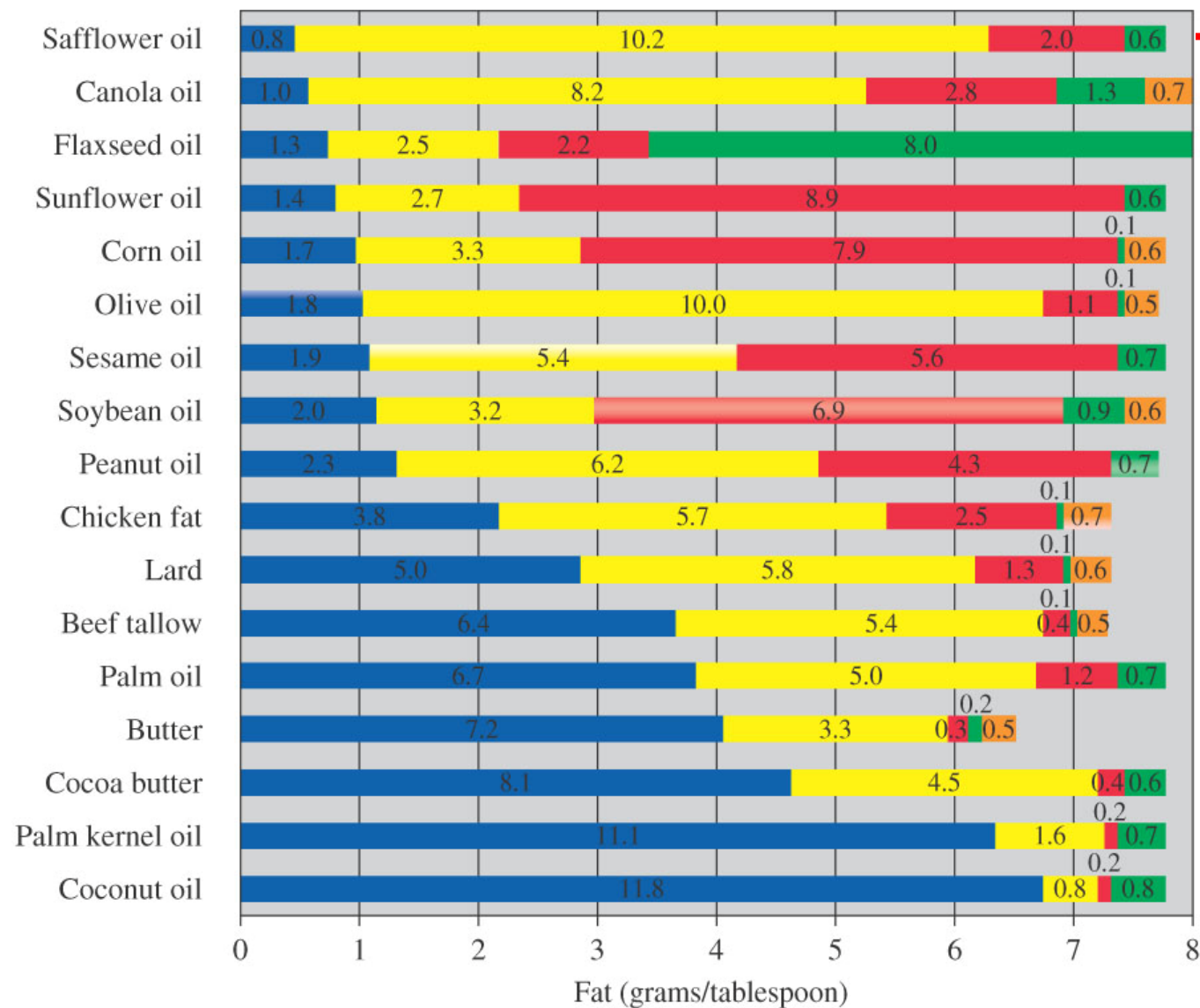
Omega-3 fatty acids are found in oily fish like salmon and flaxseed and canola oils



ADAM

Foods have different compositions of fats

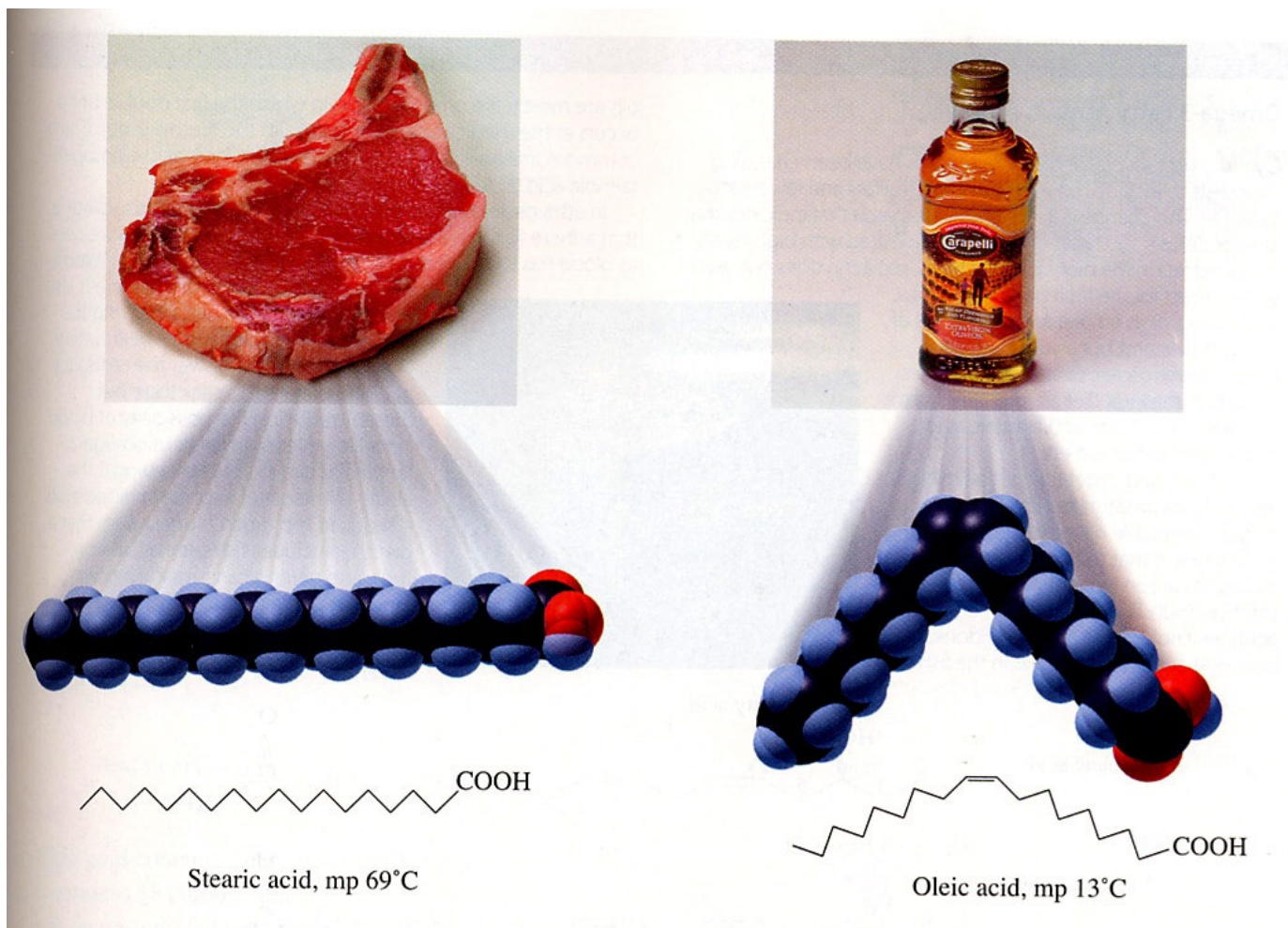
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Natural fatty acids are cis but can be **isomerized to trans**
trans- are **higher melting** than **cis-** : **solid fats** vs. **oils**

Saturated fats (no d.b.): pack better, > Mp = 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)

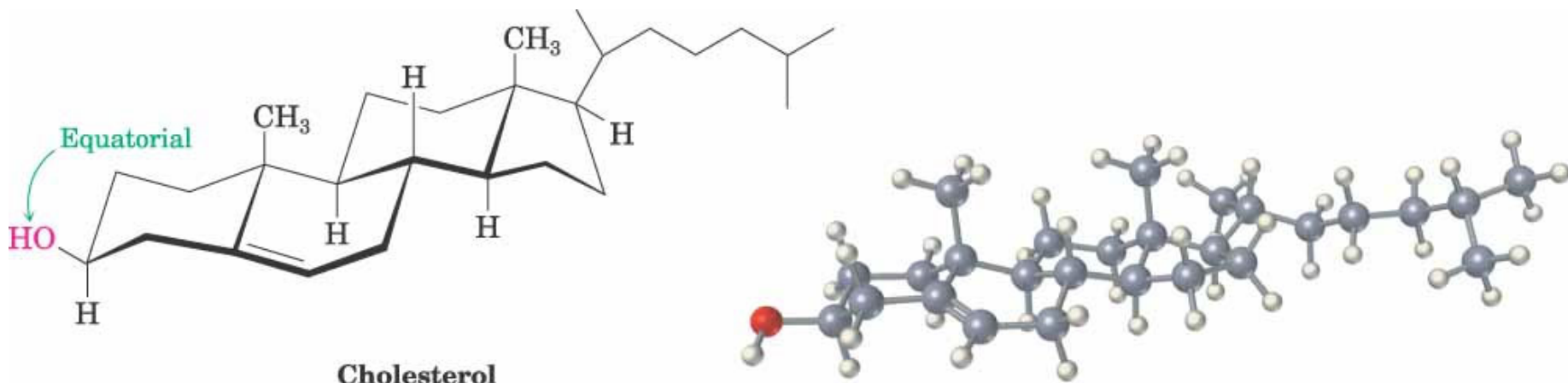
Modern margarine has some cis-bonds isomerized to trans to increase 'solidity':

Hard margarine ~12% trans-fats

Soft margarine ~5% trans-fats

Becel 0% trans-fat but still ~12% satd fat

**Current hypothesis: trans fats increase LDL's a few %
= Small increase in risk of heart attack**



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 ω -3 acid: linolenic acid) can spontaneously combust:

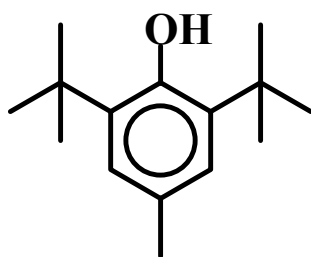
https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB0QtwlwAA&url=http%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3D9yq6VW-c2Ts&ei=fHHiVLSFD9GsogTKzIDQAw&usq=AFQjCNFQEcXcuevn6ssyR4zWNaWFKzVBNw&sig2=X3Hy7DUBRTvU_dRJCQXEzq

ANTIOXIDANT (usually 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)

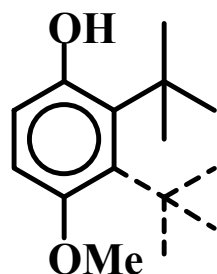


Hence need to protect fats with antioxidants:



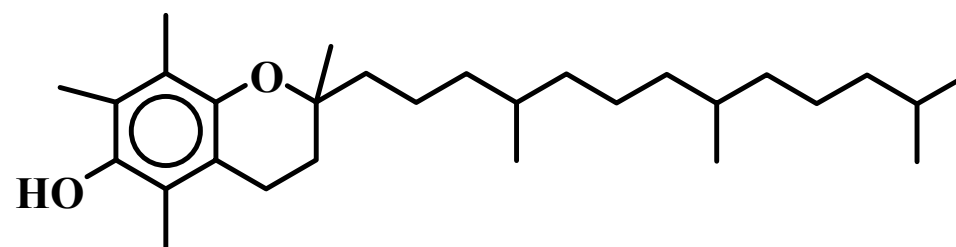
BHT

butylated-
hydroxytoluene



BHA

butylated-
hydroxyanisole



VITAMIN E

alpha-tocopherol

allowed at 0.01-0.02%

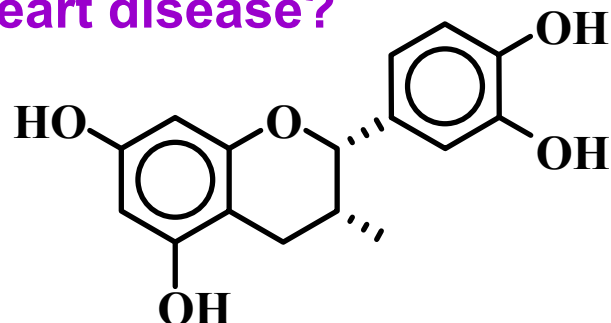
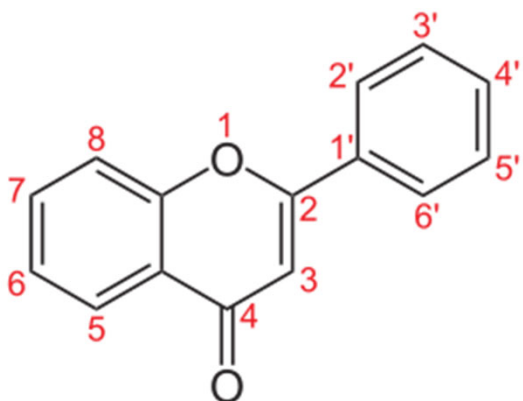
too expensive for food

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

FLAVONOIDS

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:

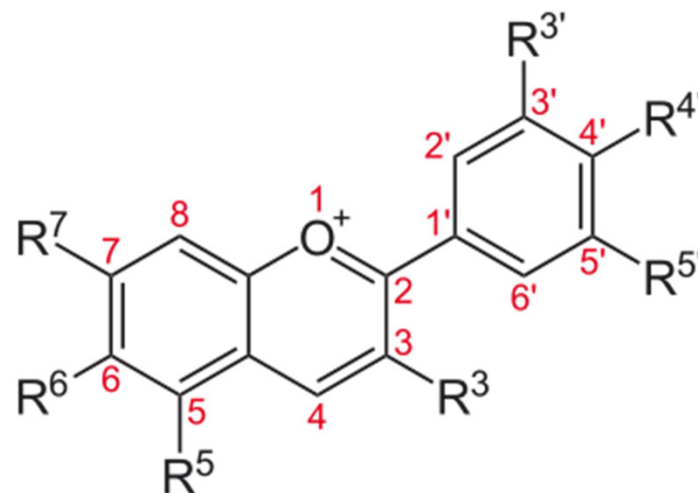
- 1) Helps weight loss**
- 2) Lowers blood pressure**
- 3) Decreases risk of Alzheimer's**
- 4) Protects brain from stroke effects**
- 5) Decreases risk of diabetes, etc.**

Your results may vary...

ANTHOCYANIDINS

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

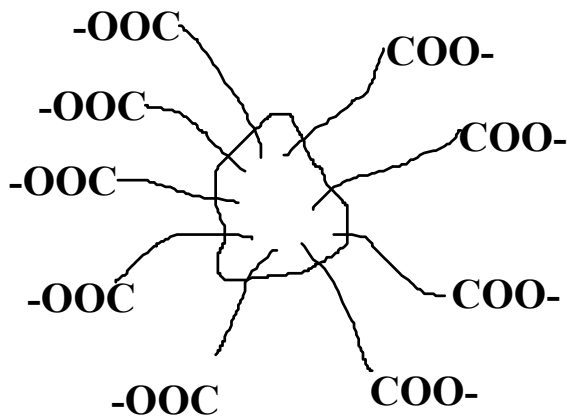
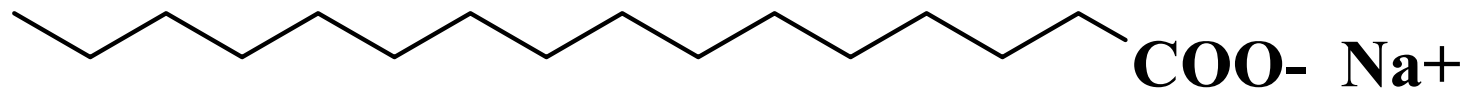
Powerful anti-oxidants found
as **pigments** in berries, flowers,
vegetables, outer skins:
blueberries, blood oranges, jalapeno peppers, purple onions,
red apple skins, many others



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

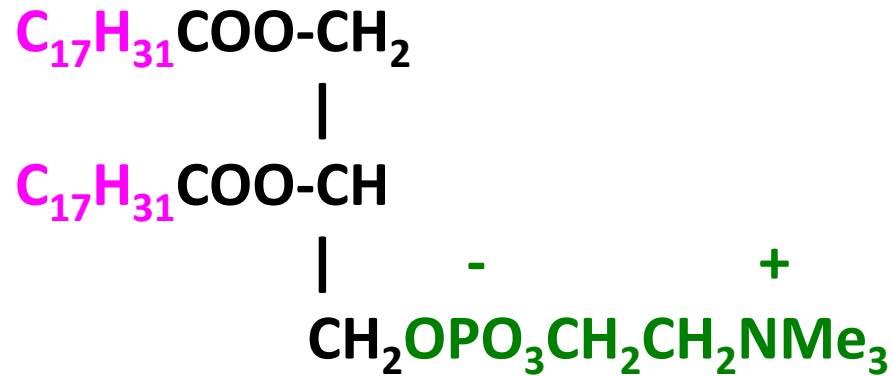
Soft margarine has	80% fat	16% water
Low fat soft margarine has	40%fat	56% water!!!

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



A piece of dirt (grease): hydrocarbon tails embed in grease; water surrounds the **-COO-** groups and the grease 'dissolves''

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

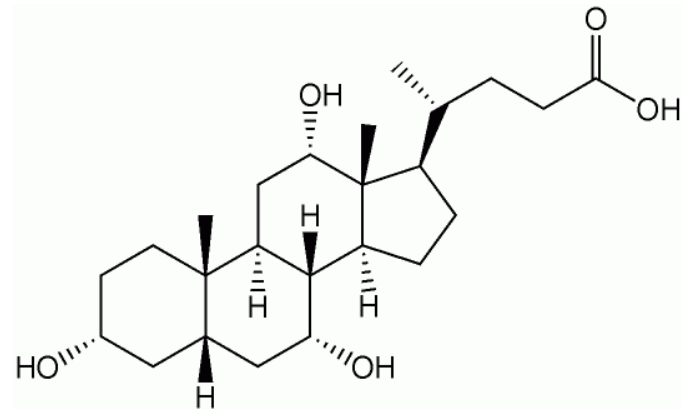


greasy end binds fat

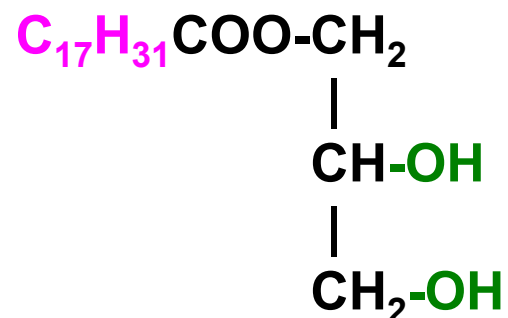
ionic end binds water

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**

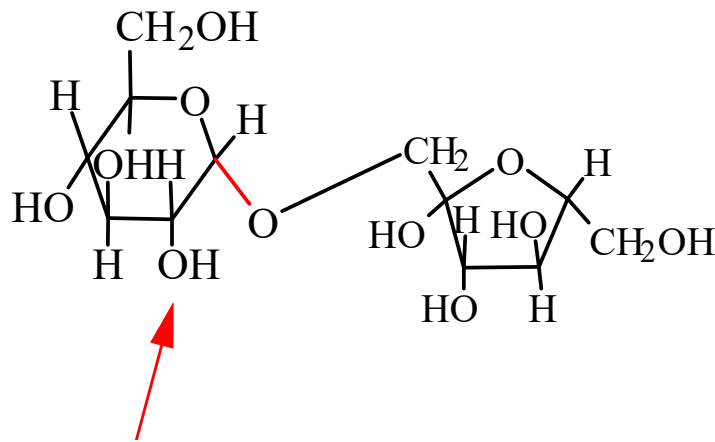
so used in ***shortenings, cakes and cookies***: can get up to 40% sugar in a cake without it being 'crunchy'; fats make cookies more 'crumbly'



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(CH₂)_{6,7,8}CH₃**

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



Cholesterol, Fats and Oils, Salt and Calories in Foods (per 100g)

Food	Cholesterol mg	Oil or Fat (grams)			Salt mg	Cal
		Satur	Mono-un	Poly-un		
Beef, raw	91	2.7	2.7	0.5	54	152
Chicken	85	1.3	1.5	1.0	70	165
Cheese (cheddar)	105	21.1	9.4	0.9	615	400
Corn oil	0	12.7	24.2	58.7	0	884
Eggs, whole	548	3.4	4.5	1.4	142	143
Hot dog, all beef	51	12.7	14.8	1.2	1026	296
Milk, whole	14	2.3	1.1	0.1	40	60
Olive oil	0	13.5	73.7	8.4	0	884
Margarine (Becel)	0	10.0	30.0	40.0	700	700
Butter	215	50.5	23.4	3.0	576	720
Tuna (canned)	63	0.2	0.1	0.2	338	116
Salmon (canned)	35	1.0	1.8	2.7	487	140
Peanut butter (unsalted)	0	9.7	23.3	15.2	17*	588
Yogurt (plain, skim milk)	6	1.0	0.4	0.04	77	56