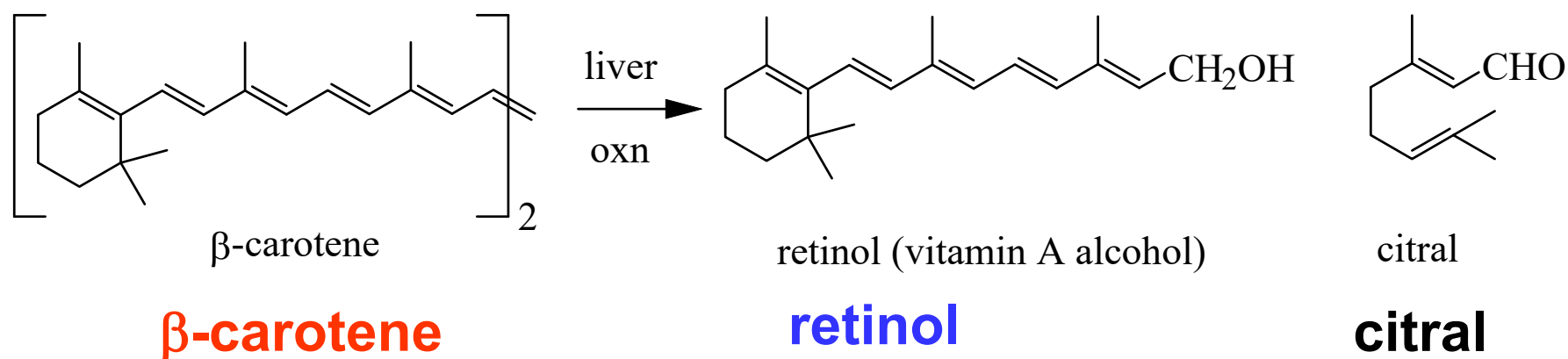


VITAMINS

OIL (FAT) SOLUBLE = A, D, E, F, K

WATER SOLUBLE = B, C.

VITAMIN A = RETINOL, derived in body from **β -carotene** (orange pigment in carrots)



Sources: fish liver oils, liver, apricots/peaches

Citral from lemon grass can be converted to Vitamin A or carotene.

Function of Vitamin A: protects against invading bacteria

- Increases mucus secretion to trap bacteria
- prevents night blindness
- keeps skin healthy
- keeps tear ducts healthy

EXCESS:

- irritability, dry peeling skin, pressure in head
- **severe liver injury if >25000IU. i.e 5x normal dose**

TERATOGENIC: birth defects of eyes, ears, heart

- pregnant women should avoid liver

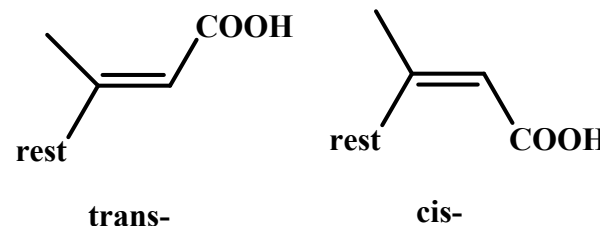
trans-RETINOIC ACID; RETIN-A; TRETINOIN

- Causes the *skin to peel*, so is used in cosmetics as anti-acne agent, anti-skin damage, anti-wrinkle.....OK in limited doses topically

Isotretinoin = cis-retinoic acid = ACCUTANE

- Orally for severe acne, BUT it has severe side effects and is a **TERATOGEN** – require two pregnancy tests
- huge number of side effects, see:
<http://www.nlm.nih.gov/medlineplus/druginfo/medmaster/a681043.html>

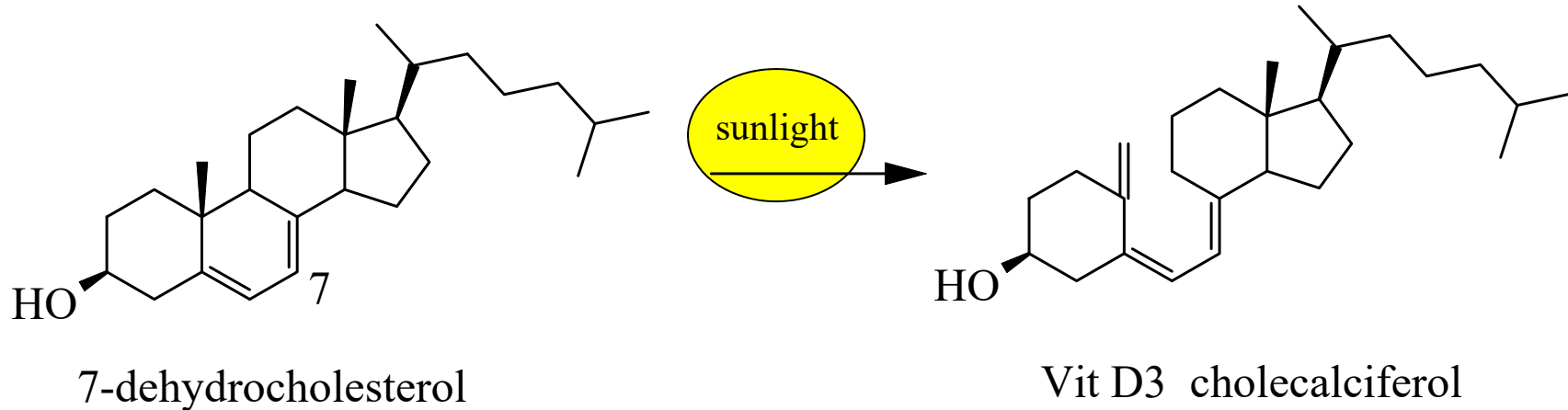
see retinol structure, $-\text{CH}_2\text{OH} \rightarrow -\text{COOH}$



VITAMIN D (calciferol) 400 IU = 10 μ g of Vit D3

US = 5-10 μ g; UK 5-7 μ g; CAN 3-5 μ g

high end for pregnant females and children



Sources: Pre-vitamin in cereals, bread, milk

- sunlight converts it to active vitamin

Function: Vitamin D controls Ca and P absorption from foods, metabolism, transport of Ca in bloodstream and formation of bones.

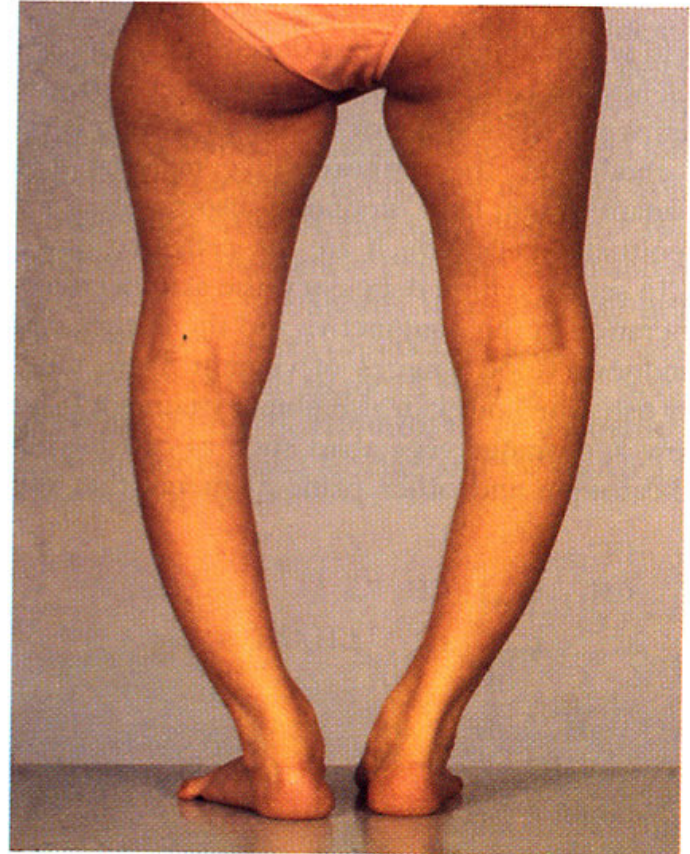
DEFICIENCY:

soft, deformed bones = **RICKETS**,
not enough $\text{Ca}_3(\text{PO}_4)_2$ to stiffen them;
poor teeth.

Too much?

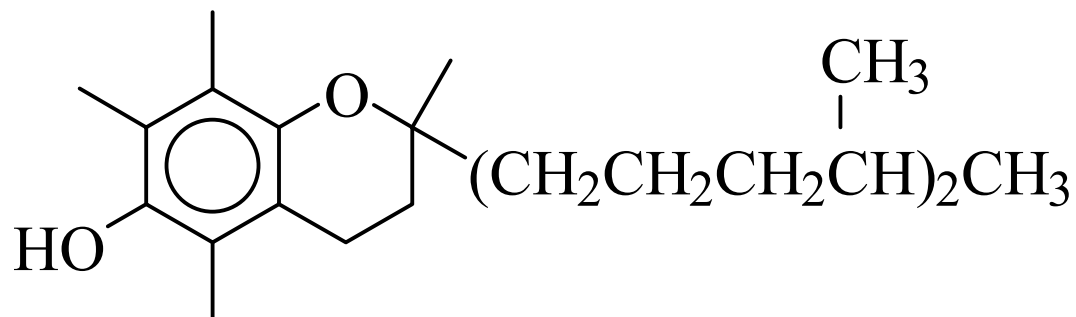
- Stiffening of joints
- Headache, nausea

Figure 17-9 A deficiency of vitamin D (calciferol) combined with a lack of sunlight causes rickets in children. As a result of abnormal bone growth caused by a disturbance in calcium metabolism, children develop bow legs and knock knees.



VITAMIN E

α -TOCOPHEROL



THE FAT ANTI-OXIDANT

myths: “sexual potency vitamin”; “anti-aging vitamin” (in rats)

Function: Prevents oxidation of fats, maintains red blood cell membranes; necessary for proper functioning of: genitals (“sexual potency”), lungs, liver, kidneys.

Sources: grains, fats (meats), eggs, nuts, salmon (oily fish)

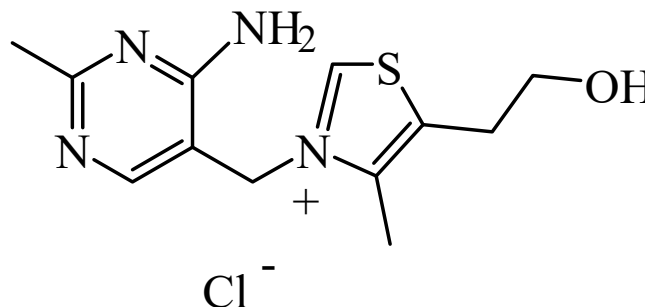
DEFICIENCY: edema (water under skin), anaemia, muscular dystrophy



THE WATER SOLUBLE VITAMINS

THE B-GROUP: co-enzymes in **growth** and **energy production**

B1 **THIAMINE**
RDA = 1.5mg

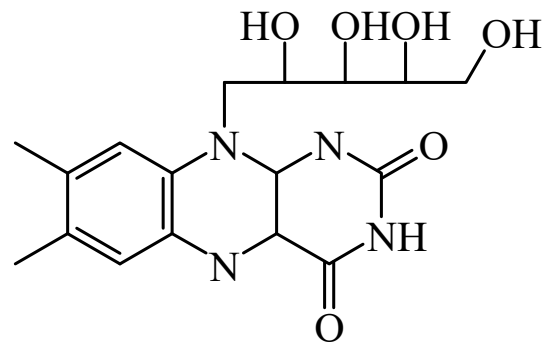


DEFICIENCY: Beri Beri, muscular atrophy, nervous disorders

Beri Beri = laboured breathing, enlarged heart, mental confusion, paralysis of arms/legs

SOURCES: grain skins, soybeans, bran, peanuts, meats, liver, eggs,

B2 RIBOFLAVIN
RDA = 1.2-1.8mg

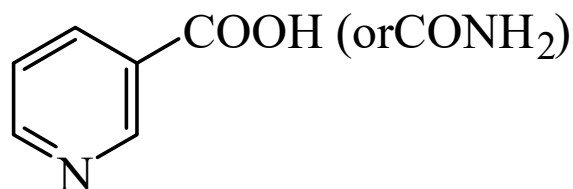


Function: metabolism of fats and proteins

DEFICIENCY: skin problems, fatigue, stops tissue growth

Sources: liver, milk, eggs, leafy veg

B3 NIACIN
RDA 13-20mg



Function: metabolism and synthesis of carbs, fats, proteins, (**alcohol**)

Deficiency: Pellagra (dermatitis, dementia), stunted growth

Sources: yeasts, liver, peanuts, whole grains, potatoes

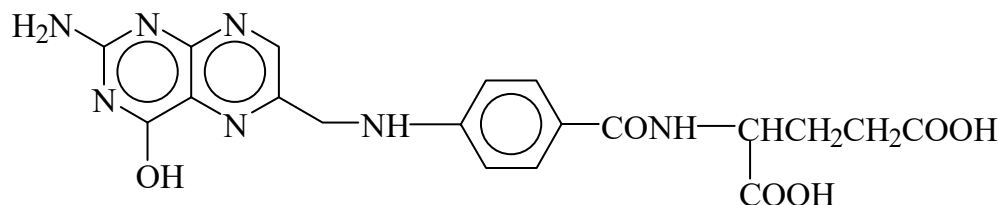
Corn is deficient in niacin, so people in SE USA used to get pellagra

BUT excess Niacin causes liver, muscle and eye damage

B9 FOLIC ACID

RDA = 0.15-0.4 mg

Preg F = 0.4-0.8 mg



Function: coenzymes of growth, especially red blood cells

Deficiency: anaemia, fatigue, poor appetite, forgetfulness

Sources: Liver, whole grains, yeast, asparagus, spinach (green veg)

Controversies? For pregnant women, it protects baby from *spina bifida* - but other studies suggest increased chance of twins with risk of cerebral palsy: which risk is greater?

US has made it a *compulsory additive in cereals*: reduces blood homocysteine, reduces heart disease

http://www.hc-sc.gc.ca/iyh-vsv/med/folic-folique_e.html

http://www.marchofdimes.com/professionals/690_1403.asp

B12 COBALAMIN
RDA = 6 µg/day

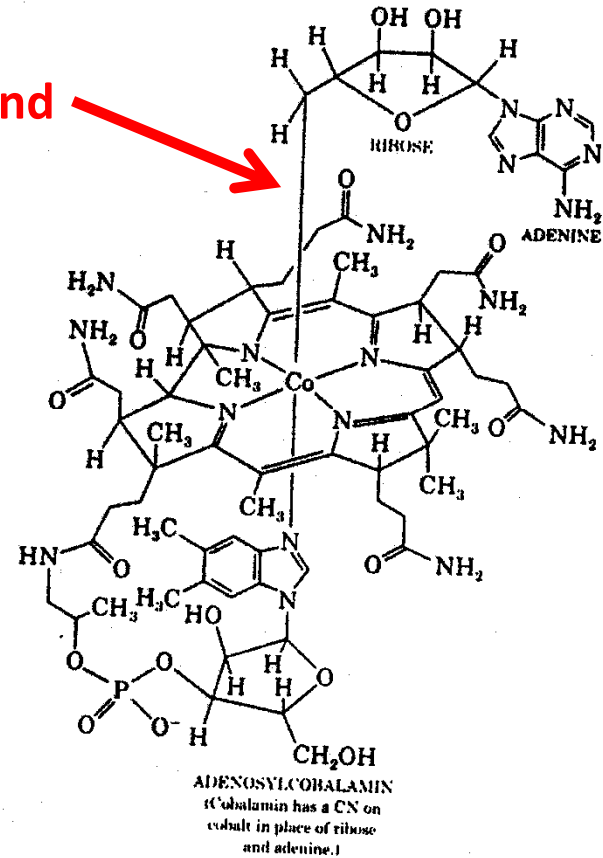
Function: synthesis of nucleic acids, red and white blood cells, RNA to DNA conversion

Deficiency: pernicious anaemia (can't absorb vitamin from food, need to have injected), jaundice, poor cell division,.....

Sources: Not in plants, only in meat, clams, oysters, egg yolks

VITAMIN USRDA* STRUCTURE AND NAME
B₁₂ 6 µg

Metal-carbon bond

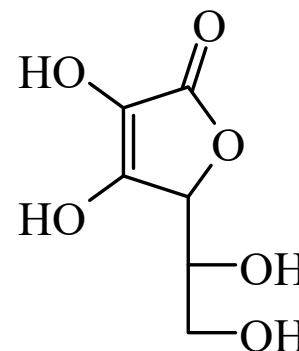


http://health.yahoo.com/ency/healthwise/hw65706; ylt=AnIs3yh6DKWemgFCu6y_gGOMxbAB

Vitamin C

ASCORBIC ACID

RDA = 50-60mg/day



Function: ANTI-OXIDANT, scavenges free radicals, maybe involved in synthesis of interferon, prevents invading viruses, hence VIT C - COLD connection

Sources: all citrus fruits, tomatoes, peppers, potatoes...

Deficiency: Scurvy, weight loss, damaged liver, swollen legs,...

Need: ~ 10mg/day to prevent scurvy (*term 'limeys'*)

Not stored in body long and excess excreted (>200mg/day)

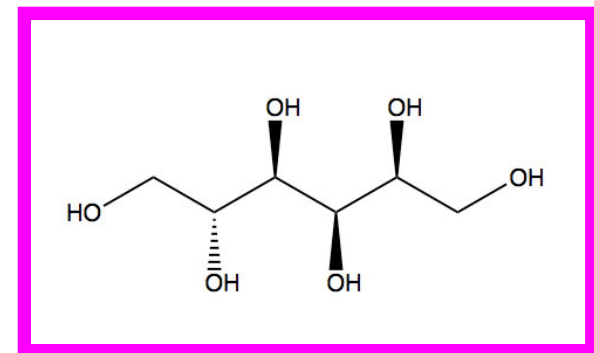
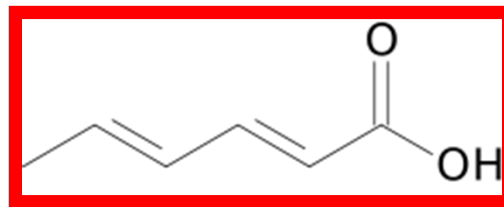
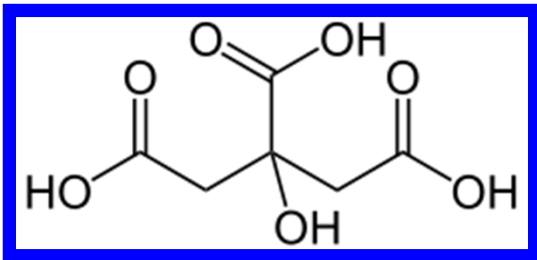
FOOD ADDITIVES

The GRAS list: 'Generally Regarded as Safe' List

Anti-caking agents: Ca silicate SiO_2 Iron ammonium citrate

Acids/bases/buffers: acetates, **citrate (left)**, lactates, phosphates, tartarates, **sorbates (middle)**

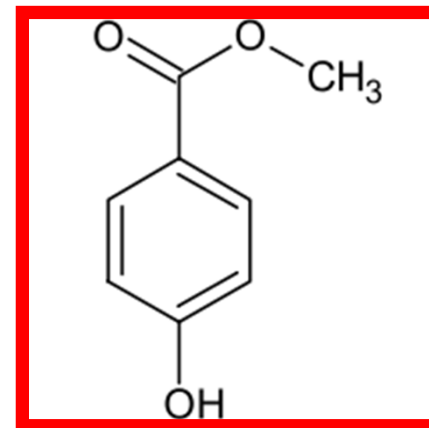
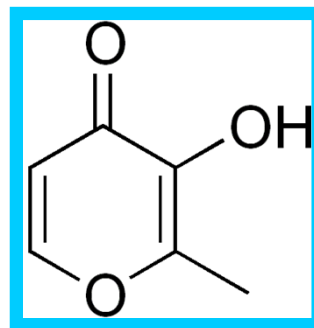
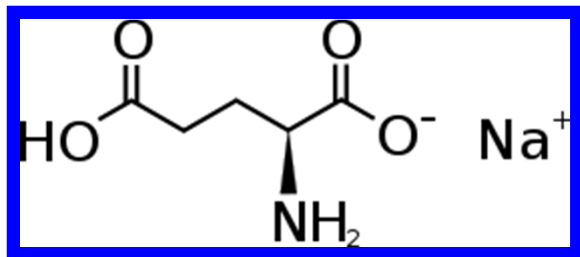
Emulsifiers (surfactants): mono- and diglycerides of fatty acids
alcohols like **sorbitol (right):**



Preservatives: benzoates, propionates, sorbates, 'parabens'

Anti-oxidants: ascorbic acid, BHA, BHT,
lecithin, SO₂ and sulphites

Flavour enhancers: MSG, maltol

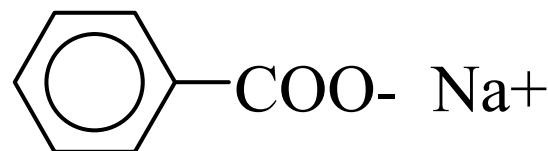


Sweeteners: Aspartame, Mannitol, Sorbitol

Flavourings: amyl butyrate (pear), carvone (spearmint), citral (lemon), ethyl vanillin (vanilla), geraniol (rose), methyl anthranilate (grape), methyl salicylate (wintergreen), eugenol (allspice)

PRESERVATIVES: prevent bacteria and oxidation
dry and/or use salt/sugar OR add a **BACTERICIDE**

SODIUM BENZOATE $\leq 0.1\%$
Used under acidic conditions



pie fillings, jams, syrups, pickles, relishes, olives, margarines, jellies, non-alcoholic beverages (found naturally in cranberries)

SODIUM PROPANOATE (PROPIONATE) $\leq 0.3\%$

$\text{CH}_3\text{CH}_2\text{COO}^- \text{Na}^+$ **Used under non-acidic conditions**
bread, chocolate, cheese, pie-crusts (found naturally in Swiss Cheese)

ACTION OF BOTH: coats cell walls, stop passage of nutrients in or out, microbe dies from starvation

BACTERIOSTATS (FUNGISTATS) Prevent the growth, don't kill

SORBIC ACID AND THE SORBATES



**used in breads, muffins,
cheese, paint, rubber,
fish products, carbonated drinks...**

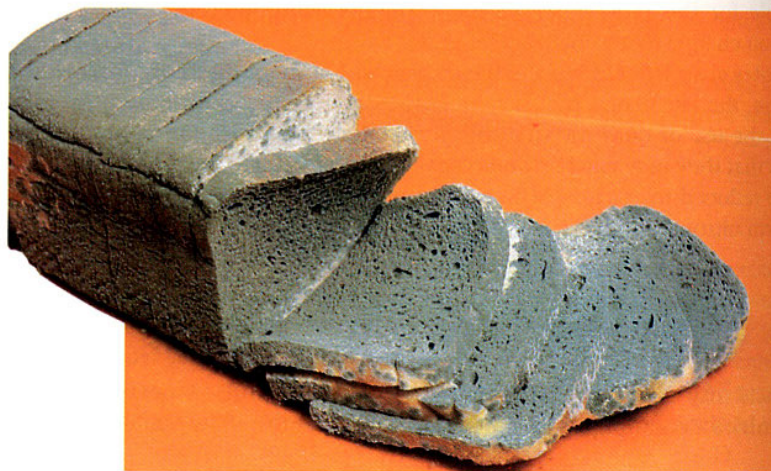
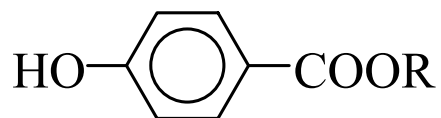
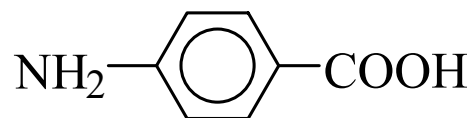


Figure 17-13 When sorbates are added to bread, molds grow much more slowly than when they are absent.

PARABENS are used more in Europe



R = methyl, propyl, ...
eg propylparabens



PABA

probably get incorporated in to Folic acid instead of PABA

very widely used in cosmetics: lipsticks, under-arm deodorants

PRESERVATIVES FOR MEATS:

NITRITES **sodium nitrite $\text{NaNO}_2 \leq 200$ ppm**
 LD_{50} 0.18 g/kg (> 20 g !! for me)

Used: in processed meats like wieners, bologna, salami...

NO_2^- inhibits botulinus bacteria: botulism toxin
and also reacts with myoglobin in meat to give a bright pink color

No nitrite, meat turns grey over time (no harm)
need about 10x amount for pink than for botulinus inhibition

Nitrates (NaNO_3) present in a wide variety of foods and water, also can produce NO_2^- in presence of reducing bacteria

Controversy:

In the stomach: HNO_2 forms, can react with amines (R_2NH) to produce **NITROSAMINES, $\text{R}_2\text{N-NO}$**

Nitrosamines are *highly* carcinogenic (to rats and other animals)

Is this a major risk? Probably NOT:

risk from botulism is much higher and food contains some nitrates naturally (lettuce, spinach, beetroot, celery ~1000 ppm; peas, beans, onions ~200 ppm and beer ~25 mg per beer)

Average daily intake ~100 mg of nitrates, which on reduction gives **~5 $\mu\text{g/mL}$ of nitrite** in saliva and about 5 mg of nitrite in the gut!

FRUITS SO_2 (sulfur dioxide) gas OR sulphite salts

Used: in dried fruits, wines, syrups, jellies, dehydrated potatoes
acts both as a bleach and to kill bacteria

IRRADIATION

^{60}Co γ -emitter: produce hydroxyl free radicals that kill most micro-organisms and inhibit many enzymes, prevent sprouting and ripening

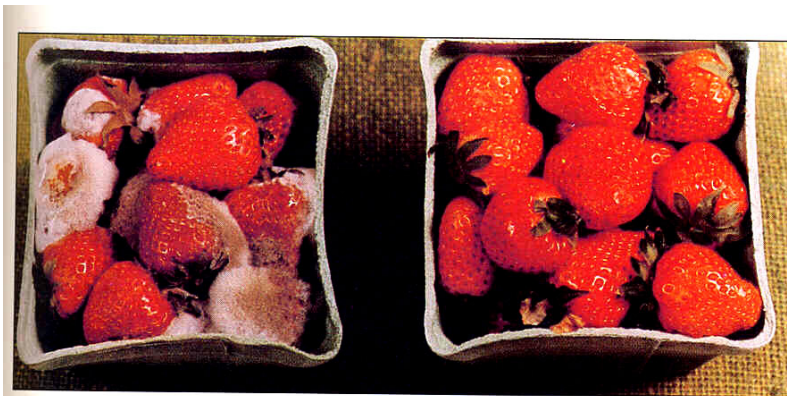
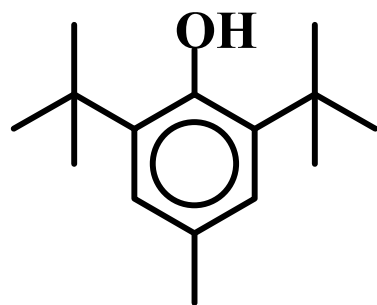


Figure 7-15 Strawberries irradiated with gamma rays from radioactive isotopes are still fresh after 15 days storage at 4° C (right). Strawberries stored under the same conditions but not irradiated are molded (left). (International Atomic Energy Agency)

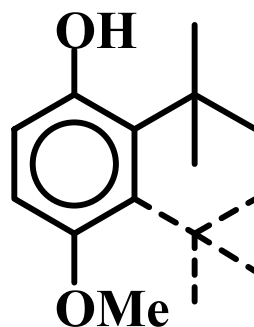


C. Bohne/D. Berg Copyright 2011-19 – For use in the Uvic Chem 400 course only – Spring 2019

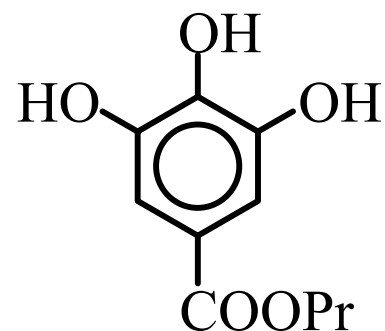
ANTI-OXIDANTS: many are phenols



BHT



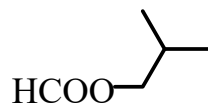
BHA



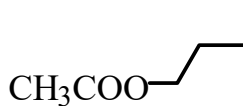
propyl gallate

used in foods containing oils and fats, up to 0.02%
(egs. Chips, cereals, breads)

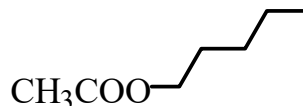
FLAVOURS: FRUITY are all esters, *same* as natural ones



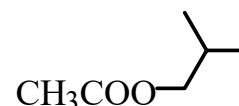
raspberries



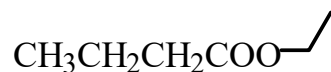
pears



bananas



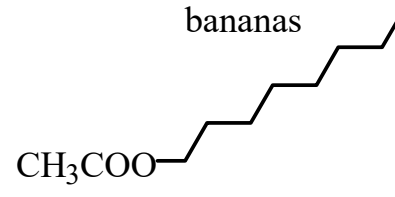
bananas



pineapples



apricots



oranges



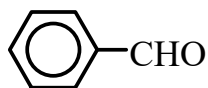
strawberries



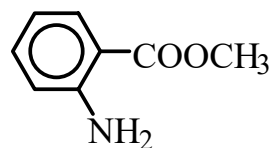
rum



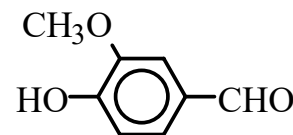
rum



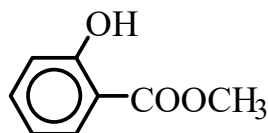
almonds,
marishino cherries



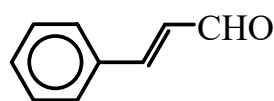
grape



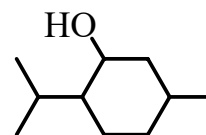
vanilla



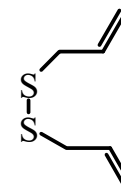
wintergreen



cinnamon



menthol

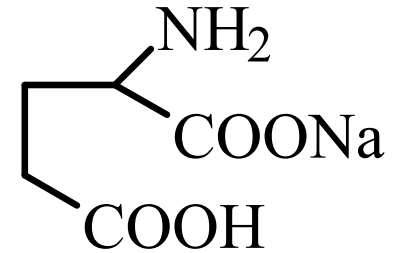


garlic

FLAVOUR ENHANCERS

Potentiators: no taste but enhance the flavour of others

MSG Monosodium glutamate (0.2-0.9%)

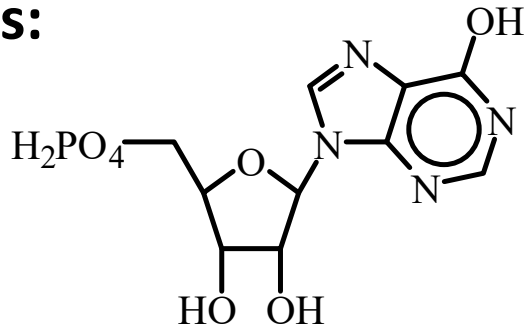


Sodium salt of the natural amino acid

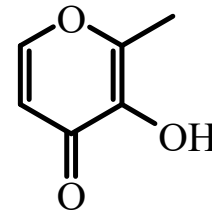
from fermenting sugar beet molasses:

used in meats, veg products, soya sauce, oriental food

Other options:



**inosinic acid,
used as sodium salt**

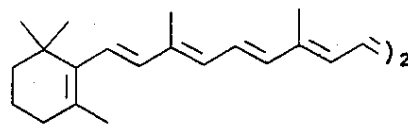


maltol (from pine needles)

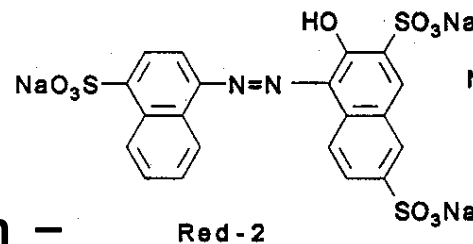
COLORS

FD&C (Food, drugs and cosmetics) approved
purely for show: ~ 30 approved as list shrinks

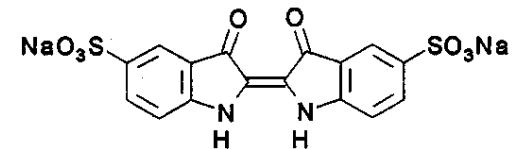
300A50 COLOURS



Orange-Yellow
 β -carotene



Red-2



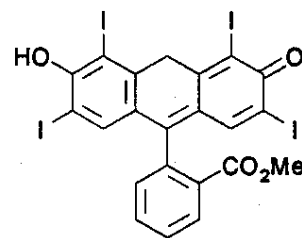
Blue-2

highly conjugated :

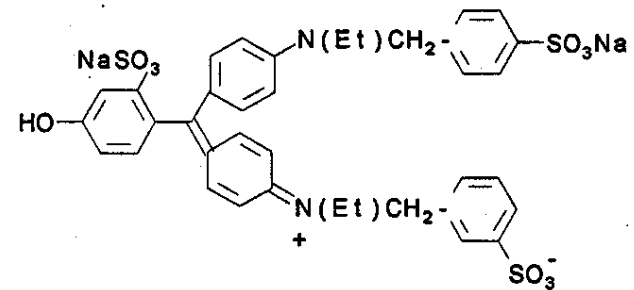
absorb visible light 400-700 nm –

we see the complimentary color

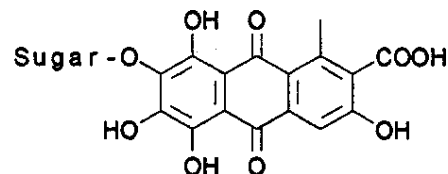
eg. β -carotene absorbs blue-violet so we see orange-red



Fluorescent Red-3



Fluorescent Green-3



COCHINEAL

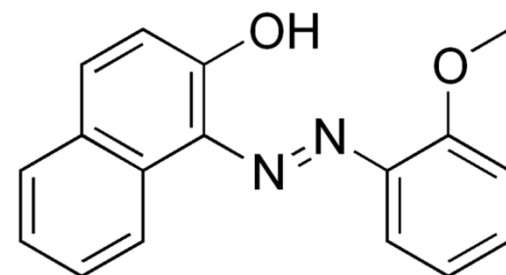
carminic acid

Al-salt = carmine

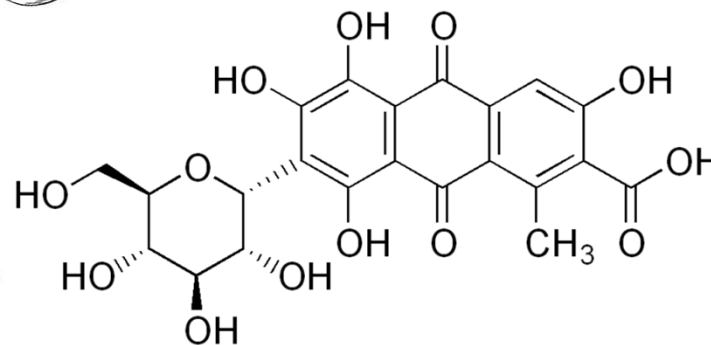
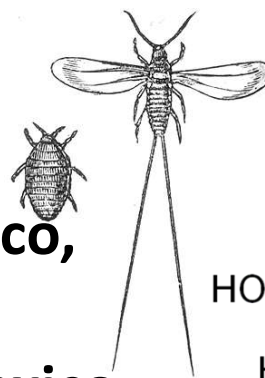
Older coal tar dyes modified with water solubilizing groups:
 SO_3^- , COO^- or OH so that dye is excreted *without* metabolizing

Fat soluble dyes have been eliminated (carcinogenic):
egs. butter yellow, yellows 3&4, orange 1, reds 2&4, violet 1

Sudan Red G (an azo dye)
caused a large food recall in UK in 2005:
No longer used - carcinogenic



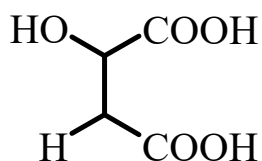
Cochineal (Carminic acid)
from dried scale insects of Mexico,
Peru and the Canary Islands:
highly valued dye in colonial Mexico;
farmed in Australia



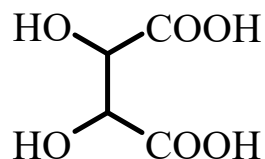
ADDITIVES TO CONTROL ACIDITY

Fruit acids: citric, tartaric, malic and lactic acid used in fruit drinks

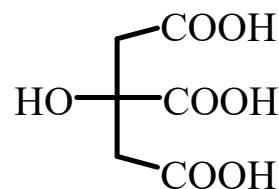
Phosphoric acid (H_3PO_4) is used in 'cola' type drinks



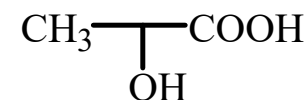
malic acid
(apples)



tartaric acid
(grapes)



citric acid
(lemons)



lactic acid
(milk)

In candy manufacture, acid converts sucrose to softer invert sugar:

LOW ACID gives hard (crystalline) candies

HIGH ACID gives softer, chewy (less crystalline) candies

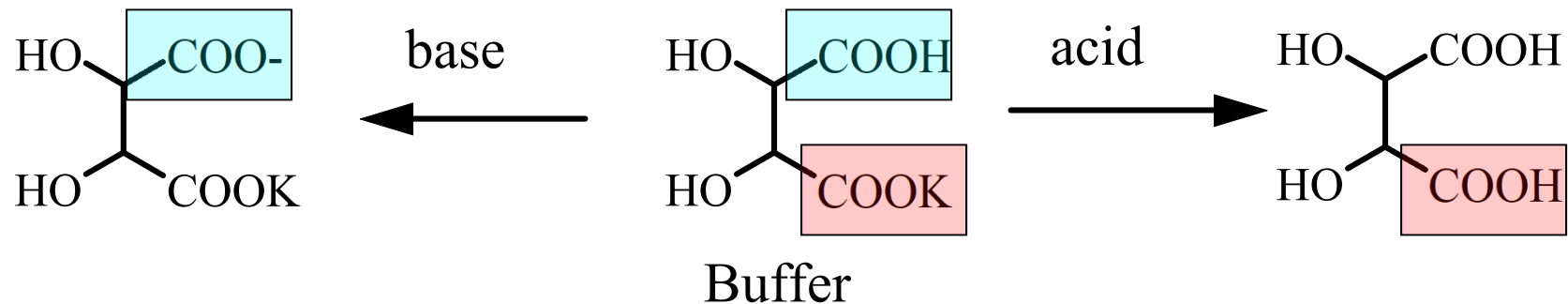


'Invert sugar' = hydrolysis of sucrose to glucose and fructose

BUFFERS

usually sodium or potassium salts of di or tri-acids

eg. **potassium acid tartrate**:



ANTI-CAKING AGENTS: prevent moisture from forming lumps

1% **magnesium silicate** in salt

sodium aluminosilicate in non-dairy creamer

silicon dioxide (silica) in soups

How to measure components of foods – analytical chemistry

Indicator displacement assay

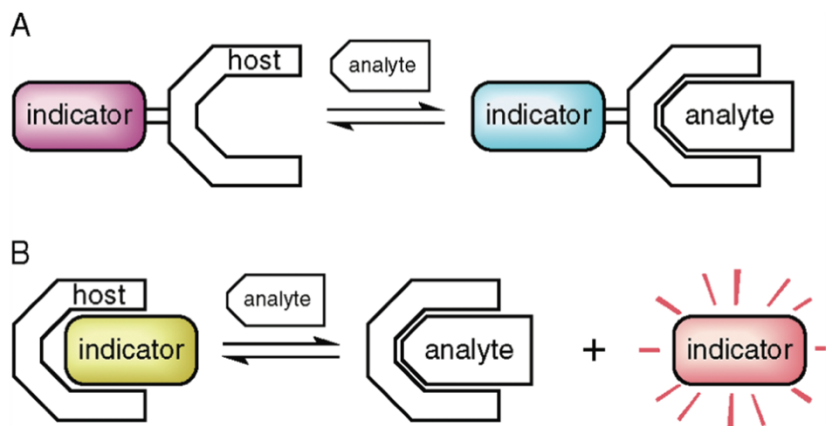


Figure 1. Traditional chemosensing assay (A) and indicator displacement assay (B).

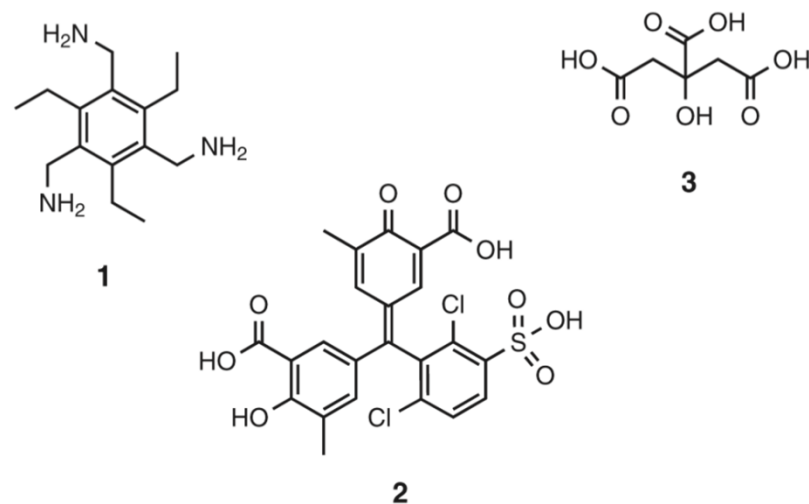


Figure 2. Neutral structures of **1**, **2**, and **3**.

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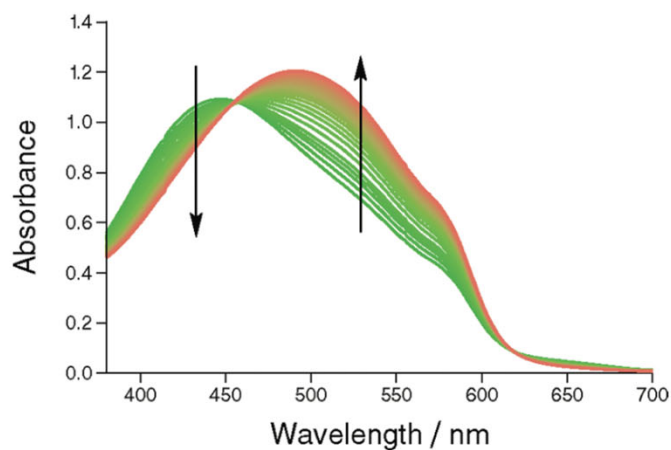


Figure 3. Student data from the spectrophotometric titration with standard citric acid. The absorbance maximum of the indicator, **2**, is shifted when it is displaced from the binding cavity of the host, **1**, by citric acid, **3**.

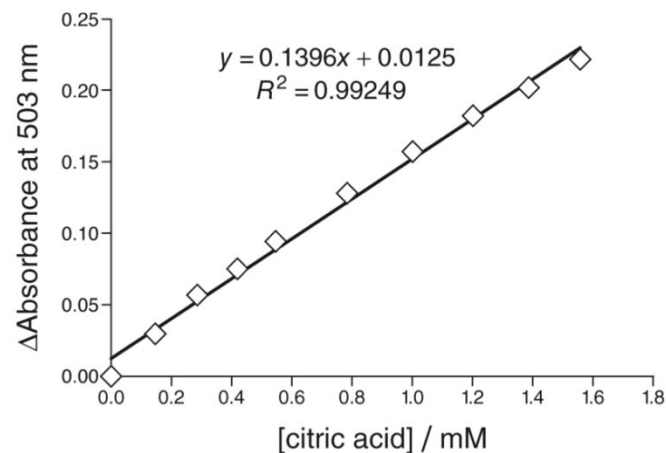


Figure 4. Calibration curve obtained from the spectra in Figure 3.

Table 3. Students' Citric Acid Concentrations of Commercially Available Beverages

beverage	av concn of citric acid/mM
Pepsi (control)	-0.559 ± 0.150
Sprite	6.33 ± 0.67
Mountain Dew	8.53 ± 1.00
HEB brand lemon-flavored water	12.8 ± 1.5
HEB brand orange-flavored water	11.7 ± 0.5

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