

Concepts of Biology: BIOL 310

Study guide for Exam 3

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Lectures 20–28

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Outline

1 Fruits and vegetables

1.1 Introduction

Fruits—and vegetables

- The main “common sense” difference is the low amounts of sugars in vegetables, plus tree origin of fruits
- However, there are multiple exceptions: beet, avocado, plantains etc.
- In addition, pumpkins and relatives (melon, watermelon, squashes) normally treated as separate group
- Morphologically, fruits are fruits (and sometimes seeds like litchi or pomegranate, or riped inflorescences like pineapple or fig), and vegetables are everything else

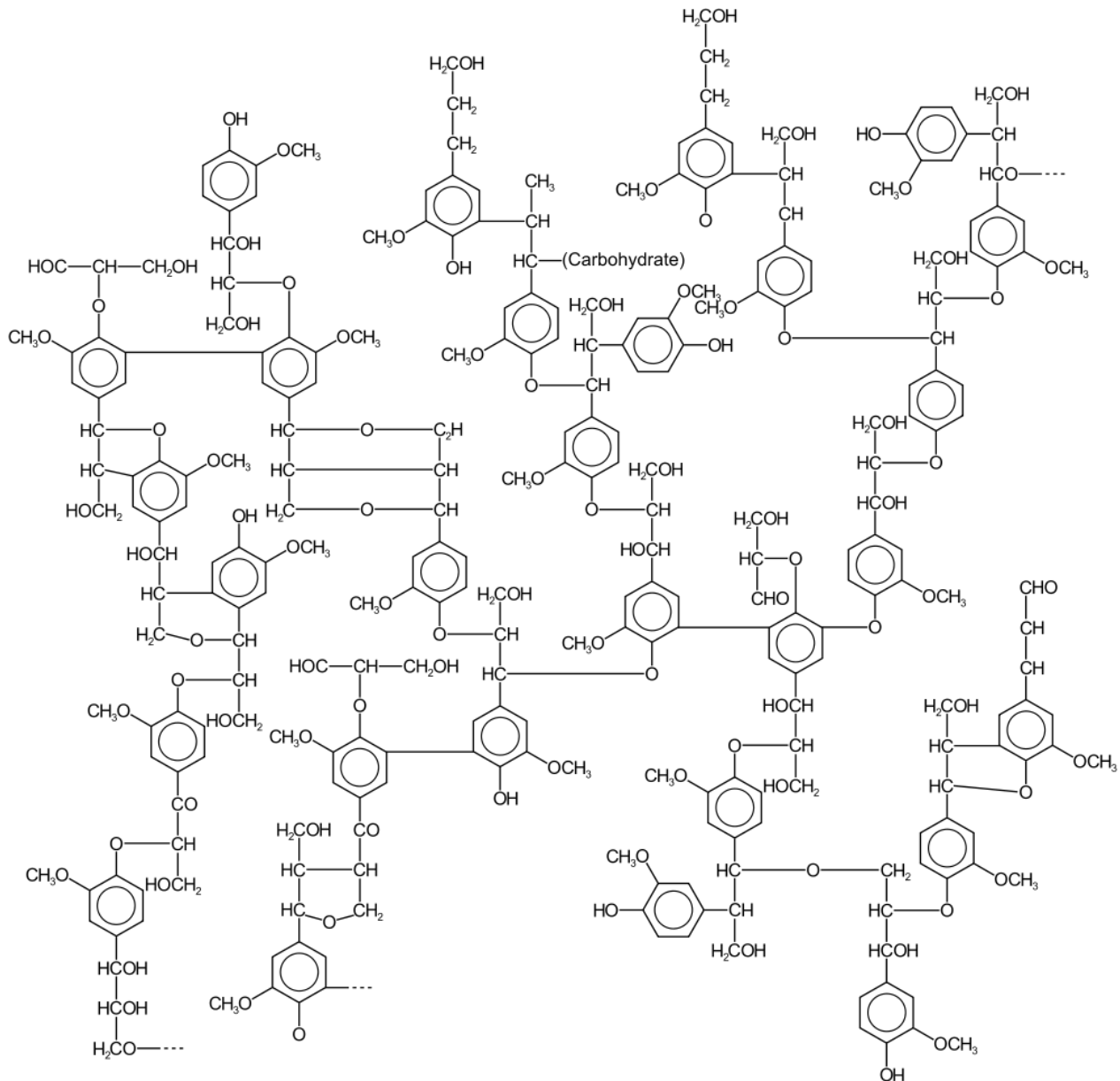
Main components of fruits

- Water
- Dietary fiber
- Sugars
- Organic acids
- Vitamins

Dietary fiber

- Polysaccharides
- Lignin
- Other constituents of plant cell walls (glycoproteins etc.)
- Improve intestinal transit, lowering the risk of colorectal cancer

Lignin



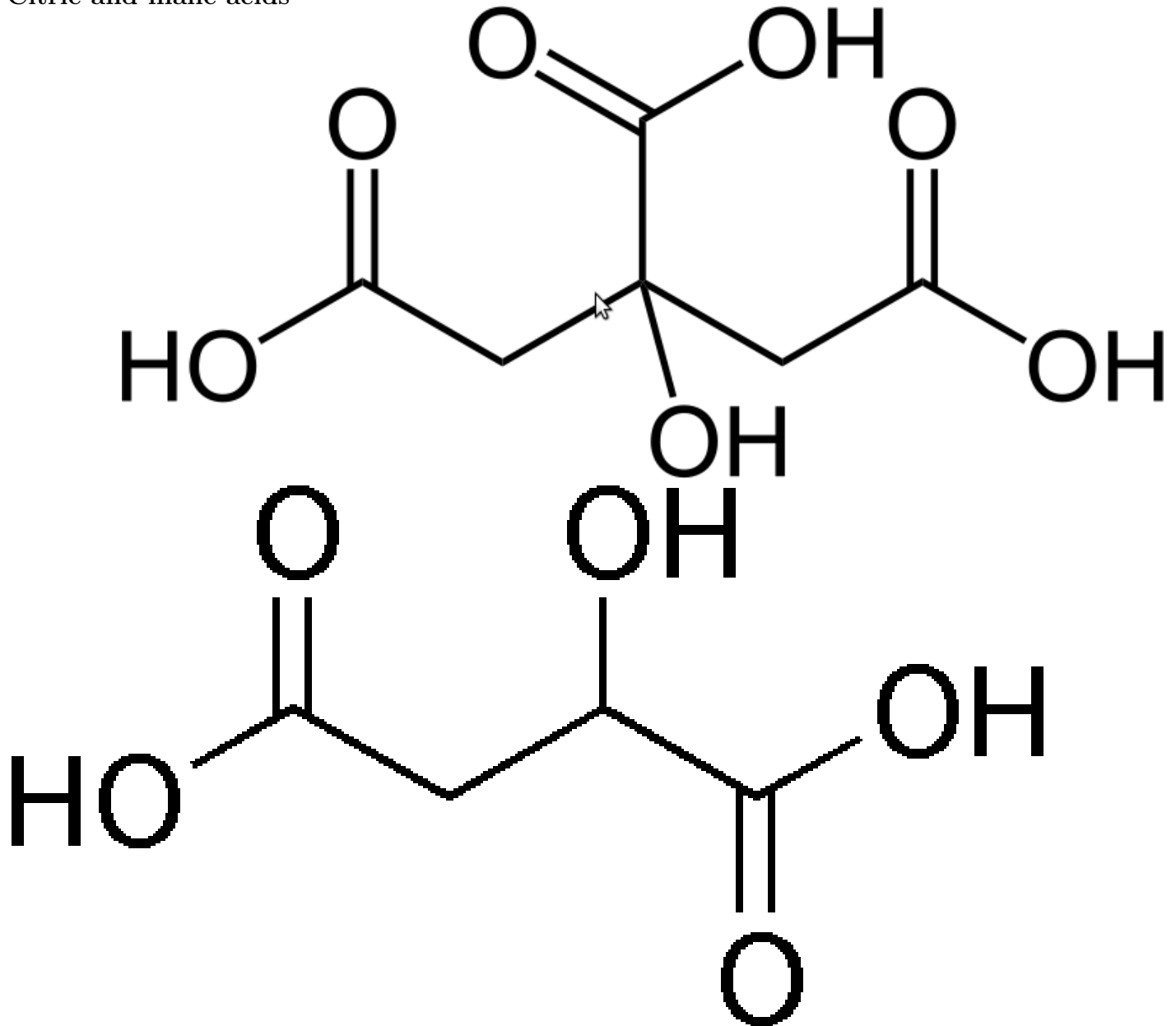
Fruit sugars

- Mostly fructose and its derivatives (kestoses)
- Sweeter 1.7 times more than sucrose, but only at room temperature

Organic acids

- Malic (*Pyrus malus*, apple and other Rosaceae fruits)
- Citric (*Citrus* fruits etc.)
- Tartaric (e.g., in wine)
- Are good antioxidants

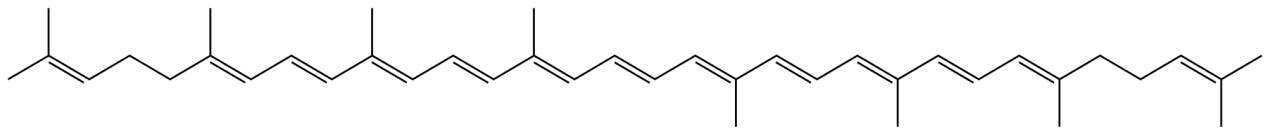
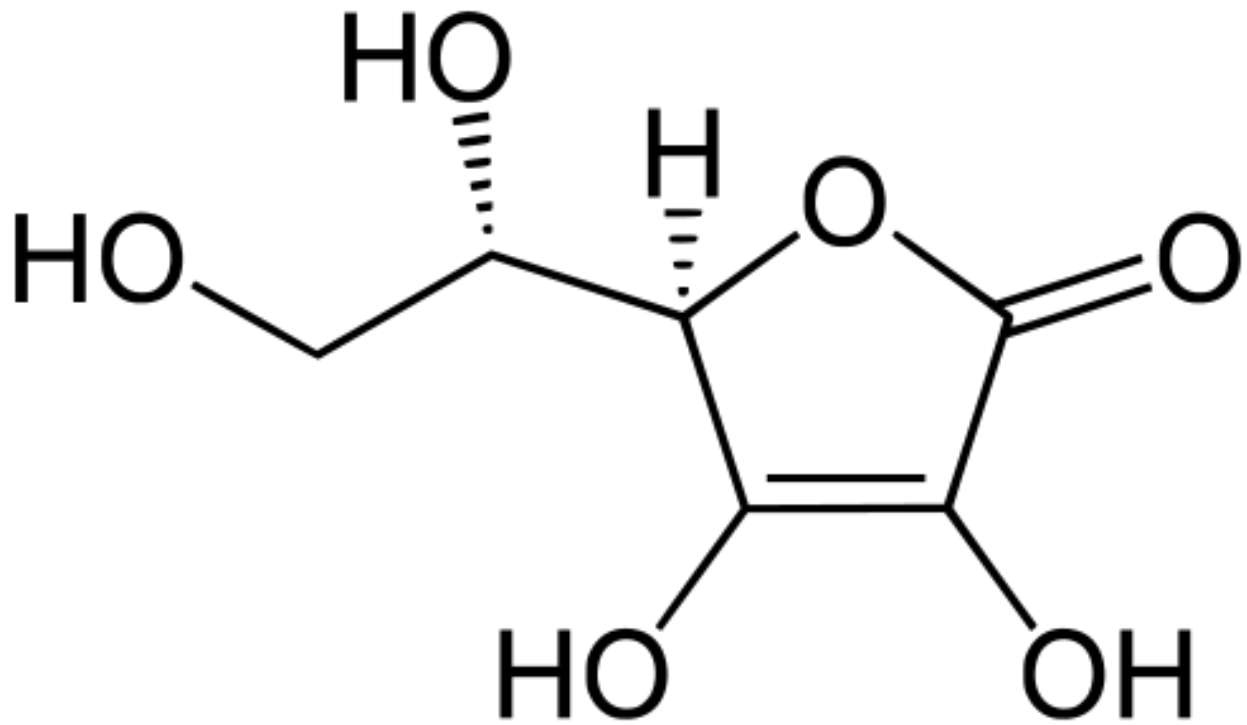
Citric and malic acids



Fruit vitamins

- Vitamin C (ascorbic acid)
- Pro-vitamin A (β -carotene)
- Other carotenes (lycopene etc.)

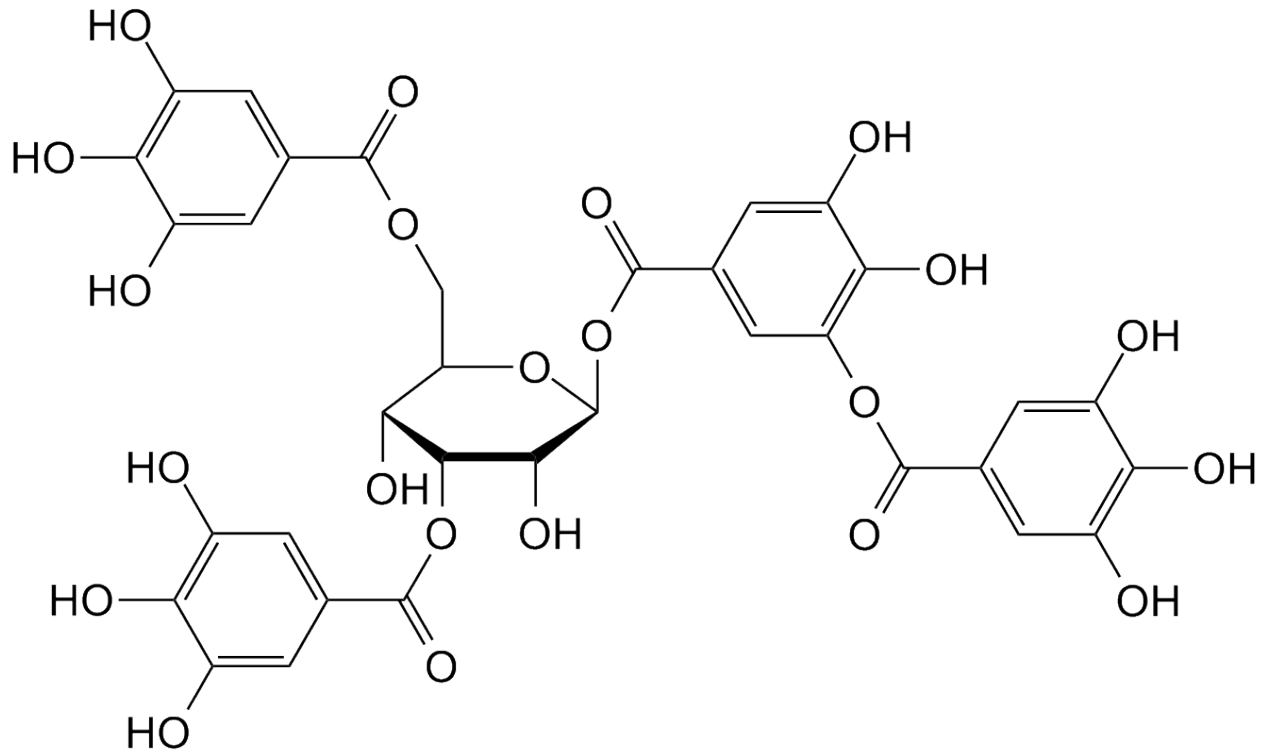
Ascorbic acid and lycopene



Specific components which are restricted to few species

- Lipids
- Starch
- Gums, mucilages, pectins
- Astringent chemicals (e.g., tannic acid)
- Aroma compounds
- Other secondary* metabolites (latex, alkaloids, glycosides)

Tannic acid



2 Rosaceae fruits

2.1 Rosaceae fruits in general

Rosaceae in general

- Medium-sized family ($\approx 3,000$ species) of small trees, shrubs and herbs from subtropical and temperate regions
- Flower contains numerous stamens (secondary multiplied), free pistils and hypanthium
- Fruit is mostly fleshy

Rosaceae groups

- Rosoideae—herbs or shrubs, leaves often compound, receptacle large, fruit aggregate
- Spiraeoideae—shrubs or trees, leaves simple, receptacle small, fruit often monomerous
- Maloideae—trees, leaves simple, receptacle and pistils fused

2.2 Rosaceae with multiple fruits

Rosaceae with multiple (aggregate) fruits

- Most primitive group
- Tangled genetic systems: apomixis, polyploidy and permanent odd pentaploidy ($2n = 35$ in *Rosa canina*)

- *Rosa* is ornamental and medicine plant with
- *Rubus* and *Fragaria* are also widely cultivated

Rubus

- Biennial semi-shrubs, sometimes herbs
- Multiple wild species, only two are widely cultivated: raspberry (*Rubus idaeus*) and blackberry, *Rubus caesius* forms and hybrids

Rubus idaeus from Koehler's "Medizinal Pflanzen"



Rubus features

- Two aboveground stem types: primocane and floricanes, plus underground rhizomes
- Fruits contain (among other) salicylic acid and different antioxidants

Blackberries on the different stages of ripening



Fragaria × *ananassa*, strawberry

- Octoploid ($2n = 56$) hybrid species of two other octoploid strawberries, *Fragaria virginiana* from North America and *F. chiloensis* from Chile.
- Garden hybrid, first occurrences are in France from ≈ 1740
- Herb with runner stems and accessory multiple nut fruit (the edible part is a receptacle)

Strawberry features

- Susceptible to multiple diseases, often cultivated in semi-artificial conditions as plasticulture
- Cultivated as annual or perennial
- Long-day cultivars flower early in May and capable to produce fruits in June

Plasticulture of strawberries



Rubus chamaemorus, cloudberry

- One of the northernmost berry plants
- Semi-shrub; the only dioecious *Rubus*
- Food of many Arctic mammals and birds, e.g. reindeer
- When ripe (yellow), have a creamy texture and tart taste
- Contains benzoic acid content acting as a natural preservative:: stays all winter without additional preparations
- Rich of vitamin C: used against scurvy

Rubus chamaemorus



Roses as food plants

- Roses (*Rosa* spp. including North Dakota state flower, *Rosa arkansana*) are edible plants.
- Hypanthium is rich of vitamins, especially vitamin C. Typically, accessibility of vitamins from fruits are higher than from synthetic products.

2.3 Rosaceae with stone fruits

Rosaceae with stone fruits, *Prunus*

- Multiple (≈ 430) species often separated in different genera on the base of fruit morphology
- Often hairy exocarp, juicy mesocarp and stone endocarp
- Distributed almost equally among Eurasia and North America
- Flower before appearance of leaves, inflorescences are umbels

Prunus avium, cherry

- Mediterranean tree, cultivated from Roman times
- Used also as timber and ornamental plant
- All parts except “berries” (drupes) contain cyanogenic glycosides
- Sweet/early and sour/late groups of cultivars.

Prunus



Cherry



Other cherries

- Black cherry (*Prunus serotina*) and choke cherry (*Prunus virginiana*) are two frequently cultivated North American species
- Choke cherry is a state fruit of North Dakota
- It is also a hosts of tent caterpillar, *Malacosoma* sp.

Choke cherry



“Nest” of tent caterpillars



***Prunus armeniaca*, apricot**

- Old culture of Central Asian origin, later spread into China and Europe
- Dry fruits were traditionally used as sugar source (along with melon)
- Fruits contain oil of cooking quality
- Biggest producer is Turkey

Drying apricots in Cappadocia, Turkey



***Prunus* × *domestica*, plum**

- Hybrid hexaploid ($2n = 48$) species, originated from cherry plum *Prunus divaricata* ($2n = 16$) and blackthorn *P. spinosa* ($2n = 32$)
- Probably of Caucasian origin, contemporary cultivars are even more complicated hybrids
- Well-known laxative fruit
- Chinese “plum” is a separate species, *Prunus mume*—kind of intermediate between apricot and plum

Plums



Blackthorn



Cherry plum



Chinese plum drawing



Prunus mume



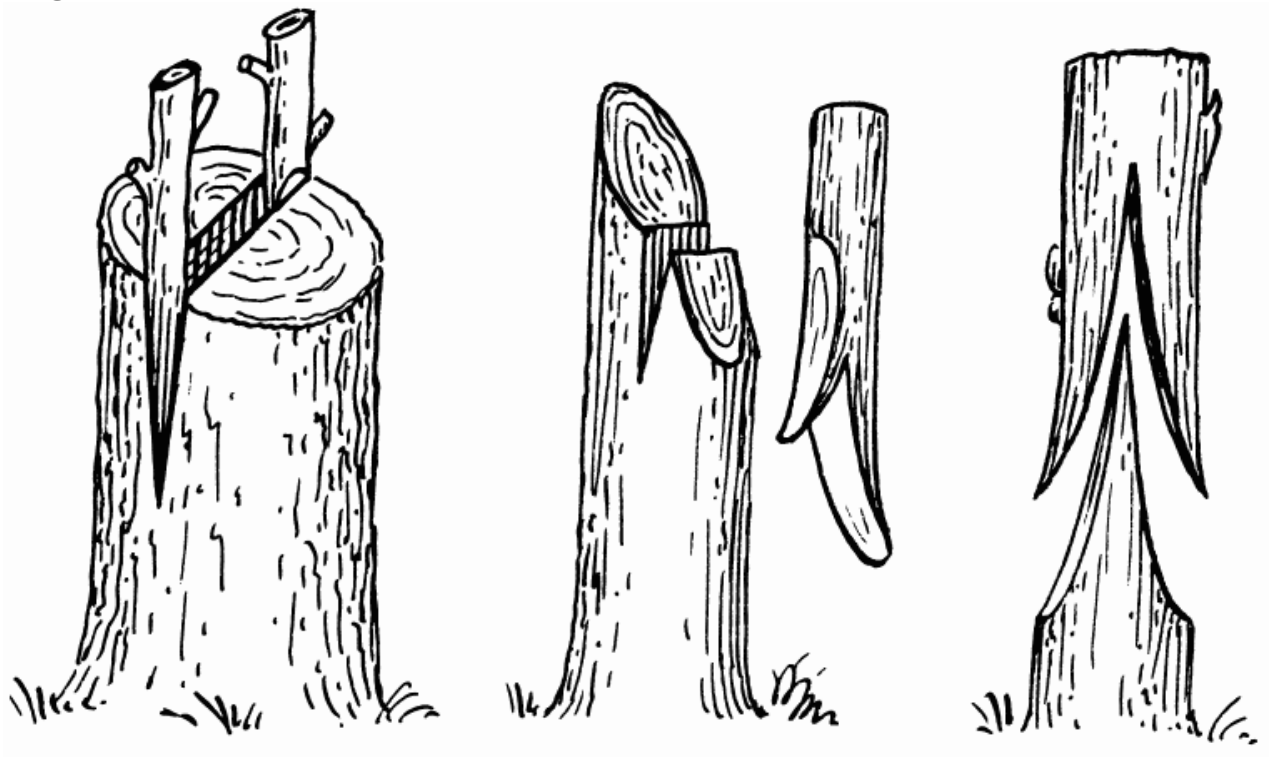
Prunus persica, peach

- Tree of Chinese origin, cultivated from 1,100 BC and spread to Europe with Alexander the Great army
- Multiple cultivars including nectarines (result of bud sport mutation) and Chinese flat peaches
- Propagated mostly by grafting on adequate rootstocks (many other *Prunus* species)
- China is still a biggest producer

Chinese flat peach



Grafting



2.4 Rosaceae with pome fruits

Pome fruits

- Result of fusion between hypanthium and pistils
- The edible part is a hypanthium wall

Pyrus malus, apple

- Sometimes treated as separate genus *Malus*, in this case species has a name *Malus domestica*
- Eurasian origin, common forest plant in Europe
- Eastern Turkey is the center of species diversity

Malus



Apple features and history

- Old culture, cultivation started in pre-Roman times
- Brought to North America in 1625 (first apple tree near Boston)
- Massive mythological background
- Temperate culture; in tropics, leaves should be removed if flowering required on next year
- Biggest producers are China, U.S. and Iran

Apple pollination



Pyrus communis, pear

- Some branches transform to thorns
- Chinese origin, cultivation started there before 1,000 BC
- Went to Europe in ancient Greek times
- *Pyrus pyrifolia* is a close species—Asian pear

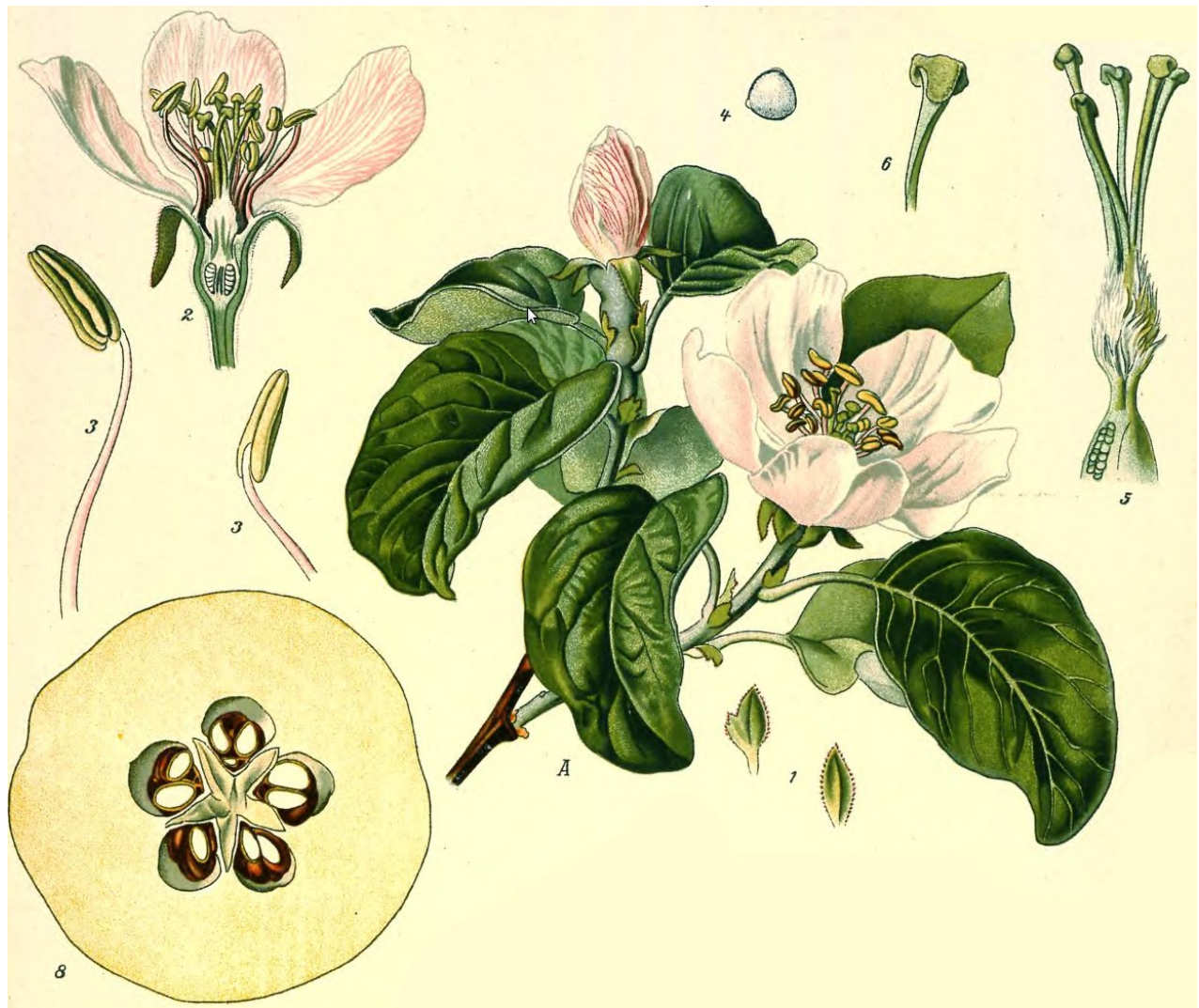
Asian pear, *Pyrus pyrifolia*



Cydonia oblonga, quince

- Caucasian origin, spread to the cultivation in Balkans
- Rich of microelements
- Used mostly for jams and jellies

Cydonia



Quince flowers



Quince fruits



Chaenomeles japonica and hybrids, Japanese Quince

- East Asian deciduous spiny shrubs, usually small
- Red flowers and relatively big, hard fruits
- Fruits are edible after frost (“bletted”)
- Have more vitamin C than lemons (up to 150 mg/100 g)

Japanese Quince, *Chaenomeles*



Mespilus germanica, medlar

- Caucasian hardy culture
- Contains significant amounts of pectins, used for jams and jellies

Medlar fruits



Eriobotrya japonica, loquat

- Evergreen tree from central China
- Flowering in November, has fruits in April and May
- Cultivated also as ornamental plant

Loquat flowers



Loquat fruits



***Aronia* spp., chokeberries**

- North American genus with 2–3 species, grows well in North Dakota
- Fruits are rich of antioxidants
- Used also as ornamental
- In Russia, cultivated hybrid (origin is still unclear, but probably with European common whitebeam, *Sorbus aria*) *Aronia* × *mitchurinii* is one of the northernmost fruit plants

Aronia* × *mitchurinii



Amelanchier spp., serviceberry, juneberry

- North American genus with ≈ 20 species, some are cultivating
- Fruits are rich of vitamins (A, C and even E) and minerals
- Grows well on poor soils and dry conditions, recommended for prairie cultivation

Serviceberry



***Sorbus* spp., mountain ash**

- Large (up to 200 species) genus occurred in North America and Eurasia
- Most species have edible fruits
- European rowan (*Sorbus aucuparia*), and common whitebeam (*Sorbus aria*) are main cultivated species (also as ornamentals)
- Fruits are mostly used for wines, jams and jellies; bitter taste is normally gone after first frosts

European rowan, *Sorbus aucuparia*



Common whitebeam, *Sorbus aria*



Crataegus spp., hawthorn

- More than 200 species of shrubs and small trees from Eurasia and North America
- Many species are cultivated for their fruits and also as ornamentals, for aroma compounds and/or as tea surrogate
- Used in multiple traditional medicine practices, one proven use is treating chronic heart diseases

Hawthorn fruits



Summary

- The main “common sense” difference of vegetables is the low amounts of sugars, most vegetables are also herbs
- Most of fruits are sources of water, sugars, organic acids and plant vitamins
- Rosaceae is one of the most important temperate fruit families
- Most of Rosaceae cultivated fruits are result of long selection involved multiple hybridization
- Most of Rosaceae cultivated fruits are propagated by grafting on appropriate rootstocks

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310
- [2] P. M. Zhukovskij. *Cultivated plants and their wild relatives* [Electronic resource]. Commonwealth Agricultural Bureaux, 1962. Abridged translation from Russian. Mode of access: http://ashipunov.info/shipunov/school/biol_310/zhukovskij1962_cultivated_plants.djvu.

Outline

3 Fruits and vegetables

3.1 Citrus and related genera

Citrus and related genera

- Belong to Rutaceae, ruta family, often treated as separate subfamily, Aurantioideae
- East Asian and/or Indonesian origin
- Have specific **hesperidium** fruit with flavedo exocarp, albedo mesocarp and membrane endocarp covered with juicy hairs

Trifoliate, *Poncirus*

- Spiny, hardy citrus, with compound leaves, growing even in warm temperate regions
- Used as a rootstock for grafting other species
- Fruits are bitter but contain vitamins and microelements

Poncirus trifoliata



Orange, *Citrus sinensis*

- All *Citrus* have unifoliate leaves but with a strip between petiole and leaf blade (remained from compound leaf)
- Chinese origin, before the Age of Discovery was known in Europe mostly as a legend about “golden apples”
- Mostly subtropical (not tropical) culture
- Also used as a rootstock for other species (e.g., grapefruit)

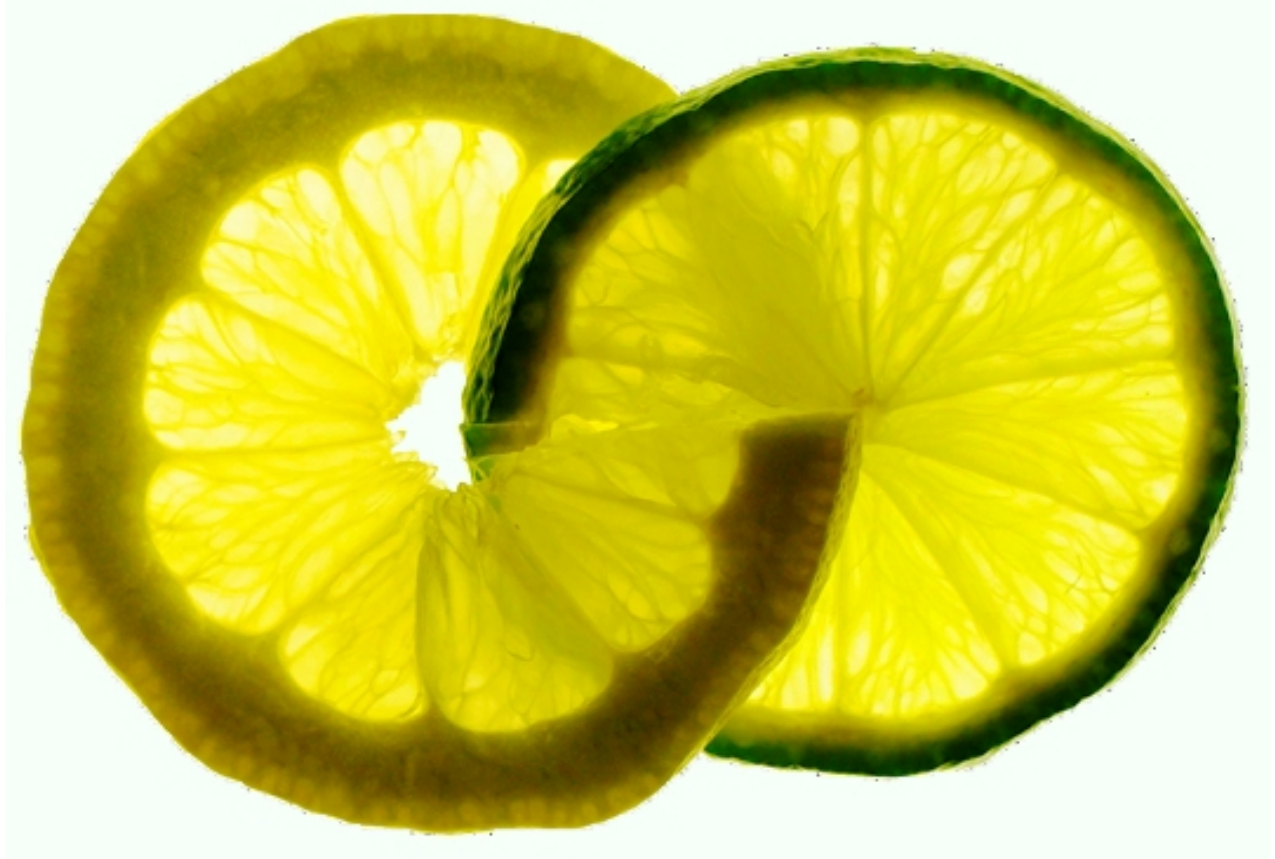
Lemon, *Citrus limon*

- Relatively big (4–6 m) spiny trees
- Flowers continuously
- Sour citrus, fruits contain up to 8% of lemon acid
- Introduced to Europe in 1000s
- There are cultivars for home growth

Lime, *Citrus aurantifolia*

- Pure tropical culture, damaged even with small frost
- Originated from Malaysia, but culture started in Caribbean
- Flavedo is green and thin; aroma compounds different from lemon

Lemon and lime



Mandarin, *Citrus reticulata*

- Extremely variable species, with multiple cultivars and hybrids
- Multiple names: tangerine, clementine, satsuma, unshiu
- Small trees or even shrubs with big leaves, some forms (unshiu) are hardy; all require humid climate

Mandarin



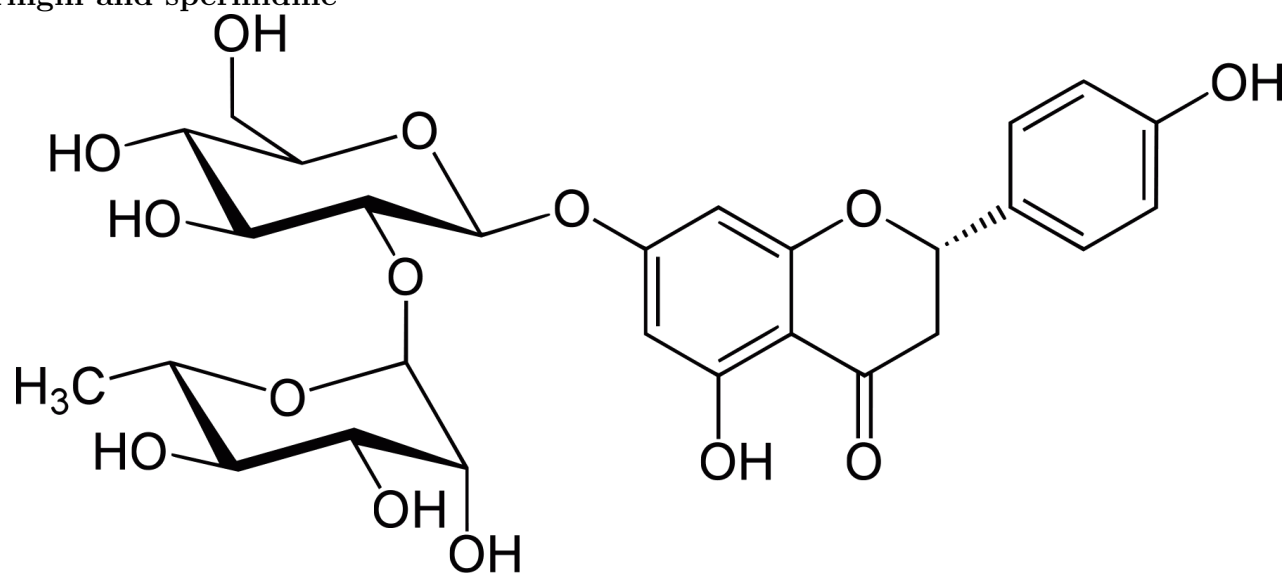
Grapefruit, *Citrus ×paradisi*

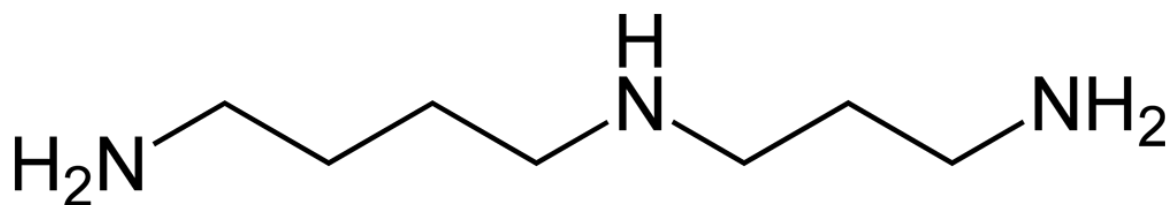
- Originated in 1750 in Barbados, most probably as a unique (!) hybrid between orange and pomelo (*Citrus maxima*)
- Cultivated mostly in USA and Caribbean countries
- Big tree, fruits larger than orange, with bitter taste due to **naringin**, the glycoside with digestive, tonic and anti-atherosclerotic effects
- Also contains significant amounts of vitamins B and polyamine spermidin (which is known to increase lifespan of different laboratory animals)

Grapefruit



Naringin and spermidine





Pomelo, *Citrus maxima*

- Pomelo, shaddock (by name of captain Shaddock who brought it to Caribbean) is widely cultivated in Thailand and neighboring countries
- Largest citrus (up to 15 m), fruits also large, up to 3 kg, contain naringin
- Tropical culture, may be cultivated even on seashores

Pomelo



Bitter orange, bergamot orange, *Citrus aurantium*

- Used mostly as a source of strong aroma compounds
- Also known as appetite suppressant

- Component of different liquors and Earl Gray tea

Bitter orange



Citron, *Citrus medica*

- Have large but somewhat bitter fruits
- Flavedo is thick, used raw and for candies
- Historically, was first citrus cultivated in Europe
- Famous “Buddha’s hand” is *Citrus medica* var. *sarcodactylis*

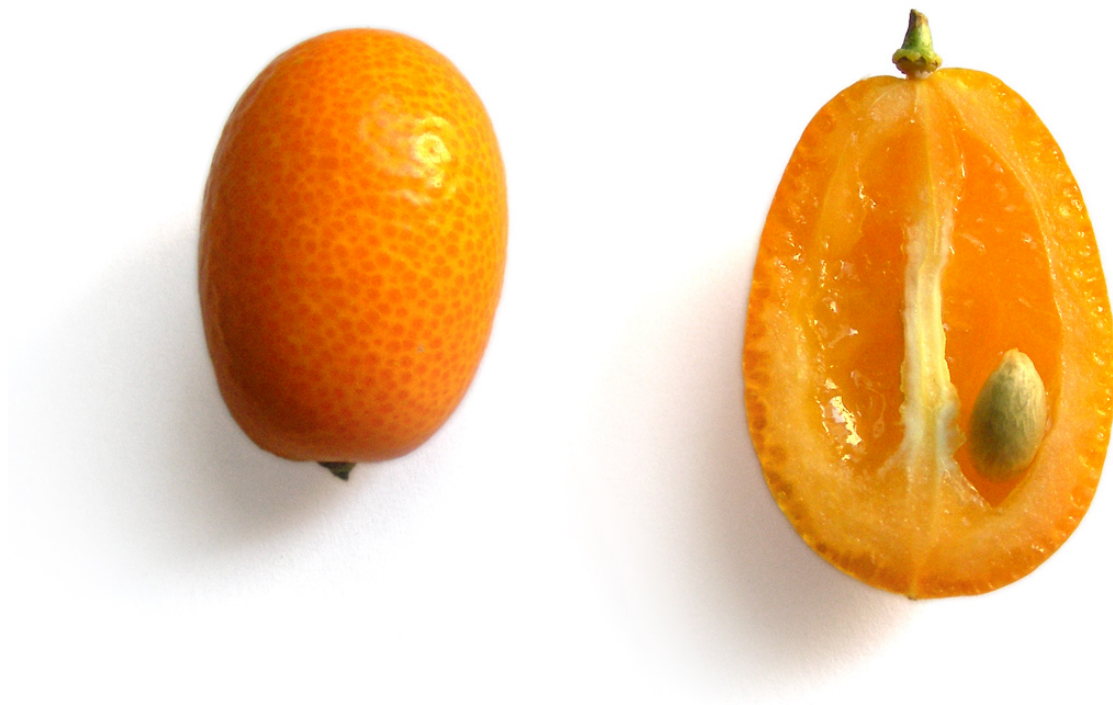
“Buddha’s hand” citron



Kumquat, *Fortunella* spp.

- Small evergreen trees from other genus (*Fortunella*) and 4 cultivated species, all from East Asia
- Sour fruit with sweet skin
- Widely hybridize with other citrus species

Kumquat



3.2 Important tropical fruits

Banana, *Musa acuminata*

- Belongs to Musaceae family of monocots
- Genus contains 11–13 species, all tropical
- Cultivated forms are seedless triploids with AAB genome, where “A” is a wild *Musa acuminata*, and “B” is *M. balbisiana*
- Fruits are rich of carbohydrates, vitamins of B group, iron and potassium

Wild diploid banana with seeds



Banana biology

- Perennial herbaceous (!) plant with large underground rhizome
- Rhizome produce groups of leaves with connected petioles (pseudo-stem)
- Inflorescence will grow through pseudo-stem and produce up to 3,000 flowers, male and female
- Wild forms are often bird-pollinated, cultivated forms are parthenocarpic

Banana corms



Banana flowers



Banana agriculture

- Propagated with slices of rhizome (corms)
- Initial growth of pseudo-stem is 5–6 months, then fruits appear after 2–3 month
- Critical to humidity (must be high) and soil richness (planted often on burnt forest plantations)

Banana plantation



Banana history

- Probably originated in southeast Asia and then distributed across the world before age of exploration
- Two main cultivar groups selected: fruit bananas and plantains (vegetable, starch-containing bananas)
- Biggest producers are India, Philippines and China

Pineapple, *Ananas comosa*

- The only fruit from Bromeliaceae family
- Herbaceous plant
- “Fruit” is a ripened inflorescence (infructescence, pseudocarp)

Pineapple biology

- Perennial herb with rigid, spiny, succulent leaves
- Leaf rosette serves as reservoir for water
- Inflorescence is a dense spike, where all flowers are fused

Pineapple flower



Pineapple agriculture

- Needs semi-dry tropical climate and lots of fertilizers
- Flowering is normally being induced by sodium acetylide and water reaction, resulted ethyne acts as a flower-stimulated hormone
- Harvesting is dangerous due to presence of protein-digesting enzyme bromelain

Pineapple field



Pineapple history

- Pineapples are extremely rich of sugars, vitamin C and essential mineral manganese (Mn)
- Originated in South America, probably near contemporary Paraguay, wild relatives are unknown
- Cultivated in greenhouses in XVIII-XIX centuries, burning dung was typically used as a source of ethyne
- Thailand and Brazil are biggest producers now

Summary

- *Citrus* is a group of genera with no wild species; different species and even genera can hybridize almost freely
- Banana is a giant perennial herbaceous plant with no true aboveground stem
- Multiple tropical fruits are mostly sources of vitamin C
- Many traditional Asian fruit cultures have also a medicinal value

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310

Outline

4 Fruits and vegetables

4.1 Important tropical fruits

Mango, *Mangifera indica*

- Evergreen massive tree from sumac (Anacardiaceae) family. Cultivated in most tropical countries, especially in Africa and South Asia.
- Low fertilization rate, from hundreds of flowers only few produce fruits
- Plant of monsoon climate: requires both dry and humid season
- Manual planting, pruning, harvesting but may give fruits for 300 years
- Rich of vitamin C, A and antioxidants; known to prevent colon cancer

Mango flowers



Papaya, *Carica papaya*

- *Belongs to small family Caricaceae (close to Cruciferae)*
- *One of the most widely cultivated tropical plants*

Papaya biology

- *Fast growing, palm-like tree with short lifespan (< 20 years)*
- *Flowers of three kinds: male, female and hermaphroditic, there are ≈ 50 sexual forms*
- *Fruits contain seeds rich of mustard oils (like in cabbage family); fruits themselves are rich of starch, sugars, vitamin A and lycopene, and also of papain, peptidase enzyme*

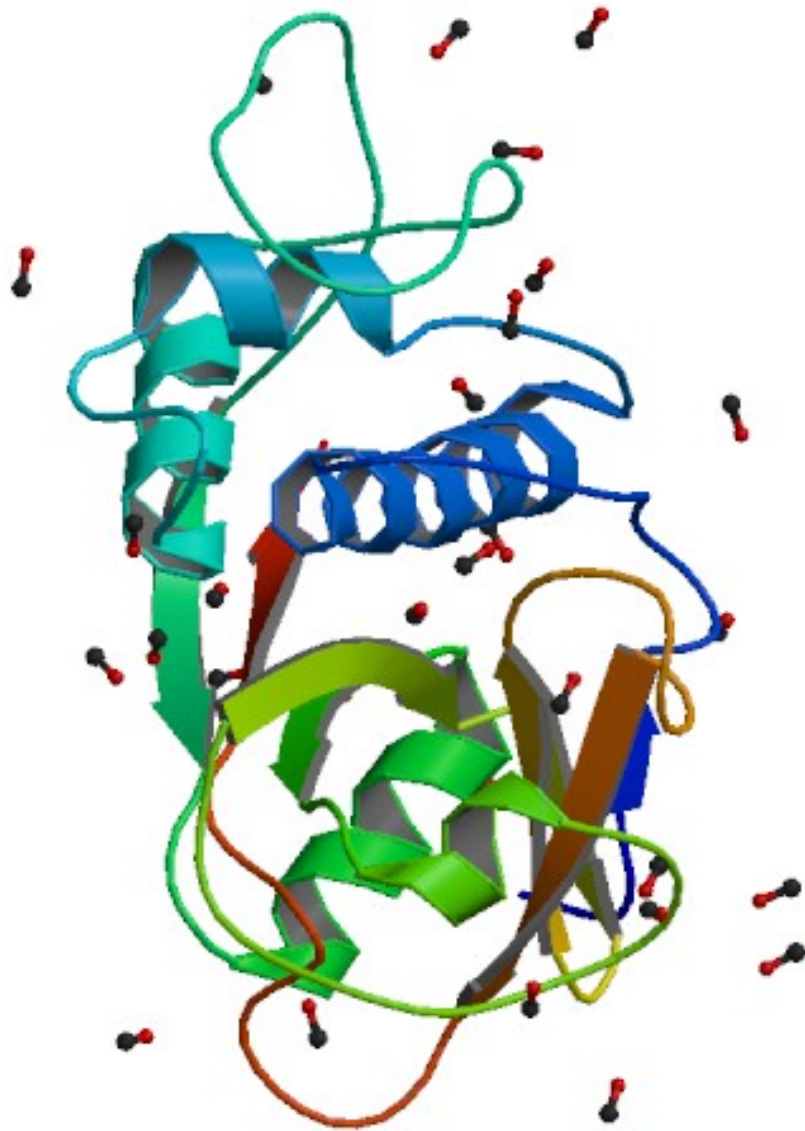
Papaya plantation



Papaya flower



Papain enzyme



Papaya history

- *Domesticated in southern Mexico in Aztec time*
- *It is still unclear if papaya occurred in south-west Asia before the age of exploration*
- *Culture of wet tropical climate, Brazil is the biggest producer*

Avocado, *Persea americana*

- Representative of Lauraceae family
- Fruits are rich of fats (14%, mostly monounsaturated) and poor of sugars (< 1%)
- Also contain vitamins B (including folate, B₉), A, K and potassium

Avocado biology

- Medium-sized evergreen tree
- Flowers are cross-pollinated, there are morning-female (A) and day-female (B) races
- Cultivars are mostly propagated by grafting
- Seeds are easy to germinate

Avocado tree



Avocado flowers



Avocado seedling



Avocado history

- Domesticated in Central America (Mayan civilization)
- Spread in many other places, including California
- Was first fruit of aircraft delivery
- Mexico and China are now biggest producers

Passion fruit, *Passiflora edulis*

- Other names: *maracuja*, *granadilla*
- Belongs to *Passifloraceae* family and *passionflower* genus, *Passiflora*

- *Amazingly complex flower structure*

Passionflower



Passionfruit



Passion fruit features

- *Perennial vine, flowering twice a year*
- *Pollinated with birds and big insects*
- *Extremely rich of vitamin C*

Litchi, lychee, *Litchi sinensis*

- Evergreen tree from Sapindaceae family
- Old traditional Chinese culture, cultivation started 2,000 BC

Litchi



Litchi seeds



Litchi features

- Edible part of litchi fruit is seed aril (seed attachment)
- Contain significant amounts of minerals like phosphorous and copper
- Mycorrhizal tree
- Fruits are canned for transportation

Durian, *Durio* spp.

- Several cultivated species, representatives of Malvaceae family
- Large size, unique odor and thorned fruit surface
- “King of the fruits”
- Odor is unusual, it is the reason why durian is banned, e.g., in public transportation. “Smell evokes reactions from deep appreciation to intense disgust, and has been described variously as almonds, rotten onions, turpentine and gym socks”...

Durian



Durian tree



Durian features

- Large tropical trees, fruits may be dangerous because they heavy, thorned and located very high
- Fruit content is rich of carbohydrates and fats
- Originated in Indonesia and became popular in Europe only in XX century

Eating durian



Carambola, starfruit, bilimbi *Averrhoa carambola*

- Tree native to Philippines
- Belongs to Oxalidaceae family
- Tree of tropical wet forests

Starfruit



Carambola features

- Harvested year round
- Fruits are rich of water, vitamin C and oxalic acid (family character)
- Contains antioxidants

Guava, *Psidium* spp.

- Representative of Myrtaceae, the family rich of useful species with medicine and other values
- All parts of plant contain essential oils
- More than 100 species, all are edible, some are cultivated (like *Psidium guajava*)

Guava flowers



Guava fruits



Guava features

- Originated in Central America
- Fruits contain up to 12% of sugars, diverse minerals (e.g., iron), many pectins
- In India, often consumed with salt

Summary

- Multiple tropical fruits are mostly sources of vitamin C
- Many traditional Asian fruit cultures have also a medicinal value

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310

Outline

5 Fruits and vegetables

5.1 Important tropical and subtropical fruits

Tamarind, *Tamarindus indica*

- The rare fruit legume (Leguminosae)
- One of traditional national Indian fruits
- Edible part of fruit is a pulp, endocarp filling all spaces between seeds

Tamarind



Tamarind candy (India)



Tamarind features

- Plant of multiple uses, legumes used also as starch source (for flour), leaves as vegetables, all parts as medicine
- Normally, do not cultivated in plantations, it is a typical “street tree”
- Well adapted for monsoon climate
- Originated in Africa and was introduced to India in prehistoric times

Acerola, barbados cherry, *Malpighia glabra*

- Caribbean tree from Malpighiaceae family
- Fruits are typically sour, known as a richest source of vitamin C (2% of dry mass)
- Also have antioxidant value

Acerola



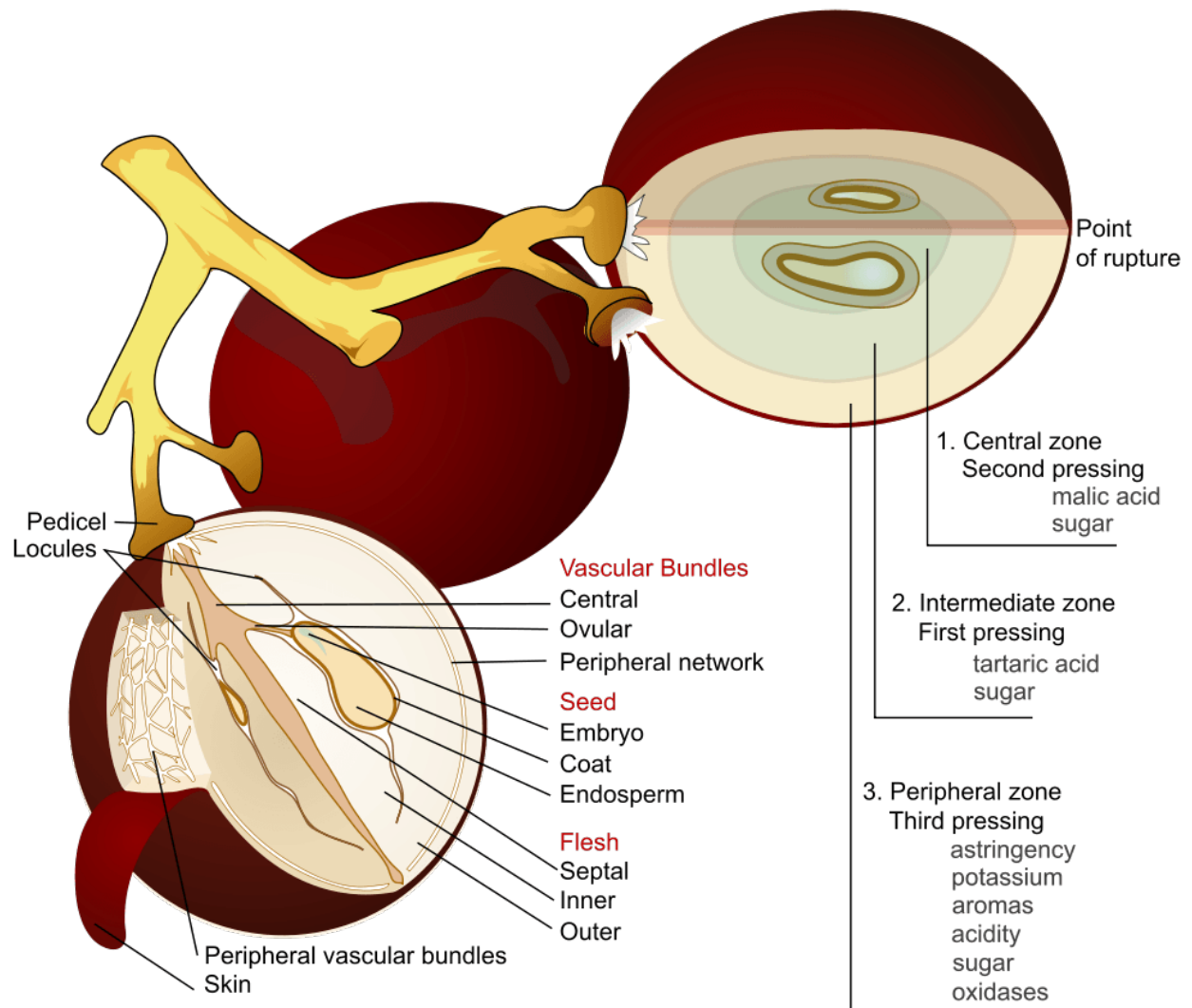
Grape, *Vitis vinifera*

- Belongs to grape family, Vitaceae
- Genus has 70 species, only several are cultivated

Grape biology and agriculture

- Woody vine with tendrils (modified shoots) and palmately lobed leaves
- Agriculture always depend on local climatic conditions
- Forming and cutting are two extremely important techniques

Grape



Grape history

- Central Asian center of origin, cultivated from 4,000 BC
- In Europe, culture flourished in XVII–XVIII centuries
- Used for wine, glucose sugar (raisins) and oil

Persimmon, *Diospiros kaki*

- Belongs to mostly tropical blackwood family, Ebenaceae
- Large genus (200) but only one deciduous species cultivated

Persimmons



Persimmon features and history

- Originates in China
- Fruits are rich of microelements and carotens
- Used also as dry fruit and in eastern medicine; wood is widely used for furniture

Persimmon tree in Japan



Pomegranate, *Punica granatum*

- Belongs to Lythraceae family, genus has only 2 species
- Semi-evergreen shrub

Pomegranate features and history

- The edible parts of fruit are seed arils (similar to litchi)
- Old Mediterranean culture
- Trees are flowering from 2nd year
- One of the most reach of biologically active compounds fruit: contain ellagitannins, punicalagins, polyphenolic catechins, galliccatechins and anthocyanins. They reduce heart disease risks, oxidation, stimulate digestion and immune system.

Pomegranate flower



Date palm, *Phoenix dactylifera*

- Belongs to palm family, Palmae; genus with several species which are cultivated mostly as ornamental palms
- Plant of multiple use: everything, from roots to dry stems, are used

Date palm



Date palm biology and agriculture

- Extremely tolerant to heat, may grow with temperatures above 50°C
- Does not tolerate precipitation; water is normally taken only from deeper soil layers
- Propagated with subsidiary shoots (grow faster than seeds)

Date palm history

- One of the oldest cultivated plants
- Dry fruits are the main food source in North Africa; ≈ 300 kcal per 100 g (highest among all fruits)
- Dates are rich of minerals, especially potassium, sodium and calcium

Fig tree, *Ficus carica*

- Belongs to mulberry family, Moraceae, and to one of the largest flowering plant genus, *Ficus* ($\approx 1,000$ species)
- One of the rare deciduous *Ficus*

Fig inflorescence



Fig tree biology and agriculture

- Edible part of fruit is the axis of inflorescence (not unlike pineapple)
- Have extremely complicated pollination system, including plants with sterile figs (caprifigs), fertile figs and fig wasps

Fig pollination

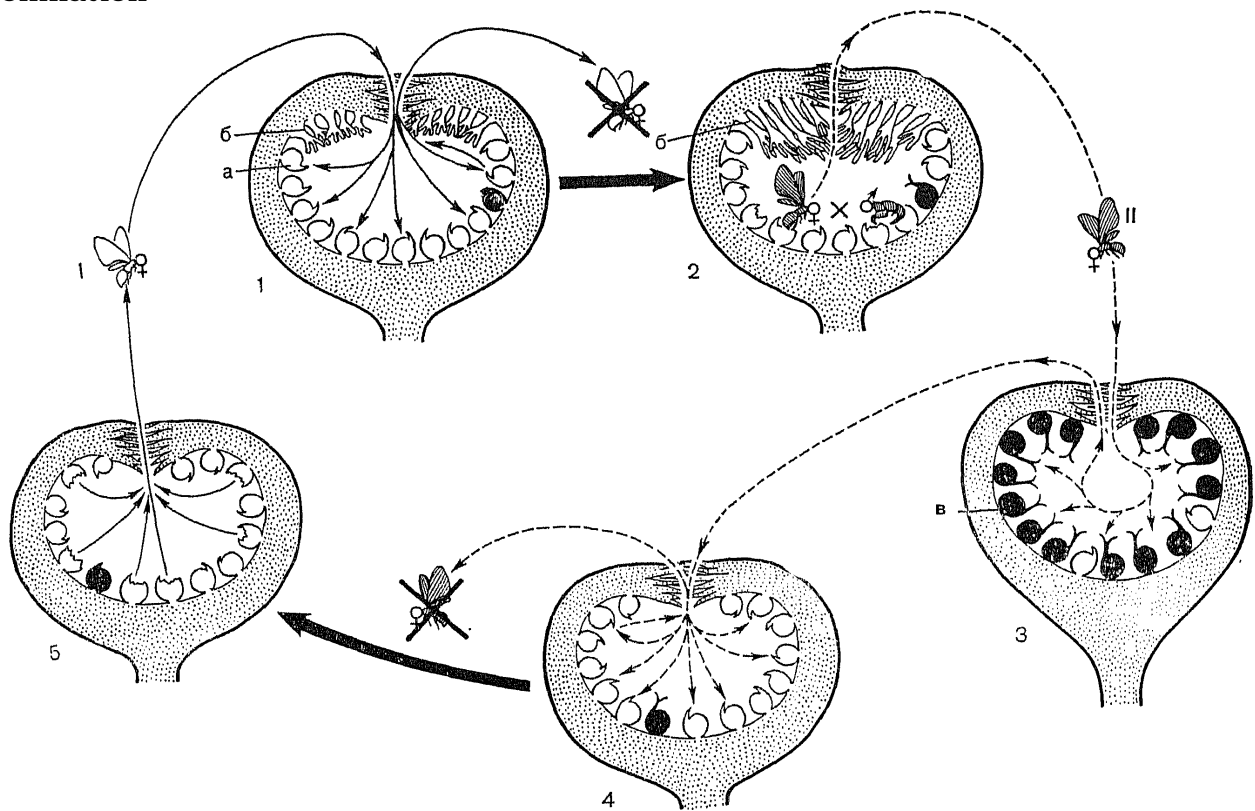


Fig tree history

- Cultivated from Old Testament times in West Asian center
- “carica” is from “Caria”, the region in contemporary Turkey

Accursed fig tree (Tissot, illustrations for New Testament)



Mulberry, *Morus* spp.

- Same mulberry family, Moraceae
- Several species are cultivated: black (*Morus nigra*), white (*M. alba*) and red (*M. rubra*)
- Occurs both in Eurasia and North America

Mulberry



Mulberry features and history

- Deciduous trees, with compact raspberry-like inflorescences
- Infructescences are rich of sugars ($\approx 22\%$), used raw, for wine, syrups etc.
- White mulberry is the feeding plant of silkworm, *Bombyx mori*

Silkworms on mulberry leaves



Cocoons



Kiwifruit, *Actinidia chinensis*

- *Belong to Actinidiaceae family, genus contains ≈ 40 species*
- *Woody vines, cultivated mostly as ornamentals*

Kiwifruit flowers



Kiwifruit biology and agriculture

- *Dioecious, fast-growing plant*
- *Biggest problem is a pollination (needs saturation pollination)*
- *Fruits rich of sugars, pectins, organic acid and enzyme actinidin (analog of papain and bromelain)*

Kiwifruit history

- *In China, was cultivated as ornamental*
- *After 30 years of intensive selection (started in 1904), New Zealand invented the kiwi fruit*

5.2 Berries

Currants and gooseberries

- Belong to Saxifragaceae family; multiple species of genus *Ribes* are cultivated
- All are shrubs, gooseberries (*Ribes uva-crispa*) have spines whereas currants (mostly *R. rubrum* and *R. nigrum*) not
- Rich of pectins and vitamin C

Gooseberry



Black currant



Blueberry and cranberry

- Belong to heath family, Ericaceae and genus *Vaccinium*
- *Vaccinium macrocarpon* is American cranberry; *V. corymbosum* is the most cultivated species of blueberries
- Have high food and medicinal value, provide vitamins, antioxidants (carotenoids) and organic acids; *V. vitis-idaea* (lingonberry) is probably most valuable

Blueberry



Cranberry



Cranberry harvesting



Lingonberry



5.3 Nuts

Nuts in general

- Contain proteins and oil in seed endosperm and/or cotyledons
- The main way of dispersal is the weak memory of collecting animals

Walnut, *Juglans regia*

- Belongs to walnut family, Juglandaceae, only one species is cultivated
- Asian origin
- Huge deciduous tree, nuts are rich of tannins and group B vitamins

Walnut



Pecan

- *Carya illinoensis*, one species of hickory
- American origin
- Similar to walnut, but has less proteins and more sugars

Pecan



Hazelnut, *Corylus avellana* and other species

- Shrub of birch family, Betulaceae; several species are cultivated
- Nut is (among other common compounds) rich of carotenes

Hazel female flower



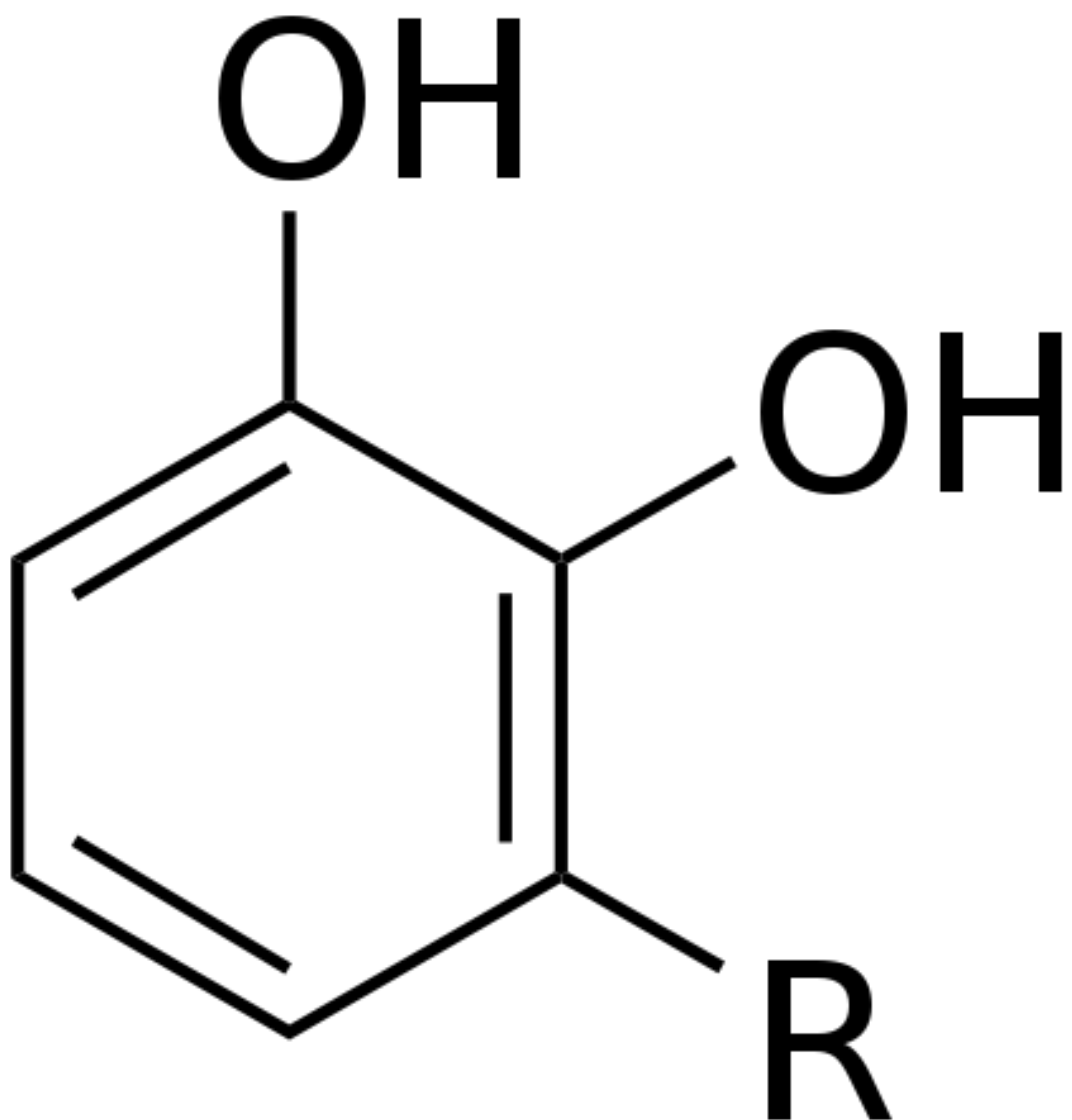
Pistachio, *Pistacia vera* and cashew, *Anacardium occidentale*

- Deciduous trees of Central Asian origin and evergreen tree from East Asia
- Nuts promote the lowering of cholesterol level
- Green parts of trees contain poisonous urushiol, like all Anacardiaceae family (including poison ivy)
- Cashew has a double use, as cashew apple and cashew nut

Pistachio



Urushiol



Brazil nut, *Bertholletia excelsa*

- Large tropical tree of Lecythidaceae family
- Among others, it is the richest dietary source of selenium

Brazil nut flowers



Brazil nut fruit



Macadamia, *Macadamia integrifolia*

- Member of Proteaceae family; Australian plant
- Rich of fats and microelements; toxic to dogs

Macadamia



Chestnut, *Castanea sativa*

- Member of oak family, Fagaceae
- Old European culture, traditional to France, England and Germany
- Rich of tannins and therefore usually fried

Chestnut



5.4 Gourd plants

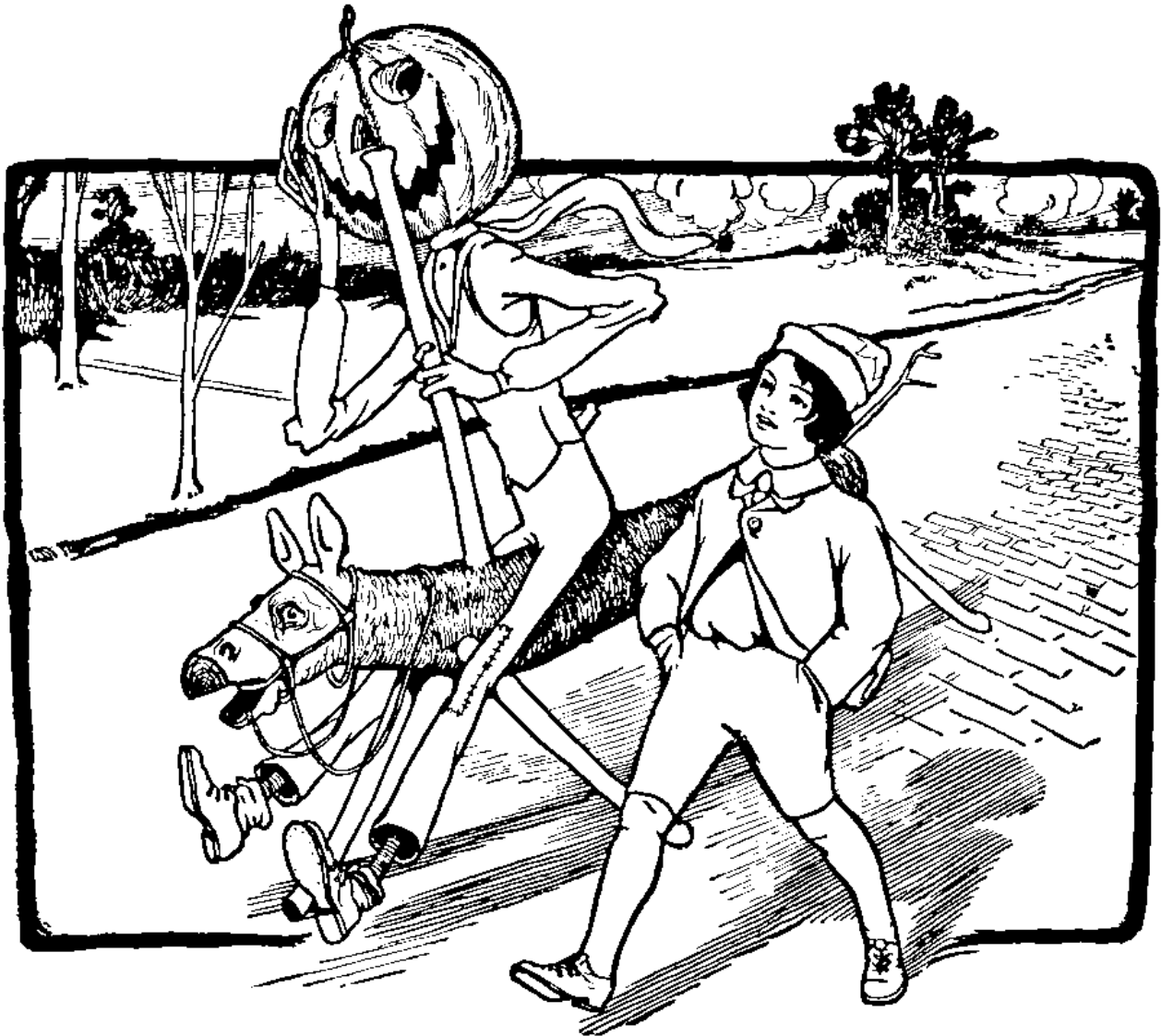
Gourds, Cucurbitaceae family

- ≈ 900 species, mostly tropical and subtropical plants
- Prefer dry regions, important component of different deserts
- Hairy herbs or vines with tendrils (modified shoots)
- Flowers unisexual
- Petals and stamens fused
- Pistil with 3 carpels, ovary inferior
- Fruit is a berry

Pumpkins and squashes, *Cucurbita* spp.

- Central American origin
- Plants of multiple uses; it is normal to harvest the underripened

Pumpkinhead, Sawhorse and Tip (Ozma)



Watermelon, *Citrullus lanatus*

- African origin
- The source of water, multiple medicine uses (e.g., for kidney diseases)

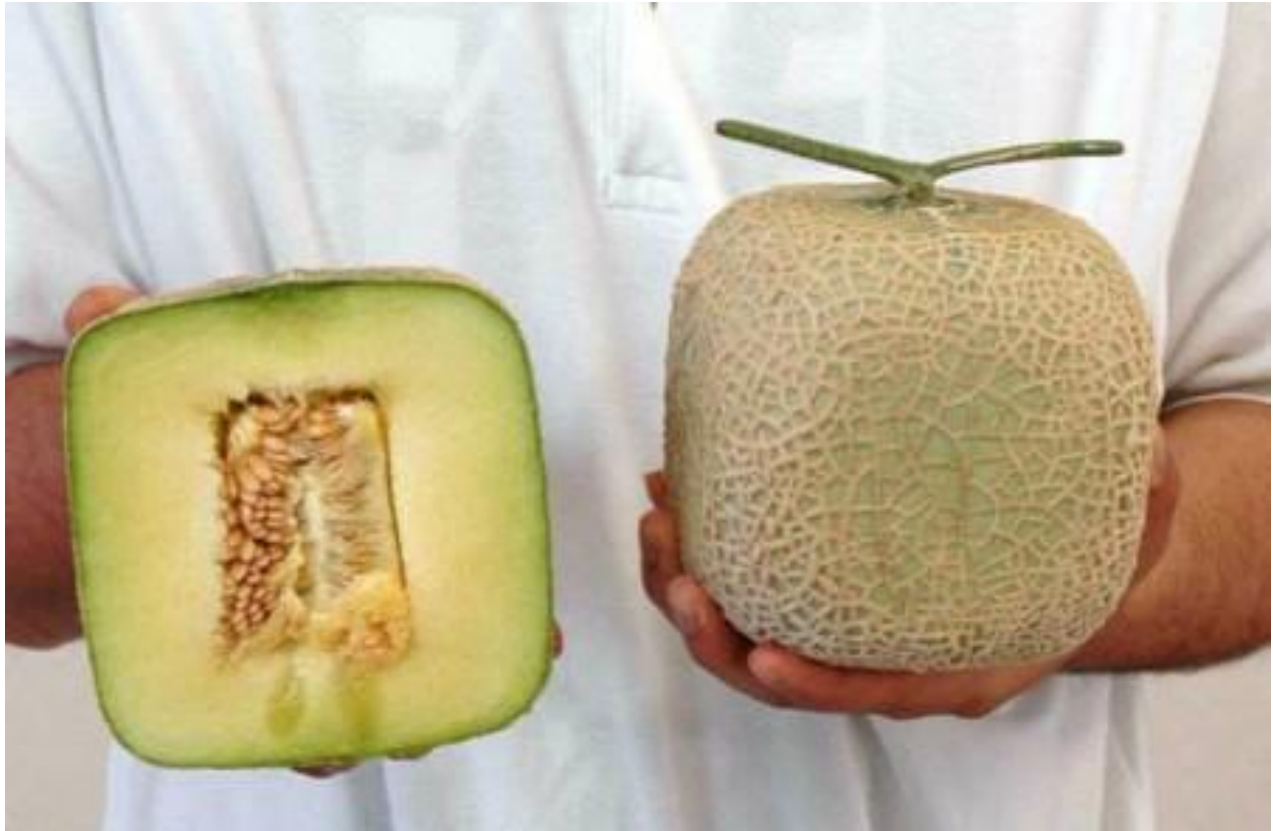
Watermelon flower



Melon, *Cucumis melo*

- Central Asian origin
- Rich of sugars (some cultivars up to 20%), used as sugar source in Central Asia

Japanese square melon



Cucumber, *Cucumis sativus*

- Annual herbaceous vine from India forests, wild relatives not found
- May grow as water culture, widely cultivated in greenhouses, some cultivars have one week for fruit development

Indian Dosakai round cucumber



Chayote, *Sechium edule*

- One of relatively “new” cultures from Mexico
- High yield culture, one plant may give up to 40 kg of fruits

Chayote



5.5 Vegetables: general view

Main families of vegetable plants

- Cruciferae, cabbage family, and its main species, *Brassica oleracea*, cabbage
- Umbelliferae, umbel family
- Solanaceae, potato family

Features of vegetables

- All vegetative organs: roots, stems and leaves—may become sources of edible vegetable
- However, fruits of Solanaceae are also considered as vegetables
- Modifications (typically, enlargement) of these organs will increase the value of vegetable
- “Herbs” are intermediates between vegetables and spices

Want more fruits and vegetables? No problem! (1)

- Samphire (*Salicornia spp.*), Amaranthaceae
- Marula (*Sclerocarya birrea*), Anacardiaceae
- Jocote (*Spondias purpurea*), Anacardiaceae

- Guanabana (soursop) (*Annona muricata*), Annonaceae
- Pitaya (dragonFruit-vegetable) (*Hylocereus undatus*), Cactaceae
- Endive (*Cichorium endivia*), Compositae
- Cucamelon (mouse melon) (*Melothria scabra*), Cucurbitaceae
- Winter melon (*Benincasa hispida*), Cucurbitaceae
- Sea-buckthorn (*Hippophae rhamnoides*), Elaeagnaceae
- Buffaloberry (*Shepherdia argentea*), Elaeagnaceae
- Strawberry tree (*Arbutus unedo*), Ericaceae
- Salal (*Gaultheria shallon*), Ericaceae
- Lingonberry (*Vaccinium vitis-idaea*), Ericaceae
- Bignay (*Antidesma bunius*), Euphorbiaceae
- Basil (*Ocimum basilicum*), Labiatae
- Shiso (wild sesame) (*Perilla spp.*), Labiatae
- Carob tree (*Ceratonia siliqua*), Leguminosae
- Langsat (*Lansium domesticum*), Meliaceae
- Santol (cotton Fruit-vegetable) (*Sandoricum koetjape*), Meliaceae
- JackFruit-vegetable (*Artocarpus heterophyllus*), Moraceae
- Yangmei (*Myrica rubra*), Myricaceae

Want more fruits and vegetables? No problem! (2)

- Feijoa (*Acca sellowiana*), Myrtaceae
- Surinam cherry (*Eugenia uniflora*), Myrtaceae
- Jabuticaba (*Plinia cauliflora*), Myrtaceae
- Wax jamboo (*Syzygium samarangense*), Myrtaceae
- Chilean guava (*Ugni molinae*), Nyrtaceae
- Salak (*Salacca zalacca*), Palmae
- Rhubarb (*Rheum rhabarbarum*), Polygonaceae
- Jujube (Chinese date) (*Ziziphus jujuba*), Rhamnaceae
- Genipapo (*Genipa americana*), Rubiaceae
- African medlar (*Vangueria infausta*), Rubiaceae
- Kumquat (*Citrus (Fortunella) japonica*), Rutaceae
- Longan (*Dimocarpus spp.*), Sapindaceae
- Rambutan (*Nephelium lappaceum*), Sapindaceae
- Cainito (*Chrysophyllum cainito*), Sapotaceae
- Sapodilla (*Manilkara zapota*), Sapotaceae
- Canistel (*Pouteria campechiana*), Sapotaceae
- Tamarillo (*Solanum betaceum*), Solanaceae
- Goji berry (*Lycium barbarum and Lycium chinense*), Solanaceae
- Celery (*Apium graveolens*), Umbelliferae
- Carrot (*Daucus sativus*), Umbelliferae
- Parsnip (*Pastinaca sativa*), Umbelliferae

Summary

- Multiple tropical fruits are mostly sources of vitamin C
- Many traditional Asian fruit cultures have also a medicinal value
- Nuts are plants accumulating oils and proteins in their seeds, they mostly dispersed by “bad memory” animals
- Gourd plants are intermediates between fruits and vegetables

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310

Outline

6 From food to medicine

6.1 Spices

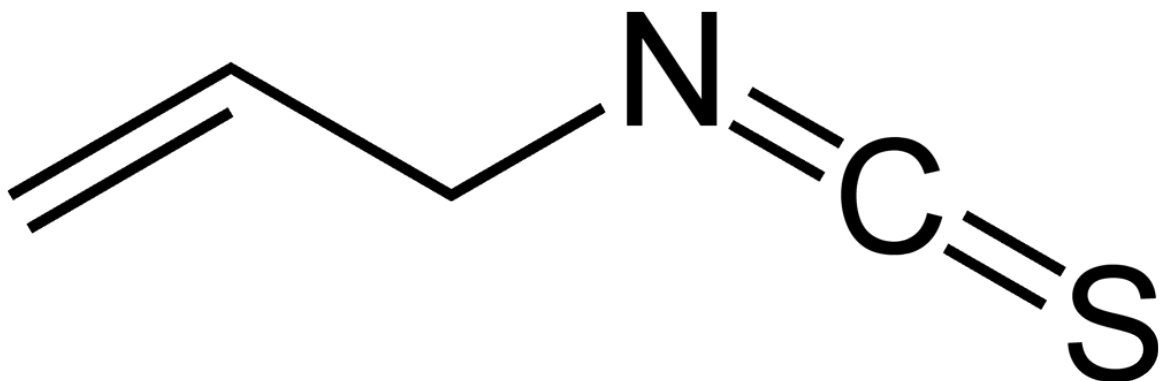
Spicy hot taste

- Caused from several different secondary metabolites which make a burning sensation
- These metabolites work with pain receptors, nociceptors
- One of proposed effects is the stimulation of endorphin and serotonin production in brain

Allyl isothiocyanate plants

- Main component of mustard oils, with formula $\text{CH}_2\text{--CH--CH}_2\text{--NCS}$
- Anti-herbivore chemical, stored in glucosinolate form and released by myrosinase when cells are broken
- Toxic, strong lachrymator, stimulates nasal and eye receptors
- Plants of Brassicales order (Cruciferae and also Moringaceae like papaya and horseradish tree) are rich of allyl isothiocyanates.

Allyl isothiocyanate



Horseradish, *Armoracia rusticana*

- Perennial plant from cabbage family (Cruciferae) with European origin
- Roots are using as a spice

Wasabi, *Wasabia japonica*

- Japanese perennial from same family
- Extremely strong flavor due to multiple isothiocyanates

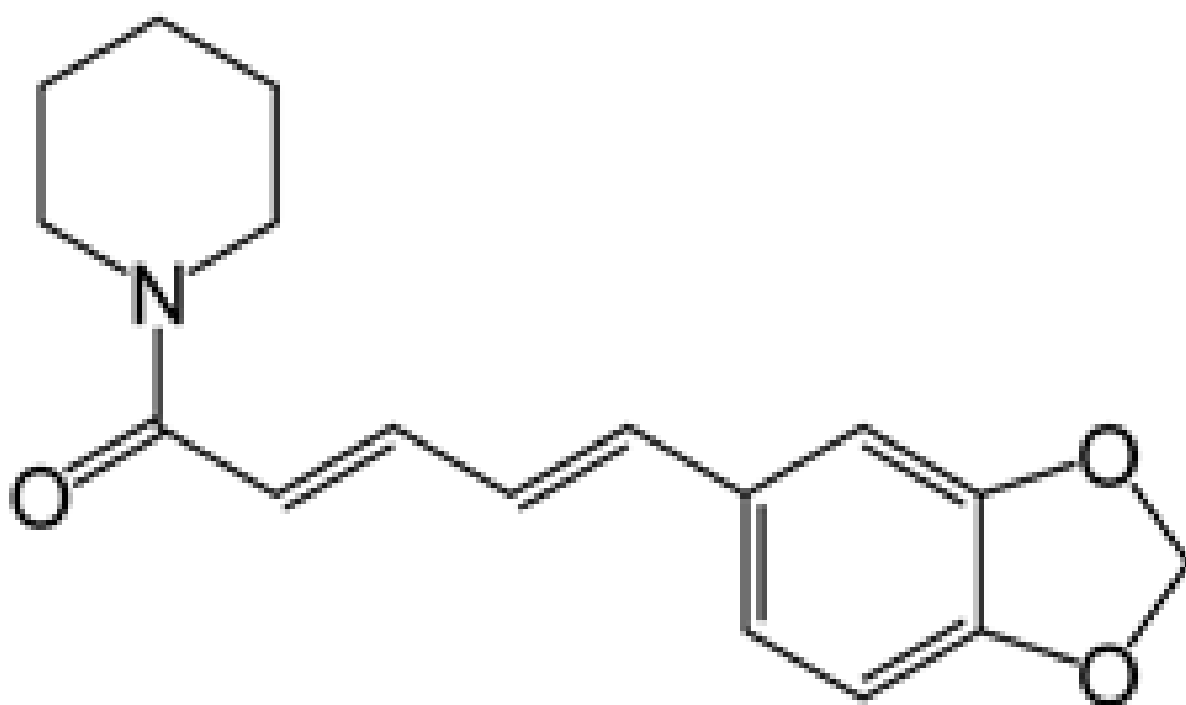
Iwasaki (1828) paint of wasabi



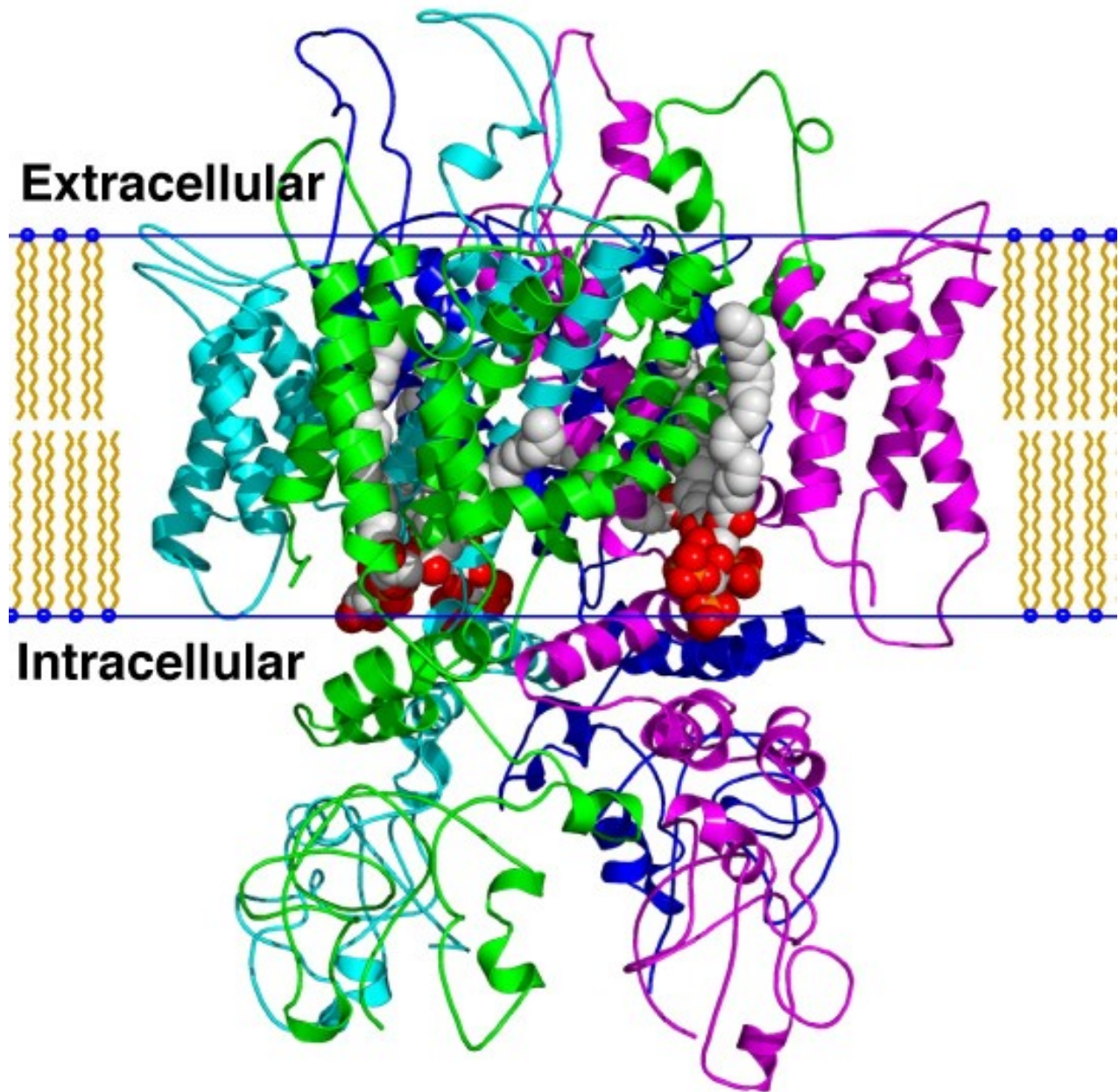
Piperine

- Alkaloid
- Activates TRPV channels in nociceptors

Piperine



TRPV channel



Black pepper, *Piper nigrum*

- Perennial vine from pepper family, Piperaceae
- Has the long and rich history: was one of primary causes of Exploration Age

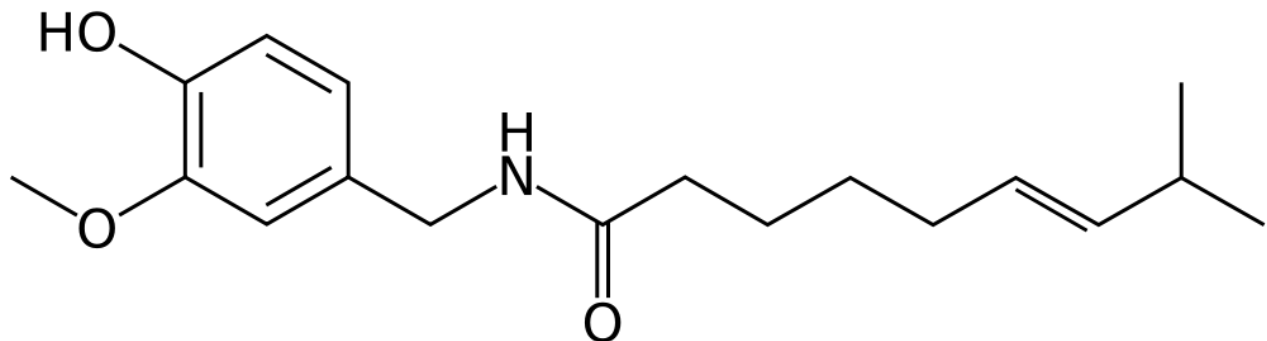
Piper nigrum



Capsaicin

- Amine, irritant for all mammals
- Binds to TRPV and provide sensation similar to burning of call damage

Capsaicin



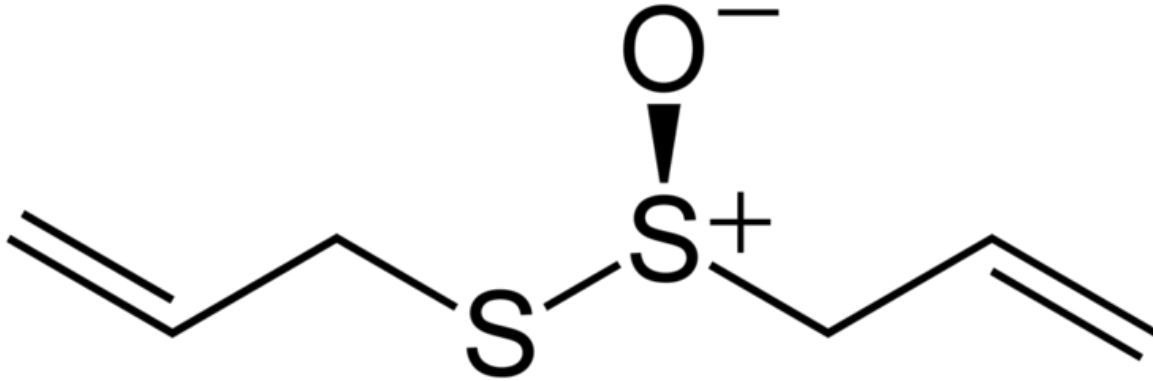
Chili peppers, *Capsicum annuum* and other species

- Multiple species of *Capsicum*, genus of Solanaceae herbs or vines from Central America
- Important component of several tropical cousins

Allicin

- Organo-sulfur compound with anti-bacterial and anti-fungal effects
- Has multiple positive health effects

Allicin



Garlic, *Allium sativum*

- Cultivated species from amaryllis family, Amaryllidaceae
- Probably originated in West Asia from wild *Allium longicuspis*

Essential oil plants from umbel family, Umbelliferae

- Coriander, *Coriandrum sativum* from West Asia, known from pre-historic times
- Dill, *Anethum graveolens* from Europe
- Cumin, *Cuminum cyminum* from Mediterranean
- Caraway (*Carum carvi*), asafoetida (*Ferula asafoetida*), anise (*Pimpinella anisum*), fennel (*Foeniculum vulgare*), sea parsley (*Ligusticum scoticum*), parsley (*Petroselinum crispum*), and many others

Cumin



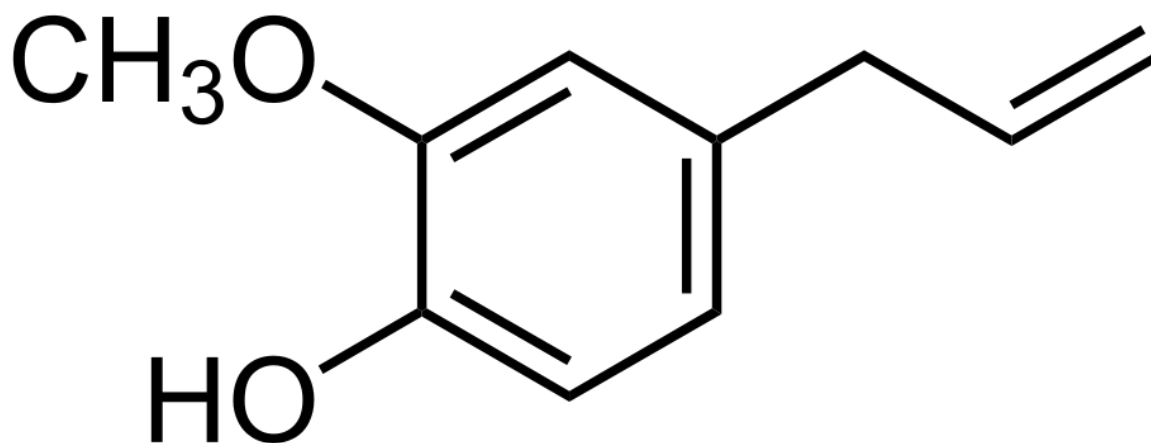
Essential oil plants from mint family, Labiatae

- Peppermint, *Mentha piperita* from Europe
- Basil, *Ocimum basilicum* with wide Eurasian distribution
- Wild bergamot (*Monarda fistulosa*), mint (*Mentha* spp.), majoram (*Origanum majorano*), oregano (*Origanum vulgare*), thyme (*Thymus* spp.), sage (*Salvia officinalis*), and many others

Eugenol and similar compounds

- Essential oils with phenol component
- Often provide a burning sensation similar to other spices

Eugenol



Plants with eugenol-like compounds

- Allspice, *Pimenta dioica* from Myrtaceae family, Caribbean origin
- Bay leaf, *Laurus nobilis* from Lauraceae, Mediterranean origin
- Nutmeg, *Myristica fragrans* from Myristicaceae, Indonesian origin
- Cinnamon, *Cinnamomum verum* from Lauraceae, Southwest Asian origin
- Ginger, *Zingiber officinale* from Zingiberaceae, South Asia
- Turmeric, *Curcuma longa* from Zingiberaceae, South Asia
- Vanilla orchid, *Vanilla planifolia*, Central America
- Sage, *Artemisia spp.* from Compositae, cosmopolitan

Bark of cinnamon



Nutmeg



Vanilla plantation



7 Natural product chemistry

7.1 Introduction

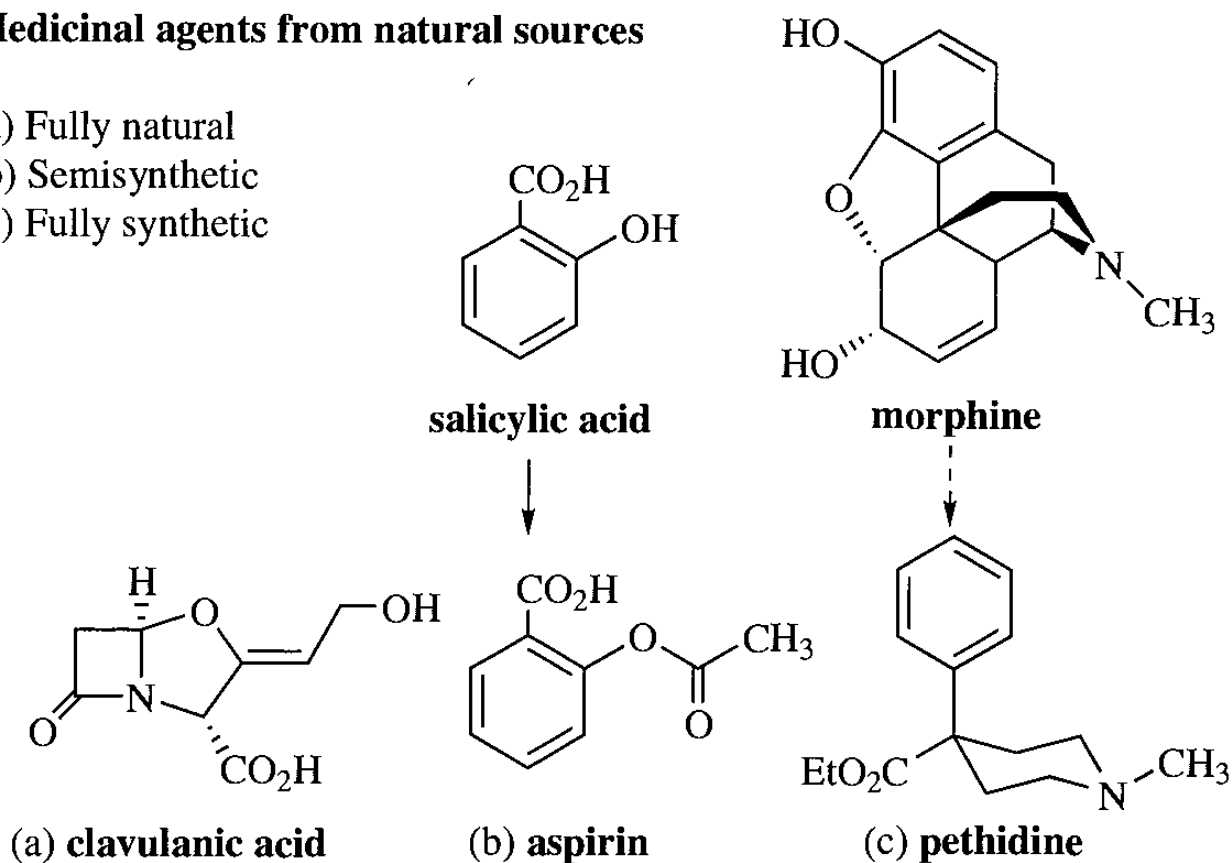
Types of drugs

- Fully natural
- Semisynthetic
- Fully synthetic

Types of medicinal agents

Medicinal agents from natural sources

- (a) Fully natural
- (b) Semisynthetic
- (c) Fully synthetic



Drug discovery

We need new drugs, and plant secondary compounds of plants could accidentally have medicinal value.

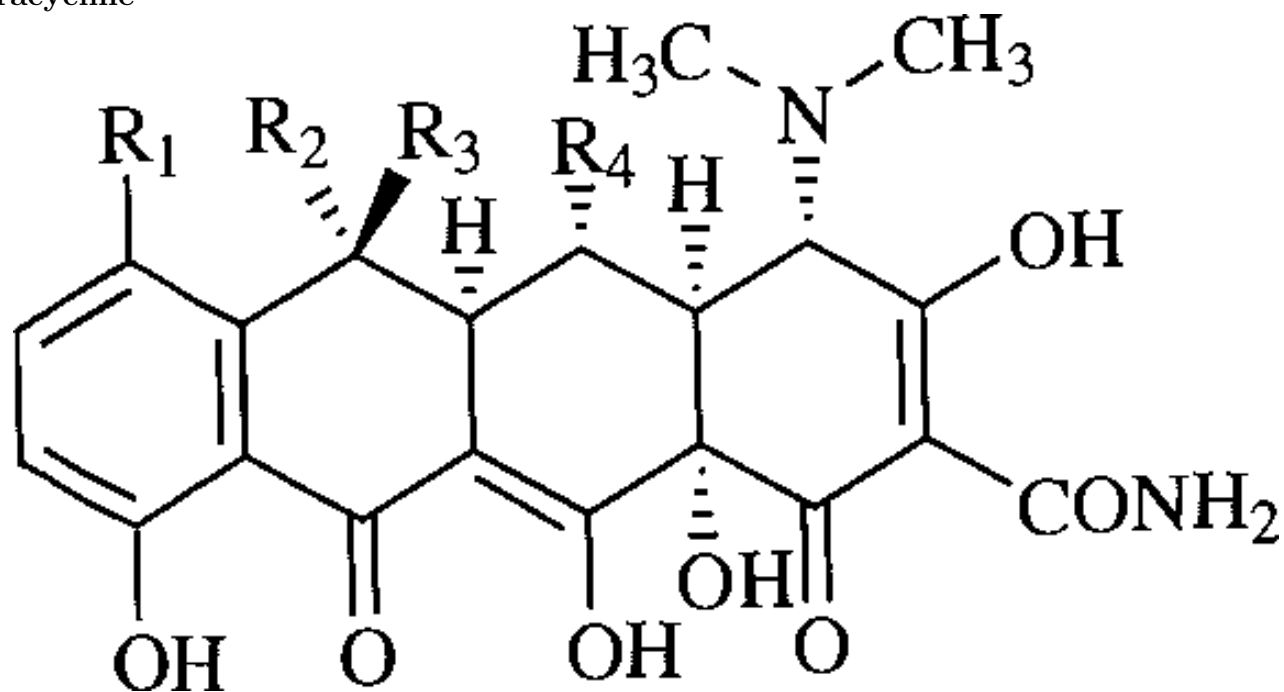
- Sampling: soil, markets, natural habitats
- Extraction
- Bioassay screening
- Structure elucidation
- Chemical modification
- Clinical trials
- Drug

7.2 Polyketides and other small molecules

Polyketides and derived products

- Short molecules with interleaving ketogroups
- Many antibiotics (e.g., tetracycline, erythromycin)

Tetracycline



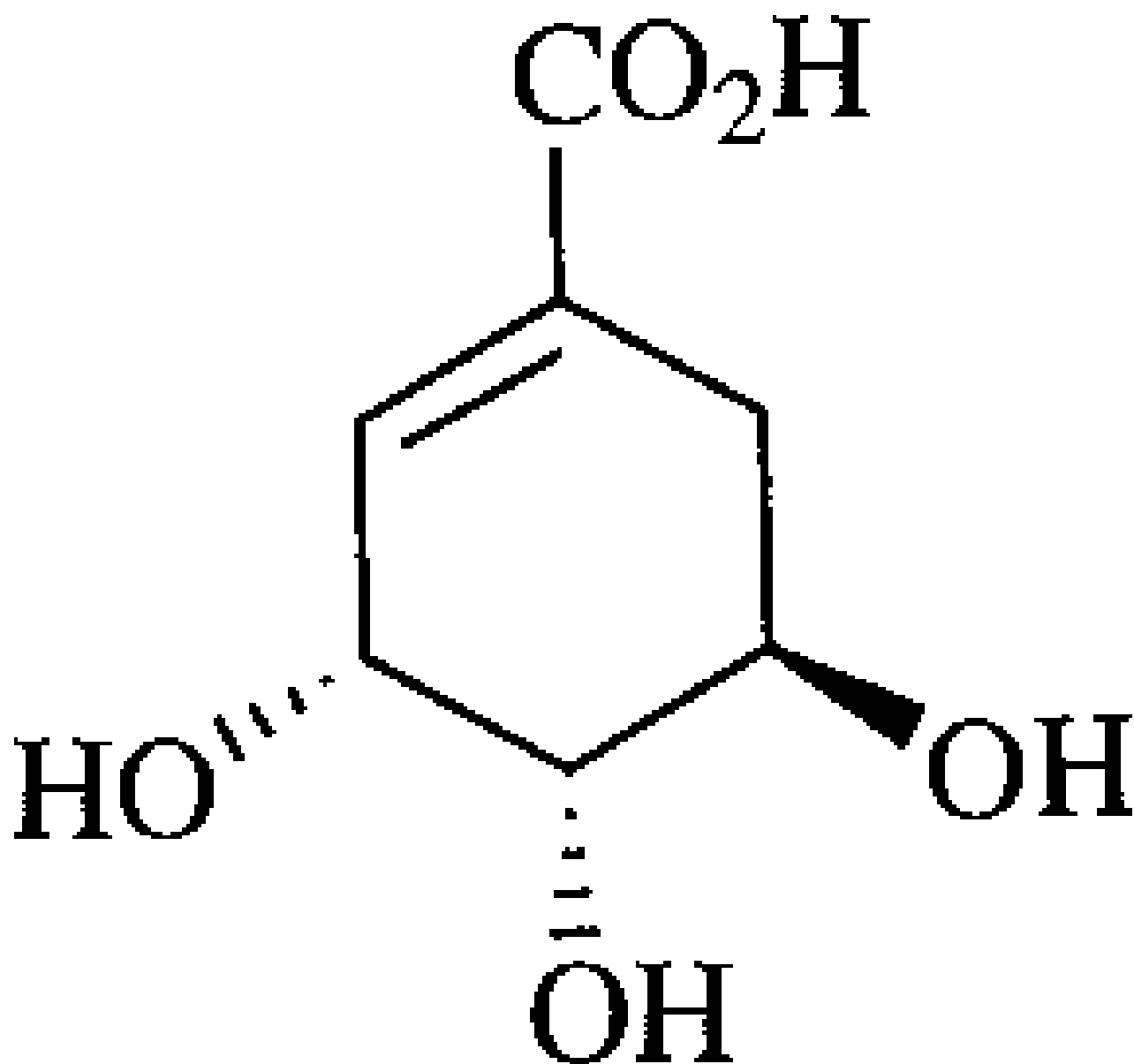
Glycerides

- Saturated fats
- Unsaturated fats, especially omega-n-unsaturated

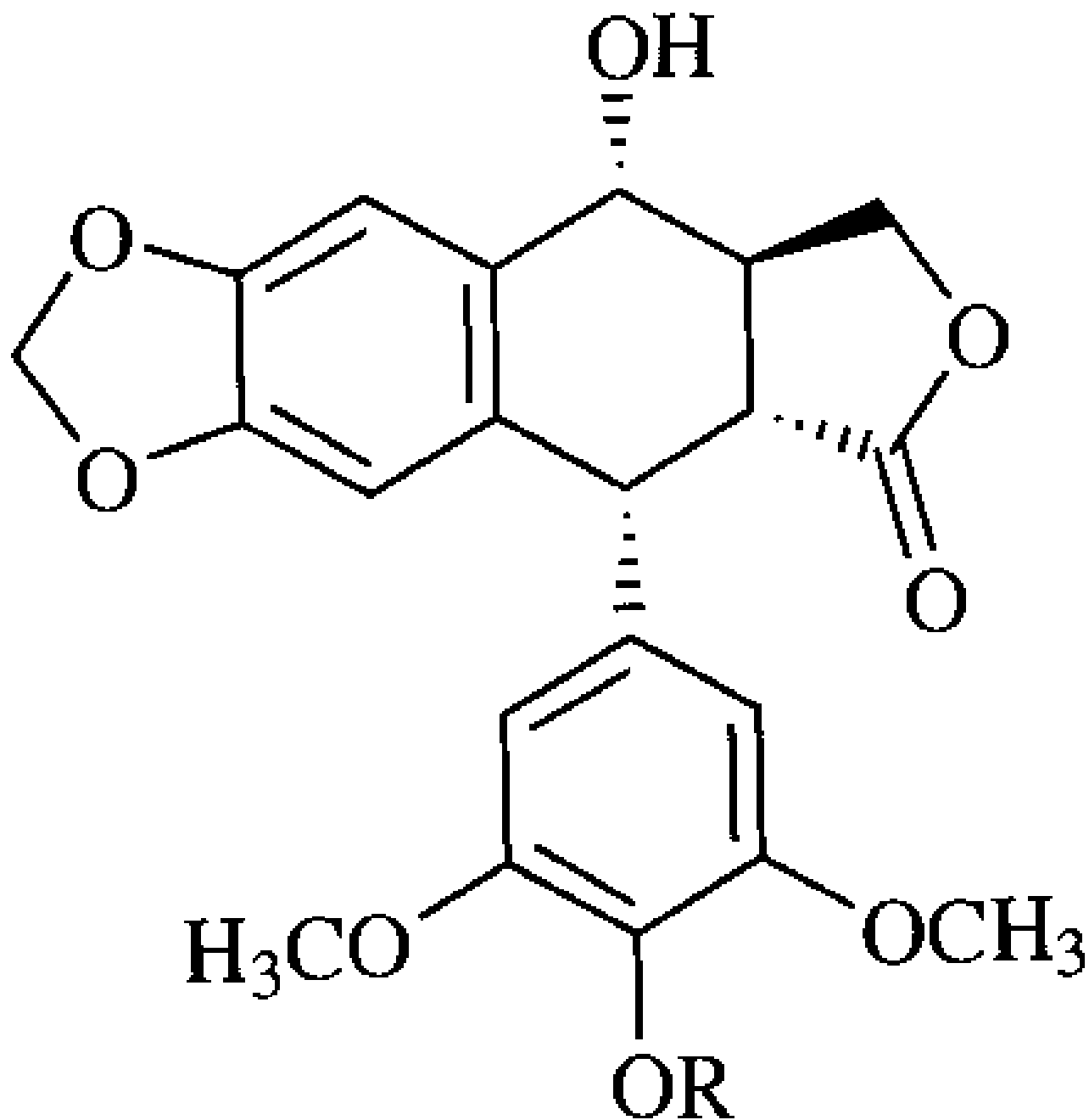
Shikimic acid and derived products

- Phenylpropenes, like eugenol
- Lignans like podophyllotoxin

Shikimic acid



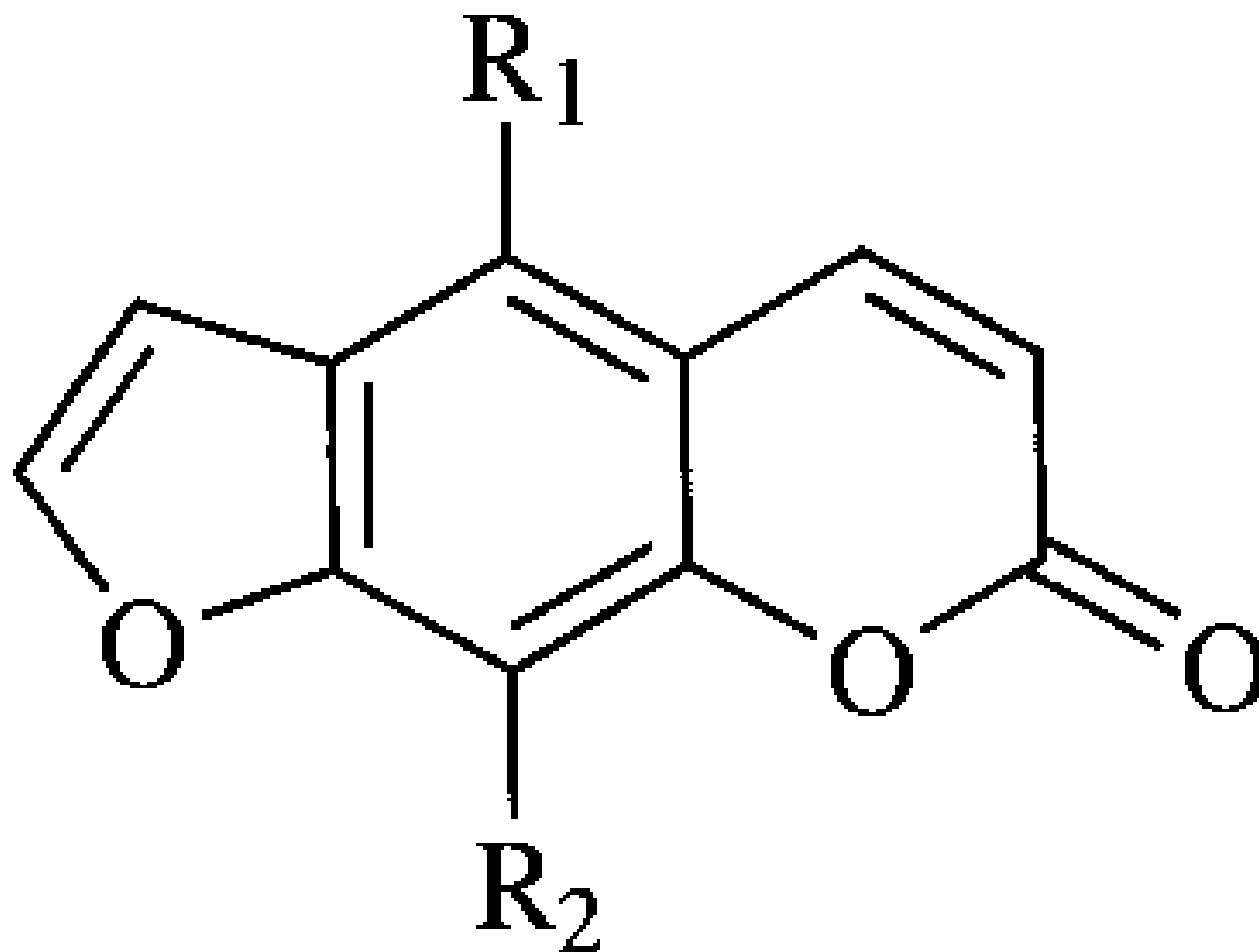
Podophyllotoxin



Coumarins

- Phytoalexins with anti-bacterial properties
- Some (psoralens from umbel family plants and bergapten from citrus family) are phototoxic

Psoralen



Summary

- Most of spicy plants produce chemicals with nociceptive (pain) effect
- Polyketides are source chemicals to many antibiotics
- Derivatives of shikimic acid are phenylpropenes, lignans, coumarins, flavonoids and tannins

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310
- [2] Heinrich et al. 2012. *Fundamentals of Pharmacognosy and Phytotherapy*. Churchill Livingstone, Edinburgh.

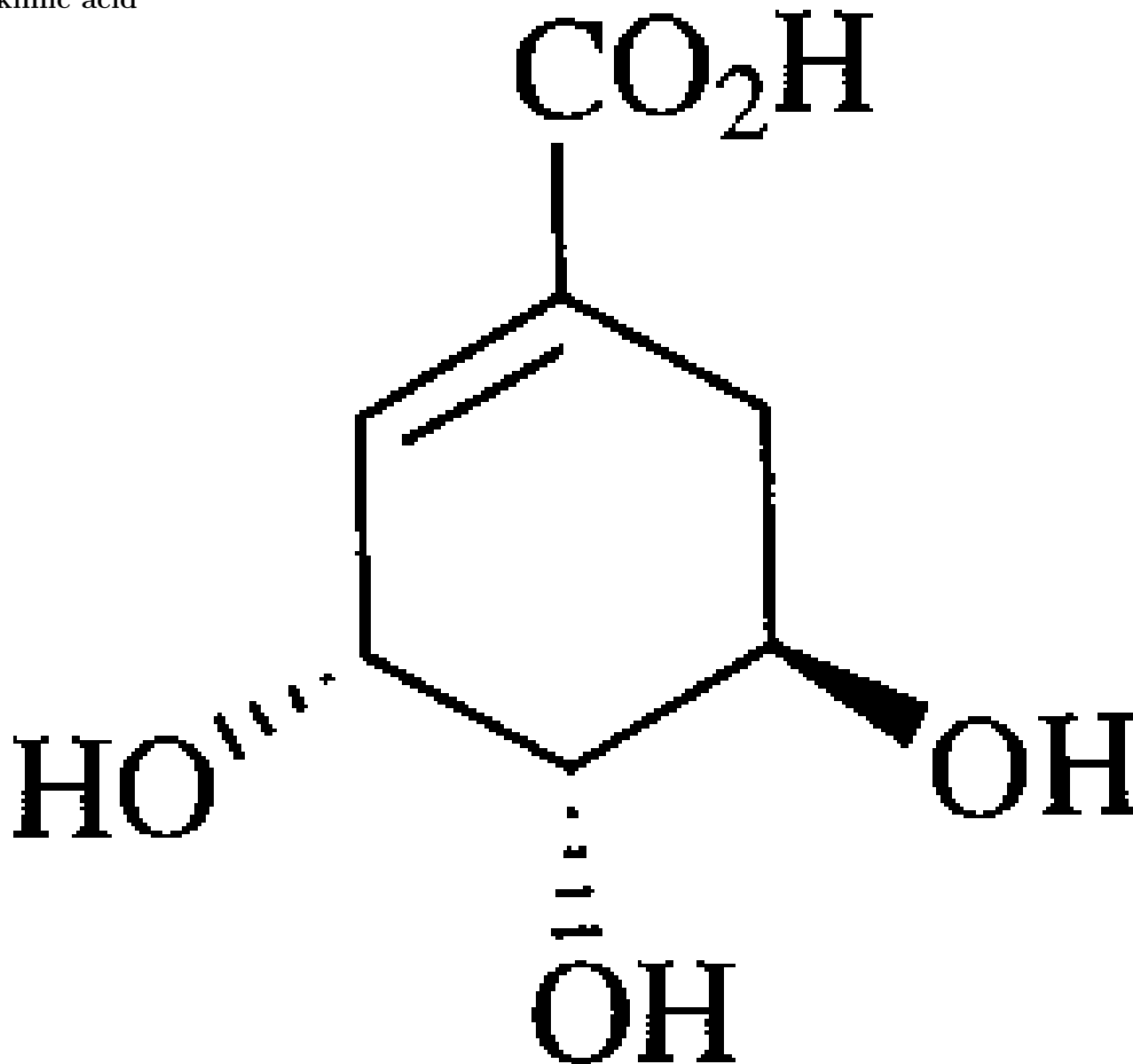
Outline

8 Natural product chemistry

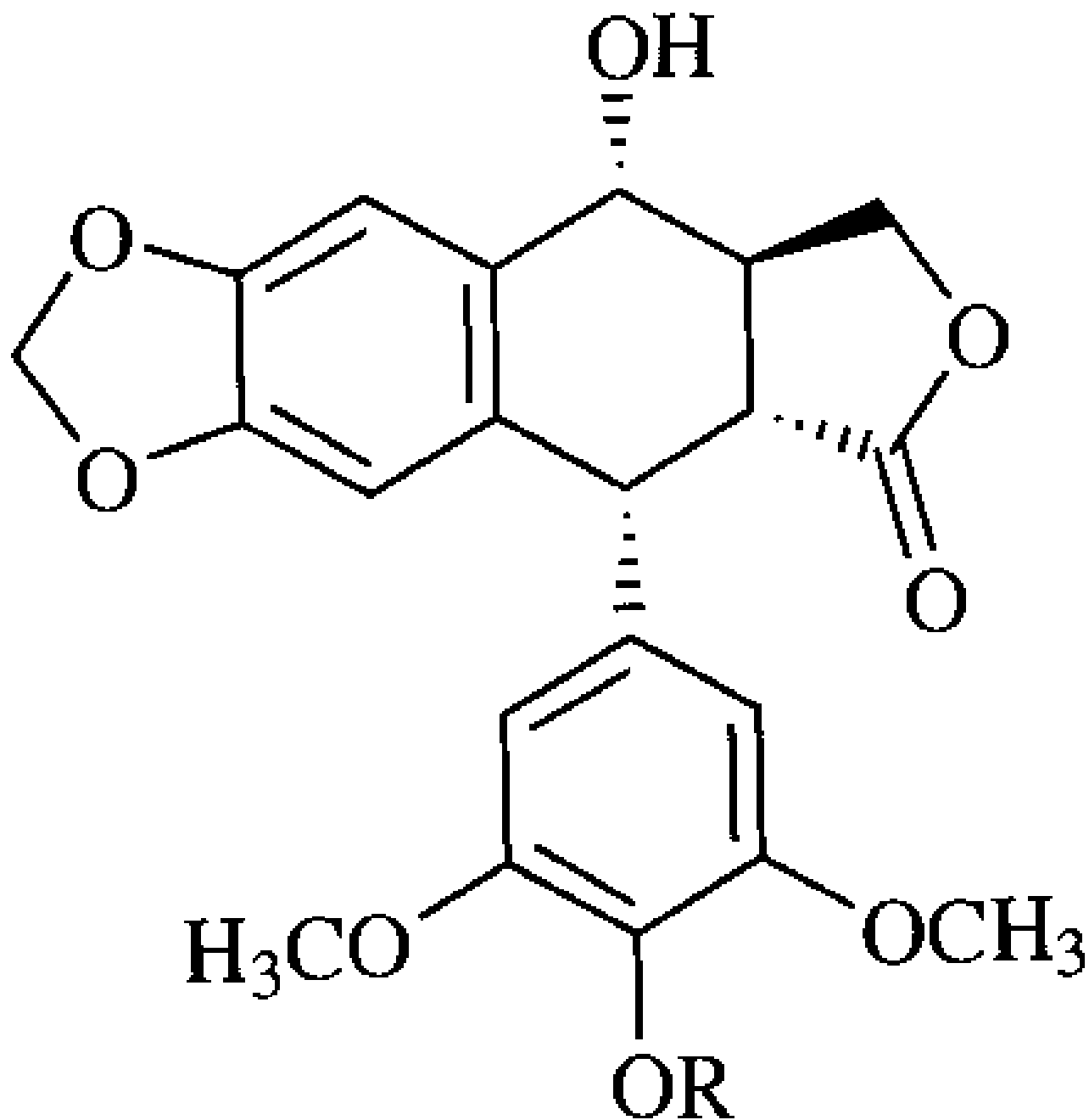
Shikimic acid and derived products

- Phenylpropenes, like eugenol
- Lignans like podophyllotoxin

Shikimic acid



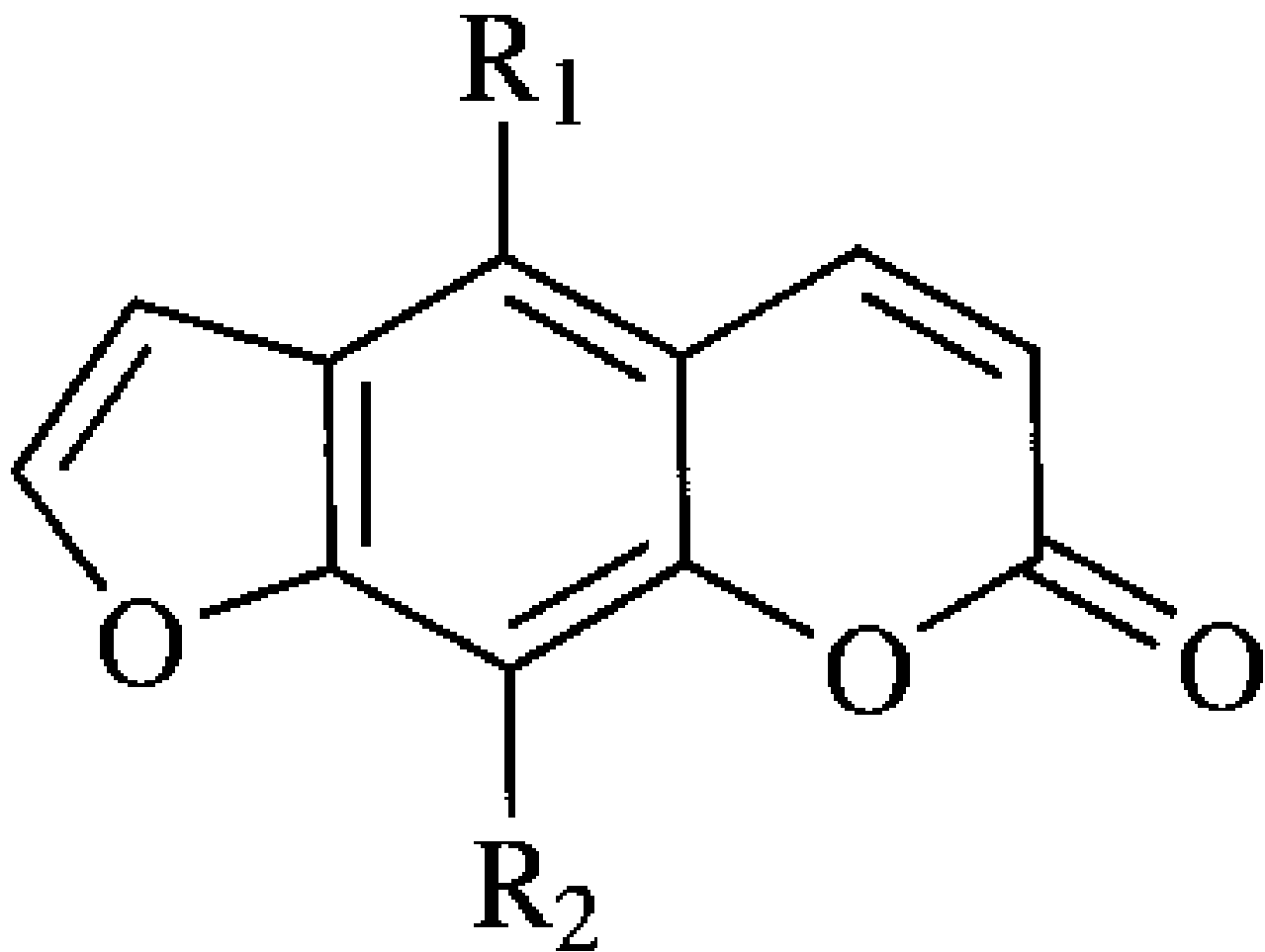
Podophyllotoxin



Coumarins

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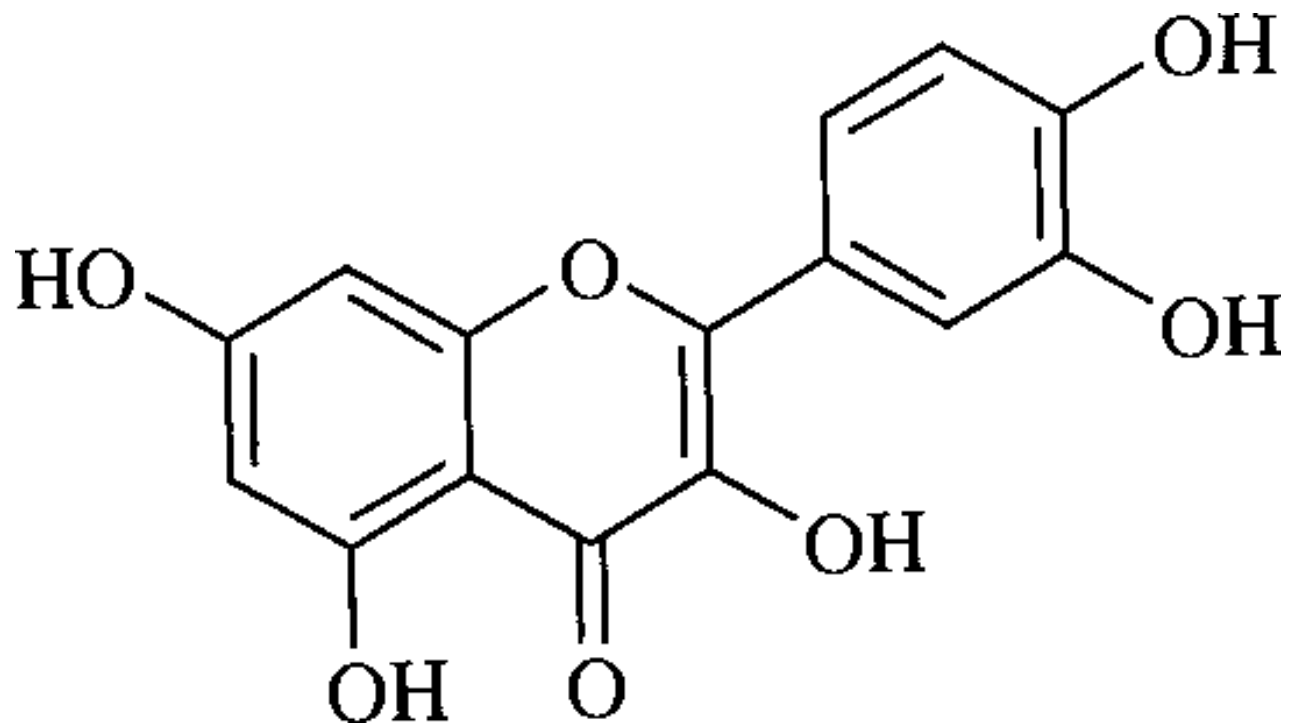
Psoralen



Flavonoids

- Derivatives of phenylpropane (C_6-C_3)
- Strong antioxidants
- Examples: naringin from grapefruit, quercetin from oak and other plants, resveratrol from grapes

Quercetin (flavonoid)



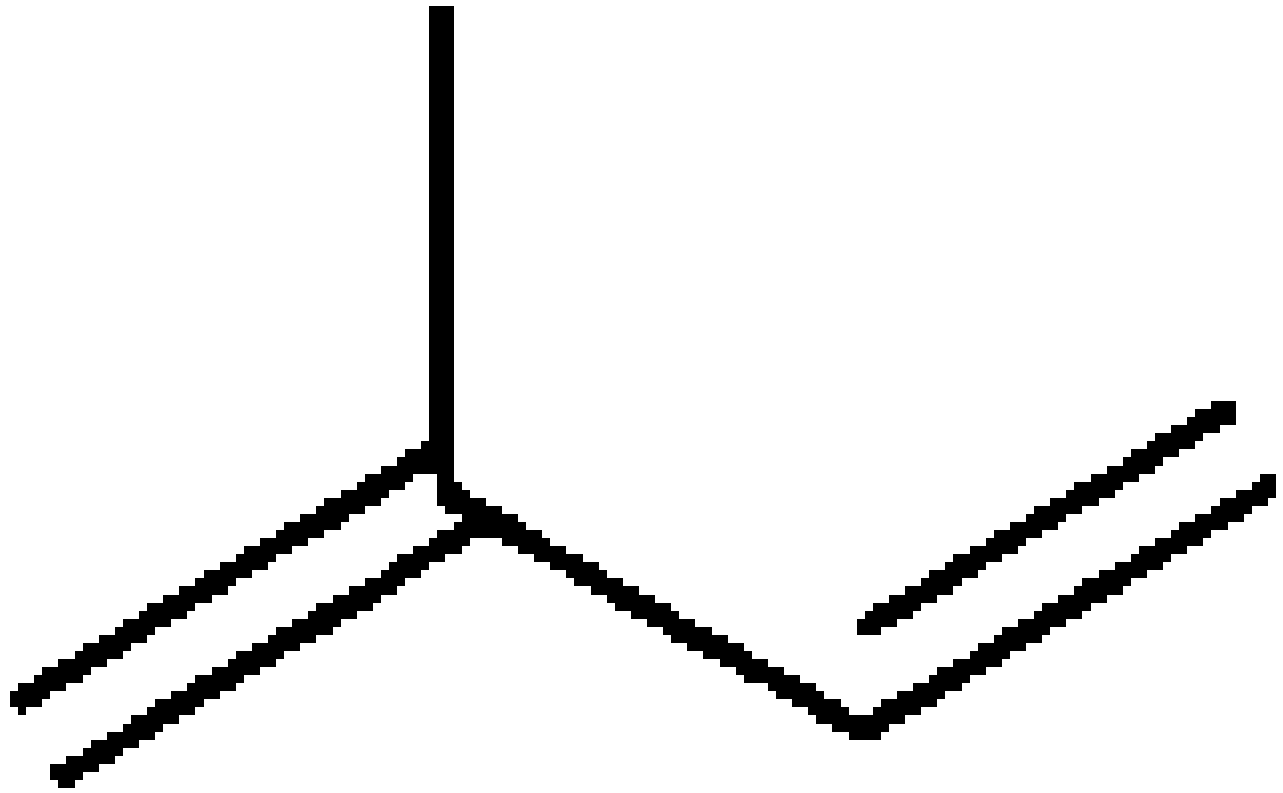
Tannins

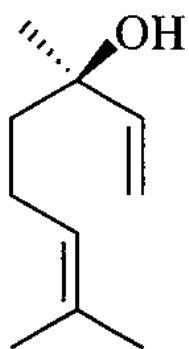
- Similar to flavonoids, but much heavier
- Bind to proteins and provide astringent taste

Terpenes and monoterpenes

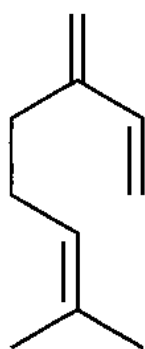
- Terpenes = isoprenoids, derivatives of isoprene (C_5 unit)
- Monoterpenes are simplest, they are constituents of volatile (essential) oils
- Examples: menthol from mint, myrcene from *Eucalyptus*, camphor, iridoids like valepotriates from valerian

Isoprene and monoterpenes

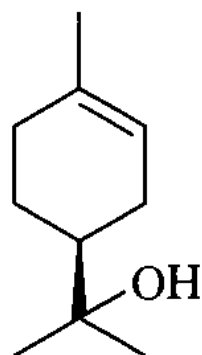




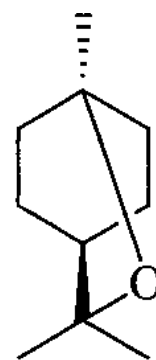
(+)-Linalool



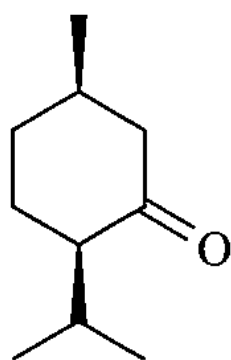
Myrcene



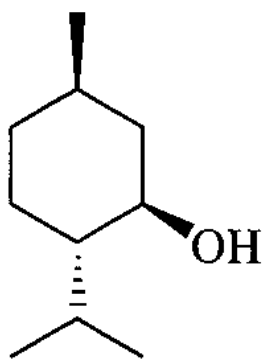
α -Terpineol



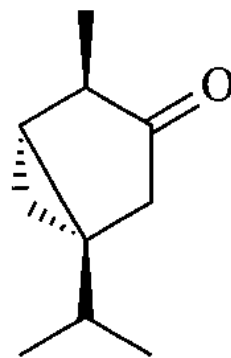
1,8-Cineole



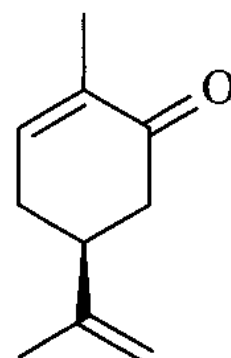
(-)-Menthone



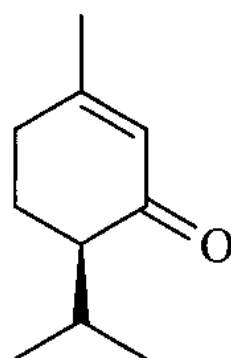
(-)-Menthol



(-)-Thujone



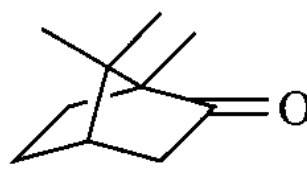
(+)-Carvone



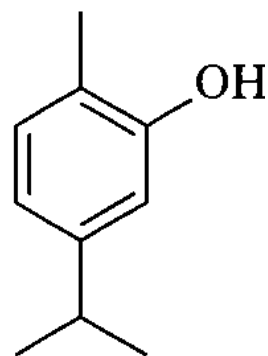
(-)-Piperitone



α -Pinene

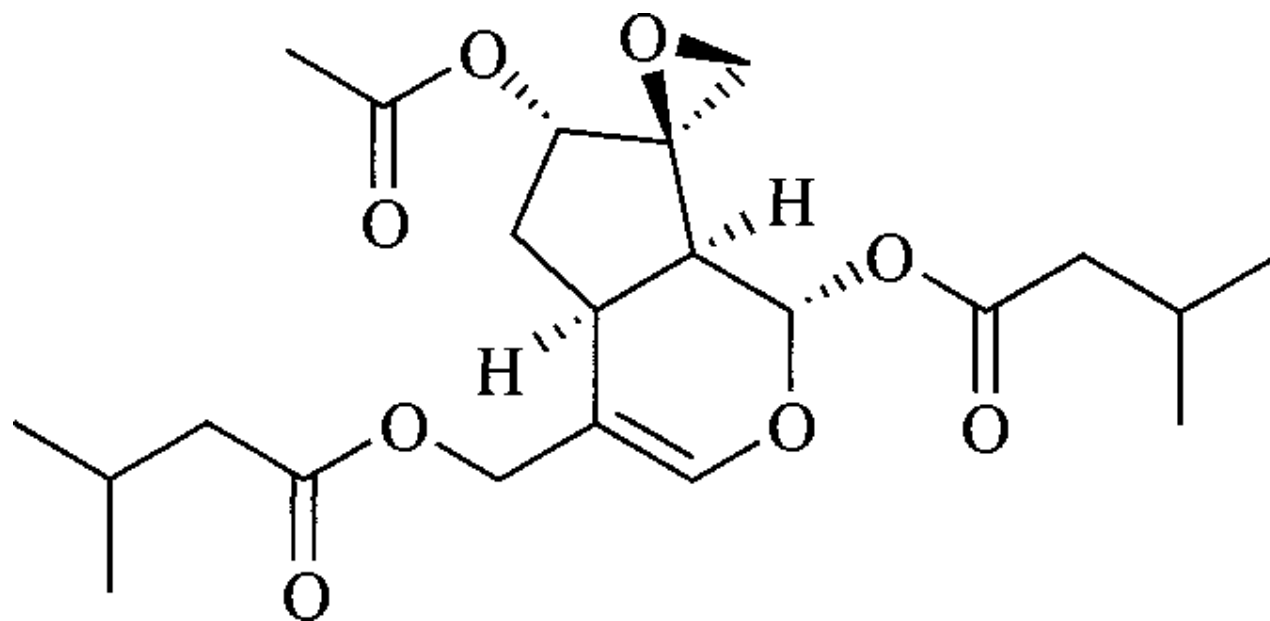


Camphor



Carvacrol

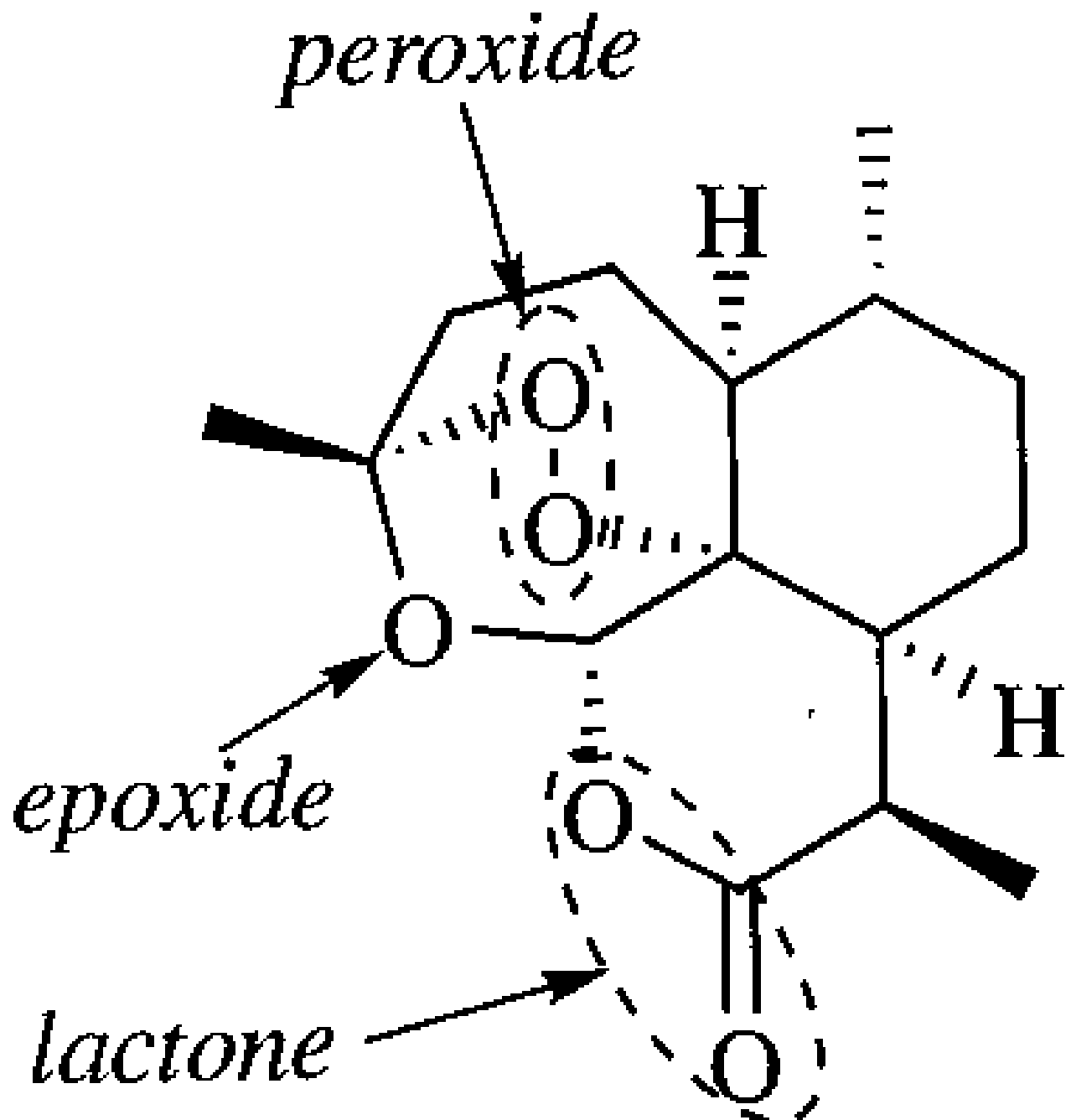
Didrovaltrate (iridoid)



Sesquiterpenes

- Have C₁₅ skeleton
- Example: artemisinin from sage

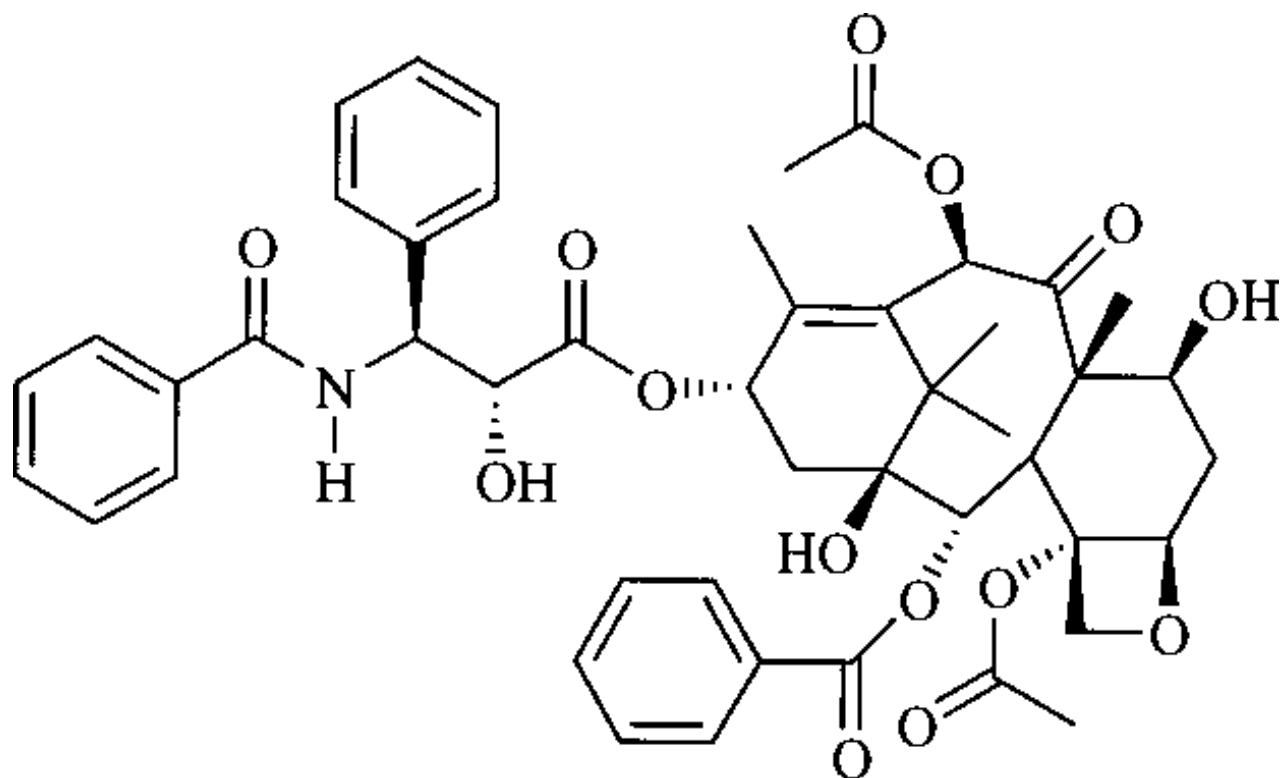
Artemisinin (sesquiterpene)



Diterpenes

- Have C₂₀ skeleton
- Example: taxol from yew tree (actually, mostly from its endophyte *Taxomyces*)

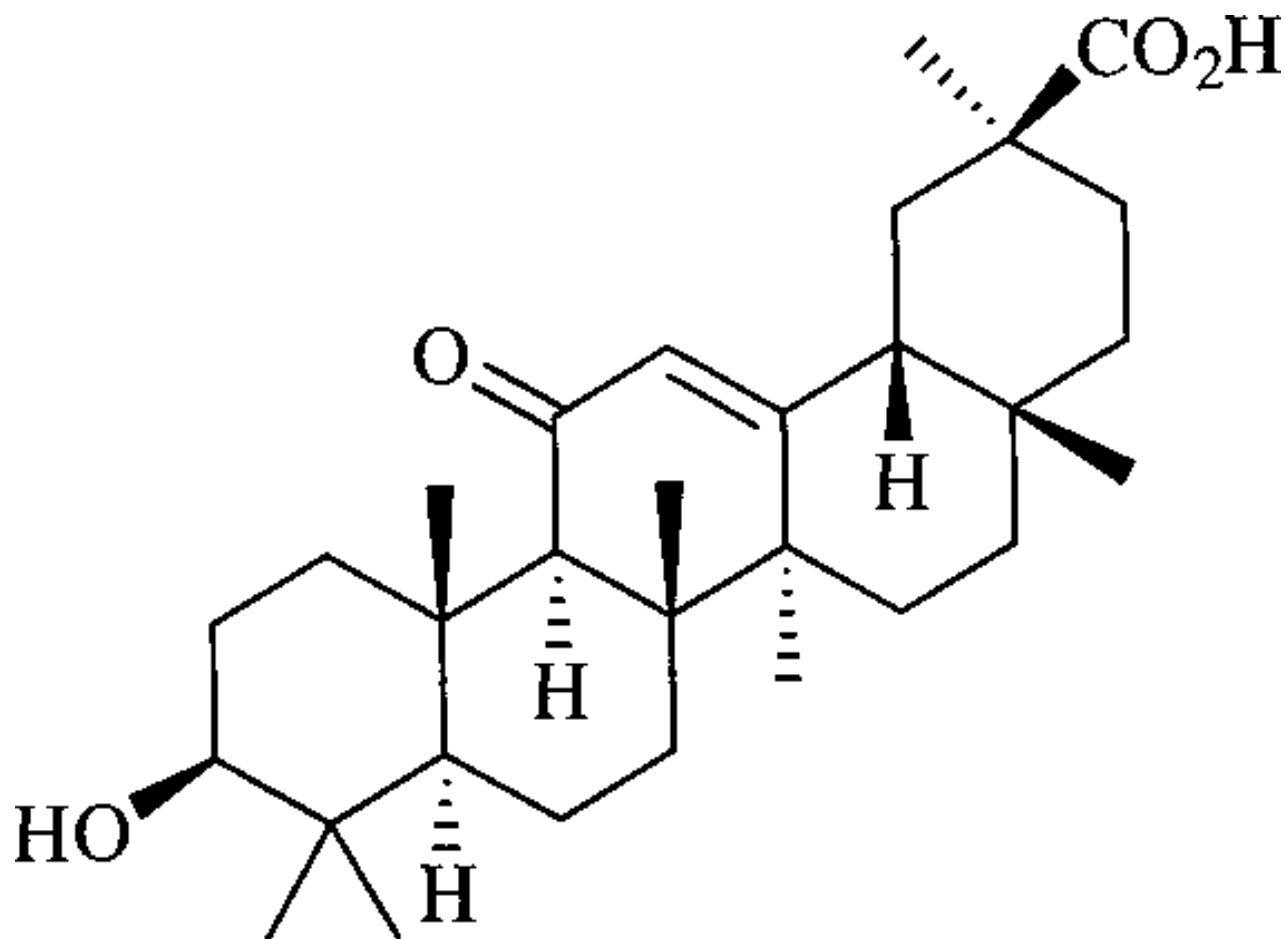
Taxol (diterpene)



Triterpenes

- Have C_{30} skeleton and (often) four condensed rings
- Examples: steroids, glycyrrhetic acid from liquorice and resins

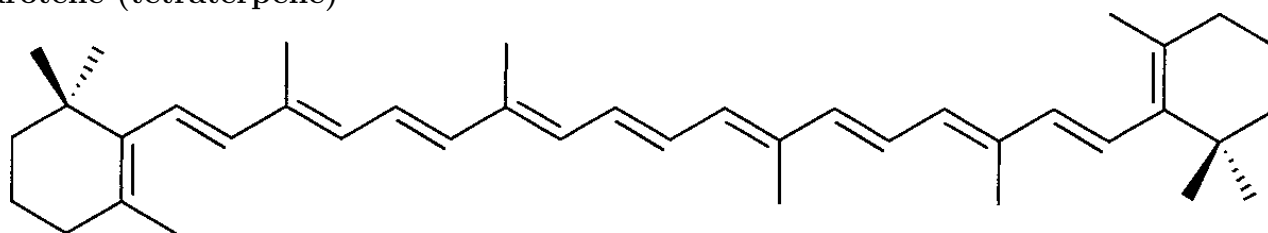
Glycyrrhetic acid (triterpene)



Tetraterpenes

- Have C₄₀ skeleton and four condensed rings
- Carotenes, like β -carotene from carrot and lycopene from tomato

β -carotene (tetraterpene)

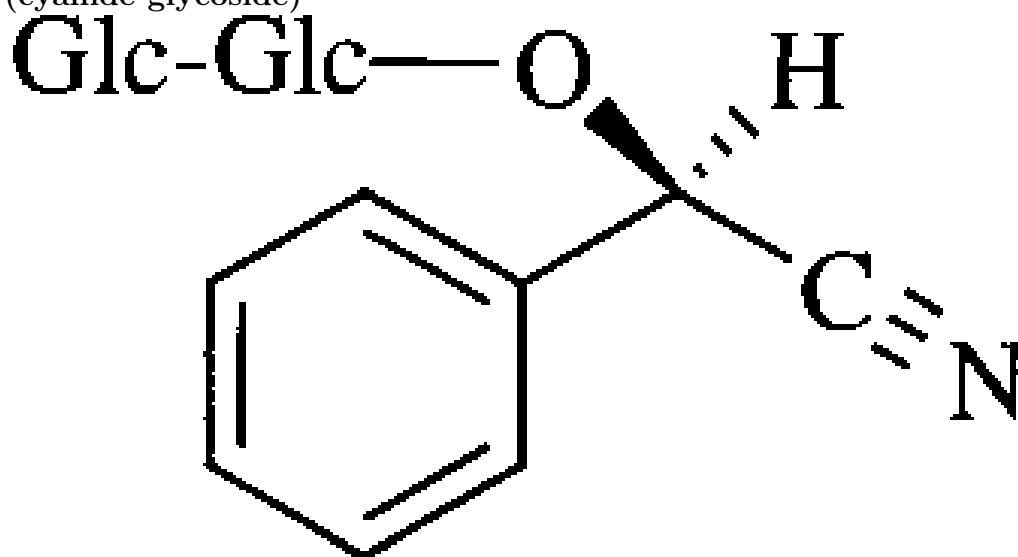


8.1 Glycosides

Glycosides I

- Glycosides are any radicals binded to monosaccharides
- Cyanide glycosides have HCN (cyanide group)
- Example: amygdalin from almond
- Glucosinolates contain allyl isothiocyanate group
- Example: mustard oils of cabbage family plants

Amygdalin (cyanide glycoside)

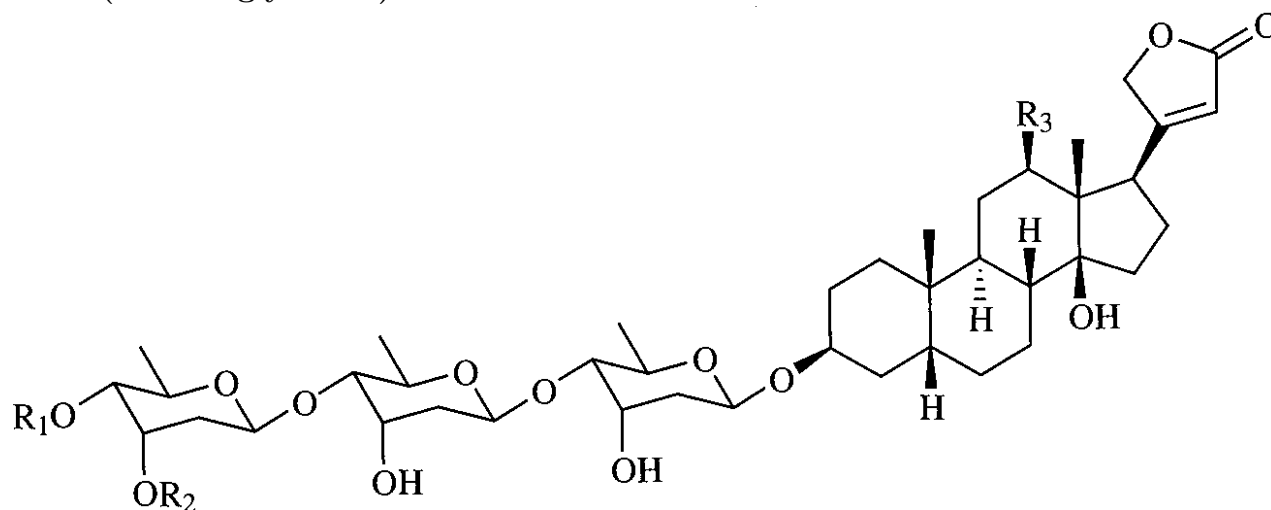


Amygdalin (Glc = glucose)

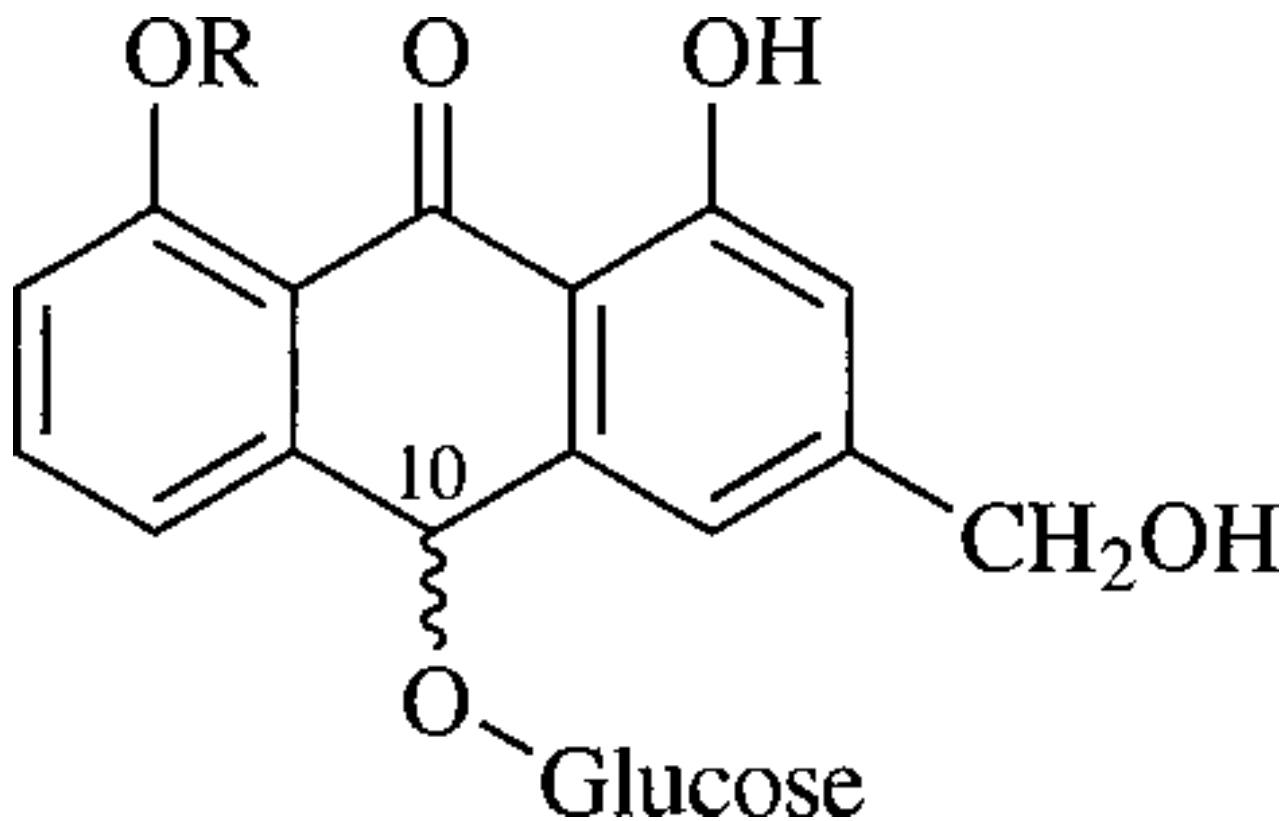
Glycosides II

- Cardiac glycosides are “steroid-like”
- Example: digotoxin from foxglove (*Digitalis*)
- Anthraquinone glycosides contain anthraquinone nucleus (3-ring system)
- Examples: aloin from *Aloë*, cascarioside from cascara (*Rhamnus purchiana*); often laxative

Digitoxin (cardiac glycoside)



Aloin (anthraquinone glycoside)



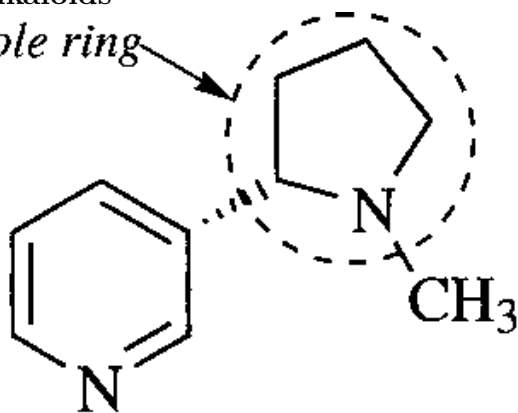
8.2 Alkaloids

Alkaloids I

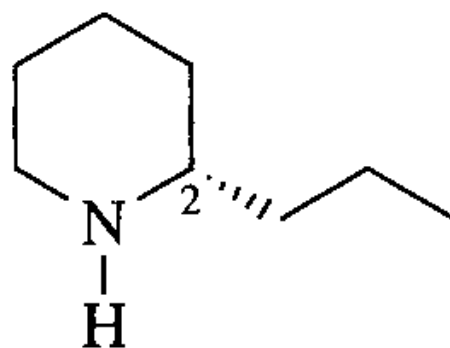
- Alkaloids are most important pharmaceutical components from plants
- They are based on heterocyclic rings and related to nucleic bases
- Pyridine-like alkaloids are based on pyridine ring
- Examples: nicotine, coniine from hemlock

Pyridine alkaloids

pyrrole ring



Nicotine

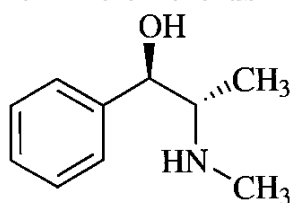


Coniine

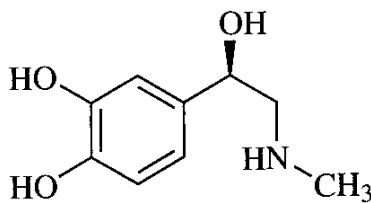
Alkaloids II

- Phenylalkamine alkaloids are amines, not heterocycles
- Ephedrine which is similar to adrenaline; hallucinogenic mescaline from peyote cactus (*Lophophora williamsii*); dangerous colchicine from autumn crocus (*Colchicum*)
- Quinoline and isoquinoline alkaloids contain more than two rings
- Famous group: quinine from *Cinchona* tree; morphines from opium poppy; tubocurarine, main component of curare poison from *Chondrodendron*; emetine from ipecac (*Caephaelis*)

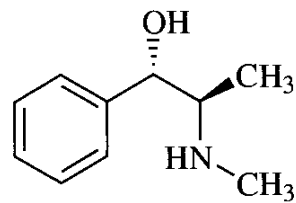
Phenylalkamine alkaloids



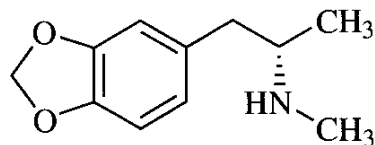
(-)-Ephedrine



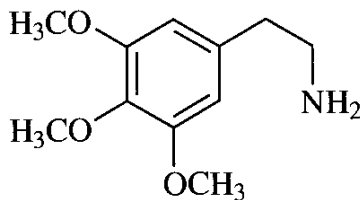
Adrenaline



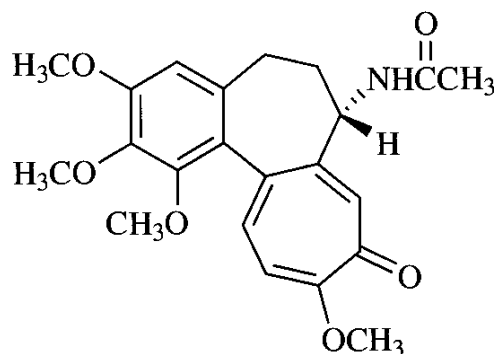
(+)-Pseudoephedrine



MDMA (ecstasy)

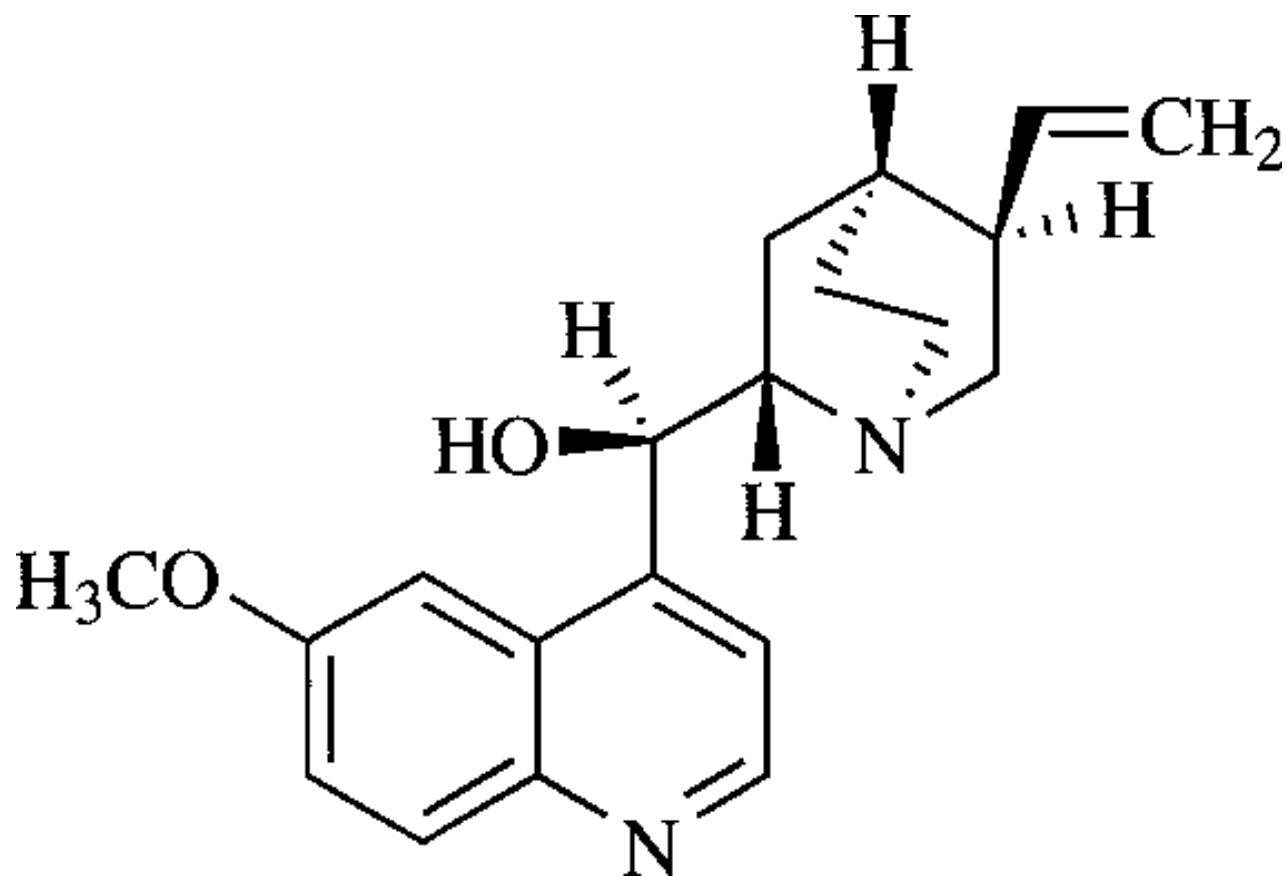


Mescaline

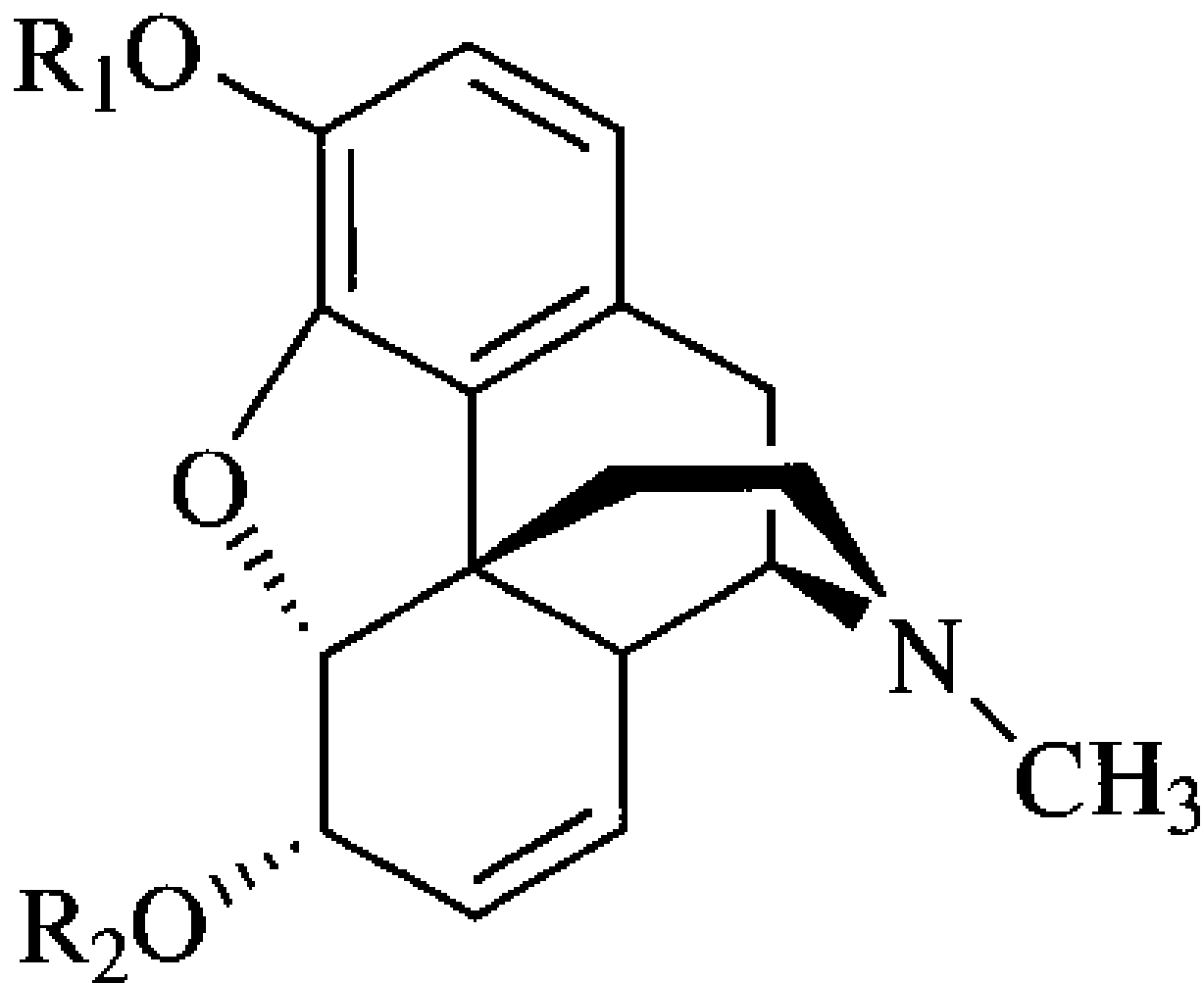


Colchicine

Quinine (quinoline alkaloid)



Morphine (isoquinoline alkaloid)



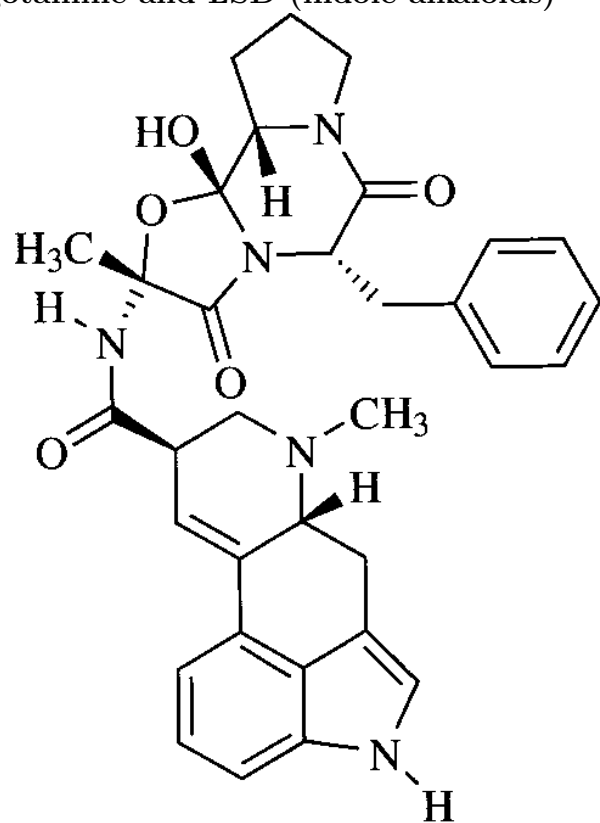
Morphine, $R_1 = R_2 = H$

Heroin, $R_1 = R_2 = \text{acetyl}$

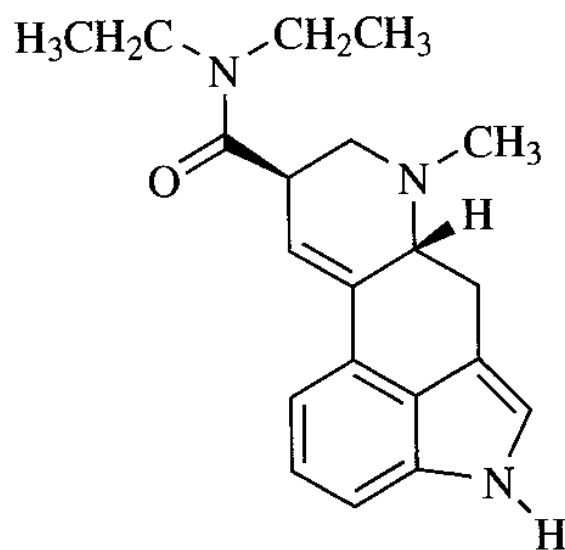
Alkaloids III

- Indole alkaloids contain connecting nitrogen atom
- Examples: reserpine from snake root (*Rauwolfia*), LSD which is a chemical analog of ergotamine from ergot fungus which is a rye parasite; brucine which is a powerful poison from nux-vomica (*Strychnos*).
- Tropane alkaloids contain tropane “chair”
- Examples: hyosciamine from deadly nightshade (*Atropa*) and cocaine from *Erythroxylon*
- Xanthine alkaloids are derivatives of xanthine (with two ketone groups)
- Examples: caffeine, theophylline, theobromine from coffee, tea and cocoa, respectively

Ergotamine and LSD (indole alkaloids)

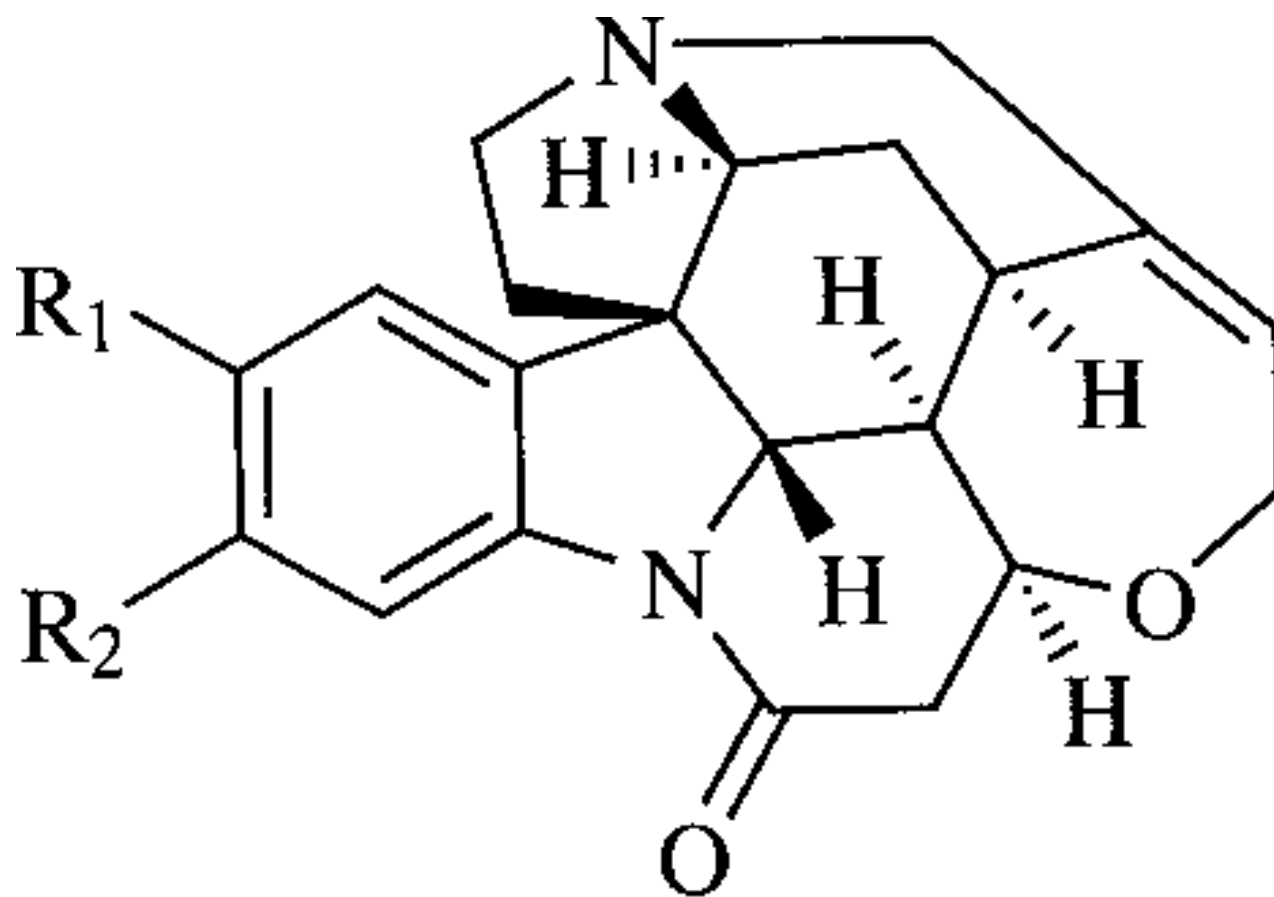


Ergotamine



LSD (Lysergic acid diethylamide)

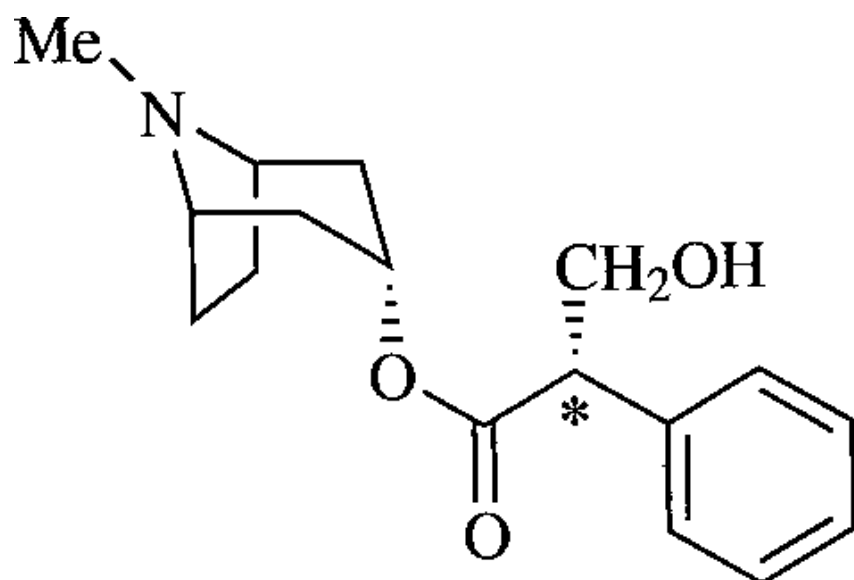
Brucine (indole alkaloid)



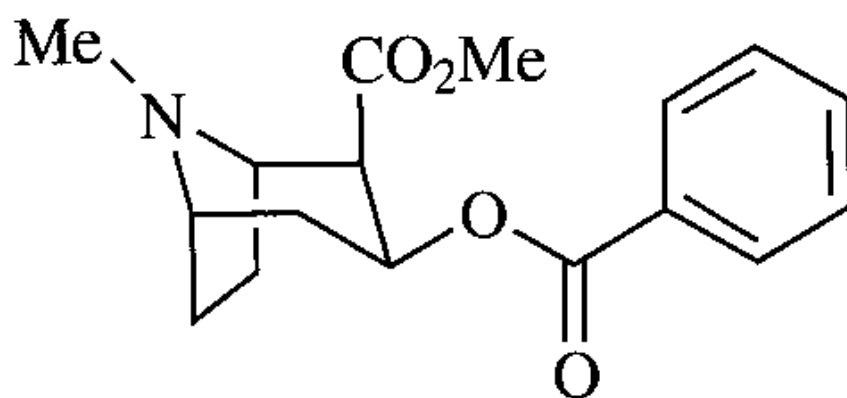
Strychnine, $R_1 = R_2 = H$

Brucine, $R_1 = R_2 = CH_3O$

Tropane alkaloids

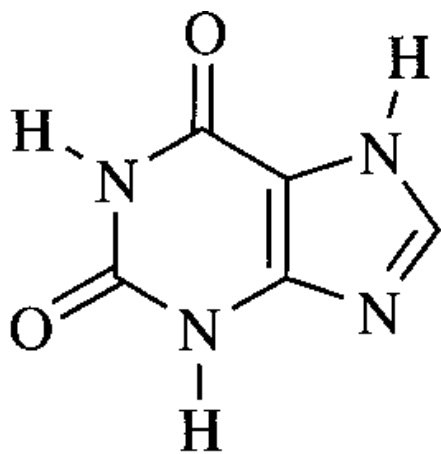


(-)-Hyoscyamine

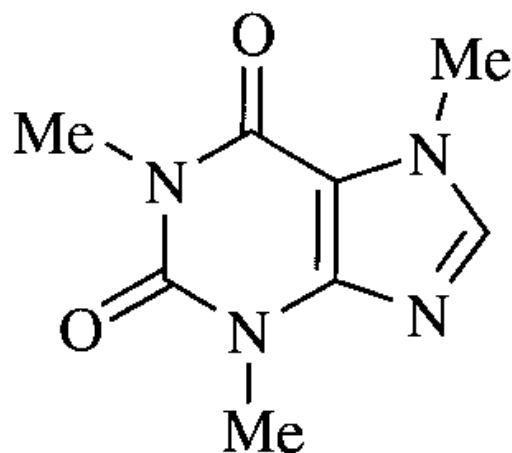


Cocaine

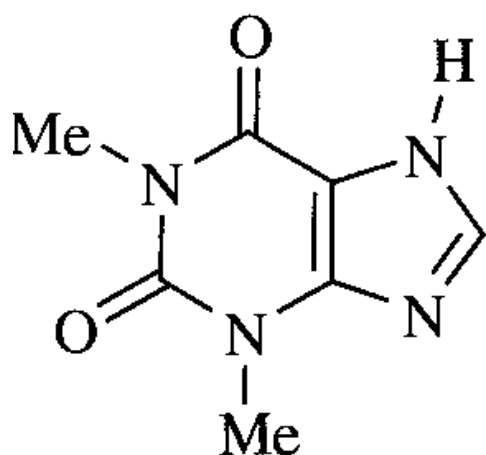
Xanthine alkaloids



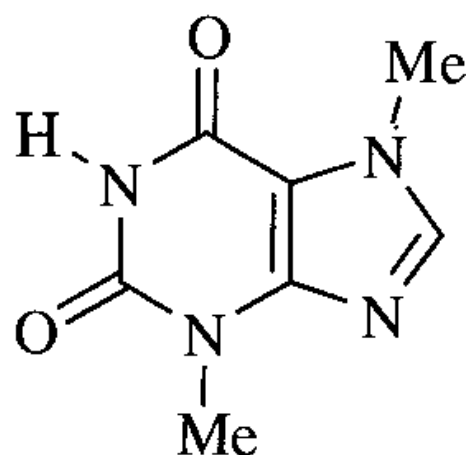
Xanthine



Caffeine



Theophylline



Theobromine

Summary

- Derivatives of shikimic acid are phenylpropenes, lignans, coumarins, flavonoids and tannins
- All terpenes (including carotenes, steroids and resins) are derivatives of isoprene
- Glycosides is an artificial group
- Alkaloids are relatives of nucleic bases; they are most important plant chemicals

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310
- [2] Heinrich et al. 2012. *Fundamentals of Pharmacognosy and Phytotherapy*. Churchill Livingstone, Edinburgh.

Outline

9 Traditional systems of herbal medicine

9.1 Basic aspects

Western medicine

- Developed with the evolution of Western science, based on strict and positive scientific evidence, experiments and statistical analysis
- For the long time, Western science ignored other branches of human medicine

Main non-western medicines

- Traditional Chinese medicine (TCM)
- Ayurveda
- Traditional African medicine
- Traditional American medicinal practices

Some general aspects

- Healing in traditional systems is mostly applicable to minor disorders
- Chronic and serious disorders often considered to be a “super-natural”
- Dose is not calculated
- Too powerful chemicals are not usually used
- There is a strong, but not absolute correlation between traditional and Western systems

9.2 Traditional Chinese medicine (TCM)

Traditional Chinese medicine (TCM)

- Started more than 3,000 BC
- Based on specific philosophy
- Uses a large variety of plants, mushrooms, animals (!) and other biological compounds

TCM history

- Started to develop in relation with Taoism and based on philosophical principle of yin and yang
- Knowledge transferred from religion (shamans) to philosophers
- In Han times (200 BC – 200 AD) Zhang Zhongjing invented acupuncture
- In Min dynasty times (≈ 1550) Li Shizhen produced the herbal encyclopedia Ben Cao Gang Mu (52 volumes)

Zhang Zhongjing (150–219)



Acupuncture map

世宗本紀





Ben Cao Gan Mu volumes



TCM concepts

- Qi (or chi) is a source of life energy (yuan qi)
- Yin and yang interactions and five elements (heart/fire, liver/wood, spleen/earth, lungs/metal and kidneys/water)
- Six excesses: wind, cold, summer heat, dampness, dryness and fire
- Seven emotions (internal causes of diseases): joy, anger, anxiety, concentration, grief, fear, fright

Diagnosis in TCM

- Based on observation of **external** characters and interview
- Normally, tongue and pulse are observed, then massage and palpation help to obtain an information

Treatment

- Purpose is to rectify harmony
- For every cause, “antidote” with alternative features should be used
- E.g., for cold TCM uses “warm” herbs as ginger

Qingping market, Guangzhou: plants



Qingping market, Guangzhou: gin seng



Qingping market, Guangzhou: animals



Kampo

- Japanese variant of TCM, started in ≈ 600 AD
- Based on acupuncture and herbs
- Pharmacopoeia contains ≈ 170 herbs and mushrooms

9.3 Traditional Indian medicine

Ayurveda

- System of sacred Hindu medicine
- Started 3,000 BC

Ayurveda principles

- Every patient is an individual
- Greatly values subjectivity
- Similarly to TCM, consider human as microcosm which should be rectified and balanced

Ayurveda basics

- Five elements (similar to TCM)
- Three humors of life: vata (air/movement), pitta (fire and water/heat energy), kapha (water and earth/structure)
- Agni (digestive fire) is essential pitta

Ayurveda diagnosis and treatment

- Malas (waste products) are important for the diagnosis
- Diagnosis also involves astrology and karma analysis
- Treatment is based on the idea of cleaning
- Among herbal remedies, rasayana plants (among them, there are amla *Emblica officinalis* and ashwagandha *Withania somnifera*) are most useful

Durga bears remedies



Amla, *Phyllanthus officinalis* (Euphorbiaceae)



Unani

- Close to Ayurveda
- Urdu (Pakistan and India), Arab and Persian traditional medicine
- Avicenna (Ibn Sina from contemporary Uzbekistan) established its main principles which went farther to Europe after translation of Arab books

Avicenna (Ibn Sina, 980–1037)



Summary

- Traditional Chinese medicine and other non-Western system are holistic (wholesome) approaches
- The goal of traditional healing is to restore a harmony
- These medicines are based on a extensive using of herbs

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310

[2] Heinrich et al. 2012. *Fundamentals of Pharmacognosy and Phytotherapy*. Churchill Livingstone, Edinburgh.

Outline

10 Traditional systems of herbal medicine

10.1 Traditional African systems

Traditional African systems (TAMS)

- Multiple systems, often independent and unrelated
- Zulu (South Africa) and Yoruba (Nigeria) traditions are best known

TAMS concepts

- Every living thing, gods and ancestral spirits are connected
- Disharmony in these connections will cause a disease
- Invisible insects and worms may start to inhabit human body and also cause disease

TAMS diagnosis and treatment

- Diagnosis involve religious practices
- Plant remedies are often not taken, but used as amulet or even without contact with patient

Sangoma healers, South Africa



10.2 Traditional American systems

Traditional American medical systems

- Multiple, often unrelated and non-standardized practices
- Have a big ceremonial component related with shamanism
- Tribal women are most important carriers of medicine information

Eskimo medicine man



Shaman dance



11 Complementary and alternative medicine (CAM)

11.1 Introduction

CAMs

- Whole medical systems such as homeopathy, naturopathy, TCM, and Ayurveda
- Mind-body medicine such as meditation, prayer, mental healing, art therapy, music therapy, and dance therapy
- Biologically based practices such as dietary supplements, herbal supplements, and other scientifically unproven therapies such as shark cartilage
- Manipulative and Body-Based Practices such as spinal manipulation (both chiropractic and osteopathic) and massage
- Energy therapies such as qi gong, reiki, therapeutic touch, and electromagnetic therapy

Alternative approaches used plants

- Medical herbalism

- Homeopathy
- Antroposophical medicine
- Aromatherapy
- Flower remedy therapy
- Naturopathy
- Orhtomolecular medicine

11.2 Herbalism

Medical herbalism

- Based on pre-scientific traditions of European cultures
- Holistic approach, similar to Eastern practices

Conditions treated

- Normally, chronic conditions which are not treated well in common medicine
- Eczema, arthritis, depression, migraine, PMS and others

Differences from rational phytotherapy

- Typically, combination of 4–6 herbs (assumes synergy)
- Most of remedies are taken as tinctures
- There is a flow of information between phytotherapy and herbalism

11.3 Homeopathy

Homeopathy

- Samuel Hahnemann (Germany, 1755–1843) founded homeopathy
- “Likes cures like”
- Always minimal dose and extremely high dilutions!
- One remedy at a time

Samuel Hahnemann (1755–1843)



Modern homeopathy

- They believe in stimulating of body's own "vital force"
- "Vital force" is strongly individual

Remedies

- Highly diluted (and poisonous when undiluted)
- 65% originates from plants

Evidence

- Despite of hundreds of trial, results are still controversial
- Some experiments on “water memory” provided the support for dilution theory, but scientific value of these experiments is also dubious

“Nature” publication of Benveniste group (1988)



The screenshot shows the Nature journal website interface. At the top is the 'nature' logo with the tagline 'International weekly journal of science' and a search bar. Below the logo, there is an 'Access' section with a red banner stating: 'To read this story in full you will need to login or make a payment (see right)'. A breadcrumb trail reads: 'Journal home > Archive > Scientific Paper > Full Text'. The main title of the article is 'Scientific Paper'. Below this, the citation information is displayed: 'Nature 333, 816-818 (30 June 1988) | doi:10.1038/333816a0; Received 24 August 1987'. The article title is 'Human basophil degranulation triggered by very dilute antiserum against IgE'. The authors listed are E. Davenas, F. Beauvais, J. Amara*, M. Oberbaum, B. Robinson†, A. Miadonnai‡, A. Tedeschi‡, B. Pomeranz§, P. Fortner§, P. Belon, J. Sainte-Laudy, B. Poitevin & J. Benveniste^{||}. On the right side, there is an 'ARTICLE TOOLS' section with a list of options: 'Send to a friend', 'Export citation', 'Export references', 'Rights and permissions', 'Order commercial reprints', and 'Bookmark in Connotea'.

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Scientific Paper

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11.4 Anthroposophy

Anthroposophical medicine

- Rudolf Steiner (Germany, 1861–1925) founded anthroposophy and related medicine approach
- Three functional systems: sense-nervous, reproductive-metabolic and rhythmic
- Popular in Germany, Austria and other continental Western European countries

Rudolf Steiner (1861–1925)



Conditions treated

- The approach is therapeutic, but sometimes used for supportive treatments of serious diseases like cancers
- Several German hospitals practice anthroposophical medicine

Antroposophic medicines

- Normally are combinations of plant components (often diluted) and minerals
- Mistletoe from different trees is a source of common drug “Isador”
- Plants should be specifically grew in accordance to anthroposophic “biodynamic farming”

Mistletoe, *Viscum album*, Santalaceae



11.5 Aromatherapy

Aromatherapy

- Rene-Maurice Gattefosse (French perfumer, 1881–1950) is a founder of aromatherapy
- Main idea is that essential oils could be used to provide general well-being
- Aromas are prescribed holistically, in terms of “energy” etc.

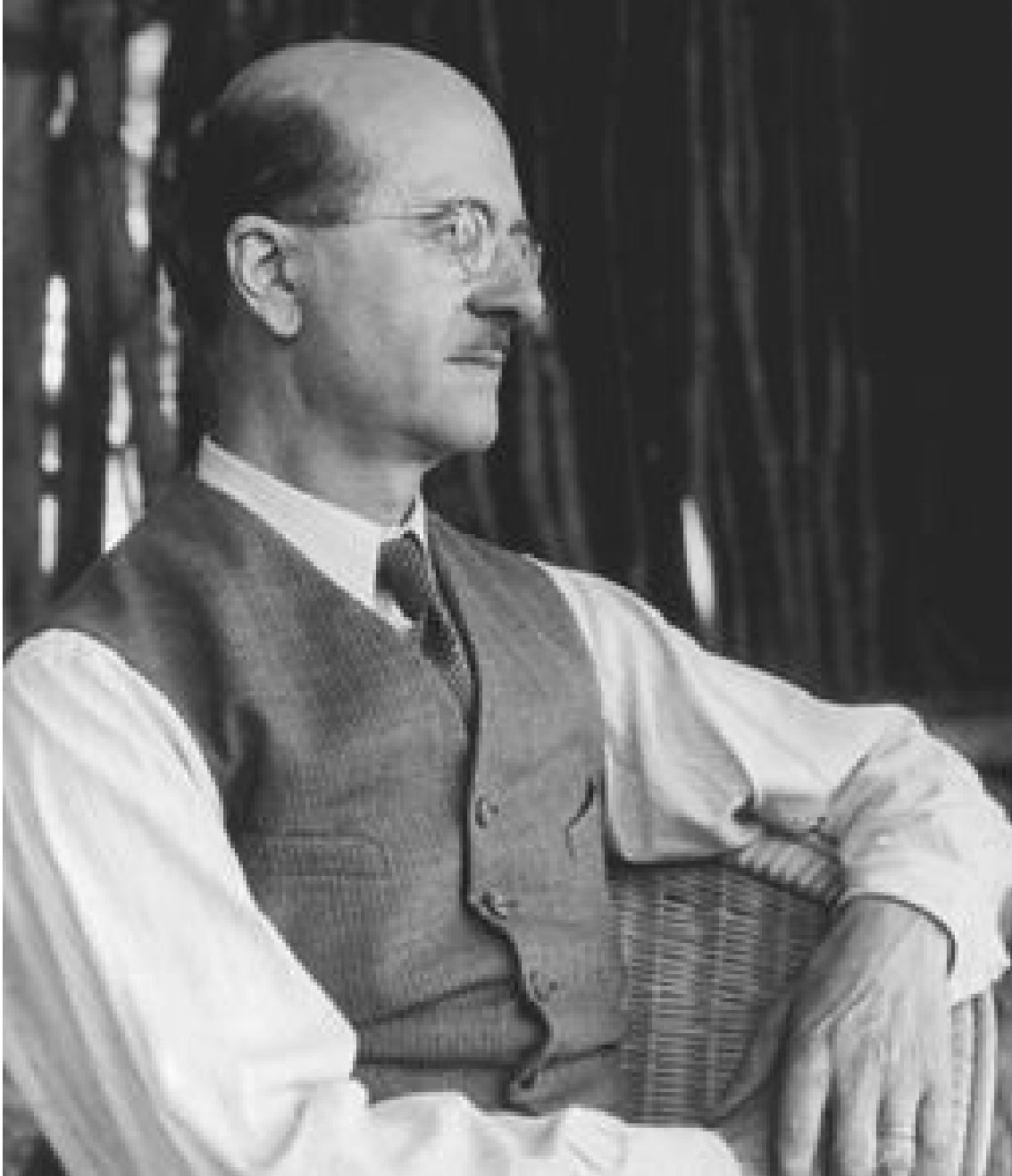
Conditions treated

- All conditions which require relaxation
- Skin diseases, different chronic disorders etc.

Aromatherapy medicines: essential oils

- Used in combinations
- Mostly by massage, but also by baths, inhalations, compresses and other external ways

Rene-Maurice Gattefosse (1881–1950)



Efficacy

- Sometimes work in relation with conventional phytotherapy
- However, most of uses were not proved scientifically

11.6 Other CAMs

Flower remedy therapy

- Edward Bach (UK, 1886–1936) invented the idea of flower remedies
- Every remedy is a flower extract which is supposed to heal specific condition

Edward Bach (1886–1936)



Remedies

- Whole flowers which are dried and/or boiled to prepare tincture or water essence
- Single species are used in majority of cases

Efficacy

- Nothing has been proved scientifically
- Requires future research

Naturopathy

- Founded by Sebastian Kneipp in 1850s
- Combination of “natural”, “organic” methods of medicine including herbalism
- Similarly to other practices, individualistic and holistic
- Includes, for example, hydrotherapy (Vincenz Priessnitz, ca. 1820) and cryotherapy

Sebastian Kneipp (1821–1897)



Orhtomolecular medicine

- Founded by Linus Pauling in 1960s
- In particular, it is a belief that over-large doses of some supplements (like vitamin C) may treat diseases

CAM in USA

- There are multiple accredited schools of CAM
- National Center for Complementary and Alternative Medicine focuses on research and integration of CAM techniques and practices

Summary

- The goal of traditional healing is to restore a harmony; these medicines are based on a extensive using of herbs
- Alternative medicine approaches are also widely using different herbal remedies; however, efficiency for most of these methods has not been scientifically proved

For Further Reading

References

- [1] A. Shipunov. *Ethnobotany* [Electronic resource]. 2011—onwards. Mode of access: http://ashipunov.info/shipunov/school/biol_310
- [2] Heinrich et al. 2012. *Fundamentals of Pharmacognosy and Phytotherapy*. Churchill Livingstone, Edinburgh.

Also, check out all presentation slides.