

Ethnobotany. Lecture 26

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Outline

Natural product chemistry

Glycosides

Alkaloids

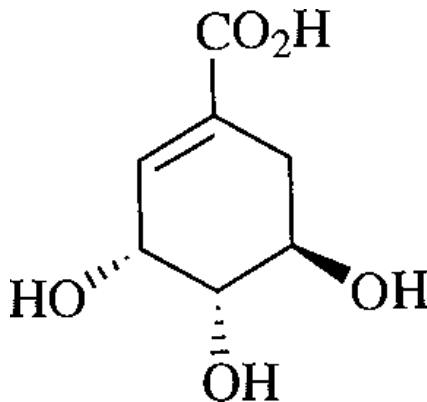


Shikimic acid and derived products

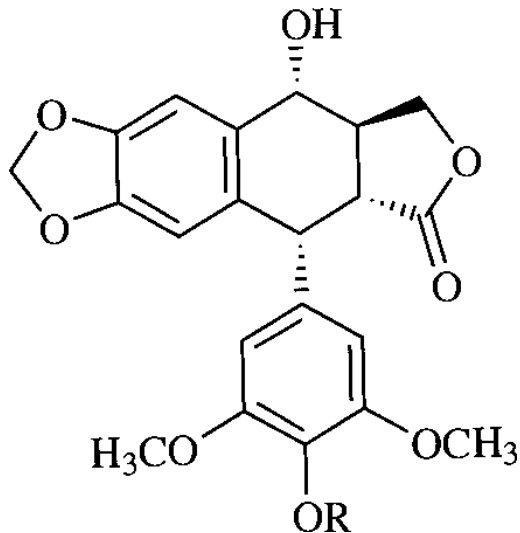
- ▶ Phenylpropenes, like eugenol
- ▶ Lignans like podophyllotoxin



Shikimic acid



Podophyllotoxin

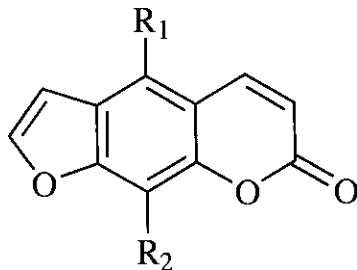


Coumarins

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



Psoralen

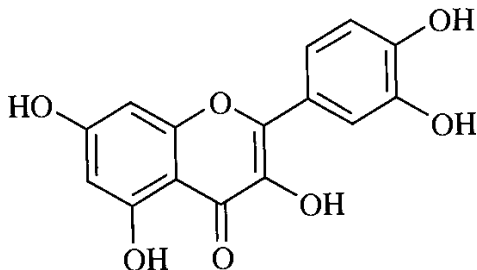


Flavonoids

- ▶ 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

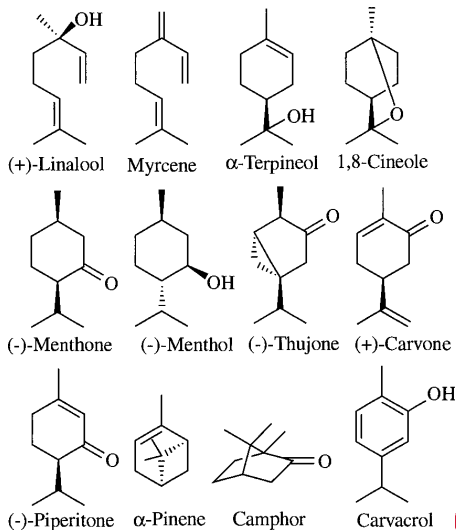
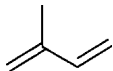


Terpenes and monoterpenes

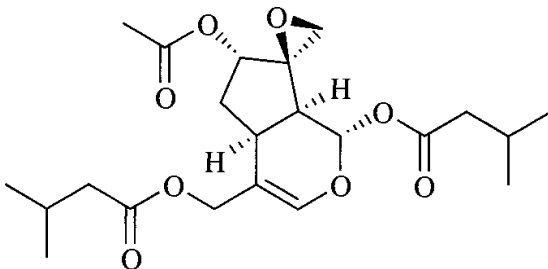
- ▶ Terpenes = isoprenoids, derivatives of isoprene (C_5 unit)
- ▶ Monoterpenes are simplest, they are constituents of volatile (essential) oils
- ▶ Examples: menthol from mint, myrcene from *Eucalyptus*, camphor, iridoids like valepotriates from valerian



Isoprene and monoterpenes



Didrovaltrate (iridoid)

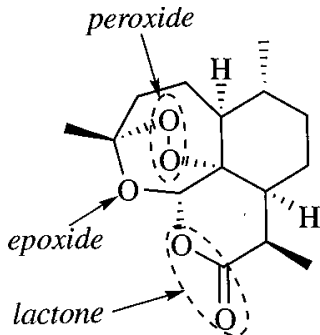


Sesquiterpenes

- ▶ Have C₁₅ skeleton
- ▶ Example: artemisinin from sage



Artemisinin (sesquiterpene)

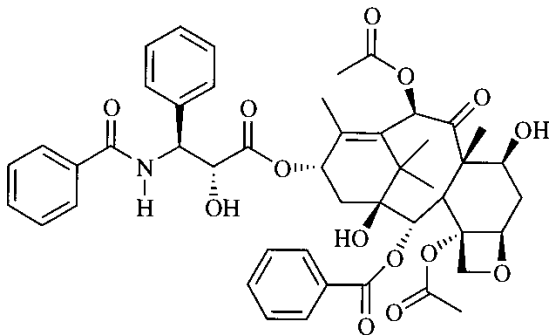


Diterpenes

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



Taxol (diterpene)

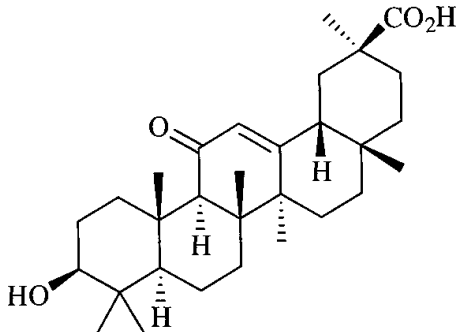


Triterpenes

- ▶ Have C₃₀ skeleton and (often) four condensed rings
- ▶ Examples: steroids, glycyrrhetic acid from liquorice and resins



Glycyrrhetic acid (triterpene)

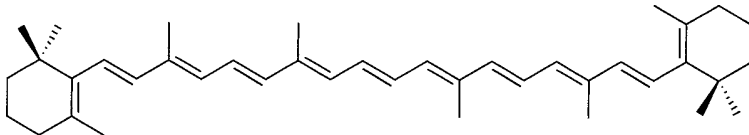


Tetraterpenes

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



β -carotene (tetraterpene)



Natural product chemistry

Glycosides

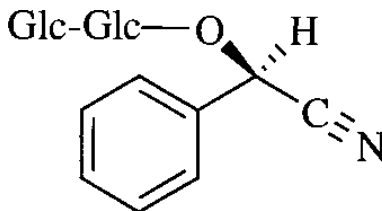


Glycosides I

- ▶ 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)

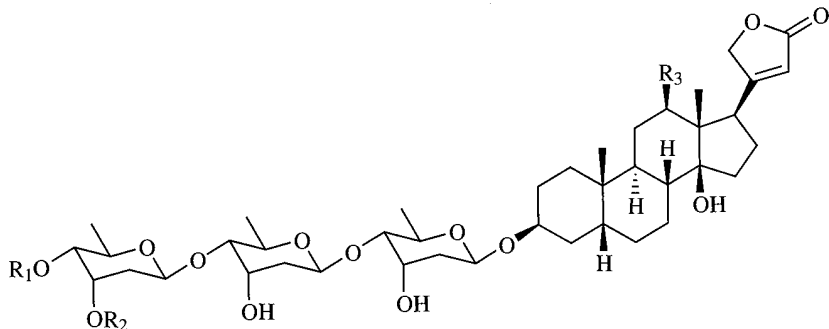


Glycosides II

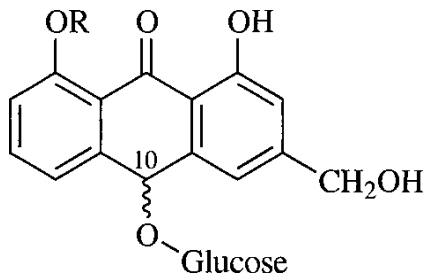
- ▶ Cardiac glycosides are “steroid-like”
- ▶ Example: digotoxin from foxglove (*Digitalis*)
- ▶ Anthraquinone glycosides contain anthraquinone nucleus (3-ring system)
- ▶ Examples: aloin from *Aloë*, cascarioside from cascara (*Rhamnus purchiana*); often laxative



Digitoxin (cardiac glycoside)



Aloin (antraquinone glycoside)



Natural product chemistry

Alkaloids

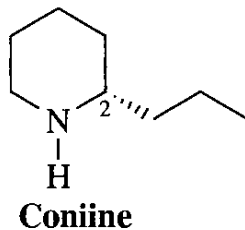
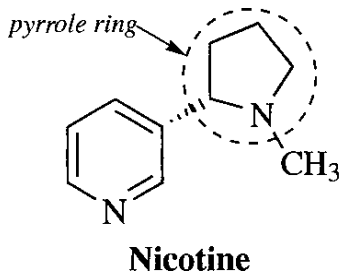


Alkaloids I

- ▶ 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, coniin from hemlock



Pyridine alkaloids

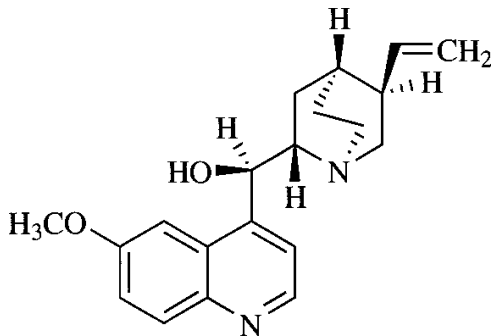


Alkaloids II

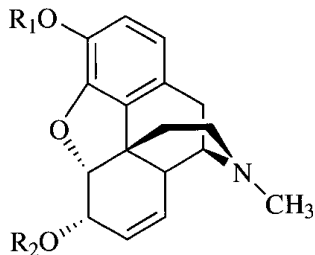
- ▶ Phenylalkamine alkaloids are amines, not heterocycles
- ▶ Ephedrine which is similar to adrenaline; hallucinogenic mescaline from peyote cactus (*Lophophora williamsii*); dangerous colchicine from autumn crocus (*Colchicum*)
- ▶ Quinoline and isoquinoline alkaloids contain more than two rings
- ▶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



Quinine (quinoline alkaloid)



Morphine (isoquinoline alkaloid)



Morphine, $R_1 = R_2 = H$

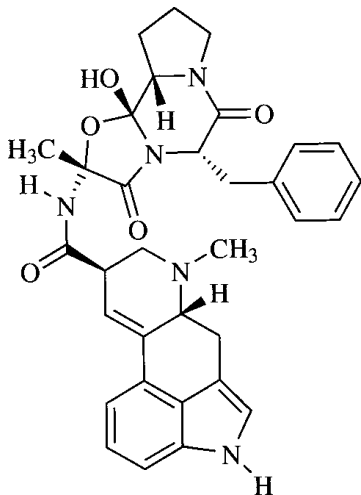
Heroin, $R_1 = R_2 = \text{acetyl}$

Alkaloids III

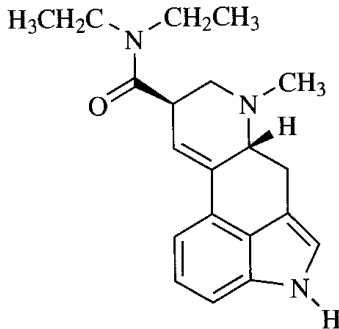
- ▶ Indole alkaloids contain connecting nitrogen atom
- ▶ Examples: reserpine from snake root (*Rauvolfia*), LSD which is a chemical analog of ergotamine from ergot fungus which is a rye parasite; brucine which is a powerful poison from nux-vomica (*Strychnos*).
- ▶ Tropane alkaloids contain tropane “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)



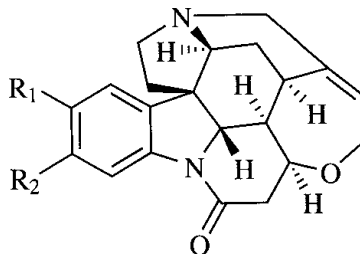
Ergotamine



LSD (Lysergic acid diethylamide)



Brucine (indole alkaloid)

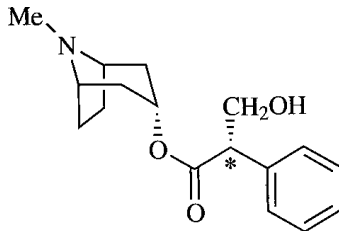


Strychnine, $R_1 = R_2 = H$

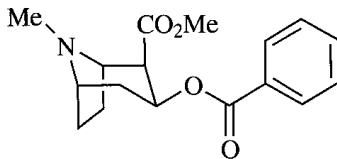
Brucine, $R_1 = R_2 = CH_3O$



Tropane alkaloids



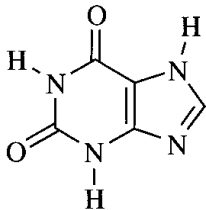
(-)-Hyoscyamine



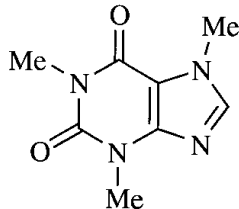
Cocaine



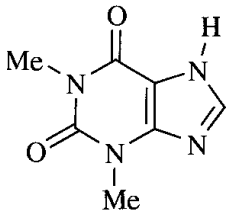
Xanthine alkaloids



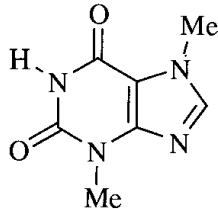
Xanthine



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



A. Shipunov.

Ethnobotany [Electronic resource].

2011—onwards.

Mode of access:

http://ashipunov.info/shipunov/school/biol_310



Heinrich et al. 2012.

Fundamentals of Pharmacognosy and Phytotherapy.

Churchill Livingstone, Edinburgh.

