The Buzz About Bugs

A Gentle Introduction to the Chemistry of Insects – and Plants

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Why “Chemistry of Insects and Plants”?

Hawkmoth

Ten-lined June beetle

About 50 % of all the insects are herbivores (eat plant materials).

Plant Perspective

Plants are autotrophs …

Photosynthesis:

$$6\ CO_2 + 6\ H_2O \xrightarrow[\text{light}]{\text{chlorophyll}} C_6H_{12}O_6 + 6\ O_2$$

Plant Perspective

Attracting Insect Pollinators

with smells, colors, offering nectar, pollen

Plant Perspective

Attracting Insect Pollinators

with Smells from Flowers

Long-distance communication

There are sweet-smelling flowers, - and stinky flowers…

Plant smells

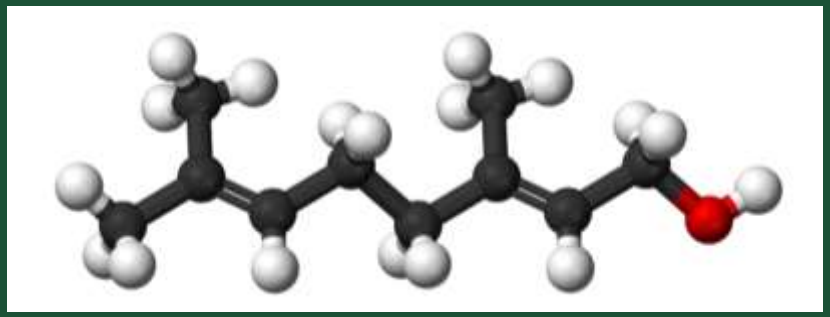
contain

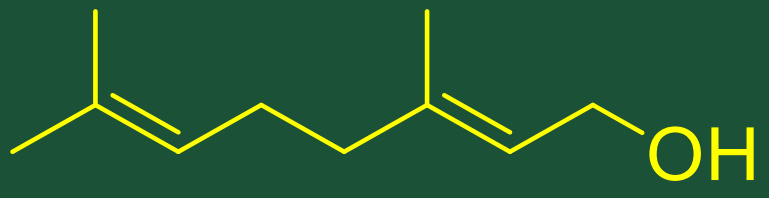
many different **organic compounds** **that**

Evaporate easily (*i.e.* are **volatile**), especially on a warm day

- Relatively low number of C's (up to about 12)
- Mostly nonpolar, *i.e.* do not dissolve in water

Example: Geraniol $C_{10}H_{18}O$





Plant Perspective

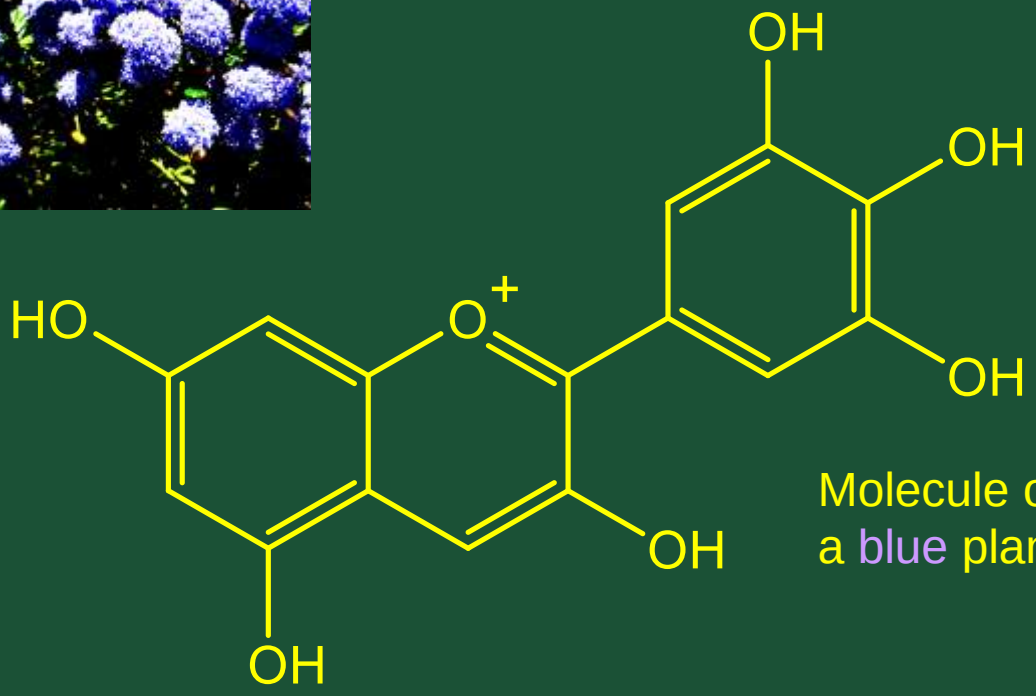
Attracting Insect Pollinators
With Colorful Flowers

Plant Perspective

Colorful Flower Pigments

Introduction to the Chemistry of Color

Anthocyanins



Molecule of delphinidine, a blue plant pigment

- Molecules in plant pigments are larger than in plant scents,
- have conjugated double bonds (alternating single bond –double bond patterns)

Plant Perspective

Attracting Insect Pollinators

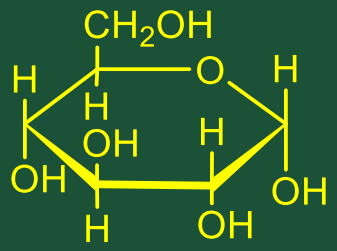
Yellow mariposa lily

with Nectar in Flowers

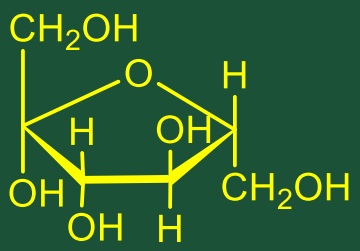
Leichtlin’s mariposa lily

Composition of nectar:
Sugars, amino acids,…

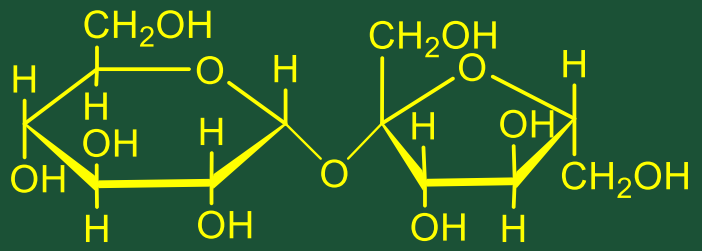
Introduction to Sugars (Carbohydrates)



Glucose



Fructose



Sucrose

Matilija poppy
(*Romneya* sp.)

Plant Perspective

Attracting Insect Pollinators

with Pollen

Pollen contains:

male gametes

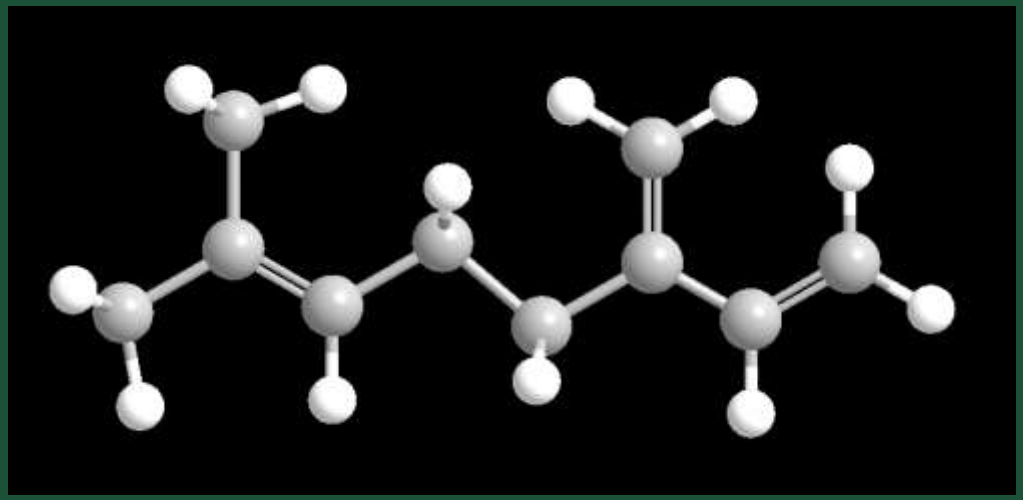
starch
(a polymeric carbohydrate)

proteins
(polymeric, with amino acid monomers)

California Bay Tree

Plant Perspective

Plants Keeping Insects Away
with strong smells in leaves

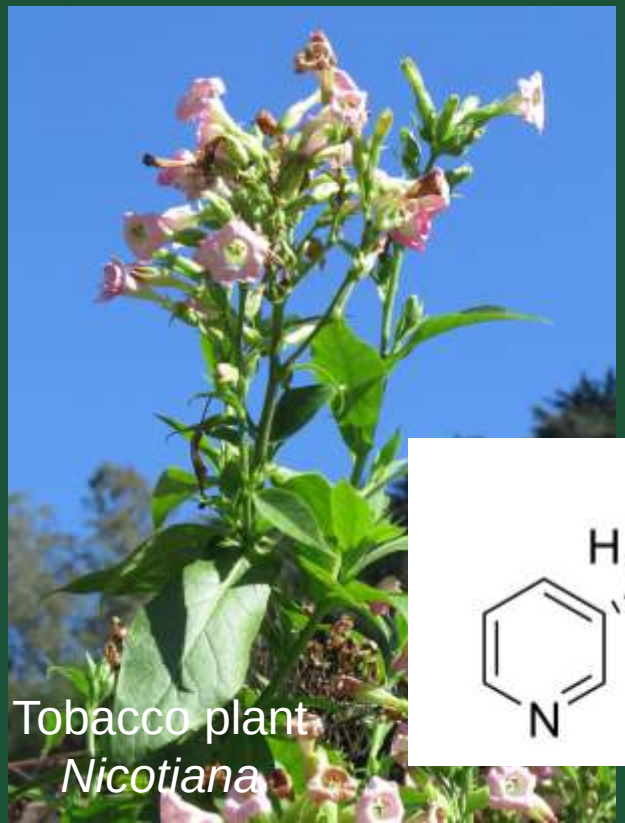


Myrcene $C_{10}H_{16}$

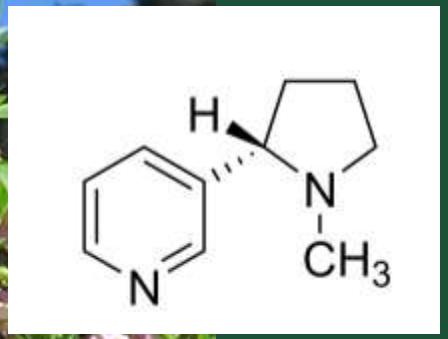
Plants Keeping Insects Away

with Plant Poisons

Jimson weed
Datura wrightii



Tobacco plant
Nicotiana



Nicotine
an alkaloid

Insect Perspective

May beetle, cockchafer
(*Melolontha* sp.)

Insects Are Heterotrophs

(unlike plants which are autotrophs)

May beetle, cockchafer
(*Melolontha* sp.)

Insects Getting Food from Plants

Herbivores (“phytophagous”)

Generalists and Specialists…

Fossilized leaf from a Cretaceous forest, with insect feeding damage

(Cretaceous: 145 – 66 mya)

Photo by Dori Lynne Contreras

Pea aphid

What Nutrients Do Insects Need?

Similar to animals and humans:

- Carbohydrates
- Essential amino acids
- Vitamins
- Minerals
- Water

What Nutrients Do Insects Need?

Similar to animals and humans:

Carbohydrates

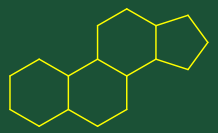
Essential amino acids

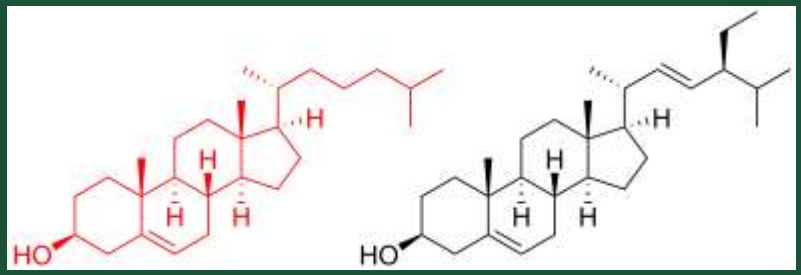
Vitamins

Minerals

Water

Special: Need to ingest
Cholesterol or similar steroids





Plants are a poor source!

Insects can synthesize most fats

How Do Insects Find Food…?

Chemistry! (Smell, taste ..)

Ten-lined June beetle
(*Polyphylla decemlineata*)

Cabbage White butterfly

attracted by glucosinolates in Swiss chard

Chemistry of Insects:

Bodies of chitin

Insects communicating: Pheromones

Insect hormones

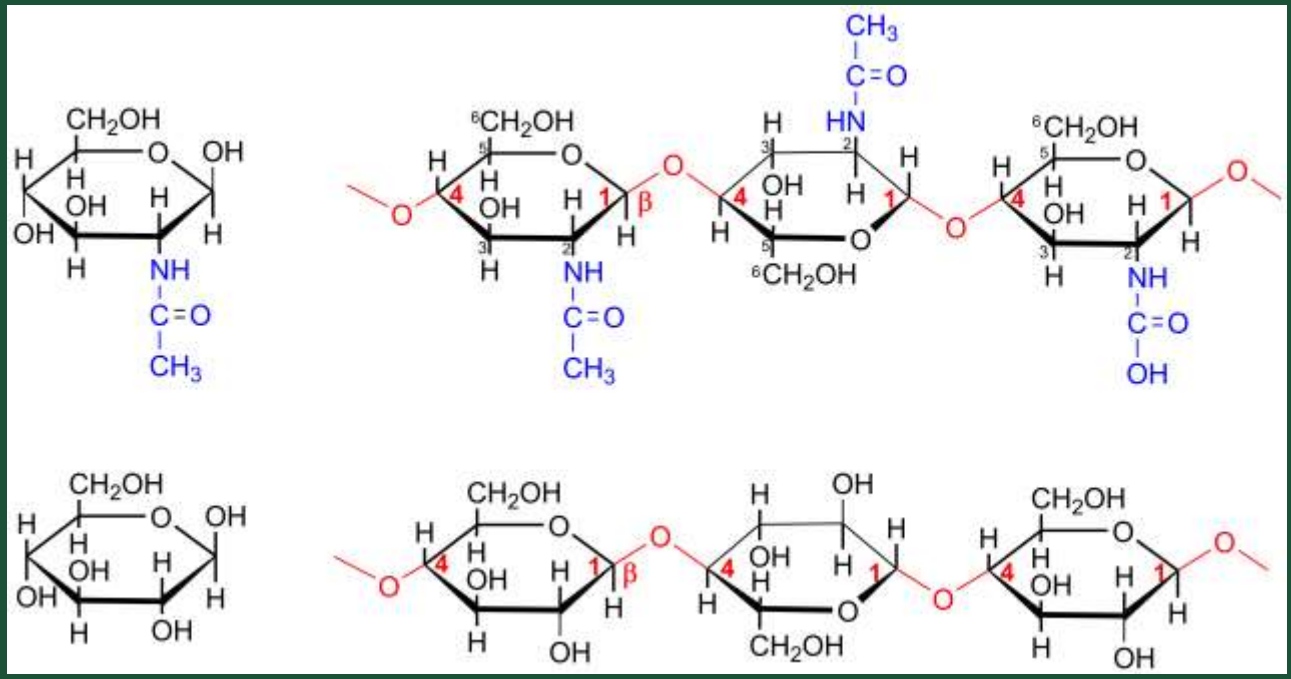
Insect pigments

Insect chemoluminescence

Insects: Chemical defense

Insects Have a Chitin Skeleton

chitin



Compare:
cellulose

Plants, “Bugs”, and Molecules

Larval stage of a ladybird beetle

Pea aphids (“true bugs”) in different developmental stages

Chemistry of Insects:
Insects Communicating: Pheromones!

Silk moth
(*Bombyx mori*)

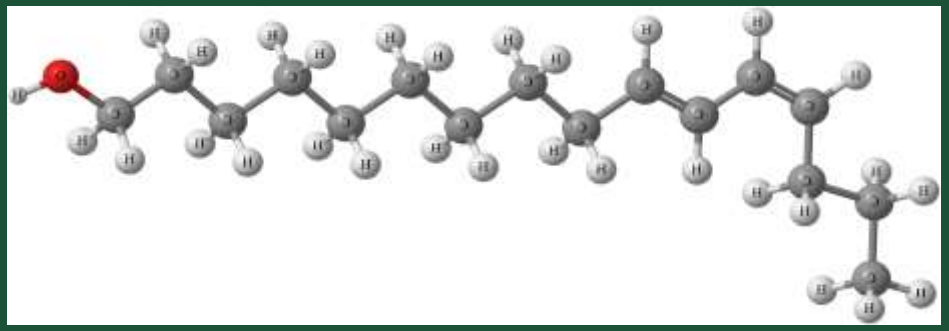
Bombykol
$C_{16}H_{30}O$

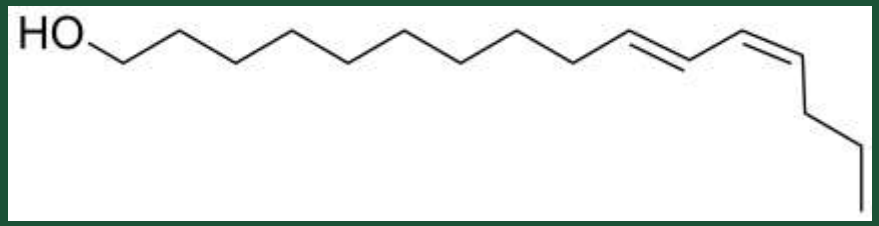
Chemistry of Insects:

Insects Communicating: Pheromones!

silk moth

(*Bombyx mori*)





Bombykol

$C_{16}H_{30}O$

Insect Colors:

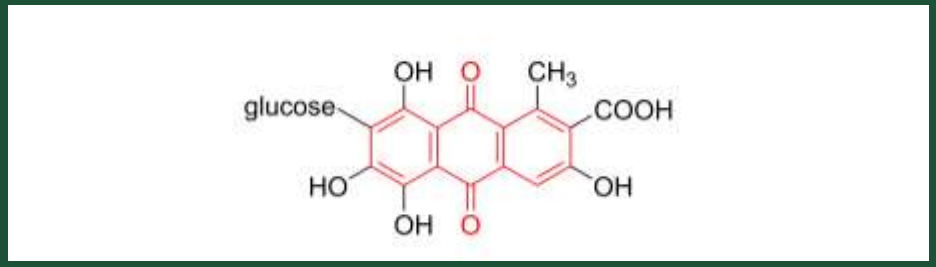
Insects have a lot of structural colors,

Blue Morpho

but also pigments

(melanins, pterins …)

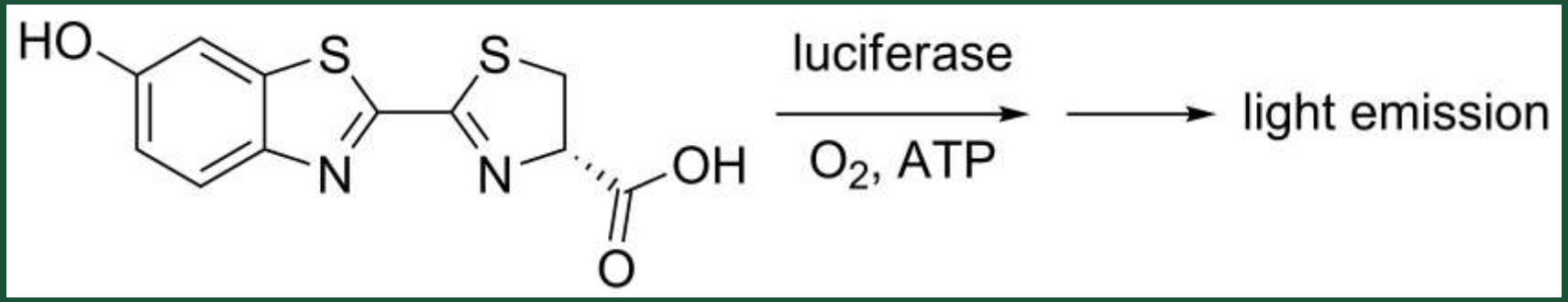
Gulf Fritillary
(*Agraulis vanillae*)



Cochineal

Insect Bioluminescence

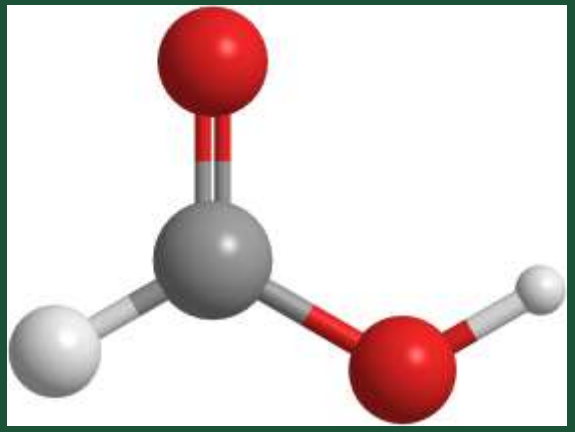
Eastern Firefly
(*Photinus pyralis*)



Luciferin

Insect Defense

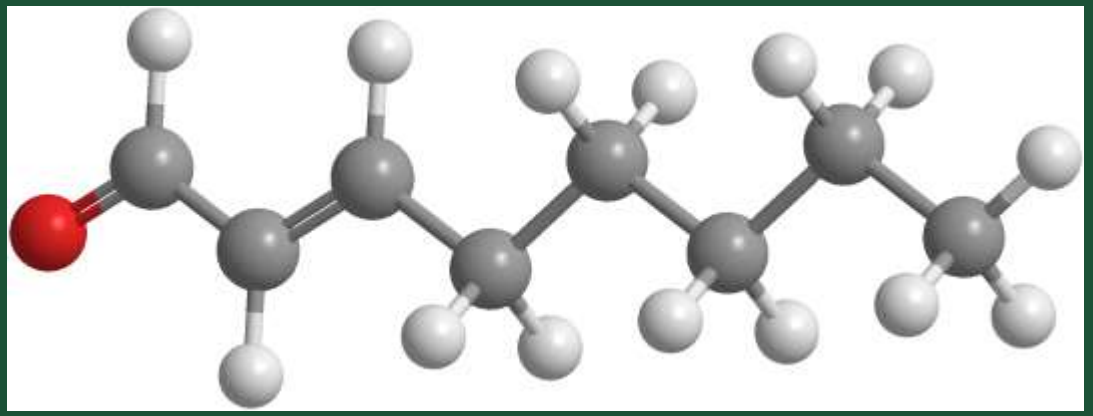
Ants



Formic Acid

Insect Defense

Stinkbeetle
(*Eleodes* sp.)



trans-2-octenal $C_8H_{14}O$

Insects: Chemical Defense from Plants

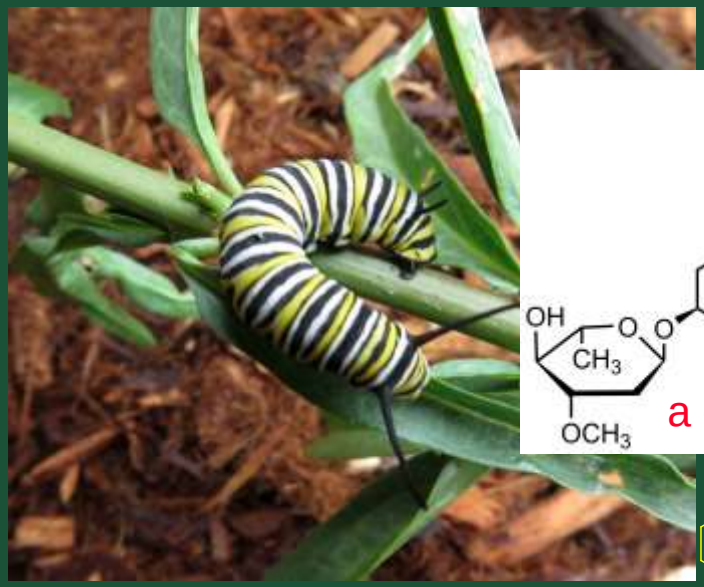
Monarch Caterpillar

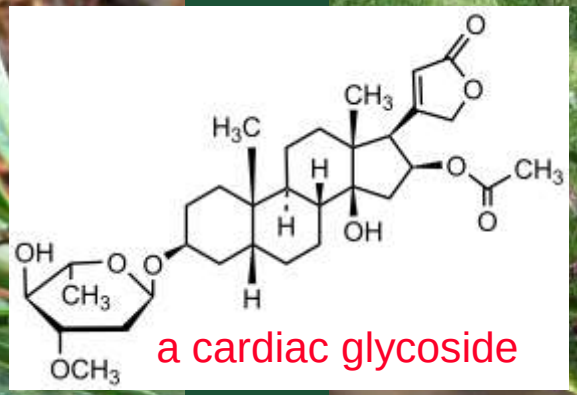
Red Milkweed Beetle

Pipevine Swallowtail Caterpillar

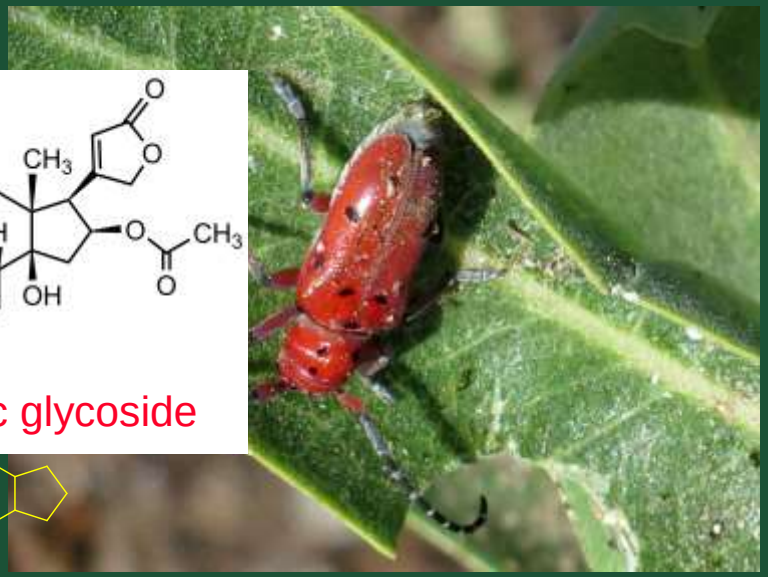
Aposematic Colors …

Insects: Chemical Defense



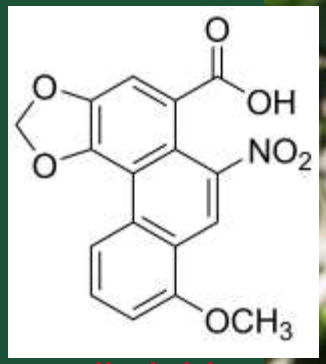


a cardiac glycoside



Monarch caterpillar

Red milkweed beetle



an alkaloid

Pipevine swallowtail caterpillar

Sources, References for

Insect Chemistry and Plant-Insect Interactions:

- Internet
- Local plant and insect guide books
- Classes, Field Trips

Sphinx moth caterpillars

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THANK YOU!