Biochimica delle sostanze naturali A.A. 2022-2023

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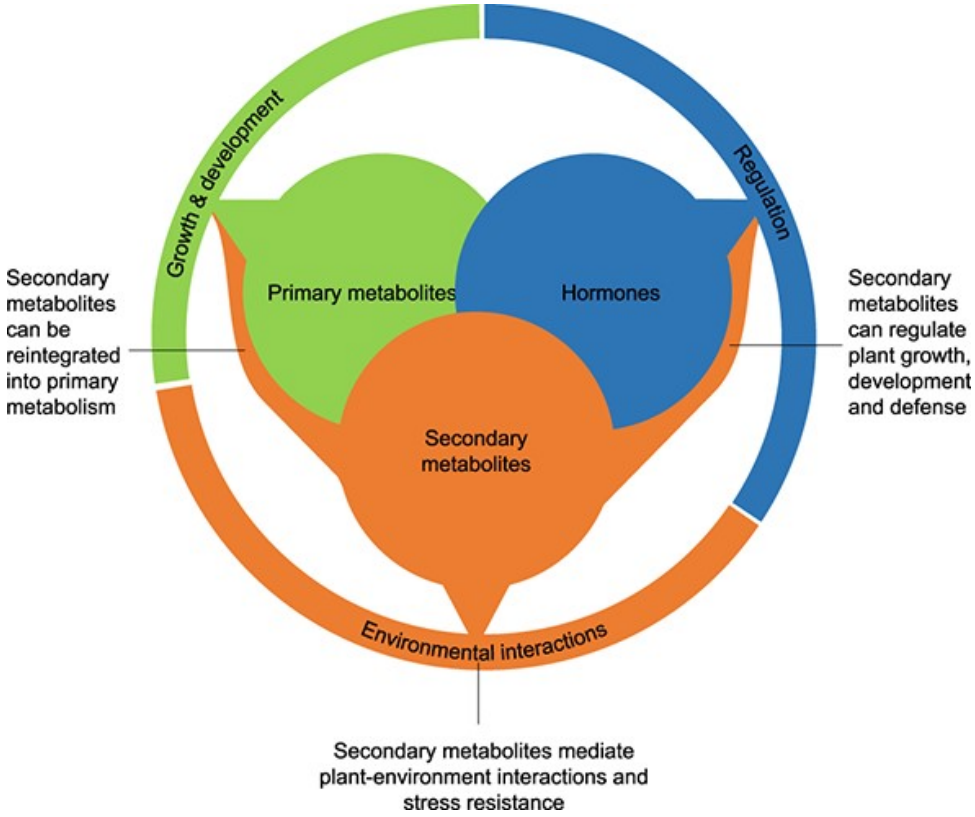
Classification of low molecular weight compounds in plants



- The plant kingdom produces hundreds of thousands of low molecular weight organic compounds (less than 3000 da).
- Based on the assumed functions of these compounds, the research community has classified them into three overarching groups:

➢ primary metabolites, which are directly required for plant growth;
➢ secondary (or specialized) metabolites, which mediate plant–environment interactions;
➢ hormones, which regulate organismal processes and metabolism.

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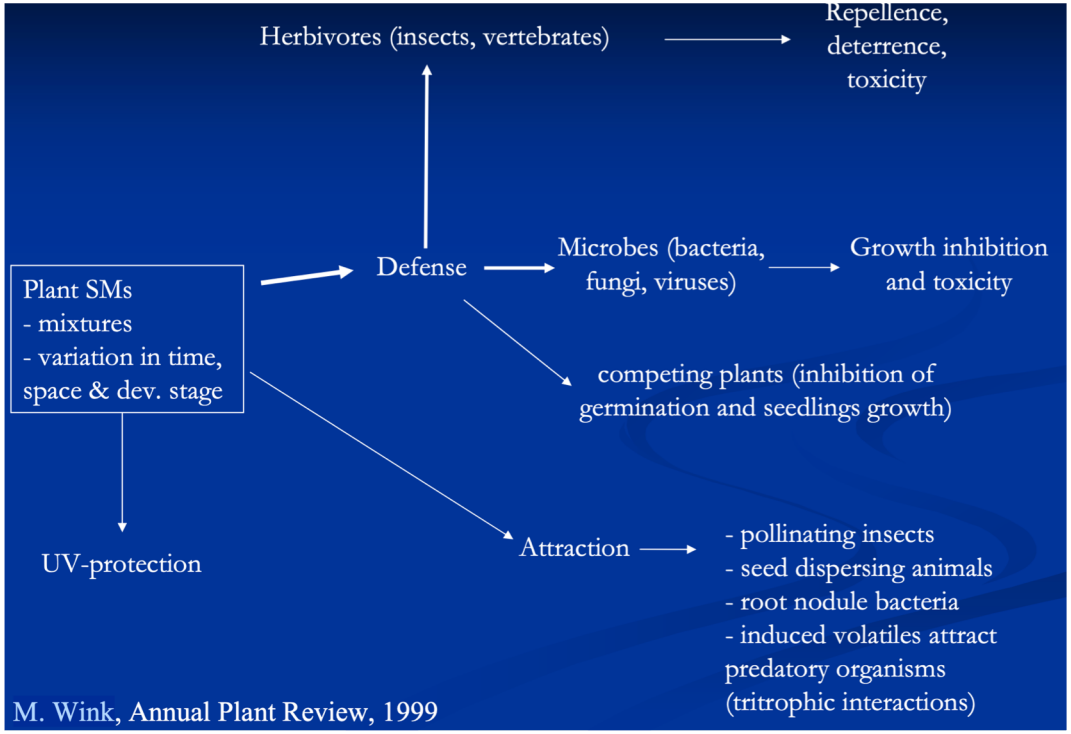
Functions of secondary metabolites



- ❖ Compounds are generally characteristic of a particular species or family (specific taxonomic distribution)
- ❖ Classified as "secondary metabolites" in contrast to "primary metabolites
- ❖ No nutritional or structural function
- ❖ Functional roles may include:
  - - color (identification) - scent (attraction or repulsion)
  - - sexual attraction - social communication
  - - defense (e.g., plant toxins and antibiotics)
  - but many still have unknown function in the organism in which they are found.

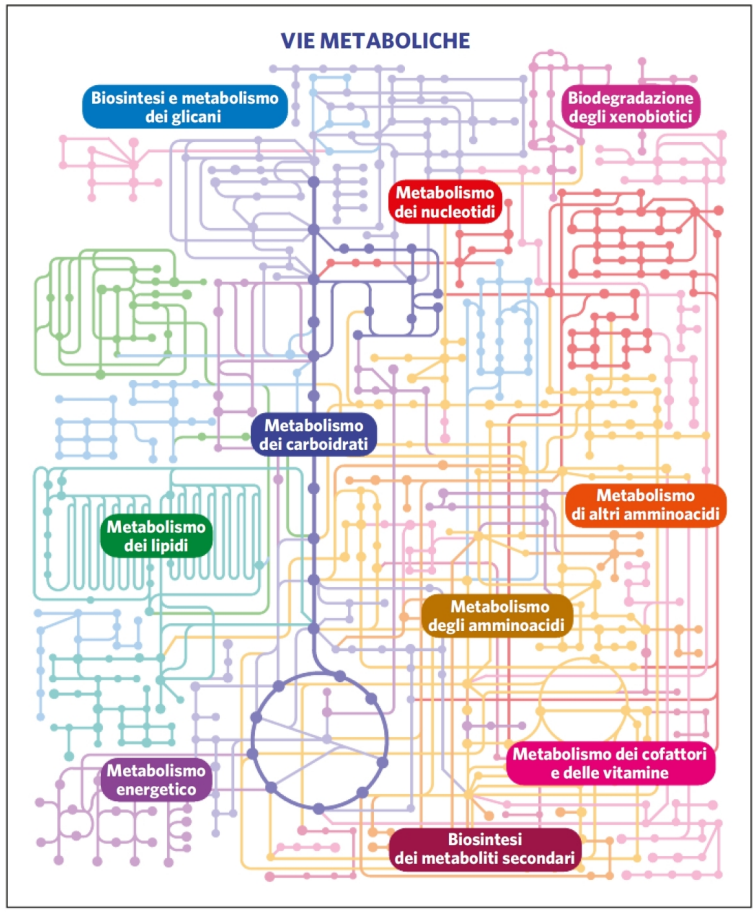
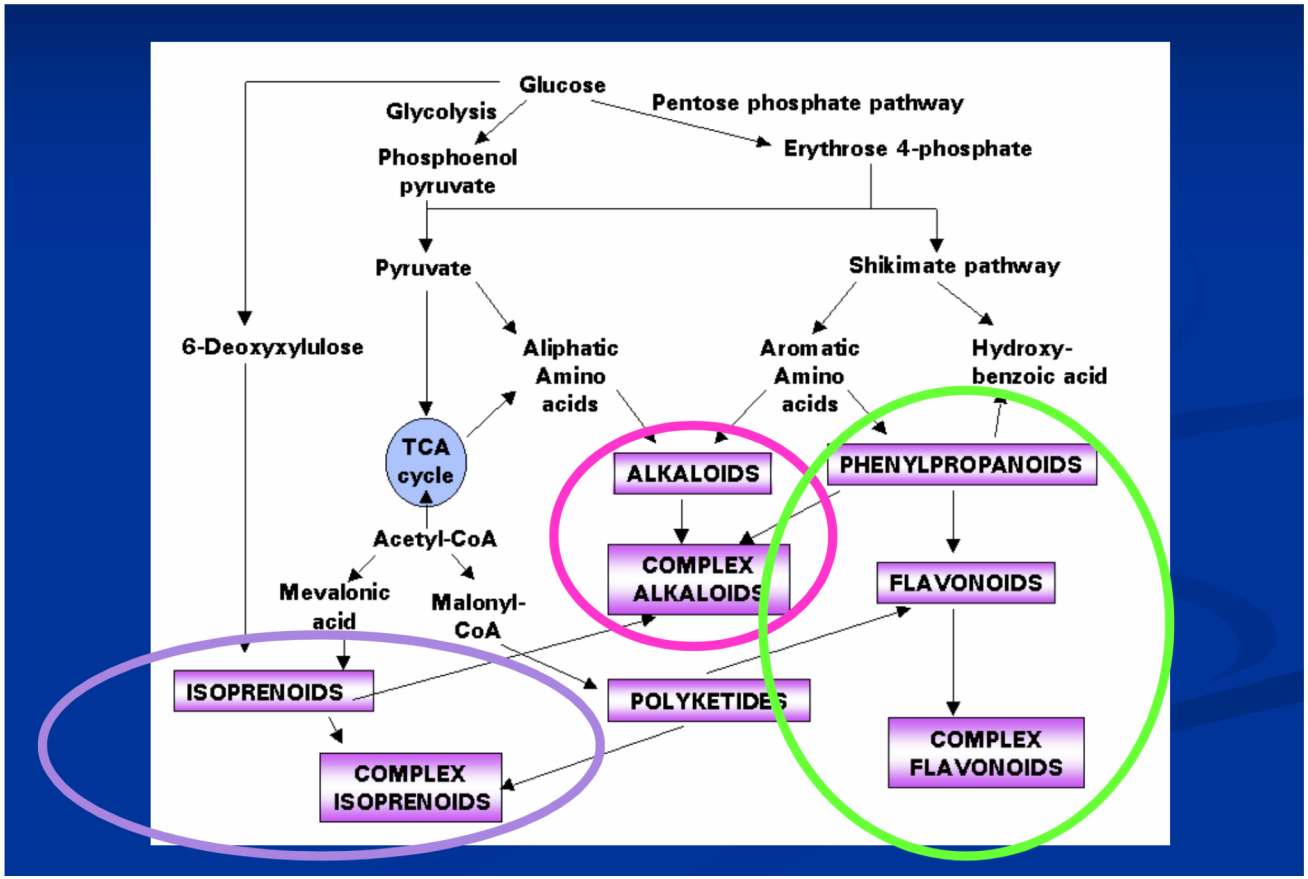
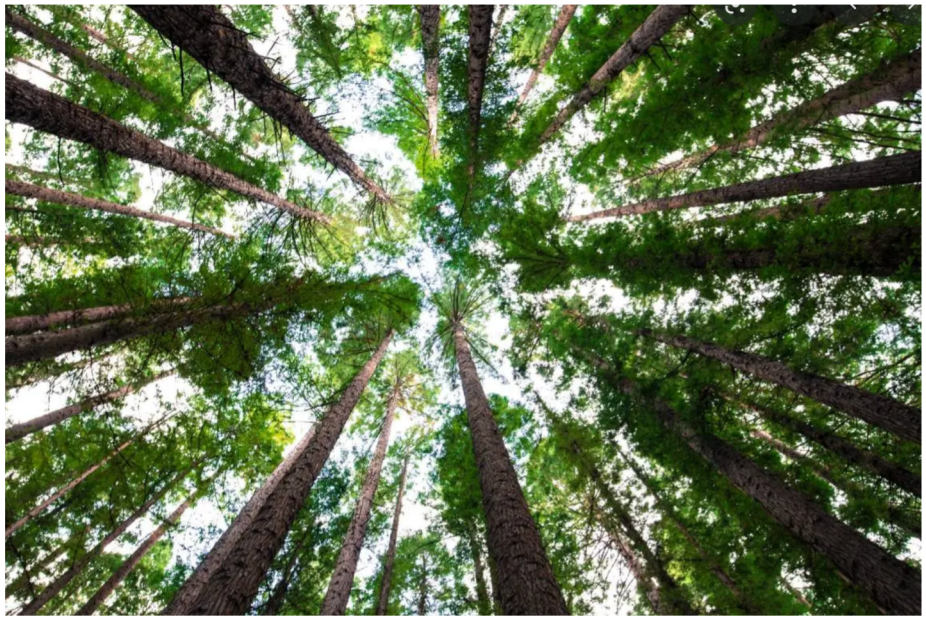


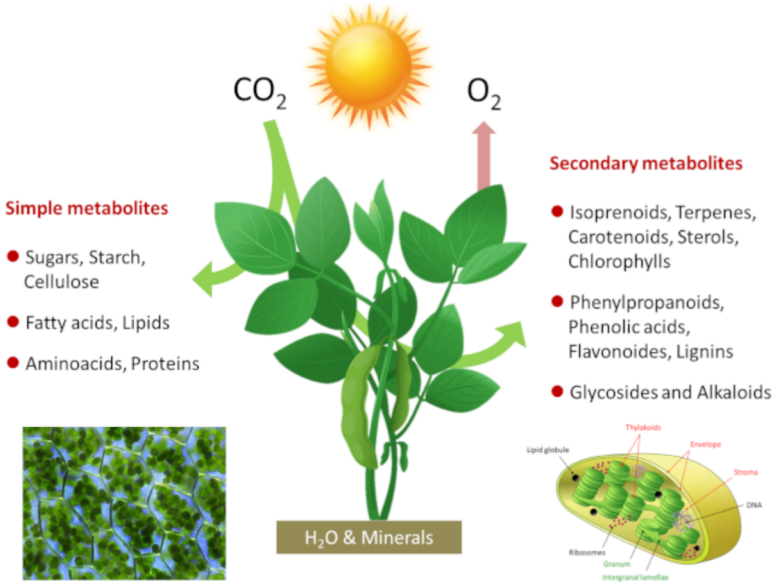
Figura 13.28 Il metabolismo può essere rappresentato come un reticolo tridimensionale. Una cellula eucariote è in grado di sintetizzare circa 30 000 differenti proteine, che catalizzano migliaia di reazioni in cui sono coinvolte molte centinaia di metaboliti, la maggior parte dei quali partecipa a più di una via metabolica. In questa visione globale molto semplificata delle vie metaboliche, ciascun puntino rappresenta un intermedio e ogni linea di connessione rappresenta una reazione enzimatica. Per un'immagine più realistica, ma al tempo stesso anche molto più complicata del metabolismo, *vedi* la banca dati online KEGG PATHWAY (www.genome.ad.jp/kegg/pathway/map/map01100.html). In questa mappa interattiva, si può cliccare su ciascun puntino per ottenere ulteriori dati sul composto corrispondente a quel puntino e agli enzimi di cui esso è substrato. [Fonte: www.genome.ad.jp/kegg/pathway/map/map01100.html.]

Primary and secondary metabolism connection



Secondary metabolites in plants





Secondary metabolites are grouped into classes on structural basis, biosynthetic pathways, or types of plants that produce them. The broadest classes are **terpenoids**, **phenolics** and **alkaloids**.

Why study Natural Products?

- Natural products are the source of the most complex and fascinating chemical structures.
- Natural products **represent biological diversity**.
- Natural products are expressions of the genome.
- Natural products **represent natural biological activity**, whether as single compounds or as complex mixtures.
- **Natural products are part of the natural wealth of the country, and can be an important source of livelihood, from agriculture and food, pharmaceuticals, fine chemicals industry.**
- **Natural products can be an effective bridge from tradition to modern scientific developments, including genetics, molecular biology, biotechnology, and pharmaceutical science.**

The market for natural products

- Pharmaceuticals
- Traditional herbal medicines:

US and Europe: gingko biloba, St. John's wort, ginseng, garlic*, echinacea, saw palmetto, soya*, kava-kava, golden seal, aloe*, gotu kola* (*also grown in the Philippines)

India, China, Japan: Ayurverda, TCM, Kampo

Philippines: lagundi, sambong, ampalaya, banaba, malunggay

- Beverages: tea (e.g., green, chinese), herbal teas, coffee
- Food supplements and health products
- Fats and oils
- Herbs and spices, food flavor ingredients
- Perfumes and scents
- Essential oils, others …

The use of plant metabolites started..

2600 BC, and in the following 4000 years, secondary metabolites originating from plants were used mainly for medicinal and poison purposes as well as food.

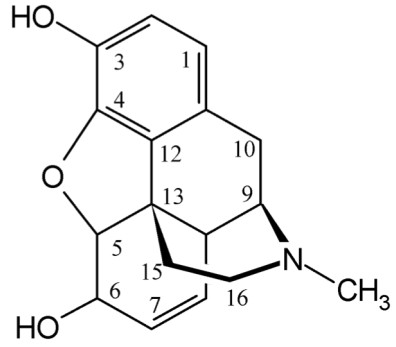
Morphine was the first natural product isolated from the opium poppy (*Papaver somniferum*) in 1806 and it opened a new era in secondary metabolite research.

Papaver somniferum

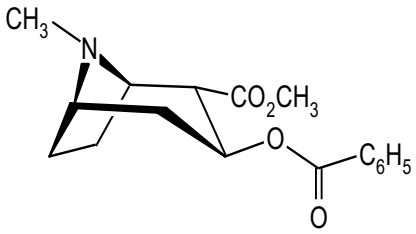
Morphine

(aromatic alkaloid from opium, *Papaver somniferum*)

Isolation: 1806, Sertürner
Structure: 1925, Robinson
Synthesis: 1954, Ginsberg
Biogenesis: 1959, Leete



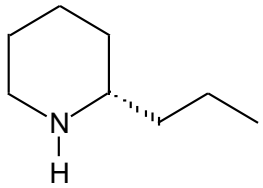
Some milestones in natural products chemistry



Cocaine

Cocaine
(aliphatic alkaloid from *Erythroxylon coca*)

Isolation: 1859, Niemann
Synthesis: 1923: Willstätter



Coniine

Coniine
(aliphatic alkaloid from hemlock, *Conium maculatum*)

Isolation: 1886, Ladenburg
Structure: 1926, Koller

Erythroxylon coca

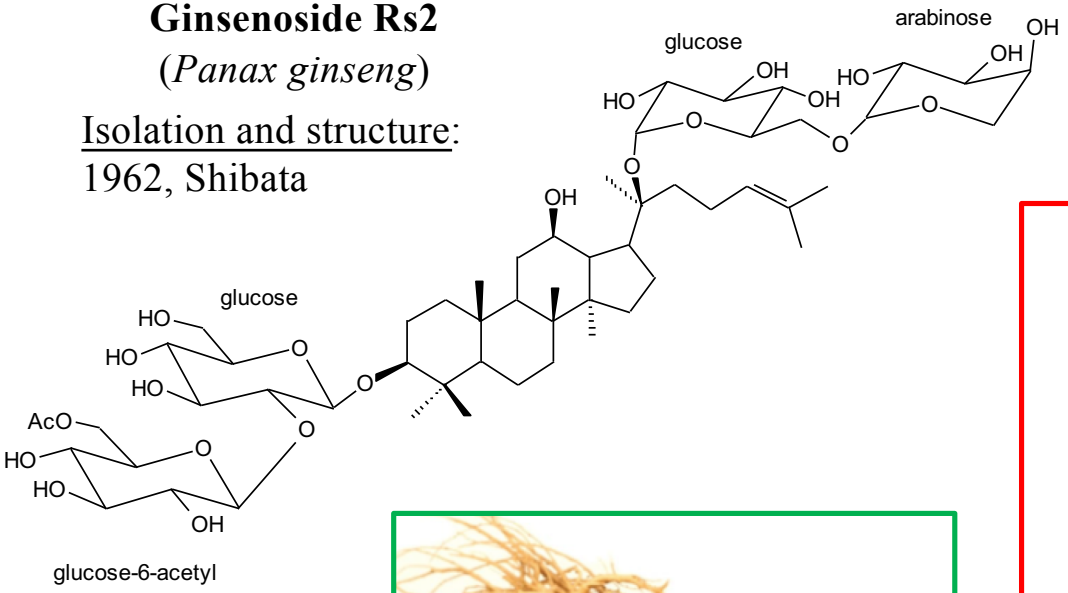
Conium maculatum

Some milestones in natural products chemistry

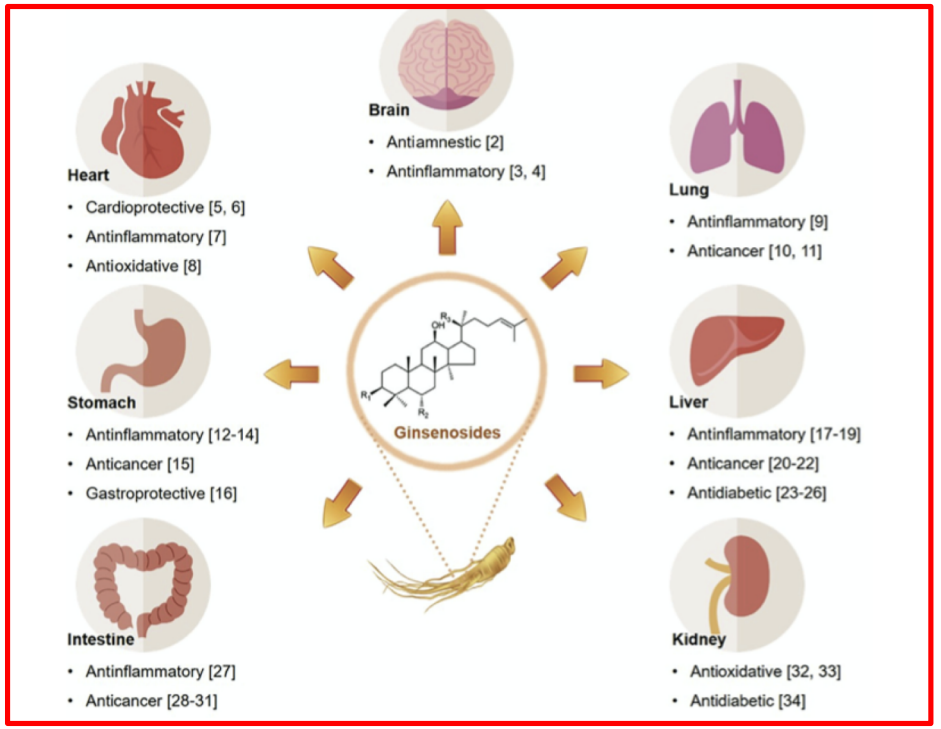
Ginsenoside Rs2

(*Panax ginseng*)

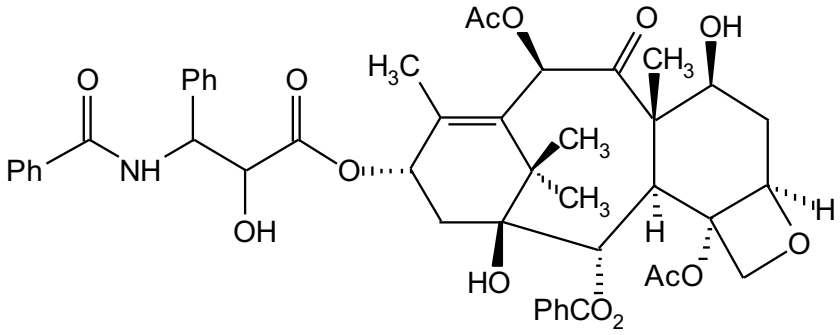
Isolation and structure:
1962, Shibata



https://doi.org/10.1016/j.jgr.2018.06.001



Some milestones in natural products chemistry

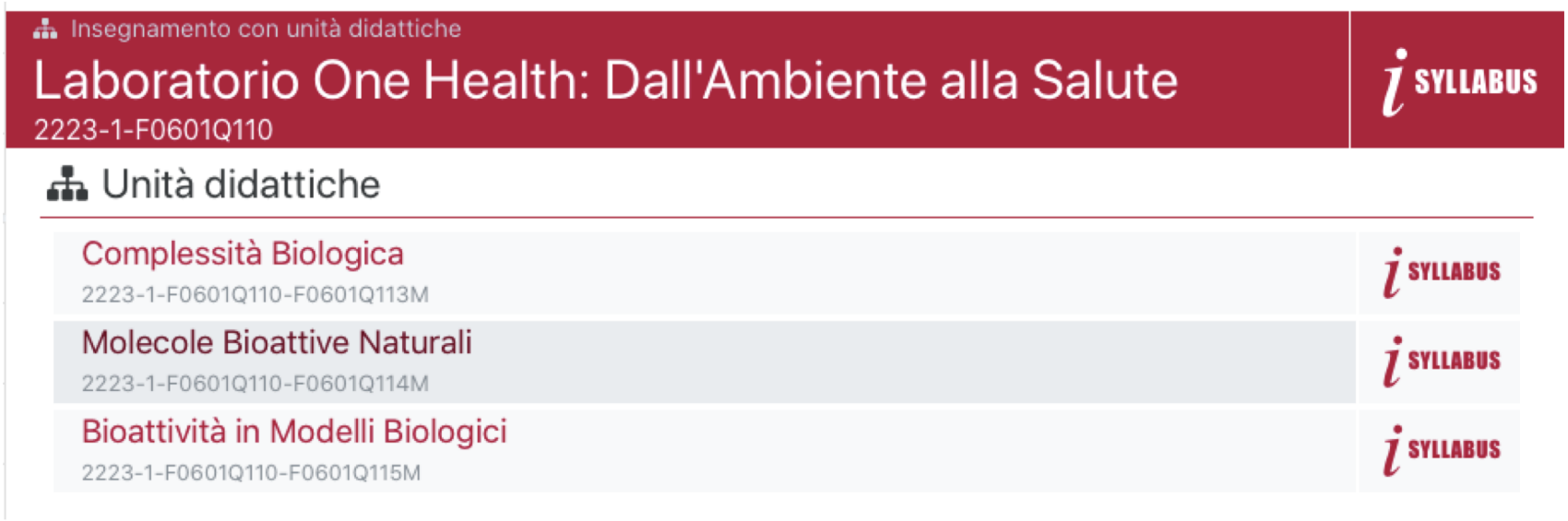


Taxol

(antitumor diterpene from Pacific yew, *Taxus* species)

Isolation: 1971, Wani *et al*.

Structure: 1971, Wani *et al*.



- Complessità biologica: **attività in campo** volto ad analizzare diversi ambienti a diverso grado di naturalità e di impatto antropico (es. aree protette, coste e città di mare) al fine di individuare fattori di stress che possono perturbare gli equilibri ecosistemici ed il benessere dell'uomo.

- Molecole bioattive naturali: **estrazione di sostanze bioattive** provenienti dalla biodiversità e la valutazione di potenziali inquinanti con effetti negativi sulla salute dell'uomo.

- Bioattività in modelli biologici: **studio degli effetti della biodiversità** e delle sostanze naturali **in sistemi biologici.**