

## CHIMICA DELLE SOSTANZE NATURALI (CSU069)

### 1. language

Italian.

### 2. course contents

Coordinator: Prof. ALBERTO VITALI

Year Course: 2<sup>nd</sup>

Semester: 1<sup>st</sup>

UFC: 18

Modules and lecturers:

- BIOSINTESI E METABOLISMO DELLE SOSTANZE NATURALI (CSU070) - 5 CFU - SSD

CHIM/06 - Prof. Alberto Vitali

- BOTANICA (CSU073) - 3 CFU - SSD BIO/01 - Prof. Francesca Sicilia

- CHIMICA DELLE SOSTANZE NATURALI AD ATTIVITÀ BIOLOGICA (CSU071) - 5 CFU - SSD

CHIM/08 - Prof. Federica Iavarone

- PREPARAZIONI ESTRATTIVE DI PIANTE MEDICINALI (CSU072) - 5 CFU - SSD CHIM/08 -

Prof. Maura Di Vito

### 3. BIBLIOGRAPHY

For each teaching module, texts related to the various disciplines of the integrated course will be used, supplemented by a bibliography derived from recently published articles, and, where necessary, in-depth handouts will be provided directly by the lecturers.

### 4. LEARNING OBJECTIVES

The integrated course aims to deepen the specialized knowledge of basic topics of Chemistry and Biosynthesis of Natural Substances, Botany and Techniques of Extraction of Natural Products, fundamental for the development of the professionalism of a Graduate in Cosmetological Science and Technology.

At the end of the Course, the student will have to demonstrate that he/she has acquired the following objectives:

- *Knowledge and ability to comprehend* - demonstrate knowledge and ability to understand the main chemical structures and biogenetic origin of natural substances, their biological activities and potential applications in the cosmetic field. Botany and systematics, as well as the main extraction techniques and consequent applicability.

- *Applied knowledge and understanding* - The student must be able to apply knowledge of the chemical structure and biosynthesis of natural molecules for application in the production field. The student must be able to identify the cosmetic properties of medicinal plants, their functional principles and define their applicability. The student must understand - and then apply the properties of natural products and the mechanisms of interaction with biological tissues.

- *Autonomy of judgement* - The student must be able to integrate the knowledge and skills learnt to identify the prerequisites and biological effects of a cosmetic based on natural products.
- *Communication skills* - The student must be able to communicate clearly and unambiguously, using technical language correctly, their conclusions and the knowledge and rationale behind them to specialists and non-specialists.
- *Ability to learn* - The student must be able to update and expand his/her knowledge by independently drawing on texts, scientific articles and online platforms and databases (NCBI, Ensemble, UniProt, PDB etc). He/she must gradually acquire the ability to attend specialized seminars, conferences, master's courses.

## 5. PREREQUISITES

A basic school education and knowledge of basic science subjects is required: chemistry, physics and mathematics, biology.

## 6. TEACHING METHODS

The course will be conducted with oral lectures using multimedia systems. Lessons will be based on interactive modes, integrating active learning activities, such as problem-based learning, self-learning and case studies, into standard teaching. Lecturers will be available throughout the duration of the course, by appointment via e-mail, to answer questions and support students during their training, including individual meetings.

For the modules Biosynthesis and Metabolism of Natural Substances and Extractive Techniques of Medicinal Plants, lectures will be accompanied by theoretical-practical sessions in dedicated chemistry laboratories.

The teaching methods used in this course are designed to enable the student to pursue the learning objectives, by virtue of the following characteristics

- *Knowledge and comprehension skills* - face-to-face teaching will systematically cover all the topics listed in the program detailed below, focusing on the most relevant and essential aspects, so as to provide students with the complete picture of the integrated topics and the correct study method to reinforce theoretical knowledge.
- *Applied knowledge and understanding* - the use of practical examples, classroom exercises and case studies enables students to learn the application potential of the topics covered. In particular: for the medicinal plant extraction techniques course, students are required to prepare a paper on the cosmetic activity of a medicinal plant.
- *Autonomy of judgement* - the active learning methods implemented in this course are designed to enable the student to formulate concepts and ideas independently.
- *Communication skills* - the active learning methods and constant interaction with the lecturer during lectures will be conducted in such a way as to allow the student the progressive acquisition of communication skills aimed at exposing chemistry and biology topics with the correct scientific terminology.
- *Ability to learn* - the use of supplementary teaching material, also in the form of articles from the international scientific literature, will enable the student to undertake subsequent studies with a high degree of autonomy.

## 7. OTHER INFORMATIONS

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## 8. METHODS FOR VERIFYING LEARNING AND FOR EVALUATION

The examination consists of an oral test for all the disciplines. Questions will be asked on theoretical aspects of the topics covered in the individual lectures and aimed at ascertaining the student's understanding and ability to present the content with propriety.

The objective of the examination is to test

- the level of knowledge of the topics covered in the syllabus and the understanding of the role of the cellular and molecular processes studied as well as the knowledge of the topics indicated in the syllabus of the various modules (Knowledge and Understanding)
- the ability to link theoretical concepts to concrete biological problems aimed at the preparation of cosmetic products (Applied knowledge and understanding)
- the ability to make transversal connections on the topics covered. (Autonomy of judgement)
- the adequate ownership of language and correct technical/scientific terminology (Communication skills)
- the ability to explore topics of biological and chemical interest in depth (Ability to learn).

The final mark will be obtained by averaging the marks obtained in the individual disciplines rounded up. It will only be possible to obtain an honours grade if the student has been assessed with top marks in all subjects and if he/she has been awarded at least one honours grade.

## 9. PROGRAM

### **Extractive preparations of medicinal plants**

Definition of phytocosmetic, active ingredients of plants, factors that may influence the presence, quality and quantity of active ingredients; harvesting and storage of drugs; extraction techniques: squeezing, centrifugation, maceration, infusion, percolation, distillation; plant extracts for cosmetic use, preparation of medicinal plant extracts; traditional uses of medicinal plants; modern aspects of phytocosmetics. Main officinal plants for topical use and their cosmetic functionality; vegetable oils, vegetable butters, vegetable waxes and essential oils in cosmetics. In-depth study of monographs of medicinal plants most commonly used in cosmetics. Study and recognition of drugs, their active ingredients and use.

Recommended texts: students will be provided with handouts relating to the course of study.

### **Biosynthesis and metabolism of natural products**

Importance of natural products in human history; Natural products as a source of biologically active molecules and drugs. Secondary metabolism - meaning and definitions; Biological function, evolutionary significance and mode of action of secondary metabolites; Introduction to the plant cell as a site of biosynthesis of secondary metabolites; Factors regulating secondary metabolism; Enzymes as catalysts of biosynthesis reactions - coenzymes; Biosynthesis of fatty acids and polyketides - biomolecular aspects. The shikimate pathway; Biosynthesis of aromatic amino acids,

phenylpropanoids, flavonoids and lignans - biomolecular aspects; Biosynthesis of terpenoids - biomolecular aspects; Biosynthesis of alkaloids - biomolecular aspects; Biosynthesis of cyanogenic glycosides and glucosinolates - biomolecular aspects; Biosynthesis of peptide antibiotics; Characteristic enzymes of secondary metabolism - functional and structural classification and description; Ways and techniques of investigating the biosynthesis of secondary metabolites - chemical, biochemical and biomolecular approaches; Application and biotechnological aspects of secondary metabolism. Biotransformation of natural products - generalities and definitions; Metabolism of flavonoids; Metabolism of alkaloids; Metabolism of drugs of natural origin. Recommended texts: students will be provided with handouts related to the course of study.

### **Chemistry of biologically active natural products.**

Primary and secondary metabolism, biogenetic and biosynthetic theories: The shikimate pathway, phenylpropanoid aromatic amino acids

Terpenes: Isoprenoids, Isoprenoid chain formation, Cyclization of isoprene units, Monoterpenes: Biosynthetic mechanisms, Linear and cyclic monoterpenes, Monoterpenes contributing to aroma; Diterpenes: Biosynthetic mechanisms, Labdanic and Copalilic intermediates Rosane, pimarane and caurane skeletons, Taxol; Sesquiterpenes: Biogenetic hypotheses of sesquiterpene skeletons from TTFPP, Biogenetic hypotheses of sesquiterpene skeletons from TCFPP, Biogenetic theories of oxygenated compounds, Biogenesis of sesquiterpene compounds; Triterpenes and Steroids: Precursor formation (squalene and presqualene pyrophosphate), Tetracyclic triterpenes, Pentacyclic triterpenes, Steroids and sterols, Phytosterols, Cardioactive glycosides. The acetate route: LIPIDS: Fatty acids, Chemical properties of fatty acids, Acylglycerols and glycerophospholipids, Sphingolipids and waxes; ALKALOIDS: Definition, Biosynthesis, Alkaloids derived from ornithine and lysine, Types of alkaloids, Pyrrolidine alkaloids, Tropane alkaloids, Quinoline alkaloids, Isoquinoline alkaloids, Morphine alkaloids and Indole alkaloids; FLAVONOIDS: Definition and classification, Importance of flavonoids, Antioxidant activity of flavonoids, Biosynthesis of flavonoids, Isoflavonoids.

Recommended text: Dewick 'Chemistry, biosynthesis and bioactivity of natural products', PICCIN.

### **Botany**

The plant cell. Adult plant tissues: the basic tissues (parenchymatous tissue, sclerenchymatous tissue, collenchymatous tissue), vascular tissues (xylem and phloem) and integumental tissues (epidermis and peridermis). The meristematic tissues (apical meristems and lateral meristems). The leaf: functions and structure, opening and closing of stomata, transpiration, guttation, abscission, leaf modifications. The stem: functions and structure, primary growth, secondary growth (wood anatomy), stem modifications. The root: functions and structure, secondary growth, root modifications, mutualistic relationships (mycorrhizal fungi and rhizobial bacteria). The soil: composition and essential elements for plants. Transport in vascular plants: water transport, sugar transport. Reproduction in angiosperms: flower structure, spores and pollination, fertilisation. Seeds and fruits: structure and functions, reserve substances, dormancy, germination. Tropisms (phototropism, heliotropism, gravitropism, hydrotropism, tigmotropism). Plant hormones (auxin, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteroids, strigolactones). Light as a light signal: phytochromes, responses to light. Hints of evolution and systematics. The classification of

plants: special attention to gymnosperms and angiosperms.

Recommended text: Thomas L Rost, Michael G Barbour, Ralph C Stocking, Terence M Murphy  
"PLANT BIOLOGY", Zanichelli.