COURSE OUTLINE

1 GENERAL

SCHOOL	School of Applied Biology and Biotechnology		
ACADEMIC UNIT	Department of Biotechnology		
LEVEL OF STUDIES	Postgraduate (Level 7)		
COURSE CODE	(To be assigned)	**SEMESTER**	1st
COURSE TITLE	Chemistry, Synthesis and Analysis of Natural Products		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, state the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures & Guided Study (Virtual & Pre-recorded)	3	
Laboratory Exercises (Analysis & Synthesis)	1	
TOTAL	4	6 ECTS
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail in section (4).		

COURSE TYPE *general background, special background, specialization, general education, skills development*	Specialization / Special Background
PREREQUISITE COURSES	Prior exposure to Organic Chemistry and Analytical Chemistry is required. Proficiency in Microsoft Windows or macOS is expected.
LANGUAGE OF INSTRUCTION AND OF ASSESSMENT	English
MODE OF TEACHING *in-person (%)* *synchronous distance learning (%)* *asynchronous distance learning (%)* *(In the case of synchronous distance learning, the total weekly duration of teaching is recorded)*	Synchronous distance learning (75%) Asynchronous distance learning (25%) Note: Includes Hybrid Laboratory components
AVAILABILITY TO ERASMUS STUDENTS	No
COURSE WEBSITE (URL)	https://purdue.brightspace.com

2 LEARNING OUTCOMES

Learning Outcomes
The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described. *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Brief Guide for drafting Learning Outcomes*
Upon successful completion of the course, students will be able to: • Recognize and classify the main categories of natural products (e.g., terpenoids, steroids, phenolics, and alkaloids).

- Apply appropriate extraction, purification, and identification techniques tailored to specific chemical classes.
- Interpret complex spectroscopic data (UV-Vis, FT-IR, Raman, NMR, and MS) to determine chemical structures.
- Design simple synthetic routes and chemical transformations for natural metabolites.
- Conduct and present comprehensive laboratory investigations, demonstrating hands-on proficiency with extraction and chromatographic separation.
- Evaluate the role of secondary metabolites in biotechnology, pharmacology, and industry.
- Demonstrate professional-level scientific communication through the drafting of manuscripts and oral presentations.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and are stated below), at which of the following does the course aim?

Search, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adaptability to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*......*
Production of new research ideas	*Other...*
	....

- Search for, analysis and synthesis of data and information, with the use of the necessary technology (through spectroscopic data interpretation and chromatographic analysis).
- Working independently (during the completion of quizzes and individual laboratory reports).
- Teamwork (facilitated through group presentations and collaborative evaluations).
- Working in an international environment (as part of a dual-degree framework requiring high proficiency in English and global scientific standards).
- Criticism and self-criticism (through the critical evaluation of primary research during oral presentations).
- Production of free, creative and inductive thinking (evidenced by the design of synthetic pathways and molecular modifications).

3 COURSE SYLLABUS

The course provides an integrated overview of the chemistry, biosynthesis, and industrial application of secondary metabolites. The content is organized into the following thematic units:

- Introduction to Natural Products: Definition, sources, and classification. Exploration of their role in pharmacology and biotechnology.
- Major Classes of Natural Products:
    - Terpenoids & Steroids: Biosynthesis and classification of monoterpenes, carotenoids, essential oils, sterols, and saponins.
    - Phenolic Compounds: Analysis of flavonoids, quinones, lignins, and tannins.
    - Alkaloids: Nomenclature and structural types including pyrrolidine, pyridine, indole, and opium alkaloids.

- Extraction and Separation Techniques: Sample pretreatment and solvent selection. Practical application of Soxhlet, maceration, and ultrasonication, alongside chromatographic methods (TLC, HPLC, GC) and coupled analytical techniques (LC–MS, GC–MS).
- Design and Synthesis of Natural Metabolites: Relationship between natural and synthetic compounds. Focus on enzymatic synthesis, chemical modification, structure–activity relationships (SAR), and molecular mechanisms of bioactivity.
- Identification and Structural Elucidation: Use of advanced spectroscopic techniques including UV–Vis, FT–IR, Raman, NMR (^1H, ^{13}C), and
- Mass Spectrometry (MS) for spectral interpretation.

Laboratory Exercises
Practical training is delivered through structured hybrid modules:

- Essential Oil Analysis: Extraction by distillation followed by GC–MS analysis.
- Quantitative Determination: HPLC or LC–MS determination of caffeine.
- Isolation & Identification: Extraction of cinnamaldehyde from cinnamon using Soxhlet and Flash Column Chromatography (FCC), followed by spectroscopic identification.
- Organic Transformations: Synthesis of cyclohexanone oxime and the synthesis of aspirin.

4 TEACHING AND LEARNING METHODS - ASSESSMENT

MODE OF TEACHING *Face-to-face, distance learning, etc.*	Distance Learning (Hybrid Approach) • Synchronous distance learning (75%): Includes live lectures and real-time laboratory demonstrations/data analysis. • Asynchronous distance learning: (25%): Includes recorded lab techniques, safety modules, and spectral interpretation exercises.
MODE AND FREQUENCY OF COMMUNICATION WITH THE STUDENTS	• Weekly Synchronous Sessions: A 3-hour theoretical lecture and a 1-hour interactive laboratory workshop are held weekly. • Scheduled Consultation: "Virtual Office Hours via teleconference or by appointment. • Discussion Forums: Moderated threads on the LMS for troubleshooting spectral interpretation and synthetic methodology, with responses provided within 24–48 hours. • Feedback on Reports: Individualized feedback is provided on laboratory reports and quizzes within two weeks to guide student progress.

	• Email Communication: Direct communication via university email with a guaranteed response time of 24 hours during the work week.
ENSURING THE MODE OF COMMUNICATION AMONG STUDENTS *Team assignments and discussions, collaborative learning platforms with the use of AI, video conference, QA sessions, κ.α.*	Interactive learning and student collaboration are core components of the course, especially regarding complex chemical analysis and laboratory reporting: • Collaborative Lab Data Analysis: During synchronous virtual lab sessions, students work in groups to interpret spectroscopic data (NMR, MS, IR) and chromatographic results, fostering peer-to-peer problem-solving. • Group Oral Presentations: Students collaborate in teams to research, prepare, and deliver virtual presentations on specific classes of natural products or synthetic methodologies, simulating scientific conference environments. • Specialized Discussion Forums: The LMS hosts moderated forums where students can discuss synthetic routes, troubleshooting extraction techniques, and spectral identification, promoting a community of practice. • Collaborative Research & Writing: Students use cloud-based tools (e.g., Google Workspace, Microsoft 365) to co-author laboratory reports and presentation materials. • Integration of AI Tools: Students are encouraged to use AI tools for brainstorming and structuring their reports, provided they adhere to the mandatory disclosure guidelines and use them as "collaborative partners" in their learning journey.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, in laboratory training, in the communication with students*	The course integrates advanced chemical software and digital analytical tools to bridge the gap between theory and laboratory practice:

	ICT in Teaching: • Learning Management System (LMS): Use of the Brightspace for hosting high-resolution video modules of laboratory procedures and spectroscopic libraries. • Synchronous Video Conferencing is used for synchronous lectures and "Virtual Lab" sessions where students observe real-time extractions and chromatographic separations. ICT in Laboratory Training: • Chemical Structure Software: Use of ChemDraw or equivalent open-source software for designing synthetic routes and drawing molecular structures. • Analytical Data Processing: Use of specialized software for the interpretation of NMR, GC-MS, and FT-IR spectra. • Digital Databases: Access to chemical databases (e.g., PubChem, ChemSpider) for identifying unknown metabolites. ICT in Communication: • Electronic Announcements: Frequent updates via the LMS regarding lab safety protocols and report deadlines. • Virtual Collaboration: Use of shared cloud drives for group oral presentations and joint laboratory data processing.

TECHNOLOGICAL EQUIPMENT REQUIREMENTS	To successfully participate in this hybrid distance-learning course, students must have access to:
	
	• Personal Computer / Laptop: A system capable of running chemical drawing and analytical software.
	• High-Speed Internet Connection: Necessary for streaming high-resolution laboratory demonstrations and participating in synchronous sessions.
	• Peripherals: A functional webcam and microphone for breakout sessions and oral presentations.
	• Software & Tools:
	    ○ LMS Access: Standard web browser for Brightspace.
	    ○ Installation of the Zoom client or other approved teleconference platform for synchronous sessions.

	- o Chemical Drawing: Access to ChemDraw (provided via institutional license) or equivalent open-source software (e.g., ChemSketch). - o Spectral Analysis: Software for viewing and processing NMR and Mass Spectrometry files. - Institutional Infrastructure: Students have access to digital library resources and chemical databases (PubChem, SciFinder) provided by the University.
PLAGIARISM POLICY/ PLAGIARISM DETECTION TOOLS	The program maintains a zero-tolerance policy towards academic dishonesty and plagiarism, ensuring that all submitted work reflects the student's original research and critical thinking. - Plagiarism Policy: Plagiarism is defined as using the words, ideas, results, or images of others without proper attribution, as well as self-plagiarism (resubmitting prior work). - Students are required to follow the Purdue Honor Pledge ("As a Boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. I will neither give nor receive aid unless the instructor authorizes it"). - In alignment with the Agricultural University of Athens (AUA) regulations, all postgraduate assignments and the final thesis must comply with the institutional standards for originality. Plagiarism Detection Tools: - Turnitin: All written assignments (Manuscript Reports, Discussion Board posts, and the final Thesis) are systematically screened through the Turnitin plagiarism detection software. - Originality Reports: Instructors review detailed similarity reports generated by Turnitin to identify improperly cited content or excessive overlap with existing literature. - AI Writing Detection: The program utilizes Turnitin's AI writing detection feature to identify instances where generative AI tools

	may have been used outside the permitted guidelines. • Consequences: Instances of academic dishonesty are handled according to the procedures of the Office of Student Rights and Responsibilities (OSRR) at Purdue and the Assembly of the Department of Biotechnology at AUA. Sanctions may range from failure of the assignment to dismissal from the dual-degree program.
ARTIFICIAL INTELLIGENCE POLICY *(1) The use of Artificial Intelligence is prohibited in all circumstances* *(2) The use of Artificial Intelligence is allowed only with the permission of the instructor* *(3) The use of Artificial Intelligence is allowed only with an explicit reference to the literature* *(4) Students are free to use Artificial Intelligence*	(2) The use of Artificial Intelligence is allowed only with the permission of the instructor (3) The use of Artificial Intelligence is allowed only with an explicit reference to the literature Description & Implementation: In this course, a constructive but regulated approach to Generative AI (e.g., ChatGPT, Gemini) is adopted: • Permitted Use: Students are allowed to use AI tools primarily as "collaborative partners" for brainstorming, structuring outlines, or refining the linguistic clarity of their written reports (e.g., the final manuscript report). • Instructor Approval: Use of AI for specific assignments must be discussed with and approved by the instructor during the initial stages of the project. • Mandatory Disclosure: If AI tools are used, students must include a dedicated "AI Disclosure Statement" in their work, explicitly describing which tool was used and for which part of the assignment. • Academic Integrity: Students remain 100% responsible for the accuracy and scientific validity of the final output. AI-generated text must be critically verified against primary peer-reviewed literature. • Prohibited Use: Using AI to generate entire assignments, perform primary data analysis without disclosure, or bypass critical thinking components of the course is strictly prohibited and constitutes academic dishonesty.
ORGANISATION OF TEACHING *The mode and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, work placements, clinical practice, art workshop, interactive teaching,*	**Activity** / **Semester workload** Lectures (Synchronous distance learning - 3h/week) / 39

Activity	***Semester workload***
Lectures (Synchronous distance learning - 3h/week)	39

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<tr><td>educational visits, project, essay writing, artworks, etc.

The student's study hours for each learning activity are stated, as well as the hours of independent study, according to the principles of the ECTS.</td><td>
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<tr><td>Laboratory Exercises & Data Analysis (Synchronous/Hybrid - 1h/week)</td><td>13</td></tr>
<tr><td>Independent study of asynchronous modules & lab safety videos</td><td>30</td></tr>
<tr><td>Study and analysis of bibliography</td><td>30</td></tr>
<tr><td>Preparation and completion of Online Quizzes (4)</td><td>10</td></tr>
<tr><td>Preparation of Six Laboratory Reports</td><td>12</td></tr>
<tr><td>Development of Semester Project (Manuscript) & Oral Presentation</td><td>16</td></tr>
<tr><td>Course total</td><td>150</td></tr>
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<tr><td>STUDENT ASSESSMENT
Description of the assessment method

Language of assessment, methods of assessment, formative or summative assessment, multiple choice questions test, short answer questions, essay questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory assignment, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</td><td>Language of assessment: English

Methods of assessment:
The assessment is summative and is designed to evaluate both theoretical proficiency in natural products chemistry and practical skills in laboratory analysis and scientific writing:

Four Quizzes (20%): Conducted via the e-class or Brightspace platform, focusing on the comprehension of theoretical modules and assigned bibliography.
Six Laboratory Reports (30%): Written reports including a summary of findings, processing of analytical data (e.g., GC-MS, HPLC results), and the interpretation of laboratory exercise outcomes.
Semester Project & Oral Presentation (40%):

Scientific Manuscript: Students draft a paper in the format of a scientific article, presenting the findings of their research project.
Oral Presentation: A virtual presentation focusing on the critical evaluation of primary research and effective scientific communication.

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- Class Participation & Discussion (10%): Active engagement during synchronous sessions and breakout discussion groups.

Evaluation Criteria:

- Specifically defined criteria: Each assignment is graded based on a detailed rubric, which outlines expectations for scientific accuracy, methodology, and the professional use of presentation tools.
- Accessibility: Evaluation criteria and the assignment schedule are permanently available to students via the LMS and the course syllabus.
- Feedback: Students receive detailed qualitative feedback at least twice during the semester (before the final withdrawal period and before the final assessment phase) to guide their academic progress.

5 RECOMMENDED BIBLIOGRAPHY

Required Textbook:

1. Dewick, P. M. *Medicinal Natural Products: A Biosynthetic Approach*, 4th ed., Wiley, 2020.
2. Harborne, J. B. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*, Springer, 1998.
3. Cseke, L. J., et al. *Natural Products from Plants*, 3rd ed., CRC Press, 2016.
4. Sarker, S. D. & Nahar, L. *Chemistry for Pharmacy Students: General, Organic and Natural Product Chemistry*, Wiley, 2018.

Additional Readings:

- Selected papers from scientific journals:

1. Sun, S., et al., Impact of extraction techniques on phytochemical composition and bioactivity of natural product mixtures. *Front. Pharmacol.* 16:1615338 (2025).
2. Guo, Y., *et al.*, Scalable total synthesis of saxitoxin and related natural products. *Nature* 646, 351–357 (2025).
3. Lijun Chen et al., Bioinspired Total Synthesis of Natural Products, *Acc. Chem. Res.*, 57, 3524−3540 (2024).
4. Fiorito, S., et al., Novel procedures for olive leaves extracts processing: Selective isolation of oleuropein and elenolic acid, *Food Chemistry* 447, 139038 (2024).
5. Atanasov, A.G., Zotchev, S.B., Dirsch, V.M. *et al.* Natural products in drug discovery: advances and opportunities. *Nat Rev Drug Discov* 20, 200–216 (2021).
6. Dixon, R. Natural products and plant disease resistance, *Nature* 411, 843–847 (2001).