UAB
Universitat Autònoma de Barcelona

Synthesis of Biologically Active Compounds

Code: 102516
ECTS Credits: 6

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Degree	Type	Year
2502444 Chemistry	OT	4

Contact

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

Students must have passed the subjects of "structure and reactivity of organic compounds", "synthetic methods" and "laboratory of Synthesis".

Objectives and Contextualisation

The general objective of the subject of *Synthesis of Biologically Active Compounds* is to complete and extend the training acquired by the students with new contents of greater specificity and level within the area of organic chemistry. It is deepened in the basic aspects treated in past courses to obtain a broader and more critical view of the processes of preparation of organic compounds with biological interest.

The training objectives of the subject can be summarized in:

1. Understanding and knowing the general methods of synthesis of organic compounds.

2. Acquire the ability to design synthesis of organic substances with biological interest for the application of retrosynthetic analysis.

3. To know the importance of organic products for their biological and pharmacological activities.

4. Knowing and using the most relevant documentary sources in organic chemistry.

Competences

- "Interpret data obtained by means of experimental measures, including the use of IT tools; identify their meaning and relate the data with appropriate chemistry, physics or biology theories."
- Adapt to new situations.
- Apply knowledge of chemistry to problem solving of a quantitative or qualitative nature in familiar and professional fields.
- Communicate orally and in writing in one's own language.
- Evaluate the health risks and environmental and socioeconomic impact associated to chemical substances and the chemistry industry.

- Handle chemical products safely.
- Handle standard instruments and material in analytic and synthetic chemical laboratories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Manage, analyse and synthesise information.
- Obtain information, including by digital means.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse chemical problems and propose suitable answers or studies to resolve them.
- Resolve problems and make decisions.
- Show an understanding of the basic concepts, principles, theories and facts of the different areas of chemistry.
- Show initiative and an enterprising spirit.
- Show sensitivity for environmental issues.
- Use IT to treat and present information.
- Use the English language properly in the field of chemistry.
- Work in a team and show concern for interpersonal relations at work.

Learning Outcomes

1. Adapt to new situations.
2. Apply procedures for the handling and interconversion of functional groups.
3. Apply retrosynthetic analysis to organic substances of biological importance.
4. Apply the principles of synthesis design to the preparation of organic substances of biological importance.
5. Carry out basic synthesis, separation and purification procedures in an organic chemistry laboratory.
6. Communicate orally and in writing in one's own language.
7. Critically analyse biosynthetic pathways described in the bibliography.
8. Critically analyse synthetic pathways described in the bibliography.
9. Handle English language terms in relation to the synthesis of organic and bioorganic compounds.
10. Identify the importance of natural products as a source of biologically active compounds.
11. Identify the most relevant documentary sources on organic chemistry.
12. Identify the risks involved in the handling of chemical compounds used in biological chemistry, and apply suitable protocols for the storage or elimination of the waste generated.
13. Justify the results obtained in the laboratory for synthesis, separation, purification and characterisation processes of organic and bioorganic compounds on the basis of knowledge about their structure and properties.
14. Learn autonomously.
15. Manage the organisation and planning of tasks.
16. Manage, analyse and synthesise information.
17. Obtain information, including by digital means.
18. Perform synthesis of organic and bioorganic compounds using protocols written in the English language.
19. Properly handle glass and other common materials in an organic chemistry laboratory.
20. Properly interpret data obtained in the laboratory after computerised treatment and on the basis of the acquired knowledge.
21. Propose creative ideas and solutions.
22. Propose synthetic pathways for natural or similar products of interest.
23. Reason in a critical manner
24. Recognise methodologies for the structural elucidation and separation of natural products.
25. Recognise the common chemical compounds found in the laboratory that require special safety measures.
26. Resolve problems and make decisions.
27. Safely manipulate chemical reagents and organic compounds.
28. Show initiative and an enterprising spirit.
29. Show sensitivity for environmental issues.
30. Use IT to treat and present information.
31. Use basic instruments to characterise organic chemical compounds.

32. Use spectroscopic techniques for the structural elucidation of organic and bioorganic compounds.
33. Work experimentally with biological material (inert, aseptic and/or controlled atmospheres).
34. Work in a team and show concern for interpersonal relations at work.

Content

Unit I. The synthesis plan

Introduction to organic synthesis: Science and Art. General concepts: Total and partial synthesis. Combinatorial synthesis. Linear and convergent synthesis. Conversion and yield. Methodology: Retrosynthetic analysis. Concepts of disconnection, synthon, precursor and intermediate. The synthesis tree.

Unit II. Disconnection of aromatic compounds

Aromatic electrophilic substitution and aromatic nucleophilic substitution. Regioselectivity. Disconnection of bonds $C\text{-}_{Ar}\text{-}C$, C_{Ar}-heteroatom. Synthesis of aliphatic-aromatic drugs.

Unit III. Disconnection of monofunctional compounds

Amines, alcohols, ethers, thioethers, halides of alkyl, alkenes, aldehydes and ketones, carboxylic acids and derivatives, alkanes. Interconversion of functional groups. Use of acetylenes.

Unit IV. Quimioselectivity and protection of functional groups

Chemioselectivity. Features of a protecting group. Protection of amines, alcohols, carboxylic acids, aldehydes and ketones. Examples of the synthesis of carbohydrates and peptides. Solid phase synthesis.

Unit V. Disconnection of difunctional compounds

1,3-, 1,5-difunctionalized compounds and alpha, beta-unsaturated carbonyl compounds. 1,2- and 1,4-difunctionalized compounds. Consonant and dissonant relationships. Reversal of polarity, umpolung. Examples in the synthesis of secondary metabolites.

Unit VI. Disconnection of cyclic compounds

Ring synthesis: S_N2, addition, addition-elimination. Cycloaddition reactions. Examples in the synthesis of heterocyclic drugs: opioid analgesics, barbiturates, beta-lactamic antibiotics. Examples of the synthesis of steroids and tetracyclines.

Unit VII. Disconnection of compounds based on the formation of C-C bonds catalyzed by transition metal complexes.

Palladium catalysis in total synthesis. Other transition metalls in organic synthesis.

Unit VIII. Synthesis of enantiomeric pure compounds

Optical purity and enantiomeric excess. Separation of racemates: preferential crystallization, formation of diastereomers, kinetic resolution. Enantiotopic and diastereotopic relationships. Prochirality. Asymmetrical induction. Chiral precursors, auxiliaries and catalysts. Examples in the synthesis of compounds with biological activity.

Unit IX. Detailed study of a published synthesis

Individual work or in pairs (depending on the number of students) with written and oral presentation.

Laboratory practices:

Preparation of 3,4-dihydropyrimidone

Synthesis of lidocaine, a topical anesthetic

Synthesis of 5,5-diphenyl-imidazolidine-2,4-dione (phenytoine, dilantin)

Synthesis of 4-benzylidene-2-methyloxazol-5-one

"**Unless the requirements enforced by the health authorities demand a prioritization or reduction of these contents.*

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Autonomous work	83	3.32	1, 8, 2, 3, 14, 6, 28, 16, 10, 11, 17, 21, 22, 23, 26, 34, 30
Laboratory practices	16	0.64	14, 18, 5, 12, 20, 13, 9, 19, 27, 29, 17, 25, 33, 31, 32
Lecture classes and problems solving sessions	36	1.44	7, 8, 4, 2, 3, 6, 15, 10, 11, 22, 23, 24, 34, 30

Methodology

According to the objectives of the subject, the student will have to be involved in a series of activities to achieve the established knowledge and skills. These activities can be grouped into three different types:

Lecture classes and problems solving sessions: Initially, the students will receive a series of knowledge articulated exclusively by the teacher. During these classes the teacher will transmit the basic knowledge of the subject, which must be complemented with the individual work of the student consulting the bibliography given by the teacher as well as participating and performing the scheduled activities. Once the fundamental knowledge has been achieved, the lecture classes will be combined with the resolution of problems encouraging the participation of students. At the beginning of the course, a dossier of exercises will be given that will be solved throughout the course. A selected part of these exercises will be solved by the teacher so that the students learn the appropriate methodology to find the solutions. In these sessions, the solutions proposed by the students will be discussed, based on autonomous work developed individually. During this process, the students' participation will be encouraged. In some units of the course, it will be used the flipped classroom as a pedagogical method where the student learns the knowledge with videos and other multimedia materials using the face-to-face class to carry out problems and other more collaborative dynamics. The teacher will help to develop the critical sense and logical reasoning, in order to increase the ability of the students to solve problems.

IIn the last unit of the course, students will do a work (individually or in pairs) of a detailed study of a published synthesis that they will present orally and in writing. These presentations will form part of the continuous assessment of the course (compulsory activity).

Laboratory practices: 4 sessions of 4 hours of laboratory will be carried out in order to learn the usual techniques of an organic synthesis laboratory. The contents of these sessions will be linked to the topics discussed in the previous class period. These practices will be part of the continuous assessment of the course (mandatory activity).

**The proposed teaching methodology may experience some modifications depending on the restrictions to face-to-face activities enforced by health authorities*.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Laboratory practices	15%	2	0.08	1, 8, 6, 28, 18, 5, 15, 12, 11, 20, 13, 9, 19, 27, 29, 23, 25, 24, 26, 33, 31, 32
Midterm and final exams	70%	9	0.36	4, 2, 3, 10, 21, 22, 23, 26
Oral and writing presentation	15%	4	0.16	7, 8, 4, 2, 3, 14, 6, 16, 11, 17, 34, 30

The evaluation of this subject will be accomplished in a continuous way, in order to achieve the main objectives:

1.- Monitor the teaching-learning process, allowing both the student and the teacher to know the degree of achievement of the competencies and correct, if possible, the deviations that occur.

2.- Encourage the student to carry out a continued effort in front of an extra effort, often useless, to study at the last minute for the final exam.

3.- Verify that the student has achieved the competences determined in the training curriculum. The assessment of the course will be done individually. This monitoring will consist of:

First Midterm exam. Once approximately half of the subject of the course is taught, an exam will be done that will allow to verify that the students are achieving the expected knowledge. This exam will account the 25% of the overall grade. Attendance to this exam is mandatory. In order to average with the other notes of the course, the students must at least achieve a 4 note of the exam. The exam will be held in the date and time that the coordination considers most appropriate and it will be indicated with weeks in advance.

Second Midterm exam. Once the theoretical-practical classes have been finished, a second midterm exam will be programmed which will include all the contents offered throughout the course. It will account the 45% of the overall grade. Attendance to this exam is mandatory. In order to average with the other notes of the course, the students must at least achieve a 5 note of the exam. The exam will be held in the date and time that the coordination considers most appropriate and it will be indicated with weeks in advance.

Work (individually or in pairs) with oral and written presentation of a detailed study of a published synthesis. This work will be carried out towards the end of the course. Each student or group of students will record a video with the oral presentation. Recorded presentations will remain in a virtual campus folder and will be accessible for course students to view. Each student will be required to watch the video of other groups and write a short assessment report. The oral presentation, the written presentation and the evaluation reports will be valued. Its weight in the final grade will be 15% of the overall grade.

Follow-up of the Laboratory Practices: In the practices, the interest, the experimental ability and the results will be valued (60% of the mark) and the last day of practices an exam will be carried out (40% of the mark). The contribution of laboratory practices in the final mark will account the 15% of the overall grade.

At the end of the course there will be a Final exam for all students who have not passed by course. This exam will contribute 75% to the final exam grade, while the remaining 25% will be the average of the midterm exams.

In order to average the other marks of the course and pass the subject, students must achieve at least a 4 mark of the final exam.

To participate in the Final exam, the students must have previously been evaluated in a set of activities equivalent to a minimum of two thirds of the total grade of the subject.

In each exam, the date of review of the qualifications will be published together with the result of the evaluation.

Considering the Regulations of evaluation in the studies of the Universitat Autònoma de Barcelona: *In the case that the student conducts any irregularity that can lead to a significant variation of the qualification of an evaluation act, it will be qualified with 0 this act of evaluation, regardless of the disciplinary process that can be instructed. In case of several irregularities in the acts of evaluation of the same subject, the final grade of this subject will be 0.*

Students that pass the subject: Students who pass the subject will be considered only those who obtain an average of5 overall assessment.

Single assessment

Students who have accepted the single assessment modality will have to take a final test which will consist of an examination of the entire theoretical syllabus and problems of the subject. This test will be carried out on the day that the students of the continuous assessment take the second part exam. Likewise, on the same day, students will deliver the written work and the recording of the oral presentation of a detailed study of a published synthesis that will have been assigned to them at the end of December.

The student's qualification will be:

Subject grade = (Final test grade 70% + Work grade 15% + Laboratory grade 15%).

To be able to average the other course grades and pass the subject, students must achieve at least a 5 grade in the exam.

If the exam grade does not reach 5, the student has another opportunity to pass the subject through the make-up exam that will be held on the date set by the degree coordinator. In this test you can recover 70% of the grade corresponding to the theory part. The laboratory practices and the written and oral work part are not recoverable. To be able to average the other course grades and pass the subject, students must achieve at least a 4 grade in the exam. Students who pass the subject will only be considered those who obtain an overall evaluation average of 5.

Not Evaluated students

An student enrolled in the subject will receive the "not evaluated" grade if he decidesnot to attend the first midterm exam. In this case, he will not be entitled to attend only to the second midterm exam or to the final exam. All those studentswho have taken the first midterm exam will be considered as presented.

In the event that an student could not attend any of the compulsory exams due to justified causes, presenting the corresponding certificates that confirm this, another date will be arranged with the professor to take the exams.

**Student's assessment may experience some modifications depending on the restrictions to face-to-face activities enforced by health authorities.*

Bibliography

The material of the course can be found in the webspace of the subject of the Virtual Campus of the UAB. Among this material it can be found: general information, transparencies used in class, support videos, exercises to be delivered, reinforcement exercises, marks of examinations and any other information that is considered of interest for the students.

J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry,* Oxford University Press, 2012.

S. Warren, P. Wyatt, *Organic Synthesis: The Disconnection Approach,* John Wiley & Sons, 2008.

M.B. Smith *Organic Synthesis,* McGraw-Hill, 2002.

M.B. Smith *Organic Synthesis,* Academic Press, 2017. (online: https://www-sciencedirect-com.are.uab.cat/book/9780128007204/organic-synthesis)

W. A. Smit, R. Caple, R A. F. Bochkov,Organic Synthesis*: The Science Behind the Art* Royal Society of Chemistry 1998. (llibre en línia: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010362830406709)

P. G. M. Wuts, *Greene's* Protective Groups in Organic Synthesis, John Wiley & Sons, Fourth Edition, 2007. (online: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118905074)

Referències primàries.

http://www.organic-chemistry.org/

http://www.organic-chemistry.org/

Software

None.

Language list

Name	Group	Language	Semester	Turn
(PLAB) Practical laboratories	1	Catalan	first semester	afternoon
(PLAB) Practical laboratories	2	Catalan	first semester	afternoon
(TE) Theory	1	Catalan	first semester	morning-mixed