

## COURSE DESCRIPTION

### *Retrosynthetic Analysis*

Academic year 2026-2027

#### 1. Programme-related data

1.1. Higher Education Institution	Babeş-Bolyai University of Cluj-Napoca
1.2. Faculty	Faculty of Chemistry and Chemical Engineering
1.3. Department	Chemistry
1.4. Field	Chemistry
1.5. Level of study	Master's degree
1.6. Degree programme / Qualification	Organic and Biochemical Processes Engineering / Chemical Engineer
1.7. Form of education	Full-time

#### 2. Course-related data

2.1. Course title	<b>Retrosynthetic Analysis</b>			Course code	<b>CMR6132</b>
2.2. Course coordinator	Prof. Niculina Hădăde				
2.3. Seminar coordinator	Prof. Niculina Hădăde				
2.4. Year of study	II	2.5. Semester	1	2.6. Type of assessment	<a href="#">Exam</a>
2.7. Course status	<a href="#">Compulsory</a>			2.8. Course type	<a href="#">Core subject</a>

#### 3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	<b>4</b>	of which: 3.2. course	<b>2</b>	3.3. seminar/ laboratory/ project	<b>2</b>
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar/ laboratory	<b>28</b>
<b>Time allocation for individual study (IS) and self-taught activities (ST)</b>					<b>hours</b>
Learning from textbooks, course materials, bibliography, and notes (IS)					20
Additional research in the library, on subject-specific electronic platforms, and on-site					28
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					14
Tutoring (professional guidance)					2
Examinations					4
Other activities					1
<b>3.7. Total hours of individual study (IS) and self-taught activities (ST)</b>				<b>69</b>	
<b>3.8. Total hours per semester</b>				<b>125</b>	
<b>3.9. Number of credits</b>				<b>5</b>	

#### 4. Prerequisites (where applicable)

4.1. curriculum-related	Basic notions of organic chemistry
4.2 skills-related	Not applicable

#### 5. Specific conditions (where applicable)

5.1. course-related	Students will access the course materials in PDF format via the group created on the Microsoft Teams platform. Interactive participation will be encouraged. Students must keep their phones switched off.
5.2. seminar/laboratory-related	Attendance is mandatory under the conditions established by the regulations. Students will have access to the educational resource for seminar preparation within the dedicated group created on the Microsoft Teams platform. Students shall attend the seminar with the bibliographic material indicated during the previous seminars.

### 6.1. Competencies resulting from the completion of the degree programme (as referred to in the curriculum)<sup>1</sup>

Professional competencies	
Competency code	Competency
PC1	Description, analysis and use of fundamental concepts and theories in the field of organic chemistry, biochemistry, microbiology, genetics and molecular biology.
PC4	The operation of installations and processes in the field of organic and biochemical processes.
PC5	Modeling biological systems/bioengineering structures and processes of fine organic synthesis.
Transversal competencies	
Competency code	Competency
TC2	Planning, monitoring, and assuming the duties of a subordinate professional group. Demonstrating the capacity of coordination, analytical thinking, adaptability and flexibility, collaboration with team members.
TC3	Self-assessment of professional performances and determining the continuous training needs, permanent information and documentation in the field of activity and related areas, according to the needs of the labour market.

### 6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)<sup>2</sup>

Learning outcomes targeted by the subject		
Competency code	Knowledge and comprehension	Specific academic skills
CP1, CP5, CP6	Knows and explains at the molecular level the role and metabolism of biomacromolecules, enzymes, their mechanism of action, and how primary/secondary metabolites are generated.	The student/graduate works with basic concepts, principles, and methods of organic chemistry, biochemistry, enzymology, and metabolism..
CP1, CP3, CP5	Knows and works with the principles of retrosynthetic analysis for the synthesis of organic compounds with specific applications	The student/graduate applies the principles of organic retrosynthesis to propose synthesis schemes for complex molecules and to carry them out experimentally.
CP3, CP5	Knows advanced methods for analyzing and characterizing raw materials and finished products with organic structures using appropriate techniques	The student/graduate performs the analysis of organic compounds with complex structures using optimal methods (spectroscopic, chromatographic, genetic, and immunochemical methods), interprets the analyses, and formulates conclusions..

### 7. Subject-specific learning outcomes

Knowledge and comprehension
1. Explains the terminology and fundamental concepts of retrosynthetic analysis, including the notions of target compound, transformation, retron, disconnection, synthon, and synthetic equivalent, as well as their role in the systematic reduction of molecular complexity.
2. Describes the main retrosynthetic analysis strategies based on transformations, functional-group interconversions, molecular skeleton disconnection, and the identification of retrons specific to acyclic and cyclic organic compounds.
3. Explains the criteria for selecting and evaluating retrosynthetic routes for monocyclic, polycyclic, heterocyclic, and macrocyclic structures, including the relevant topological and stereochemical aspects.

<sup>1</sup> The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

<sup>2</sup> The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

4. Understands the criteria of coherence, validity, and relevance used in arguing a retrosynthetic analysis and in justifying the stages proposed for the synthesis of a complex organic compound.
<b>Specific academic skills</b>
1. Develops retrosynthetic analyses for complex organic compounds by strategically identifying retrons, disconnections, relevant synthons, and their appropriate synthetic equivalents.
2. Critically compares alternative synthetic routes and argues for the choice of a retrosynthetic strategy based on chemical feasibility, step economy, stereochemical control, and precursor accessibility.
3. Communicates clearly and persuasively, both orally and in writing, the conclusions of a retrosynthetic analysis and collaborates effectively in seminar activities by formulating, supporting, and revising the proposed solutions.

## 8. Contents

8.1. Course	Teaching and learning methods	Remarks <sup>3</sup>
8.1.1. Definition of terms specific to retrosynthetic analysis (target compound, transformation, retron, disconnection, synthons).	Lecture, discussion, problem-based learning	2 hours
8.1.2. Strategies based on transformations and functional groups. Structural simplification transformations based on molecular skeleton disconnection: chain disconnection (synthons for carbon-chain formation).	Lecture, discussion, problem-based learning	2 hours
8.1.3. Structural simplification transformations based on identifying a retron of the difunctionalized aliphatic residue type (disconnection of 1,2- and 1,3-difunctional derivatives).	Lecture, discussion, problem-based learning	2 hours
8.1.4. Structural simplification transformations based on identifying a retron of the difunctionalized aliphatic residue type (disconnection of 1,4-, 1,5-, and 1,6-difunctional derivatives).	Lecture, discussion, problem-based learning	2 hours
8.1.5. Structural simplification transformations based on identifying a ring-type retron. Disconnection of small rings (3, 4 atoms/(hetero)atoms).	Lecture, discussion, problem-based learning	2 hours
8.1.6. Structural simplification transformations based on identifying a medium-ring retron. Disconnection of medium rings (5, 6 atoms).	Lecture, discussion, problem-based learning	2 hours
8.1.7. Transformations without simplification of the molecular skeleton (molecular skeleton rearrangements, functional-group rearrangements, inversion of stereocenter configuration).	Lecture, discussion, problem-based learning	2 hours
8.1.8. Transformations based on reaction mechanisms.	Lecture, discussion, problem-based learning	2 hours
8.1.9. Strategies based on the similarity between the structure of the target compound and the structures of starting materials.	Lecture, discussion, problem-based learning	2 hours
8.1.10. Topological strategies: for acyclic systems and polycyclic systems (isolated, spiro, or bridged rings).	Lecture, discussion, problem-based learning	2 hours

<sup>3</sup> For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

8.1.11. The strategy of stereochemical approaches and functional-group modification.	Lecture, discussion, problem-based learning	2 hours
8.1.12. Multistrategic retrosynthetic analysis of macrocyclic structures.	Lecture, discussion, problem-based learning	2 hours
8.1.13. Multistrategic retrosynthetic analysis of heterocyclic structures.	Lecture with PPT support, discussion, problem-based learning	2 hours
8.1.14. Multistrategic retrosynthetic analysis of polycyclic structures.	Lecture, discussion, problem-based learning	2 hours
Bibliography		
1. E. J. Corey, Xue-Min Cheng, The Logic of Chemical Synthesis, Wiley, 1995. 2. P. Laszlo, Logique de la synthese organique, Marketing, Paris, 1993. 3. M. B. Smith, Organic Synthesis, McGraw-Hill, 1994. 4. R. O. C. Norman, Principles of Organic Synthesis, Chapman and Hall, 1981.		
<b>8.2. Seminar/ laboratory</b>	<b>Teaching and learning methods</b>	<b>Remarks</b>
8.2.1. Simplifying transformations, disconnections, synthons, and their synthetic equivalents.	Problem solving	2 hours
8.2.2. Functional-group interconversions in the structure of organic compounds.	Problem solving	2 hours
8.2.3. Retrosynthetic analysis and transformation-based strategies for the 1,2-difunctional retron ( $\alpha$ -hydroxy carbonyls, $\alpha$ -diketones, $\alpha$ -oxo acids).	Problem solving	2 hours
8.2.4. Retrosynthetic analysis and transformation-based strategies for the 1,3-difunctional retron ( $\beta$ -hydroxy carbonyls, $\beta$ -diketones, $\beta$ -oxo acids).	Problem solving	2 hours
8.2.5. Retrosynthetic analysis and transformation-based strategies for the 1,4-difunctional retron (hydroxy carbonyls, hydroxy acids, unsaturated acids).	Problem solving	2 hours
8.2.6. Retrosynthetic analysis and transformation-based strategies for the 1,5-difunctional retron (hydroxy carbonyls, hydroxy acids, unsaturated acids).	Problem solving	2 hours
8.2.7. Retrosynthetic analysis and transformation-based strategies for the 1,6-difunctional retron (hydroxy carbonyls, hydroxy acids, unsaturated acids).	Problem solving	2 hours
8.2.8. Retrosynthetic analysis and transformation-based strategies for monocyclic compounds (retron: cyclopropane).	Problem solving	2 hours
8.2.9. Retrosynthetic analysis and transformation-based strategies for monocyclic compounds (retron: cyclobutane).	Problem solving	2 hours
8.2.10. Retrosynthetic analysis and transformation-based strategies for monocyclic compounds (retron: cyclopentane).	Problem solving	2 hours
8.2.11. Retrosynthetic analysis and transformation-based strategies for	Problem solving	2 hours

monocyclic compounds (retron: cyclohexane).		
8.2.12. Retrosynthetic analysis and transformation-based strategies for monocyclic polycyclic compounds (with isolated and spiro rings).	Problem solving	2 hours
8.2.13. Retrosynthetic analysis and synthesis strategy of polycyclic compounds (with fused rings).	Problem solving	2 hours
8.2.14. Multistrategic retrosynthetic analysis.	Problem solving	2 hours
Bibliography: <b>1.</b> I. Schiketanz, I. Costea, Retrosinteza Organica, Printech, 2006. <b>2.</b> M. E. Alonso, The Art of Problem Solving in Organic Chemistry, John Wiley & Sons, 1987. <b>3.</b> C. Cristea, I. Hopârtean, I. A. Silberg, Chimia organică a produşilor naturali, Risoprint, 2002.		

## 9. Evaluation





































Type of activity	9.1 Evaluation criteria <sup>4</sup>	9.2 Evaluation methods <sup>5</sup>	9.3 Percentage in the final grade
9.4. Course	Knowledge of the concepts underlying the theoretical methods for the systematic reduction of the molecular complexity of organic compounds.	Written paper in which the retrosynthetic analysis of a complex target organic compound and the planning of the chemical synthesis stages are described in detail. Oral presentation, with PPT support, of the key elements of the retrosynthetic analysis and the planning of the synthesis stages. Answers to the questions.	80 %
	Development of skills for using the concepts of retrosynthetic analysis in planning the synthesis of organic compounds.		
9.5. Seminar/ laboratory	Understanding and assimilation of the topics covered in the course and seminar.	Active participation in problem solving.	20%
	Capacity for the appropriate use of theoretical concepts and methods.	Completion of assignments during the semester.	
9.6 Minimum standard for passing			
Grade 5 (five): systematic reduction of the molecular complexity of an organic compound with a cyclic structure, side chains, and functional groups.			

## 10. SDG labels (Sustainable Development Goals)<sup>6</sup>

<sup>4</sup> The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

<sup>5</sup> Both final evaluation methods and ongoing evaluation strategies should be established.

<sup>6</sup> Select a single label which, according to the [Implementation of SDG labels in the academic process](#), best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: "No label applies."

		Sustainable Development Generic Label						
								
			X					
								No label applies
								

Date of entry:  
17.04.2026

Signature of course coordinator

Prof. Dr. Niculina Hădade

Signature of seminar coordinator

Prof. Dr. Niculina Hădade

Date of approval in the department:  
24.04.2026

Signature of the head of department

Prof. Dr. Monica Toșa