File of the Discipline

1. Information regarding the program

1.1 Higher education institution	Babeş-Bolyai University, Cluj-Napoca
1.2 Faculty	Chemistry and Chemical Engineering
1.3 Department	Chemistry and Chemical Engineering in Hungarian Language
1.4 Field of study	Chemistry/ Chemical Engineering
1.5 Study cycle	Master
1.6 Study programme / Qualification	Chemistry – Modern Chemical Synthesis Techniques Chemical Engineering – The Chemistry and Engineering of Nano- and Biomaterials

2. Information regarding the discipline

2.1 Name of the discipline			**Asymmetric syntheses CMM6622**				
2.2 Course coordinator			**Prof. Habil. Dr. Csaba Paizs**				
2.3 Seminar coordinator			**Prof. Habil. Dr. Csaba Paizs**				
2.4 Year of study	I	2.5 Semester	2	2.6. Type of evaluation	Ex	2.7 Type of discipline	DS

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					**20**
Additional documentation (in libraries, on electronic platforms, field documentation)					**20**
Preparation for seminars/labs, homework, papers, portfolios and essays					**20**
Tutorship					**6**
Evaluations					**3**
Other activities: not the case					-

3.7 Total individual study hours	**69**
3.8 Total hours per semester	**125**
3.9 Number of ECTS credits	**5**

4. Prerequisites (if necessary)

4.1 curriculum	• Not the case
4.2 competencies	• Not the case

5. Conditions (if necessary)

5.1 for the course	• Students will attend the courses having the materials made available prior to each course • Students will turn off their mobile phones
5.2 for the seminar /lab activities	• Students will attend the lab activities with the materials made available prior to each meeting • During lab activities students will wear protective equipment (lab

	coat, gloves and protective glasses) • Students will turn off their mobile phones

6. Specific competencies acquired

Professional competences	• C1. Description, analysis and use of fundamental concepts and theories in the field of organic chemistry, biochemistry • C1.1. Identification and application of concepts, methods and theories of asymmetric synthesis to solve chemical and engineering synthesis problems under conditions of qualified assistance • C1.2 Critical analysis and use of advanced working principles, methods and techniques for the quantitative and qualitative evaluation of asymmetric synthesis procedures • C1.3 Application of advanced concepts and theories in the field of chemistry and chemical engineering for the development of an asymmetric synthesis process, in order to obtain a useful product • C2. Description, analysis and use of fundamental concepts and theories in the field of engineering sciences and biotechnologies • C2.1 Formulation, development and creative elaboration of solutions for the development of asymmetric synthesis solutions, to obtain valuable organic compounds • C3. The description, analysis and use of analysis, characterization and control methods specific to natural products and synthesis and biosynthesis products • C3.1. Definition of the language and identification of advanced concepts in the field of stereoselective synthesis, methods of analysis, characterization and control specific to chiral, natural and synthetic products • C3.2. Applying the basic principles of stereoselective synthesis to obtain a useful product (biologically active) and specific analysis methods
Transversal competencies	• CT1 The independent execution of complex professional tasks and the autonomous development of research-design activities, using computer-assisted techniques and respecting the norms of professional ethics and moral conduct • CT2 Planning, monitoring and assuming the professional tasks of a subordinate professional group. Demonstrating the ability to coordinate the activity, analytical thinking, adaptability and flexibility, collaboration with team members

7. Objectives of the discipline (outcome of the acquired competencies)

7. General objective of the discipline	• Information (training) on fine organic synthesis, including technological, with the objective of obtaining organic compounds with a complex structure, chiral and enantiomerically pure: theoretical principles and synthesis strategies, analytical control, types of reactions and asymmetric processes, concrete examples from the chemical field -pharmaceutical. The notion of stereoselective synthesis
7.2 Specific objective of the discipline	• The notion of stereoselective synthesis, particularly asymmetric. The motivation of the need to apply the asymmetric strategy. Basic concepts: structural, kinetic, thermodynamic and analytical. Nomenclature specific to asymmetric synthesis. Fundamental reactions in organic synthesis through the prism of the asymmetric approach. Feasibility and limits of the asymmetric strategy.

8. Content

8.1. Course	Teaching methods	Remarks
8.1.1. Basic concepts, keywords, summary: 1. SELECTIVITY vs. SPECIFICITY IN REACTIONS OF ORGANIC COMPOUNDS. 1.1. Specific substrate-selective product reactions. 1.2. Selective product reactions. 2. DEFINITIONS OF ASYMMETRICAL SYNTHESIS (Stereoselective product reaction). 3. TYPES OF ORGANIC COMPOUNDS IN RELATION TO ASYMMETRICAL SYNTHESIS.	Presentation; Explanation, Conversation; Description; Debate	

3.1. Symmetric achiral organic compounds that cannot be desymmetrized. 3.2. Symmetric achiral organic compounds that can be desymmetrized. 3.3. Non-chiral symmetric compounds by (non)selective desymmetrization. 3.4. Asymmetric, chiral and enantiomerically pure compounds without diastereotopic structural elements (ligands and/or faces): conservation and accumulation of molecular asymmetry. 3.5. Asymmetric, chiral and enantiomerically pure compounds with diastereotopic structural elements (ligands and/or faces): the extension of molecular asymmetry.		
8.1.2. Basic concepts, keywords, summary: 4. MINIMUM GLOSSARY OF SPECIFIC TERMS OF ASYMMETRICAL SYNTHESIS (I) 4.1. Anti-Syn (Formulae). 4.2. Bürgi-Dunitz (Trajectory). 4.3. Chiropractor(s) (Properties). 4.4. Cram. 4.4.1. The rule of the non-cyclic model (Felkin-Ahn). 4.4.2. The cyclic pattern rule. 4.5. Diastereomeric (Excess). 4.6. E(O), Z(O) (Enolates). 4.7. Enantiomeric (Excess). 4.8. Epimers. 4.9. Optics (Activity).	Presentation; Explanation, Conversation; Description; Debate	
8.1.3. Basic concepts, keywords, summary: 4. MINIMUM GLOSSARY OF SPECIFIC TERMS OF ASYMMETRICAL SYNTHESIS (II). 4.10. Stereoconvergent(a) (Synthesis). 4.11. Stereochemical (Descriptor). 4.12. Stereoelectronic (Effect). 4.13. (In)variable (Reflexive). 5. KINETIC AND THERMODYNAMIC CONTROL IN ASYMMETRICAL SYNTHESES. 5.1. The interaction between a racemic mixture and an achiral reactant. 5.2. The interaction between a racemic mixture and an enantiomerically pure reactant. 5.2.1. The kinetic resolution of a racemic mixture ("deracemization"). 5.2.1.1. Kinetic resolution in abiotic conditions. 5.2.1.2. Kinetic resolution under enzymatic conditions.	Presentation; Explanation, Conversation; Description; Debate	
8.1.4. Basic concepts, keywords, summary: 5.2.2. Kinetic resolution - dynamic (D.K.R. Dynamic kinetic resolution). 5.3. Influence of kinetic and thermodynamic parameters. 5.3.1. Curtin & Hammet's principle in the case of kinetic control. 5.3.2. Cases in which Curtin & Hammet's principle does not apply.	Presentation; Explanation, Conversation; Description;Debate	
8.1.5. Basic concepts, keywords, summary: 5.4. Stereodifferentiation in asymmetric synthesis. 5.4.1. Problem. 5.4.2. Simple asymmetric synthesis: simple stereodifferentiation. 5.4.2. Double asymmetric synthesis: double stereodifferentiation. 6. ANALYTICAL METHODS IN THE PRACTICE OF ASYMMETRIC SYNTHESES. 6.1. The importance of the analysis and the chosen method. 6.2. Polarimetry. Molecular chiroptical properties. 6.2.1. The phenomenon.	Presentation; Explanation, Conversation; Description;Debate	
8.1.6. Basic concepts, keywords, summary: 6.2.2. Applications of polarimetry. 6.2.2.1. The use of the relation of definition and variants. 6.2.2.2. Fluctuations of the specific rotation value. 6.2.2.3. Empirical assignments of the absolute configuration of an organic compound based on the specific rotation. 6.2.3. Rotary Optical Dispersion (R.O.D.) and Circular Dichroism (C.D.). 6.2.3.1. The phenomenon. 6.2.3.2. Applications of R.O.D. and C.D. to the semi-empirical deduction of the absolute configuration.	Presentation; Explanation, Conversation; Description; Debate	
8.1.7. Basic concepts, keywords, summary: 6.2.3.3. Conclusions. 6.3. Nuclear Magnetic Resonance (N.M.N.). 6.3.1. Chiral Derivatizing Agents (CDA): "static" derivatization. 6.3.1.1. Problem. 6.3.1.2. The use of Mosher acids in the analysis of the results of an asymmetric synthesis. 6.3.2. Achiral derivatization agents: "static-statistical" derivatization. 6.3.2.1. Dimerization method. 6.3.2.2. Cycling method. 6.3.3. Chemical Shift Reagents (CSR): "dynamic" derivatization. 6.3.3.1. Chiral chemical shift reagents (CSR).	Presentation; Explanation, Conversation; Description; Debate	

8.1.8. Basic concepts, keywords, summary: 6.3.3.2. Usefulness of chemical shift reagents (CSR). 6.3.4. Chiral Solvating Agents (CSA): "dynamic" derivatization. 6.3.4.1. Problem. 6.3.4.2. The use of chiral and enantiopure solvating agents. 6.3.4.3. Conclusions. 6.4. Chromatography. 6.4.1. The problem in the context of asymmetric synthesis. 6.4.2. General aspects. 6.4.3. General mechanisms of chromatographic separation of enantiomers.	Presentation; Explanation, Conversation; Description; Debate	
8.1.9. Basic concepts, keywords, summary: 6.4.4. Types of chiral and enantiopure stationary phases. 6.4.4.1. For gas chromatography (GC). 6.4.4.2. For liquid chromatography (HPLC). 6.4.4.3. General conclusions. 6.5. Recapitulation of the main methods for determining the enantiomeric composition. 7. MAIN METHODS AND STRATEGIES IN ASYMMETRIC SYNTHESIS. 7.1. Formation of new C-C bonds through asymmetric synthesis. 7.1.1. Asymmetric syntheses mediated by chiral auxiliaries. 7.1.1.1. Asymmetric Diels-Alder reactions. 7.1.1.2. Asymmetric α-C-alkylation reactions of oxyenolates.	Presentation; Explanation, Conversation; Description; Debate	
8.1.10. Basic concepts, keywords, summary: 7.1.1.3. Asymmetric α-C-alkylation reactions of azaenolates. 7.1.1.3. Conclusions. 7.1.2. Asymmetric nucleophilic additions to the carbonyl group. 7.1.2.1. Diastereoselective product addition of organomagnesium reagents to enantiopure carbonyl compounds. 7.1.2.2. The diastereoselective product aldol condensation. 7.1.3. Diastereoselective product transpositions.	Presentation; Explanation, Conversation; Description; Debate	
8.1.11. Basic concepts, keywords, summary: 7.2. Formation of new C-heteroatom bonds by asymmetric synthesis. 7.1.2. Product diastereoselective addition of hydrides to enantiopure carbonyl compounds. 7.1.3. Reagents and chiral catalysts. 7.1.4. Sharpless epoxidation. 7.1.5. Asymmetric dihydroxylation. 7.1.6. Asymmetric oxidation of suSem.hides.	Presentation; Explanation, Conversation; Description; Debate	
8.1.12. Basic concepts, keywords, summary: 8. NOTIONS OF INDUSTRIAL PRACTICE OF FINE AND ASYMMETRICAL ORGANIC SYNTHESIS (I). RAW MATERIALS: SOLVENTS, REAGENTS, AUXILIARY: the concept of "scale up", industrial synthesis in discontinuous regime, preparation and purification of solvents and reagents in fine organic synthesis on an industrial scale (examples), normal technological risk in fine organic synthesis on an industrial scale, the preparation of specific catalysts (Ni Raney, Pd/C), the practice of Grignard syntheses on an industrial scale.	Presentation; Explanation, Conversation; Description; Debate	
8.1.13. Basic concepts, key words, summary. 8. NOTIONS OF INDUSTRIAL PRACTICE OF FINE AND ASYMMETRICAL ORGANIC SYNTHESIS (II). MULTISTEP SYNTHESIS. Steroid hormones, reductions, oxidations, epoxidations, stereocontrolled nucleophilic additions to the >C=O group, stereocontrolled electrophilic additions to the >C=C< link on a pilot and industrial scale.	Presentation; Explanation, Conversation; Description; Debate	
8.1.14. Basic concepts, key words, summary. 9. SPECIALIST LITERATURE IN ASYMMETRICAL SYNTHESIS. 9.1. The main profile magazines. 9.1.1. Standards and conventions. 9.1.2. How to read an article in the field of asymmetric synthesis. 9.2. The main monographs in asymmetric synthesis. 9.2.1. Representative authors. 9.2.2. The place of asymmetric synthesis in the field of stereochemistry.	Presentation; Explanation, Conversation; Description; Debate	

Bibliography 1. S. Mager, M. Horn Stereochimia compusilor organici, Editura Dacia, Cluj-Napoca 1984. 2. S. Mager, L. David, I. Grosu Stereochimia compusilor organici, Editura Dacia, Cluj-Napoca, 2006. 3. E. L. Eliel, H. S. Wilen Stereochemistry of the Organic Compounds; John Wiley & Sons, Inc. 1994. 4. R. E. Gawley, J. Aubé, Principles of Asymmetric Synthesis, Pergamon (Tetrahedron Organic Chemistry Series) Elsevier Science Ltd. 1996. 5. M. Nógrádi Stereoselective Synthesis VCH Verlagsgesellschaft GmbH, D-69451 Weinheim (Germany) 1995. 6. A. Collet, J. Crassous, J. P. Dutasa, L. Guy, Molécules chirales (Stéréochimie et Propriétés) E.D.P. Science / C.N.R.S. Editions 2006. 7. J. Clayden, N. Greeves, S. Warren, P. Wothers Organic Chemistry, De Boeck Diffusion s.a., 2003, Oxford University Press 2001. 8. Colectiile de Publicatii (titluri reprezentative): Journal of the American Chemical Society, Organic Letters, Journal of the Organic Chemistry, Tetrahedron, Tetrahedron Asymmetry, Tetrahedron Letters, Chemistry an European Journal, European Journal of the Organic Chemistry.

8.2. Lab/Seminar	Teaching methods	Remarks
SEM. (7 x 2 = 14 hours) OBJECTIVE: Elaboration, by each Master's Student, of an Essay written from an Article in the field of Asymmetric Synthesis according to the Bibliography (pos. 8). SEM.-1 (2 hours): allocation of Articles by public drawing of lots; the detailed discussion of the writing requirements of the written Essay. SEM.-2 (2 hours): identifying the topic of the article (title, abstract, introduction, etc.) and locating the Authors of the Article in the field; identification of similar Articles by the Authors. SEM.-3 (2 hours): choosing the representative synthesis from the Article, writing its chemistry in the Essay by using the appropriate stereochemical representations. SEM.-4, -5 (2 x 2 hours): drafting, through detailed explanation, the organic structural analysis of the result of the previously chosen asymmetric synthesis. SEM.-6 (2 hours): writing, through a detailed explanation, the (stereo)reaction mechanism. SEM.-7 (2 hours): final check of the Essay. L (7 x 2 = 14 hours) OBJECTIVE: Resolution of a crude racemic mixture of free amine by derivatization with a pure optical acid L-1 (4 hours): purification of the raw material (recrystallization); L-2 (4 hours): formation of the diastereoisomeric salts of the free (racemic) amine with pure optical acid and their separation by fractional crystallization; L-3 (4 hours): release and purification (by recrystallization) of the free amine enantiomers; L-4 (2 hours): investigating the properties of enantiomers (optical rotation measurements)	Working groups 2 student	

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- By acquiring the theoretical-methodological concepts and approaching the practical aspects included in the discipline Asymmetric Syntheses, the master's students acquire a consistent body of knowledge, in accordance with the partial competencies required for the possible occupations provided in Grid 2M - RNCIS.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the final grade (%)
10.4 Course	Correctness of answers – proper understanding and learning of notions and concepts discussed during lectures; Correct use of learned concept withinnew contexts. Correct solving of the problems as part of the examination subjects	Oral examination: access to exam is conditioned by the laboratory colloquium and the presentation of laboratory reports corresponding to all practical works, but also by the activity at the seminars Proven or intended fraud is punished according to the ECST rules of UBB.	**60%** The final grade will consist of an average of two qualifications with equal weight: i) a grade (1 ÷ 10) for the Essay. ii) a grade (1 ÷ 10) in the Written Test. If the Essay grade is at least 8.00, attendance at the Written Test is optional and the final

			grade becomes the Essay grade.
10.5 Seminar/laboratory	Correctness of answers – proper understanding and learning of notions and concepts discussed during lab activities; Correct use of learned concept within new contexts. Quality of reports	The laboratory reports corresponding to all practical works – must be given in the last week of teaching activity, Laboratory colloquium - test - is held in the last week of the semester.	**40%** (20% for seminar activity and 20% for lab)
10.6 Minimum performance standards			

- The recognition, in proportion of 50%, of the stereoselective character of an asymmetric chemical process.
- Recognition, in proportion of 50%, of the specificity and selectivity of an asymmetric chemical process.
- The recognition, in proportion of 50%, of the chirality that appeared during an asymmetric chemical process.
- Recognition, in a proportion of 50%, of the enantiomerism appearing during an asymmetric chemical process.
- Recognition, in proportion of 50%, of the most appropriate analytical method for the control of an asymmetric chemical process.
- Recognition, in a proportion of 50%, of the most appropriate reaction conditions for carrying out an asymmetric chemical process.

Date
12.04.2024

Signature of course coordinator

Prof. Dr. Csaba Paizs

Signature of seminar coordinator

Prof. Dr. Csaba Paizs

Date of approval
12.04.2024

Signature of the head of department
Prof. Dr. Csaba Paizs