**Federal State Autonomous Educational Institution of Higher Education**
**PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA**
**RUDN University**

**Faculty of Science**

educational division (faculty/institute/academy) as higher education programme developer

# COURSE SYLLABUS

Modern organic synthesis and pharmacology

course title

**Recommended by the Didactic Council for the Education Field of:**

04.04.01 «Chemistry»

field of studies / speciality code and title

**The course instruction is implemented within the professional education programme of higher education:**

«Bioenergies and Biorefineries»

higher education programme profile/specialisation title

**2025**

## 1. COURSE GOAL

The goal of the course "Modern organic synthesis and pharmacology" is to familiarize with the basic concepts of Green Chemistry principles in modern organic chemistry. To introduce students to Alternative Synthetic Pathways. To define the applicability limits and the existing methods problems.

## 2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the course "Modern organic synthesis and pharmacology" is aimed at the development of the following competences:

*Table 2.1. List of competences that students acquire through the course study*

| **Competence code** | **Competence descriptor** | **Competence formation indicators** (within this course) |
|---|---|---|
| GPC-2 | Ability to analyze, interpret and generalize the results of experimental and computational-theoretical work in the chosen field of chemistry or related sciences. | GPC-2.1 Ability to carry out a critical analysis of the results of own experimental and computational-theoretical works and to interpret them correctly |
| | | GPC-2.2. Ability to formulate summary and conclusions based on the results of the analysis of literature data, own experimental and computational-theoretical works in the chosen field of chemistry or related sciences |
| PC-1 | Ability to develop a work plan and to choose adequate methods for solving research problems in the chosen field of chemistry, chemical technology or sciences related to chemistry | PC-1.1. Ability to prepare a general plan of research and detailed plans for individual stages; |
| | | PC-1.2. Ability to select experimental and calculation-theoretical methods for solving the problems based on the available material and time resources |

## 3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course "Modern organic synthesis and pharmacology" refers to the **variable** component of B1 block of the higher educational programme curriculum.

Within the higher education programme students also master other (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course study.

*Table 3.1. The list of the higher education programme components/disciplines that contribute to the achievement of the expected learning outcomes as the course study results*

| **Competence code** | **Competence descriptor** | **Previous courses/modules*** | **Subsequent courses/modules*** |
|---|---|---|---|
| GPC-2 | Ability to analyze, interpret and generalize the results of experimental and computational- | | Actual problems of modern chemistry<br>Bioproducts, Biomaterials and Biorefineries<br>Advanced Organic Synthesis |

| Competence code | Competence descriptor | Previous courses/modules* | Subsequent courses/modules* |
|---|---|---|---|
| | theoretical work in the chosen field of chemistry or related sciences. | | Catalyst (nanomaterials) design and applications<br>Catalysis: from Basic principles to applications. Homogeneous, Heterogeneous, PhotoCatalysis, Biocatalysis, Electrocatalysis<br>Experimental lab 1: Flow synthesis and alternative technologies<br>Experimental lab 2: Biorefineries and Bioproducts<br>Experimental lab 3: Advanced Organic Synthesis<br>Student Scientific-Research work<br>Pre-graduation practical training |
| PC-1 | Ability to develop a work plan and to choose adequate methods for solving research problems in the chosen field of chemistry, chemical technology or sciences related to chemistry | | Advanced Organic Synthesis<br>Catalyst (nanomaterials) design and applications<br>Experimental lab 1: Flow synthesis and alternative technologies<br>Experimental lab 2: Biorefineries and Bioproducts<br>Experimental lab 3: Advanced Organic Synthesis<br>Emerging contaminants: from fate to environmental remediation<br>The methods of working with databases<br>Student Scientific-Research work<br>Pre-graduation practical training |

* To be filled in according to the competence matrix of the higher education programme.

## 4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course “Modern organic synthesis and pharmacology” is 4 credits (144 academic hours).

*Table 4.1. Types of academic activities during the periods of higher education programme mastering (**full-time training**)**

| Type of academic activities | Total academic hours | Training modules | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Contact academic hours* | *27* | *27* | | | |

| Type of academic activities | | Total academic | Training modules | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| including: | | | | | | |
| Lectures (LC) | | 18 | 18 | | | |
| Lab work (LW) | | 9 | 9 | | | |
| Seminars (workshops/tutorials) (S) | | | | | | |
| *Self-studies* | | *108* | *108* | | | |
| *Evaluation and assessment (exam/passing/failing grade)* | | *9* | *9* | | | |
| **Course workload** | academic hours | **144** | **144** | | | |
| | credits | **4** | **4** | | | |

## 5. COURSE MODULES AND CONTENTS

*Table 5.1. Course contents and academic activities types*

| Course module title | Course module contents (topics) | Academic activities types |
|---|---|---|
| Module 1. Pharmacology | Topic 1.1 Introduction to Pharmacology | LC |
| | Topic 1.2 Physicochemical properties of Active Pharmaceutical Ingredients (APIs). Ionization of pharma compounds. Acidic APIs. Basic APIs. Isoelectric point. pKa and pKb. Partition coefficient. | LC |
| | Topic 1.3 Pharmacokinetics and pharmacodynamics: Concepts and examples. Pharmacokinetics: Absorption and distribution of APIs. Bioavailability. Pharmacodynamics. Pharmacological receptors. Agonist and antagonist molecules. APIs classification: structural specific and nonspecific APIs | LC, LW |
| | Topic 1.4 Structural characteristics of APIs and Pharmacological action. Stereoisomerism. Optic, geometric and conformational isomers and pharmacological action. Chemical Isostery. Concept. Bioisosterism. Classic and non classic bio-isosterism | LC, LW |
| | Topic 1.5 Rational design of APIs. Pharmacological design. Pharmacomodulation. QSAR methods for pharma design. Hammet equation. Taft equation. Hansch method. Method of Free-Wilson. QSAR-3D methodologies. Examples. | LC, LW |
| | Topic 1.6 Metabolic pathways of APIs. Definition of toxicology. Basic principles of toxicology. Synergism, potentiation and antagonism. Dose-response relationships. Xenobiotics and endogenous substances. Examples. Pharma metabolism. Metabolic reactions (Phase I, Phase II). Metabolic routes. Examples for common | LC, LW |

| Course module title | Course module contents (topics) | Academic activities types |
|---|---|---|
| | pharmaceuticals. | |
| Module 2. Pharma synthesis | Topic 2.1 Green metrics and Green Chemistry in Pharma<br>Introduction and applications of fundamental green metrics into modern synthesis; solvent selections and applications of sustainable solvent systems in modern approaches to organic synthesis and catalysis. Atom economy. E-factor. Functional Oriented Synthesis (FOS). | LC, LW |
| | Topic 2.2 Real examples of application of Green Chemistry principles I in Pharma synthesis:<br>Synthesis of Sildenafil (Viagra®, Pfizer), Synthesis of Talampanel (LY300164, Lilly Research Laboratories, Green Chemistry Award 1999), Synthesis of Ganciclovir (Cytovene®, Roche, Green Chemistry Award 2000). | LC |
| | Topic 2.3 Real examples of application of Green Chemistry principles II in pharma synthesis:<br>Synthesis of Sertraline (Zoloft®, Pfizer, Green Chemistry Award 2002), Synthesis of Aprepitant (Emend®, Merck &Co., Green Chemistry Award 2005); Synthesis of Sitagliptin (Juvenia™, Merck &Co. Green Chemistry Award 2006). | LC, LW |
| | Topic 2.4 Flow approaches to sustainable pharmaceuticals synthesis | LC, LW |

* - to be filled in only for **full** -time training: *LC - lectures; LW - lab work; S - seminars.*

## 6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

*Table 6.1. Classroom equipment and technology support requirements*

| Type of academic activities | Classroom equipment | Specialised educational / laboratory equipment, software, and materials for course study (if necessary) |
|---|---|---|
| Lecture | A lecture hall for lecture-type classes, equipped with a set of specialised furniture; board (screen) and a set of devices for multimedia presentations. | Projector, motorized screen for projectors, Wi-Fi |
| Lab work | A classroom for laboratory work, individual consultations, current and mid-term assessment; equipped with a set of specialised furniture and machinery. | A set of specialized furniture; specialized equipment of the chemical laboratory: fume hood SHVP-4, fume hood SHVP-2, rotary evaporator Hei-value digital G3B, rotary evaporator IKA, digital devices for determining the |

| Type of academic activities | Classroom equipment | Specialised educational / laboratory equipment, software, and materials for course study (if necessary) |
|---|---|---|
| | | melting point SMP10; electronic laboratory scales AND EK-610, MK-M flask heaters of different volumes, drying cabinet, magnetic stirrer MRHei-Mix S, magnetic stirrer with heating MRHei-Standart, refractometer, combined laboratory water bath, vacuum chemical station RS3001 VARIO-pro, circulation cooler Rotacool Mini, rotary plate pump vacuum RZ2.5, membrane vacuum chemical pump MZ2CNT, Steinel thermal air blower, Spectroline UV lamp, electronic vacuum controller with CVC3000 detect Vacuumbrand valve, stainless steel emergency cabin SHVV, chemical dishes, refrigerator; wi-fi |
| Self-studies | A classroom for self-studies (can be used for seminars and consultations), equipped with a set of specialised furniture and computers with access to the electronic information and educational environment. | **Faculty of Science Reading Room**<br>Ordzhonikidze D.3.<br>Coworking area<br>Monday - Friday 10.00 – 22.00<br>**Reading room of the main building of the RUDN**<br>Coworking area<br>Monday - Saturday 9.00 - 23.00<br>Hall No. 2<br>Monday - Thursday 10.00 - 17.45<br>Friday 10.00 - 16.45<br>Hall No. 6<br>Monday - Thursday 10.00 - 17.45<br>Friday 10.00 - 16.45 |

* The premises for students' self-studies are subject to **MANDATORY** mention

## 7. RECOMMENDED RESOURCES FOR COURSE STUDY

*Main sources:*

1. L. D. Field, S. Sternhell y J. R. Kalman, Organic Structures from Spectra, Wiley, 2002.
2. Green Chemistry in the synthesis of pharmaceuticals, S. Kar, H. Sanderson, K. Roy, E. Benfenati, J. Leszczynski, Chem. Rev. 2022, 122, 3637-3710.
3. Green Chemistry and Sustainability metrics in the pharmaceutical manufacturing sector, J. Becker, C. manske, S. Randl, Current Opinion in Green and Sustainable Chemistry 2022, 33, 100562

*Additional sources:*

1. Website of the American Chemical Society ACS Publications: Chemistry journals, books, and references https://pubs.acs.org/
2. http://www.thieme.com/journals-main
3. http://onlinelibrary.wiley.com/
4. http://www.springer.com/gp/products/journals
5. Server with the ability to search for methods for synthesizing compounds http://www.orgsyn.org/

*Internet sources*

1. Electronic libraries with access for RUDN students:
- RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
- EL "University Library Online" http://www.biblioclub.ru
- EL "Yurayt" http://www.biblio-online.ru
- EL "Student Consultant" www.studentlibrary.ru
- EL "Lan" http://e.lanbook.com/
- EL "Trinity Bridge"

Databases and search engines:

- electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- Scopus abstract database http://www.elsevierscience.ru/products/scopus/
- www.scholar.google.ru

*Training toolkit for self- studies to master the course *:*

1. A set of lectures on “Modern organic synthesis and pharmacology”
2. The laboratory workshop on “Modern organic synthesis and pharmacology”

* The training toolkit for self- studies to master the course is placed on the course page in the university telecommunication training and information system under the set procedure.

**DEVELOPERS:**

| | | |
|---|---|---|
| **Organic Chemistry Department** | | **Luigi Vaccaro** |
| position, department | signature | name and surname |
| **Organic Chemistry Department** | | **Rafael Luque** |
| position, department | signature | name and surname |

**HEAD OF EDUCATIONAL DEPARTMENT:**

| | | |
|---|---|---|
| **Organic Chemistry Department** | | **Voskressensky L.G** |
| name of department | signature | name and surname |

**HEAD OF HIGHER EDUCATION PROGRAMME:**

| | | |
|---|---|---|
| **Dean of Faculty of Science, Head of Organic Chemistry Department** | | **Voskressensky L.G** |
| position, department | signature | name and surname |