University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Methodology of scientific research

Teachers: Savić M. Miroslav, Krajnović M. Dušanka, Kotur-Stevuljević M. Jelena, Bogavac-Stanojević B. Nataša

Course status: Mandatory common, module: Doctoral academic studies

Semester: I	**Year of studies:** I
ECTS points: 5	**Course code:** Д1О31

Requirements: none

Course aims:

The aim of this course is to provide participants with general scientific skills in order to formulate a scientific problem and plan the experiment, as well as to understand the complete process of preparation and publication of scientific research results

Course outcomes:

By the end of this course participants will be able to summarize and apply the principles of the methodology of scientific-researh work and scientific writing

Course contents:

Science and scientific method. Problem and scientific problem. Hypothesis. Hypothesis verification: scientific observation and scientific experiment. Common methodology of scientific research in biomedicine. Classification of research. Experimental research in laboratory. Animal experiments. Types of studies in epidemiological investigations. Ethics and biomedical investigations. Ethical codex of scientific-researh work. Generation of biomedical information. Communications. Networks. Internet. Internet search engines. Authorship/co-authorship. Role and duties of principal investigator. Protection of intellectual property. Classification of scientific work. Writing of scientific and professional papers. Literature citing. Review process. Oral presentation of scientific work (adaptation to audience and situation). Designing PowerPoint slides for a scientific presentation. Introduction to writing of project proposals. Master's thesis and doctoral dissertation.

Recommended literature:

1 Cargill, M, O'Connor P. Writing scientific research articles: Strategy and steps. John Wiley & Sons, 2013.

2. Baumgartner TA, Hensley LD. Conducting and Reading Research in Health and Human performance. Mc Graw Hill, Boston, 2006

3. Machin D, Campbell MJ. Design of studies for medical research. John Wiley & Sons, Hoboken, 2005.

4. Peat J, Elliot E, Baur L, Keena V. Scientific writing – easy when you know how. BMJ Books, London, 2002.

5. Albert T. The A-Z of medical writing. BMJ Books, London, 2000.

6. Hudson Jones A, McLeallan F. Ethical Issues in Biomedical Publication. Baltimore: John Hopkins University Press, 2000.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures and study-research work

Grading system:

Seminar: 30 points; written exam: 70 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Statistics in research

Teachers: Bogavac-Stanojević B. Nataša, Kotur-Stevuljević M. Jelena

Course status: Mandatory common, module: Doctoral academic studies

Semester: I	**Year of studies:** I
ECTS points: 5	**Course code:** Д1О32

Requirements: One semester of undergraduate studies in mathematics and statistics
pharmaceutical / medical biochemistry / medicine

Course aims:

Understanding advanced statistical methods. Applying advanced statistical analyses in scientific research.

Course outcomes:

After completing the course students will be trained to:

- Recognizing the type of statistical analysis
- Interpret the significance of the obtained statistical indicators and discuss the results,
- Understand the importance of the application of statistical methods in the scientific research,
- Use statistical software in the data analysis

Course contents:

One-way analysis of variance (ANOVA). Two-way analysis of variance. ANOVA with replication. Post-hoc tests. Simple linear regression analysis. Multiple regression analyses. Logistic regression. Analysis of covariance. Nonparametric analysis of variance. Nonparametric correlation. Chi-square test. Confidence interval.

Student's research: Solving different statistical problems and tasks.

Recommended literature:

1. Sheskin DJ. Handbook of parametric and nonparametric statistical procedures Chapman & Hall/CRC, Washington, D.C., 2000.
2. Vitingoff E, Shiboski SC, Glidden DV, McCulloch CE. Regression Methods in Biostatistics,Springer Science + Business Media, New York, 2005.
3. Selvin S. Statistica Analysis of Epidemiological Data, Oxfor University Press, Oxford, 1996.
4. Tamhane AJ, Dunlop DD. Statistics and Data Analysis, Prentice Hall, Upper Saddle River, NJ, 2000.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, computer exercises, solving practical problems

Grading system:

The presence at lectures: 30 points; Written Exam: 70 points.

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Seminar 1

Teachers: Ivanović P. Darko, Zečević L. Mira, Malenović M. Anđelija, Stojanović S. Biljana, Miletić Đ. Ivanka, Šobajić S. Slađana, Stanković M. Ivan, Đorđević I. Brižita, Vuleta M. Gordana, Milić R. Jela, Primorac M. Marija, Savić D. Snežana, Vasiljević D. Dragana, Krajišnik R. Danina, Đekić M. Ljiljana, Spasić M. Slavica, Jelić-Ivanović D. Zorana, Spasojević-Kalimanovska V. Vesna, Stojanov D. Marina, Ignjatović D. Svetlana, Topić S. Aleksandra, Dopsaj B. Violeta, Bogavac-Stanojević B. Nataša, Kotur-Stevuljević M. Jelena, Tasić M. Ljiljana, Marinković D. Valentina, Krajnović M. Dušanka, Miljković R. Branislava, Vezmar Kovačević D. Sandra, Vučićević M. Katarina, Kovačević N. Nada, Petrović D. Silvana, Maksimović A. Zoran, Kundaković D. Tatjana, Drobac M. Milica, Ugrešić D. Nenad, Stepanović-Petrović M. Radica, Savić M. Miroslav, Ilić V. Katarina, Novaković N. Aleksandra, Tomić A. Maja, Leposavić M. Gordana, Arsenović-Ranin M. Nevena, Stojić-Vukanić M. Zorica, Plećaš-Solarović A. Bosiljka, Pešić P. Vesna, Nedeljković S. Miodrag, Milenković T. Marina, Antić Stanković A. Jelena, Parojčić V. Jelena, Ibrić R.Svetlana, Đuriš D.Jelena, Grbić V. Sandra, Đurić R. Zorica, Vladimirov M.Sote, Agbaba D. Danica, Bulat L. Zorica,

Matović J. Vesna, Antonijević M. Biljana, Vujanović L. Dragana, Đukić M. Mirjana

Course status: Mandatory common, module: Doctoral academic studies

Semester: I	**Year of studies:** I
ECTS points: 5	**Course code:** Д1О33

Requirements: none

Course aims:

This course aims to enable the participant to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; apply the principles of making a successful oral presentation in English.

Course outcomes:

By the end of this course participants will be able to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; apply the principles of making a successful oral presentation in English

Course contents:

Collecction of pertinent literature (by use of bibliographic databases, web sites of publishers, general search engines). Preparation of personal databases. Contextual analysis of key publications in a field. Preparation and presentation of the published results.

Recommended literature:

1. Alley M. The craft of scientific presentations. Critical steps to succeed and critical errors to avoid. Springer-Verlag New York, Inc., 2003.
2. Original scientific papers and review articles in the field of the participant's research activity.

The total of active learning classes	**Lectures:** 30
	Individual research work: 60

Teaching methods:

Study-research work

Grading system:

Seminar: 70 points; written exam: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Seminar 2

Teachers: Ivanović P. Darko, Zečević L. Mira, Malenović M. Anđelija, Stojanović S. Biljana, Miletić Đ. Ivanka, Šobajić S. Slađana, Stanković M. Ivan, Đorđević I. Brižita, Vuleta M. Gordana, Milić R. Jela, Primorac M. Marija, Savić D. Snežana, Vasiljević D. Dragana, Krajišnik R. Danina, Đekić M. Ljiljana, Spasić M. Slavica, Jelić-Ivanović D. Zorana, Spasojević-Kalimanovska V. Vesna, Stojanov D. Marina, Ignjatović D. Svetlana, Topić S. Aleksandra, Dopsaj B. Violeta, Bogavac-Stanojević B. Nataša, Kotur-Stevuljević M. Jelena, Tasić M. Ljiljana, Marinković D. Valentina, Krajnović M. Dušanka, Miljković R. Branislava, Vezmar Kovačević D. Sandra, Vučićević M. Katarina, Kovačević N. Nada, Petrović D. Silvana, Maksimović A. Zoran, Kundaković D. Tatjana, Drobac M. Milica, Ugrešić D. Nenad, Stepanović-Petrović M. Radica, Savić M. Miroslav, Ilić V. Katarina, Novaković N. Aleksandra, Tomić A. Maja, Leposavić M. Gordana, Arsenović-Ranin M. Nevena, Stojić-Vukanić M. Zorica, Plećaš-Solarović A. Bosiljka, Pešić P. Vesna, Nedeljković S. Miodrag, Milenković T. Marina, Antić Stanković A. Jelena, Parojčić V. Jelena, Ibrić R.Svetlana, Đuriš D.Jelena, Grbić V. Sandra, Đurić R. Zorica, Vujić B. Zorica, Čudina A. Olivera, Bulat L. Zorica, Matović J. Vesna, Antonijević M. Biljana, Vujanović L. Dragana, Đukić M. Mirjana

Course status: Mandatory common, module: Doctoral academic studies

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** Д1О34

Requirements: none

Course aims:

This course aims to enable the participant to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; upgrade his/her capacities for giving a successful oral presentation in English.

Course outcomes:

By the end of this course participants will be able to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; apply the principles of making a successful oral presentation in English

Course contents:

Collecction of pertinent literature (by use of bibliographic databases, web sites of publishers, general search engines). Preparation of personal databases. Contextual analysis of key publications in a field. Preparation and presentation of the published results.

Recommended literature:

1. Alley M. The craft of scientific presentations. Critical steps to succeed and critical errors to avoid. Springer-Verlag New York, Inc., 2003.

2. Original scientific papers and review articles in the field of the participant's research activity.

The total of active learning classes	**Lectures:** 30
	Individual research work: 60

Teaching methods:

Study-research work

Grading system:

Seminar: 70 points; written exam: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Seminar 3

Teachers: Ivanović P. Darko, Zečević L. Mira, Malenović M. Anđelija, Stojanović S. Biljana, Miletić Đ. Ivanka, Šobajić S. Slađana, Stanković M. Ivan, Đorđević I. Brižita, Vuleta M. Gordana, Milić R. Jela, Primorac M. Marija, Savić D. Snežana, Vasiljević D. Dragana, Krajišnik R. Danina, Đekić M. Ljiljana, Spasić M. Slavica, Jelić-Ivanović D. Zorana, Spasojević-Kalimanovska V. Vesna, Stojanov D. Marina, Ignjatović D. Svetlana, Topić S. Aleksandra, Dopsaj B. Violeta, Bogavac-Stanojević B. Nataša, Kotur-Stevuljević M. Jelena, Tasić M. Ljiljana, Marinković D. Valentina, Krajnović M. Dušanka, Miljković R. Branislava, Vezmar Kovačević D. Sandra, Vučićević M. Katarina, Kovačević N. Nada, Petrović D. Silvana, Maksimović A. Zoran, Kundaković D. Tatjana, Drobac M. Milica, Ugrešić D. Nenad, Stepanović-Petrović M. Radica, Savić M. Miroslav, Ilić V. Katarina, Novaković N. Aleksandra, Tomić A. Maja, Leposavić M. Gordana, Arsenović-Ranin M. Nevena, Stojić-Vukanić M. Zorica, Plećaš-Solarović A. Bosiljka, Pešić P. Vesna, Nedeljković S. Miodrag, Milenković T. Marina, Antić Stanković A. Jelena, Parojčić V. Jelena, Ibrić R.Svetlana, Đuriš D.Jelena, Grbić V. Sandra, Đurić R. Zorica, Vujić B. Zorica, Čudina A. Olivera, Bulat L. Zorica, Matović J. Vesna, Antonijević M. Biljana, Vujanović L. Dragana, Đukić M. Mirjana

Course status: Mandatory common, module: Doctoral academic studies

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** Д2О31

Requirements: none

Course aims:

This course aims to enable the participant to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; upgrade his/her capacities for giving a successful oral presentation of results of personal reserch activities

Course outcomes:

By the end of this course participants will be able to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; apply the principles of making a successful oral presentation in English

Course contents:

Collecction of pertinent literature (by use of bibliographic databases, web sites of publishers, general search engines). Preparation of personal databases. Contextual analysis of key publications in a field. Preparation and presentation of the published results.

Recommended literature:

1. Alley M. The craft of scientific presentations. Critical steps to succeed and critical errors to avoid. Springer-Verlag New York, Inc., 2003.

2. Original scientific papers and review articles in the field of the participant's research activity.

The total of active learning classes	**Lectures:** 30
	Individual research work: 60

Teaching methods:

Study-research work

Grading system:

Seminar: 70 points; written exam: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Seminar 4

Teachers: Ivanović P. Darko, Zečević L. Mira, Malenović M. Anđelija, Stojanović S. Biljana, Miletić Đ. Ivanka, Šobajić S. Slađana, Stanković M. Ivan, Đorđević I. Brižita, Vuleta M. Gordana, Milić R. Jela, Primorac M. Marija, Savić D. Snežana, Vasiljević D. Dragana, Krajišnik R. Danina, Đekić M. Ljiljana, Spasić M. Slavica, Jelić-Ivanović D. Zorana, Spasojević-Kalimanovska V. Vesna, Stojanov D. Marina, Ignjatović D. Svetlana, Topić S. Aleksandra, Dopsaj B. Violeta, Bogavac-Stanojević B. Nataša, Kotur-Stevuljević M. Jelena, Tasić M. Ljiljana, Marinković D. Valentina, Krajnović M. Dušanka, Miljković R. Branislava, Vezmar Kovačević D. Sandra, Vučićević M. Katarina, Kovačević N. Nada, Petrović D. Silvana, Maksimović A. Zoran, Kundaković D. Tatjana, Drobac M. Milica, Ugrešić D. Nenad, Stepanović-Petrović M. Radica, Savić M. Miroslav, Ilić V. Katarina, Novaković N. Aleksandra, Tomić A. Maja, Leposavić M. Gordana, Arsenović-Ranin M. Nevena, Stojić-Vukanić M. Zorica, Plećaš-Solarović A. Bosiljka, Pešić P. Vesna, Nedeljković S. Miodrag, Milenković T. Marina, Antić Stanković A. Jelena, Parojčić V. Jelena, Ibrić R.Svetlana, Đuriš D.Jelena, Grbić V. Sandra, Đurić R. Zorica, Vujić B. Zorica, Čudina A. Olivera, Bulat L. Zorica, Matović J. Vesna, Antonijević M. Biljana, Vujanović L. Dragana, Đukić M. Mirjana

Course status: Mandatory common, module: Doctoral academic studies

Semester: IV	**Year of studies:** II
ECTS points: 5	**Course code:** Д2О32

Requirements: none

Course aims:

This course aims to enable the participant to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; upgrade his/her capacities for giving a successful oral presentation of results of personal reserch activities; prepare publications containing the results obtained in the performed personal investigation

Course outcomes:

By the end of this course participants will be able to: search the scientific literature effectively and thoroughly; perform a critical analysis of publications relevant for his/her study field; apply the principles of making a successful oral presentation and preparing publications containing the personal results

Course contents:

Collecction of pertinent literature (by use of bibliographic databases, web sites of publishers, general search engines). Preparation of personal databases. Contextual analysis of key publications in a field. Preparation and oral and written presentation of the personal results.

Recommended literature:

1. Alley M. The craft of scientific presentations. Critical steps to succeed and critical errors to avoid. Springer-Verlag New York, Inc., 2003.
2. Original scientific papers and review articles in the field of the participant's research activity.

The total of active learning classes	**Lectures:** 30
	Individual research work: 60

Teaching methods:

Study-research work

Grading system:

Seminar: 70 points; written exam: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Selected topics in organic chemistry

Teachers: Savić M. Vladimir

Course status: Mandatory modules, module: Pharmaceutical Chemistry

Semester: I	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1ОМ1

Requirements: None

Course aims:

To demonstrate general principles of synthetic methodologies such as solid phase synthesis, combinatorial and parallel synthesis and their application in drug design and development. To describe stereochemical properties of organic molecules and their significance for biological profile of drugs.

Course outcomes:

Acquired knowledge should provide a. understanding of some modern synthetic technologies and their application in drug design b. understanding of significance of drug stereochemical properties and their influence on biological behavior.

Course contents:

Basic stereochemical terms. Enantiomers and diastereoisomers. Stereochemical features important for biological properties. Interactions of chiral compounds and biomolecules. Eutomers and distomers. Activity of enantiomers. The effect of drug stereochemistry on pharmacokinetics and metabolism. Stereochemistry in patent application. Enantiomeric purity, significance and determination (polarimetry, GC, HPLC, NMR). Asymmetric synthesis, application in pharmaceutical industry. Solid phase synthesis. Polymers and linkers. Combinatorial and parallel synthesis. Peptidomimetics. Process development.

Recommended literature:

1.Medicinal chemistry, Principles and Practice; 2.F.D.King;An introduction to medicinal chemistry; 3.G.L.Patrick;Contemporary drug synthesis; J.Li, D.S.Johnson, D.R.Sliskovic, B.D.Roth; 4.Stereochemistry of organic compounds; E.L.eliel, S.H.Wilen 5. Original scientific articles

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Seminars, consultative teaching

Grading system:

Seminar 50 points, Written/oral exam 50 points (max 100 points)

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: The chemical and biopharmaceutical aspects of the design of biologically active molecules

Teachers: Vladimirov M.Sote, Agbaba D. Danica

Course status: Mandatory modules, module: Pharmaceutical Chemistry

Semester: I	**Year of studies:** I
ECTS points: 10	**Course code:** ДФХ1ОМ2

Requirements: Previously Passed Selected topics in organic chemistry

Course aims:

Introduction; structure, chemical and biopharmaceutical properties and metabolic processes of selected stuctural models of substances/ligands used as drugs.

Course outcomes:

Acquired knowledge should provide an understanding of structural and physicochemical properties of molecules, ligand-receptor-enzymes interaction, as well as certain skills in predicition of physicochemical properties of newly sinthesized compounds with potential biological acivity.

Course contents:

Solubility of biologically active molecules and methods of calculation . Acid- base properties of molecules , conjugated base and acids. Ionization of biologically active molecules and types of interaction with biomolecules under in vivo conditions. Amphiphilicity of molecules. Lipophilicity of molecules, methods of determination and experimental calculation. Structures of biological membranes or receptors, and their functionallity in humans. Impact of chemical stuctures and physico-chemical properties of pharmacologically active compounds/ligands on different modes of drug absorption. Permeability. Biopharmaceutical clasification of biologically active substances. Role, types and functionalities of bological transportes on resorption (eflux transpoters). Concept of pro drug forms.

Recommended literature:

1. Patrick GL. Medicinal chemistry, Principles and Practice; 3rd edition,Oxford University Press, Oxford, 2005.

2. King F.D. An introduction to medicinal chemistry; 2nd edition, RSC,Cambridge, 2005.

3..Li J, Johnson DS,Slišković DR. Roth BD. Contemporary drug synthesis;; Wiley Interscience, Hoboken, 2004.

4. Eliel EL,Wilen SH. Stereochemistry of organic compounds, John Wiley and Sons, INC, 1994.

5. Original scientific papers

The total of active learning classes	**Lectures:** 60
	Individual research work: 60

Teaching methods:

Seminars, consultative teaching

Grading system:

Seminar 30 points, Written/oral exam 70 points (max 100 points)

University of Belgrade Faculty of Pharmacy	DOCTORAL ACADEMIC STUDIES	

Course title: Methods in Computer-Assisted Drug Design

Teachers: Erić M. Slavica, Nikolić M.Katarina

Course status: Mandatory modules, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 10	**Course code:** ДФХ1ОМ3

Requirements: None

Course aims:

Advancing the knowledge about theoretical methods for molecular modelling, conformational analysis, calculation and selection of molecular descriptors, pharmacophore mapping and search. Gaining the skills for analysis of quantitative structure-activity and structure-property relationships, as well as for prediction and modification of ADMET properties.

Course outcomes:

Knowledge of basic and advanced theoretical methods and computational programs for: QSAR and molecular modelling; calculation, selection and interpretation of molecular descriptors; fragment design; mapping and analysis of pharmacophores; protein-protein docking; homology modeling; virtual docking, and molecular dynamics. The application of computational models for prediction and optimization of ADMET properties.

Course contents:

Theoretical and computational programs for molecular modelling, conformational analysis and calculation of molecular descriptors; QSAR/QSPR studies by use of various mathematical methods and application of QSAR/QSPR models for the prediction and interpretation of activities and properties of novel designed structures; principles of three-dimensional QSAR modelling; mapping and analysis of three-dimensional pharmacophores; fragment design; computational methods for homology modelling of specific targets and study of protein-protein and drug-target interactions by use of docking and molecular dynamic methods. Computational methods for prediction of absorption, distribution, metabolism, excretion and toxicity (ADMET); analysis of structural requirements of pharmacologically active compounds for optimization of ADMET properties. Case studies for the design of novel drugs by methods of ligand-based and structure-based drug design. The use of programs for the design of new drugs.

Recommended literature:

1. Partick GL. An Introduction to Medicinal Chemistry, 4th Edition, Oxford University Press, ed.. 2009.

2. Abraham DJ. Burger's Medicinal Chemistry and Drug Discovery, 7th Edition, volume 1: Methods in Drug Discovery and volume 2: Discovering Lead Molecules, John Wiley&Sons, Inc.,2010.

3. Merz KM, Ringe D, Reynolds CH. Drug design: Structure and Ligand-based Approaches, Cambridge University Press, 2010.

4. Krogsgaard-Larsen P, Madsen U, Stromgaard K. Textbook of Drug Design and Discovery, 4th ed. CRC Press; 2009.

The total of active learning classes	**Lectures:** 60
	Individual research work: 60

Teaching methods:

Lectures. Practical examples by use of computational medicinal chemistry tools.

Grading system:

Final exam: 60 points; Project: 20 points; Presentation of project: 20 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Mechanisms of degradation and origin of impurities in pharmaceuticals

Teachers: Vujić B. Zorica, Čudina A. Olivera, Brborić S. Jasmina

Course status: Mandatory modules, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2ОМ1

Requirements: None

Course aims:

To gain a knowledge about API impurity profile and impurities in pharmaceutical-technological formulations from chemical and safety aspects.

Course outcomes:

Use of knowledge in assessment of drug substance quality. Understanding of degradation mechanisms and in vitro stability, terms of related substances, impurities and safety assessment based on valid regulatory requirements.

Course contents:

Functional groups, basic mechanisms and kinetics of degradation. Chemical degradation (hydrolysis, dehydratation, isomerization, decarboxylation, oxidation, photodegradation); physical degradation (crystallization of amorphous drugs, transition state, sublimation, moisture adsorption), degradation kinetics and methods for detection of chemical and physical degradation. Thermal analysis (differential scanning calorimetry, differential thermal analysis, differential thermogravimetry). Origin of imuprities, process impurities (organic, inorganic), identification, qualification and specification of impurities, purification processes (crystallization, filtration, preparative chromatography), control, standard analytical methods, measurement of drug substance impurities, spectroscopic techniques, NMR, HPLC, MS, acceptance criteria. Impurities introduced during storage. Standard, spectroscopic and separation techniques as analytical procedures in impurity control. Prevention of chemical degradation: molecular modification, complex formation, cyclodextrin inclusion complexes, antioxidants and stabilizers. Regulatory law, acceptance criteria.

Recommended literature:

1. Li M. Organic chemistry of drug degradation, RSC Publishing, Cambridge, UK, 2012.

2. Beale JM, Block JH. Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, Lippincot Williams&Wilkins, 2011.

3. Carstensen JT, Rhode CT. Drug stability Principles and Practices, 3rd Edition, 1998.

4. Connors KA, Amidon GL, Stella VJ. Chemical stability of pharmaceuticals: a handbook for pharmacists, 2nd Edition, John Willey&Sons, 1986.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, case-study, seminar papers. Reading and analysis of original scientific papers relevant to selected topics.

Grading system:

Written exam: 40 points; Oral exam: 30 points; Seminar papers: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Modern Drug Synthesis

Teachers: Vladimir M. Savić, Jasmina S. Brborić

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ1И1

Requirements: none

Course aims:

To learn about strategies in drug design and development based on organic chemistry and synthetic routes applied in drug synthesis.

Course outcomes:

To learn about general principles of drug synthesis and methodologies used for the synthesis of various drug classes. General understanding of drug/biological active compounds synthesis in laboratory and industrial environment.

Course contents:

Organic synthesis. "Ideal" synthetic route, properties. Laboratory vs industrial synthesis. Importance and role of organic synthesis in drug development. Standard and combinatorial synthesis. Solid phase synthesis and application in pharmaceutical industry. Synthesis of selected drug classes: e.g. antiinflammatory agents, kinase inhibitors, antidepressant, ATPase inhibitors, HIV drugs.

Recommended literature:

1. Lednicer D. Strategies for Organic Drug Synthesis and Design, 2 ed, John Wiley&Sons, 2008.

2. Johnson DS, Li JL. The Art of Drug Synthesis, John Wiley&Sons, 2007.

3. Li JL, Johnson DS. Modern Drug Synthesis, John Wiley&Sons, 2010.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Seminars, consultative teaching

Grading system:

Seminar 50 points, Written exam 50 points (max 100 points)

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Electrochemical methods used in the study of biologically active molecules in vitro and in vivo

Teachers: Kapetanović P. Vera

Course status: elective, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1И2

Requirements: None

Course aims:

The use of electrochemical methods for studying of mechanism of reduction/oxidation processes of biologically active molecules. Development of new electrochemical methods for detection and determination of biologically active compounds in buffer system and in the biological medium as well (urine, plasma and serum). Study of interactions of biologically active substances with DNA and their electrochemical detection based on the principle of a biosensor.

Course outcomes:

Getting of skills in elecrtochenical methods applied in the study of redox processes of biologically active compunds with the aim of their detection and determination in vitro and in vivo .

Course contents:

A modern access in electrochemical charactersation of biologically active moleculs requires knowledge of complex electrochemical processes, an appropriate methodology in order to be able to explain the processes involved by using the modern adsorptive techniques with different solid electrodes as BDDE, GC and CP. The interaction of DNA modified electrodes with biologically active substaces could be a good basis for biosensors characteristics of this couple. Development of the new electroanalytical methods for detection and determination of biologically active substances in buffers and biological system (urine, plasma, serum..).

Recommended literature:

1.Wang J. Electroanalytical Techniques in Clinical Chemistry and Laboratory Medicine, VCH Publisher, New York, 1988.

2.Ozkan SA. Electroanalytical methods in pharmaceutical analysis and their validation, HNB Publisher, USA, 2011.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Individual activities, seminars

Grading system:

Oral exam 50 points, seminars 50 points.

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Protolytic equilibria

Teachers: Popović V. Gordana

Course status: elective, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1И3

Requirements: None

Course aims:

Introduction to the physical-chemical parameters of importance for the mechanism of action of biologically active substances and analysis of pharmaceuticals.

Course outcomes:

Implementation physicochemical principles to predict the ADME characteristics (absorption, distribution, metabolism, elimination) of potentially biologically active substances and the re-evaluation of the existing ones. A rational approach to the selection optimal conditions for the analysis of pharmaceuticals.

Course contents:

Protolytic equilibria of monoprotic and polyprotic acids and bases, ampholytes, zwitterion ions; micro and macro

equilibrium constants; distribution equilibrium species as a function of pH, pKa, log P and log D; methods and techniques for experimental determination of pKa values (spectrophotometry, potentiometry, electrophoresis, HPLC, NMR); parameters that affect the choice of the appropriate method for the determination of pKa values . Protolytic equilibrium in heterogeneous systems (solubility); the solubility - pH profile of a biologically active substance; mathematical interpretation protolytic equilibria in saturated solution; the methods, techniques , and selection of the experimental conditions for the determination of solubility; protocol for determining the solubility using the "shake-flask" method, the effect of buffer, co-solvents, surfactants and complexing agents on the solubility.

Recommended literature:

1. Florence AT, Attwood D. Physicochemical principles of pharmacy, Pharmaceutical Press, London, 2006.

2. 2. Sinko PJ. Martin’s physical pharmacy and pharmaceutical sciences, Lippincott Williams & Wilkins, Philadelphia, PA, 2006.

3. Avdeef A. Absorption and drug development: Solubility, permeability, and charge state, John Wiley & Sons, Inc., Hoboken, New Jersey, 2012

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, practical work, seminars.

Grading system:

Written exam: 30 points; oral exam: 10 points; practical work: 10 points; Seminar: 20 points, seminar presentations: 30 points.

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Structure analysis of solid state

Teachers: Sote M. Vladimirov, Bojan D. Marković

Course status: elective, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1И4

Requirements: None

Course aims:

Introduction to basic physicochemical parameters and methods used in the characterization of the solid state (amorphous, crystalline state, phase transitions, polymorphism, monocrystals).

Course outcomes:

It is expected that students expand additional knowledge about the methods of structural analysis used in the characterization of a solid state and application of appropriate methods, significant for the assessment of biopharmaceutical properties of drugs.

Course contents:

Solid, crystalline, amorphous state, liquid crystals. Polymorphism and phase transitions. X-ray diffraction analysis, x-ray source and absorption of monochromatic x-rays. Thermogravimetry. TGA-FTIR spectroscopy. Case study from literature and practical examples. Crystallisation methods. Determining the crystal composition. Monocrystal definition and characterization. Unit cell, symmetry of the crystal system, space group, factor P, structural parameters of molecular geometry, molecular modelling, 3D structure of small molecules, intermolecular interactions, hydrogen bonds. Crystallization methods. Introduction to modern tandem methods used in the characterization of crystalline state of molecule. The applying of appropriate methods to define the solid state (Ph.Eur. 8 official methods). The influence of polymorphism and other properties of solid state substances to do use in the pharmacy, on the stability characteristics and biopharmaceutical properties of drugs. Examples of drugs where polymorphism is essential for bioavailability and drug-excipients interactions.

Recommended literature:

1. Chatten L. Pharmaceutical Chemistry volume 1 Theory and Application, UMI, Michigan, 1992.
2. Chatten L. Pharmaceutical Chemistry volume 2 Instrumental Techniques, UMI, Michigan, 1992.
3. Wermuth C. The Practice of Medicinal Chemistry, Academic Press, San Diego, 2008.
4. Krogssgaard-Larsen P, Liljefors T, Madsen U.Textbook of Drug Design and Discovery, Taylor & Francis, New York, 2002.
5. Babine R, Abdel-Meguid S. Protein Crystallography in Drug Discovery, Wiley-VCH, Weinheim, 2004.
6. Thomas G, Fundamentals of Medicinal Chemistry, Wiley, Chichester, 2003.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Seminar work, case study

Grading system:

Seminar work: 70 points, exam: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Spectroscopic methods 1

Teachers: Katarina D.Karljiković-Rajić, Bojan D.Marković

Course status: elective, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1И5

Requirements: None

Course aims:

Knowledge improvement of applications of UV-visible spectrophotometry with special topics of derivative spectrophotometry (DS) and applications of IR spectroscopy in the studies of importance in pharmaceutical chemistry.

Course outcomes:

Enhancement of knowledge on spectroscopic methods applications (UV-visible spectrophotometry and IR spectroscopy) of significance for pharmaceutical chemistry intended for investigations in stability studies, pharmaceutical purity, molecular interactions, determination of partition coefficients, inclusion complex formation and evaluation of bioactivation via monitoring in vitro processes, with special topic of IR spectroscopy applications for investigations of polymorphism and polymers.

Course contents:

Fundamental principles of the spectroscopic method's applications in pharmaceutical chemistry including stability studies, pharmaceutical purity, molecular interactions, determination of partition coefficients, inclusion complex formation and evaluation of bioactivation via monitoring in vitro processes, with special topic of IR spectroscopy applications for investigations of polymorphism and polymers.

The significance of the selection of: working (analytical) wavelength; solvent; absorption bands shifting; chromospheres evaluation; amplitudes in DS, method's elimination of interferences and technique selection for demanding problematical systems in DS; decreasing noise signals for limits of detection and quantification; characteristic shifting of absorption bands in IR spectra caused by molecular interactions, inclusion complexes and polymorphic forms.

Recommended literature:

1.Brittain HG.Spectroscopy of Pharmaceutical Solids, Taylor & Francis Group, LLC., 2006.

2.Stuart B. Infrared Spectroscopy: Fundamentals and Applications", Analytical Techniques in Sciences, AnTS, Wiley, 2004.

3.Talsky G. Derivative Spectrophotometry, VCH, (1994; 2004.), Verlagsgesellschaft GmbH, online library 2004. Wiley

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, problem oriented teaching methods, structural discussion about topics. Reading and analyses of original scientific papers of significance for selected topics.

Grading system:

Written exam: 40 points; oral exam: 30 points; seminar paper: 30 points.

University of Belgrade Faculty of Pharmacy	DOCTORAL ACADEMIC STUDIES	

Course title: Spectroscopic methods 2

Teachers: Agbaba D. Danica, Nikolić M. Katarina

Course status: elective, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1И6

Requirements: none

Course aims:

Advancing the knowledge about spectroscopic methods as infrared spectrometry, near-infrared spectrometry, nuclear magnetic resonance spectroscopy and mass spectrometry.

Course outcomes:

Knowledge of spectroscopic methods and TLC-MS/LC-MS/LC-NMR techniques for structural characterisation and determination of drugs and related substances. Gaining knowledge about the application of spectroscopic methods in study of drug-target complexes and inclusion complexes of drugs with other macromolecules.

Course contents:

Principles of spectroscopic methods, infrared spectrometry, near-infrared spectrometry, nuclear magnetic resonance spectroscopy and mass spectrometry . Application of spectroscopic methods and TLC-MS/LC-MS/LC-NMR techniques for structural characterisation and determination of drugs and related substances. The use of nuclear magnetic resonance spectroscopy in structural characterisation of drug-target complexes. Application of nuclear magnetic resonance spectroscopy in study of the inclusion complexes of drugs and macromolecules.

Recommended literature:

1. Partick GL. An Introduction to Medicinal Chemistry 4th Edition, Oxford University Press UK,2009.

2. Roberts G, Lian LY. Protein NMR Spectroscopy: Practical Techniques and Applications Wiley, 2011.

3. Hoffmann E, Stroobant V. Mass Spectrometry: Principles and Applications, 3rd Edition, Wiley, 2007.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Practical examples of spectroscopic methods in pharmaceutical chemistry, research work, projects

Grading system:

Final exam: Project: 50 points; Presentation of project: 50 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Chemometric methods in pharmaceutical chemistry

Teachers: Nikolić M.Katarina

Course status: elective, module: Pharmaceutical Chemistry

Semester: II	**Year of studies:** I
ECTS points: 5	**Course code:** ДФХ1И7

Requirements: None

Course aims:

Advancing the knowledge about principles of analytical methods for study lipophilicity/retention/migration parameters of pharmacologically active compounds. Gaining the knowledge about advanced chemometric methods in pharmaceutical chemistry.

Course outcomes:

Knowledge of experimental methods for study lipophilicity/chromatographic retention/migration parameters of pharmacologically active compounds. Gaining the knowledge in molecular modeling, conformational analysis, molecular descriptors, and theoretical and chemometric methods.

Course contents:

Chromatographic retention parameters in pharmaceutical chemistry: hydrophobicity-thermodynamic approach, chromatographic retention parameters and lipophilicity of pharmacologically active compounds, correlation studies. Development of new analytical method by use of various designs of experiment and mathematical analysis of the obtained results. Theoretical predictions of the dominant ionic and tautomeric forms of the analyte at a given pH value, the theoretical methods and computer programs for optimization of three-dimensional structure of the analyte, conformational analysis and calculation of molecular descriptors, forming QSPR/QSRR models using different mathematical methods; validation QSPR/QSRR model and application of QSPR/QSRR models to predict the parameters/retention of related compounds. Case Studies in QSPR/QSRR modeling and design of experiment.

Recommended literature:

1. L. Eriksson, E. Johansson, N. Kettaneh-Wold, J. Trygg, C. Wikstrom, and S. Wold ed. (2008) „Design of Experiments, Principles and Applications“, Third edition, Umetrics Academy, Umea, Sweden;

2. R. Brereton ed. (2009) „Applied Chemometrics for Scientists“, John Wiley&Sons, Inc;

3. G. Hanrahan, F. A. Gomez ed. (2009) “Chemometric Methods in Capillary Electrophoresis”, John Wiley&Sons, Inc.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures. Practical example of chemometric methods in pharmaceutical chemistry. Reading and analysis of original scientific research relevant to date teaching unit.

Grading system:

Final exam: 60 points; Project: 20 points; Presentation of project: 20 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Computation Methods in Chemical Biology

Teachers: Nevena V. Veljković, Katarina M. Nikolić

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И1

Requirements: None

Course aims:

Advancing the knowledge about the drug targets as a basis for the design of drugs, signaling pathways that transmit signals from the extracellular environment and activate cellular responses. Gaining knowledge about design of drugs that acting on one or more targets at the same time (multi-target drugs).

Course outcomes:

Knowledge of biological databases and tools used to identify potential targets for new drugs and computational methods for their identification on the basis of the expression data or Next Generation Sequencing (NGS) data.

Course contents:

Molecular biological phenomena and technologies relevant to the development of new drugs. Bioinformatical methods for identification of a drug target. Computational tools for analysis sequences of the biological molecules. Data bases of bioactive compounds, drugs, targets, and signaling pathways. Drugs able to modify the specific signaling pathways. Macromolecular descriptors. Computational methods for the analysis of molecular biological data. Genomic informatics and systems biology. Identification of the target molecule (the target site) for the discovery of new drugs. Computational approaches in pharmacogenomics. The development of new drugs. Experimental methods for testing the bioactivity of the drug. The development of medicines that act on a number of targets simultaneously. Case Studies.

Recommended literature:

1.Yuryev A. Pathway analyses for drug discovery: Computational Infrastructure and Applications, Wiley-VCH; 2008.

2. Waldmann H, Janning P. Chemical biology: learning through case studies Wiley-VCH, 2009.

3. Bunnage ME. New Frontiers in Chemical Biology" RSC Publishing 2010.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures. Problem-oriented education (working on a practical example that is solved by means of bioinformatics and cheminformatics method) and discussions. Reading and analysis of original scientific research relevant to date teaching unit.

Grading system:

Final exam: 60 points; Practical work: 20 points; Presentation of project: 20 points

University of Belgrade Faculty of Pharmacy	DOCTORAL ACADEMIC STUDIES	

Course title: Targeted Drug Design

Teachers: Erić M.Slavica

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И3

Requirements: None

Course aims:

Advancing the knowledge of function, role, characterization and validation of molecular targets for the diseases of interest. Gaining the knowledge about new methods for the discovery of leading compounds for the specific targets, as well as strategies for optimization of properties of new pharmacologically active compounds.

Course outcomes:

Knowledge of basic methods for selection, characterization and validation of the molecular targets for the design of novel pharmacologically active compounds. Knowledge of basic methods for discovery and optimization of novel pharmacologically active compounds for specific targets.

Course contents:

Function and role of molecular targets that are involved in the process of specific disease development. Characterization and validation of specific molecular targets for the design of new pharmacologically active compounds. Strategies of optimization of leading compounds for specific targets with aim of modification of efficacy, selectivity, solubility and permeability through cell membranes, safety and minimization of side effects. Case studies of selection and validation of targets for the diseases of interest: neoplasms, infections caused by resistant bacterias, viruses and parasites. Study of the basic methods for the discovery of leading compounds for specific targets: high-throughput screening, virtual screening, combinatorial synthesis, screening of natural compounds. Case studies of natural products, i.e. estimation of their potential as leading compounds. Study of the concept of privileged structures. Case studies of drugs discovered by targeted-design methods. Case studies of the drugs designed for multiple targets. Study of the various strategies for modification of physico-chemical properties, efficacy, selectivity and safety as well as minimization of side effects of leading compounds designed for specific target.

Recommended literature:

1. Merz K.M. Drug Design, Cambridge University Press, UK; 2010;

2. Fernandez A. Transformative Concepts for Drug Design: Target Wrapping, Springer, 2010;

3. Klebl B, Miller G, Hamacher M, Mannhold R, Kubinyi H, Folkers G. Protein Kinases as Drug Targets, John Whiley and sons, 2011;

4. D. Thurston. Designing multi-targeted drugs, Royal Society of Chemistry, London, UK, 2012.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, problem-oriented teaching, practical exercises, case studies, analysis and presentation of original scientific work relevant for teaching subject.

Grading system:

Final exam: 50 points; practical exercises: 30 points; seminar paper: 20 points;

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Radiopharmaceutical chemistry

Teachers: Brborić S. Jasmina

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И4

Requirements: no

Course aims:

Improving of knowledge about the basic principles of nuclear physics and nuclear chemistry, properties and production of radioisotopes for use in nuclear medicine. Acquiring of necessary knowledge about the characteristics and production of various types of radiopharmaceuticals, quality control in nuclear medical centres and the requirements of good manufacture practice. Providing advanced knowledge related to the application of radiopharmaceuticals in nuclear medicine: use in diagnosis with special emphasis on PET radiopharmaceuticals and use in therapy.

Course outcomes:

Understanding of basic principles of nuclear physics and nuclear chemistry, properties and production of radioisotopes for use in nuclear medicine; Detailed knowledge of the characteristics and production of various types of radiopharmaceuticals and quality control in nuclear medical centres and the requirements of good radiopharmaceutical manufacture practice. Detailed knowledge about the application of radiopharmaceuticals in nuclear medicine:use in diagnosis with special emphasis on PET radiopharmaceuticals and use in therapy.

Course contents:

The basic principles of nuclear physics and nuclear chemistry. Properties and production of radioisotopes for use in nuclear medicine. Measures of protection against ionizing radiation. Properties and production of various types of radiopharmaceuticals: methods of radiolabeling, chemistry of technetium and technetium complexes, radiopharmaceutical kits preparing. Quality control of radiopharmaceuticals: physicochemical and biological tests. Monographs of radiopharmaceuticals. European Regulations governing radiopharmaceuticals. Preparation of radiopharmaceuticals and quality control in nuclear medicine centers, good manufacturing practice. Radiation regulations and radiation protection. Diagnostic uses of radiopharmaceuticals in nuclear medicine. PET radiopharmaceuticals. Therapeutic uses of radiopharmaceuticals.

Recommended literature:

1. Saha GB. Fundamentals of Nuclear Pharmacy, 6th edition, Springer, 2010.

2. Zolle I. Technetium-99m Pharmaceuticals, Preparation and Quality control in Nuclear Medicine, Springer, 2007.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, problem-based learning and structured class discussions. Reading and analysis of original scientific papers relevant to selected topics.

Grading system:

seminar work: 30 points, Final exam - written: 40 points,
oral: 30 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Chemical approach to prodrug design of pharmacologically active compounds

Teachers: Čudina A. Olivera, Brborić S. Jasmina, Marković D. Bojan, Vujić B. Zorica

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И5

Requirements: None

Course aims:

Improvement of knowledge about prodrugs: definitions, properties, classification, use; various types of prodrugs, properties, mechanisms of prodrug activation and their application.

Course outcomes:

Detailed knowledge about prodrugs: definition, properties, classification, use; various types of prodrugs, properties, mechanisms of prodrug activation and their application.

Course contents:

Prodrug: definitions, characteristics, classification and application of prodrugs. Types of Prodrugs: Bioprecursor prodrug and Carrier-linked prodrug (bipartate, tripartate and mutual). Ideal drug carriers. Mechanisms of prodrug activation: hydrolytic activation, oxidative activation (N-dealkylation, O-dealkylation, oxidative deamination, N-oxidation, S-oxidation, aromatic hydroxylation, alkene epoxidation), reductive activation (azo, azido, nitro, disulfide and sulfoxide reduction), phosphorylation activation, decarboxylation activation...

Carrier linkages for various functional groups: alcohols, carboxylic acids and related groups, amine and imine prodrugs, Mannich base as prodrugs.

Examples of carrier-linked bipartate prodrugs: Prodrugs to improve membrane permeability, Prodrugs for improved absorption through skin, Prodrugs for increased water solubility, Prodrugs to lower water solubility, Prodrugs for stability protection from first-pass effect, Prodrugs to minimize toxicity and side effects, Prodrugs for slow and prolonged release, Prodrugs for site specificity, Prodrugs to increase patient acceptance, Prodrugs to eliminate formulation problems

Recommended literature:

1. Patrick GL. An Introduction to Medicinal Chemistry, 4th Edition, Oxford University Press UK, 2009.

2. Silverman RB. The Organic Chemistry of Drug Design and Drug Action, 2nd Edition, Elsevier Academic Press, 2004.

3. Wermuth CG. The Practice of Medicinal Chemistry, 3rd ed., Elsevier, 2008.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Lectures, problem-based learning and structured class discussions. Reading and analysis of original scientific papers relevant to selected topics.

Grading system:

Written exam: 40 points; oral exam: 30 points; seminar: 30 points.

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Biophysical approaches of G-protein coupled receptor: structure, function and pharmacological aspects

Teachers: Agbaba D.Danica, Vladimirov M.Sote, Vujić B. Zorica

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И2

Requirements: None

Course aims:

An introduction to new therapeutic drug classes.

Course outcomes:

Discovery and development of drugs acting on G protein-coupled receptor.

Course contents:

G protein-coupled receptors structure and classification. GPCRs Class A, rhodopsin-type receptors; GPCRs, Class B, glucagon-type receptors; GPCRs Class C, glutamate type, metabotropic receptor. Receptor activation; Conformational change of receptors caused by activation. Structure of G protein, GPCRs interaction with G protein. G protein subtypes and their function. GPCR dimerization, homo-oligomerization and hetero-oligomerization, GPCR dimers and bivalent ligands. New therapies based on G protein-coupled receptor hetero-oligomerization. Chemistry of new therapeutic drugs acting on GPCRs.

Recommended literature:

1. Abraham DJ., Rotella, DP.Burger`s Medicinal Chemisty, Drug Discovery and Development, 2010.
2. Annual Reports in Medicinal Chemistry, Ed. John E.Macor, Academic Press, USA ,2012.
3. Current Medicinal Chemistry, Bentham Science Publishers.
4. Original scientific papers

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Analysis of original scientific paper related to the course or doctoral thesis.

Grading system:

Seminar 50 points, Exam 50 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Biophysical approaches of ion channel: structure, function and pharmacological aspects

Teachers: Agbaba D.Danica, Vladimirov M.Sote, Vujić B.Zorica

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И7

Requirements: None

Course aims:

An introduction to new therapeutic drugs.

Course outcomes:

Discovery and development of drugs acting on ion channel receptor.

Course contents:

Definition of ion pumps, cotransporters and channels. Active transport, voltage-gated ion channels, action potential. Ion channels structure and classification, sodium and potassium channels, voltage-gated calcium channels. Voltage-gated ion channels as drug target. Sodium-channel blockers and local anesthetic. Voltage-gated ion channels in epilepsy. Ion channels and transporters in cardiovascular diseases. Structure and structure-function correlations in ion channels: classification of ion channels, pharmacological properties of ion channels, chemistry of new therapeutic drugs acting on ion channels.

Recommended literature:

1. Abraham DJ, Rotella, DP.Burger`s Medicinal Chemisty, Drug Discovery and Development, 2010.
2. Annual Reports in Medicinal Chemistry, Ed. John E.Macor, Academic Press, USA ,2012.
3. Current Medicinal Chemistry, Bentham Science Publishers.
4. Original scientific papers.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Analysis of original scientific paper related to the course or doctoral thesis.

Grading system:

Seminar 50 points, exam 50 points

University of Belgrade Faculty of Pharmacy	**DOCTORAL ACADEMIC STUDIES**	

Course title: Peptides and peptidomimetics

Teachers: Vladimirov M.Sote, Agbaba D.Danica, Vujić B.Zorica

Course status: elective, module: Pharmaceutical Chemistry

Semester: III	**Year of studies:** II
ECTS points: 5	**Course code:** ДФХ2И6

Requirements: None

Course aims:

An introduction to new therapeutic drugs.

Course outcomes:

Trends in development of protein and peptide-based therapeutics.

Course contents:

Chemical and physical properties of peptide and proteins. Structural and stereochemical features of peptides and proteins. Metabolism, proteolytic processing, chemical modifications and biopharmaceutical applications of protein modifications. Pseudopeptides, retro-inverso peptides, peptide and protein drugs in medicine and pharmacy.

Recommended literature:

1. Abraham DJ, Rotella, DP.Burger`s Medicinal Chemisty, Drug Discovery and Development, 2010.
2. Annual Reports in Medicinal Chemistry, Ed. John E.Macor, Academic Press, USA ,2012.
3. Current Medicinal Chemistry, Bentham Science Publishers.
4. Original scientific papers.

The total of active learning classes	**Lectures:** 30
	Individual research work: 30

Teaching methods:

Analysis of original scientific paper related to the course or doctoral thesis.

Grading system:

Seminar 50 points, exam 50 points