

**PROSPECTUS**  
**MASTER'S PROGRAMME**  
**LABORATORY BIOMEDICINE**  
**FACULTY OF PHARMACY, UNIVERSITY OF LJUBLJANA**

**Presentation of the study programme:**

**1. Information on the study programme:**

The Laboratory Medicine master's programme consists of 2 years (4 semesters) of studies and comprises 120 credits. Academic title awarded to the graduates is Magister/Magistrica laboratorijske biomedicine (mag. lab. biomed). (Master of Laboratory Biomedicine).

**2. Fundamental objectives of the programme and course specific competences**

The main objective of the master's (second cycle) study programme Laboratory Biomedicine is to train skilled professionals for analytical jobs in medical laboratories of different specific fields within laboratory medicine, in research institutions and in laboratory medicine related fields of activity, such as agencies, industry and national authorities. Graduates will be able to independently follow new findings and use them in the field of laboratory medicine, and adapt to the requirements of laboratory diagnostics. They will also gain applicative knowledge from the fields of research work and management fundamentals, administration and legislation. The programme provides the basics for lifelong technical training. Upon completion of the study, the graduates will fill the gap in this area of health care professions of current university education. Master's degree enables the graduates to continue their studies in the programme Biomedicine or in laboratory oriented specializations (e.g. medicinal biochemistry).

General competences:

With modern teaching methods and integration of course contents with the skills acquired within experimental exercises, realistic medical laboratory work environments and project works, the programme provides the students with:

- the ability of analysing, critically evaluating, searching for solutions and solving relevant problems in the field of laboratory biomedicine;
- appropriate qualifications for autonomous implementation of professional and research work;
- proper skills for understanding, introduction, application and evaluation of modern techniques and methods for the use in the entire field of laboratory biomedicine;
- competence for assurance of quality procedures;
- capacity to perform individual research work, to work in a team, and knowledge needed for communication and publication of results; and
- appropriate ethically shaped personality for work with patients and human biological material, and for work in biomedical researches.

Course specific competences:

During their training, the students acquire skills and competences needed:

- for independent performance of complex analyses and examinations (in relation to the procedure or sample type) of human biological material
- to evaluate the applicability of methods and results of laboratory examinations for the assessment of the examinee's health condition;
- for explanation (interpretation) of laboratory findings (results);
- for modern approaches to rational laboratory diagnostics;

- for searching of new indicators applicable in diagnostics of various diseases;
- for understanding of laboratory biomedicine as an interdisciplinary field linked with natural mathematical sciences and medicine;
- for classification of new information and interpretations in the field of laboratory biomedicine;
- for development of new analytical methods or applications for specific biological samples (EF, HPLC, ELISA, etc.);
- for application of modern information technologies (e.g.: databases from the fields of genomics, proteomics, metabolomics, etc.); and
- for understanding of legislation, regulations and ethics in the field of laboratory medicine.

### **3. Enrolment requirements and selection criteria in case of restricted enrolment**

Master's study programme Laboratory Biomedicine is intended for the candidates who have completed:

- first cycle university study programme Laboratory Biomedicine (180 ECTS credits) or first cycle university study programme Biochemistry (180 ECTS credits)
- old non-Bologna professional higher education programme Laboratory Biomedicine
- first cycle university study programme in other fields if they gather additional 10 – 60 credits within the courses of the first cycle university programme Laboratory Biomedicine; these obligations are based on the diversity of the professional field and are determined individually for each student by the competent academic affairs commission:
  - graduates of comparable study programmes must complete the courses from the range of professional courses;
  - graduates of study programmes with comparable number of main courses must complete the courses from the range of professional courses;
  - graduates of other study programmes, which do not have comparable number of main and professional courses, must fulfil additional obligations from the range of mandatory main and professional courses.

The conditions apply also to the candidates who have completed an equivalent training abroad. Forty enrolment places are predicted for the first year. This study programme will be carried out if at least 15 candidates enrol in it. In case of restricted entry, candidates shall be selected based on their first cycle study results (average grade of the exams and thesis).

### **4. Criteria for recognition of knowledge and skills acquired prior to the enrolment in the programme**

Knowledge acquired by a student prior to the enrolment in the study programme in different forms of formal training to obtain qualifications, parts of study programme or programmes for advanced training whose content complies with the teaching contents of Laboratory Biomedicine programme courses may be recognised as fulfilled academic obligations. Recognition of knowledge and skills gained prior to the enrolment is determined by the Academic Affairs Commission of the Faculty of Pharmacy (University of Ljubljana) based on a written application submitted by a student and supported by certificates and other documentation that prove successful acquisition and content of this knowledge to enable its evaluation with the ECTS credits.

Recognition of knowledge acquired prior to the enrolment is subject to the following criteria:

- fulfilled requirements for the enrolment and required prior education for the inclusion in education;
- comparable range of education including the content of the course for which the obligation is to be recognised (e.g.: passed Legislation and Ethics exam from the first cycle programme Laboratory Biomedicine may be recognised within optional courses);

- appropriate content of the training with respect to the content of the course for which the obligation is to be recognised. In case the commission recognizes the acquired knowledge, it is awarded with the same number of ECTS credits as the corresponding course.

Knowledge acquired by a student prior to the enrolment in the study programme in different forms of informal training (as part of working experience, self-education, amateur activities) as well as with experience learning may be recognised as fulfilled academic obligations in total amount of 6 ECTS credits, which can compensate for the optional courses of the study programme. Recognition of knowledge is deliberated by the Academic Affairs Commission of the Faculty of Pharmacy (University of Ljubljana) based on a written application submitted by a student and supported by certificates or bibliography in accordance with the Rules of procedure and criteria for recognition of informally acquired knowledge and skills adopted by the UL Senate on 29 May 2007.

Provisions regarding the recognition of knowledge and skills acquired prior to the enrolment in the study programme shall be reasonably applied also to the recognition of knowledge and skills gained during the studies.

## **5. Requirements for advancement within the programme**

Advancement to the next year of study:

- Students may enrol in the next year of study if they complete by the end of the year all the obligations determined in the curriculum for the enrolment in the next year.
- To be able to advance to the second year, students must meet all academic requirements of all mandatory courses in the first year (48 ECTS credits).
- Possibilities for the conditional enrolment in the second year are deliberated according to the regulations by the FFA Senate at the level of principles, and by the FFA Academic Affairs Commission at the individual level.

Other provisions:

- Students may only repeat one year during their course of studies.
- During their course of studies, students are entitled to one exceptional enrolment in the next year, even if they have not fulfilled all the obligations set in the study curriculum. This is decided upon by the FFA Field of Study Commission which can, according to article 153 of the UL Statute and the FFA Academic Regulations, allow exceptional advancement when it determines the student has failed to fulfil required conditions due to substantial and verified reasons.

## **6. Requirements for completion of study**

Candidates must successfully fulfil all academic obligations laid down in the curriculum, in the total amount of 120 credits, including a successful defence of master's thesis.

## **7. Transfers between study programmes**

Transfers between the Faculty of Pharmacy study programmes are regulated by the Statute of the University of Ljubljana and the Criteria for Transfers between Study Programmes.

Candidates may transfer from non-Bologna university programmes, including natural science, biotechnical and medical programmes, to the Laboratory Medicine master's programme if they meet the enrolment requirements. After the enrolment, the FFA Academic Affairs Commission deliberates the recognition of the tasks completed at the other faculties or determines the year the candidate may enrol in.

Transfers are also possible from other Bologna master's programmes of the same fields that are predicted for the admission in the programme and last no less than two years. After the enrolment, the FFA Academic Affairs Commission deliberates whether the knowledge acquired by the student in the programme from which they are transferring should be recognised as a fulfilled obligation of the Laboratory Biomedicine master's programme.

Provided they have gathered the required 180 credits in their current study programme, students of the uniform master's Pharmacy programme may transfer to the appropriate year of the university programme Laboratory Biomedicine. The Academic Affairs Commission may determine substantially lacking obligations for the student, in the amount of 10 to no more than 60 ECTS credits.

## 8. Assessment schemes

Each course has its own assessment scheme which is set in the course curriculum. Assessment schemes include oral and written exams, partial exams, seminar papers, etc. The assessment scale ranges from 6 – 10 (positive) and 1 – 5 (negative). Assessment is subject to the provisions laid down in the Statute of the University of Ljubljana and FFA Academic Regulations.

## 9. Programme curriculum

Credit evaluation, presentation of the entire programme, individual learning units per years and total number of hours

<i>First year</i>	<i>Contact hours</i>					$\Sigma$ SL	<i>ECTS</i>
	L	P	S, SP	OW	$\Sigma$		
<b>Semester 1</b>							
1. Selected Topics in Biochemistry	45	15			60	150	6
2. Molecular Enzymology	20	10	20	10	60	150	6
3. Molecular Biophysics	30	15	15		60	150	6
4. Selected Topics in Biomedical Informatics	30	25	5		60	150	6
5. Biomedical Analysis	15	30	15		60	150	6
<b>Semester Total</b>	<b>155</b>	<b>85</b>	<b>50</b>	<b>10</b>	<b>300</b>	<b>750</b>	<b>30</b>
<b>Semester 2</b>							
6. Pathologic Physiology	45	15			60	150	6
7. Management and Communication in Biomedicine	30	30			60	150	6
8. Design and Quality Assurance in a Medical Laboratory	45		15		60	150	6
OPTIONAL COURSE I	30	15	15		60	150	6
OPTIONAL COURSE II	30		30		60	150	6
<b>Semester Total</b>	<b>165</b>	<b>60</b>	<b>75</b>		<b>300</b>	<b>750</b>	<b>30</b>
<b>First Year Total</b>	<b>320</b>	<b>145</b>	<b>125</b>	<b>10</b>	<b>600</b>	<b>1500</b>	<b>60</b>

<i>Second year</i>	<i>Contact hours</i>					$\Sigma$ SL	<i>ECTS</i>
	L	P	S, SP	OW	$\Sigma$		
<b>Semester 3</b>							
9. Immunology in Laboratory Diagnostics	30	15	15		60	150	6
10. Clinical Biochemical Diagnostics	45		15		60	150	6
OPTIONAL COURSE III	30		30		60	150	6
OPTIONAL COURSE IV	30		30		60	150	6
OPTIONAL COURSE V	30	15	15		60	150	6
<b>Semester Total</b>	<b>165</b>	<b>40</b>	<b>95</b>		<b>300</b>	<b>750</b>	<b>30</b>
<b>Semester 4</b>							
11. Individual Research Work for the Master's Thesis				290	290	600	24
12. Master's Thesis Defence				10	10	150	6
<b>Semester Total</b>				<b>300</b>	<b>300</b>	<b>750</b>	<b>30</b>
<b>Second Year Total</b>	<b>165</b>	<b>40</b>	<b>95</b>	<b>300</b>	<b>600</b>	<b>1500</b>	<b>60</b>

P – lectures; V – practice; S – seminar; SV – seminar practice; DD – other forms of organized work (various forms of individual teacher-student work);  $\Sigma$ SL – student load (hours); ECTS- European Credit Transfer System (1 credit equals to 25 hours of student workload);

## 10. Study programme selectivity

In both years of studies, students may choose five optional courses altogether. At least three (or all five) of them must belong to the Basic range of optional courses of the master's study programme Laboratory Biomedicine (with the subgroup of professional optional courses), whereas two of them may be chosen from other UL study programmes – one of them may be selected randomly, and one (or both) of them must be selected from the Extended list of optional courses, prepared annually by the FFA and consisting of the courses from other FFA programmes and UL member programmes respectively that are related to the content of the master's study programme Laboratory Biomedicine.

The course Legislation and Ethics in Biomedicine is mandatory for the students who have not attended this course in the undergraduate programme.

### Basic range of optional courses of the master's study programme Laboratory Biomedicine

<i>Optional Courses I and V</i>	<i>Contact hours</i>			$\Sigma$ SL	<i>ECTS</i>	
	L	P, S, SP, OW				
13. Legislation and Ethics in Biomedicine	30	15	15	60	150	6
14. Laboratory Transfusion Medicine and Transplantation	30	15	15	60	150	6
15. Research Design, Analysis and Interpretation	30	15	15	60	150	6
16. Basics of Clinical Pharmacokinetics	30	15	15	60	150	6

<i>Optional Courses II, III and IV</i>	L	<i>Contact hours</i> P, S, SP, OW	$\Sigma$	$\Sigma SL$	<i>ECTS</i>
17. Selected Topics in Haematology	30	30	60	150	6
18. Reactive Oxygen and Nitrogen Intermediates	30	30	60	150	6
19. Basics of Imaging Techniques in Biomedicine	30	30	60	150	6
20. Medicinal Products	30	30	60	150	6
21. Development and Implementation of Diagnostic Methods	30	30	60	150	6
22. Toxicological Chemistry	30	30	60	150	6

P – lectures; V – practice; S – seminar; SV – seminar practice; DD – other forms of organized work (various forms of individual teacher-student work);  $\Sigma SL$ -student load (hours); ECTS- European Credit Transfer System (1 credit equals to 25 hours of student workload);

#### Extended list of optional courses (from the programmes of FFA and other UL members)

Selected Topics in Clinical Biochemistry (Marc)  
Molecular and Cellular Diagnostics with Pharmacogenetics (Marc, Jeras)  
Biochemistry of Cancer Development and Progression (Kos)  
Health (UL – EF)  
Healthcare Human Resource Management (UL – EF)  
Courses of other FFA and UL member programmes  
Final list of courses is prepared by the FFA for each individual year.

### 11. Manners and forms of study programme implementation

This study programme is implemented in full-time and – upon request – also in part-time form.

Full-time study programme is carried out during the week (Monday to Friday) in form of organized activities, whereby one study year corresponds to one academic year as determined in the academic calendar adopted by the Senate of the University of Ljubljana.

In case of part-time study, the programme can be carried out in form of organized activities (lectures, practice, seminars, seminar practice, etc.) outside normal working hours, usually Thursday through Saturday. Examination is generally scheduled for work-free days. The time frame of the complete programme implementation equals to that of full-time (two years). Organized activities are more intense, whereas students make up for reduced direct contact hours with more extensive homework. In agreement with the pro-dean of the FFA academic affairs, the course holders decide on which forms of organized work shall be implemented in concise form and what the extent of direct contact hours reduction shall be; at the same time, they must ensure:

- o that students acquire all general and subject-specific competences laid down in the curriculum, and
- o that the entire amount of direct contact hours for the course is not less than 60% of the full-time hours.

Notwithstanding the form of study, the lectures and seminars shall be carried out with the entire group of students, whereas the other forms of organized work shall be implemented in the manner determined in the curricula of individual learning units.

### 12. Parts of the study programme

The study programme consists of individual parts that comprise groups of courses with related topics. Students can choose from three different parts of the programme, each worth 30 ECTS credits,

whose content complies with individual semesters of the master's study: **Fundamental natural scientific and biomedical contents, General subject-specific contents of laboratory biomedicine,** and **Oriented subject-specific contents of laboratory biomedicine.** Students or other education participants who fulfil the obligations set for a certain part of the master's study programme Laboratory Biomedicine receive a certificate, which is an authentic instrument, and an annex containing a description of competences acquired and subjects of the relevant part of the study programme passed. Upon their enrolment in the full study programme, students may enforce the completed parts of the study programme as fulfilled obligations for individual semesters.

More information on the parts of the study programme (programme objectives, acquired general and subject-specific competences, programme curriculum, enrolment requirements, criteria for recognition

of previously acquired knowledge and skills, manner of study programme implementation and requirements for completion of the programme) can be obtained in the students affairs office.

### **13. Presentation of individual courses**

#### **1. Selected Topics in Biochemistry (6 ECTS credits):**

Protein structure, protein isolation and purification techniques, protein folding, dynamics and structural evolution, lipids and lipoproteins, biochemical balance, enzymes and their function, catalytic mechanisms, oxidation-reduction reactions, metabolic flux control, thermodynamics of different membrane transport mechanisms, citrate cycle amphiboly, oxidative phosphorylation, amino acid biosynthesis, metabolic adaptation, molecular cloning, immune response molecules, gene expression in eukaryotes, gene silencing methods.

#### **2. Molecular Enzymology (6 ECTS credits):**

Enzymes: definition, structure and active site. Covalent, acid-base catalysis, enzyme catalysis, approaching and orientation. Enzyme catalysis thermodynamics; balance, prestationary and stationary states. Effects on enzyme reaction velocity; regulation of enzymatic activity. Collection and analysis of enzymatic kinetic and thermodynamic data. Enzyme classification and examples of activity of typical representatives of individual enzyme classes. Ribozymes and catalytic antibodies. Use of enzymology in medicine (diagnostics, therapy, enzymes as targets of medicinal products) and biotechnology.

#### **3. Molecular Biophysics (6 ECTS credits):**

Elements and their interactions: fundamental molecular elements of biological systems, functional groups and interactions among the elements, complex systems, phase separation principle – entropic and energetic contributions to the phase separation in complex systems. Macromolecular structures and their dynamics: typical representatives of macromolecular structures, internal dynamic processes, diffusion, system interoperability in 2D and 3D spaces, thermodynamics of macromolecular structures, state coexistence and system dynamics. Structures/functions of supramolecular structures: DNA, protein superstructures, biological membranes, polysaccharide arrays. Transmission of a nervous impulse and light detection: coupled system of receptors / channels / pumps in the transmission of a nervous signal, light detection at the biological membrane level, biophysical system of signal filtering and amplification. Biophysical findings at new crossroads: presentation of current research areas in the field of biophysics in Slovenia, the most interesting fields of biophysics.

#### **4. Selected Topics in Biomedical Informatics (6 ECTS credits):**

Statistical part (multivariable methods): analysis of variance (ANOVA), multiple linear regression, logistic regression, application of the SPSS statistical software package. Informational part: information system in laboratory biomedicine, coding and classification (MKB, ATC, SPP, etc.), signal analysis in biomedicine.

#### **5. Biomedical Analysis (6 ECTS credits)**

Spectroscopic, separation and immunochemical techniques in laboratory medicine, coupled techniques in biomedicine, use of biochemical analyzers, nucleic acid analyses in laboratory medicine, haematology analyzer, flow cytometer, real time microscopy, automation of work and evaluation of methods in a medical laboratory, analysis outcome and test result ratio, laboratory information system.

#### **6. Pathologic Physiology (6 ECTS credits):**

Organism's response to stress, inflammation, ageing, atherosclerosis, cancerogenesis, hereditary disease, disorders of acid-base balance, integration mechanisms of metabolism, starvation, diabetes, fatness, internal respiration disorders and hypovitaminoses, liver function disorders, digestive disorders, disorders of haemostasis, anaemias, hyperlipoproteinemia, respiratory disorders, disorders of calcium and phosphorus metabolism, conformational diseases, organophosphate poisoning. Kidney function disorders, disorders in composition of electrolytes in extracellular fluid, hypoglycemia, liver tests, plasma protein changes, pathophysiology of the adrenal cortex, thyroid function disorders.



**7. Management and Communication in Biomedicine (6 ECTS credits)**

Role and identity, management of oneself, work and problems, supervision, project work, characteristics of work organisation in a medical laboratory, communication with a patient or a customer, communication with colleagues and other healthcare workers, communication with the public, conflict settlement, negotiations.

**8. Design and Quality Assurance in a Medical Laboratory (6 ECTS credits):**

Basic quality criteria in clinical chemistry and laboratory medicine. Analytical goals and existent standards for uniqueness, irregularity and full measurement uncertainty. Evaluation techniques of analytical methods: acceptability, comparability and applicability criteria. Establishment of analytical quality through design, evaluation and standardization of analytical systems, from pre-analysis (sampling, storage and transport in relation to the analyte stability) to test results, based on modern standards and recommendations, clinical requirements and applicability (laboratory profiles, reference values). Internal quality control system (control materials and calibrators, interferences and matrix effects) and external assessment of the results based on external evaluation schemes with the emphasis on the Slovenian Quality Assessment (SNEQAS) in laboratory medicine. Automation, consolidation and accreditation in laboratory medicine. Cost analysis of quality medical laboratory work.

**9. Immunology in Laboratory Diagnostics (6 ECTS credits):**

Laboratory diagnostics of immunologic diseases: theoretical models of immune unresponsiveness and tolerance, immune deficiency (congenital, acquired), autoimmune reactions and autoimmune diseases, hypersensitivity reactions (reagin, cytotoxic, immune complex, delayed), tissue compatibility: transfusions, transplantations and rejections, tumour immunology (characteristics of tumour cells, responses to tumour growth, avoidance of immune response). Immunological and immunochemical methods: laboratory methods for detection of a complement, antibodies and antigens, laboratory methods for determination of cellular functions and hypersensitivity reactions. Antibodies as a biochemical reagent: application of in vitro immune reaction in laboratory biomedicine (affinity, avidity, specificity).

**10. Clinical Biochemical Diagnostics (6 ECTS credits):**

Significance and application of molecular and cellular biochemical markers in laboratory diagnostics on examples of some selected diseases, their advance and complications: acute and chronic complications of diabetes, insulin resistance, metabolic syndrome, acute coronary syndrome, cerebral apoplexy, celiac disease, Gilbert's syndrome, selected causes of chronic kidney diseases and permanent kidney failure, renal osteodystrophy, inflammation of thyroid gland, Cushing's syndrome, rheumatoid arthritis, systemic lupus erythematosus, acquired myosites, osteoporosis, some poisonings (benzodiazepines, ethanol, carbon monoxide, opioids, cardiac glycosides).

**11. Individual Research Work for Master's Thesis (6 ECTS credits):**

Master's thesis is an independent professional research project from a student's field of choice and monitored by a mentor of his/her choice.

Definition of the scientific – professional question, purposes, approaches, methods, presentations; understanding of the mentoring process; use and overview of available bibliography data via the library and internet, and their application in actual problem solving situation; understanding of a problem, basic approaches, methods and experimental techniques; independent experimental work with adequate recording; analysis of results, making partial decisions and their testing; written submission of the scientific work; research as a creative process; research as an interdisciplinary teamwork.

**12. Master's Thesis Defence (6 ECTS credits)**

The master's thesis structure that contains all elements of a scientific article: title, contents, summary, list of abbreviations, introduction, aim of the study with a working hypothesis, materials and methods, results, discussion, conclusions, bibliography.

Presentation of the master's thesis content: clarity and transparency of the coloured substance, work methods, results and evaluation of the results supported by a computer projection. Master's degree examination: testing the student's ability to synthesize knowledge of a broader research area.

**13. Legislation and Ethics in Biomedicine (6 ECTS credits):**

Theoretical basics of bioethics (historical, philosophical and biological basics). Bioethics and the future of humankind (prenatal diagnostics, genetic information management, genetic treatment, embryonic stem cells, tissue stem cells).

Deontology in laboratory medicine (principles of ethical conduct, attitude towards a patient and patient's biological sample, towards the selected methodology and technology, towards the work quality control, towards urgent examinations, towards the confidentiality of test results, towards medical researches and publication).

Legislation that defines laboratory medicine as part of the healthcare system, and relation between legal acts (regarding the duties of healthcare workers, patients' rights, etc.) and ethical codes. Bioethics and animals (animals in science; animal testing, animals and modern biotechnology, animals as bioreactors).

Bioethics and the environment (biocentrism, ecocentrism).

**14. Laboratory Transfusion Medicine and Transplantation (6 ECTS credits):**

Transfusion medicine: treatment with blood, cells and transplantation of blood-producing and other tissues. Laboratory tests supporting transfusion, transplantation, cell therapies and tissue engineering. Laboratory biotechnological methods in transfusion medicine, transplantation and cell therapy (aphereses, transplantations of blood producing tissue, adoptive immunotherapy, stem cell transplantation, cellular and tissue engineering). Laboratory methods for assurance of tissue compatibility. technical implementation (in vitro cultivation of human cells, their long-term storage, bioreactors for the TI needs, development of cultures, biocompatible carriers for cultivation of cells, analytical methods for the cell preparation quality control. Therapeutic cloning, gene therapy, ex-vivo cell therapy and somatic cell therapies. Autologous, allogeneic and xenogeneic cells in medicine, and overview of the use of cells and tissues.

**15. Research Design, Analysis and Interpretation (6 ECTS credits):**

Research types: observational studies and randomized controlled trials, indicators and substitute indicators in healthcare, risk and risk ratio, expectations and expectation ratio, design of the sample size and appropriate strength of the study, factor analysis, meta-analysis.

**16. Basics of Clinical Pharmacokinetics (6 ECTS credits):**

Active substance, pharmaceutical form (delivery system), pharmacokinetics, pharmacodynamics, clinical effects. Systemic and regional delivery of active substances. Kinetics and mechanisms of the LADME system processes. Determination of active substances in biological materials with the HPLC and LC-MS/MS methods. Validation of analytical methods used in pharmacokinetics. Compartmental and physiological as well as linear and nonlinear pharmacokinetic models. Compartmental and noncompartmental pharmacokinetic analysis. Therapeutic window, therapeutic index. Principles of medicinal product dosing (dose, dosing interval, pharmaceutical form/route of administration). Individual dosing of medicinal products. Dosing based on the patient's age (newborns, children, adults, elderly people). Dosing based on the patient's medical condition (kidney dysfunction, liver dysfunction, digestive tract dysfunction, fatness, critical conditions). Dosing in cases of haemodialysis, peritoneal dialysis, plasmapheresis and haemofiltration. Influence of the food on dosing. Pharmacokinetic interactions of active substances, mechanisms, consequences, measures. Pharmacokinetic aspects of the adverse reactions of medicinal products. Individual and population pharmacokinetics.

**17. Selected Topics in Haematology (6 ECTS credits):**

Formation of blood cells: microenvironment, stem cells, cytokines, regulation of haematopoiesis. Biology of a haematopoietic stem cell. Clonal descent of cancer cells, transplantation of haematopoietic stem cells, use of growth factors for the treatment. Laboratory tests in clinical haematology: basic (haemogram, cytologic examination of bone marrow) and special (flow cytometric analyses of cell markers, cytogenetic and molecular genetic testing of the DNA and RNA) tests for

determination of malignant lymphomas. Regulation of normal erythropoiesis (metabolism of iron, folates and cobalamin, laboratory testing). Anaemia caused by iron deficiencies, kidney and liver diseases and megaloblastic anaemias. Haemoglobin structure and function; hemoglobinopathies and thalassaemias; mechanisms of erythrocyte haemolysis and haemolytic anaemias. Haematopoietic stem cell diseases: aplastic anaemia, myelodysplastic syndromes; acute leukaemia and chronic myeloproliferative diseases. Cells responsible for the immune response. Lymphatic neoplasms; laboratory tests. Physiology and pathophysiology of haemostasis; tests for determination of haemorrhages and proneness to haemorrhages, disturbed thrombotic functions, hereditary and acquired coagulation disorders; fibrinolysis disorders; thrombosis.

**18. Reactive oxygen and nitrogen intermediates (6 ECTS credits):**

Radicals: formation, chemical and physical properties, determination methods. Reactive oxygen and nitrogen intermediates under physiological and pathophysiological conditions. Radical reactions in the organism, characteristics, significance and consequences. Reactive intermediates and genetic material, proteins, lipid membranes. Methods for determination of reactive intermediates. Physiological antioxidants, antioxidant status.

**19. Basics of Imaging Techniques in Biomedicine (6 ECTS credits):**

Introduction to imaging techniques: comparison of physical bases of techniques and their function, comparison with other non-imaging diagnostic techniques.

Magnetic resonance imaging (MRI): basics of nuclear magnetic resonance, basic principle of magnetic resonance (MR) imaging, overview of MR imaging sequences, MR signal localization methods, MR spectroscopy of biological systems, MR imaging equipment, MR imaging quality factors and hazards of MR imaging, trends in the development of new MR methods.

Positron tomography (PT): physical bases of positron tomography, positron-emitting radionuclides and marked substances, construction of the tomography device, factors affecting image quality, image reconstruction basics, trends in the development of new PT methods.

Computed tomography (CT): X-ray radiation: sources and characteristics of x-ray radiation, ionizing radiation protection, x-ray radiation detectors, construction of computed tomography (CT) device; basics of digital capture, reconstruction and data display systems, types of CT devices, quality assurance and verification, application of CT imaging in medical diagnostics, trends in the development of new CT methods.

Ultrasound: ultrasound characteristics, ultrasound interactions in a substance, trends in the development of new ultrasound methods.

**20. Medicinal Products (6 ECTS credits):**

Medicinal products, active substances, pharmaceutical forms, routes of administration. Physicochemical properties, transport of active substances, specific and non-specific interactions of active substances and membranes, effects on transmembrane signalling. Enzymes as targets of active substances, operation mechanisms of enzyme activity inhibitors and modulators. Selectivity and specificity, selective toxicity. Examples of active substances among chemotherapeutic agents and other substances. Receptors as targets of active substances, operation mechanisms of agonists and antagonists. Active substances affecting the receptors of the nerve impulse transmitters, points of application in nerve synapse, steroid hormone receptors. Nucleic acids as targets of active substances, types of reversible and irreversible interactions, intercalators, antitumor and antiviral active substances. Cell tubular system as a point of application of active substance activity. Inhibitors and inductors of nitrogen oxide synthesis. Basics of active substance pharmacokinetics, LADME processes, biological applicability of medicinal products, biological equivalence of medicinal products. Interchangeable and comparable medicinal products. Prodrugs. Medicinal product metabolism, I and II phase processes, pharmacokinetic and pharmacodynamic effects of metabolism. Tolerance to medicinal products, occurrences of resistance. Medicinal product interactions. Adverse reactions and toxic effects of medicinal products.

**21. Development and Implementation of diagnostic methods (6 ECTS):**

Review of diagnostic laboratory tests (enzyme tests, DNA/RNA tests, immunological tests and biosensors). Automated processes in diagnostics. Biological macromolecules in diagnostics. Definition of analytical and diagnostic characteristics of tests. Quality assurance and control. Structure

of medical laboratories. Overview of legislation and guidelines.

22. Toxicological Chemistry (6 ECTS credits):

Definition and classification of toxins. Toxins: structure, classification and activity. Factors influencing toxicity of a substance. Effect of metabolism on substance toxicity. Toxicology of substances from working and living environments that are foreign to the body. Genotoxic, carcinogenic and co-carcinogenic substances. Immunotoxic substances. Toxic gases: carbon monoxide, hydrogen cyanide, hydrogensulphide, sulphur dioxide, singlet oxygen, ozone, nitrogen oxides. Heavy metal toxicity and speciation. Organic solvents: aliphates, aromatics, halogenated hydrocarbons, alcohols, ethers, aldehydes, ketones and esters. Pesticides (insecticides, herbicides, fungicides and rodenticides). Chemical weapons, protection. Addiction causing substances and illegal narcotics. Biological, instrumental and chemical analysis of toxic substances: separation, identification and quantification of active substances and their metabolites.