Course learning outcomes and learning content

Study programme name: Biotechnology

Course name: **Commercialization and patenting of research results**
On successful completion of this course, a student
in terms of knowledge:
1. knows the concept of intellectual property, is able to identify the objectives of protection of intellectual property and the legal acts governing the principles of protection
2. knows the division of intellectual property: industrial property rights (patents, utility models, trade marks, industrial designs), copyrights, know how and trade secrets
3. knows the types of biotechnological inventions, the possibilities of protecting specific biotechnological solutions and the exceptions to patentability
4. is familiar with the definitions of innovation, research and development project, industrial research and experimental development, technology readiness levels
5. knows the patent examination methodology

in terms of skills:
1. is able to make a preliminary assessment of the ability of an innovative solution to obtain legal protection
2. is able to use available patent databases in practice
3. is able to conduct a preliminary patent search and present its findings
4. distinguishes between the following methods of commercialisation: indirect - licence, sale of rights, direct - contribution of the R&D results to a company
5. identifies target markets and their potential using databases, reports and market data
6. can give examples of implemented innovations in biotechnology

in terms of social competences:
1. is able to take part in discussions on the basis of the knowledge acquired
2. is able to can present the results clearly and understandably

Course learning content:
What intellectual property is and its legal basis.
Intellectual property protection - basic information on protection options, assessment of legal protectability, strategies for protecting intellectual property.
Sources and databases of patent information, methods of conducting patent searches (subject, keywords, International Patent Classification).
Specific protection for biotechnological inventions.
Determining the commercialisation potential of R&D project - stages in the development of a research project, criteria and choice of commercialisation method, finding a target market for the implementation of the innovation.
Examples of successful commercialisation of biotechnology innovations.

Course name: **Quantitative PCR methods**
On successful completion of this course, a student
in terms of knowledge:
1. understands the principles of Real-time PCR and ddPCR technology. Can use appropriate primers, probes and reagents.
2. correctly interprets Real-time PCR and ddPCR results. Student is able to evaluate the results in terms of their statistical significance. Is able to use appropriate software for quality Real-time PCR results verification (LinRegPCR).

in terms of skills:
1. is able to perform RNA isolation, cDNA synthesis and RT-qPCR and ddPCR reactions.
2. could perform gene expression analysis using Real-time PCR and ddPCR techniques. Student selects appropriate reference genes.
3. uses appropriate software for primers design, Real-time PCR and ddPCR data analysis.
4. uses different Real-time PCR and ddPCR applications for mutations detection in human gene, detection of genome editing events generated by CRISPR/Cas9, can count mitochondrial DNA copy numbers per cell.

in terms of social competences:

1. work in group to design, perform reactions. Discuss within the group about the significance of the received results.

Course learning content:

Real-time PCR (qPCR) and Droplet Digital PCR techniques, SybrGreen, EvaGreen dyes and TaqMan probes usage, primer design.
Two methods for the quantitative assessment of gene expression: absolute and relative quantification.
Digital PCR analysis used in molecular diagnostics. Applications used for mutations detection.
Statistical concepts: Poisson correction, mean, median, standard deviation, p-value, p-value correction, T-test.
Real-time PCR results calculations, results verification using LinRegPCR software.
Interpretation of the ddPCR results, preparation of reports describing obtained results.

Course name: **MSc seminar: animal and human development**

On successful completion of this course, a student

in terms of knowledge:

1. defines research problems within the scope of the thematic area related to the planned diploma thesis in the field of animal and human development.

in terms of skills:

1. is able to utilize literary sources while respecting intellectual property rights.
2. is able to present individual stages of the completion of a master's thesis in the form of a multimedia presentation.

in terms of social competences:

1. is ready to participate in the discussion, providing substantive answers.

Course learning content:

Review of international literature on current topics, taking into account the research interests of the student group in the field of animal and human development. Working with databases.
Analysis of selected experimental and review papers within the research area related to the ongoing master's thesis work in the field of animal and human development.
Presentation of results from individual stages of the ongoing diploma thesis work; discussion of animal and human development.
Group discussion on the presented topics within the field of microbial biotechnology.

Course name: **Animal models of human diseases**

On successful completion of this course, a student

in terms of knowledge:

1. creatively utilize current state of the art technologies, concepts and biotechnological applications of animal models in modern medicine.

in terms of skills:

1. reading, understanding and presenting principles of the primary research literature applied to animal models in modern medicine.

in terms of social competences:

1. practical introduction to basic techniques of working in an animal facility and handling mice.

Course learning content:

Genetic strategies of generating Animal models: Mouse.
Genetic strategies of generating Animal models: Other model organisms (Drosophila, C.Elegans, Zebra Fish, Yeast..).
Animal Models of Cancer.
Animal Models of Cardiovascular diseases.
Animal Models of Covid-19.
Drug screening and development using animal disease models.
Animal models in Neurodevelopmental disorders and neurodegenerative diseases.
Literature knowledge.
Practicals.

Course name: **MSc project: applied medical biotechnology**

On successful completion of this course, a student

in terms of knowledge:

1. apply the knowledge obtained during the studies to solve a specific research problem related to medical biotechnology.
2. select the state-of-the-art literature including breakthrough and hot topics of medical biotechnology.

3. present the results of a study using various forms of scientific expression.
in terms of skills:
1. apply the skills obtained during the studies to solve a specific research problem realated to medical biotechnology.
2. use the right research methods for his/her purposes.
3. find the literature useful for analysis of a particular scientific issue/problem in the field of medical biotechnology and its application.
4. present research results using various forms of scientific expression.
in terms of social competences:
1. assess the appropriateness of the methods used in the reviewed literature.
2. selects the most modern literature containing the latest information in the field of medical biotechnology applications
3. assess the adequateness of the conclusions with reference to results of Master project
Course learning content:
Analyzing the problem or topic.
Conducting extensive research.
Summarizing findings from the research investigation.
Recommending additional research on the topic.
Drawing conclusions and making recommendations.
Documenting the results of the research.
Defending conclusions and recommendations.

Course name: **Applied protein structure bioinformatics**
On successful completion of this course, a student
in terms of knowledge:
1. is able to describe the structures of proteins and knows the general principles of the methods for their determination and predictions.
2. understands the biophysical origins of structure, function and dynamics of proteins.
3. knows key structural bioinformatics methods to analyze the structures of proteins and their complexes to obtain information about their function, dynamics and stability.
4. knows principles of data-driven protein engineering strategies.
5. knows methods for identification of putative inhibitors and substrates of enzymes.
6. understands the most prevalent mechanism behind the effects of deleterious and beneficial mutations.
7. knows the key benefits and limitations of applications of structural bioinformatics methods.
in terms of skills:
1. is able to select appropriate protein structures from relevant databases, being aware of possible errors in these structures.
Course learning content:
Basic physical principles of protein structure and its hierarchy.
Experimental and computatioanl sources of protein structures.
Structure quality control.
Structure visualization.
Analysis of protein structures.
Common molecular foundations of the effects of mutation.
Protein engineering objectives and targets.
Computer-guided semi-rational protein design.
Rational protein design.
Mutant structure prediction.
Protein stabilization approaches.
Stability–solubility trade-off.
Predicting inhibitors and substrates of enzymes with molecular docking methods.

Course name: **MSc project: human disease and therapy**
On successful completion of this course, a student
in terms of knowledge:
1. apply the knowledge obtained during the studies to solve a specific research problem related to human disease and therapy.
2. select the state-of-the-art literature including breakthrough and hot topics of human disease and therapy.

3. present the results of a study using various forms of scientific expression.
in terms of skills:
1. apply the skills obtained during the studies to solve a specific research problem related to human disease and therapy.
2. use the right research methods for his/her purposes.
3. find the literature useful for analysis of a particular scientific issue/problem concern human disease and therapy.
4. present research results using various forms of scientific expression.
in terms of social competences:
1. assess the appropriateness of the methods used in the reviewed literature.
2. selects the most modern literature containing the latest information in the field of human disease and therapy.
3. assess the adequateness of the conclusions with reference to results of Master project.
Course learning content:
Analyzing the problem or topic.
Conducting extensive research.
Summarizing findings from the research investigation.
Recommending additional research on the topic.
Drawing conclusions and making recommendations.
Documenting the results of the research.
Defending conclusions and recommendations.

Course name: **New generation pharmaceuticals**
On successful completion of this course, a student
in terms of knowledge:
1. knows and understands phenotypic changes resulting from pathological processes and the effect of active compounds and drugs.
2. knows the process of selecting, designing, and constructing biochemical and biological model systems for testing the activity of active substances.
3. can select and apply molecular biology and cell-based techniques and functional tests to monitor the activity of active substances.
4. can explain bioinformatic approaches to design ligands binding to macromolecules by modeling their structure and dynamics.
in terms of skills:
1. can determine the structural and biochemical basics of biologically active substances.
2. can monitor phenotypic changes resulting from pathological processes and the effect of active compounds and drugs.
3. can apply safety rules in the laboratory.
in terms of social competences:
1. can cooperate in a group.
Course learning content:
Review of the molecular basis of the pathomechanism of several diseases and design of biochemical and biological model systems of these diseases.
Approaches to study the activity of active substances in model biochemical and biological systems.
Ways to design and search for new active compounds to endure specific pathological changes or to obtain a different phenotypic effect.
Study on the activity of active substances in pre-clinical tests and clinical trials.
The use of biochemical and biological control models in the study of the activity of biologically active substances and drugs.
Health and safety principles in the cell culture and molecular biology laboratories.

Course name: **High-throughput technologies in biotechnology**
On successful completion of this course, a student
in terms of knowledge:
1. knows the principles of planning the experiments in genomics, transcriptomics, proteomics and metabolomics techniques.
2. understands the basics of high-throughput technologies used in scientific research.
3. knows how to analyze data from high-throughput technologies and how to interpret the results of respective analyses.
in terms of skills:

1. is able to plan an experiment involving large-scale technologies.
2. can prepare material for specialized large-scale experiments.
3. can perform basic large-scale experiments: a sequencing experiment using a third generation sequencer and proteomics experiment involving mass spectrometry techniques.
4. can perform basic analysis of data from high-throughput technologies.
5. is able to prepare a report on carried out experiments and analyses.

in terms of social competences:

1. is able to plan and conduct an experiment collaborating with other group members.
2. is able to critically evaluate the results of experiments and conduct data analysis.

Course learning content:

High-throughput sequencing techniques - second and third generation technologies.
Principles of designing large-scale experiments - biological and technical replicates, selecting platforms for particular research purposes.
Preparing libraries for specialized high-throughput sequencing - RNA-seq, ChIP-seq.
RNA-seq sequencing on the Oxford Nanopore platform.
Qualitative analysis of sequencing results - tools and methods.
Principles of protein structure, proteome composition and analytical pipelines used in proteomics. Several basic methods related to protein chemistry and proteomics will be presented in more detail.
Principles of analyses utilizing mass spectrometry. The basics of the use of mass spectrometry techniques in proteomics will be discussed in more detail.
Principles and techniques of proteomic measurements. The principles/applications related to top-down and bottom-up techniques in proteomic research will be described in more detail.
Qualitative and quantitative methods in proteomics. Selected methods will be presented, as well as case studies related to tissue and cellular organelles-related proteomics, with basics of multiomics data integration. More details will be given on how to plan and conduct the proteomics experiments.
Ways to combine tissue and single cell isolation techniques, mass spectrometry and microarrays for future proteomics applications.
Tissue imaging techniques utlizing mass spectrometry (proteomics, metabolomics, drug research) with specific examples.
Basic principles of metabolomics measurements. Application of mass spectrometry in metabolomics, types of analyses.
Application of targeted and non-targeted metabolomics in the analysis of tissues, biological fluids and in clinical trials.
Lipidomic analysis of tissues, biological fluids and imaging of tissues derived from plant and animal material.

Course name: **Molecular basis of cytoprotection**

On successful completion of this course, a student

in terms of knowledge:

1. to define cell death mechanisms at the molecular level.
2. to delineate signalling pathways triggering cell death as well as protecting cells against the mechanisms of cell death.
3. propose possible sites of signaling pathway modulation to construct a preventive or therapeutic strategy based on cytoprotection or cytotoxic effect.

in terms of skills:

1. critically analyze scientific papers written in English, prepare and present scientific presentation and participate in discussion.

in terms of social competences:

1. developing the ability to work in a group and in cooperation, critically solve scientific problems.

Course learning content:

Cytoprotective cell mechanisms: hem oxygenase, antioxidant systems, HIF, Hsp, NO.
The study of SAR-COV2: 1. Signalling pathways, receptor AC2, types of therapy, vaccines.
How to kill and cure the cell: CarT cancer therapy and/or tyrosine kinases in cancer.
Mitochondria in cell homeostasis: sensing (receptors, metabolite signaling, ion channels, protein import channels) and integration (mitochondrial: homologous communication, fusion, fission, motility, communication with organells); signalling (apoptotic, metabolite, ROS, hormones, mitochondria derived peptides).

How to protect a cell: implications for degenerative diseases (examples Parkinson`s disease, Alzheime`s disease, Atrophy Lateral sclerosis).

Classification of the cell death pathways.

Course name: **Molecular therapies**
On successful completion of this course, a student
in terms of knowledge:
1. knowledge about current state of the art therapy-based technologies, concepts and biotechnological applications in modern medicine.
in terms of skills:
1. reading, understanding and presenting principles of the primary research literature applied to molecular therapeutics.
in terms of social competences:
1. practising theorectical design of small drug-able compounds using R-scripts and online tools, and applying virtual screening to identify novel pharmaceuticals.
Course learning content:
Personilized Medicine, Molecular Diagnostics.
Cell therapy and stem cell therapy.
Nanotechnology.
Small compound inhibitors.
Novel generation cancer therapies.
RNA interference technology.
Immune therapy/antibodies.
CRISPR-directed therapies.
Tissue engineering/Xenotransplantation.

Course name: **Endocrinology**
On successful completion of this course, a student
in terms of knowledge:
1. knows at an advanced level the mechanisms of hormone functioning.
2. understands the regulatory importance of the endocrine system and hormonal signals for maintaining homeostasis of the human and animal body.
in terms of skills:
1. is able to use scientific literature in the field of endocrinology.
2. is able to assess the threat resulting from lifestyle to the health of the endocrine system and the entire body.
3. can design and perform determinations of level of hormones in body fluids.
in terms of social competences:
1. is focused on updating knowledge in the field of endocrinology.
Course learning content:
Endocrine system - structure and role in maintaining homeostasis and adaptive abilities of the body.
Molecular hormone receptors, signal transduction pathways, interdependencies between them, cross-talk.
Methods used in endocrinological studies.
Hypothalamus - pituitary gland as a system integrating and controlling the activity of peripheral endocrine glands.
Hormonal regulation of metabolic processes in the body of animals and humans.
Disorders of the endocrine system.

Course name: **Advances in molecular medicine**
On successful completion of this course, a student
in terms of knowledge:
1. understands molecular tools with appropriate properties to answer various scientific questions (taking into consideration a molecular target, type of information required and biological model).
2. understands differences in the requirements for tools to visualise / measure and modify / change molecular processes in biological models.
3. knows pros and cons of various designs of responsive probes in terms of their reliability and biocompatibility.

4. understands mechanism of action of molecular tools – responsive fluorescent and bioluminescent probes (discuss differences and advantages of fluorescence vs bioluminescence).
5. knows suitable molecular designs of probes for studying various biological targets, including metal ions, reactive oxygen species, proteins (enzymes, receptors) and nucleic acids.
6. knows various stages of a modern workflow for the search and development of bioactive molecules.
7. knows differences and compare top-down (phenotypic) and bottom-up (target-based) approaches in the search for bioactive molecules.
8. knows appropriate tools and workflows for a search of molecular therapies for new diseases.
9. understands strategies for turning bioactive molecules (drugs) into activatable ones (pro-drugs),in particular pro-drugs (pro-effectors) activated by enzymes and light.

in terms of skills:

1. chooses molecular tools with appropriate properties to answer various scientific questions (taking into consideration a molecular target, type of information required and biological model).
2. can discuss pros and cons of various designs of responsive probes in terms of their reliability and biocompatibility.
3. describes mechanism of action of molecular tools – responsive fluorescent and bioluminescent probes (discuss differences and advantages of fluorescence vs bioluminescence).
4. selects suitable molecular designs of probes for studying various biological targets, including metal ions, reactive oxygen species, proteins (enzymes, receptors) and nucleic acids.
5. describes various stages of a modern workflow for the search and development of bioactive molecules.
6. discusses differences and compare top-down (phenotypic) and bottom-up (target-based) approaches in the search for bioactive molecules.
7. selects appropriate tools and workflows for a search of molecular therapies for new diseases.
8. describes strategies for turning bioactive molecules (drugs) into activatable ones (pro-drugs),in particular pro-drugs (pro-effectors) activated by enzymes and light.

in terms of social competences:

1. critically evaluate molecular tools on the basis of scientific literature, reported experimental results and share knowledge and constantly update it.

Course learning content:

Overview of types and molecular designs of tools to investigate molecular mechanisms of the disease.
Molecular aspects of biocompatibility of probes.
Mechanisms of action of fluorescent and bioluminescent probes.
Responsive probes for various molecular targets (metal ions, reactive oxygen species, hypoxia, enzymatic activity, receptors, nucleic acids).
Modern workflows and state-of-the-art tools in the development and optimisation of bioactive molecules.
Activiatable bioactive molecules (pro-drugs).
Development of small-molecule-based drugs for new diseases (case study: molecular mechanisms and therapy development for COVID-19).

Course name: **Blood physiology**

On successful completion of this course, a student

in terms of knowledge:

1. knows and understands correlation between blood rheology and blood components properties, including external and internal factors that modulate blood visosity.
2. compares and explains the dynamics of pre- and postnatal haematopoiesis and describes the diversity of hematopoietic cell types and blood cellular components.
3. describes bone marrow structure under physiological and pathological conditions and explains the objectives, types, trends, and risks associated with hematopoietic stem cell transplantation or CAR-T therapy.
4. explains types, mechanism, symptoms of hematopoietic and lymphoid systems disorders.
5. knows how to conduct research using isolated human erythrocytes as a cellular model and assesses the biological activity of natural and synthetic compounds under physiological and oxidative stress conditions.
6. indicate principles and rules for using human erythrocytes as carriers for wide range of drugs and for diagnostic purposes, including bioimaging.
7. knows and understands the problems associated with conventional blood storage in blood banks and their impact on critical transfusion parameters and artificial blood developments.
8. performs analyses of cytological and histological slides from healthy donnors and patients with difefernt hematological dissorders using various microscopic methods.

9. carries out analyses of results obtained and presents conclusions regarding potential applications and existing limitations in in vivo studies or in clinic.
10. works effectively individually and as part of team, selects literature and presents research findings to group.

in terms of skills:
1. recognizes cytological and histological slides in hematology in physiological conditions and in course of selected diseases, including anemia and different blood cancers.
2. is able to work in laboratory with isolated human erythrocytes and knows the techniques to evaluate the hematocompatibility and hemoprotective properties of various natural and synthetic compounds for biomedical applications.
3. searches for and skillfully uses literature data to extend and update his knowledge and leads a discussion on tasks completed.

in terms of social competences:
1. demonstrates willingness to continually expand and share his knowledge in field of hematology with particular emphasis on research methods and new therapeutic strategies in disorders of haematopoietic system.

Course learning content:
Overview of blood and blood cellular components properties and modifications of blood rheology by external and internal factors in health and disease.
Pre- and post-natal hematopoiesis - the properties that define multipotent hematopoietic stem cells and mesenchymal stem cells in hematopoetic niches.
Bone marrow structure and functions in health and diseases - osteopetrosis, aplastic anemia, acute and chronic leukemia, lymphoma; radiation-induced and aging-relating changes in hematopoesis.
Hematopoietic stem cells transplantation in blood and bone marrow diseases and CAR-T therapy in hematooncology.
Human red blood cells as a cell model for screening of biological activity of blood-contacting compounds with potential for biomedical applications.
Application and safety of red blood cells as carriers for drugs and for diagnostic purposes.
Blood banking and blood transfusions - rules, procedures, actual problems, and artificial blood marked perspectives; storage lesion in blood componnts during banking and post-transfusion effects.
Microscopic methods in evaluation of red blood cells properties under physiological and pathological conditions.

Course name: **Methods in molecular diagnostics**
On successful completion of this course, a student
in terms of knowledge:
1. knows of current state of the art of next generation sequencing (NGS)-based methods in Molecular Diagnostics, prognostics and predictive medicine.

in terms of skills:
1. understands of the presented principles through critical readings from the primary research literature, as well as student-prepared presentations of individual topics during journal clubs.

in terms of social competences:
1. knows and understands theorectical RNAseq design and experimentation and perform data analysis to identify inflammation-monitoring gene signatures for clinical diagnostics.

Course learning content:
Gene expression profiling technologies (Microarrays, RNAseq).
Gene expression signatures in cancer Diagnostics, prognostics and predictive medicine.
Chromatin binding technologies (ChIPseq).
Diagnostics and Prognostics of Kidney Cancer.
Diagnostics and Therapeutics of Cardiovascular Disease.
Pre-natal Diagnostics (Genetics and Targeted Gene Sequencing-based techniques).
Clinical Diagnostics: Multiplex Real-time PCR and NGS-based assays.

Course name: **Human molecular genetics**
On successful completion of this course, a student
in terms of knowledge:

1. will be able to list basic topics, issues and problems connected to analysis of traits and diseases in humans.
2. will be capable of designing, performing and analyzing results of experiments dealing with identification of genes underlying monogenic and polygenic disease,
3. can critically analyze scientific papers written in English, prepare and present scientific presentation and participate in discussion.

in terms of skills:

1. will recognize and classification of modes of inheritance.
2. will have the knowledge of principles of linkage analysis for monogenic traits.
3. understand the basis of multifactorial inheritance and common diseases.
4. will be familiar with the principles of genetic epidemiology.
5. will have knowledge of the basis of mitochondrial diseases.
6. will be familiar with the rationale behind genome-wide association studies, their advantages and disadvantages.
7. will have a general knowledge about cancer genetics.

in terms of social competences:

1. should be open to new challenges connected to genetics of diseases.

Course learning content:

Basics of inheritance.
Linkage analysis in identification of monogenic traits.
Complex diseases, multigenic inheritance and analysis tools.
Genome wide association studies the principles, advantages and disadvantages.
Mitochindrial disease and their inheritance.
Genetics and molecular mechanisms of cancer development.

Course name: **Nanobiotechnology in medicine**

On successful completion of this course, a student

in terms of knowledge:

1. know what nanotechnology is.
2. know the methodology of synthesis and characterization of iron oxide nanoparticles.
3. know the methodology of synthesis and characterization of carbon nanotubes.

in terms of skills:

1. know how to characterize nanomaterials.
2. know how to use bioprinter.

Course learning content:

History and Basics of Nanotechnology.
Nanoparticles.
Carbon Nanotubes and Graphene.
Characterization Methods.
3D Bioprinting.

Course name: **MSc seminar: applied medical biotechnology**

On successful completion of this course, a student

in terms of knowledge:

1. defines research problems within the scope of the thematic area related to the planned diploma thesis in the field of applied medical biotechnology.

in terms of skills:

1. is able to utilize literary sources while respecting intellectual property rights.
2. is able to present individual stages of the completion of a master's thesis in the form of a multimedia presentation.

in terms of social competences:

1. is ready to participate in the discussion, providing substantive answers i the filed of applied medical biotechnology.

Course learning content:

Review of international literature on current topics, taking into account the research interests of the student group in the field of medical biotechnology. Working with databases.
Analysis of selected experimental and review papers within the research area related to the ongoing master's thesis work in the field of applied medical biotechnology.
Presentation of results from individual stages of the ongoing diploma thesis work; discussion of research problems.

Group discussion on the presented topics within the field of applied medical biotechnology.

Course name: **MSc project: animal and human development**
On successful completion of this course, a student
in terms of knowledge:
1. apply the knowledge obtained during the studies to solve a specific research problem related to animal and human development.
2. select the state-of-the-art literature including breakthrough and hot topics of animal and human development.
3. present the results of a study using various forms of scientific expression.
in terms of skills:
1. apply the skills obtained during the studies to solve a specific research problem related to animal and human development.
2. use the right research methods for his/her purposes.
3. find the literature useful for analysis of a particular scientific issue/problem in the filed of animal and human development.
4. present research results using various forms of scientific expression.
in terms of social competences:
1. assess the appropriateness of the methods used in the reviewed literature.
2. selects the most modern literature containing the latest information in the field of animal and human development.
3. assess the adequateness of the conclusions with reference to results of Master project.
Course learning content:
Analyzing the problem or topic.
Conducting extensive research.
Summarizing findings from the research investigation.
Recommending additional research on the topic.
Drawing conclusions and making recommendations.
Documenting the results of the research.
Defending conclusions and recommendations.

Course name: **MSc seminar: human disease and therapy**
On successful completion of this course, a student
in terms of knowledge:
1. defines research problems within the scope of the thematic area related to the planned diploma thesis in the field of human disease and therapy.
in terms of skills:
1. is able to utilize literary sources while respecting intellectual property rights.
2. is able to present individual stages of the completion of a master's thesis in the form of a multimedia presentation.
in terms of social competences:
1. is ready to participate in the discussion, providing substantive answers i the filed of human disease and therapy.
Course learning content:
Review of international literature on current topics, taking into account the research interests of the student group in the field of human disease and therapy. Working with databases.
Analysis of selected experimental and review papers within the research area related to the ongoing master's thesis work in the field of human disease and therapy.
Presentation of results from individual stages of the ongoing diploma thesis work; discussion of research problems.
Group discussion on the presented topics within the field of human disease and therapy.

Course name: **Human diseases – epidemiology, etiology and therapy**
On successful completion of this course, a student
in terms of knowledge:
1. understands scientific terminology in the field of human carcinogenesis, metabolic and rare diseases.

2. knows genetic background and etiology of human cancer, metabolic and rare diseases.
3. knows epidemiology of human cancer, metabolic and rare diseases worldwide and can explain ethnic as well as socio-economic and other differences.
4. will be able to explain different therapeutic approaches to treat human pathological conditions including cancer, metabolic and rare diseases; knows advanced models of human diseases.
5. knows advanced models of human diseases.
6. knows molecular techniques for diagnosis of human cancer, metabolic and rare diseases.

in terms of skills:

1. can use scientific terminology in the field of human carcinogenesis, metabolic and are diseases.
2. can explain genetic background and etiology of human cancer, metabolic and rare diseases.
3. can explain epidemiology of human cancer, metabolic and rare diseases worldwide and can explain ethnic as well as socio-economic and other differences.
4. explain different therapeutic approaches to treat human pathological conditions including cancer, metabolic and rare diseases;
5. explanins how to: 1) monitor glucose uptake by different cell types in vitro, 2) perform karyotyping, chromosome identification, G-band staining and analyze relationships within a kindred. Pedigrees.
6. will be able to find adequate scientific literature covering topics of human diseases – epidemiology, etiology and therapy and can express critical assessment.
7. will be able to select and use molecular techniques for diagnosis of human cancer, metabolic and rare diseases.

in terms of social competences:

1. is able to list and explain ethical and legal problems related to human genome research in the aspect of cancer diagnosis and prediction.

Course learning content:

Medical history of cancer, and classification of cancer; classification of rare diseases (nuclear and mitochondrial); the concept of rare diseases: definitions, frequency; metabolic syndromes: definition, examples, components, risk factors and causes; pre-diabetes and diabetes: classification, prevalence, etiology, and molecularmechanisms.

Actions of mutagens (chemical, physical, viral), DNA adducts, types of DNA damage, types of mutations in cancer; mechanisms of DNA damage repair and related diseases when these mechanisms are defective; genetic basis of rare metabolic diseases: de novo mutations and hereditary mutations. Chromosomes - types, division into groups, karyotypes and idiograms; genetic instability, examples of chromosomal translocation and hybrid genes in several types of cancer; chromosome structure abnormalities diseases: e.g. microdeletion, microduplication syndromes; chromosome number abnormalities: trisomies, monosomies, chromosome instability syndromes such as Bloom Syndrome, Fanconi Anemia, Nijmegen Syndrome - etiology and diagnostics

Cell cycle control by products of proto-oncogenes and tumor suppressor genes; oncogenes – how their activity is altered in cancer cells.

Colon cancer as a multistage process involving oncogenes and tumor suppressor genes; cancer-susceptibility genes in APC: concepts of gatekeepers, caretakers, landscapers; two-hits hypothesis of Knudson, statistical/mathematical deduction using an example of retinoblastoma, germ-line and somatic mutations; inherited metabolic disorders; to explain genetic metabolic diseases: Gaucher, Fabry, Mucopolysaccharidosis, Pompe; dynamic mutation diseases - neurodegenerative and neuromuscular - etiology and diagnostics.

Beta cell fault, insulin resistance, immune defect, insulin excels in developing diabetes; regenerative medicine application for metabolic disorders; atypical cases of metabolic diseases modeling in vitro; human mini-organs, organ-on-chip, multi-organ systems.

Epidemiology and diagnostics of cancer worldwide; diagnostic methods for sporadic and hereditary mutations causing human rare diseases. Genetic epidemiology of rare diseases. Pedigrees

Different cancer treatments: surgery, radiotherapy, chemotherapy, modern therapies (specific drugs blocking products of cancer genes, immunotherapies, oncolytic viruses); personalized therapeutic nutrition for metabolic disorders and treatment of rare diseases.

Course name: **Biostatistics**

On successful completion of this course, a student

in terms of knowledge:

1. knows the basic concepts and statistical methods used in biology and biotechnology and is able to statistically describe the results obtained in experiments.

2. understands the need to apply statistical analysis in practically all aspects of human activity.
3. knows the appropriate methods for the statistical description of various types of data.

in terms of skills:

1. is able to formulate scientific hypotheses and verify them.
2. is able to choose the appropriate statistical method to solve a given issue.
3. is able to correctly interpret the obtained results and draw appropriate conclusions.
4. is able to use statistical software, in particular STATISTICA and R pacage, for data analysis and graphical visualization of results.

in terms of social competences:

1. is prepared to work in a group and understands the principles of teamwork when solving tasks using statistical methods.

Course learning content:

Populations and samples in statistics, representative sample, types of variables and measurement scales, descriptive statistics, basic theoretical distributions: binomial, Poisson, normal, Student's t-distribution, graphical presentation of statistical data.
Statistical inference techniques, point and interval estimation, verification of statistical hypotheses: the concept of statistical hypothesis and its formulation, types of errors (type I and II error), principles of applying statistical significance tests.
Parametric and non-parametric significance tests for related and unrelated variables, rules for selecting the appropriate test for the problem being solved.
Correlation and regression and their statistical significance, non-parametric correlation (Spearman's correlation coefficient).
Selected methods of multivariate data analysis, including cluster analysis and principal components analysis.

Course name: **Methods of the experimental work**

On successful completion of this course, a student

in terms of knowledge:

1. can choose the right tools to work in the laboratory.
2. explain the principles of operation and utilization techniques: Real-Time PCR, ddPCR, NGS, NGS data analysis, CRISPR/Cas9, protein structure analysis, plant and animal cells transformation.
3. explain the mechanisms leading to the emergence of diseases caused by the expansion of trinucleotide repeats, plan, and select appropriate research tools for conducting the selected experiment within the presented research topic (TREDs) and perform the analysis of the obtained data, be able to search for grant opportunities.

in terms of skills:

1. knows how to: calculate the standard deviation values using a calculator, use basic commands in Linux, perform NGS bioinformatics analyses.
2. present student’s research project.

in terms of social competences:

1. assimilate/develop new social competences related to the ability to discuss the project presented in a larger group of people, manage stress.

Course learning content:

Health and safety rules in the laboratory.
Planning the experiment and taking notes from it.
Basic issues related to life sciences at the molecular level: genomics, proteomics, transcriptomics.
Modern techniques/methods used in life sciences and especially in biotechnology: Real time PCR, ddPCR, NGS, FLIM-FRET, CRISPR/Cas9, plant and animal cells transformation.
Basic statistical concepts: mean, median, standard deviation, basic Linux commands, Poisson statistic.
Example of a research topic: genetic diseases associated with the expansion of trinucleotide repeats (Triplet Repeat Expansion Diseases (TREDs)).
Preparation of student’s own research projects based on proposed topics.
Project presentation and its evaluation.

Course name: **Bioinformatic data analysis**

On successful completion of this course, a student

in terms of knowledge:

1. know the critical steps of the bioinformatic project.
2. knows the public repositories of biological data and bioinformatic tools necessary for their interpretation.

in terms of skills:
1. can use publicly available biological data for investigation of biological problem.
2. can interpret and discuss the results of bioinformatic analysis of biological data.

in terms of social competences:
1. is ready for critical selection of publicly available biological data.

Course learning content:
Planing of the bioinformatic research project aimed for characterization of a given biological process.
Public resources for biological data aquisition and analysis.
Bioinformatic analysis of biological data to solve the selected biological problem.

Course name: **Research methodology**

On successful completion of this course, a student

in terms of knowledge:
1. knows the main parameters of diagnostic tests and understands their importance for the medical diagnosis process.
2. understands the importance of Bayes' theorem in determining diagnostic probability.
3. knows what the cognitive goals are in the field of basic research in the area of pharmacodynamics and preclinical research involving animals in the area of pharmacokinetics.
4. understands the differences between biomedical research and clinical research in accordance with applicable EU regulations.
5. knows the phases of clinical trials and understands what are the characteristics of these types of research.
6. knows the structure of research: cohort studies, case-control studies, randomized control trial, nested case-control studies, meta-analyses, subgroup-analysis. He/she undderstands the research goals that are realized in them and the limitations of these research.
7. knows types of advers drug reactions (ADR) and understands the concepts of clinical outcomes and surrogate clinical outcomes and knows the importance of endpoints for assessing the effectiveness and safety of therapy.
8. knows the concepts of risk, relative risk (RR), relative risk reduction (RRR), absolute risk reduction (ARR) and number needed to treat (NNT), relative risk increase (RRI), absolute risk increase (ARI).
9. understands the methods of linear and cross-over randomization. He/she knows also the method of block stratification and the Pockocs minimization method.
10. knows basic legal regulations devoted to advanced therapy medicinal products (ATMP) by Committee for Advanced Therapies (CAT).
11. understands the problems connected with the specificity of clinical trials in testing advanced therapy medicinal products (ATMP) that are results of: orphan disease, using historical control groups, randomization problem, limiting the amounts of phases of clinical trials.

in terms of skills:
1. can calculate parameters: diagnostic sensitivity, diagnostic specificity, prevalence value, likelihood ratio.
2. can calculate diagnostic probability withe the use of nomogram or Bayes' Theorem.
3. is able to determine what kind of study or trials should be used to achieve specific research goals in the development of a pharmacological agent.
4. can calculate values of risk, relative risk (RR), relative risk reduction (RRR), absolute risk reduction (ARR) and number needed to treat (NNT), relative risk increase (RRI), absolute risk increase (ARI) for the goal of evaluation of efficiency and harms of therapy.
5. is able to select an appropriate randomization design for the needs of a specific clinical trial.

in terms of social competences:
1. is able to cooperate within a team to solve a given problem.
2. Tdevelops analytical and critical thinking skills.

Course learning content:
Methodology of medical diagnosis
Stages of diagnostic process.
Subjective and objective data obtained in diagnosis.
Threshold approach
Qualitative and quantitative data in diagnostic process
Normal distribution and cut points for quantitative diagnostic tests.
Diagnostic sensitivity
Diagnostic specificity
Prevalence value

Methodology of medical diagnosis
Likelihoods (nosographic probabilities) vs. diagnostic probabilities
Likelihood ratio
Bayes theorem in medical diagnosis
Stages of drug development
Biomedical research and clinical studies - legal regulations
Phases of clinical trials
Characteristic of 0, I, II, III pohases of clinical trials with distingusihing of methodological structres of research and their goals
Observational studies vs. expeerimental research
Prospective vs. retrospective research
Cohort studies
Case-control studies
Nested case-control studies
The problem of counfanders in observational studies
Randomized control trial
Types of blinding in experimental
Problems with meta-analyses.
Subgroup-analysis of RCT and its limits.
Adaptive trials
Pragmatic trials
Adverse drug reaction vs. adverse event
Types of adverse drug reactions
Clinical endpoints / outcomes
Primary and secondary endpoints
The problem of surrogate clinical endpoints on the example of objective response rate and progression free survival.
Estimation of efficiency of therapy
Concepts of "risk", "relative risk" "relative risk reduction", "absolute risk reduction", "number needed to treat" and their calculation.
Concepts of "number needed to treat" (NNT), "relative risk increase" (RRI) and "absolute risk increase" (ARI) and their calcualtion.
Simply and complex randomization
Block stratification
Minimization method
Legal regulation on Advanced Medicinal Products (ATMP)
The function of Comitte of Advanced Therapies
Marketing Authorization
Exceptional Marketing Authorization
Marketing Authorization of ATMP under exceptional circumsatnces (UEC)
Specificity of clnical trials of ATMP
Problems of blinding, active control group, historical control grouop, surrogate endpoints, observational studies

Course name: **Stem cells**
On successful completion of this course, a student
in terms of knowledge:
1. should have advanced knowledge on the different types of stem cells (embryonic, adult, and induced pluripotent), their unique properties, and the mechanisms that govern their self-renewal and differentiation potential.
2. should critically analyze the progress and challenges in stem cell-based therapies for different medical conditions.
3. should understand the feasibility and efficiency of transdifferentiation (direct conversion of one cell type to another), the underlying mechanisms, and critically evaluate the potential and current limitations of this approach.
4. should gain a thorough understanding of the signaling pathways, growth factors, and bioengineering approaches employed to achieve directed differentiation towards desired cell lineages in a controlled laboratory setting.
in terms of skills:

1. should gain hands-on experience or in-depth understanding of stem cell isolation, culture, and differentiation techniques, which are essential for stem cell research and therapeutic applications.
2. should gain hands-on experience or in-depth understanding of techniques associated with stem cell assessment and in vitro differentiation including flow cytometry, immunofluorescence and others

in terms of social competences:

1. should be able to clearly and concisely communicate complex scientific concepts related to stem cells in both written and oral formats. This involves tailoring presentations to the audience (specialists vs. general public) and utilizing appropriate scientific language and visuals.
2. will master teamwork skills, to effectively work in teams, delegate tasks, share responsibilities, and communicate effectively to achieve common goals.

Course learning content:

Types of stem cells, their origin, derfivation, characteristics.
The different types of pluripotency.
The principles, mechanism and practical approaches for adult somatic cells reprograming.
In vitro stem cell differenitation approaches.
Transdifferentiation: the principles. mechanisms and examples.
Stem cell dervied mini-organs and disease modeling.
Cell-based screens for inducers of directed differentiation.
Cell therapies and In vivo delivery of stem-cell derived products.

Course name: **Genetic recombination**

On successful completion of this course, a student

in terms of knowledge:

1. can describe molecular pathways of genetic recombination.
2. can present functions of recombination in the light of evolution.
3. can describe the significance of meiotic recombination for plant and animal breeding.
4. can list and explain methods in analysis of genetic recombination.

in terms of skills:

1. can construct of Illumina-compatible DNA libraries for Genotyping-by-Sequencing approach and analyse high-throughput sequencing data.
2. can work with epifluorescent stereomicroscope.
3. can investigate basic analysis of the natural phenotypic variation using QTL and GWAS approaches.
4. can correctly and independently plan genetic experiments with the use of genetic mutants, interpret their results and draw out conclusions.

in terms of social competences:

1. is able to engage in a scientific discussion on genetic recombination and its role in evolution and shaping population variability.

Course learning content:

Cell division, cell cycle, chromosome segregation, somatic recombination events, meiotic crossover, genetic interference.
Methods for measurements of recombination frequency and chromosomal distribution of recombination.
Methods for identification of genetic basis of phenotypic variation.
The role of recombination in functioning of organisms.
The impact of recombination on the evolution of natural populations and species.
Genetic approaches for generation of new varieties, application of recombination in biotechnology.

Course name: **Funding of research and internships**

On successful completion of this course, a student

in terms of knowledge:

1. knows and understands the achievements of world science in the discipline in which the education takes place, as well as the paradigms and directions of development of this discipline.
2. knows mechanisms for funding research and fundraising for research and internships.
3. knows basic principles for knowledge transfer to the economic and social spheres.

in terms of skills:

1. use knowledge from various disciplines of science to creatively identify, formulate and innovatively solve research problems.
2. effectively retrieve information related to scientific activity from various sources, including from sources in foreign languages, and to properly select this information to assess its relevance for scientific development.

in terms of social competences:

1. is ready for critical evaluation of the work in the field of the scientific discipline within which the education is provided and its own contribution to the development of this discipline.
2. acting in accordance with the ethical principles of scientific work and interpersonal relations.
3. thinking and acting in an entrepreneurial way, creating new ideas and searching - in cooperation with people from other disciplines - for innovative solutions, as well as taking up challenges and intellectual risk in the scientific and public spheres and taking responsibility for the consequences of their decisions.

Course learning content:
Career planning.
Networking.
Europass CV.
Sources of project financing.Project portfolio. Platforms and systems used.Administrative support at AMU.
Basic principles of good research proposal.How to write a competitive project proposal step by step?- literature review
- hypotheses/research questions
- state-of-the-art.
- research plan
- resources

Course name: **Biomedical engineering**
On successful completion of this course, a student
in terms of knowledge:
1. select (considering pros and cons) the methods necessary for the upstream and downstream stages in the biotechnological process.

in terms of skills:
1. perform basic laboratory calculations
2. develop a work plan based on the protocol
3. keep laboratory notes and report obtained results
4. select appropriate analytical methods for technological process control

Course learning content:
Upstream:
Designing plasmidAmplification of plasmid in E. coliTransfection of HEK cellsCell culture and protein production
Downstream:
Collection and preparation of media (preliminary purification)Liquid chromatographyFinal antibody purification (membrane filtration + lyophilization)
Application: Preparation of ELISA test Bioprinting with RBD addition → immunohistological analysis.

Course name: **Developmental biology**
On successful completion of this course, a student
in terms of knowledge:
1. understands basic processes of animal development.
2. perceives close connections between developmental processes - both in health and in human disease.
3. knows and recognizes the importance of animal models used to study developmental processes and how they can be ethicly employed for medical biotechnology.
4. understands and correctly applies specific terms used in developmental biology.

in terms of skills:
1. studies those processes in more details based on the proposed literature.
2. is able to study developmental processes using microscopy, computationally analyze published microscopy data, and present and discuss own findings with peers.
3. can use a genomic browser to access, browse and interpret epigenetic developmental biology data.

in terms of social competences:
1. recognizes the importance of the research in developmental biology for medicine.
2. is able to hold scientific discussion on topics related to developmental biology.
3. appreciates developmental processes viewed at the level of whole organisms, organs/tissues and single cells, is able to consolidate them.

Course learning content:
Animal and human sex determination including human pathologies of that process.
Specification and development of germ cell line in lower organisms and mammals.

Molecular processes of early stages of the body patterning in lower organisms and mammals.
Parental imprinting and human syndromes caused by disruption of that process.
X-inactivation and its significance in development.
Posttranscriptional regulation of development, involvement of RNA-binding proteins and small RNAs.
Molecular mechanisms of ageing, from Drosophila up to humans.
Following animal development in model organisms.
Organ and tissue development on the example of the epidermis and hair follicle.
Transcriptional and epigenetic regulation of development.

Course name: **Legal and ethical dimensions in medical biotechnology**
On successful completion of this course, a student
in terms of knowledge:
1. has knowledge of the legal and ethical regulations governing the study and application of medical biotechnologies (including innovative and experimental therapies) given various risks, hazards, and controversies associated with these biotechnologies.
in terms of skills:
1. has knowledge of the ethical and legal prerequisites, short-term and long-term consequences of testing and applying medical biotechnologies for scientific purposes, for therapeutic and health-related purposes; modifications and the so-called human enhancement 1) on biological materials of human origin, 2) on living organisms – particularly human organisms, 3) for genetic-evolutionary heritage and biodiversity, 4) for social contexts.
in terms of social competences:
1. has the ability to plan and conduct research on medical biotechnologies in an ethically and legally responsible manner, respecting best practice and key international regulations, and with a readiness to consult societal priorities and concerns transparently.
Course learning content:
Established, new and experimental stage medical biotechnologies: 1) societal expectations; 2) beneficence; 3) risks and hazards; 4) an overview of legal and ethical regulations worldwide, in the EU and in Poland. Dealing with responsibility and self-regulation as a Researcher when scientific progress is ahead of legislation.
Collecting, reviewing and weighing up the effects of testing/application of various medical biotechnologies and biomedical engineering on individual health and well-being (concepts of health and well-being) versus costs (risks, hazards) for individual health, for genetic-evolutionary heritage, for biodiversity; beyond therapy: modifications and human enhancement; justified and unjustified normative objections discussed using examples (case studies); molecular microscale may imply extensive challenges; absolute or limited research freedom? progress at any cost?
Legal and ethical framework of testing medical biotechnologies on 1) biological materials of human origin (including donation, biobank, good laboratory practices), 2) animals (application for approval of the ethics board for animal research, 3xR principle), 3) with human participants (application for approval of the bioethics board; legal and ethical arcana of clinical research with humans – including the principle of informed and free consent to participate in the research; who is a vulnerable research participant?; good clinical practice; useful forms and questionnaires; access to medical personal data).

Course name: **Advanced Scientific English**
On successful completion of this course, a student
in terms of skills:
1. speaks fluent English to communicate effectively on a variety of topics, take part in scientific discourse andbe able to form properly structured questions and answers.
2. understands spoken English to participate in class activities.
3. uses more complex grammatical structures at the advanced and proficiency levels.
4. writes properly a variety of texts in academic English.
5. uses the enriched vocabulary including formal, academic terminology as well as technical terms and scientific vocabulary used by biologists.
in terms of social competences:
1. is able to give a short and profesional presentation in fluent English and handling discussion.
Course learning content:
Listening comprehension practice – exposure to a variety of texts ranging from informal to formal ones including the texts containing academic and scientific biological vocabulary.

Speaking – discussions on the basis of texts given during the classes and the ones given prior to the class; discussions following listening comprehension practice; in-class discussions based on students' presentations.
Vocabulary – enriching students' vocabulary and enforcing its use for everyday stituations as well as formal ones such as presentations. Vocabulary tasks will be incorporated in listening, writing, speaking and grammar practice.
Grammar- revision of the grammatical rules and structures learned so far; focus on more complex structures and their effective use in both spoken and written register; grammar will be explained in reference to listening and presentation skill practice as well.
Writing – introduction of elements of a coherent paragraph (topic sentence, body, concluding sentence); various types of paragraphs; exposure to a variety of esseys; characteristics of proper academic writing; short forms – emails, abstract.
Presentation – a structure of a coherent presentation; use of proper vocabulary, grammar and speaking skills to deliver a presentation; the presentation will be followed by in-class discussion.

Course name: **Bioimaging**
On successful completion of this course, a student
in terms of knowledge:
1. knows and understands the basic principles of construction and operation of various types of microscopes.
2. is familiar with the methods used in the analysis of biological material in various types of microscopes.
3. is familiar with software for processing and qualitative and quantitative analysis of microscopic images.
4. is familiar with the scientific literature in the field of microscopy.
in terms of skills:
1. can apply appropriate methods used in the analysis of biological material in various types of microscopes.
2. can analyze and interpret the experimental results .
3. can use software for processing and qualitative and quantitative analysis of microscopic images.
in terms of social competences:
1. can present and discuss the latest developments in the field of microscopy.
Course learning content:
Overview of optical microscopy, ray and wave optics, polarization and interference.
Introduction to photophysics: fluorescence, fluorescence polarisation and FRET.
Theoretical background of electron microscopy.
Commercial microscopy systems; fundamental operating principles of different microscope types.
Novel microscopy techniques (single molecule detection, fluorescence lifetime measurement, superresolution microscopy,two-photon microscopy, TIRF, superresolution microscopy, Raman microscopy, Atomic Force Microscopy, Cryo-EM, electron tomography).
Image processing and image processing software (open and commercial sources).
Probes for light and electron microscopy: antibody labeling, bioluminiscence, fluorescence, fluorescent proteins, labels for nucleic acids, quantum. dots
Tissue preparation for immunocytochemistry and electron microscopy.
Techniques for in vivo imaging of 3D organization, multicellular dynamics and complexity of living organisms.

Course name: **Tumors and their microenvironments - cellular and histopathological aspects**
On successful completion of this course, a student
in terms of knowledge:
1. mentions methods used in tumor visualisation and studies, including these with cell lines in searching new therapies.
2. explains on the basis of current knowledge heterogeneity of tumor cells with respect of tumor development, metastasis and resistance to therapy.
3. describes the role of tumor microenvironment in tumor development, metastasis, angiogenesis and immunosuppression.
4. indicates and describes targets (in tumor cells and their microenvironment) of traditional anticancer therapies and new therapies, including immunotherapy with checkpoint inhibitors.

in terms of skills:
1. uses with understanding scientific terminology in the field of oncology, tumor cell biology, tumor microenvironment and histology.
2. uses with understanding epidemiological data of human malignant tumors in Poland and in the World and indicates similarities, differences, trends.
3. explains why triple negative breast cancer is one of the tumors with very poor prognosis using actual view on diagnostic/therapeutic limitations and the role of genome sequencing and new clinical trials in anticancer strategy.
4. recognises the histopathological preparations, interprets histological/cellular features of human tumors and explains the contribution of immunohistochemical reactions in tumor diagnostics/classification.
5. selects and uses literature data, presents and discusses them.
6. works in group, prepares tasks.

in terms of social competences:
1. is ready to develop the knowledge about tumors and look for the current data.

Course learning content:
Scientific terminology in oncology, tumor cell biology, tumor microenvironment and histology.
Methods used in tumor visualisation and studies, including these with tumor cell lines in searching new therapies.
Epidemiological data of human malignant tumors in Poland and in the World (similarities, differences, trends).
Heterogeneity of tumor cells (biochemical, morphological features, cancer stem cells, epithelial-mesenchymal transition in metastasis, resistance to apoptosis/anticancer drugs).
Communication of tumor cells with their microenvironment (cross-talk via different mechanisms e.g. tunneling membrane nanotubes, exosomes, trogocytosis, intercellular connections).
Tumor invasion, migration, metastasis, angiogenesis and immunosupression (recruitment of different cells, tumor blood vessels formation, mimicry, extravasation/intravasation, organ/tissue specificity of tumor metastasis, sentinel lymph nodes etc.
Tumor cells and elements of their microenvironment as targets of traditional anticancer therapies and innovative therapies, including immunotherapy with checkpoint inhibitors (PD-1, PD-L1, CTLA-4) and CAR-T cell therapy.
Triple negative breast cancer as the tumor with very poor prognosis - actual view on the possibilities and obstacles in tumor classification and application of effective therapy.
Histological/cellular features of human tumors in preparations and the role of immunohistochemistry in tumor diagnostics/classification/mode of treatment.

Course name: **Mechanisms, effects of drugs action and drug interactions in humans**
On successful completion of this course, a student
in terms of knowledge:
1. mentions and characterises discovering and production process of original drugs.
2. indicates main targets for drugs in human cells and diversity of drugs action mechanisms.

in terms of skills:
1. explains similarities, differences between original and generic drugs.
2. characterises biopharmaceutics and biosimilar drugs (with regard to their production, biological features, immunogenicity) and gives examples of these drugs.
3. recognises the effect of genes to drug metabolism (poor/intermediate/ultrafast metabolisers) and explains interactions between drugs/diet ingredients.
4. explains the influence of MDR proteins to multidrug resistance phenomenon and contribution of biotechnology, nanotechnology in enhancement of drug affinity to human cells.
5. gives examples of the innovatie therapies used in treatment of tumors and other diseases and shows trends in biological and medical studies.

in terms of social competences:
1. develops own awareness regarding challenges in contemporary medicine and stimulates curiosity about trends in biological and medical studies.

Course learning content:
Discovering and production of original drugs – pre-clinical studies, clinical trials, drug patent and its expiration, serendipity in drug discovery, personalised medicine.
Synthetic original drugs and generic drugs - similarities and differences.
Biopharmaceutics (biological drugs) and biosimilar/biobetter drugs – production, contribution to pharmaceutical market, immunogenicity.

Drug metabolism and interactions of drugs with other drugs or diet ingredients (poor, intermediate, ultrafast metabolizers).
Cellular targets of drugs, diversity of drug action mechanisms and enhancement of drug affinity (monoclonal antibodies, liposomes, molecular Troian horse strategy).
Multidrug resistance phenomenon in human cells (chemoresistance, MDR proteins).
The innovative therapies used in tumors and other diseases (targeted therapies, cell therapies) FDA/EMA approved.
Trends in biological and medical studies focused on new potential drugs and combine therapies.

Course name: **Viruses in biotechnology**
On successful completion of this course, a student
in terms of knowledge:
1. understands and explains Virus-Like Particles (structure, production and characterization).
2. understands and explains the role of viruses in biological science.
3. knows and describes the role of Virus-Llike Particles in vaccines production.
4. understands and explains the role of viruses as carriers of therapeutic agents and genes.
5. understands and explains the role of viruses in nanotechnology.
in terms of skills:
1. knows and describes the safety rules in laboratory of virology.
2. explain the role of viruses in biological science.
in terms of social competences:
1. constantly updates the knowledge in the field of virology and related sciences.
Course learning content:
The difference between BSL2 and BSL3 laboratories.
The properties of virus like particles (types of VLPs, production platforms).
The positive role of viruses in biological science (studies on: viral life cycle, cell biology, antiviral activity of different compounds).
The role of virus-like particles in vaccines production.
Viruses as carriers of therapeutic agents and genes.
The role of viruses in nanotechnology (viruses as scaffolds and templates for nanomaterials).

Course name: **Research project**
On successful completion of this course, a student
in terms of knowledge:
1. knows and understands the tasks carried out during the internship.
in terms of skills:
1. carries out research tasks under the supervision of a practice supervisor.
2. cooperates with other people in the implementation of common tasks within the framework of research practice.
3. applies research techniques and tools in the field of medical biotechnology adequate to solve the tasks set.
in terms of social competences:
1. demonstrates readiness to improve research competences.
2. demonstrates readiness for individual and team work, as he understands the importance of systematic work on all group tasks/projects.
3. demonstrates readiness to carry out research tasks in compliance with the principles of occupational health and safety, with a sense of responsibility for the entrusted equipment and respect for their own work and that of others.
Course learning content:
Research profile of the research unit/group in which the practice is carried out and the research methods and techniques used.
Legal and ethical conditions of the tasks performed and health and safety rules at the place of research practice.
Broadening specialist knowledge, shaping and developing research skills and social competences as a necessary condition for scientific development.