

Molecular Medicine

2-year Master of Science (MSc)

Programme Code: MSMOLMED

Webpage: www.ntnu.edu/studies/msmolmed

This programme description is valid for students admitted in the academic year 2012/2013.

Introduction

The field of Molecular Medicine is often referred to as “tomorrow’s medicine”. It aims to provide a molecular understanding of how normal cellular processes change, fail or are destroyed by disease.

The mapping of the human genome in 2003 was a turning point, and our knowledge and understanding of molecules in living organisms are advancing at a fast rate. Modern technologies such as high-throughput analyses (microarray and proteomics) enable us to study thousands of genes and proteins simultaneously. This provides the foundation for a totally new understanding of biological systems and generates fresh hypotheses about the importance of genes and proteins for different diseases.

The MSc in Molecular Medicine is administered by the Department of Laboratory Medicine, Children’s and Women’s Health at the Faculty of Medicine.

Learning Outcome

The graduated student should be able to:

- demonstrate a strong background in molecular medicine (i.e. molecular/cell biology relevant to medical applications) and have practical skills relevant for the field;
- describe the organization of the human genome and its functional regulation (i.e. replication, gene expression, genome maintenance, and signal transduction principles);
- describe the impact of genes, inheritance and environment on disease, and understand how normal cellular processes change, fail or are destroyed by disease development, in particular for common diseases such as cancer, diabetes, and heart disease;
- explain principles of molecular diagnostics and advantages/limitations of its applications;
- recognize and explain current strategies and state-of-the-art approaches within functional genomics;
- collect relevant background information about topics within molecular medicine;
- present, evaluate and discuss scientific results in English (orally and in writing);
- reflect on the existence of ethical aspects, sound experimental approaches and scientific thinking.

Target Groups and Admission Requirements

Admission requirements to the MSc in Molecular Medicine is a bachelor’s degree (or an equivalent 3-year education) in biology, biomedical science, biotechnology, chemistry or similar, with an average grade of C or higher. A solid background in cell and molecular biology is highly recommended within the bachelor’s degree.

International applicants need to submit proof of English proficiency (TOEFL, IELTS, APIEL or University of Cambridge test). More details about the language requirements are available at www.ntnu.edu/studies/langcourses/languagerequirements. Applicants who are not citizens of the European Union (EU) or the European Economic Area (EEA) need to provide a financial guarantee to get a residence permit in Norway.

Teaching Methods and Learning Activities

In 2005 the new Laboratory Centre opened at Øya campus in Trondheim. In this building students get to work in high-tech laboratory environments side by side with researchers both from NTNU, Sør-Trøndelag University College and St. Olav's Hospital.

The teaching methods and learning activities include lectures, colloquiums, problem-based learning (PBL), seminars, demonstrations, excursions, practical training, self-tuition, and independent work. During the work with the master's thesis the student will do research in our well-equipped laboratories.

Programme Structure

The MSc is a two-year, full-time programme of study starting in the autumn semester. There are two main components:

- Master's thesis (60 credits)
- Theoretical and methodological courses (totalling 60 credits). Two courses, making up 15 credits, are compulsory. The remaining courses, adding up to 45 credits, are selected from lists of electives. Ideally, electives should be linked to the topic of the master's thesis.

There are two lists of elective courses (see below). *Two courses* must be selected from 'Electives 1'. The remaining elective courses can be chosen from both 'Electives 1' and 'Electives 2'. Additional relevant courses may be taken at NTNU or other educational institutions subject to the approval of the Faculty of Medicine.

A master's thesis agreement, including a project description, must be submitted by 15 March in the second semester. Potential projects will be presented in advance.

Master's Thesis

MOL3901	Thesis in Molecular Medicine	60 credits
---------	------------------------------	------------

Compulsory Courses

MOL3000	Introduction to Molecular Medicine	7.5 credits (autumn)
Various codes ¹	Experts in Teamwork	7.5 credits (spring)

Electives 1

BI3016	Molecular Cell Biology	7.5 credits (autumn)
MOL3001	Medical Genetics	7.5 credits (spring)
MOL3005	Immunology	7.5 credits (autumn)
MOL3007	Functional Genomics	7.5 credits (spring)
MTEK3001	Applied Bioinformatics and Systems Biology	7.5 credits (spring)

¹ Experts in Teamwork (EiT) is taught intensively in the weeks 2, 3 and 4 in the second semester. Read more about EiT on this webpage: www.ntnu.edu/dmf/studies/eit

Electives 2

BI3013 ²	Experimental Cell and Molecular Biology	7.5 credits (autumn)
BI3018	Patenting and Commercialization of Biotech and Medtech Inventions	7.5 credits (spring)
KLH3100	Introduction to Medical Statistics	7.5 credits (autumn)
MOL3003 ³	Molecular Medical Microbiology	7.5 credits (autumn)
MOL3009	Biobanking	7.5 credits (autumn)
MOL3010	Animal Cell Culture	7.5 credits (autumn)
MOL3014	Nanomedicine I – Bioanalysis	7.5 credits (autumn)
MOL3015	Nanomedicine II – Therapy	7.5 credits (spring)
MOL3018	Medical Toxicology	7.5 credits (spring)
MOL8002 ⁴	Molecular Mechanisms of Host Defence	9.0 credits (autumn)
MOL8003 ⁴	High-Throughput Genomics	7.5 credits (spring)
MOL8005 ⁴	Molecular Mechanisms of Host Defence – Essay	6.0 credits (autumn)
NEVR8014 ⁴	Laboratory Animal Science for Researchers	7.5 credits (autumn)

Some of the elective 2 courses may be cancelled if few students register for the examination.

Model of the MSc Programme (Example)

Year 1		Year 2	
<i>1st semester (autumn)</i>	<i>2nd semester (spring)</i>	<i>3rd semester (autumn)</i>	<i>4th semester (spring)</i>
Introduction to Molecular Medicine	Experts in Teamwork	Thesis in Molecular Medicine	
Elective course	Elective course		
Elective course	Elective course		
Elective course	Elective course		

Please note that this is only a suggestion. The student can choose to start with the thesis already in the first year and postpone one or more of the elective courses to the second year.

The student must have passed all examinations in compulsory and elective courses before he/she can submit the thesis.

² The course has restricted admission, and will be open for master's students in Molecular Medicine only if there are any available seats. Please contact the Department of Biology if you are interested.

³ The course has restricted admission. Two-thirds of the seats are reserved for the first-year master's students in Molecular Medicine. One-third of the seats are reserved for second-year master's students in Molecular Medicine and other master's students at NTNU.

⁴ The course is at PhD level, but it is open for qualified and motivated master's students.

Course Descriptions

Courses offered by the Faculty of Medicine

KLH3100	Introduction to Medical Statistics
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures and compulsory exercises.
Required previous knowledge:	The course is primarily intended for students admitted to a 2-year master's programme at the Faculty of Medicine, NTNU. Other students may be accepted after an individual evaluation.
Compulsory activity:	Exercise assignments
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	HLS3550: 7.5 credits KLH3004: 7.5 credits KLMED8004: 5.0 credits MNFSIB1: 7.5 credits ST3000: 7.5 credits ST3001: 7.5 credits
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Professor Grethe Albrektsen

Learning outcome

After completing the course the student understands basic concepts and principles of statistical analysis, and is able to perform and interpret results from simple statistical analyses.

Academic content

- Introduction to SPSS (statistical program package).
- Descriptive statistic for continuous and categorical variables (measures of location and spread, graphical display), probability, probability distribution, estimation, hypothesis testing, one- and two-sample test on mean values (Student T-test), non-parametric tests (Wilcoxon and Mann-Whitney U-test), tests on differences in proportions (cross-table analysis; chi-square- and McNemar's test), correlation, linear regression.

MOL3000	Introduction to Molecular Medicine
Credits:	7.5
Period:	Autumn
Teaching methods:	The curriculum of the course is defined by learning objectives. The course includes a compulsory project which accounts for 30 % of the final grade. The language of instruction and examination is English. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic knowledge of cell biology, microbiology, biochemistry, genetics and molecular biology.
Required previous knowledge:	Admission to a bachelor's or master's degree in Biochemistry, Biology, Biomedical Science, Biotechnology, Molecular Medicine or Medical Technology.
Mode of assessment:	4-hour written examination – 70 % of the final grade Project – 30 % of the final grade Letter grades (A-F)
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Professor Marit Otterlei

Learning outcome

After completing the course MOL3000 the student is able to:

- describe the organization of the human genome and its functional regulation (i.e. replication, gene expression, genome maintenance, and signal transduction principles);
- describe the impact of genes, inheritance and environment on disease;
- understand how normal cellular processes change, fail or are destroyed by disease development, in particular for common diseases such as cancer, diabetes, and heart disease;
- collect relevant background information about topics within molecular medicine, use EndNote, and to write a scientific review article of a given topic in English;
- reflect on the existence of ethical aspects within molecular medicine.

Academic content

The lectures will cover the organization and major features of the regulation of the function of the human genome, such as gene expression, replication and genome maintenance. Consequences of mutations and polymorphisms, and impacts of genes and environment on major common diseases, such as cancer, diabetes, vascular and coronary disease, will be covered. Basic principles of extracellular and intracellular signalling systems will also be included. Methods of DNA analysis, gene technology and applied bioinformatics will be discussed.

MOL3001	Medical Genetics
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures, student presentations, laboratory course and PBL. The lectures and the exam will be in English. If few candidates, alternative exam arrangements may be used. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Biochemistry and basic genetics
Compulsory activities:	Laboratory course
Mode of assessment:	4-hour written examination Letter grades (A-F)
Host department:	Department of Laboratory Medicine, Children's and Women's Health
Course coordinator:	Associate Professor Wenche Sjørusen

Learning outcome

After completing the course MOL3001 the student is able to:

- describe central examples of monogenic, polygenic and chromosomal disorders;
- recognise patterns of mendelian inheritance of monogenic diseases, and explain genetic and biochemical mechanisms of some central monogenic disorders;
- describe and understand mechanisms underlying numerical and structural chromosomal aberrations and principles mediating chromosomal disease;
- describe what genetic counselling and risk assessment are, and how genetic counselling is regulated by law in Norway;
- describe and understand central principles and examples in cancer genetics, including sporadic and hereditary cancers;
- describe and understand principles for methods of genetic diagnosis, i.e. gene tests and cytogenetic methods;
- describe and understand principles and methods for gene mapping - calculate frequencies of genetic variants at individual and population based level.

Academic content

The course will give an overview of mechanisms for development of genetic diseases. Topics include different patterns of inheritance, like dominant, recessive, autosomal and sex linked inheritance. Genetic

diseases will be classified in single-gene, chromosomal and multifactorial disorders. It will be discussed how identification of genes and variants in the genome, including gene mapping, make it possible to understand how variation can lead to disease.

MOL3003	Molecular Medical Microbiology
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures, seminars, laboratory exercises, a compulsory written assignment (which counts 30% of the final grade) and demonstrations. The language of teaching and examination is English. Timetables for courses at the Faculty of Medicine are available at https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic knowledge in microbiology, cell biology, biochemistry, and molecular biology
Compulsory activities:	Guided self-study, including laboratory work
Mode of assessment:	Oral examination – 70 % of the final grade Written assignment – 30 % of the final grade Letter grades (A-F)
Host department:	Department of Laboratory Medicine, Children's and Women's Health
Course coordinator:	Associate professor Jan Egil Afset

The course has restricted admission. Two-thirds of the seats are reserved for first-year master's students in molecular medicine. One-third of the seats are reserved for second-year master's students in molecular medicine and other master's students at NTNU.

Learning outcome

After completing the course MOL3003 the student is able to:

- demonstrate a strong general knowledge in molecular medical microbiology;
- have good knowledge of the PCR method including design, optimization and validation for detection, identification and quantification of microorganisms, and be able to interpret PCR results and discuss limitations of the method;
- demonstrate basic skills in performing PCR in the laboratory;
- discuss interpretation of PCR results and limitations of the method;
- demonstrate knowledge of other molecular methods for identification and quantification of microorganisms;
- demonstrate good knowledge of molecular methods for genotyping of microbial agents, and discuss the use of molecular epidemiological methods in the investigation of infectious diseases;
- describe the use of bioinformatics tools in molecular medical microbiology, and should have basic skills in the use of such methods;
- describe and discuss the use of relevant quality control measures in the molecular medical microbiology laboratory.

Academic content

The intention of the course is to introduce the student to the use of molecular genetic methods in the detection and characterisation of microorganisms. Methods for extraction methods, qualitative and quantitative PCR methods and DNA sequencing will be presented. The students will also be introduced to the principles for primer and probe design. The use of databases will be the subject of lectures, and the use of databases aiming at establishing molecular genetic assays. The application of genotypic assays for the purpose of molecular epidemiology will be discussed and demonstrated.

MOL3005	Immunology
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures and colloquiums (not compulsory). The language of teaching is English. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic knowledge within cell biology and biochemistry/molecular biology.
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	BI2013: 7.5 credits MNKBI213: 7.5 credits
Host department:	Department of Laboratory Medicine, Children's and Women's Health
Course coordinator:	Researcher Trude Helen Flo

Learning outcome

After completing the course MOL3005 the student is able to:

- demonstrate the basic knowledge of immunological processes at cellular and molecular level;
- outline, compare and contrast the key mechanisms and cellular players of innate and adaptive immunity and how they relate;
- understand the principles of central (antibody-based) immunological methods to an extent that he/she can set up a theoretical experiment;
- elucidate the genetic basis for immunological diversity and the generation of adaptive immune responses;
- understand the role of the Major Histocompatibility Complex in antigen presentation and transplantation immunology;
- identify the main mechanisms of inflammation, immune tolerance and autoimmunity;
- understand the principles governing vaccination and the mechanisms of protection against disease.

Academic content

The immune system governs defence against pathogens and is of importance for development of autoimmune diseases, allergy and cancer. The course discusses basic immunology including cellular and molecular processes that represents the human immune system. Subjects to be presented include cells and organs of the immune system, antigen, immunoglobulins and antibody diversity, molecular mechanisms of innate immunity, antigen presentation, cell-mediated effector responses, the complement system, cancer and the immune system, immunological techniques.

MOL3007	Functional Genomics
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures, laboratory course. The lectures are held in the spring semester, and starts in early February. The language of instruction and examination is English. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic skills in molecular biology and physiology.
Compulsory activity:	Laboratory course
Mode of assessment:	4-hour written examination Letter grades (A-F)
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Professor Astrid Lægreid

Learning outcome

After completing the course MOL3007 the student is able to:

- describe what is meant by functional genomics and how this area of research contributes both to new basic biomedical knowledge and to new developments in molecular medicine, including improved diagnostics and treatment of diseases;
- understand the interdependence of biomedicine, bioinformatics and bioethics within this field of research - reflect on ethical and societal aspects of functional genomics translated to health care;
- explain how genetically modified organisms can contribute basic biomedicine and to molecular medicine;
- explain main principles of high throughput analysis of gene expression and gene function by microarray and sequencing;
- explain the concepts of structural motifs and domains in proteins and methods used to assess these structures;
- explain main principles of some methods used in separation of protein;
- explain main methods for ionisation of peptides and how mass analysis of peptides and fragments thereof can be used to identify proteins and their post-translational modifications;
- explain main principles of bioinformatic tools used for data analysis, biological background knowledge management and modelling.

Academic content

- Fundamental principles within functional genomics, emphasizing the transcriptome and the proteome.
- Hypothesis generation/experimental design.
- Microarray-technology.
- HTP sequencing technology.
- Structure biology.
- Experimental model systems.
- Heterologous expression.
- Imaging.
- MicroRNA and manipulation of gene expression by RNA interference.
- Protein separation (2D-PAGE, 2D-LC).
- Mass spectrometry (MALDI-TOF, ESI-MS).
- Protein structure analysis (X-ray crystallography, NMR).
- Ethical perspectives within functional genomics and genetic risk information.

MOL3009	Biobanking
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures, seminar, group exercises, laboratory exercise, excursion, semester project. The language of teaching and examination is English.
Recommended previous knowledge:	Basic knowledge in medical genetics and cell biology
Compulsory activities:	Excursion, laboratory exercise and project work
Mode of assessment:	Oral examination Letter grades (A-F)
Host department:	Department of Laboratory Medicine, Children's and Women's Health
Course coordinators:	Associate Professor Jostein Halgunset

Learning outcome

After completing the course MOL3009 the student is able to:

- describe and explain universal and special features of the different types of biobanks;

- explain the different conditions and requirements that must be fulfilled with regard to operation and use of research biobanks;
- describe quality management, quality assurance, logistics and data management related to biobanks;
- discuss ethical issues and policy guidance regarding research involving human biological materials;
- outline the main features of laws and other directives which are relevant for biobanking;
- discuss the use and the potential utility values of biobanks;
- outline how to establish and operate a biobank;
- describe in detail the application process for the establishment of a research biobank - sketch the plan for a research project using human biological material.

Academic content

This course will focus on the following topics:

- Biobanks: classifications, common and distinctive features of the different types of biobanks.
- National regulations and international conventions concerning biobanks, use of human biological materials and personal data.
- Research biobanks: formal and practical aspects of the establishment, operation and use
- Ethical aspects of utilization of human biological materials; The role of Research Ethics Committees
- Different types of consent as basis for biobanking; alternatives to consent
- Logistics and quality management; quality assurance and quality control of collection, storage, retrieval and use of samples
- Methods for analysis of human biological materials; assessment and interpretation of data
- Extraction and quality assessment of DNA and/or RNA from various sources
- Collection and storage of data; databases and data security
- Statistical and epidemiological methods in biobank related research
- The role of biobanks in health surveys like HUNT, Mother-Child etc.
- Research for the future: National and transnational genetic and epidemiological research collaboration

MOL3010	Animal Cell Culture
Credits:	7.5
Period:	Autumn
Teaching methods:	Self-tuition. The language of the examination is English.
Recommended previous knowledge:	Basic knowledge in cell biology and biochemistry. One should have some experience with cell culture work.
Mode of assessment:	Oral examination Letter grades (A-F)
Host department:	Department of Laboratory Medicine, Children's and Women's Health
Course coordinator:	Professor Svanhild Margrethe Schønberg

Please note that this course is based on self-tuition. It will not be given any lectures.

Learning outcome

After completing the course MOL3010 the student is able to:

- demonstrate knowledge of basic cell culture techniques;
- demonstrate knowledge of establishment of cell inlines and their maintenance;
- demonstrate knowledge on design and use the cell culture facilities;
- critically evaluate cell cultures constraints and possibilities as an in vitro model;
- discuss the advantages and limitations of primary cell culture compared to immortalized or transformed cell lines.

Academic content

The course will focus on practical aspects of cell culture, like design and layout of the laboratory, aseptic technique, cloning and selection of specific cell types, contamination, methods for measuring viability and cytotoxicity, cell culture environment (substrate, gas phase, medium) and the culturing of specific cell types.

MOL3014	Nanomedicine I - Bioanalysis
Credits:	7.5
Period:	Autumn
Teaching methods:	The syllabus of the course is defined by the learning objectives. The course is based on lectures given by experienced researchers within each theme. The course includes a compulsory project providing an in-depth review of the primary literature, which will account for 25 % of the final grade. There might be simple lab exercises dependent on number of students enrolled. The language of instruction is English. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic skills in molecular biology, cell biology, chemistry, physics. Most suited for students who have completed courses in basic molecular and cell biology.
Mode of assessment:	4-hour written examination – 75 % of the final grade Exercise / Project – 25 % of the final grade Letter grades (A-F)
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Associate Professor Øyvind Halaas

Learning outcome

After completing the course MOL3014 the student is able to:

- understand how nanotechnology can be tailored and used for biomedical purposes;
- understand the problems and possibilities for analysis of proteins, nucleic acids and cells by micro fabricated devices and nanotechnological solutions;
- outline fabrication procedures and general considerations for microfluidics;
- understand how nano-relevant instruments such as focused ion beam scanning electron microscopes, atomic force microscopes and optical microscopes can be used in biomedicine;
- perform simple micro fabrication procedure;
- find, refer and consider relevant information.

Academic content

This course will cover fundamentals of bioanalysis and module integration for applications. In detail the course will contain:

- Advanced protein and DNA chemistry.
- Methods for quantification and identification of DNA/RNA and protein with focus on technical principles and emerging nanotechnologies.
- Use of imaging in nanoscale for biomedical research.
- Microfluidics.
- Principles for and construction of lab-on-a-chip and biosensors.
- Nanoneuroscience.

This course is focused on technology rather than biology.

MOL3015	Nanomedicine II - Therapy
Credits:	7,5
Period:	Spring
Teaching methods:	The syllabus of the course is defined by the learning objectives. The course is based on lectures given by experienced researchers within each theme. The course includes a compulsory project providing an in-depth review of the primary literature, which will account for 25 % of the final grade. The language of instruction is English. The lectures are held in the spring semester and start in early February. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic skills in molecular biology.
Mode of assessment:	4-hour written examination – 75 % of the final grade Exercise / Project – 25 % of the final grade Letter grades (A-F)
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Associate Professor Øyvind Halaas

Learning outcome

After completing the course MOL3015 the student is able to:

- understand how nanotechnological approaches can be used in biomedical therapies;
- understand biomaterials and interaction of biomaterials with cells, body fluids and tissues;
- understand basic stem cell biology and corresponding requirement for tissue engineering;
- understand the need, obstacles and solutions for polymeric, lipidous and solid nanosized drug delivery systems;
- understand the toxicological aspects of nanosized surfaces and particles;
- find, refer and evaluate available information.

Academic content

The course will introduce use of nanotechnology in therapy. In detail, the course will cover

- Clinical biomaterials, tissue regeneration, including stem cell technology, immunological limitations and encapsulation strategies.
- Methods and possibilities for drug discovery.
- Use and design of nanoparticles for gene therapy, drug delivery and drug targeting.
- Physiological, cellular and toxicological limitations for medical use of nanoparticles.
- Theranostics, the combined use of in vivo imaging/diagnostics and therapy.
- Ethical, legal and social aspects (ELSA) related to use of medical nanotechnology will be discussed.

A written report is included, where the student will choose a theme from the lectures, review the literature, describe current methods, consider and recommend use of emerging nanotechnologies in a therapeutic setting.

MOL3018	Medical Toxicology
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures. The language of instruction and examination is English. The course is taught in the spring semester, and starts in late January or early February. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Passed examinations in BI1001 and BI1004, or TBT4100 and TBT4105 (or similar courses).
Required previous knowledge:	Basic knowledge of physiology, chemistry and biochemistry.
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	TOKS1010: 7.5 credits TOKS3010: 7.5 credits
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Senior Engineer Bent Håvard Hellum

Learning outcome

After completing the course MOL3018, the student is able to:

- describe and explain toxicological mechanisms;
- perform simple analysis of how some chemicals might be a possible health hazard upon exposure;
- explain how certain xenobiotics in the environment and work can have toxic effects on central organs and organ systems in humans;
- collect relevant background data regarding toxicological problems.

Academic content

The course gives an introduction to general pharmacokinetic models. Liver, kidney, lung, the immuno- and nervous system will be discussed as target organs for chemical toxicity. Groups of toxic agents and substances of abuse will also be included. Major weight will be put on available methods for risk assessment of human exposure to cancer and non-cancer agents.

MOL3901	Thesis in Molecular Medicine
Credits:	60
Teaching method:	Individual supervision
Admission requirements:	The student must be admitted to the Master of Science in Molecular Medicine. In order to be eligible to defend his/her master's thesis the student must have passed all exams, i.e. compulsory and elective courses worth 60 credits in total.
Compulsory activity:	Individual supervision
Form of examination:	Thesis and oral presentation / examination. The grade given on the thesis may be adjusted after the oral examination.
Host department:	Department of Laboratory Medicine, Children's and Women's Health
Course coordinator:	Professor Marit Walbye Anthonsen

Learning outcomes

After successful defense of the thesis the student is able to:

- formulate a precise research problem;
- scientifically test and answer a research problem;
- prepare and analyze data from a study/experiment - master methods and techniques relevant for the research problem;

- present a research problem and discuss the results critically by use of relevant scientific literature;
- describe a scientific work in a clearly written report (master's thesis);
- present the results, both in writing and orally, with sound language and precise statements.

Academic content

The master's thesis in molecular medicine could have a basal or a medical direction. The thesis should have a scientific composition and be founded on applicable theory and literature within the specific subject.

Current topics could be molecular mechanisms and epidemiological causes, diagnostic problems and therapeutic measures. It is a great advantage that the thesis is connected to the existing research activities at the Faculty of Medicine. The principal supervisor is chosen among the scientific staff with permanent positions.

The thesis should be a monograph or a scientific paper with concluding remarks. In both cases, the student should document a theoretical comprehension and a broad understanding of the methods that have been used. Students enrolled in the master's programme in 2007 or earlier can write the thesis in Norwegian or English. Students enrolled in the master's programme in 2008 or later must write the thesis in English.

Details regulating the work with and assessment of the thesis are given in Guidelines for the Master's Thesis in Molecular Medicine. More information is available at www.ntnu.edu/dmf/studies/master (in English) or www.ntnu.no/dmf/studier/master (in Norwegian).

MOL8002	Molecular Mechanisms of Host Defence
Credits:	9
Period:	Autumn
Recommended previous knowledge:	Fundamental skills in medicine, immunology, cell biology, molecular biology at master degree level.
Required previous knowledge:	Master's degree in biology, chemistry, physics. Medical Doctors degree. Candidates with lower degree will be assessed individually.
Compulsory activity:	Seminars
Mode of assessment:	4-hour written examination Passed/not passed
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Professor Jan Kristian Damås

This course is at PhD level, but it is open for qualified master's degree students.

Learning outcome

After completing the course MOL8002 the student:

- has insight in basal cellular and molecular biology within the Department of Cancer Research and Molecular Medicine;
- has knowledge on experimental biological research on cellular and molecular level;
- has knowledge of the implications that fundamental scientific problems have on medical treatment;
- knows of the possibilities that biological research on the cell and molecular levels have on medical treatment.

Academic content

- Cell biology and molecular biology view of understanding cell growth and cell death, cell repair and maintenance.

- Innate and adaptive immunological mechanisms in organisms.
- Description of host defence mechanisms on three levels; molecular, cellular and organism.

MOL8003	High-Throughput Genomics
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures, demonstrations, laboratory work. 18 hours of lectures 10 hours of supervised self-tuition 20 hours of laboratory work excercises 5 hours of laboratory lectures
Recommended previous knowledge:	Basic knowledge in molecular biology, molecular cell biology and data analysis equivalent to MOL4010, BI1001, BI1005, BI2012, BI2014 BI3016, MA0301, ST1201, ST1101, IT1103, IT1105 (TDT4120), TDT4145, TKJ4175, BT8102.
Required previous knowledge:	Master's degree or similar, Medical students at the Student Research Programme, other candidates with a lower degree will be individually evaluated.
Compulsory activities:	Lectures. Laboratory work excercises. Self-tuition
Mode of assessment:	2-hour written examination + excercises
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Professor Arne Kristian Sandvik

This course is at PhD level, but it is open for qualified master's degree students.

Learning outcome

After completing the course MOL8003 the student:

- is familiar with molecular and bioinformatics principles for genomwide gene expression analysis;
- is familiar with commonly used technologies for genomwide gene expression analysis;
- is familiar with commonly used bioinformatics methods for analysis of datasets from genomwide gene expression analysis;
- is able to collaborate with bioinformatics specialists in the analysis of datasets from genomwide gene expression analysis;
- can assess the use of genomwide gene expression analysis in a research project;
- is able to critically assess the results from a successfully performed genomwide gene expression analysis;
- is able to discuss analysis problems with laboratory personnel and bioinformaticists.

Academic content

- High-throughput genomics technology including DNA microarrays for gene expression and SNP analyses, and high-throughput sequencing (DNA/RNA applications, analysis formats, sample preparation).
- Relevant bioinformatics including experimental design, data preprocessing and data analysis (statistical methods, databases for storing experiment data, methods of analysis).
- High-throughput genomics based research of the human genome and model organisms.

MOL8005	Molecular Mechanisms of Host Defence – Essay
Credits:	6
Period:	Autumn
Teaching methods:	Self-tuition. Writing an essay.
Recommended previous knowledge:	Master's degree or equivalent degree in medicine, cell biology or molecular biology.
Required previous knowledge:	Passed exam in MOL8002 or MOL8006.
Compulsory activity:	2-hour written examination Passed/not passed
Mode of assessment:	Home Examination Passed/not passed
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Researcher Markus Haug

This course is at PhD level, but it is open for qualified master's degree students.

Learning outcome

After completing the course MOL8005 the student is able to:

- independently write a paper on a scientific topic;
- search for relevant literature.

MTEK3001	Applied Bioinformatics and Systems Biology
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures and exercises (in computer lab). The lectures are given in the spring semester and start late January / early February. The exam in the spring semester is written, whereas exam in the autumn semester will be oral. The language of instruction and exam is English. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	Basic knowledge in molecular biology, statistics and informatics.
Compulsory activity:	Exercises
Mode of assessment:	4-hour written examination Letter grades (A-F)
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Professor Finn Drabløs

Learning outcome

After completing the course MTEK3001 the student is able to:

- explain the main principles of important algorithms and methods used in bioinformatics tools, including dynamic programming, hidden Markov models and neural networks;
- explain function and use of important bioinformatic tools, in particular tools for sequence level analyses (genome, gene, RNA, protein);
- describe important formats for storage and exchange of bioinformatic data;
- describe content and use of important bioinformatic databases and web portals;
- describe the use of bioinformatic tools and databases as a basis for systems biology;
- use bioinformatic tools and databases to analyse relevant data from molecular biology.

Academic content

The course aims at providing an introduction to the use of important methods in bioinformatics, including sequence library searches, pair wise and multiple alignment, phylogenetic analysis, gene prediction and structure prediction. The usage of these methods is also discussed in a systems biology

context, and ontologies, large scale analysis and studies of complex systems will be discussed. The students will be able to test the methods on realistic problems through PC-based exercises. There will be emphasis on using an interdisciplinary approach during presentations and exercises, in order to make the course accessible to students in informatics as well as medicine and molecular biology.

NEVR8014	Laboratory Animal Science for Researchers
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures, demonstrations and tours, study groups and individual assignments. The course consists of 35 hours of lectures and preparations for these, 24 hours of self-tuition (group work and individual assignments) and 21 hours of practical training. The requirements are set by the Department of Agriculture. (http://oslovet.veths.no/Oppl/nye.html#KatC)
Recommended previous knowledge:	Biomedical education, courses in statistics, knowledge of literature search on the internet and in the library.
Required previous knowledge:	A 3-year education on university or college level is a prerequisite in order for the participant to use the title "FELASA category C, Researcher" when the compulsory activities (see the below) have been carried out. Enrolment in a PhD programme, master programme or at "forskerlinjen" in medicine at NTNU. PhD- and "forskerlinje" students at the medical faculties at the universities in Bergen, Oslo and Tromsø are given access according to a mutual agreement between these institutions. Others are referred to the course MDV6003.
Compulsory activities:	Lectures (five days). Colloquiums. Individual assignment.
Mode of assessment:	2-hour written examination Passed/not passed
Host department:	Department of Cancer Research and Molecular Medicine
Course coordinator:	Post Doctor Marianne Waldum Furnes

Learning outcome

After completing the course NEVR8014 the student:

- shall know the principles behind modern theory on animal experiments and welfare
- knows the legislature regulating the use of lab animals in Norway
- knows the potential health hazards related to animal experiments, and how to minimize these hazards
- understands the significance of the internal and external factors influencing a lab animal and which thereby may influence the outcome of the experiment
- knows roughly how to monitor the health of lab animals
- understands the most important principles for choosing methods for handling and treating lab animals
- understand the principles behind anaesthesia, analgesia and humane killing of lab animals
- understands the general principles for planning animal experiments, including quality control and know of the potential alternatives and supplements to animal experiments which exist
- is able to evaluate a published article on animal experiments with emphasis on how the animals are described and used and know of and be able to use guidelines for good reporting of animal experiments
- has insight into the most important factors which decide the running of a research department using lab animals and be able to do a simple evaluation of a department
- has an attitude towards the lab animals which reflect "the three R's" with focus on animal protection and animal welfare (Replace, Reduce, Refine).

Academic content

Legislation, Ethics and views in society; the course of events in animal experiments; biology of lab animals; the choice of species; genetical and environmental factors influencing animal experiments; health hazards; principles concerning the handling of animals, anesthesia, analgesia and humane killing of lab animals; evaluation and quality control of animal experiments; reporting; alternatives to animals experiments; literature search.

The course is divided into two sections; a general section (3 days) and an elective section (2 days), where the students can choose between traditional laboratory animals, fish/aquatic organisms, or wild life/field experiments.

Courses offered by the Faculty of Natural Sciences and Technology

BI3013	Experimental Cell and Molecular Biology
Credits:	7.5
Period:	Autumn
Teaching methods:	Laboratory course / demonstrations (40 hours, compulsory) Lectures (20 hours, compulsory)
Compulsory activities:	Laboratory course / demonstrations Approved report
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	MNKBI313: 7.5 credits
Host department:	Department of Biology
Course coordinator:	Professor Berit Johansen

The course has restricted admission, and will be open for master's students in Molecular Medicine only if there are any available seats. Please contact the Department of Biology if you are interested.

Learning outcome

The aim of the course is to introduce basic methods in cell- and molecular biology. The course includes practical exercises in modern experimental techniques and instruments, and also training in literature search and the use of Internet. Selected analytical methods will be presented and tested. The course also includes analyses of problems and artefacts that generally occur in biological samples examined using chemical and biological analyses.

Academic content

On completion of the course students should be familiar with basic methods in cell- and molecular biology. Students should also be able to demonstrate knowledge of how to use modern experimental techniques and instruments.

BI3016	Molecular Cell Biology
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures (26 hours) and seminars (24 hours, mandatory)
Mode of assessment:	4-hour written examination
Credit reductions due to overlapping courses:	MNKBI316 7.5 credits
Host department:	Department of Biology
Course coordinator:	Professor Berit Johansen

Learning outcome

On completion of the course students should have an understanding of cell biology mechanisms on a molecular level, and of the regulation of such mechanisms.

Academic content

Subjects covered include: Apoptose/necrose mechanisms; Kinases/phosphatases classification and regulation; Transcription factors, classification and regulation; Lipid mediators, regulation and function mechanisms; DNA repair mechanisms. Syllabus will mainly be based on research- and review articles.

BI3018	Patenting and Commercialization of Biotech and Medtech Inventions
Credits:	7.5
Period:	Spring
Teaching methods:	The course is held intensively during one week during the months march/april. Lectures and case-based work in groups are repeated for every theme in the course. Oral presentation of work in groups by students. Written assignments are to be submitted two/three weeks after completion of the intensive part of the course. These are performed in groups. Submission written project assignment.
Recommended previous knowledge:	Target group: Master's and PhD students, Tech Trans personnel, Biotech/Medtech staff
Required previous knowledge:	Bachelor's degree or equivalent.
Mode of assessment:	Report Letter grades (A-F)
Host department:	Department of Biology
Course coordinator:	Professor Berit Johansen

Learning outcome

Knowledge: The candidate shall have knowledge about:

- aspects involved in transforming a research project to commercial product
- IP management;
- patenting; basics, process, national/international law, regulations, practising, similarities/differences;
- scientific versus commercial aspects on patenting strategy/IP evaluations;
- processes involved in transforming a research product to a clinical product;
- models for sale of IP, licensing versus sale;
- business development: IP, business plan, coworkers, financing.

Skills: The candidate can:

- identify and describe the different processes important for conservation of intellectual property of an invention and how to commercialize;
- identify and describe criteria and processes for sale of IP, including business development.

General competence: The candidate can:

- identify and explain principles in processes regulating protection and sale of IP.

Academic content

Topics that will be covered in the course include:

- Patenting: Principles, process, national/international laws, regulations and practice, similarities/differences between European and US patenting laws and practise.
- IPR strategies: Scientific/commercial aspects, how to develop an IP strategy to accelerate the innovation process and to safeguard IP investments, mastering freedom to operate in the Biotech/MedTech industry, Patent litigations, infringements and enforcements.

- Licensing: Models and negotiation strategies.
- Clinical testing: Design, implementation, analysis and presentation of clinical trials, adaptive clinical trial designs.
- Bio-tech/Med-tech business development: Strategy and organization when transferring a scientific idea into a commercial product/business, business plan development, product pipeline analysis, market analysis, market potential prediction, alliance structures and negotiation conditions, capital capture (pre-seed, seed, VC).

Target group: master's and PhD students, Tech Trans personnel, Biotech/Medtech staff, university academic staff.