Neuroscience

2-year Master of Science (MSc)

Programme code: MSNEUR
Webpage: www.ntnu.edu/studies/msneur

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

Introduction

The MSc in Neuroscience provides an in-depth study of brain structure and -function, reaching from the molecular to systems level. A central aim for students is to understand how neural systems may contribute to sensory experiences, thoughts, emotions and behaviour, and learn to adopt experimental methods to gain new knowledge in the field.

The MSc in Neuroscience is an interdisciplinary collaboration between the following faculties:

- Humanities
- Information Technology, Mathematics and Electrical Engineering
- Medicine
- Natural Sciences and Technology
- Social Sciences and Technology Management

The MSc is coordinated by the Programme Board of Neuroscience, with representatives from the students and the participating faculties. It is administered by the Department of Neuroscience at the Faculty of Medicine.

The degree awarded to students completing the programme will be *Master of Science in Neuroscience*. Completion of the master's degree is a qualification for studies at the PhD level.

Learning Outcome

General learning outcome

A solid knowledge about neuroscience, good experimental and theoretical skills, and competence to obtain and critically appraise own and already published experimental and theoretical data and to pursue a career in neuroscience.

Specific learning outcome

Knowledge

- The student has advanced knowledge of the research field of neuroscience including its subareas (Molecular and Cellular neuroscience, Systems Neuroscience (including comparative neuroscience), Computational Neuroscience and Cognitive Neuroscience) and disciplines (Anatomy, Physiology, Biochemistry, in vivo and in vitro Imaging techniques at cellular and network level, neurogenetics, neurophysics).
- The student has knowledge of relevant methodologies and techniques in neuroscience including both historical as well as more recent techniques.
- The student has knowledge about:
    - Sensory systems (somatosensory, visual, auditory, olfactory and taste, vestibular, pain, visual streams, barrel cortex, topographic organization, homunculus)
    - Motor systems (prim motor system, basal ganglia, cerebellum)

  - association cortex (definitions and different levels such as prefrontal, parietal, temporal cortex, etc.)
  - monosynaptic and complex reflex networks at spinal cord and brainstem levels.
- The student has specialized knowledge in at least one of the above mentioned disciplines.
- The student has knowledge about the main current theoretical concepts in Neuroscience, and can apply this to his/her own research: Chemical and electrical signaling, cellular integration, regulation of neuronal activity, excitatory and inhibitory transmission and the related cellular mechanisms (transmitter synthesis, packaging, release, receptor binding, location and regulation of receptor expression). Theorems include cortical networks, hierarchical processing, feedforward and feedback connectivity. Primary and higher order (association) cortex, oscillations and their functions, concepts of neuronal networks. Role of thalamocortical and cortico-basal ganglia networks, default networks, (monoaminergic/subcortical)modulation, and computational models including connectionists models (small world networks, spin glass models) and oscillatory models.
- The student has knowledge about mainstream concepts of neurophilosophy and ethics. The student is aware of and has knowledge of the relevant historical perspectives in neuroscience, its traditions and the position in the society. Is aware of debates in the field on neurophilosophy, theory of mind and discussions on consciousness.

Skills
- The student is capable of analyzing main outstanding issues in neurosciences, follow and analyze ongoing debates in the field, with special knowledge in at least one domain.
- The student knows how to find relevant methods and how to apply those to his/her project/question of interest.
- The student has competence to analyze experimental data, put them in a context of relevant available (published) data in neuroscience and directly adjacent fields such as psychology, and the ethical and societal issues related to neuroscience research and is able to communicate experimental results both orally and in a number of specific written formats.
- The student can analyze existing theories, methods and assumptions within the field of neuroscience.
- The student can recognize and validate problems; formulate and test hypotheses.
- The student can evaluate and formulate a theoretical concept. Evaluation includes originality, independence and applicability.
- The student can, with supervision, perform a research project independently, including the formulation of the research question based on good general insight in the field, experimental design and implementation, results analyses and reporting.
- The student is capable of adequate analysis of findings, including appropriate levels of statistics and integration with existing (published) information.
- The student can summarize, document, report, and reflect on own findings.

General competence
- The student knows how to analyse relevant general issues in neuroscience including field specific theorems and ethical issues, including how to decide on animal and human research, general insight in ways to diminish research that causes suffering to humans and animals and knows how to evaluate and weight the outcome to the inflicted suffering.
- The student is capable to apply his/her knowledge and capabilities to analyse and carry out complex experiments in neuroscience in not-familiar domains.

- The student has proven capability to apply his/her knowledge to new domains within neuroscience; has skills and knowledge to search for relevant data on his/her own scientific question, and can critically assess published data within the theoretical framework chosen for a particular project.
- The student can carry out research independently and knows how to formulate and express results and interpretations of the research outcomes.
- The student knows how to participate in discussions, put forward his/her results both in a constellation of peers as well as for lay-people.
- The student has proven capabilities to contribute to the generation of new idea/concepts/technical approaches to experimental research questions.
- The student can summarize, document, report, and reflect on own findings.

Learning outcome for Master of Science in Neuroscience

After completion of the programme the student	**Knowledge**	**Skill**	**General competence**
has in depth insight in basic brain structure and function reaching from the molecular to systems level.	3	1	3
understands how neural systems contribute to sensory experiences, thoughts, emotions, behaviour	2	2	3
can apply and adopt experimental methods to gain new knowledge	2	3	2
can formulate a research question based on adequate insight into current knowledge	3	3	2
is able to report outcomes of research in a coherent oral and written report	3	2	2

1 = elementary; 2 = average; 3 = advanced

Target Groups and Admission Requirements

The master's programme is suitable for students motivated towards research or teaching in Neuroscience in particular or the natural sciences in general. The introduction to experimental and analytical methods is relevant to other academic areas as well. The methodological introduction also provides a good background for positions in public health administration, academic journalism and medical publishing.

Admission to the MSc in Neuroscience requires a bachelor’s degree (or an equivalent 3-year education) in biochemistry, biophysics, biology, biomedical science, neuroscience or psychology. Other relevant disciplines (e.g. biotechnology, informatics, mathematics, medicine, movement science, philosophy, radiography) may be accepted after an individual evaluation of the applicant’s qualifications. The minimum average grade required is the Norwegian "C".

Applicants are encouraged to include the NTNU-based course NEVR2010 – *Introduction to Neuroscience* as a part of their bachelor’s degree. Students who do not have NEVR2010 (or an equivalent background in Neuroscience) when admitted, may be required to follow the NEVR2010 lectures during their first semester of the master’s programme.

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

The MSc in Neuroscience is a two-year, full-time programme. The teaching includes lectures, laboratory work/demonstrations and supervised project work. The language of instruction is English.

The master's programme has small classes, which stimulates a good study environment. The students contribute to the interdisciplinary environment with their different educational and ethnical backgrounds. Master's thesis projects are offered in multidisciplinary research teams such that students are exposed to and encouraged to participate in collaborative projects. The language of instruction and examinations is English.

Students will get access to high-tech laboratory environments, and modern reading and lecture rooms, computer labs and library facilities at Øya campus in Trondheim. NTNU shares this campus with St. Olav's University Hospital and Sør-Trøndelag University College.

Soma is an academic and social organization for master's students at the Faculty of Medicine. Soma runs a buddy programme at the start of the semester, and various events through the academic year. For more information, visit http://somantnu.blogspot.com/

Programme Structure

The master program is made up of the following three components:

- Master's thesis (60 credits)
- Compulsory courses (37.5 credits)
- Elective courses (22.5 credits)

Master's Thesis

NEVR3901*	Thesis in Neuroscience	60 credits

* The course code FY3901 is used by students with a supervisor at the Department of Physics.

Compulsory Courses

NEVR3001	Basic Neuroscience	7.5 credits (autumn)
NEVR3002	Systems Neuroscience	7.5 credits (autumn)
NEVR3003	Behavioural and Cognitive Neuroscience	7.5 credits (spring)
NEVR3004	Neural Networks	7.5 credits (spring)
Various	Experts in Teamwork	7.5 credits (spring)

Elective Courses

A selection of suggested elective courses is presented below. Other courses at NTNU or other universities can be approved by the Programme Board on request.

Some of the courses have entry requirements and/or restricted admission. Be sure to check this before you register for a course.

Courses with a course code in the 8000-series are at PhD level, but are open for qualified and motivated master's degree students.

The elective courses should normally be at master's degree level (3000-series or higher). However, if the student lacks appropriate background in areas relevant for the master's thesis, undergraduate courses in biology, chemistry, informatics, mathematics, medicine, physics, psychology or statistics may be accepted as well.

Faculty of Humanities:

FI3107	Biotechnology and Ethics	7.5 credits (autumn)
NEVR3005	Philosophy of Neuroscience	15 credits (spring)

Faculty of Information Technology, Mathematics and Electrical Engineering:

IT3708	Sub-symbolic AI Methods	7.5 credits (spring)
TMA4255	Applied Statistics	7.5 credits (spring)

Faculty of Medicine:

KLH3101	Introduction to Medical Statistics	7.5 credits (autumn)
MOL3001	Medical Genetics	7.5 credits (spring)
MOL3005	Immunology	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)
NEVR3040	Private Study of Neuroscience I	7.5 credits (both)
NEVR3050	Private Study of Neuroscience II	15 credits (both)
NEVR8001	Brain Metabolism Studied by 13C Nuclear Magnet Resonance Spectroscopy and Other Methods	7.5 credits (autumn)
NEVR8002	Aspects of Neurobiology	4.5 (both)
NEVR8014	Laboratory Animal Science for Researchers	7.5 credits (autumn)

Faculty of Natural Sciences and Technology:

BI3010	Population Genetics	7.5 credits (autumn)
BI3013	Experimental Cell and Molecular Biology	7.5 credits (autumn)
BI3016	Molecular Cell Biology	7.5 credits (autumn)
BI3017*	Bio Visualisation	7.5 credits (spring)
BI3018	Patenting and Commercialization of Biotech and Medtech Inventions	7.5 credits (spring)
TBT4145	Molecular Genetics	7.5 credits (autumn)
TFY4265	Biophysical Micromethods	7.5 credits (autumn)
TFY4280	Signal Processing	7.5 credits (spring)
TFY4310	Molecular Biophysics	7.5 credits (autumn)
TFY4320	Medical Physics	7.5 credits (spring)
TMT4300	Light and Electron Microscopy	7.5 credits (spring)

*Course not offered in the academic year 2012/13.

Progression

NEVR3001 and NEVR3002 should be taken during the first semester. NEVR3001 is taught in the first half of the semester, and the final written examination is held in October. NEVR3002 is taught in the second half of the semester and the final written examination is held in December.

NEVR3003 and NEVR3004 should be taken during the second semester. NEVR3003 is taught in the first half of the semester, and the final written examination is held in March. NEVR3004 is taught in the second half of the semester and the final written examination is held in May or June.

The modular course *Information Literacy* is embedded in the four compulsory courses NEVR3001, NEVR3002, NEVR3003 and NEVR3004.

The course *Experts in Teamwork* (EiT) is compulsory for all master's degree students at NTNU, and is taught intensively in the weeks 2, 3 and 4 in the second semester. Read more about EiT here: http://www.ntnu.edu/eit

The elective courses are to be taken when convenient for the work with the master's thesis. In the second semester, the student must choose a topic for the thesis. A contract for the master's thesis including a project description is drawn up by the student and his/her supervisor and submitted to the Department of Neuroscience within 15 March. Due to the nature of experimental projects in Neuroscience, it is recommended to work continuously with the master's thesis during the two years of the programme.

Model of the MSc in Neuroscience (example):

<table>
<tr><th colspan="2">Year 1</th><th colspan="2">Year 2</th></tr>
<tr><td>1st semester (autumn)</td><td>2nd semester (spring)</td><td>3rd semester (autumn)</td><td>4th semester (spring)</td></tr>
<tr><td>NEVR3001</td><td>NEVR3003</td><td colspan="2" rowspan="4">Thesis</td></tr>
<tr><td>NEVR3002</td><td>NEVR3004</td></tr>
<tr><td>Elective course</td><td>Experts in Teamwork</td></tr>
<tr><td>Elective course</td><td>Elective course</td></tr>
</table>

Please note that this is only a suggestion. As mentioned above, 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 the thesis can be submitted.

Course Descriptions

See next page.

Compulsory Courses

NEVR3001	**Basic Neuroscience**
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures and supervised project. The course is taught in the first half of the autumn semester with a final examination in October. The language of teaching and examination is English. Regular final examination is given in the autumn semester only. Students with legitimate leave of absence at the final examination and students who receive the grade F may take a re-sit examination in the spring semester. The re-sit examination may be conducted as an oral examination. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	NEVR2010 (Introduction to Neuroscience) or equivalent background.
Compulsory activity:	Project (essay based on literature search)
Mode of assessment:	4-hour written examination. Letter grades (A-F)
Credit reduction:	NEVR3020: 7.5 credits
Host department:	Department of Neuroscience
Course coordinator:	Professor Linda White

NEVR3001 has restricted admission. Students admitted to the MSc in Neuroscience are guaranteed a seat. Other students must apply for a seat by the given deadlines.

General learning outcome

The student has an in-depth understanding of mechanisms related to neurotransmitter signaling and glial-neuronal interactions in health and disease

Specific learning outcomes

Knowledge

The student has knowledge about:

- the most common cell types in the nervous system, their individual components and relationships;
- molecular and cellular mechanisms underlying synaptic transmission and plasticity;
- membrane properties resulting in membrane potential, depolarization and hyperpolarization, action potential generation, membrane oscillations;
- cellular signaling cascades, receptor-second messenger systems, receptors in relation to the common transmitters, transmembrane transport, transporters and channels;
- the role of the various glial celltypes and glial-neuronal interaction, in particular glutamine-glutamate cycle

Skills

The student is capable of:

- applying the knowledge to normal signal transduction in neuronal networks;
- applying the knowledge to altered signal transduction as seen in some examples of diseased networks;
- finding relevant published information and writing about a theme within basic neuroscience in a scientific and coherent manner.

General competence

The student is capable of:

- formulating one relevant problem in cellular/molecular neuronal functioning;
- translating this problem in an adequate strategy to find relevant published information;
- summarize the obtained information into a coherent, scientifically acceptable answer to the question posed;
- write a short essay on the problem, possible answers or pragmatic ways to obtain an answer.

Learning outcomes for NEVR3001

After completing and passing the course NEVR3001 the student:	**Knowledge**	**Skill**	**General Competence**
has in-depth insight of basic brain structure and function from the molecular to the anatomical level	3	1	2
understands how molecular, biochemical, cellular and physiological aspects mutually contribute to neural systems	2	1	3
can search relevant sources of information to acquire literacy in basic neuroscience	1	1	1
can formulate a research question based on adequate insight into current knowledge	3	2	2
can report outcomes of research in a coherent oral and written report	1	1	1

1 = elementary; 2 = average; 3 = advanced

Academic content

The course will introduce the student to methods for studying cellular and molecular mechanisms, including mechanisms of synaptic plasticity in relation to long-term potentiation and depression. The course will also deal with signalling events in brain, receptors and transport systems for important neuroactive substances, and the function of the various cell types in brain will be explained. There will be a particular focus on excitatory and inhibitory signalling and its importance in normal functioning. The course starts with a few introductory lectures on molecular and cellular biology for students with no such background.

The course includes a project equivalent to 2.5 credits. The project involves writing an essay, usually under supervision and based on a literature search of a topic. The project is evaluated as passed/failed. The student must pass the project assignment before (s)he can take the exam.

NEVR3002	Systems Neuroscience
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures and supervised project (essay based on literature search). The course is taught in the second half of the autumn semester. The language of teaching and examination is English. Regular final examination is given in the autumn semester only. Students with legitimate leave of absence at the final examination and students who receive the grade F may take a re-sit examination in the spring semester. In case of only a few candidates, the re-sit examination may be conducted as an oral examination. Timetable will be made available here: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	NEVR2010 (Introduction to Neuroscience) or equivalent background.
Compulsory activity:	Project (essay based on literature search)
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	NEVR3020: 7.5 credits
Host department:	Department of Biology
Course coordinator:	Associate Professor Tor Jørgen Almaas

General learning outcome

The student has an in-depth understanding of the overall organization of the vertebrate nervous system, including prevailing concepts on systems-level organization of the CNS.

Specific learning outcomes

Knowledge

The student has knowledge about:

- the definition of a primary cortical system, including thalamo-cortical and cortico-cortical hierarchical processing (feedforward, feedback and parallel transmission/processing pathways);
- sensory processing in the brain (somatosensory, visual, auditory, vestibular, olfactory, taste), including general anatomical and physiological principles, such as primary, secondary hierarchy , topographical organization (homunculus, tonotopy, retinotopy), and elementary processing as found in the visual system (hierarchical processing from edge detection and movement to complex scene recognition, color);
- the organization of the peripheral components of all sensory systems, including receptor types,peripheral-to-central pathways, topology;
- the motor system (primary cortical system including descending pathways, motor unit, basal ganglia, cerebellum);
- unconscious stimulus-response coupling in the brain, (spinal cord segmental reflexes, intersegmental reflexes, complex spinal cord brainstem reflexes, including the proprioceptive reflexus, vestibulo-oculomotor reflexes at the level of mesencephalon, cortex) corticobulbar and corticocerebellar integration;
- role/concept of the thalamus, basal forebrain, amygdala;
- main modulatory systems, cholinergic, histaminergic, dopaminergic, serotonergic and noradrenergic): anatomical location and organization, functional concepts;
- Comparative organization of sensory, motor and modulatory systems –evolutionary concepts.

Skills

The student is capable of:

- applying the knowledge to sensory-motor integration;
- integrating information from different systems into a high order integrative neuronal processing system within the domain of sensory-motor coupling;
- understanding of and conceptualizing different ways in biology to represent the outside world in the brain (multiple ways to solve the problem) in order to generate simple motor responses;
- finding relevant published information and writing about a theme within basic systems neuroscience in a scientific and coherent manner.

General competence

The student is capable of:

- formulating one relevant problem in systems neuroscience;
- translating this problem in an adequate strategy to find relevant published information;
- summarize the obtained information into a coherent, scientifically acceptable answer to the question posed;
- write a short essay on the problem, possible answers or pragmatic ways to obtain an answer.

Learning outcomes for NEVR3002

After completing and passing the course NEVR3002 the student :	**Knowledge**	**Skill**	**General Competence**
has in-depth insight of the basic concepts of the organization of sensory and motor systems	3	1	2
has insight of the basic structural and functional concepts of the major reflex pathways and modulatory systems in the central nervous	3	1	2
has knowledge about the organization of main subcortical integrative systems in the brain	2	1	2
can search and compare relevant sources of information to acquire literacy in basic neuroscience	2	2	2
can report outcomes of research in a coherent oral and written report	2	2	2

1 = elementary; 2 = average; 3 = advanced

Academic content

The lectures describe signalling events of sensory transduction, coding of sensory information, and cellular mechanisms involved in learning and memory of invertebrate model organisms. The lectures also include the motor system and some important neurological diseases presented in the context of the mechanisms described. The course includes a project equivalent to 2.5 credits. The project involves writing an essay, usually under supervision and based on a literature search of a topic. The project is evaluated as passed/failed. The student must pass the project assignment before (s)he can take the exam.

NEVR3003	Behavioural and Cognitive Neuroscience
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures and supervised project (essay based on literature search). The course is taught in the first half of the spring semester (normally in February and March), with a final examination at the end of March. The language of teaching and examination is English. Regular final examination is given in the spring semester only. Students with legitimate leave of absence at the final examination and students who receive the grade F may take a re-sit examination in the autumn semester. If few candidates, the re-sit examination may be conducted as an oral examination. Timetable will be made available here: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	NEVR2010 (Introduction to Neuroscience) or equivalent background.
Compulsory activity:	Project (essay based on literature search)
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	NEVR3030: 7.5 credits
Host department:	Department of Neuroscience
Course coordinator:	Professor May-Britt Moser

NEVR3003 has restricted admission. Students admitted to the MSc in Neuroscience are guaranteed a seat. Other students must apply for a seat by the given deadlines.

General learning outcome

The student has an in-depth understanding of the neural foundation of behaviour and cognition.

Specific learning outcomes

Knowledge

The student has knowledge about:

- the neural mechanisms for behavior and cognition, covering topics such as reward processing and emotion, planning and behaviour, appetite, pair bonding, learning and memory, sleep, spatial processing, perception and language;
- the neuronal networks/substrates underlying these cognitive and behavioural processes;
- mainstream theoretical concepts on how alterations in these main neuronal networks underly / cause main neurological and psychiatric clusters of disease;
- the potential relevance of main modulatory systems, cholinergic, histaminergic, dopaminergic, serotonergic and noradrenergic, for normal and abnormal cognitive functioning.

Skills

The student is capable of:

- applying the knowledge to formulate descriptions of cortical integrative processes that serve cognition and conscious behaviour;
- conceiving of and theorizing about the brain as comprised of multiple, mutually dependent functional networks that together generate appropriate adaptive behaviour;
- understanding how cortical and subcortical systems together contribute to complex cognitive behaviour.

General competence

The student is capable of:

- integrating knowledge about the brain into a coherent representation resulting in a consistent explanation of behaviour;
- selecting, evaluating, and integrating of published information on brain and behaviour into a coherent written or verbal account.

Learning outcomes for NEVR3003

After completing and passing the course the student :	**Knowledge**	**Skill**	**General Competence**
has in-depth insight of the basic concepts of the organization of higher order cortical systems	3	2	2
has insight of the basic structural and functional concepts of the major interactions between subcortical and cortical systems	2	2	2
is capable of describing certain cognitive behavioural processes in terms of contributions of and interactions between numerous brain systems	2	1	2
can acquire and evaluate published information relevant to our understanding of cognitive behavior	3	2	2
can report outcomes of research in a coherent oral and written report	3	2	2

1 = elementary; 2 = average; 3 = advanced

Academic content

The course provides a thorough introduction to the biological foundation of behaviour and cognition. It focuses on the neural mechanisms for behaviour and cognition, with particular emphasis on sleep, motivation, learning and memory, language, attention, perception and emotions. Lectures are also given on important neurological and psychiatric syndromes and disorders, with emphasis on the mechanisms behind the different conditions. The course includes a project equivalent to 2.5 credits. The project involves writing an essay, usually under supervision and based on a literature search of a topic. The project is evaluated as passed/failed. The student must pass the project assignment before (s)he can take the exam.

NEVR3004	**Neural Networks**
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures and demonstrations. The course is taught in the second half of the spring semester. The language of teaching and examination is English. Regular final examination is given in the spring semester only. Students with legitimate leave of absence at the final examination and students who receive the grade F may take a re-sit examination in the autumn semester. In case of only a few candidates, the re-sit examination may be conducted as an oral examination. Timetable: https://timeplan.medisin.ntnu.no/timetable_show.php
Recommended previous knowledge:	NEVR2010 (Introduction to Neuroscience) or equivalent background.
Compulsory activity:	An essay on a course related topic has to be handed in through it's learning. Further information on possible topics and requirements will be given at the onset of the course. The essay will be evaluated as pass/fail, and a score "pass" is required to be allowed to participate in the written examination.
Mode of assessment:	Assignments and presentations according to information given at the onset of the course (50 % of the final grade). Written examination (50 % of the final grade). Letter grades (A-F)
Credit reductions due to overlapping courses:	NEVR3030 7.5 credits
Host department:	Department of Neuroscience
Course coordinator:	Researcher Yasser Rashtabadi Roudi

NEVR3004 has restricted admission. Students admitted to the MSc in Neuroscience are guaranteed a seat. Other students must apply for a seat by the given deadlines.

General learning outcome

The student has an understanding of neural network mechanisms of cognition and how these can be studied with and represented by realistic network models at an experimental and computational level.

Specific learning outcomes

Knowledge

The student has knowledge about:

- different classes of network models/modeling approaches currently used in neuroscience;
- different simulation programs/approaches;
- essential mathematical and theoretical concepts relevant to neural networks and theoretical modeling.

Skills

The student is capable of:

- writing simple codes for modeling;

- translating simple biological data sets on neuronal firing or network properties into a theoretical representation.

General competence

The student is capable of:

- critically appraise neural network descriptions and theoretical models of neural networks;
- understanding the difference between neuronal coding and network coding;
- writing a short essay, based on a critical appraisal and integration of a number of computational/theoretical modeling studies on specific neural or network properties.

Learning outcomes for NEVR3004

After completing and passing the course the student :	**Knowledge**	**Skill**	**General Competence**
has an understanding of neural network mechanisms of cognition	2	1	1
Can read and critically appraise publications dealing with modeling of neural network properties	1	2	2
has knowledge about the main types of models currently in use	2	na	na
can search and compare relevant sources of information to acquire literacy in basic neuroscience	3	2	2
Can critically appraise sources of information and contents of scientific publications and choose relevant information	2	2	2
can report outcomes of research in a coherent written report that meets requirements of a scholarly publication	3	2	3

1 = elementary; 2 = average; 3 = advanced

Academic content

Neuroinformatics and network models of brain functions are major topics. The course has a strong focus on models of memory in realistic cortical networks, using both experimental and theoretical (computational) approaches.

NEVR3901 / FY3901	**Thesis in Neuroscience**
Credits:	60
Period:	2 semesters, though it is recommended to work gradually with the thesis during the entire study period.
Teaching methods:	Supervised project according to given guidelines. Practical information is available at www.ntnu.edu/dmf/studies/master
Entry requirements:	The student must be admitted to the Master of Science in Neuroscience. 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.
Mode of assessment:	Thesis and oral presentation/examination. The grade given on the thesis may be adjusted after the oral examination.
Host department:	Department of Neuroscience
Course coordinator:	Professor Menno Witter

General learning outcome

The student has mastered the principles of an independent problem-focussed experimental approach in neuroscience and can interpret experimental results in the context of critically appraised published information. The student has the skills and competences for continued scientific learning and education.

Specific learning outcomes

Knowledge

The student has advanced knowledge of:

- one subfield/discipline of neuroscience;
- relevant methodologies and techniques in neuroscience including both historical as well as more recent techniques;
- main resources to retrieve scientific information;
- general rules of reporting and publishing scientific reports;
- guidelines for oral presentation;
- best practice in scientific ethical behavior.

Skills

The student is capable of:

- performing a research project independently, but with supervision;
- recognizing, formulating and testing an hypothesis/research question;
- finding relevant methods and to applying those in order to experimentally address a scientific problem/question/hypothesis;
- adequate reporting of applied experimental approaches and obtained experimental results;
- adequate analysis of findings, including appropriate levels of statistics and integration with existing (published) information;
- retrieving and obtaining relevant published scientific information;
- communicating and defending own experimental results and their interpretations both orally and in the format of a master thesis;
- summarizing, documenting, reporting, and reflecting on own findings.

General competence

The student is competent to:

- evaluate ethical principles on animal and human research;
- search for relevant data on his/her own scientific question, and critically assess published data within the theoretical framework chosen for a particular project;
- carry out research independently and knows how to formulate and express results and interpretations of the research outcomes;
- participate in discussions, put forward his/her results both in a constellation of peers as well as for lay-people.

Learning outcomes for NEVR3901/FY3901

After successful defense of the thesis the student	**Knowledge**	**Skill**	**General competence**
has in depth insight one subfield of neuroscience.	3	1	2
can formulate a research question based on adequate insight into current knowledge	2	2	2
can apply and adopt experimental methods to gain new knowledge	2	2	3
can obtain, record and interpret experimental data	3	2	2
can retrieve and interpret published scientific data	3	2	2
is able to report outcomes of research and defend interpretations and conclusions in a coherent way both orally and in writing	3	3	2

Elective courses
(Sorted by course codes)

BI3010	**Population Genetics**
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures: 30 hours Auditorium lectures with chapter-wise Powerpoint presentations uploaded to It's learning. Control questions (chapter-wise) uploaded to It's learning and treated in plenary sessions in auditory. Various software for genetic simulations and analysis is demonstrated in auditory and made available on It's learning. Lecturers may be available for answering questions sent by email.
Entry requirements:	Basic skills in biology, maths and statistical analysis. Basic skills in English.
Recommended previous knowledge:	The students need previous knowledge corresponding to BI1001, BI1004, BI1003 and BI2017. The students need basic knowledge in algebra, probability theory and statistics.
Mode of assessment:	4-hour written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	MNKBI310 6.0 credits
Host department:	Department of Biology
Course coordinator:	Professor Jarle Mork

Learning outcomes

Knowledge
The candidate shall receive:
- insight in central themes of population genetics;
- knowledge of population genetics analytical tools.

Skills
The candidate shall know and understand:
- basic statistical analyses of genotypic distributions;
- estimates and statistical tests of genetic differences between populations;
- formulae for genetic equilibria between the four evolutionary forces;
- calculations of coancestry- and inbreeding coefficients from pedigree;
- methods for mapping of QTL (queantitative trait loci);
- estimating number of polymorphic loci affecting quantitative traits;
- estimating genetic response in specified selection experiments;
- genetic isolation and different types of speciation processes.

General competence
The candidate shall know and understand:
- general theory and analytical methods in qualitative and quantitative population genetics;
- implementing theory and methods for practical scientific purposes.

Academic content

The course gives an introduction to population genetics (qualitative and quantitative) and its analytical tools. Panmictic populations and genetic equilibium (Hardy-Weinberg). Genetically effective population size (Ne). Wahlund effect. Deviation from panmixia – genetic consequences. Change in gene frequencies due to the evolutionary forces mutation, genetic drift, gene flow, and selection. Measuring genetic differentiation between populations, speciation. Genetic processes in small populations (inbreeding, genetic drift). Molecular evolution and phylogenetics. Neutral and near-neutral theory, geneaology and coalescence. Different types of selection. Breeding genetics theory and methods. Epistasis and pleiotrophy. Evolutionary genetics.

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

BI3013 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.

BI3017	**Bio Visualisation**
Credits:	7.5
Period:	Spring ****not offered spring 2013****
Teaching methods:	Lectures: 36 hours Laboratory course/demonstrations: 60 hours, mandatory
Compulsory activity:	Laboratory course/demonstrations. Approved report.
Mode of assessment:	Written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	MNKBI317 7.5 credits
Host department:	Department of Biology

Admission to this course is restricted. The course is offered every second year only: 2012 and 2014.

Learning outcomes

On completion of the course the students should be familiar with modern imaging techniques.

Academic content

The course will include information and practical experiments about modern imaging techniques. The exact content will be adjusted so to fit to the equipment available. Examples of techniques to be discussed are: fluorescence stereomicroscopy/microscopy, immunogold-EM, use of reporter genes and various promoter- and gene-constructs for sub- and cellular localisation and confocal laser scanning microscopy. Other potential topics are 3-D-reconstructions, AFM (atomic force microscopy) and NMRi (imaging using NMR).

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 tranforming a research project to commersial 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.

FI3107	Biotechnology and Ethics
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures, plenary discussions, group work. About the essay: The essay topic must be approved by the course instructors. The essay should be approx. 15 pages long in 12-point Times New Roman, 1.5-line spacing. The essay should be argumentative. The essay can be written in either Norwegian or English. The oral exam will focus on a discussion of the essay and selected topics from the curriculum.
Compulsory activity:	Oral presentation
Mode of assessment:	Essay (70 % of the final grade) Oral examination (30 % of the final grade) Letter grades (A-F)
Credit reductions due to overlapping courses:	HFFI007 7.5 SP
Host department:	Department of Philosophy
Course coordinator:	Professor Bjørn Kåre Myskja

Learning outcomes

The students will acquire an overview of essential issues related to the development and application of modern biotechnology. They should be able to analyze these issues and to discuss and reflect on how to solve problems within this field, both orally and in writing.

Academic content

FI3107 reviews the ethical debate concerning both the research and application of modern biotechnology in a broad sense. Biotechnology is discussed in view of relevant ethical theories, worldviews, and central historical examples and lines of development. Relevant topics are debates concerning assisted reproduction, animal experimentation, organ donation, genetic improvement, the use of genetic information, selective abortion and euthanasia. Other issues of importance are precaution and risk assessment in relation to applications of biotechnology in agriculture and aquaculture.

IT3708	Sub-symbolic AI Methods
Credits:	7.5
Period:	Spring
Teaching methods:	Regular lectures, homework and a project, along with a take-home final exam. This course is VERY programming intensive, with each homework taking 2-4 weeks to complete. There are normally 4-5 such homework assignments. Group work on homeworks is acceptable, but group size cannot exceed 2 members. The take home exam is to be done individually, with absolutely no discussion with other students. Violation of this rule will result in a failing mark for the course.
Entry requirements:	TDT4136 Logic and Reasoning Systems, TDT4110 Information Technology, Introduction and at least one university-level course in mathematics or equivalent.
Recommended previous knowledge:	TDT4120 Algorithms and Data Structures and MA0301 Elementary Discrete Mathematics.
Mode of assessment:	The final grade is based 75 % on the homeworks/projects and 25% on the home examination.
Credit reductions due to overlapping courses:	IT8801 7.5 credits MNFIT378 7.5 credits MNFIT378(v.2) 7.5 credits
Host department:	Department of Computer and Information Science
Course coordinator:	Professor Keith Downing

Learning outcomes

Students will get both theoretical and practical programming experience with two of the best known sub-symbolic AI methods: artificial neural networks and evolutionary algorithms.

Academic content

The main focus of the course is to build intelligent systems based on two key natural concepts: the brain, and evolution by natural selection. In computer-science, the analogs for these are artificial neural networks (ANNs) and evolutionary algorithms (EAs). Both methods have thousands of useful applications in fields as diverse as control theory, telecommunications, music and art. This course discusses both methods in great detail along with providing a bit of the biological basis for each.

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 activitiy:	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.

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 Sjursen

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.

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 adamptive 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 Histocompability 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.

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 litterature, 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 contruction 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 litterature, 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 xenibiotics in the environment and work can have toxic effects on central organs and organ systems in humans;
- collect relevant background data regarding toxicologial 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 expose to cancer and non-cancer agents.

NEVR3005	Philosophy of Neuroscience
Credits:	15
Period:	Spring
Teaching methods:	Lectures, supervision and self-study. The assessment is based on an essay written with supervision, which makes up 60% of the final grade, and a six-hour written exam (no materials), which makes up 40% of the final grade. Both parts of the form of assessment must be given a pass grade. The written exam aims to test a wide part of the curriculum of the course. In case of retakes, students must redo both exams. Practical information regarding the essay: Date for submission available later. Three hard copies before 2 p.m. to the Department of Philosophy Office or the Department of Neuroscience Office. Length: 15-20 pages using 12-point Times New Roman, 1.5 line spacing. Front page: Course code, date, candidate number.
Entry requirements	NEVR2010 or equivalent
Recommended previous knowledge:	Basic knowledge of philosophy of science Basic knowledge of molecular and cellular neuroscience
Compulsory activity:	Approved course material/reading list
Mode of assessment:	Take home examination (60%) Written examination (40%) Letter grades (A-F)
Host department:	Department of Philosophy
Course coordinator:	PhD candidate Ronny Selbæk Myhre

Learning outcomes

To acquire the knowledge and ability to be able to discuss and evaluate some of the foundational philosophical problems in neuroscience, e.g. the nature of explanation in neuroscience, the relationship(s) between the self and the brain, and in what way neural mechanisms enable consciousness and the will.

Academic content

The aim of the course is to address some foundational philosophical problems in neuroscience. The course will focus on three areas: 1) the nature of mechanisms in neuroscience; 2) the nature of biological emergence and complexity; and 3) the neurobiological basis of the self. These areas, not independent of each other, will be investigated through different accounts of the relationship between cognitive phenomena such as perception and memory and the neural mechanisms underpinning such mental functions. This problem, however, is just a part of the more general problem of relating the mind to the brain. How are we to link molecules to mind? Can the mind be wholly decomposed to neural signalling and interacting molecules? Or is the way cells and molecules are organized in circuits, tissues and organs causally and explanatory essential? Perhaps a plausible account of the mind/brain nexus must, explain how mental phenomena are enabled by 'lower level' mechanisms, and how emergent 'higher-level' structures and processes at the system level can influence their component parts. In short, examining the nature of neural mechanisms and the way these mechanisms are organized in nervous systems may shed light on the fundamental nature of the self, consciousness and the will.

NEVR3040	Private Study of Neuroscience I
Credits:	7.5
Period:	Autumn / spring
Teaching methods:	Private study. The language of examination is English.
Entry requirement:	The student must be admitted to the Master of Science in Neuroscience.
Recommended previous knowledge:	Passed NEVR3001, NEVR3002, NEVR3003 and NEVR3004.
Mode of assessment:	Oral examination Letter grades (A-F)
Credit reductions due to overlapping courses:	NEVR3050 7.5 credits
Host department:	Department of neuroscience
Course coordinator:	Associate professor Bente Gunnveig Berg

Learning outcomes

After completing the course NEVR3040, the student

1. has detailed knowledge about a specific topic in neuroscience;
2. is capable of applying this knowledge to obtain an advanced functional understanding, ranging from underlying mechanisms to general principles;
3. can obtain relevant published information on that topic;
4. can critically assess and integrate published scientific information into a coherent and scientifically acceptable summary.

Academic content

The course consists of an individual curriculum associated with the master's thesis. The topic may, but does not have to be related to the thesis. The examination is normally held at the same day as the master's thesis examination, and with the same examiner.

NEVR3050	Private Study of Neuroscience II
Credits:	15
Period:	Autumn / spring
Teaching methods:	Private study, 2-3 semesters. The language of examination is English.
Entry requirements:	The student must be admitted to the Master of Science in Neuroscience.
Recommended previous knowledge:	Passed NEVR3001, NEVR3002, NEVR3003 and NEVR3004.
Mode of assessment:	Oral examination Letter grades (A-F)
Credit reductions due to overlapping courses:	NEVR3040 7.5 credits
Host department:	Department of neuroscience
Course coordinator:	Associate professor Bente Gunnveig Berg

Learning outcomes

After completing the course NEVR3050, the student:

1. has detailed knowledge about a specific topic in neuroscience;
2. is capable of applying this knowledge to obtain an advanced functional understanding, ranging from underlying mechanisms to general principles;
3. can obtain relevant published information on that topic;

4. can critically assess and integrate published scientific information into a coherent and scientifically acceptable summary.

Academic content

The course consists of an individual curriculum associated with the master's thesis. The topic may, but does not have to, be related to the thesis. The examination is normally held at the same day as the master's thesis examination, and with the same examiner.

NEVR8001	**Brain Metabolism Studied by 13C Nuclear Magnet Resonance Spectroscopy and Other Methods**
Credits:	7.5
Period:	Autumn
Entry requirements:	Basic knowledge of brain function and biochemistry. Master's Degree or equivalent education. Candidates with a lower degree will be assessed individually.
Teaching methods:	33 course hours
Recommended previous knowledge:	NEVR2010 or equivalent
Compulsory activity:	Oral presentation Lectures
Mode of assessment:	Oral examination (50 % of the final grade) Report (50 % of the final grade) Passed/ not passed
Host department:	Department of Neuroscience
Course coordinator:	Professor Ursula Sonnewald

Learning outcomes

After completing the course, the student should be able to interpret 13C NMR spectra, GC-MS and HPLC results. Furthermore, the student should understand mitochondrial energy metabolism, the synthesis and degradation of amino acid neurotransmitters, the astrocyte – neuronal metabolic interaction for synthesis of glutamate and GABA.

Academic content

The course will give a general introduction to brain metabolism with focus on interactions between neurons and astrocytes. These interactions are studied in cell cultures and animal models of neurological and psychiatric disorders. In-depth knowledge of NMR theory is not required, since the course emphasizes practical use in neuroscience. Theories and results of other related methods are introduced.

NEVR8002	Aspects of Neurobiology
Credits:	4.5
Period:	Autumn / spring
Teaching methods:	Seminars one hour every second week throughout the fall and spring semesters. Students may start to follow the seminars at any given time during the year. Contact Ursula Sonnewald for schedule.
Entry requirements:	Basic knowledge of biochemistry and neurobiology. Master's Degree or equivalent education. Candidates with a lower degree will be assessed individually.
Recommended previous knowledge:	NEVR2010 or equivalent.
Compulsory activity:	Seminars
Mode of assessment:	Oral examination Passed / not passed
Host department:	Department of Neuroscience
Course coordinator:	Professor Ursula Sonnewald

Learning outcomes

After completing the course the student should be able to understand the importance of metabolic studies, of using animal models of human disease. Furthermore, the student should understand glucose metabolism, the synthesis and degradation of amino acid neurotransmitters and the astrocyte – neuronal metabolic interaction for synthesis of glutamate and GABA.

Academic content

The course focuses on different aspects of neurobiology with emphasis on metabolism and nuclear magnetic resonance spectroscopy (NMR). The topics covered are: interactions between neurons and astrocytes in cell cultures and animal models of neurological disorders, like epilepsy and schizophrenia; influence of heavy metals on neurons; in vivo NMR spectroscopy of animals and humans; ex vivo NMR spectroscopy of cell extracts and extracts from different brain areas.

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.
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 chosing 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.

TBT4145	**Molecular Genetics**
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures, laboratory work. The course will be given in English. If there is a re-sit examination, the examination form may be changed from written to oral.
Recommended previous knowledge:	Background in biochemistry basic and advanced course (TBT4102 and TBT4107). The course has limited attendance. Please register for attendance in accordance with general deadlines.
Compulsory activity:	Assignments
Mode of assessment:	Written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	SIK4045 7.5 SP
Host department:	Department of Biotechnology
Course coordinator:	Professor Sergey Zotchev

Restricted admission. Application deadline 1 June (studentweb) or Contact Department of Biotechnology.

Learning outcomes

To understand how the genetic information in prokaryotic and eukaryotic organisms is organized and realized, and to acquire basic knowledge about the methods used to study these topics. It will be important to understand a link between bioinformatics and laboratory-based experiments. The students should also obtain a basic understanding of how this knowledge can be used in applied biotechnology, and be able to suggest experimental solutions to common problems occurring in basic and applied molecular genetic research.

Academic content

The course aims at providing an introduction to the basic principles of the molecular genetics of prokaryotic and eukaryotic organisms. The main areas of recombinant DNA technology applications will also be covered. Examples of important topics that will be discussed are: gene organization in pro- and eukaryotes, regulation of transcription and translation, techniques in recombinant DNA technology, bioinformatics in gene and genome analyses, biotechnolgical applications of molecular genetics.

TFY4265	**Biophysical Micromethods**
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures and laboratory excercises. Teaching will be in English if students on international master programs are attending the course.
Recommended previous knowledge:	Background in Cell biology.
Compulsory activity:	Laboratory assignments and report
Mode of assessment:	Portfolio assessment is the basis for the grade in the course. The portfolio includes a final written exam (80%) and exercises (20%). The results for the parts are given in %-scores, while the entire portfolio is assigned a letter grade. A re-sit examination may be changed from written to oral.
Credit reductions due to overlapping courses:	FY8906 7.5 credits, FY8410 5.0 credits, SIF4071 7.5 credits.
Host department:	Department of Physics
Course coordinator:	Associate professor Marit Sletmoen

Learning outcomes

The student should have knowledge concerning the mechanism of molecular exitation and deexitation as well as understand the interaction between light and biological samples. The student should have knowledge about the central techniques within lightmicrosopy as well as practical knowledge concerning the operation of a selection of these techniques. This includes an understanding of the construction, mode of function as well as application area of the following microscopy techniques: - Bright field microscopy with different contrast techniques (Phasecontrast-, Differentiel interference-, Modulationcontrast-, Polarisation-, Darkfield-, Reflection interference contrast microscopy (RICM)). - Epiilluminationmicroscopy, including Fluorescencemicroscopy, Confocal laser sanning microskopy, Multiphotonmicroskopy. - Total internal reflection interference microskopy. - Stimulated emission depletion microscopy (STED). - Nearfield microscopy. The student should have knowledge concerning the design and moe of funtion of Flowcytometry. The student should have knowledge concerning the mode of function of the following detectors: The human eye, Photon multiplicator tubes (PMT), Photodiodes, Videocamera, CCD camera. The student should have knowledge concerning the construction, mode of function and application area of optical tweezers. This includes knowledge concerning the prosesses underlying the trapping of particles with light as well as an understanding of the determination of forces using optical tweezers. The student should have knowledge concerning the construction, mode of function and application area of atomic force microsscpy. This includes knowledge converning intermolecular forces, different imaging modes and dynamic force spectroscopy. The student should have knowledge concerning electronmicroscopy and its use for the study of biological samples. This includes knowledge concerning the interaction electrons – biological samples, electron optics, transmission electronmicroscopy (TEM), scanning elektronmicroscopy (SEM), scanning transmission electronmicroscopy (STEM) and preparation techniques for electronmicroscopy. The student should have knowledge concerning bionanophotonics and microarray technology (DNA and protein microarrays). The student should have skills concerning interpretation and presentation of scientific data obtained during the pratical work in the laboratory. The student should have skills concerning reading of research literature and both written and oral presentation of the content of this literature.

Academic content

The course gives an introduction into the mode of different types of instrumentation that is important for studies of biological macromolecules, cells and other soft materials. The course aims at providing an understanding of the mode of function of the components that the instrumentation consists of as well as a theoretical and practical understanding of how to operate the instrument, including i.e. calibration procedures and maintenance. For each instrument the presentation of the components and the operation principles will be followed by examples of high quality resent research data obtained when using the instrumentation.

TFY4280	**Signal Processing**
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures, calculation assignments, compulsory computer laboratory exercises (MATLAB). A re-sit examination may be changed from written to oral.
Recommended previous knowledge:	Basic physics, mathematics and statistics
Compulsory activity:	Laboratory assignments
Mode of assessment:	Written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	SIF4076 7.5 SP
Host department:	Department of Physics
Course coordinator:	Associate professor Pawel Tadeusz Sikorski

Learning outcomes

The student is expected to:

1. obtain, through a combined theoretical and experimental approach to the subject, a fundamental understanding of signal processing and needed theoretical and mathematical background to describe signals and systems, experimental measurement signals and time series;
2. learn how to analyze various problems in signal processing using mathematical methods involving differential and integral calculus, as well as ICT-based/numerical methods by using Matlab.

Academic content

The course focuses on basic tools in analysis of analogue and digital signals and systems. Time and frequency domain description of signals. Use of Laplace, Fourier, and Z-transforms. Basic analogue and digital filter design, frequency response, data sampling. Excitation-response analysis of linear systems. Description and analysis of stochastic signals and measured signals with noise, correlations and energy spectrum analysis. Analysis of signals and systems using mathematical methods involving differential and integral calculus, as well as numerical methods using Matlab.

TFY4310	**Molecular Biophysics**
Credits:	7.5
Period:	Autumn
Teaching methods:	Lectures, voluntary problems and mandatory laboratory exercises. Teaching can be in English if students on international master programs are attending the course. A re-sit examination may be changed from written to oral.
Recommended previous knowledge:	Knowledge in physics, mathematics and chemistry according to three years university studies in physics.
Compulsory activity:	Laboratory assignments
Mode of assessment:	Written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	SIF4090 7.5 SP
Host department:	Department of Physics
Course coordinator:	Professor Bjørn Torger Stokke

Learning outcomes

Intended learning outcomes: The student should have knowledge of the fundamental molecular principles that underpins the physical properties of biological polymers and biopolymer assemblies: Interactomic bonds and interactions, such as covalent bonds, orbitaltheory, inter- and intramoleluar interactions, the hydrophobic effect, and water – lipid structures. - Dynamics and static properties of biopolymers such as molecular dynamics, the conformation of chain molecules, and swelling properties of biopolymer hydrogels. The student should have knowledge of key experimental methods for the detrmination of the physical properties of biological polymers and biopolymer assemblies: - Methods for determining rheological proprerties of solutions of macromolecules, viscosity and viscoelasticity, transport properties (translational- and rotational diffusion, sedimentation) - Methods for determining spectroscopic properties such as nuclear magnetic resonance, electron spin resonance, optical absorption spectroscopy, circular dichroism, and optical rotation. - Methods for determination of structure and properties by quasielastic scattering techniques, such as X-ray diffraction, fiberdiffraction and light scattering applied to biopolymers. The student should have skills within the practice of applying physical principles for describing molecular properties of biological polymers and biological assemblies. The student should have practical skills in carrying out selected experiments to determine the molecular properties of biopolymers and their assemblies, and communicate this in writing.

Academic content

The course focuses on application of selected topics within physics to describe the molecular properties of biological molecules and biopolymer assemblies, and physical characterisation techniques for their determination.

TFY4320	**Medical Physics**
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures at NTNU. Mandatory laboratory assignments during excursion to the Norwegian Radium Hospital in Oslo. Teaching will be in English if students on international master programs are attending the course. A re-sit examination may be changed from written to oral.
Recommended previous knowledge:	Course TFY4225 Nuclear and Radiation Physics or equivalent is required.
Compulsory activity:	Laboratory assignments
Mode of assessment:	Written examination Letter grades (A-F)
Credit reductions due to overlapping courses:	SIF4094 7.5 credits
Host department:	Department of Physics
Course coordinator:	Professor Tore Lindmo

Learning outcomes

The student acquires knowledge about physical priciples and methods used in medical diagnostics based on medical imaging. This includes being able to explain principles and implementations of computed tomography (CT) based on the use of nuclear medicine, roentgen X-rays, and magnetic resonance. The student can explain different forms of imaging by ultrasound, and how such imaging is principally different from CT-based imaging. The student acquires skills in evaluating performance parameters, application areas, as well as advantages and disadvantages of different modalities of medical imaging.

Academic content

Medical imaging modalities based on nuclear medicine (SPECT, PET), X-ray computed tomography (CT), ultrasound, and magnetic resonance imaging. Theory for image formation, image noise, image reconstruction and image processing. Quality assurance of medical imaging diagnostics.

TMA4255	Applied Statistics
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures and exercises with the use of a computer (computing programme MINITAB or R). The lectures may be given in English.
Recommended previous knowledge:	The course is based on ST0103 Statistics with Applications/TMA4240 Statistics/4245 Statistics, or equivalent.
Compulsory activity:	Assignments
Mode of assessment:	Portfolio assessment is the basis for the grade awarded in the course. This portfolio comprises a written final examination 80% and selected parts of the exercises 20%. The results for the constituent parts are to be given in %-points, while the grade for the whole portfolio (course grade) is given by the letter grading system. Retake of examination may be given as an oral examination.
Credit reductions due to overlapping courses:	ST2304 7.5 credits TMA4260 7.5 credits TMA4267 5.0 credits ST2202 7.5 credits SIF5066(v.2) 7.5 credits
Host department:	Department of Mathematical Sciences
Course coordinator:	Associate professor Mette Langaas

Learning outcomes

The objective of the course is to give the students a solid foundation for use of basic statistical methods in science and technology. In addition the students shall be capable of planning collection of data and to use statistical software for analysing data.

Academic content

Hypotheses testing, simple and multiple linear regression, residual plots and selection of variables, transformations, design of experiments, 2^k experiments and fraction of these. Special designs. Graphical methods. Error propagation formula. Analysis of variance, statistical process control, contingency tables and non-parametric methods. Use of statistical computer package.

TMT4300	Light and Electron Microscopy
Credits:	7.5
Period:	Spring
Teaching methods:	Lectures and mandatory tutorials and laboratory exercises. If there is a re-sit examination, the examination form may change from written to oral.
Compulsory activity:	Tutorials and laboratory exercises.
Mode of assessment:	Written examination. Letter grades (A-F)
Credit reductions due to overlapping courses:	SIK5077 7.5 credits
Host department:	Department of Materials Science and Engineering
Course coordinator:	Professor Jan Ketil Solberg

Learning outcomes:

The course teaches the students to use the light microscope (LM), the scanning electron microscope (SEM), and the transmission electron microscope (TEM). For LM and SEM the students should obtain a profound understanding of the theory behind the microscopes, how they are constructed, how they work and how they are used. Concerning TEM, the course gives a simple theoretical introduction based on Bragg's law and a simple introduction in construction and use. Only to a limited extent the course deals with specimen preparation. The course should give the students the necessary skills to carry out the most common microscopy investigations, in the first instance within their project and master projects. In addition, the course also serves as a qualification course for the PhD course Electron microscopy. Within light microscopy the students should be able to explain the theory for image formation, contrast, resolution, polarized light applied on metals, interference microscopy, interference films and fluorescence, and they should be able to explain the manner and mode of operation of accessories like diaphragms, filters, prisms, stoppers and objective lenses. In addition, the students should be able to carry out estimates of resolving power and height differences in the specimen surface (interference microscopy). The students should also know different methods for measuring grain and particle sizes directly in the microscope. Within SEM the students should be able to explain the theories for electron optics, the interactions between electron beam and specimen (secondary and backscattered electrons, X-ray formation), microanalysis (EDS and WDS), image formation (detectors, contrast mechanisms), diffraction (EBSD), fractography, as well as different types of SEM microscopes. Furtermore, the students should be able to carry out calculations associated with resolution power, depth of view, atomic number contrast, and element number (Moseleys law). Through practical laboratory work the students should also be able to operate the microscopes and to do necessary adjustments to obtain optimum conditions for imaging, diffraction studies and chemical analysis, i.e. adjustment of acceleration voltage, beam current, working distance, astigmatism and objective aperture. Within TEM the students should be able to explain the most common imaging techniques bright field, dark field, lattice imaging and diffraction. From Bragg's law they should be able to explain how diffraction patterns are formed in the microscope and how diffraction contrast is obtained in bright field and dark field images. Of common adjustments, it is expected that the students should be able to adjust the specimen height and the condensor aperture (in addition to focus). From diffraction patterns, the students should be able to calculate atomic plane distances of phases that are contained within the specimen. Through laboratory work and report writing the students should develop their skills in collaboration and written communication of scientific results.

Academic Content

Construction, manner of operation, and application of the microscopes. Light microscopy: Contrast, resolution, illumination modes, polarized light, interference microscopy, interference layer, fluorescence. Scanning electron microscopy: electron optics, interaction electron beam - specimen (secondary electrons, backscattered electrons, X-rays), micro analyses, imaging (detectors, contrast mechanisms), diffraction, fractography, low-vacuum SEM, field emission SEM. transmission electron microscopy: Diffraction, brightfield, darkfield.