Systems Biology

Find another programme

Core courses

Core Courses Systems Biology

Faculty of Science and Engineering

Systems Biology

Full course description

In this course you will focus on: * Applications of Systems Biology * The multi-scale and multi-disciplinary nature of Systems Biology * Current research topics within the field * Ongoing Systems Biology research projects within Maastricht University * Writing and presenting a competitive research proposal.

Course objectives

This course introduces the field of Systems Biology, giving a birds-eye- view of key publications, successful applications, novel developments, and ongoing research. You will get acquainted with the large diversity of model types and mathematical frameworks used in systems biology, and their application to a range of biological systems and processes. Furthermore, you will familiarize yourself with the writing of a competitive research proposal, the design of a scientific research strategy and presenting/orally defending your research proposal.

Recommended reading

Literature will be provided at the start of the course
MSB1001
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Coordinators:

- I.C.W. Arts
- M.E. Adriaens

Teaching methods:
Lecture(s), PBL, Skills, Assignment(s)
Assessment methods:
Attendance, Assignment, Presentation
Faculty of Science and Engineering

Biology and Physiology

Full course description

This course introduces the students to basic biological concept. Main focus will be on cell biology and molecular biology. The students will get acquainted with the different cellular compartments and functions and the molecular processes within cells in relation to genetics/genomics and metabolism. Furthermore, the students will be introduced in the field of evolution and ecology. • The topics within this course include: • Basic cell biology and cellular organelles • Membranes and cellular transport • Cellular Metabolism and Respiration • Genetics and Genomics • Evolution and Phylogenetics • Ecology

Course objectives

Understanding basic biological concepts including: cell biology, genetics/genomics, metabolism, evolution and ecology Understanding basic molecular genetic techniques Being able to perform standard molecular techniques and being able to explain/discuss the results obtained

Recommended reading

1. Reece, Urry, Cain, Wasserman, Minorsky, Jackson. Campbell Biology. Pearson 2014 2. Alberts, B. Molecular Biology of the cell 3. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald. Systems Biology: A Textbook, 2nd Edition, ISBN: 978-3-527-33636- 4, Wiley-Blackwell, 2016.
MSB1002
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Coordinator:

- M. Gerards

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Participation, Presentation, Written exam
Faculty of Science and Engineering

Mathematics of Biological Systems

Full course description

This course gives a basic grounding in several key areas of mathematics; calculus, linear algebra, basic skills, statistics and additionally will provide an introduction to Matlab. These topics are grouped into four strands. As students enter this course with differing backgrounds, the aim here is to bring everyone up to a level which will enable them to engage with the later compulsory courses and electives. An initial self- assessment will be completed by all students and the teaching will be adapted based on these results. Finally, the aim of this course is that students can not only solve mathematical problems when presented with them in a mathematical formulation, but also that students are able to independently generate simple mathematical formulations of biological problems and then solve them.

Course objectives

Calculus Students should be able to: ● Appreciate the difference between functions using discrete and continuous time and be able to suggest when each is appropriate. ● Be able to calculate limits ● Be able to integrate and differentiate a wide range of functions ● Solve basic differential equations ● Understand the use of calculus and be able to select the correct method for solving a problem framed solely in a biological context Basic skills and statistics Students should be able to: ● Distinguish between the forms of linear, polynomial, rational, exponential and logarithmic functions and know their properties. ● Work with real and complex numbers, understand their properties and graphical representations. ● Sketch graphs, using function, its first derivative, and the second derivative. ● Apply different types of curve fitting in the biological context. ● Understand the basic principles of probability including Bayes theorem. ● Understand the definitions of discrete and continuous variables, probability and cumulative distribution functions. ● Calculate expectation, variance, covariance and correlation. ● Appreciate the basic components of hypothesis testing. Linear algebra Students should be able to: ● Solve systems of linear equations, understand different types of possible solutions, and use the ideas in applied problems. ● Perform the common operations of matrix algebra and use them to solve applied problems. ● Compute determinant of a square matrix and understand its properties. ● Understands the concepts of linear independence, spanning set, basis, rank of matrix, vector space and subspace, and linear transformation. ● Understand eigenvectors and eigenvalues, how they characterize the action of some linear transformations and how to used them to solve applied problems. ● Use the ideas of inner products, orthogonality, and projections to determine least square solutions to a linear systems. Matlab Students should be able to: ● Use Matlab to import/export data and produce figures based on this data ● Understand and run code provided to them, and interpret the output ● Computationally check results from any of the other strands of the course ● Adapt code provided to them to improve or alter its functionality

Recommended reading

There are many good textbooks for all areas of this course, in particular due to their emphasis on the connection between mathematics and biology and their many biological examples, we recommend; ● Calculus for biology and medicine Claudia Neuhauser (2014) Pearson. ● Elementary linear algebra - Applications version Howard Anton and Chris Rorres (10th edition) John Wiley&Sons, Inc. ● Mathematics for the life sciences Erin N. Bodine, Suzanne Lenhart and Louis J. Gross (2014) Princeton University Press

MSB1003
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Coordinators:

- R. Cavill
- M. Havlicek

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Written exam, Assignment
Faculty of Science and Engineering

Modelling Biosystems

Full course description

The field of physiology describes the function and interaction of various building blocks (cells, tissues, organs, organ systems) of the human body. Models of physiological systems can be used to gain better understanding of (patho-) physiological events. In addition, models may be used to translate clinically measurable information into information that cannot be measured, but is of great diagnostic value.

The aim of this course is to provide an overview over various “mechanistic” or “white box” modeling approaches. The course will introduce the generic modeling process, important modeling concepts and terminology, and focus on equation-based modeling (and in particular ordinary and partial differential equations), agent-based modeling and constraint-based modeling. We will also touch upon the challenges of multiphysics and multiscale modeling and the inspiring avenues of in silico clinical trials and computational modeling for regulatory approval. To illustrate the various modeling approaches we cover different biological scales (intracellular, cellular/tissue and organ/patient) as well as different applications. The course will not only provide theoretical knowledge, but will apply the various modeling approaches in hands-on practicals, thereby equipping students with Matlab skills needed in the curriculum later on. The course is thus complementary to the parallel MSB1005 Experimental Design and Data Management course which focuses on data management and analysis and introduces R. It is furthermore complementary to the preceding MSB1001 Systems Biology, in that it focuses specifically on mechanistic modeling approaches (in contrast to –omics approaches) and provides both a theoretical comprehension as well as practical training in these mechanistic approaches.

Course objectives

The intended learning objectives of this course are to: 1) understand the scope and limitations of mechanistic modeling in biology, 2) be able to identify appropriate modeling paradigms and approaches for a given research problem, 3) understand and be able to explain important concepts of mechanistic modeling in biology, 4) be able to apply Matlab and Python for scientific applications, 5) be able to implement and manipulate ODEs and PDEs for particular research questions, 6) know important applications of mechanistic models in biomedical contexts, 7) understand the scope and limitations of important software tools for mechanistic modeling in biomedical contexts, 8) be able to critically read, evaluate and review a modeling paper.

Recommended reading

- Voit: ‘A first course in systems biology‘, Taylor & Francis Inc, 2017, ISBN:9780815345688

- Wilensky & Rand: ‘An introduction to agent-based modelling: modelling natural, social and engineered complex systems with Netlogo’, MIT press, 2015, ISBN 9780262731898

- Palsson: ‘Systems Biology: Constraint-based Reconstruction and Analysis’, Cambridge University Press, 2015, ISBN: 9781107038851

MSB1004
Period 2

Systems Biology
26 Oct 2020
18 Dec 2020
Print course description
ECTS credits:
6.0
Coordinators:

- A.M.F. Carlier
- M. Breuer

Teaching methods:
Lecture(s), PBL, Assignment(s), Skills
Assessment methods:
Assignment, Oral exam, Computer test, Take home exam
Faculty of Science and Engineering

Experimental Design and Data Management

Full course description

When publishing in a scientific journal, you often have the choice to make your findings available freely, openly accessible for the entire world. Additionally, a standard requirement is that all of the source data underlying your findings are openly shared using the FAIR ('Findable, Accessible, Interoperable, and Reusable') data principles. In Systems Biology research, these datasets are generally huge. Hence, next to proper experimental design, data management has become of utmost importance in Systems Biology research. This course covers all aspects of study design and data management, including scientific data analysis and the FAIR data principles. Additionally, you will learn how to perform basic as well as advanced data analyses in the scientific programming language R. The R skills trainings within the course are supported by DataCamp. DataCamp offers interactive, online courses in R and Python for data scientists and students. For more information, please visit: https://www.datacamp.com/

Course objectives

* Learn to explain important aspects of scientific data management, including data analysis, data stewardship, data archiving and data sharing; * Learn to distinguish between the relative merits and use cases for the diversity of study designs used in the field of Systems Biology research; * Learn to explain the principles of FAIR data sharing and open-access publishing; * Learn to perform analyses on biomedical research data in the statistical programming language R; * Learn to critically review research quality and methodology as they are used in daily practice, with a focus on study design, open-access and adherence to the FAIR data principles.

Recommended reading

Literature will be provided at the start of the course.
MSB1005
Period 2
26 Oct 2020
18 Dec 2020
Print course description
ECTS credits:
6.0

Systems Biology

Coordinators:

- M.E. Adriaens
- A.J. Isaacs

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Elective courses

Courses Master Systems Biology

Faculty of Science and Engineering

Omics

Full course description

In this course, you will explore the rich world of omics technologies and their applications. This not only includes the detailed study of the technological possibilities, but also of the data generating by experiments using these. The course will combine biological understanding with computational understanding, and discuss which methods can be applied to bring the two together.

We will discuss how a wide variety of omics technologies work, what they require and what they can deliver and we will detail their features and limitations. Also we will explore the entire trajectory of applying an omics method, checking and pre-processing the data to make them suited for statistical evaluation, perform the statistical tests, and apply further methods to help interpret the results and put them in a biological context. The initial phases of the analytical process will mainly depend on the exact technology used, whereas the later steps rather depend on the specific scientific questions to be answered.

Also we will look into specific examples of domains and specific studies in which omics technologies have been applied.

For some of the follow-up methods (learning objective 6), we will only discuss them on a generic level, as they will be studied in more detail in modules MSB1011 (Machine Learning, period 5, year 1) and MSB1014 (Network Biology, period 1, year2).

During the skills training, you will dive into data generated by real omics experiments of different types. You will explore how to obtain data related to published experiments and how to use the meta-data to be able to reuse the datasets. You will apply basic processing methods, statistical analysis, and follow-up methods to extract biologically understandable results from these experiments. You will use a variety of tools, both locally installed and available online.

Course objectives

The learning objectives of this course are:

- To know and understand commonly used technologies for genomics applications:
   * DNA/cDNA microarrays

* Next generation sequencing/ Massive parallel sequencing
  . Whole-genome and whole-exome
  . RNA
  . Bisulfite-based
  . In combination with immunoprecipitation

- To know and understand commonly used applications of high-throughput biological profiling, including
  * Genetics / Genetic variation
  * Comparative genomics
  * Transcriptomics
  * Epigenomics
  * Metabolomics
  * Proteomics
  * Microbiomics

- To understand and be able to apply the initial processing steps required to check data quality and prepare high-throughput data for statistical or biological analysis

- To understand and apply the statistical methods used for analysis of high-throughput data

- To be able to apply and understand the results of overrepresentation analysis methods, including:
  * Pathway analysis
  * Gene Ontology analysis

- To know other methods used for further data processing:
  * Clustering-based methods
  * Correlation-based methods
  * Classification-based methods
  * Network analysis-based methods

- To be able to describe how multiple types of omics data can be brought together and commonly analysed to increase biological understanding

- To be able to find repositories for omics data and to use retrieved data and meta-data for integrative or comparative analysis

- To be able to give the possibilities and limitations and the advantages and disadvantages of:
  * Genomics technologies
  * Applications of high-throughput biological profiling
  * Pre-processing and statistical methods for processing of high-throughput data
  * Analysis methods for further processes and biological interpretation of the results

- To be able to describe real use cases for each of the applications studied

To be able to design an experiment tuned to answer a specific biological question, using –omics technologies

Recommended reading

During this course, we will make use of study books, but also of scientific papers, dedicated study guides, and online study materials related to several tools and techniques.

MSB1006
Period 4
1 Feb 2021
2 Apr 2021
Print course description
ECTS credits:
6.0
Coordinator:

- L.M.T. Eijssen

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Faculty of Science and Engineering

Cardiovascular Systems Biology

Full course description

The course consists of lectures and journal clubs on the following topics: 1) Cardiac ion channels and cellular electrophysiology 2) Fundamental arrhythmia mechanisms 3) Computational modeling of cardiac electrophysiology 4) Signal processing and imaging of cardiac electrophysiology 5) Clinical arrhythmia syndromes and antiarrhythmic therapies 6) Cardiac arrhythmia management in the era of complex genetics In parallel, participants will obtain hands-on research experience working on a project investigating the potential proarrhythmic consequences of ion-channel mutations using computational modeling (in Python and/or Matlab). The mathematical and programming skills needed for this research (e.g., parameter optimization techniques) will be trained during a number of computer labs. Finally, a demonstration of experimental cellular electrophysiology (patch-clamp) techniques will be given during a lab visit.

Course objectives

Since the first quantitative description of neuronal electrophysiology in the Nobel prize-winning work of Hodgkin and Huxley in the 1950s, computational and systems biology approaches have also gained increasing prominence in the field of cardiology. These approaches span spatial levels ranging from individual ion channels to the whole heart and have produced significant insight into the mechanisms of cardiac arrhythmias and improved treatment strategies. Some systems biology approaches are even actively used in clinical practice to guide management of patients. In this course, participants will explore the experimental, computational, and clinical components of cardiovascular systems biology with particular emphasis on cardiac electrophysiology and arrhythmogenesis. We will highlight the multidisciplinary nature of this topic, addressing fundamental pathophysiological concepts, computational approaches and clinical implications.

Recommended reading

References supporting the information presented during lectures will be noted on the lecture slides and participants are strongly encouraged to employ these to obtain additional information to answer their questions and expand their knowledge on topics of interest. In addition, the following papers

provide a relevant general introduction into cardiovascular systems biology: 1. Grace AA, Roden DM. Systems biology and cardiac arrhythmias. Lancet. 2012 Oct 27;380(9852):1498-508. 2. Rudy Y, Silva JR. Computational biology in the study of cardiac ion channels and cell electrophysiology. Q Rev Biophys. 2006 Feb;39 (1):57-116. 3. Heijman J, Erfanian Abdoust P, Voigt N, Nattel S, Dobrev D. Computational models of atrial cellular electrophysiology and calcium handling, and their role in atrial fibrillation. J Physiol. 2016 Feb 1;594(3):537-53. 4. Trayanova NA, Chang KC. How computer simulations of the human heart can improve anti-arrhythmia therapy. J Physiol. 2016 May 1;594 (9):2483-502. 5. Viceconti M, Hunter P. The Virtual Physiological Human: Ten Years After. Annu Rev Biomed Eng. 2016 Jul 11;18:103-23. 6. Cluitmans MJ, Peeters RL, Westra RL, Volders PG. Noninvasive reconstruction of cardiac electrical activity: update on current methods, applications and challenges. Neth Heart J. 2015 Jun;23(6):301- 11. 7. Wilde AA, Behr ER. Genetic testing for inherited cardiac disease. Nat Rev Cardiol. 2013 Oct;10(10):571-83.
MSB1007
Period 4
1 Feb 2021
2 Apr 2021
Print course description
ECTS credits:
6.0
Coordinator:

- J. Heijman

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Written exam, Assignment
Faculty of Science and Engineering

Dynamical Systems and Non-Linear Dynamics

Full course description

The course Dynamical Systems and Nonlinear Dynamics will provide you an introduction into the analysis and visualization of the complex behavior of dynamical systems . We will look at a many features of nonlinear systems, starting from first-order differential equations, covering phase-plane analysis and eventually study the famous Lorenz-equations. Topics will include fixed points and stability, numerical methods, bifurcations, oscillators, attractors, chaos, fractals and recurrence analysis. The theory will always be supported by many practical examples and applications, and assignments will be mostly done with the help of the computer, using MATLAB and/or Octave. Journal clubs will provide further insight into various applications of dynamical systems theory in the field of Systems Biology.

Course objectives

This course aims to provide a solid basis for the understanding of the behavior of dynamical systems and to provide tools to visualize and analyze these systems, with a limited amount of fundamental mathematical theory. The focus will be on practical applications of the theory, by analyzing and visualizing systems using the computer. Participants will learn to use MATLAB/Octave to define, analyze and visualize dynamic behavior in multiple ways, study the effect of parameter changes and initial conditions, see how deterministic chaos can arise in relatively simple systems, have fun with fractals and discover recurrent patterns in biomedical signals. Prerequisites are an introductory level of calculus and physiology, as covered by the courses Mathematics of Biological Systems and Biology and Physiology.

Recommended reading

The course will be given following the material discussed in: Steven H. Strogatz, Nonlinear Dynamics and Chaos, 2nd edition. Students are strongly recommended to obtain a copy of this book, as it provides a gentle but thorough introduction into the analysis of nonlinear systems with many examples from physics, biology, chemistry and engineering.

MSB1008
Period 4
1 Feb 2021
2 Apr 2021
Print course description
ECTS credits:
6.0
Coordinator:

- S. Zeemering

Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Fundamental and Systems Neuroscience

Full course description

The brain and its neural circuitry are among the most complex and perplexing natural systems. Brain networks have a storage capacity and flexibility that far exceed modern supercomputers, or any artificial intelligent system. A main question in neuroscience is how such complex networks process incoming multisensory information, and match these percepts to stored mnemonic information to direct behaviour. In this course, you will gain more insights in these processes by examining brain functions at various scales, i.e. at the micro-, meso- and macro- level. You will get an overview of the full spectrum of neuroscience, from neuron to brain to mind, and from experiment to advanced theory and models. Furthermore, by learning how to unify novel findings in Fundamental Neuroscience and Systems Neuroscience into a neuroscientific concept, you will develop an integrated and multidisciplinary perspective on neuroscience. Finally, the skills training will provide you with hands-on experience on various state-of-the-art neuroscientific techniques and methods. During the skills training, you will visit labs in which neuroimaging data are acquired. In addition, you will acquire neuroimaging data yourself. Finally, you will analyse data of different types of neuroimaging datasets (e.g., fMRI and EEG analyses). You will learn to apply standard processing methods and statistical analysis, and learn to interpret experimental results for various types of neuroimaging studies. You will use a variety of dedicated tools, which are locally installed in the labs and computer rooms.

Course objectives

The learning objectives of this course are: • To know and understand neural processes at the microlevel (cellular), mesolevel (local circuits, neural populations), and macrolevel (large-scale brain networks, network integration) on topics in: o Cellular neuroscience o Neurogenetics and neural transcription factors o Neural electrical & chemical transmission and psychopharmacology o Brain metabolism o Neural oscillations o Neuroplasticity (Learning & Neurodevelopment) o Neuropathology • To know and understand neural mechanisms of major cognitive brain functions, such as Vison, Audition, Sensori-Motor control, Memory, Communication, Attention & Consciousness. • To know and understand techniques and methods commonly used within neuroscience, including o Neuroimaging methods: § (functional) Magnetic Resonance Imaging (MRI/fMRI) § Electroencephalography (EEG) § Near-infrared spectroscopy (NIRS) § Magnetic Resonance Spectroscopy o Neurogenomics and –transcriptomics o Neural Modulation (Optogenetics, Psychopharmacology, various Brain Stimulation methods) o Connectomics and Graph theoretical analysis o Brain-Computer Interfaces • To be able to apply these techniques to neuroscience themes discussed in the course • To be able to evaluate the possibilities & limitations and pros & cons of the different techniques in relation to the considered research. • To be able to describe how multiple types of neuroscientific data can be integrated to gain deeper insights in neural mechanisms across brain scales • To be able to design a neuroscientific experiment • To be able to apply their knowledge to review the scientific quality of neuroscientific papers

Recommended reading

During this course, we will make use of study books, scientific papers, and dedicated study guides.
MSB1009
Period 5
5 Apr 2021
4 Jun 2021
Print course description
ECTS credits:
6.0
Coordinator:

- J.C. Peters

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Faculty of Science and Engineering

Modeling Metabolism

Full course description

The eight-week course is divided into two main parts, covering (i) kinetic modelling of physiological and biochemical systems using ordinary differential equations and (ii) genome-scale metabolic modelling of intracellular metabolism using constraint-based modelling methods such as flux balance analysis.

In the first part, students will learn to build kinetic models of biochemical reactions using massaction and enzyme kinetics as well as to build whole-body physiological models (e.g. for plasma glucose control). Furthermore, a focus will be on model fitting, parameter estimation, and sensitivity analysis. The second part of the course covers the reconstruction of genome-scale metabolic models (GEMs), as well as different approaches to study steady-state reaction flux distributions through these networks; with an emphasis on applications to human metabolism.

The hands-on part of the course will focus on the implementation of the acquired theoretical knowledge in Matlab, including the use of ODE solvers, optimization methods, and the COBRA toolbox for constraint-based reconstruction and analysis of genome-scale metabolic models.

Course objectives

During this course, students will learn theoretical concepts of and gain practical experience with metabolic modelling approaches using Matlab. The focus will be both on kinetic and constraint-based (genome-scale) metabolic models. Furthermore, students will learn to understand and interpret recent research articles in the field.

Recommended reading

Suggested textbooks:

- Klipp, Liebermeister, Wierling, Kowald: ‘Systems Biology’, Wiley-VCH, 2016, ISBN: 9783527336364;

- Palsson: ‘Systems Biology: Constraint-based Reconstruction and Analysis’, Cambridge University Press, 2015, ISBN: 9781107038851

In addition, several papers of recent research topics in metabolic modelling will be discussed in dedicated journal club sessions

MSB1010
Period 5
5 Apr 2021
4 Jun 2021
Print course description
ECTS credits:
6.0
Coordinator:

- M. Breuer

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Faculty of Science and Engineering

Machine Learning and Multivariate Statistics

Full course description

The course will be run over eight weeks. The first six will include lectures, practicals and journal clubs in which students will be introduced to: week 1) the basic concepts in machine learning (e.g. feature extraction, feature selection, training testing and evaluation); week 2) classification (e.g. Naïve Bayes, Logistic Regression and Support Vector Machines); week 3) multivariate regression (e.g. Ridge Regression) and modelling of neural response data; week 4) bio-inspired machine learning approaches including (deep) neuronal networks and evolutionary computation; week 5) advanced concepts in feature selection (e.g. bagging); week 6) unsupervised learning. In the last two weeks the students will be given a data set on which they will have to apply the concepts they have previously acquired by implementing a classification/regression/clustering analysis pipeline.

Course objectives

To introduce students to the basic and advanced concepts of machine learning and multivariate statistics. The course will introduce supervised (classification and regression) and unsupervised (clustering) learning

Recommended reading

Pattern Classification – R.O. Duda, P.E. Hart, D.G. Stork; John Wiley & Sons (2012) Various articles for the Journal clubs will be selected by the tutors
MSB1011
Period 5
5 Apr 2021
4 Jun 2021
Print course description
ECTS credits:
6.0
Coordinators:

- F. de Martino
- R. Cavill

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Participation, Assignment, Final paper
Faculty of Science and Engineering

Computational Neuroscience

Full course description

The human brain is a highly sophisticated biological information processor exhibiting complex dynamics at several spatial and temporal scales. It is not surprising therefore that understanding the brain requires the development of theoretical constructs and mathematical models to interpret and predict empirical findings. In this course, you will learn about such models at the micro-, meso-, and macrolevel, how they capture essential features of neural dynamics, how simulating them can lead to new insights, and how they relate to empirical data. You will get an overview of computational neuroscience, from neuron models to models of the whole brain. During skill training sessions you will be able to consolidate your understanding of core concepts through computer exercises. Finally, you will be able to apply knowledge in a direct hands-on manner by designing and conducting your own computer simulation study. For the skills, you will have weekly peer group meetings to advance your research project (on which you will have to write a final report) by discussing your plans and your progress with your peers and the instructors. During these sessions, you will have to give short presentations wherein you need to review the relevant literature behind your research question, propose a project, update on your progress, and provide an overview of your findings.

Course objectives

The learning objectives of this course are: • To know and understand theoretical/mathematical models of neural processes at the microlevel (cellular), mesolevel (local circuits, neural populations), and macrolevel (large-scale brain networks, network integration). • To be able to simulate these models using tools and programming languages such as o NEURON o NEST o MATLAB o Python • To know and understand how these models are evaluated against as well as informed by empirical data. • To know and understand how these models are used as an investigative tool for neuroscientific themes discussed in the course • To be able to evaluate the possibilities & limitations of the different models in the context of a specific research question. • To be able to design and execute a simulation study addressing a neuroscientific research question. • To be able to apply their knowledge to review the scientific quality of neuroscientific papers.

Recommended reading

The literature of this course will largely comprise of scientific articles. For a review of fundamental concepts we recommend the book: Gerstner, W., & Kistler, W. M. (2002). Spiking Neuron Models: Single Neurons, Populations, Plasticity. Cambridge University Press.
MSB1013
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Coordinator:

- M. Senden

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Faculty of Science and Engineering

Network Biology

Full course description

We are surrounded by complex systems and their understanding, mathematical description, and interpretation are major challenges of the 21st century. In this course, students will be introduced into the world of networks and their application in the analysis of biomedical data. A human body consists of more than 37 billion cells and our existence depends on the harmonious interaction between thousands of genes, proteins and metabolites within our cells. Networks are the ideal tool to capture, explore and evaluate these interactions. The course covers both the fundamental graph theory concepts and their application in network biology. After completing this course, the student is able to analyse biomedical research data using network science approaches. Additionally, the student will be aware of best practises in network visualisation to facilitate interpretation and communication of research results. In the skills training, held in the computer rooms, the students will apply the topics discussed in the lectures and tutorials. The content of the training will be directly linked to tutorials. Importantly, in the final project the students will apply the acquired skills to answer their biological research question.

Course objectives

1. Understanding basic concepts of graph theory and network science 2. Understanding and applying of network algorithms to investigate network properties 3. Using and evaluating online resources for biological network data 4. Performing analyses with biomedical research data using network science approaches 5. Learning how to use Cytoscape to analyse, visualise and interpret biological networks 6. Creating intuitive visualisation for network interpretation

Recommended reading

1. Network Science Book, Albert-László Barabási http://barabasi.com/networksciencebook/ 2. Relevant papers will be provided during the course
MSB1014
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Coordinators:

- S.L.M. Steinbusch - Coort
- M. Summer - Kutmon

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Faculty of Science and Engineering

Scientific Programming

Full course description

Scientific programming is quite like performing a wetlab experiment: there is a research question, an experimental design, materials, and results. Of course, one important difference is once you run your experiment once, repeating the experiment becomes a lot easier. This course assumes programming experience and covers various aspects of using scientific programming for development of software to answer biological questions. During this course the students will using professional software development standards and values for research integrity, particularly around reproducibility. Regarding algorithm development, the course focuses on programming approaches like parallel computing,

client-server communication, and automating statistical analysis using
interactive notebooks.

Course objectives

1. Create software to implement an algorithm answering a biological question
2. Learn about parallel computing
3. Learn about server-client interaction
4. Learn about making multivariate statistics reproducible
5. Apply version control in software development
6. Explain algorithms and implementations in software in appropriate documentation

MSB1015
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Coordinator:

- A.M. Blanchet - Smolinska

Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Commercialization and Entrepreneurship

Full course description

A key role of corporate R & D is to investigate novel products and technologies and translate these into new business. In the case of biobased materials, the transition towards increased sustainability and green technology can trigger new business development. Imagining how a novel product or technology can lead to new business is an inherently creative process that should also be mastered by scientists. In this course the focus lies on developing important competences in the process of business development: 1) discovering opportunities and 2) developing business concepts.

Important characteristics for a scientist in developing business opportunities are creativity and persistence. These are important in problem solving during the process of business development.

In this course your entrepreneurship competences will be tested, and where possible improved. You will have to actively participate and take a creative attitude. A business model will have to be made, using all the information and help you can obtain during this course from the experts.

Course objectives

- To understand how science and technology can be transferred from the lab to start-ups and established companies

Systems Biology

- To create a detailed understanding of science and technology commercialization modes: licensing, spin-offs, spinning out, new business development
- To understand the process and regulations concerning intellectual property, patenting and licensing, etc.
- To create and foster a entrepreneurial spirit

MSB1017
Period 1
1 Sep 2020
23 Oct 2020
Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinator:

- R.J.C.M. Delissen

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment, Written exam
Projects

Projects Master Systems Biology

Faculty of Science and Engineering

Research project 1

Full course description

The project period is based on research based learning (RBL). In RBL, you are challenged with a real-life problem and have to come up with a creative solution. You have to embrace the project, make it your own, and take responsibility in order to make it a worthwhile learning experience. In addition, you should experience that research is challenging, sometimes a bit frustrating, but above all fun. This way of working is very challenging, but it also offers opportunity to learn teamwork by sharing responsibilities, which is important for your future career. Furthermore, in the projects you have to use all knowledge and skills you gathered in the programme up to that point. Only when you work together, you can truly excel. That is, you can propose and execute a project that surpasses the regular master level. Innovation and creativity are important, as well as solid scientific method and proper argumentation and discussion. The success of the project depends on your enthusiasm and motivation.

PRO4002
Period 3
4 Jan 2021
29 Jan 2021
Print course description
ECTS credits:

Systems Biology

6.0
Instruction language:
English
Coordinator:

- A.J. Isaacs

Faculty of Science and Engineering

Research project 2

Full course description

The project period is based on research based learning (RBL). In RBL, you are challenged with a real-life problem and have to come up with a creative solution. You have to embrace the project, make it your own, and take responsibility in order to make it a worthwhile learning experience. In addition, you should experience that research is challenging, sometimes a bit frustrating, but above all fun. This way of working is very challenging, but it also offers opportunity to learn teamwork by sharing responsibilities, which is important for your future career. Furthermore, in the projects you have to use all knowledge and skills you gathered in the programme up to that point. Only when you work together, you can truly excel. That is, you can propose and execute a project that surpasses the regular master level. Innovation and creativity are important, as well as solid scientific method and proper argumentation and discussion. The success of the project depends on your enthusiasm and motivation.

PRO4003
Period 6
7 Jun 2021
2 Jul 2021
Print course description
ECTS credits:
6.0
Instruction language:
English
Coordinators:

- I. Zulfiqar
- M.M.L. Moerel

Teaching methods:
Lecture(s), PBL
Assessment methods:
Attendance, Assignment
Thesis

Thesis Research Master Systems Biology

Faculty of Science and Engineering

Master Thesis Systems Biology

Full course description

The curriculum of the UM master Systems Biology culminates in the master thesis research project. This part of the curriculum is a final proof-of-capability for the master students. It allows the students to demonstrate that they have gained sufficient knowledge, competences and skills to do independent scientific research.

Thesis projects can be carried out under supervision of staff of the MaCSBio, UM research groups, at other faculties, universities, research institutes or companies in the Netherlands or abroad. Irrespective of the internship location or organization, the topic of the thesis should be scientific and directly related to the field of systems biology. The master thesis is concluded with the written master thesis report and an in depth defense of the conducted research, its results and conclusions.

Description of skills training during the course

Ideally, the thesis project allows students to integrate all knowledge, competences and skills they have gained throughout the master programme and their academic career.

Course objectives

The master thesis is an individual research project in which the students should be able to:

1. demonstrate the ability to plan and perform an individual high-level scientific research project in the field of systems biology;
2. work in a research team and communicate with the members of this team while performing the master thesis;
3. solve the scientific problems that are encountered during the master thesis research;
4. write and defend the master thesis research describing the results, conclusions and the relevance of the conducted research.

MSB5000
Semester 2
1 Feb 2021
3 Jul 2021
Print course description
ECTS credits:
48.0
Coordinator:

- M.M.L. Moerel