MSP Course Catalogue 2022-2023

Disclaimer

The course and skills descriptions provided herein are for the guidance of (prospective) students of the Maastricht Science Programme (MSP) and every effort is made to ensure their accuracy. However, the MSP reserves the right to make variations to the content and pre- and co-requisites, to discontinue courses and to merge or combine courses without prior notice.

Overview of Courses and Skills for the Academic Year 2022-2023 (Version April 2022)

	Biology	Chemistry	Physics	Mathematics and Computer Sciences #	Interdisciplinary
Core Courses	**BIO1101** Introduction to Biology (P2 & P5)	**CHE1101** Introduction to Chemistry (P1 & P4)	**PHY1101** Introduction to Physics (P1 & P4)		**INT1101** Introduction to Liberal Arts and Sciences (P2 & P5)
1000 Level Courses				**MAT1006** Applied Statistics (P2 & P4)	**INT1003** Introduction to Biomedical Engineering (P4)
				MAT1007 Mathematical Tools for Scientists (P5)	**INT1005** Commercializing Science and Technology (P5)
					INT1006 Sustainable Development (P2)
					INT1007 Introduction to Earth Sciences (P1 & P4)
					NEU1001 Introduction to Neuroscience (P4)
					NEU1002 Cognitive Neurosiences: Biological Foundations of Behavior (P5)
2000 Level Courses	**BIO2001** Cell Biology (P1 & P4)	**CHE2001** Organic Chemistry (P1 & P4)	**PHY2001** Classical Mechanics (P5)	**MAT2002** Optimization (P1)	**INT2007** Science in Action (P2)•
	BIO2002 Ecology (P5)	**CHE2002** Inorganic Chemistry (P1)	**PHY2002** Thermodynamics and Statistical Physics (P4)	**MAT2004** Linear Algebra (P5)	**INT2008** Molecular Toxicology (P4)
	BIO2003 General Botany (P4)	**CHE2003** Physical Chemistry (P1)	**PHY2003** Vibrations and Waves (P1)	**MAT2005** Statistics (P5)	**INT2009** Biophysics (P4)
	BIO2004 General Zoology (P1)	**CHE2004** Spectroscopy (P1)	**PHY2004** Electromagnetism (P4)	**MAT2006** Calculus (P4)	**INT2010** Principles of Mass Spectrometry (P4)
	BIO2005 Evolutionary Biology (P4)	**CHE2006** Biochemistry (P2)	**PHY2005** Quantum Theory (P5)	**MAT2007** Introduction to Programming (P1)	**NEU2001** Cognitive Neurosciences: Perception (P2)
	BIO2007 Genetics (P1 & P4)	**CHE2007** Solid State Chemistry (P5)	**PHY2006** Electronics (P1)	**MAT2008** Differential Equations (P4)	**NEU2002** Neuropsychopharmacology (P5)
	BIO2008 Great Transformations in Vertebrate Evolution (P2)	**CHE2008** Main-Group Element Chemistry (P2)	**PHY2007** Optics (P2)	**MAT2009** Multivariable Calculus (P2)	
	BIO2010 Human Anatomy and Physiology (P4)		**PHY2008** Solar System Astronomy (P4)		
			PHY2009 Stellar Astronomy (P1)		
			PHY2010 Galactic Astronomy (P2)		
3000 Level Courses	**BIO3001** Molecular Biology (P2 & P5)	**CHE3001** Organic Reactions (P2)	**PHY3001** Quantum Mechanics (P1)		**INT3001** The Philosophy of Technology (P1)•
	BIO3002** Ecophysiology (P2) */ *Offered once every other year.* *Not offered in 22/23.*	**CHE3002** Transition Metal Chemistry (P5)	**PHY3002** Theory of Relativity (P2)		**INT3002** Advanced Microscopy: Theory and Applications (P1)
	BIO3003 Microbiology (P5)	*CHE3004 Modern Catalytic Chemistry (P2) *** *Offered once every other year, not 2022-2023*	**PHY3004** Elementary Particle Physics (P2)		**INT3003** Biomaterials (P4)
	BIO3004 Animal Behavior (P5)	**CHE3006** Quantum Chemistry (P5)	**PHY3005** Relativistic Electrodynamics (P4)		**INT3005** Biobased Materials and Technology (P2)
					INT3007 Systems Biology (P2)
	BIO3007 Tropical Ecology (P2)	**CHE3007** Advanced Physical Chemistry (P2)	**PHY3006** General Relativity (P5)		**INT3008** Regenerative Medicine (P4)
	BIO3008 Hominin Paleontology (P5)	**CHE3008** Analytical Science and Technology (P1)	**PHY3007** Advanced Mathematical Techniques of Physics (P1)		***INT3009** Chemical Ecology (P2) *** *Offered once every other year*
	BIO3010 Genomics and Proteomics (P4)	**CHE3009** Crystallography (P4)	**PHY3008** Cosmology (P4)		**INT3010** Science and the Visual Arts (P4)
					NEU3001 Neuroscience of Action (P1)

Overview of Courses and Skills for the Academic Year 2022-2023 (Version April 2022)

	Biology	Chemistry	Physics	Mathematics and Computer Sciences #	Interdisciplinary
Core Skills					**PRA1101** Introduction to Scientific Research I (P1 & P4)
					PRA1102 Introduction to Scientific Research II (P2 & P5)
1000 Level Skills			**PRA1003** Basic Physics Laboratory (P2 & P5)		**PRA1005** Data Collection Techniques in the Neurosciences (P4)
2000 Level Skills	**PRA2009** Field Skills in Biology (P5)	**PRA2002** Chemical Synthesis (P1 & P4)	**PRA2006** Electronics Lab (P1)	**PRA2003** Programming (P2)	**PRA2005** Advanced Molecular Laboratory Skills (P4)
	PRA2011 Exploring the World of Plants (P4)	**PRA2004** Inorganic Synthesis (P1)	**PRA2007** Physics Laboratory (P5)		**PRA2010** Synthetic Biology (P2)
	PRA2013 Practical Zoology (P2)	**PRA2008** Physical Chemistry (P4)	**PRA2023** Astronomical Observing Techniques (P5)		**PRA2015** Advanced Academic Skills (P1)
	PRA2014 Genetics (P1 & P4)	**PRA2021** Historical Pigments Synthesis (P5)			**PRA2017** NanoBiology (P1)
					PRA2018 Capita Selecta in Life Sciences (P2)
					PRA2019 Natural Science Illustration (P4)
					PRA2020 Practical Mass Spectrometry (P5)
					PRA2022 Integrated Assessment Modelling of Climate Change (P4)
					PRA2024 Geology (P5)
3000 Level Skills	**PRA3003** Molecular Biology (P2 & P5)	**PRA3001** Advanced Organic Synthesis (P2)	**PRA3002** Advanced Physics Laboratory (P2)	**PRA3021** Topics in Scientific Computing (P1)	**PRA3005** Polymer Processing (P2)
	PRA3010 Microbiology (P5)	**PRA3008** Transition Metal Chemistry (P5)	**PRA3012** Advanced Electronics (P4)		**PRA3006** Programming in the Life Sciences (P2)
	PRA3011 The Limburg Landscape (P5)	**PRA3014** Spectroscopic Methods (P4)	**PRA3024** Analysis of Big Data in Physics (P4)		**PRA3022** iGem Project (P1)
	PRA3017 Applied Cell Biology (P4)	**PRA3018** Molecular Modelling (P1)			***PRA3504*** *The Academic Life Cycle (P5) ** Offered once every other year*
	PRA3023 Plant Physiology and Microbiomes (P2)	**PRA3020** Analytical Chemistry in the Art World (P4)			
	PRA3503 Microbiome Analysis (P1)				

** Not offered in 2022-2023*

*** Offered once every other year*

All courses are 5 ECTS All skills are 2.5 ECTS

● *Note: this course fulfils the LAS topic requirement   #all MAT courses fulfil the MAT requirement*

ACADEMIC YEAR 2022-2023 - FALL SEMESTER

	Period 1		Period 2	
	Courses	**Skills**	**Courses**	**Skills**
Biology	BIO2001 Cell Biology	PRA2014 Genetics	BIO1101 Introduction to Biology	PRA2013 Practical Zoology
	BIO2004 General Zoology	PRA3503 Microbiome Analysis	BIO2008 Great Transformations in Vertebrate Evolution	PRA3003 Molecular Biology
	BIO2007 Genetics		BIO3001 Molecular Biology	PRA3023 Plant Physiology and Microbiomes
			BIO3007 Tropical Ecology	
Chemistry	CHE1101 Introduction to Chemistry	PRA2002 Chemical Synthesis	CHE2006 Biochemistry	PRA3001 Advanced Organic Synthesis
	CHE2001 Organic Chemistry	PRA2004 Inorganic Synthesis	CHE2008 Main-Group Element Chemistry	
	CHE2002 Inorganic Chemistry	PRA3018 Molecular Modelling	CHE3001 Organic Reactions	
	CHE2003 Physical Chemistry		CHE3007 Advanced Physical Chemistry	
	CHE2004 Spectroscopy			
	CHE3008 Analytical Science and Technology			
Physics	PHY1101 Introduction to Physics	PRA2006 Electronics Lab	PHY2007 Optics	PRA1003 Basic Physics Laboratory
	PHY2003 Vibrations and Waves		PHY2010 Galactic Astronomy	PRA3002 Advanced Physics Laboratory
	PHY2006 Electronics		PHY3002 Theory of Relativity	
	PHY2009 Stellar Astronomy		PHY3004 Elementary Particle Physics	
	PHY3001 Quantum Mechanics			
	PHY3007 Advanced Mathematical Techniques of Physics			
Mathematics & Computer Science	MAT2002 Optimization	PRA3021 Topics in Scientific Computing	MAT1006 Applied Statistics	PRA2003 Programming
	MAT2007 Introduction to Programming		MAT2009 Multivariable Calculus	
Interdisciplinary	INT1007 Introduction to Earth Sciences	PRA1101 Introduction to Scientific Research I	INT1101 Introduction to Liberal Arts and Sciences	PRA1102 Introduction to Scientific Research II
	INT3001 Philosophy of Technology	PRA2015 Advanced Academic Skills	INT1006 Sustainable Development	PRA2010 Synthetic Biology
	INT3002 Advanced Microscopy: Theory and Applications	PRA2017 NanoBiology	INT2007 Science in Action	PRA2018 Capita Selecta in Life Sciences
	NEU3001 Neuroscience of Action	PRA3022 iGem Project	INT3005 Biobased Materials and Technology	PRA3005 Polymer Processing
			INT3007 Systems Biology	PRA3006 Programming in the Life Sciences
			INT3009 Chemical Ecology	
			NEU2001 Cognitive Neurosciences: Perception	

ACADEMIC YEAR 2022-2023 - SPRING SEMESTER

	Period 4		Period 5	
	Courses	**Skills**	**Courses**	**Skills**
Biology	BIO2001 Cell Biology	PRA2011 Exploring the World of Plants	BIO1101 Introduction to Biology	PRA2009 Field Skills in Biology
	BIO2003 General Botany	PRA2014 Genetics	BIO2002 Ecology	PRA3003 Molecular Biology
	BIO2005 Evolutionary Biology	PRA3017 Applied Cell Biology	BIO3001 Molecular Biology	PRA3010 Microbiology
	BIO2007 Genetics		BIO3003 Microbiology	PRA3011 The Limburg Landscape
	BIO2010 Human Anatomy and Physiology		BIO3004 Animal Behaviour	
	BIO3010 Genomics and Proteomics		BIO3008 Hominin Paleontology	
Chemistry	CHE1101 Introduction to Chemistry	PRA2002 Chemical Synthesis	CHE2007 Solid State Chemistry	PRA2021 Historical Pigment Synthesis
	CHE2001 Organic Chemistry	PRA2008 Physical Chemistry	CHE3002 Transition Metal Chemistry	PRA3008 Transition Metal Chemistry
	CHE3009 Crystallography	PRA3014 Spectroscopic Methods	CHE3006 Quantum Chemistry	
		PRA3020 Analytical Chemistry in the Art World		
Physics	PHY1101 Introduction to Physics	PRA3012 Advanced Electronics	PHY2001 Classical Mechanics	PRA1003 Basic Physics Laboratory
	PHY2002 Thermodynamics and Statistical Physics	PRA3024 Analysis of Big Data in Physics	PHY2005 Quantum Theory	PRA2007 Physics Laboratory
	PHY2004 Electromagnetism		PHY3006 General Relativity	PRA2023 Astronomical Observing Techniques
	PHY2008 Solar System Astronomy			
	PHY3005 Relativistic Electrodynamics			
	PHY3008 Cosmology			
Mathematics & Computer Science	MAT1006 Applied Statistics		MAT1007 Mathematical Tools for Scientists	
	MAT2006 Calculus		MAT2004 Linear Algebra	
	MAT2008 Differential Equations		MAT2005 Statistics	
Interdisciplinary	INT1003 Introduction to Biomedical Engineering	PRA1101 Introduction to Scientific Research I	INT1101 Introduction to Liberal Arts and Sciences	PRA1102 Introduction to Scientific Research II
	INT1007 Introduction to Earth Sciences	PRA1005 Data Collection Techniques in the Neurosciences	INT1005 Commercializing Science and Technology	PRA2020 Practical Mass Spectometry
	INT2008 Molecular Toxicology	PRA2005 Advanced Molecular Laboratory Skills	NEU1002 Cognitive Neurosciences: Biological Foundations of Behaviour	PRA2024 Geology
	INT2009 Biophysics	PRA2019 Natural Science Illustration	NEU2002 Neuropsychopharmacology	PRA3504 The Academic Life Cycle
	Int2010 Principles of Mass Spectrometry	PRA2022 Integrated Assessment Modelling of Climate Change		
	INT3003 Biomaterials			
	INT3008 Regenerative Medicine			
	INT3010 Science and the Visual Arts			
	NEU1001 Introduction to Neuroscience			

Contents

BIO1101 Introduction to Biology

Course coordinator
Dr. Martina Calore, Faculty of Health, Medicine and Life Sciences
Contact: m.calore@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ PRA1102 Introduction to Scientific Research II

Objectives
After this course, students should be able to:
- Apply basic knowledge of ecology, evolution, and molecular and organismal biology to discuss cutting-edge biological research and its impacts on society;
- Explain how the following six core biological concepts apply to the multiple scales of organization and time in biological systems: regulation, self-organization, evolution, inheritance, communication, and interaction;
- Do calculations relevant to biological concepts.

Description of the course
This course provides an overview of the major branches of biological sciences and the fundamental processes relevant to each. The major topic areas covered are ecology, evolution, cell and molecular biology, genetics, and organismal biology. For each topic, you will explore how the content connects to the central concepts of all biological sciences: regulation, self-organization, evolution, inheritance, communication, and interaction.

Literature
Taylor et al. (2021). Campbell Biology: Concepts & Connections (10th edition, global edition). Pearson.
ISBN10: 1-292-40134-6 ISBN13: 978-1-292-40134-8

Instructional format
One question and answer session and two PBL tutorials per week.

Assessment
Evaluation of student performance will be based on:
- Weekly homework assignments;
- Contribution to the discussion during tutorial meeting;
- A final exam at the end of the course.

BIO2001 Cell Biology

Course coordinators
Prof. dr. Martijn van Griensven and Dr Aart van Apeldoorn: Department cBITE, MERLN Institute for Technology-Inspired Regenerative Medicine; Faculty of Health, Medicine and Life Sciences.
Contact (Period 1): a.vanapeldoorn@maastrichtuniversity.nl
Contact (Period 4): m.vangriensven@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
- To present the structure of prokaryote (bacteria) and eukaryote cells (animal, plant, fungal);
- To comprehend the structure/function relationship of the plasma membrane;
- To understand the functions of cell organelles and sub-cellular structures;
- To deepen the knowledge about transport of material in- and out of the cell;
- To understand the principles of transport between the different cell organelles and how molecules and proteins are reliably transported to the different organelles;
- To create understanding of cell motility and how the cell controls its shape (cytoskeleton);
- To understand how the cell produces the energy it needs to function;
- To understand communication between the cell interior and exterior of the cell (cell signalling).

Description of the course
This course aims to develop a detailed understanding of the cell as the basic unit of life. The basic builtup of a cell including cell membrane composition, cytoplasm and organelles will be eluded. Furthermore, methods of visualisation of those will be discussed in detail. The cell can be seen as an organism that can perform a wide range of functions. In eukaryotes, these functions are linked to the different compartments/organelles in the cell: nucleus, mitochondria, chloroplasts, endoplasmatic reticulum, lysosomes, endosomes, *etc*. Proteins need to move into organelles through translocation and there is a continuous transport between the different organelles (intracellular vesicular transport) and between the cell interior and the extracellular environment (endocytosis and exocytosis). All of these cellular transport mechanisms will be studied in detail. Additionally, the cell contains intracellular structures that regulate shape, strength, and motility, *i.e.* the cytoskeleton. The cytoskeleton is a highly dynamic structure and the different components of the cytoskeleton (microtubules, F-actin, intermediate filaments) and their assembly and disassembly will be explained. And the cell needs energy from oxidative phosphorylation or photosynthesis to perform these functions. Finally the basic principles of signal transduction will be studied, *i.e.* how does the cell react to signals from the environment, how are these signals detected and how are these processed into a primary cellular response?

Literature
“Molecular Biology of the cell” 6th edition (2014). B. Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter; Garland Science: Taylor and Francis Group, New York, NY10017, USA (ISBN: 9780 8153 44643).

Instructional format
The course will be divided into tasks which will be introduced, explained, supplemented and discussed in the preceding lecture. There are five main lectures. A more detailed study will take place in tutorial groups using PBL.

Assessment
Evaluation of student performance will be based on:
- A written midterm exam;
- A final exam at the end of the course period (open book);
- A poster (period 4) or a presentation (period 1) made in a small group that will be presented in a public session at the end of the course

BIO2002 Ecology

Course coordinator

Dr. John Sloggett, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: j.sloggett@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To understand what ecology as a discipline encompasses and its relevance for humanity;
- To understand the different levels of organisation that ecology is studied at from the level of the organism up to the level of the entire planet, and how studies at these different levels interact;
- To understand concepts, theories, and evidence about the ecological processes that determine the distribution and abundance of organisms;
- To understand the impact that humans exert on natural processes and the ecological consequences of anthropogenic activity.

Description of the course

Ecology is the study of the interactions of organisms with each other and with the abiotic environment. It covers many levels, including individuals, populations, communities and ecosystems. In this course we will examine the ecological patterns and processes that operate at these various levels and how they interact. Particular focus will be placed on the role that humankind plays in ecology today and on how factors such as deforestation, eutrophication and invasive species have affected natural systems.

Literature

Smith, T.M. & Smith, R.L. *Elements of Ecology*, most recent edition (details closer to course).

Instructional format

One lecture plus two tutorials per week.

Assessment

- Tutorial grade (if tutorials in person);
- Video;
- Exam.

BIO2003 General Botany

Course coordinator
Dr. Roy Erkens: Faculty of Science and Engineering, Maastricht Science Programme

Contact: roy.erkens@maastrichtuniversity.nl.

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
During this course, you will gain insight in the importance of plants for life on earth and the unique adaptations that plants have. The course will illustrate major aspects of plant form, function and development, and the evolution of the major plant groups.

Description of the course
Plants are a vital part of anyone's life. However, many people suffer from plant blindness: the inability to notice the plants in one's own environment. This blindness can lead to the inability to recognize the importance of plants in the biosphere, and in human affairs. However, it also leads to a lower appreciationof the aesthetic and unique biological features of the life forms belonging to the Plant Kingdom. Finally,the blindness contributes to the misguided and anthropocentric ranking of plants as inferior to animals.This course is designed to show the general importance of plants and illustrate their unique adaptations.Topics that will be covered are divided into two main categories: plant structure, and plant physiology and development. Topics of plant structure include: growth and division of cells, primary growth of stems(the herbaceous plant), leaves, roots, secondary growth (the woody plant), and flowers and reproduction. Plant physiology and development will include plants and energy (e.g. photosynthesis, respiration), nutrition and transport in plants (soils, mineral uptake and water flows), and plant growth and development.

Literature
Botany, an introduction to plant biology. J.D. Mauseth, 7th ed. 2021. Jones & Bartlett Learning. ISBN: 978-1-284-15735-2

Instructional format
You will have two 1½h (standing) PBL tutorials per week followed by an interactive lecture to revise the study material. Also, you will do a group poster assignment and two self-reflections and peer-reviews, and built a botanical portfolio.

Assessment
The assessments will include:
- Group poster on a plant division;
- Two peer review grades;
- Self-reflections;
- An individual botanical portfolio.

BIO2004 General Zoology

Course coordinator
Dr. John Sloggett: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: j.sloggett@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
- To characterise the defining biological features of the animal kingdom;
- To provide an overview of the characteristics of the major animal groups;
- To explain the systematics and phylogenetics of major groups within the animal kingdom;
- To place the morphological, anatomical and behavioural aspects of animal groups in an evolutionary context;
- To examine in more detail particular biological adaptations using specific animal groups as examples.

Description of the course
Animals are everywhere, on land, in water and in the air. They comprise an extremely diverse kingdom, with all species being a mixture of shared and unique biological characteristics. These characteristics area product of evolutionary history and adaptation to particular features of the abiotic and biotic environment. In this course you will focus on the major groups within the animal kingdom, what definesthem, how they are organised and how they are related to each other; you will also examine the specificadaptations of certain animals in more depth. The question "What is an animal?" will be considered as will the issue of how animals are grouped and related to each other. This will be done in the context of the major phyla, their defining morphological, anatomical and physiological features and the sorts of adaptations and behaviours that they exhibit. You will also examine certain adaptations such as bright colouration, feeding or parental care in greater depth, using particular animal groups as a source of examples.

Literature
Miller, S.A & Tupper, T.A. *Zoology*, most recent edition (more details closer to course).

Instructional format
One lecture, one PBL tutorial, one interactive lecture/tutorial.

Assessment
- Poster;
- Exam.

BIO2005 Evolutionary Biology

Course coordinator
Dr. Linnea van Griethuijsen, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: l.vangriethuijsen@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Recommended
- ✓ BIO2007 Genetics

Objectives
During this course you will gain insight in the most important patterns and processes of evolution. Furthermore, you will be able to explain and illustrate the synthetic character of evolutionary theory with examples (i.e. you understand and can explain why evolutionary theory is a unifying concept for all biological sciences and an important foundation for the "human sciences" of medicine, psychology and sociology).

Description of the course
Evolution is the most important principle in biology. It is the only scientific biologically theory that unifiesall phenomena of life from the level of (macro)molecules to ecosystems. Ever since the Modern Synthesisearly last century (when Darwin's insights were combined with modern genetics), evolutionary researchhas expanded enormously. Subsequent developments – the birth of molecular biology, the ever increasing power of computers and the development of phylogenetics - have led to an enormous increasein our understanding of the processes and patterns of evolution. This course emphasizes the general principles of evolution, the hypotheses on the causes of evolutionary change (relevant for most organisms), and the large patterns which are visible in the history of the earth. This course is an excellentopportunity to obtain a base in evolutionary knowledge, regardless of the field you will work in (biologyor elsewhere).
The course zooms in from macro-evolutionary patterns to micro-evolutionary processes. You will look at the geological and paleontological history of the earth and how biologists use phylogeny to reconstruct deep past (the tree of life) using genetic data. A fundamental unit within biology is the species and therefore also theories of species and speciation will be discussed. Furthermore, how random changes in populations (genetic drift) and natural selection influence evolution will be investigated using simulation models. In relation to this you will look beyond alleles into quantitative genetics and the evolution of phenotypes, and also at the process of adaptation. Finally, evolution is used to 1) explain life history characters (e.g. how many children does an organism produce) and obtain a different view on human medicine, and 2) understand co-evolution between species.

Literature
- Evolution, making sense of life. C. Zimmer and D.J. Emlen, 3rd ed. 2019. W.H.Freeman & Co Ltd.;
- One module of Simbio's evobeaker package (http://simbio.com/products-college/EvoBeaker) for evolutionary simulations (will be provided by MSP).

Instructional format
Interactive lecture followed by two tutorials per week. Also, you will do a PechaKucha presentation and a computer simulation on natural selection.

Assessment
Three grades will be awarded during this course:
- MC questions of the simulation assignment;
- PechaKucha presentation;
- Final exam.

BIO2007 Genetics

Course coordinator
Prof. dr. Leon de Windt, Department of Molecular Genetics (DMG), Faculty of Science and Engineering, Faculty of Health, Medicine and Life Sciences, Maastricht University.
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Pre-requisites
- ✓ BIO2001 Cell Biology

Co-requisites
- ✓ None

Objectives
- To understand the chemical structure of DNA and the molecular mechanisms of DNA replication.
- To get familiar with the basic principles how information that is stored in genes is converted to a (cellular) phenotype in the form of RNA and protein.
- To get familiar with the mechanisms how eukaryotes extract information from their genome and how mutations impact phenotypes.
- To understand the molecular basis of single gene inheritance (Mendel's first law), sex-linked single gene inheritance and to interpret human pedigrees.
- To apply DNA sequencing technologies and interpret the results.
- To have sufficient background for advanced courses in biochemistry and the life sciences.

Description of the course
The course discusses the principles of genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms, including humans. The topics include: structure and function of genes; chromosomes and genomes; biological variation resulting from replication and recombination, mutation and selection; DNA repair and the genetic basis of disease inheritance.

Literature
"Introduction to Genetic Analysis" by Griffiths, Wessler, Carrol, Doebley (Palgrave Macmillan, 12th edition, 2020. ISBN-13: 9781319114770).

Instructional format
Lectures and tutorial group meetings.

Assessment
- A group presentation on a paper related to the course's topics to be delivered at the end of the course;
- A final theoretical examination on all lectures and theoretical content of BIO2007 consists of ± 30 questions of which about half in multiple-choice format and half as open questions;
- A final evaluation on tutorial attendance and active participation.

BIO2008 Great Transformations in Vertebrate Evolution

Course coordinator

Prof. Dr. Leon Claessens, Faculty of Science and Engineering, Maastricht Science Programme.

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Pre-requisites

- ✓ BIO2004 General Zoology or BIO2005 Evolutionary Biology

Co-requisites

- ✓ None

Objectives

In this course you will gain insight into evolutionary change over geological time, focusing on our own biological lineage, the vertebrates. You will gain a broader understanding of vertebrate paleontology, phylogeny, biomechanics and physiology. You will learn how to contextualize, examine and explain biological and evolutionary processes in deep time.

Description of the course

An exploration of vertebrate evolution and paleobiology, with emphasis on the anatomical and physiological transformations that occurred at the evolutionary originations of major vertebrate groups. Structure and function of both extant and extinct taxa are explored, as documented by modern fauna and the fossil record. Topics studied include locomotion and the origin of fins and limbs, the transition from water to land, dinosaur physiology, the origin of flight, and mammalian reproduction.

Literature

- Benton, M.J. (2014). Vertebrate Palaeontology. 4th Ed. Wiley-Blackwell. ISBN: 1118406842;
- Select scientific articles; access through the UM library.

Instructional format

One lecture and two tutorials per week.

Assessment

- Midterm and final examination;
- Contribution to tutorial group meetings;
- Tutorial exercises and tutorial project.

BIO2010 Human Anatomy and Physiology

Course coordinator
Aaron Isaacs, Faculty of Health, Medicine and Life Sciences, CARIM, Department of Physiology.

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Pre-requisites
- ✓ None (basic knowledge of biology, including cell biology, would be helpful)

Co-requisites
- ✓ None

Objectives
- To understand membrane and electrophysiology, particularly in the heart;
- To elucidate the structure and function of the cardiovascular system;
- To describe blood pressure and gas homeostasis and the role of hormonal and neurological control in regulating them;
- To describe the systems involved in energy balance and volume control;
- To investigate the interplay between organs (and systems) to better comprehend the function of humans as complete organisms.

Description of the course
BIO2010 focuses on the structure (anatomy) and function (physiology) of some of the major systems in the human body. As structure and function are closely interrelated, with function often following from form, this course seeks to illuminate the interplay between these two disciplines and how they relate to individual organ systems (as well as the interactions between them).

The course starts with a brief recap of the smallest living subunit of the human body – the cell – and subsequently delves into some of the different organ networks of the body, including the cardiovascular, respiratory, renal, endocrine, nervous (particularly autonomic), and gastro-intestinal systems. Finally, those disparate complexes will be integrated at the level of the complete human organism.

A central feature of the course will be "homeostasis", that is "the processes by which the body reacts to changes in order to keep conditions inside the body, for example temperature, the same". As this course is too short to elaborate on all aspects of anatomy and physiology, particular attention is paid to the cardiovascular system. This is especially relevant as the circulatory network is involved in many aspects of homeostatic regulation.

The course will provide a foundation for those who pursue a(n) (academic) career in Life Sciences, Biometrics, Biomaterials, Biochemistry, or Medicine.

Literature
Online library accessmedicine.mhmedical.com. Several books will be of use, including Guyton and Hall (Textbook of Medical Physiology), Marieb and Hoehn (Human Anatomy and Physiology), Ganong (Review of Medical Physiology) and Silverthorn (Human Physiology: An Integrated Approach).

Instructional format
Lectures and tutorials.

Assessment
- Professional Conduct;
- Collaboration;
- Oral presentation;
- Written Test.

BIO3001 Molecular Biology

Course coordinator
Dr. Paula da Costa Martins, Faculty of Health, Medicine and Life Sciences, Maastricht University.
Contact: p.dacostamartins@maastrichtuniversity.nl

Pre-requisites
- ✓ BIO2001 Cell Biology
- ✓ BIO2007 Genetics

Co-requisites
- ✓ None

Objectives
- To get acquainted with the best-characterized cell signaling mechanisms in eukaryotic cells;
- To understand gene structure/function and different gene regulatory mechanisms (chromatin remodeling and (post)transcriptional regulation) in prokaryotes and eukaryotes;
- To understand how molecular biology, when used in combination with other biological disciplines (e.g. biochemistry, genetics, imaging), can provide tools to understand (diagnostics) and intervene (therapy) in the cellular complexity of human disease.

Description of the course
The general aim of this course is to obtain detailed knowledge about the molecular processes in cell signaling and control of gene expression. Topics include intracellular signaling pathways; chromatin structure and remodeling; recruitment and assembly of transcription factors; eukaryote mRNA synthesis, processing, modification, stability and translation; stem cells and reprogramming; and the culmination of the above factors that drive common complex human disease. The tutorials will be partially in Problem Based Learning (PBL) and multiple-choice format, with exercises designed to provide a perspective of how cutting edge molecular biological techniques are applied to tackle major research questions in modern biomedical research.

Literature
Recommended literature source are:
- "Molecular Cell Biology" by Lodish, Berk, Kaiser (W.H. Freeman, 8thedition, 2016);
- "Introduction to Genetic Analysis" by Griffiths, Wessler, Carrol, Doebley (W.H. Freeman, 10thedition, International Edition, 2012);
- "Molecular biology of the Cell" by Alberts et al. Additional literature will be provided as a reader.

Instructional format
The course will be given throughout 12 tutorial sessions, all onsite. Any exceptions need to be discussed and agreed upon with the course coordinator.Every week starts with an expert lecture on the respective topic, prior to the pre-discussion. Every tutorial will have a chairperson and a scribe appointed so that every student gets to perform in one of these roles.
Pre-discussions will be done on the whiteboard, post-discussions can be flexible (white board or google doc).

Assessment
The course will be assessed at the end through a final exam and an oral presentation. The final exam accounts for 70% of the final grade. The oral presentation is a group grade, resulting from a group essay and respective presentation and discussion. Every student in one group will have the same grade, unless there are problems in the group's dynamic and which should always be discussed with the coordinator of the course. The presentation grade accounts for 30% of the final grade.

BIO3002 Ecophysiology

PLEASE NOTE: This course only runs in alternate years (odd), alternating with INT3009 Chemical Ecology (even). It will run in academic year 2023-2024 but not in 2022-2023.

Course coordinator

Dr. John Sloggett: Faculty of Science and Engineering, Maastricht Science Programme

Contact: j.sloggett@maastrichtuniversity.nl

Pre-requisites

- ✓ BIO2001 Cell Biology

Co-requisites

- ✓ None

Recommended

- ✓ BIO2004 General Zoology

Objectives

- To understand what ecophysiology is and the role in plays in an academic and applied context;
- To gain a basic knowledge of the physiology of certain non-human organismic groups;
- To understand in detail the characteristics of different abiotic environments that impose strong adaptive pressures on organismal physiology;
- To understand specific direct physiological adaptations evolved in response to these environmental pressures;
- To gain an insight into physiological adaptations to the biotic environment;
- To understand the principle of convergent evolution and how different groups may have evolved different physiological solutions to the same evolutionary pressures.

Description of the course

Ecophysiology is the study of physiological adaptations of organisms in relation to the environments in which they live. It has become an increasingly important science, because an understanding of the relationship between organism and environment is essential in order to predict the effects of man-made environmental change. The physiology of an organism incorporates many of its most important adaptations to the environment in which it lives. In this course you will consider the variety of environmental pressures imposed on organismal physiology. You will examine the often ingenious solutions that evolve in response to these pressures, and how different organisms and groups of organisms have evolved different physiological means of dealing with the same problem. The course will focus both on the abiotic environment (e.g. issues related to climate, gas exchange) and the biotic environment (e.g. how digestive physiology is adapted to plant toxins). Towards the end of the course you will look at Conservation Physiology, one of the practical applications of ecophysiology. There is a particular focus on the physiological adaptations of animals.

Literature

Scientific papers.

Instructional format

Lectures, tutorial sessions and seminar.

Assessment

- Tutorial grade;
- Group report on an ecophysiological subject;
- Final (open) exam.

BIO3003 Microbiology

Course coordinator
Frank Stassen, Faculty of Health, Medicine and Life Sciences.

Contact: f.stassen@maastrichtuniversity.nl

Pre-requisites
- ✓ BIO2001 Cell Biology
- ✓ BIO2007 Genetics

Co-requisites
- ✓ None

Objectives
- To obtain basic knowledge of medical microbiology, i.e. of bacteriology, virology and genetically modification of microorganisms;
- To study the characteristics of a selection of micro-organisms in relation to their related infectious diseases, more specific pathogenesis, epidemiology, diagnosis and therapy.

Description of the course
The 7 weeks course will start with two introduction lectures on Bacteriology and Virology. The general principles of replication, classification, metabolism and antibiotic resistance of bacteria as well as the presence of bacteria in several organ systems and the composition of the indigenous flora will be discussed in week 1. The general priciples of replication, classification and pathogenesis of viruses will be discussed in the introduction lecture of week 2. Several aspects of bacteriology and virology will be further discussed in the expert and tutorial group meetings, which will include topics as HIV, Tuberculosisand ESBL.
The knowledge you have obtained in the first two weeks will serve the basis for the following three weeks, where Infectious diseases, Outbreaks & resistance and Microbiological diagnostics will be discussed in the lectures as well as in the tutorial groups. In these topics, both the bacterial and viral aspects will be discussed.
The last part of this course will deal with genetically modified microorganisms, in which you gain inside in the purposes of modification and the tools that are available.

Literature
Murray. *Medical Microbiology*. (8^{th} ed.), Elsevier Mosby.

Instructional format
Lectures, expert meetings and tutorial group meetings.

Assessment
- A final examination, which consists of both MC and open questions;
- A PowerPoint presentation on a selected topic in microbiology;
- Active participation in the expert meetings and tutorial groups.

BIO3004 Animal Behaviour

Course coordinator
Dr. Linnea van Griethuijsen, Faculty of Science & Engineering, Maastricht Science Programme.

Contact: l.vangriethuijsen@maastrichtuniversity.nl

Pre-requisites
- ✓ BIO2004 General Zoology*
- ✓ BIO2005 Evolutionary biology

Co-requisites
- ✓ none

Objectives
- To gain an understanding of how animal behaviour is studied;
- To recognize ultimate and proximate causes of behaviour and understand how they are related;
- To understand what triggers behaviour and the importance of behaviour in an animal's chances of survival and reproductive success;
- To gain a general knowledge of the development of the field of animal behaviour and how it is linked to related fields such as neurobiology and behavioural ecology.

Description of the course
This course will introduce you to how behaviour of animals is studied and the (relatively young) historyof this field. We will look at the origins (ultimate cause) of behaviour; the function of behaviour in an animal's survival and reproduction, and how behaviours evolve over evolutionary time. In particular wewill study the evolution of altruism, reproductive behaviour and communication. We will also discuss how animals decide on foraging strategies, how they avoid predators,find suitable territories or decide to migrate. Behavioural research in zoo's and their role in species conservation will be discussed. Proximate causes of behaviour, what triggers behaviours and what is the role of ontogeny (organismal development), are also part of the course. Although the basisof behaviour lies in neurobiology and the brain, these will *not* be discussed in detail in this course. We will discuss the role of memory and learning in relation to animal behaviour.

* Students who have not done BIO2004 General Zoology, but with sufficient biology background *may* be able to take this course with a waiver. Contact the coordinator.

Literature
- Rubenstein and Alcock, J. (2019). *Animal Behavior* (11th international edition). Sinauer / Oxford University Press. (ISBN 9781605358949);
- Scientific articles which can be obtained online via UM library.

Instructional format
Lecture and 2 tutorials per week.

Assessment
- Final exam;
- Presentation;
- Animal behaviour video;
- Interaction with literature using an online tool.

BIO3007 Tropical ecology

Course coordinator
Dr. Roy Erkens: Faculty of Science and Engineering, Maastricht Science Programme
Contact: roy.erkens@maastrichtuniversity.nl

Pre-requisites
- ✓ BIO2002 Ecology

Objectives
Rain forests are perhaps the most interesting of all biomes in the popular imagination. However, rain forests on different continents have fundamentally different characteristics that make each of them unique. Also within continents, regions, or overall zones the differences might be quite large. In this course, you will get an overview of the characteristics and importance of tropical rain forests, study their history and think about their future.

Description of the course
Tropical forests are amongst the most species-rich biomes of the world. Yet, our understanding of their evolution, functioning and development are far from complete. There are three main tropical rainforest areas, the Neotropics (Central and South America), Africa and Asia, but for this course you will mainly focus on the Neotropics. You will look at what defines the tropical region, the differences and similarities between the three large blocks of rainforest, and investigate the structure and biodiversity of tropical rain forests. Also, you will look at the development of tropical forests, how biodiversity changes over time (ecologically and evolutionarily) and how trophic levels work within these forests. Furthermore, therole of tropical forests in relation to climate change and global carbon cycling will be investigated, and alink will be made to tropical savannas and dry tropical forests. Finally, you will investigate the IUCN redlist and will experience the practices of nature conservation in tropical areas.

Literature
This course will use solely primary literature as a basis for the tasks. No textbook is required.

Instructional format
Each week is devoted to a major topic in tropical rain forest ecology that will be studied using 1½h (standing)PBL tutorials. A mandatory guest lecture is part of this course. Also, an assignment called "Gallery of Endangered Tropical Biodiversity" has to be completed (consisting of two written texts, two presentations and a general final session in which you decide on the best proposals).

Assessment
The assessment will consist of three parts:
- Group grade for final exam assignment;
- Individual fact sheet grade (including the presentation);
- Individual counter-proposal grade (including the presentation).

BIO3008 Hominin Paleontology

Course coordinator

Prof. Dr. José Joordens, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: j.joordens@maastrichtuniversity.nl

Pre-requisites

- ✓ BIO2005 Evolutionary Biology or
- ✓ BIO2008 Great Transformations in Vertebrate Evolution

Objectives

In this course you will gain insight into the evolution of the hominin lineage, focussing on the evolutionary developments over the past 7 million years. You will gain a broader understanding of the correlations between climatic, environmental and ecological changes and the development of our own genus *Homo*. You will learn about the importance of combining geological and fossil records, and interpreting them in the light of ecosystems and biogeography.

Description of the course

An overview of hominin paleoecology and evolution, with emphasis on the overarching question: what made us human? The course combines insights from three disciplines: geology, biology and archaeology. We will explore the presently known and still expanding hominin fossil record, using a natural selection and sexual selection perspective. Topics studied include the history of the field, the origin of hominin bipedality, the evolution of the body plan, development of tool use, expansion of hominins out of Africa into Eurasia, speciation and extinction.

Literature

- Neil Shubin (2008). Your Inner Fish: a journey into the 3.5-billion-year history of the human body. Penguin Books;
- Bernard Wood (2019). Human Evolution, a Very Short Introduction (2nd edition). Oxford University Press;
- Carl Zimmer & Douglas J. Emlen (2016, second edition). Evolution: Making Sense of Life. Chapter 17, Human Evolution; **or**
- Douglas J. Emlen & Carl Zimmer (2020, third edition). Evolution: Making Sense of Life. Chapter 17, Human Evolution;
- Select scientific articles; access through the UM library.

Instructional format

One lecture and two tutorials per week.

Assessment

- Final examination;
- Contribution to tutorial group meetings;
- Pecha Kucha presentation;
- Assignments during course.

BIO3010 Genomics and Proteomics

Course coordinator
Prof. Dr. M.Honing, Faculty of Health, Medicine and Life Sciences, M4i, Maastricht University.
Contact: m.honing@maastrichtuniversity.nl

Pre-requisites
- ✓ BIO2007 Genetics

Recommended
- ✓ Knowledge at the level of Genetics by Peter J. Russell.

Objectives
- To understand how technologies in genomics applications are used to unravel the biology of life;
- To understand the basic principles analytical techniques in support of genomics, proteomics, metabolomics and data sciences;
- To gain insight in the experimental design of in-vitro and in-vivo research and its impact on the results envisioned to be gained;
- To gain insight and basic understanding in the evaluation of scientific literature (Journal club);
- To appreciate the surplus value of the processing and mining of complex data sets;
- To provide the basis for gaining insight in bioinformatics and computational genomics.

Description of the course
With introduction of genomics in the early 90's of the last century, it has added an extra dimension to the understanding of the molecular nature of life, allowing the detection of many different endogenous compounds. Prerequisites were the unraveling of the genome, the proteome and metabolome ofhumans and other organisms, with special attention to the development of biomedical and analytical methods for the simultaneous analysis of the expression levels of as much as possible genes, proteins and endogenous metabolites. This course will give students insight in the analytical principles behind omics-technologies such as array-based analysis (PCR, DNA sequencing), 2D and capillary electrophoresis, mass spectrometry, NMR and advanced statistical and data informatics. It will discuss the information that can or cannot be obtained by the different 'omics'-approaches, and in the novel developments of omics-applications such as miRNA arrays, analysis of the epigenome, and next generation sequencing. The journal club uses six selected scientific manuscripts to be evaluated on their experimental design, results & discussion, together with a critical assessment of its scientific quality. Specific themes of the course are transcriptomics, proteomics, metabolomics withspecial attention for the surplus value of combining data from various omics-approaches as the best wayto understand life (Systems Biology). Special areas of attention are Nutrigenomics and Toxicogenomics.

Literature
PowerPoint presentations, specific literature distributed

Instructional format
Thematic lectures on methodological principles and techniques, with examples of omics-applications. PBL and Journal club sessions to address in more detail some of the thematic subjects of the lectures. Journal club sessions to study and discuss relevant literature on the application of omics-methods in life sciences.

Assessment
- Mid-term presentation of self-chosen research topic, focused on the scientific hypothesis and especially experimental design of a research project (20%);
- Final written exam with five open questions, increasing in complexity (70%);
- Presence and participation in the "Journal Club" (10%).

CHE1101 Introduction to Chemistry

Course coordinator

Dr. Chris Bahn, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: chris.bahn@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ PRA1101 Introduction to Scientific Research I

Objectives

- To gain an understanding of the nature of atoms and their organization in the periodic table;
- To recognize various classes of chemical compounds and to understand their chemical and physical properties;
- To obtain an understanding of the physical chemistry fundamentally important to biological and chemical processes, with an emphasis on thermodynamics and kinetics;
- To use concepts acquired from kinetics, thermodynamics, acid-base chemistry, and electrochemistry, to predict the potential outcome of chemical reactions;
- To acquire sufficient background for more advanced courses in chemistry, biochemistry and the life sciences.

Description of the course

The emphasis of this course will be on a number of essential topics in modern chemistry. The first part of the course will provide an overview of the structure of atoms and their place in the periodic table as well as the properties of various types of chemical bonds and chemical bonding theory. The second partwill present an introduction to physical chemistry with important topics such as the characteristics of gases/liquids/solids, thermodynamics and reaction kinetics. In the final part, the course focuses on a selection of important chemical subjects which form the basis of chemical studies in general. Typical topics in this part of the course are based on acid-base chemistry and electrochemistry.

Literature

Chemistry, via OpenStax (https://openstax.org/subjects/science)
ISBN-10: 1-947172-63-8
ISBN-13: 978-1-947172-63-0

Instructional format

Lectures and tutorial group meetings.

Assessment

- A midterm examination consisting of multiple choice, short answer, calculation and explanation questions;
- Weekly tutorials – attendance and contributions;
- A final (cumulative) examination consisting of multiple choice, short answer, calculation and explanation questions.

CHE2001 Organic Chemistry

Course coordinators

Dr. Matt Baker, Faculty of Health, Medicine and Life Sciences, MERLN and Dr. Hanne Diliën, Faculty of Science and Engineering, Maastricht Science Programme.

Contact (Period 1): m.baker@maastrichtuniversity.nl

Contact (Period 4): hanne.dilien@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ PRA2002 Chemical Synthesis

Objectives

- To give the ability to recognize and name common organic compounds;
- To know the basic physical and chemical properties of common organic compounds;
- To understand stereochemistry and its impact on the properties and applications of organic molecules;
- To enable you to understand the most important organic reactions and be able to apply these reactions to obtain well defined organic compounds.

Description of the course

This course focuses on the basis of organic chemistry. In the first part of the course, important fundamental topics, such as atomic theory, bonding theory, hybridization, molecular orbital theory and resonance will be discussed. A special topic will be stereochemistry, which is an essential topic in organic chemistry and the life sciences, since stereochemistry often determines the activity of biological compounds or medicines. Subsequently, the course continues with an introduction into reactivity of organic molecules. Focus, will be on a selection of fundamental organic reactions, which form the basis for a wide array of other organic reactions. To this end, a logical review will be provided of the reactivityof the most important functional groups, as applied in organic synthesis.

Literature

Klein; "Organic Chemistry"; 2th edition or 3rd edition; Wiley (ISBN: 9781118452288/978-1119110477).

Instructional format

Lectures and tutorial group meetings. The tutorial group meetings will also be used to prepare with tasks for the co-requisite skill in chemical synthesis.

Assessment

- A midterm examination, which consists of multiple choice questions;
- A final examination, which consists of open questions;
- The contributions to the tutorial group meetings.

CHE2002 Inorganic Chemistry

Course coordinators

Dr. Burgert Blom and Dr. Giuditta Perversi, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: burgert.blom@maastrichtuniversity.nl and g.perversi@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ PRA2004 Inorganic Synthesis

Recommended

- ✓ CHE2001 Organic Chemistry (strongly)
- ✓ PRA2002 Chemical Synthesis

Objectives

- To introduce the student to the general principles of inorganic chemistry. To provide an understanding of the basic bonding relationships amongst atoms in inorganiccompounds;
- To introduce the student to d-block chemistry (coordination chemistry);
- To introduce students to the basic ideas in organometallic chemistry;
- To provide a descriptive survey of non-carbon elements and their properties;
- To provide the basis for the further studies of inorganic chemistry.

Description of the course

This survey course will introduce the students to the world of chemistry beyond carbon. As an introductory course it will focus on the principles of bonding and interaction between atoms, both of themain group and the d-block elements. A review of VSEPR and VB theory and molecular orbital theory (MO), crystal field theory (CFT); Molecular symmetry and a quick overview of some possible applications;A comprehensive overview of coordination chemistry: nomenclature, coordination number and geometry, oxidation states, d-electron counting and the 18-VE rule; Organometallic chemistry: history,alkyl, aryl, alkene, carbene and carbyne complexes. An introduction to nanoparticles, some paths of synthesis and applications.

Literature

To be determined amongst:

- Shriver and Atkins: Inorganic Chemistry (Oxford);
- Huheey, Keiter, Keiter: Inorganic Chemistry (Harper Collins);
- Wulfsberg: Inorganic Chemistry (University Science Books).

Instructional format

Lectures and tutorial group meetings.

Assessment

There will be a minimum of two points of assessment. Assessment points may include but may not be limited to any amongst:

- Exams;
- Take home problem sets;
- Tutorial group participation;
- Oral presentations;
- Written assignments;
- Poster presentations.

CHE2003 Physical Chemistry

Course coordinator
Dr. Veaceslav Vieru, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: v.vieru@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Recommended
- ✓ MAT1007 Mathematical Tools for Scientists

Objectives
- To provide a molecular and mathematical understanding of basic concepts in physical chemistry on a more advanced level;
- To explain and describe the behaviour of systems when temperature and pressure is changed;
- To apply the general principles of thermodynamics to describe and understand chemical and environmental processes;
- To derive via statistical thermodynamics important thermodynamic quantities (e.g. internal energy, enthalpy, entropy, Gibbs and Helmholtz energies).

Description of the course
This course aims to introduce the students to the core of physical chemistry – thermodynamics. First, it introduces classical thermodynamics and applies it to macroscopic systems. Subsequently, statistical thermodynamics is introduced and linked to the main thermodynamic quantities. Students will learn throughout the course how to apply thermodynamics to analyse the physical and chemical properties of gases, solutions and solids, with a focus on mathematical derivations of formulas. The course covers, *inter alia*, the laws of thermodynamics; chemical potentials; phase diagrams; mixing of solutions; properties of gases; statistical thermodynamics and the derivation of internal energy, enthalpy, entropy,equilibrium constants.

Literature
- McQuarrie, Donald A.; Simon, John D. *Physical Chemistry: A Molecular Approach* (any edition). University Science Books.
- Atkins, Peter. *Physical Chemistry* (any edition). Oxford University Press.

Instructional format
Lectures and tutorials.

Assessment
Assessment will be based on:
- Two written exams, a mid-term exam covering topics of the first three weeks, and a final examconsisting of open questions at the end of the course;
- Participation in and contribution to the tutorials as assessed by the attending tutor.

CHE2004 Spectroscopy

Course coordinator

Dr Burgert Blom, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: burgert.blom@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry

Co-requisites

- ✓ None

Objectives

- To have a basic understanding of the theoretical background of the measurement principles typically used in spectroscopy and spectrometry;
- To learn to read and interpret the diverse types of spectral data obtained from the most common spectroscopic techniques;
- To learn to identify and characterize chemical compounds using a variety of available analytical techniques;
- To be able to develop an analytical strategy to identify an unknown compound.

Description of the course

The emphasis of this course will be on a number of essential topics in the field of spectroscopy. The course will focus on several spectroscopic and chromatographic techniques such as Nuclear Magnetic Resonance (NMR), UV-Vis spectroscopy, FT-IR spectroscopy, gas and liquid chromatography and mass spectrometry. Additional excursions to EPR and possibly, time permitting, Moessbauer spectroscopy will also be undertaken. First, the theoretical background and physical basics of the techniques will be discussed. Then, the reading and interpretation of spectral analysis will be covered. The main focus of the course will be on the acquiring of knowledge and practical expertise to characterize chemical compounds. An analytical strategy to get structural information for unknown molecules from experimental data will be developed.

Literature

Spectroscopy; Lampman, Pavia, Kriz, Vyvyan; 4th or 5th edition (International Edition): Brooks/Cole.

Instructional format

Lectures and tutorial group meetings.

Assessment

- A midterm examination, which consists of open questions and problems;
- A final examination, which consists of open questions and problems;
- The contributions to the tutorial group meetings.

CHE2006 Biochemistry

Course coordinators

Prof. dr. L. Schurgers and N. Deckers, Faculty of Health, Medicine and Life Sciences, Department of Biochemistry.

Contact: l.schurgers@maastrichtuniversity.nl
Contact (corresponding coordinator)*:* n.deckers@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

At the end of the course, you will be able to:

- Communicate on fundamental principles governing structure, function, and interactions of biological molecules;
- Appreciate the science of biochemistry and its relevance to Health and Disease;
- Understand the roles of macromolecules such as proteins, lipids, polysaccharides, and DNA in living cells and relate to diseases such as hyperventilation, thrombosis and scurvy;
- Identify, explain, and discuss the basic principles of enzyme catalysis and inhibition;
- Enter advanced courses that require more detailed biochemistry knowledge and enroll to various Master programs in life sciences.

Description of the course

Biochemistry is considered the mother of all life sciences. Understanding biochemical principles will facilitate learning of more specialised life sciences such as molecular and cell biology. This course will present the essentials of biochemistry during 6 lectures and 10 tutorials. We will cover the structures, functions and interactions of biomacromolecules including proteins, lipids, carbohydrates, and DNA which are key molecules associated in life. We will further provide insight in the specificity and actions of enzymes, the biocatalysts of the cell. Additionally, we will explain metabolic pathways that result inthe generation of ATP, the major energy source in life and how certain substances can interfere and lead to disease or death. Finally, we will discuss recent concepts of genome editing that revolutionise treatment of diseases by gene therapy.

Literature

- Biochemistry (9th ed). ; Berg, J.M., Tymoczko, J.L., Gatto G.J., Stryer, L. ; W.H. Freeman and company. ISBN-10: 1-319-11465-2; ISBN-13: 978-1-319-11465-7;
- Biochemistry (6th ed.); Garrett R.H. and Grisham C.M. ; Cengage Learning. Student ed. ISBN: 978-1-305-57720-6; Loose-leaf ed. ISBN: 978-1-305-88604-9.

Instructional format

The course is subdivided into contextual topics which are covered during lectures and tutorial groups. Students are expected to participate actively in *Problem-Based-Learning* tutorial groups to acquire conceptual knowledge of biochemistry to better understand the fundamentals of health and disease.

Assessment

- Mid-term examination;
- Final examination.

CHE2007 Solid State Chemistry

Course coordinator

Dr. Giuditta Perversi, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: g.perversi@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To expand on the student's knowledge of Chemistry and understand how properties are modified in a solid state framework;
- To introduce the student to the fundamental science behind chemistry in solid state and the processes that steer it;
- To familiarise the students with materials of high technological relevancy and show the clear relationship between theory and its applications;
- To understand the state-of-the-art and have some indication of the challenges of the field;
- To give a stable foundation to pursue future master-level studies in the field.

Description of the course

Solid state chemistry, also referred to as Materials chemistry, is a very technologically relevant branchof chemistry. Treating materials as a bulk, however, requires a slightly different theoretical background. This course aims to provide the correct technical framework to chemistry in the solid state, and combine basic theory with very real-life applications.
The six weeks of the course will aim to cover a total of six modules on key themes, among batteries, magnets, superconductors, semiconductors and solar cells, multiferroics, thermoelectrics, porous systems (MOFs/zeolites), fuel cells and oxygen ion conductors. The students' preferences and specific interests will be taken into account for one or two modules. The tutorials sessions will complement this approach and help the students familiarise with the concepts.
The course it its entirety will aim to provide the students with the tools needed to understand the strengths, state-of-the-art and upcoming challenges of the very varied field that solid state chemistry represents.

Literature

- A.R. West, "Solid State Chemistry and its applications", 2nd Ed, 2014;
- P. M. Woodward, P. Karen,. J. S. O. Evans and T. Vogt. "Solid State Materials Chemistry" Cambridge University Press, 2021.

In addition, the students can also refer to the following advanced literature for a more support:

- P. A. Cox, "The electronic structure and chemistry of solids", Oxford Science Pub., 1999;
- C. Kittel, "Introduction to solid state physics", John Wiley & Sons Inc., 8th Ed, 2005.

Additional references will be given on a lecture-by-lecture base.

Instructional format

The course is lecture-based, with one lecture and two corresponding tutorials to attend each week.

Assessment

The student's performance will be assessed with:

- A midterm written examination;
- A final examination with open and multiple choice questions on all the six themes covered;
- Homework assignments and the contribution to the tutorial sessions.

CHE2008 Main-Group Element Chemistry

Course coordinator
Dr. Burgert Blom: Faculty of Science and Engineering, Maastricht Science Programme.

Contact: burgert.blom@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Recommended
- ✓ CHE2002 Inorganic Chemistry

Co-requisites
- ✓ None

Objectives
- To survey the structures and reactivity of main-group elements period for period.
- To discuss the notion of allotropy;
- Dissect structure, bonding and reactivity in main-group element compounds;
- To examine modern developments (since 1980) in this rapidly moving field;
- To look at molecular compounds of heavy main-group elements (Sn, Ge, Pb, As, Sb, etc.) and their bonding patterns and reactivity;
- Discuss compounds violating the double-bond rule and their chemistry.

Description of the course
This course will provide a comprehensive survey of main-group element chemistry from a traditional perspective (looking at the main-group elements and their structures, bonding patterns, properties, reactivity and allotropes) but also focus on modern developments in the field. Since the early 1980s main-group chemistry has experienced burgeoning growth since it was found that main-group elements can also participate in multiple bonding. This will be discussed, and the chemistry of these compounds, which violate the so-called double-bond rule compared to that of carbon compounds. Reactivity and applications of reactive main-group element compounds will be introduced.

Literature
Inorganic Chemistry (Weller, Overton, Rourke, Armstrong) and Research Publications.

Instructional format
Lectures and tutorial group meetings.

Assessment
There will be a minimum of two points of assessment. Assessment points may include but may not be limited to any amongst:

- Exams;
- Take home problem sets;
- Tutorial group participation;
- Oral presentations;
- Written assignments;
- Poster presentations.

CHE3001 Organic Reactions

Course coordinator

Dr. Hanne Diliën, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: hanne.dilien@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry
- ✓ CHE2004 Spectroscopy

Co-requisites

- ✓ PRA3001 Advanced Organic Synthesis

Objectives

- To provide a comprehensive overview of chemical reactivity;
- To understand the reactivity of most common functional groups;
- To be able to present detailed reaction mechanisms for typical organic reactions;
- To give the ability to design multi-step reaction sequences to obtain a specific organic compound.

Description of the course

This course focuses on chemical reactivity. In this course, a broad review will be presented of the most important functional groups and their reactivity. This review will describe the synthesis and reactivity of molecules, such as alcohols, aldehydes, ketones, carboxylic acids and amines. It will also discuss reactions involving orbitals, the so-called pericyclic reactions. Knowledge of the various types of organicreactions will provide the basic skills to design multistep synthesis sequences to obtain specific organic compounds. Furthermore, the reaction types will be placed in an appropriate context with regard to practical applicability and industrial processing. Finally, also theoretical aspects regarding reaction mechanisms will be presented.

Literature

Klein; "Organic Chemistry"; 2th edition or 3rd edition; Wiley (ISBN: 9781118452288/978-1119110477).

Instructional format

Lectures and tutorial group meetings. The tutorial group meetings will also be used to prepare with tasks for the co-requisite skill in advanced organic synthesis.

Assessment

- Midterm examination, which consists of open questions and problems;
- Final examination, which consists of open questions and problems;
- A paper or presentation on multistep synthesis;
- The contributions to the tutorial group meetings.

CHE3002 Transition Metal Chemistry

Course coordinator
Dr. Burgert Blom, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: burgert.blom@maastrichtuniversity.nl

Pre-requisites
- ✓ CHE2001 Organic Chemistry
- ✓ CHE2002 Inorganic Chemistry

Recommended
- ✓ CHE3001 Organic Reactions

Co-requisites
- ✓ PRA3008 Transition Metal Chemistry

Objectives
- To build up on the student's knowledge of d-block elements acquired during Inorganic Chemistry (CHE2002);
- To allow the student to gain deeper understanding of the electronic structure and properties of d-block elements;
- A solid introduction and careful analysis of organometallic chemistry;
- A survey of several important classes of compounds in organometallic chemistry;
- Introduction and survey of state of the art spectroscopic techniques (for example EPR, ^{57}Fe Moessbauer, SQUID, Multinuclear NMR etc.);
- To give the student a brief introduction to molecular catalysis;
- Ultimately, to prepare the student for a Masters program in chemistry.

Description of the course
This course is divided into 6 main themes over a 6 week period. Each week a different important class of organometallic compound will be discussed in terms of synthesis, structure, properties, and bonding. In addition, the reactivity of each class of compound will be highlighted. Moreover, later in the course, advanced spectroscopic methods will be studied, including state of the art techniques such as EPR, ^{57}Fe Moessbauer, Magnetochemical techniques, such as SQUID, and others. An introduction to very contemporary and innovative themes in organometallic chemistry will be provided. Survey of themes covered: Associative, Dissociative and Interchange mechanisms, Eigen-Wilkins mechanism, Inner and outer-sphere electron transfer, Marcus Theory. The MO description of the 18VE rule for the three classesof octahedral complexes (I, II and III); Transition metal alkyl complexes synthesis and reactivity, Transition metal Fischer and Schrock Type carbenes: synthesis and reactivity; Carbyne complexes; Themolecular orbital description of ferrocene and related Cp complexes and reactivity; The Doetz Reaction and alkyne and alkene metathesis, Triple bonding in heavy alkynes and alkenes (Ge, Sn and Pb), Hydrides: classical and non-classical; An introduction to the notion of a catalyst cycle; Clusters, M-M bonding, and Isolobal Theory; N-Heterocyclic Ylenes.

Literature
Robert H. Crabtree: The Organometallic Chemistry of the Transition Metals, Wiley (any edition will do).
Christoph Elschenbroich: Organometallics (any edition will do).

Instructional format
This will be a lecture-based course. The students will be expected to attend lecture one time per week and the corresponding tutorial meetings two times per week.

Assessment
Assessment for this course will be determined by the student's performance in:
- A midterm;
- A final exam exclusively and/or a written review paper to replace the midterm.

CHE3004 Modern Catalytic Chemistry

PLEASE NOTE: This course only runs in alternate years (even). It will not run in academic year 2022-2023.

Course coordinator

Dr. Burgert Blom, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: burgert.blom@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry

Recommended

- ✓ CHE2002 Inorganic Chemistry
- ✓ CHE3001 Organic Reactions
- ✓ CHE3002 Transition Metal Chemistry

Co-requisites

- ✓ None

Objectives

- To outline, describe and discuss the essential principles of catalysis;
- To provide a survey of the different types of chemical catalysis, to include transition metals, organocatalysis;
- To introduce the state-of-art in the field, illustrated by appropriate examples;
- To examine case studies of key reactions for the synthesis of fine chemicals;
- To provide the basis for the further studies in this rapidly-moving field, and to link catalysis to other areas of chemistry.

Description of the course

This course will provide a comprehensive introduction to the topic of catalysis, with a focus on homogeneous catalysis mediated by organometallic compounds; and emphasis on modern chemistry and key processes. Each week a different important and relevant catalytic process will be reviewed in detail: Polymerisation and selective oligomerisation; catalytic C-C coupling reactions; Hydroformylation (including the Monsanto process); Hydrosilylation (with modern developments) and other hydrometalation reactions; catalytic metathesis (alkene and alkyne), and their applications in some modern cases studies; etc. It is recommended that this course is taken after CHE3002, or concurrent, as the key fundamental reaction steps are organometallic in nature.

Literature

To be determined amongst:

- Organic Chemistry (Bruice), Inorganic Chemistry (Shriver and Atkins), Organic Chemistry, 2nd ed. (Clayden, Greeves, Warren);
- Catalysis in Asymmetric Synthesis, 2nd ed. (Caprio, Williams), Applied Organometallic Chemistry and Catalysis (Whyman);
- Primary scientific and patent literature as appropriate: Crabtree : The Organometallic Chemistry of the Transition Metals": N.B. C. Elschenbroich Organometallics.

Instructional format

Lectures and tutorial group meetings.

Assessment

There will be a minimum of two points of assessment. Assessment points may include but may not be limited to any amongst:

- Exams;
- Take home problem sets;
- Tutorial group participation;
- Oral presentations;
- Written assignments;
- Poster presentations.

CHE3006 Quantum Chemistry

Course coordinator
Dr. Veaceslav Vieru, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: v.vieru@maastrichtuniversity.nl

Pre-requisites
- ✓ MAT1007 Mathematical Tools for Scientists

Co-requisites
- ✓ None

Recommended
- ✓ MAT2004 and/or MAT2008 and/or MAT2009

Objectives
- To apply the quantum model to describe real chemical examples;
- To predict some molecular properties by solving quantum chemistry equations;
- To recognise and critique the failures of the model.

Description of the course
This course will introduce students to the foundations of quantum mechanics and its application in chemistry. It will start with the introduction of quantum mechanics through the analysis of Stern-Gerlach spin measurements to allow students to learn about the Dirac and matrix notation. The basic postulates of quantum mechanics will be introduced through their manifestation in the Stern-Gerlach experiments. Subsequently, traditional wave-function aspects of quantum mechanics will be studied via a few exactly solvable models - a particle in a box, the hydrogen atom, the harmonic oscillator, with a view to emphasizing their connections to the basic postulates. The course will conclude by presenting the basics of approximation methods, such as variational method and perturbation theory and their application to multielectron systems.

Literature
- McIntyre, David H. *Quantum mechanics: A paradigms Approach*. Pearson Education;
- McQuarrie, Donald A., and Simon, John D. *Physical Chemistry: A Molecular Approach* (any edition). University Science Books.

Instructional format
Lectures and tutorials.

Assessment
Assessment will be based on:
- Two written tests, a mid-term exam covering topics of the first three weeks, and a final exam consisting of open questions at the end of the course;
- Participation in and contribution to the tutorials as assessed by the attending tutor.

CHE3007 Advanced Physical Chemistry

Course coordinator

Dr. Veaceslav Vieru, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: v.vieru@maastrichtuniversity.nl

Pre-requisites

- ✓ MAT1007 Mathematical Tools for Scientists

Recommended

- ✓ CHE2003 Physical Chemistry

Co-requisites

- ✓ None

Objectives

Students are expected to:

- Calculate and interpret kinetics data (e. g. chemical reaction rates, rate constants);
- Use steady state approximation and predict mechanisms of chemical reactions;
- Apply transition state theory and collision theory;
- Understand photochemistry and Jablonski diagrams.

Description of the course

The course introduces students to chemical kinetics, the branch of physical chemistry that helps to understand the rates of chemical reactions and provide concrete evidence for the mechanisms of chemical reactions. It will first cover phenomenological kinetics of simple and complex reactions (e.g. parallel, consecutive, chain reactions, chemical oscillations), before moving on to collision theory and transition state theory (developed by Eyring, Evans and Polanyi). The course will end by presenting elements of photochemistry and some kinetic theories of catalysis.

Literature

- Atkins, Peter. *Physical chemistry* (any edition). Oxford University Press;
- McQuarrie, Donald A.; Simon, John D. *Physical Chemistry: A Molecular Approach* (any edition). University Science Books.

Instructional format

Lectures and tutorials.

Assessment

Assessment will be based on:

- Two written exams, a mid-term exam covering topics of the first three weeks, and a final exam consisting of open questions at the end of the course;
- Participation in and contribution to the tutorials as assessed by the attending tutor.

CHE3008 Analytical Science and Technology

Course coordinator

Prof. dr. Maarten Honing: Faculty of Health, Medicine & Life Sciences.

Contact: m.honing@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry
- ✓ CHE2004 Spectroscopy

Co-requisites

- ✓ None

Objectives

- To gain an understanding of analytical sciences & technologies, molecular structures, their chemical & biological properties the importance for the design of analytical methodologies;
- Create a fundamental understanding in "sampling and sample pre-treatment" in the analysis of a variety of molecules like, hormones, lipids, proteins and synthetic polymers;
- Insight into fundamental mechanisms of separation technologies (chromatography & electrophoresis), and correlate the chemical properties of molecules to the "mode of action" in, e.g., gas- super critical and liquid chromatography;
- To obtain a fundamental understanding of the basics and application of various spectroscopic technologies, like UV/VIS, IR/Raman, MS and NMR for the assessment of molecular structures;
- To become familiar with molecular structure assesssment of chemicals, metabolites, bio- and synthetic polymers using hyphenated technologies, e.g. LC-MS/MS, LC- flow-NMR;
- Obtain insight into different applications of analytical methodologies and acquire sufficient background for more advanced courses in chemical synthesis, polymer-, bio-chemistry and life;
- To gain insight in "Process Analytical Technologies" applied by in-, at and on-line detection technologies. Application of technologies in (micro) flow- reactors.

Description of the course

Next to the MSP courses on spectroscopy (CHE 2004) and mass spectrometry (INT2010), the emphasis of this course will be on the technologies in analytical sciences and in the context of pharmaceutical research, bio- and polymerchemistry and chemical engineering. It will touch upon the basic physical chemical properties of molecules and the assessment of molecular structures. It forms a solid basis for chemists and biologists using analytical methodologies in their day-to-day research. Besides sample pre-treatment, molecular structure assessment, advanced separation technologies, the course focuses on the hyphenation of the analytical technologies (LC-MS/MS)and their application in chemical and biological sciences. Typical topics in the course are based on the quantification and molecular structure assessment of chemical, biological relevant metabolites, bio- andsynthetic polymers. In the end the students should be able to design a analytical methodologies.

Literature

Fundamentals of Analytical Chemistry, Skoog (ed. 2014), power point slides, articles to be distributed.

Instructional format

Lectures (6) and tutorial group meetings (12).

Assessment

- "Mid-term" Presentation of gained knowledge for specific technology on basis of a small literature research (20% of final mark);
- Weekly tutorials – attendance and contributions;
- A final examination (80% of final mark) consisting of short answer and explanation questions.

CHE3009 Chrystallography

Course coordinator

Dr. Giuditta Perversi, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: g.perversi@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2002 Inorganic Chemistry OR
- ✓ CHE2001 Organic Chemistry OR
- ✓ MAT2004 Linear Algebra

Recommended

- ✓ CHE2007 Solid State Chemistry

Given the nature of the course, waivers will be granted if the student even without the strict Pre-requisites has a sufficient scientific background to benefit from the course. This is at the course coordinator’s discretion. This course is not recommended to students in their first year of study.

Objectives

- To introduce the students to the extensive and interdisciplinary field of crystallography;
- To provide the basis on how crystals can be classified and treated with group theory;
- To familiarise the students with the International Tables of Crystallography;
- To outline the process of diffraction and the available experimental techniques;
- To suggest some advanced application and state-of-the-art advancement to understand the potential of the field.

Description of the course

The six lectures of this course will lay the foundations of crystallography, starting from group theory and symmetry as a concept, extending it to crystal families and space groups and applying it in diffraction principles and experimental techniques. Beyond these basics, more advanced discussion topics will be discussed according to the students’ preferences, among local structure analysis, magnetism in crystallography, phase transitions, mineralogy, andprotein crystallography. The tutorials sessions will complement the lectures and help the students gain a deeper understanding of the topic and some methodological approaches to state-of-the-art problems that involve crystallography. Though the course will have a physical chemistry approach to the subject, crystallography is an inherently interdisciplinary field and students that are passionate about mathematics and physics are encouraged to join.

Literature

- Michael Glazer and Gerald Burns, “Space Groups for Solid State Scientists”, 3rd Ed., 2013;
- C. Giacovazzo, "Fundamentals of crystallography”, *Oxford University Press, 1992.*

The second book is advanced and covers a wide breadth of crystallography. The students can refer to it for deeper mathematics and extensive commentary. Additional material for specific subjects will be given in the relevant lectures, when applicable.)

Instructional format

The course is lecture-based, with one lecture and two corresponding tutorials to attend each week.

Assessment

The student’s performance will be assessed with:

- Tutorial participations and weekly homework;
- A midterm examination consisting a group assignment;
- A final examination with open and multiple choice questions.

INT1101 Introduction to Liberal Arts and Science

Course coordinator
Dr. Kasper Eersels, Faculty of Science and Engineering, Sensor Engineering Department.

Contact: kasper.eersels@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ PRA1102 Introduction to Scientific Research II

Objectives
The objective of this course is to make you think about the natural sciences from a philosophical perspective: what is science; what is the scientific method? The course also challenges you to develop your intellectual and generic skills further: how to integrate different perspectives; what is ethical in science; how to communicate in/about science? To achieve these, you will be able:

- To understand the main theoretical approaches within the philosophy of science and its usefulness in a natural sciences context;
- To understand the nature of academic knowledge and the process of scientific development;
- To know how science is done ("the scientific method");
- To discuss the importance norms and values in scientific environments;
- To explore the structure and use of basic argumentation in various formats of communication;
- To use historical and sociological case studies of scientific practice in mastering the above objectives.

Description of the course
The first part of the course aims at providing you with an understanding of the natural sciences from a philosophical perspective. What is science? What is the scientific methodology? What are the norms and values in a scientific environment? The variety of perspectives that you are introduced to when answering these questions will allow you to develop critical thinking skills and provide you with insight that can be used in your personal development as a scientist. After exploring the philosophy of science in the first part of the course, the second part teaches you to apply and communicate your knowledge and ideas effectively by devoting attention to argumentation and science communication.

Literature
All students are required to read:

- Peter Godfrey-Smith: Theory and Reality: An Introduction to the Philosophy of Science, Second Edition. (ISBN: 978-0-2266-1865-4)

In addition, students will study a variety of articles and book chapters which will be made available onlineon a weekly basis.

Instructional format
This course is structured around 10 PBL assignments with weekly lectures to provide background to the topics discussed.

Assessment
Assessments in this course include:

- An essay assignment;
- A debate assignment.

INT1003 Introduction to Biomedical Engineering

Course coordinator

Dr. Federico De Martino, Faculty of Psychology & Neuroscience, Department of Experimental Psychology.

Contact: f.demartino@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

To provide an overview of the different fields of biomedical engineering.

Description of the course

Biomedical engineering is a highly interdisciplinary field at the interface between engineering medicine and biology. In biomedical engineering, principles and methodologies typical of engineering are applied to solve problems from the medical and biological sciences. This course will introduce (some of) the subdisciplines within biomedical engineering. In particular, the course includes an introduction to systems physiology, basic concepts of bioinstrumentation, an introduction to biomedical signal analysis and modeling and biomedical imaging. General issues of each of the subdisciplines will be illustrated together with selected examples and neuroscience applications.

Literature

Various book chapters and research articles.

Instructional format

Lecture, lab visits and tutorial meeting.

Assessment

- Midterm;
- Final written exam.

INT1005 Commercializing Science and Technology

Course coordinator

Dr. Jermain Kaminski, School of Business Economics, Department of Organization, Strategy and Entrepreneurship
Contact: jermain.kaminski@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Objectives

- Fostering an entrepreneurial spirit, regardless of your background;
- Develop a basic understanding of the commercialization of science and technology;
- Exploring and discussing scientific literature and practical case studies;
- Getting to know technology entrepreneurs and experts;
- Learning science communication in a new technological context;
- Developing and presenting your own business idea.

Description of the course

This course is designed to help you understand how science-based research and technological breakthroughs can be transformed into new businesses. The course is designed for students who want to understand how a scientific idea can make it from the lab to the marketplace. As part of this course, you will have the opportunity to immerse yourself in a technology field of your choice, such as biotechnology, machine learning, or quantum computing. You will develop a solid theoretical understanding of the process of identifying and evaluating market opportunities related to new technologies, explore current knowledge in managing early-stage commercialisation processes, and apply your knowledge to a thought early-stage commercialisation venture.

Through a series of real-world cases, readings, media, and activities involving group work, you will explore key entrepreneurial topics: Idea generation, market research, product development and branding, business planning and strategy, teams and founder characteristics, intellectual property (patents), technology transfer, geolocation and fundraising. With guest expert input, we will also explore the human aspects of innovation and the dynamics in a startup.

Assessments in this course will include a) participation, b) an individual case-based research essay about a new innovation and its commercialisation trajectory, and c) a group presentation of a new startup idea in a technology field of your choice, based on scientific and analytical evidence.

It is our hope that the thinking and tools learned in this course will one day help you start your own company, turn your research into a product, or successfully innovate within an existing company.

Literature

Canvas will include all academic papers, case materials, and websites.

Instructional format

This course is taught through a combination of problem-based learning, a science communication task, and a startup project that will challenge you to apply your newly acquired knowledge to realistic problem situations of entrepreneurs that want to start a new venture.

Assessment

- Participation;
- Session chairing;
- Case-based research essay in a chosen technology field;
- Formulation and presentation of a science-based startup idea.

INT1006 Sustainable Development

Note: this course replaces INT2002 Science and Sustainable Development. If you have successfully completed INT2002 you may not participate in INT1006.

Course coordinator

Prof. dr. Pim Martens, University College Venlo.
Contact: p.martens@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To gain a basic understanding of the (various perspectives on the) concept of sustainable development and some of the main related ideas, concepts and theories;
- To gain insights into (the limits to) our immense global human impact on the earth's systems and the underlying drivers of these unsustainable trends;
- To explore ideas about how to achieve a more sustainable society.

Description of the course

Today it is acknowledged that achieving sustainable development at the local, regional and global scaleis one of the greatest challenges for the 21st century. But in many cases the term 'sustainable development' functions as little more than a vacuous buzzword. So what does sustainable developmentactually mean? How unsustainable is our global society at the moment? Are we contributing to irreversible climate change? Are we already passing dangerous global environmental tipping points? Whyare humans acting in such unsustainable ways? And, of course, what are sustainable ways forward?
This course aims to enhance student's understanding of 'sustainable development', based on the notion that human development can only be sustainable when environmental boundaries are respected. The course introduces the main concepts, ideas and theories related to the term sustainable development. Students will gain insights into (the limits to) humanity's immense impact on the earth's systems and the underlying drivers of these unsustainable trends. Furthermore, sustainable development requires an understanding that inaction has consequences. Students will explore ideas about how to achieve a more sustainable society. As part of the examination students will link theories/concepts/ideas discussed in the course to a self-selected case study (a promising way forward towards sustainability) in a poster presentation.

Literature

E-Readers.

Instructional format

Tutorial group meetings and lectures.

Assessment

- Practical assignment (poster presentation);
- Written exams.

INT1007 Introduction to Earth Sciences

Course coordinator
Dr. Jesse Hennekam, Faculty of Science & Engineering, Maastricht Science Programme
Contact: j.hennekam@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
During this course you will develop a fundamental understanding of the abiotic and biotic processes responsible for shaping our planet. From the formation of our Solar System to the Earth as we know it today, you will gain insight on the enormous powers continuously impacting and changing the planet.

Description of the course

This course will provide you with a basic understanding of processes acting on our planet. Earth Sciences is an interdisciplinary field, combining branches of physics, chemistry and biology in a pursuit to better understand the Earth and its features. We will unravel the geological past and gain a better understanding of all the factors impacting our planet, responsible for shaping the Earth as we know it. You will become aware of the importance of time, and learn how to think in different timescales. The continents with its mountain ranges, the vast oceans, the atmosphere and life, all are continuously subjected to change, although often hidden on human timescales. This course will focus on how the Earth continuously seems to change throughout its 4.5 billion years of existence.

Literature
"Earth: portrait of a planet" by S. Marshak, 7th International Student Ed. 2018. W. W. Norton & Company, ISBN: 978-0-393-64031-1

Instructional format
Lectures and tutorials

Assessment
- Oral presentation;
- Weekly assignments;
- Exam.

INT2007 Science in Action

Note: this course fulfils the LAS topic requirement

Course coordinator

Jessica Mesman, Faculty of Arts and Social Sciences, Department of Society Studies.
Contact: j.mesman@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

By the end of this course students should be able to:

- Describe the contemporary social, economic, political, and cultural dynamics of knowledgeproduction in the sciences;
- Identify the complexities of how scientific knowledge is distributed, communicated and debated in society;
- Critically analyze 'common sense' views of the making and use of scientific claims.

Description of the course

This course is situated in the field of Science and Technology Studies (STS) and analyses the social and cultural complexities involved in the production and dissemination of scientific knowledge. The course aims to clarify how social, cultural, political, or economic forces play inextricable roles in the practice and production of Western science. To gain insight in the science-society relation we analys for example, the historical context in which Einstein developed his Theory of Relativity. In addition, insights from cultural anthropology allow us to discuss how ethnicity, gender and social class affects scientific practices and its output. Debates about the bell-shape of distributions, cell structure and the value of the IQ-test act as emperical exemplars. Studies on bipolar disorder and immunology will exemplify the role of metaphors in our understanding and conceptualisation of reality. An analysis of the science-society relationship can not ignore the digital world we live in. Therefore the course will also pay attention to 'fake-facts' and the role of Wikipedia and Google Scholar in the production of knowledge. Beside the wider socio-economic context in which science operates, the course also takes into account the immediate context in which scientific facts are established (i.e. the lab). This involves not only the involvement of industry but also the way credibility affects the daily business of doing research. It is along these lines that we enter the world of the scientists.

Literature

Available on Canvas section: Modules and Resources

Instructional format

Tutorial group meetings (be aware: a format is chosen by you and one of your fellow students in close consultation with the tutor), lectures, video analyses, and an interview of a researcher.

Assessment

- Participation in -and preparation of- discussions and assignments (team/individual);
- Group presentation on basis of interview results;
- A individual paper.

INT2008 Molecular Toxicology

Course coordinator

Dr Gertjan den Hartog, Faculty of Health, Medicine and Life Sciences Maastricht University, Department of Pharmacology and Toxicology.
Contact: gj.denhartog@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To gain knowledge on experimental approaches to identify and quantify metabolites, reactive intermediates and their selective interaction with specific cellular target molecules (selective toxicity);
- To get acquainted with the procedures applied to assess the toxicity of drugs and chemicals;
- To understand the role of bio activation and bio-inactivation in the toxicity of drugs and other xenobiotics and natural toxins;
- To be able to apply strategies used to predict toxicity;
- To understand strategies to reduce or prevent toxicity;
- To understand risk factors involved in inter-individual susceptibility to xenobiotics, including genetic polymorphisms, drug-drug and food-drug interactions.

Description of the course

Human molecular toxicology studies the molecular mechanisms underlying toxicity of compounds in man. The conversion to reactive intermediates and metabolites is key in the actual toxicity of compounds. Therefore, the role of metabolism in the formation of metabolites and reactive intermediates and the protection against these species is extensively addressed. Moreover, compounds generally display a toxicity that is restricted to a specific organ and type of toxicity. This concept of selective toxicity is elaborated. Focus is on redox-controlled processes in biotransformation and in modulation of cell function. Topics include a survey of the molecular mechanisms determining (selective) toxicity; the versatility of enzymes, such as cytochrome P450 and glutathione S-transferases in the biotransformationof compounds; consequences of genetic polymorphisms of biotransformation enzymes; chemical and biological properties of various classes of reactive intermediates; structure-activity relationships and other approaches applied to predict metabolism; and strategies to reduce toxicity including those employed in Chinese traditional medicine.

Literature

During the course, a selection of book chapters and scientific papers is made available.

Instructional format

Lectures, short practicals and tutorial group meetings.

Assessment

- A final examination, which consists of open questions and multiple choice questions;
- A presentation on a selected topic;
- The contributions to the tutorial group meetings.

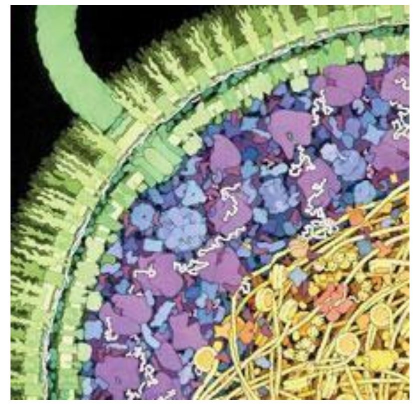
INT2009 Biophysics

Coordinator
Dr Raimond Ravelli: M4I Nanoscopy, Faculty of Health, Medicine and Life Sciences.
Contact: rbg.ravelli@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Recommended
- ✓ CHE2006 Biochemistry
- ✓ BIO2001 Cell Biology

Objectives



- Students can understand the key concepts in molecular and cellular biophysics;
- Students will have a comprehensive overview of the different biophysical techniques that can be used to study biological molecules in vitro and in vivo;
- Students will be able to compare different biophysical techniques and choose the appropriate one to study different biological phenomena;
- Students will be able to get the gist of a scientific publication that uses one or more of the biophysical methods that were introduced in the course.

Description of the course
Although the life we see around us appears very diverse it is remarkably similar at the level of molecules.

Biophysics applies the principles of physics and chemistry, the methods of mathematical analysis, and computer modelling to understand how biological systems work. It seeks to explain biological function in terms of the structures and properties of specific molecules. The aim of this course is to provide a comprehensive overview of many biophysical techniques, to relate them to each other, and to show how these can be used to study biological molecules. The biophysical techniques will be introduced following the outline of one book [1], and cover transport, hydrodynamics, spectroscopy, diffraction, microscopy, computational modelling, and NMR. You will learn how to determine molecular structures, how to study dynamic diffusion properties, how to measure ion transport and protein folding, and how to characterise conformational changes. The course will introduce the mathematical and physical knowledge that needed for this course. Each lecture will deal with one or two groups of techniques. The tutorials will go into more depth for some of those techniques.

Literature
[1] "Biophysical Techniques" by Iain D. Campbell. Oxford University Press, ISBN 978-0199642144;
[2] "Methods in Molecular Biophysics" by Serdyuk and Zaccai. Cambridge University Press, ISBN978-0511811166.

Instructional format
The course is divided into topics that will be introduced, explained, supplemented and discussed in the lecture. A more detailed study will take place in tutorial groups using PBL.

Assessment
The assessment will be based on:
- Tutorial performance;
- Three essays.

INT2010 Principles of Mass Spectrometry

Course coordinator
Prof. Dr. Ron Heeren, Imaging Mass Spectrometry, Faculty of Health, Medicine and Life Sciences.
Contact: r.heeren@maastrichtuniversity.nl

Prerequisite
- ✓ None

Objectives
- Understand the basics of mass spectrometry;
- Learn the physical basis of modern mass analyzers and understand how a mass spectrometer works;
- Describe and understand different ion generation techniques and their usage for the analysis of different types of molecules;
- To become familiar with ion optics, ion transport systems, ion detection systems;
- Understand the basics of tandem mass spectrometry for molecular structural analysis;
- Understand how to determine a molecular identity based on mass spectra;
- To gain insight in the application of mass spectrometry for local surface analysis and the generation of molecular images;
- To become familiar with data analysis technique for mass spectral interpretation, spectral libraries and “omics” based data analysis.

Description of the course
Physics, chemistry, bio-chemistry, and all their various subdisciplines find their way into the general topic of mass spectrometry. Experimentation starts with a good understanding of the physics of the technology. In this course, students will acquire core knowledge and skills to understand and utilize a complete mass analyzer. Additionally, students will develop in-depth knowledge of the theory, physics, chemistry and practical implementation of modern mass spectrometry systems. They will dissect the details on the different ionization mechanisms and the effect these have on the nature and type of detected molecules. Students will gain insight in the manipulation of molecules, ions and electrons and their interaction using electric, radiofrequency and magnetic fields to understand the physical, chemicaland biological properties of a molecule. They will also apprehend the achievable molecular resolution andthe detailed approaches for molecular structural analysis. The design and construction of different ion sources, ion optical systems and complete mass spectrometers will be discussed to provide the studentswith the competences to utilize innovative MS-based instruments across scientific disciplines. A key learning objective is the analysis of mass spectral data for compound identification with spectral librariesand databases. Each course element will be illustrated using everyday examples of applied mass spectrometry across the scientific disciplines.

Literature
Mass Spectrometry Principles and Applications, de Hoffman, articles to be distributed.

Instructional format
Lectures, tutorial group meetings and journal club meetings.

Assessment
- Presentation of gained knowledge for specific technology on basis of concise literature research;
- Weekly tutorials attendance and contributions;
- A final examination consisting of short answer and explanation questions and mass spectral interpretation assignments.

INT3001 The Philosophy of Technology

Note: this course fulfils the LAS topic requirement

Course coordinator

Tsjalling Swierstra, Faculty of Arts and Social Sciences.

Contact: t.swierstra@maastrichtuniversity.nl

Pre-requisites

- ✓ PRO1002 Research project

Co-requisites

- ✓ None

Objectives

- To teach students to think critically about the social, political and ethical impacts of technology and science on the contemporary world;
- To introduce a number of key thinkers, approaches and themes in the philosophy of technology;
- To grasp the important contribution philosophy can make to understanding technological and scientific developments;
- To further acquaint students, following course PRO1001, with humanistic interpretations and analyses of science and technology.

Description of the course

Technology is everywhere. From care robots to GMOs, from the internet to genome sequencing – it impacts every aspect of our lives, from how we care for each other, to what we eat, what we know and how we age. Technological innovations usually come with a series of bright promises: robots will reduce tedious manual labor; medical innovations will help eliminate disease; the internet will democratize society and foster peace. But history teaches us that well-intentioned scientific and technological developments rarely do only what they set out to do. They often have unforeseen consequences and contribute to far-reaching transformations of our scientific and social worlds. Can we try to anticipate these transformations? Are there recurrent promises and societal impacts that we can identify? Can westeer technological development in a certain direction? What is the relationship between technology, society and the good life? This course offers an overview of the main themes and approaches in the philosophy of technology, to help you learn to reflect critically on how techno-scientific innovations impact society. We will study key classic and modern philosophers of technology and apply their work tonew and emerging science and technology, including: the use of genetic screening and psycho- pharmaceuticals for enhancement purposes, the role of artificial intelligence in the automation of work,and the use of the smart technologies in medical and other types of surveillance.

Literature

Swierstra, T., Lemmens, P., Sharon, T., Vermaas, P. (Eds) (2022). *The Technical Condition. The Entanglement of Technology, Culture, and Society*. Boom. [isbn 978 90 8953 895 6]
Additional obligatory readings will be provided in the course manual; For the assignments, students have to find some literature themselves.

Instructional format

Lectures and tutorial group meetings.

Assessment

- Preparation of reading materials and active participation in group discussions;
- Participation in a debate that will take place in class;
- A mid-term assignment (33,3%);
- A final take-home exam on issues, literature and perspectives discussed in the course (66,6%).

INT3002 Advanced Microscopy: Theory and Applications

Course coordinator

Dimitris Kapsokalyvas (MOLCELB), Faculty of Health, Medicine and Life Sciences.
Contact: d.kapsokalyvas@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Recommended

- ✓ PHY1001 Elements of Physics or PHY1101 Introduction to Physics

Co-requisites

- ✓ None

Objectives

- To acquaint the student with an understanding of principles of optical microscopy and limiting factors in resolution;
- To introduce and detail a number of microscope techniques and the theory behind them;
- To discuss the factors that limit contrast, resolution, and penetration depth of these techniques;
- To explain sample preparation procedures;
- To have hands-on experience with each of the techniques.

Description of the course

Light microscopy is an established visualization method used in many fields as a standard analysis tool - from histopathological examination of biopsies, to observation of rare minerals' optical properties. Technological advances in light sources and electronics have made possible the development of advanced imaging modalities. Such modalities can be used to image anything from the detailed structure of the nuclear pore, to the development of a whole zebrafish embryo in real time, with subcellular resolution. Advanced techniques include Confocal microscopy, Two-photon microscopy, Light Sheet microscopy and Super-resolution microscopy. In this course the advantages and disadvantages of each technique are going to be discussed and relevant applications are going to be presented. Practical sessions will help students get acquainted with such techniques and experience how microscopic images are created. Basic image processing of these images is going to be performed. This course is aimed at any student with an interest in imaging and its principles.

Literature

TBC

Instructional format

This course follows the Problem-Based Learning (PBL) method. Each week of this course, one of the microscope techniques takes central stage, first in a lecture, then in two tutorial meetings. During these tutorial meetings participants will combine hands-on practical experience and PBL to solve problems and case studies in the field of microscopy. This way, optimal understanding of both optical theory and its applications in the natural sciences is achieved. Lectures and PBL are given at the advanced optical microscopy facilities of the Faculty of Health, Medicine, and Life sciences.

Assessment

Will consist of the combination of

- Weekly assignments - Image Portfolio;
- Written exam at the end of the course.

INT3003 Biomaterials

Course coordinators

Dr. C. Mota & Dr. P. Wieringa, Department of Complex Tissue Regeneration, MERLN Institute for Technology-Inspired Regenerative Medicine, Maastricht University.
Contact: c.mota@maastrichtuniversity.nl
Contact: p.wieringa@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry

Co-requisites

- ✓ None

Objectives

- To provide an overview of all materials that are used in biomedical applications;
- To understand the synthesis and structure of different biomaterials; metals, ceramics, polymers, and composites thereof;
- To introduce the student to the evaluation, characterization, and testing of biomaterials;
- To introduce the student to the selection of processing techniques and their working principles;
- To provide a detailed understanding of the interaction of biomaterials with surrounding tissues and the complete organism;
- Translational pathway of the different biomaterials to clinical applications.

Description of the course

What makes a material a biomaterial? The overall objective of the course Biomaterials is for the student to gain insight in the role that materials can play in solving biomedical problems. Relevant questions inthis context are: which requirements make a material suitable for a specific biomedical application? Which biomedical problem is to be solved, and which material offers the best solution? What manufacturing techniques should be considered? A logical framework will be introduced to help navigate the selection criteria to match an application with a possible biomaterial solution.
A biomaterial is defined as "any substance or combination of substances, other than drugs, synthetic or natural in origin, which can be used for any period of time, which augments or replaces partially or totally any tissue, organ or function of the body, in order to maintain or improve the quality of life of the individual". In this course, the exact structure and physico-chemical characteristics of various biomaterials (metals, ceramics, polymers, composites) will be explained. For instance, the composition,degradation behavior and mechanical properties are important parameters. The working principles of the processing techniques commonly used to modify a raw biomaterial to develop a clinical product willbe explained. The techniques that are used to evaluate the physico-chemical characteristics of biomaterials are, consequently, an important subject. Furthermore, the interactions between different biomaterials and the biological environment (cells, extracellular matrix, tissues, organs) will be studied. The concepts of biocompatibility, bioinertness and bioactivity will be introduced, as well as various methods used to determine the biological response to a biomaterial. The translational pathway will be explained highlighting the complex implementation necessary to bring a biomaterial medical product tothe clinic.

Literature

Biomaterials Science: An Introduction to Materials in Medicine ISBN 9780123746269 (hardcover), ISBN 9780080877808 (eBook). Ebook available Maastricht University library.

Instructional format

Lectures, tutorial groups meetings and a small research based project using literature resources.

Examination

- Two multiple choice mid-terms;
- A poster presentation on the short project concerning biomaterials research;
- A final examination with open questions.

INT3005 Biobased Materials and Technology

Course coordinators

Prof. Yvonne van der Meer, Aachen Maastricht Institute for Biobased Materials.

Contact: Yvonne.vanderMeer@maastrichtuniversity.nl

Dr. Katie Saralidze, Aachen Maastricht Institute for Biobased Materials

Contact: k.saralidze@maastrichtuniversity.nl

Prerequisite

CHE2001 Organic Chemistry

Objectives

- To understand what biobased materials are and what their impact is on the environment and society;
- To study different types of feedstocks and their conversion pathways via biorefineries towards biobased building blocks, intermediates, and materials;
- To understand the relationship between material composition, properties, applications, and circularity approaches;
- To understand the impact of biobased materials and technologies on the environment (biodegradation, composting, recycling, sustainability assessment, carbon footprint);
- To apply and integrate the acquired knowledge of biobased materials on a case study.

Description of the course

Concerns about climate change and the security of industrial feedstock sources have accelerated the interest and development of biobased materials. However, scientists, policymakers, and companies face technical, environmental, and societal challenges to implement the transition from a linear and fossil-based to a circular and biobased society.

The scientific field of Biobased Materials provides a multidisciplinary approach in which biology, chemistry, chemical engineering, and sustainability assessment are integrated to develop the materials of the future. This creates an opportunity to not only replace currently made materials (like plastics and polymers) with biobased alternatives but also to produce new materials with additional functionalities derived from renewable biological sources. New technologies may be required to obtain suitable synthesis routes to produce biobased materials, with tunable performance properties forapplications in the health industry, packaging, consumer products, textiles, etc.

This course exploits the development of biobased materials involving the biology of biological feedstock, the chemistry of biobased building blocks and polymers, the technical processes, principles of circularity, and environmental and societal implications. This course also aims to create a critical as well as a creative attitude towards biobased materials and technologies. The students should be able to recognize the challenges and possibilities concerning materials in the transition towards a sustainable biobased circular economy and society.

Literature

A list of selected scientific papers will be provided during the course.

Instructional format

Lectures, guest lectures from experts in different fields, and tutorial group meetings.

Assessment

- Presentation + discussion session on a particular biobased material/technology (at least 40 minutes). The case study for the presentation can be selected by the students;
- Peer review report of assigned presentation;
- Written exam.

INT3007 Systems Biology

Course coordinators
Dr. Martina Summer-Kutmon, Maastricht Centre for Systems Biology (MaCSBio), Department of Bioinformatics (BiGCaT).

Contact: martina.kutmon@maastrichtuniversity.nl

Dr. Judith Peters, Department of Cognitive Neuroscience.

Contact: j.peters@maastrichtuniversity.nl

Pre-requisites
- ✓ PRO1002 Research Project

Co-requisites
- ✓ None

Recommendations
- ✓ We strongly advise students to have followed at least one level 2000 course in biology, chemistry, mathematics, or neuroscience. Third year DKE students interested in following the course are welcome to contact us about a waiver for the pre-requisite.

Objectives
- To give an overview of the relevant areas of Systems Biology from cellular to tissue to whole-body level;
- Studying relevant mathematical and computational techniques;
- Understanding complex and multiscale biological processes;
- Applying this knowledge about complex systems in concrete biomedical contexts;
- Integrate mathematical and biological concepts;
- To introduce the student to the major Systems Biology tools and software.

Description of the course
With the progress of genome sequencing and other -omics technologies, a wealth of multilevel data on the molecular nature of biological systems has been generated. Although systems are composed of elements, the essence of a system lies in its dynamics and interactions. It is evident that neither the biologist nor the mathematician can integrate their current expertise and knowledge in the required way. Systems biology must fill that gap. Systems biology is a new approach to biological and biomedical research based on a more holistic perspective and relying on the use of mathematical and computational models, complementing experiments in the lab.
The goal of this course is to provide an overview of systems biology and its building blocks, experimental approaches, and a variety of mathematical models and tools. Students will be introduced to the mathematical basis of dynamic systems, networks, and constraint-based modelling. We discuss many examples from amongst others cancer metabolism (molecular modeling), neuroscience (tissue-level modeling), and diabetes (whole-body level modeling). Practical skills will be trained in computer practicals. Successful participation at this course is the perfect preparation for a Master in Systems Biology.

Literature
A list of papers and suggested books for additional information will be provided during the course.

Instructional format
Lectures, tutorial group meetings, and computer practicals.

Assessment
- A final written exam;
- A group presentation.

INT3008 Regenerative Medicine

Course coordinator

Prof. L. Moroni, MERLN Institute for Technology-Inspired Regenerative Medicine, Complex Tissue Regeneration Group, FHML, Maastricht University.

Contact: l.moroni@maastrichtuniversity.nl

Pre-requisites

- ✓ BIO2001 Cell Biology
- ✓ CHE2001 Organic Chemistry

Objectives

The objectives of the course "Regenerative Medicine" are to introduce students to classic and novel concepts at the base of strategies to regenerate tissues and organs. The courses will briefly overview the biomaterial classes used to fabricate scaffolds and the processing technologies used for fabrication. Further insights on cell sources and cell nutrition will be explained. Different applications will be discussedspanning from skin to skeletal tissues and organ regeneration. After attending the course, students willbe able to understand:

- Biomaterials and processing technologies used to fabricate scaffolds for tissue engineering;
- Cell sources and activity;
- Cell nutrient limitations in engineered tissues and technologies used to enhance cell viability;
- Successful and unsuccessful strategies to regenerate tissue and organs;
- Ethical principles revolving around regenerative medicine and clinical applications.

Description of the course

Regenerative medicine has been defined as an interdisciplinary field that integrates principles of engineering and life sciences to develop biological substitutes that restore, maintain, or improve tissue and organ functions. Three main gears are generally needed to achieve tissue regeneration: cell-based therapies, tissue-inducing factors, and biocompatible matrices or scaffolds. These components have been investigated singularly or in combination to create engineered tissues. Regenerative medicine research includes the following areas:

- Biomaterials: including novel biomaterials that are designed to direct the organization, growth, and differentiation of cells in the process of forming functional tissue by providing both physical and chemical cues;
- Cells: including enabling methodologies for the proliferation and differentiation of cells, acquiring the appropriate source of cells such as autologous cells, allogeneic cells, xenogeneic cells, stem cells, genetically engineered cells, and immunological manipulation;
- Biomolecules: including growth and other differentiating factors;
- Biofabrication: including technologies that enables the production of scaffolds and biological constructs;
- Engineering design aspects: including 2D cell expansion, 3D tissue growth, bioreactors, engineering of surface properties to guide cell-material interactions, vascularization, cell and tissue storage and shipping (biological packaging);
- Biomechanical aspects of design: including properties of native tissues, identification of minimum properties required for engineered tissues, mechanical signals regulating engineered tissues, and efficacy and safety of engineered tissues.

In this course, we will introduce most of these elements through some examples that have already successfully reached the clinics and others that have still to be further improved to enter daily clinical practices.

Literature

- "Tissue Engineering", editors J. de Boer and C.A. van Blitterwijk, Academic Press Series in Biomedical Engineering, Elsevier Inc (2015).
- "Principles of Regenerative Medicine", editors A. Atala, R. Lanza, J.A. Thomson, and R.M. Nerem, Elsevier Inc (2008).

Instructional format

Lectures, tutorial groups meetings, a small research based project using literature resources.

Assessment

- A final examination, which consists of open questions;
- A written report;
- An oral presentation on the short project concerning regenerative medicine research.

INT3009 Chemical Ecology

Note: This course only runs in alternate years (even), alternating with BIO3002 Ecophysiology (odd). It will run in academic year 2022-23, but not in 2023-24.

Course coordinator

Dr. John Sloggett, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: j.sloggett@maastrichtuniversity.nl

Pre-requisites

- ✓ BIO2001 Cell Biology
- ✓ CHE2001 Organic Chemistry

Co-requisites

- ✓ None

Objectives

- To understand what chemical ecology is;
- To gain a knowledge of the chemical bases of a diversity of intraspecific and interspecific interactions;
- To understand the contributions that both chemists and biologists make to chemical ecology;
- To understand a variety of the methodological techniques used in chemical ecology;
- To understand how semiochemicals may be used in human endeavours such as pest control.

Description of the course

Chemical ecology is the study of how chemicals, called semiochemicals, mediate interactions within and between species. In this course we will examine how the different classes of semiochemicals are used by organisms. We will examine how chemists and biologists study these interactions and how some of these interactions can be used to assist humans, by manipulating organisms in the nature.

Literature

Scientific papers.

Instructional format

Lectures, tutorial sessions and seminars.

Assessment

- Research pitch;
- Exam.

INT3010 Science and the Visual Arts

Course coordinator

Dr. Vivian van Saaze, Faculty of Arts & Social Sciences.

Contact: vivian.vansaaze@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To get acquainted with an important field of applied scientific research: conservation science;
- To obtain understanding of the historical development of conservation science as a discipline and profession;
- To obtain understanding of how scientific practices function in cultural contexts such as fine arts conservation;
- To recognise the debates and controversies scientific research and its applications may raise in the context of the arts;
- To acquire some hands-on experience with the laboratory practice of fine arts conservation.

Description of the course

This course is ideal for students who are interested in the broad application of science and in the interaction between science and the fine arts. Contemporary conservation of paintings, sculptures and other works of visual art is unthinkable without the natural sciences. Since the 19th century, scientists have investigated the behaviour of paints and other materials such as plastics in order to prevent or repair degradation. Sophisticated spectroscopic techniques are employed to look through paint layers and discover hidden information. Laboratory analytical techniques are used to identify and help characterise materials used by artists to create art works and those used by conservators to repair them. Time and again, however, the question is raised how the information provided through these techniques relates to the aesthetics of the artworks. This course will trace the breaking of disciplinary boundaries; the growing impact of the sciences in the fine arts and their conservation and how it has reframed the way museums define their task of preserving and presenting cultural heritage. Actual case histories, like the much disputed restoration of Barnett Newman's painting Who is Afraid of Red, Yellow and Blue III and the interdisciplinary research project around Mondrian's Victory Boogie Woogie will illustrate both the tensions and the fruitful collaborations between the scientific and the aesthetic approaches to art. This course is developed together with the Stichting Restauratie Atelier Limburg (SRAL: http://www.sral.nl/en)) and is a unique opportunity to work with professional experts from a wide arrayof disciplines. Theoretical discussions are provided context through practical sessions given at the SRAL studios by their conservation staff. Students will handle art works, investigating their materiality and discover the manner in which they are constructed using non-invasive non-destructive analytical techniques and equipment.

Literature

Selected articles and chapters will be provided to the students.

Instructional format

Lectures, tutorial group meetings, conservation studio workshops and practical exercises.

Assessment

- A final examination, which consists of essay questions;
- A PowerPoint presentation on a selected conservation problem;
- A mid-term examination;
- The contributions to the tutorial group meetings.

MAT1006 Applied Statistics

Note: this course fulfils the MAT requirement.

Course coordinators

TBD, Faculty of Science and Engineering, Maastricht Science Programme

Contact: msp-studentaffairs@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To enhance students' understanding of the basics of inferential statistics;
- To broaden the scope of statistical methods that students are acquainted with by introducing a number of widely used applied tests that were not covered in PRA1002;
- To understand how researchers determine required sample sizes for a number of (simple) designs and to be able to apply these methods;
- To familiarize students with statistical software, so that they can independently run the analyses that are covered in this course and are able to correctly interpret the corresponding output.

Description of the course

At the end of this course, students should be familiar with the basic concepts of inferential statistics, and will be able to perform basic statistical analyses in a variety of scenarios.
In most scientific research, researchers have to deal with the problem of drawing conclusions about a population characteristic of interest, relying only on a sample of observations from that population. Inferential statistics is a way to tackle this problem. This course starts by covering the foundations of inferential statistics, emphasizing the logic behind the statistical reasoning process. This logic is the basisfor explaining a number of widely used applied statistical methods: ANOVA, Chi-square and Nonparametric tests. Students will learn how to run each of these methods using the statistical softwarepackage SPSS. Additionally, they will learn how to determine the required number of observations needed to be able to show, with a fixed probability, a specified research hypothesis.

Literature

Suggested: Statistics for the Life Sciences (5th ed.) by Samuels, M.L., Witmer, J.A. & Schaffner, A. Publisher: Pearson (2016).

Instructional format

Lectures and tutorial group meetings.

Examination

- A midterm assessment (topics: weeks 1 through 3);
- A final exam (topics: week 1 through 6).

MAT1007 Mathematical tools for scientists

Note: this course fulfils the MAT requirement.

Course coordinator

Dr. Claire Blackman, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: c.blackman@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Note: It is not intended that this course be a pre-requisite for further mathematics courses.

Objectives

- To acquire an understanding of mathematical tools that are useful in solving problems within the Natural Sciences;
- To be able to apply these tools to appropriate situations and correctly evaluate numerical solutions;
- To gain an appreciation of the suitability for using mathematical tools in certain scientific situations and develop a lifelong appreciation for the use of mathematics in science.

Description of the course

This course builds on the material in PHY1101 and introduces some new concepts that are important in many natural sciences. It is most suitable for students interested in taking non-mathematical focused courses who want to further their understanding of mathematics. (Physics, mathematics and computer science focused students should expect to take other Mathematics courses – rather than this one).
The topics covered include further differentiation and integration, differential equations, mathematical series, exponential decay and growth. Some vectors and matrices may be covered, as well as an introduction to linear algebra. This course will focus on the application of mathematical tools to problems which are challenging or impractical to solve without them.

Literature

- Active Prelude to Calculus, Matthew Boelkins, 2019, https://activecalculus.org/;
- Active Calculus, Matthew Boelkins, David Austin & Steven Schlicker, 2018, https://activecalculus.org/;
- Active Calculus Multivariate, Steven Schlicker, David Austin & Matthew Boelkins, 2018, https://activecalculus.org/;
- Other open source mathematical literature will be used as required to supplement the above texts.

Instructional format

This course follows a derivative of the Problem-Based Learning (PBL) method. Each week of this course consists of a lecture and two tutorial meetings. In parallel to these there will also be ‘individual exercises’to be completed outside of the classroom.

Assessment

- Online quizzes;
- Written assignment;
- Midterm;
- Final examination.

MAT2002 Optimization

Note: this course fulfils the MAT requirement.

Course coordinator

Dr. Georgios Stamoulis, Faculty of Science and Engineering, Department of Data Science and Knowledge Engineering.

Contact: georgios.stamoulis@maastrichtuniversity.nl

Pre-requisites

- ✓ MAT2004 Linear Algebra

Recommended

In addition, it is very useful to understand approximation by Taylor series and basics of (multivariate) calculus.

Co-requisites

- ✓ None

Objectives

- To become familiar with the basic concepts and methods of optimization;
- To understand how techniques from calculus and linear algebra are useful for optimization;
- To become familiar with a diversity of optimization problems and solution techniques;
- To be able to cast certain real-world problems into the form of optimization problems;
- To be able to solve certain optimization problems with software (Matlab).

Description of the course

Optimization occurs in most branches of science and in many different forms. In this course we address the most common and basic optimization techniques. First, we consider unconstrained functions in several variables. We discuss stationary points and optima, and provide analytical methods based on solving systems of equations. Computer implementations use iterative numerical techniques (gradient methods and hill climbing, Newton methods, etc.) Next, we address linear functions subject to linear constraints, which give linear programming problems. These have many applications, and several solution methods are available (e.g., the simplex algorithm, interior point methods and primal-dual methods). We discuss many examples and exercises. To demonstrate the wide range of applicability, these are taken from different fields of science and engineering.

Literature

Hand-outs will be distributed during the course.
Recommended literature:

- F.S. Hillier and G.J. Lieberman: Introduction to Operations Research (10th edition). McGraw-Hill, 2015 ISBN 978-0-07-352345-3;
- A.D. Belegundu and T.R. Chandrupatla: Optimization Concepts and Applications in Engineering (2nd ed.). Cambridge University Press, 2011.

Instructional format

Lectures and exercises, in order to study optimization in a mixed and interactive way.

Assessment

A written final exam, with open question.

MAT2004 Linear Algebra

Note: this course fulfils the MAT requirement.

Course coordinator

Mathias Staudigl, Faculty of Science and Engineering, Department of Data Science and Knowledge Engineering.

Contact: m.staudigl@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

In this course we provide an introduction to the main topics of linear algebra. Emphasis is on an understanding of the basic concepts and techniques, and on developing the practical, computational skills to solve problems from a wide range of application areas.

Description of the course

Linear algebra is incredibly useful in many fields ranging from statistics, computer vision to chemistry and biology. The lectures and tutorials will include examples from many areas of science, and the recommended textbook contains even more examples from a wider range of applications.
Throughout the course we maintain a strong emphasis on the geometrical interpretations, illustrating our understanding of the mathematics at play.
We start with matrices, and their usages. We then look at linear transformations and move into vector spaces. We build up to understanding and calculating eigenvalues and eigenvectors, we then look at howto simplify large matrices through techniques such as diagonalization and finish with practical examples how linear algebra is used in data analysis across the modern sciences.

Literature

Lay, David C. (2012). *Linear Algebra and Its Applications.* 5 th ed.). Pearson.ISBN 13: 9780321982384.

Instructional format

Every week we will have one lecture and two tutorial sessions. The tutorials are devoted to the working on examples illustrating and supporting the theory learned in the lecture. Whenever useful, we will use numerical linear algebra software.

Assessment

The following assessment points apply to this course:

- 2 take home assignments (one around week 3, the other at the end of the period);
- An extended problem set .

For those who do not score sufficiently in these assessment points, there will be a resit exam covering the material of the entire course. Depending on the prevailing covid measures, the resit will either be an online examination or a written exam on campus.

MAT2005 Statistics

Note: this course fulfils the MAT requirement

Course coordinator

Dr. Gijs Schoenmakers: Faculty of Science and Engineering, Department of Data Science and Knowledge Engineering.

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To have deep understanding of fundamental concepts in probability and statistics, including how these concepts are derived, why they are useful, what assumptions you have to pose when applying them, etc.;
- To be familiar with the most frequently used probability distributions/densities and statistical procedures (statistical estimation and hypothesis tests), here again with focus on the deep understanding as opposed to approaching these concepts as a "black box" or a "recipe";
- To develop a critical thinking when deciding whether certain statistical procedure is the most suitable for a certain problem, as opposed to blindly applying a pre-specified procedure;
- To be able to read and summarize scientific articles in applied probability/statistics.

Description of the course

Many real-life situations involve uncertainty and give rise to problems in the fields of probability theoryor statistics. In this course, the focus will be on the deep understanding of tools which are necessary to analyse such situations. Firstly, we will address (or refresh) basics of probability theory and the underlying combinatorial principles, because it is impossible to properly understand statistical conceptswithout understanding probability and its mathematical foundations. Subsequently, we will focus on (both discrete and continuous) random variables, concepts of expectation, mean, variance and independence, proceeding to probability distributions (e.g. discrete uniform, binomial, multinomial, hypergeometric, geometric, Poisson, continuous uniform, normal, gamma, exponential). Here we will learn for what problems these distributions are useful and under which assumptions they can/should beapplied, stressing also common misconceptions when trying to apply certain concept blindly (which unfortunately happens very often among applied scientists). We will extend our scope to multi- dimensional random variables and joint, conditional, and marginal probability distributions. We will alsodiscuss random sampling, sample distributions of means and variances, and the central limit theorem, again focusing on common misconceptions related to these topics. Then we address statistical estimation(point estimation and interval estimation; confidence intervals). Finally, we will discuss various hypothesis tests, goodness-of-fit tests and tests for independence and homogeneity. In their presentation/report, students will focus on a selected statistical topic and how this can be applied in practice, using scientific articles in applied probability/statistics as their study source.

Literature

- Book: Walpole, Myers, Myers & Ye: Probability & Statistics for Engineers & Scientists. Any edition (pdf format will be provided);
- Lecture notes and selected scientific articles (will be provided via Canvas).

Instructional format

Lectures and tutorials.

Assessment

- A midterm exam (topics: first half of the course, worth 40% of the final grade);
- A final exam (topics: second half of the course, worth 40% of the final grade);
- A layman's description of a selected statistical topic (worth 20% of the final grade).

MAT2006 Calculus

Note: this course fulfils the MAT requirement.

Course coordinator

Mirela Popa, Faculty of Science and Engineering, Department of Data Science and Knowledge Engineering.
Contact: mirela.popa@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Co-requisites

- ✓ None

Objectives

- To become familiar with functions and limits;
- To become familiar with differentiation and integration;
- To understand how to use differentiation and limits/continuity of a function to sketch the graph of a function;
- To become familiar with sequences and series;
- To understand the basic of differential equations and Taylor series.

Description of the course

In this course, we will discuss, among others, the following topics: limits and continuity, integration and differentiation, inverse and transcendental functions, mean value theorem, sequences and series. In addition to the main facts and concepts, problem solving strategies will be discussed as well. Both the intuition behind the concepts and their rigorous definitions will be presented along with a number of examples and formal mathematical proofs, to facilitate a better understanding of the concepts. Furthermore, these objectives will be reinforced through short digital interactive sessions organized during the lectures.
Knowledge and understanding: Calculus offers an indispensable basis, in the contents as well as in the methodologies, for studying and applying exact sciences, which will be built on during the rest of the curriculum.
Applying knowledge: The skills and facts which are taught in this course are of use for most of modern engineering or scientific problems. After the completion of the course, the students should be able to solve simple problems in the areas mentioned above and to judge the validity of a mathematical argument, which is related to the material of the course.
Skills: After having passed the exam, the student will be able to tackle not only the standard type of problems (graph-drawing, calculation of maxima and minima of functions, computing limits, summing infinite series etc.), but also apply his/her knowledge to considerably more relevant problems.

Literature

Recommended literature:

- Calculus, A Complete Course by A. Adams and C. Essex, 8th Edition – Pearson 2014;
- Thomas’ Calculus' by M. Weir, J. Hass, and C. Heil, 12th Ed. Or newer – Pearson.

Instructional format

Lectures and exercises.

Assessment

- A written midterm exam;
- A written final exam.

All examinations include open questions.

MAT2007 Introduction to Programming

Course coordinator
Francesco Barile, Faculty of Science and Engineering Department of Data Science& Knowledge Engineering.
Contact: f.barile@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
- Identify, interpret and apply fundamentals of imperative programming such as variables, conditionals, iteration, etc.;
- Identify, interpret and apply fundamentals of object-oriented programming, including defining classes, invoking methods, using class libraries, etc.;
- Give examples of important topics and principles of software development;
- Point out obvious mistakes in programs and analyze how they run;
- Design, compose and evaluate programs that solve specific problems;
- Use a software development environment to create, debug, and run programs.

Description of the course
The course provides the basics of computer science and computer programming. After a shortintroduction to computer organization, the principles of structured programming in Java are presented.The main topics of the course are: data types, statements and sequential execution, conditional statements, loops, methods, and recursion. Final part of the course introduces students to the conceptsof object-oriented programming design and teaches them how to design their own classes to model andsolve several problems. No prior programming experience is assumed.

Literature
- Allen B. Downey, Think Java: How to Think like a Computer Scientist, Green Tea Press, 2012. http://www.greenteapress.com/thinkapjava/;
- David J. Eck, Introduction to Programming Using Java, Sixth Edition, 2011. http://math.hws.edu/javanotes/;

Instructional format
Lectures, tutorials and lab group meetings.

Assessment
- A final examination, which consists of questions related to the course material;
- Programming assignments;
- Lab exercises.

MAT2008 Differential Equations

Note: this course replaces MAT3004 Differential Equations. If you have successfully completed MAT3004 you may not participate in MAT2008. This course fulfils the MAT requirement.

Course coordinator

Dr. Claire Blackman, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: c.blackman@maastrichtuniversity.nl

Pre-requisites

- ✓ MAT2006 Calculus

Objectives

- To develop the insight that certain problems in natural sciences can be modelled through differential and difference equations;
- To be able to solve specific types of differential and difference equations, including linear differential and difference equations, with constant coefficients.

Description of the course

In many Sciences, among which Physics, Chemistry, Biology, Computer Science and Economics, differential and difference equations help to model processes of change. In this introductory course, we will focus on the basics of differential and difference equations. In particular, we study first order difference and differential equations as well as the solution set of higher order linear versions of these, having constant coefficients.

Literature

Handouts will be distributed during the course (Canvas). Examples of books on (ordinary) differential equations are:

- An Introduction to Ordinary Differential Equations – J.C. Robinson – 2004 – Cambridge University Press;
- A first course in Differential Equations with Modelling Applications – D.G. Zill – 2013 – BROOKS/COLE Cengage Learning;
- Ordinary Differential Equations – W. Adkins and M. Davidson – 2012 – Springer;
- Onlinear dynamics and Chaos, 2nd Ed. – Steven H. Strogatz – 2015 – Westview Press.

Instructional format

Lectures and exercises.

Assessment

- Online quizzes;
- Written midterm exam;
- Written final exam with open questions.

MAT2009 Multivariable Calculus

Note: this course fulfils the MAT requirement

Course coordinator

Dr. Claire Blackman, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: c.blackman@maastrichtuniversity.nl

Pre-requisites

- ✓ MAT2006 Calculus

Recommended

- ✓ MAT1002 or MAT2004 Linear Algebra (highly recommended)

Objectives

This course is intended to introduce Science students in the essential mathematics to describe continuous systems with multiple variables, especially to analyse continuous time-varying systems as they occur in Electromagnetism, Hydrodynamics, and Quantum Mechanics.

Description of the course

Multivariate calculus is the extension of calculus of one variable to calculus with functions of several variables: notably the differentiation and integration of functions involving multiple variables. Considerable attention will be devoted to vector calculus, with focus on differentiation and integration of vector fields, primarily in 3-dimensional Euclidean space. Other topics include the curvature and torsionof curves and manifolds, differential geometry, and orthogonal parameterization, and partial differential equations of multiple variables. Throughout the course, we maintain a strong emphasis on its applicationin Physics and Chemistry.

Literature

We will use (note that you use the right edition!!!): "Calculus, A Complete Course" by A. Adams and C. Essex, (7 or 8) th Edition – Pearson 2014

Instructional format

The course consists of 6 weeks, each week containing one lecture and two tutorial class. The tutorial class uses a mixture of case studies and sets of exercises.

Assessment

There will be two written exams on parts of the course:

- The first of these takes place around the midpoint of the course;
- The second in the last week of the course.

For those who do not pass these tests and are eligible for a resit according to MSP's rules and regulations, there will be a resit exam provided on the entire course in the resit week.

NEU1001 Introduction to Neuroscience

Course coordinator

Dr. L. de Nijs, School for Mental Health and Neuroscience, Division neuroscience, FHML, Maastricht University.

Contact: laurence.denijs@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Recommended

- ✓ Knowledge of biology and chemistry at the high school level is assumed.

Objectives

- To introduce the students to the field of neuroscience, the study of the nervous system;
- To provide fundamental basis of the anatomy, development, and physiology of the nervous system.

Description of the course

This course begins with the study of the nervous system structure, ranging from the macroscopical to microscopical level, and its development. Next, the fundamental mechanisms by which information flows within and between nerve cells will be addressed. This includes the aspects of membrane permeability, action potential generation and propagation, synaptic transmission, post-synaptic mechanisms of signal integration and the construction of neural circuits. Finally, the vascular system and the microenvironmentof the brain will be discussed.

Literature

- M.F. Bear, B.W. Connors, M.A. Paradiso. Neuroscience, Exploring the Brain. Wolters Kluwer Health, 2015 (4th edition);
- D. Purves, G.J. Augustine, D. Fitzpatrick, W.C. Hall, A.S. LaMantia, L.E. White, Neuroscience, Sinauer Associates, 2012 (5the edition);
- E.R. Kandel, J.H. Schwartz, T.M. Jessell, S. A. Siegelbaum, A.J. Hudspeth. Principles of Neural Science, McGraw-Hill, 2012 (5th edition).

Instructional format

Tutorial groups meetings and lectures.

Examination

- An oral presentation on the content of tutorial meetings;
- A final exam (open questions).

NEU1002 Cognitive Neurosciences: Biological Foundations of Behaviour

Course coordinator
Dr. Peter van Ruitenbeek, Faculty of Psychology and Neuroscience.

Contact: p.vanruitenbeek@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
- Students will have a basic understanding of biological foundations (emphasis on the brain) of behaviour, such as sleep/wake behaviour, language, memory, eating and drinking, and emotion;
- Comprehension of chemical control (neurotransmission and hormones) by the brain and dysfunctional control (e.g. addiction or anxiety disorders);
- A basic understanding of how to study the biological foundations of behavior;
- Obtain understanding of and experience in how present within the scientific process.

Description of the course
Why do some people develop into a male and some into a female? Does a clear dichotomy even exist? Why are we hungry in the morning?Why do people become addicted to drugs? Is our brain active during sleep? How are mood disorders explained from a neuroscience perspective? These and other questions will be addressed in this course. The most important part of our body to explain behaviour is our brain. This course will provide basic knowledge of neuroanatomy (howcertain parts of the brain are connected) and neurophysiology (how neurons operate to communicate) in order to understand several themes of behaviour (e.g. eating, addiction, sleep) and disorders.

Literature
- *Required literature*
  Neuroscience: Exploring the Brain – Bear, 4th edition;
- *Additional literature*
  A couple of journal articles will be used and several biological psychology books can be used in addition (Biological psychology – Breedlove, 2013; or Biopsychology 10th ed – Pinel, 2018; or Physiology of Behavior 12th ed – Carlson, 2017).

Instructional format
The course consists of a combination of Lectures and PBL tutorial groups.

Assessment
To do justice to the objectives of this course, students will be assessed in two different ways:

- A written exam;
- A practical assignment (oral presentation or poster).

NEU2001 Cognitive Neurosciences: Perception

Course coordinator
Lars Hausfeld, Faculty of Psychology & Neuroscience.

Contact: lars.hausfeld@maastrichtuniversity.nl

Pre-requisites
- ✓ NEU1002 Cognitive Neurosciences: Biological Foundations of Behaviour

Co-requisites
- ✓ None

Objectives
To understand the physiological basis of visual and auditory perception.

Description of the course
The goal of this course is to understand the basic physiologic principles that underlie visual and auditory perception. The course will introduce the sensory systems that are responsible for vision and hearing in humans. Central topics include the nature of the stimulus (physical attributes such as frequency and amplitude, and perceptual attributes such as colour and intensity), the transduction process (the transformation of a physical stimulus into a neural signal leading to a subjective experience), the functional neuroanatomy of the human sensory system (the organization of sensory neurons into functional maps, columns, and pathways), and mechanisms for object perception (the organization of sensory features into meaningful percepts, for example, a face in a crowd or speaker at a loud party). Finally, the course will introduce psychophysical and neuroscientific methods designed for measuring perception.

Literature
- Goldstein, E. & Cacciami, L. (2021). Sensation and perception (11th edition). Cengage Learning. [ISBN: 978-0-357-44659-1];
- E-readers.

Instructional format
Lectures and tutorials.

Assessment
- Oral presentation;
- Final exam.

NEU2002 Neuropsychopharmacology

Note: this course replaces INT3004 Neuropsychopharmacology. If you have successfully completed INT3004 you may not participate in NEU2002.

Course coordinator

Nadia Hutten, Department of Neuropsychology & Psychopharmacology, Faculty of Psychology and Neuroscience.

Contact: nadia.hutten@maastrichtuniversity.nl

Pre-requisites

- ✓ INT1002 Basic Principles of Pharmacology* or
- ✓ NEU1001 Introduction to Neuroscience or
- ✓ INT2008 Molecular Toxicology

**Note: the course INT1002 will no longer be offered at MSP.*

Co-requisites

- ✓ None

Objectives

- To know the basic principles of neurotransmission & the basic mechanism of drug-receptor interaction;
- To understand the mechanism of action of the major groups of drugs acting in the central nervous system;
- To understand the major neurotransmitter systems in the brain and their role in cognitive and affective disorders and functions;
- To understand the pharmacotherapy of anxiety disorders, CNS degenerative disorders, ADHD;
- To understand the acute and long term effects of drugs of abuse.

Description of the course

In the first part of the course the focus will be on the neurotransmission process, in particular the role of neurotransmitter receptors as a basis for understanding the mode of action of CNS drugs. The secondpart of the course will give an overview of the major classes of a number of CNS drugs: the hypnotics and sedatives, the anxiolytics, the psychostimulants, the antidepressants and the drugs used to treat CNS degenerative disorders. The pharmacology of these drugs will be put in the perspective of their clinical use. The final part of the course will be devoted to illicit drugs, their acute and long term effects,and their potential as medicines.

Literature

- Journal articles;
- Book(s) chapter(s).

Instructional format

Lectures and tutorial group meetings.

Assessment

- Written assignments;
- Presentations.

NEU3001 Neuroscience of Action

Course coordinator
Pim Heckman, Faculty of Psychology & Neuroscience.
Contact: p.heckman@maastrichtuniversity.nl

Pre-requisites
- ✓ NEU1002 Cognitive Neurosciences: Biological Foundations of Behaviour
- ✓ NEU2001 Cognitive Neurosciences: Perception

Co-requisites
- ✓ None

Objectives
The course investigates the neural implementation of action, from the lowest level of simple reflexes tothe highest level of the decision to act in order to obtain a goal.

Description of the course
The most general function of our brain is to interact with our environment to obtain what we desire and to avoid what is disadvantageous. The brain plans and executes actions to accomplish this. Actions canbe simple (e.g., picking up a pencil), effortful (e.g., endurance running), complex (e.g., dancing), or symbolic (e.g., stick up your thumb to get a ride), etc. In all of these actions our brain is involved, but not to the same degree. Evolution has organized motor functions in a hierarchical system that delegatesimportant motor and control functions to lower levels of the nervous system. This allows the brain to spent more time on other important functions, among which the selection of goals and the planning of how to pursuit them. Our understanding of the neural mechanisms of decision making, action selection,action planning, and action execution has gained a lot from studying neural disorders (Parkinson's disease, orbitofrontal patients, obsessive compulsive disorder, etc.) which will also be considered in thecourse.

Literature
- Journal articles;
- Book chapters.

Instructional format
Lectures and tutorials.

Assessment
- Oral presentation;
- Final exam.

PHY1101 Introduction to Physics

Course coordinator
MSP Staff, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: msp-studentaffairs@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ PRA1101 Introduction to Scientific Research I

Objectives
At the conclusion of this module, participants are able to:

- Explain the underlying principle of the problem solving approach in physics and apply this to the PBL classroom as a team;
- Predict outcomes from physics (thought) experiments using relevant mathematical skills and compare results obtained using different assumptions;
- Experiment and examine physical models for the natural world;
- Link different topics in physics together and demonstrate connections between them;
- Calculate the outcome of physics (thought) experiments and comment/reflect on the suitability of the answer.

Description of the course
Physics is the study of all aspects of Nature, covering the behavior of objects under the action of given forces and the nature and origin of gravitational, electromagnetic, and nuclear force fields interactions, and the nature of space, time, and matter, and their interactions. This is an introductory course in physics intended for a broad audience with a scientific interest, that comprehensively trains students to the basic, classical, and essential fundamentals of physics. The course aims at an understanding of the fundamental principles of Nature and how to apply them in concrete practical situations. The emphasis is on intuition rather than mathematical rigor; this is addressed in the follow-up physics courses. In this course we address the principal corner stones of physics. Each of these subjects is taught on a theoretical level as lectures, and trained on a practical level with exercises and by using knowledge in applied situations in PBL tasks.

Literature
The textbook for this course is a free and online textbook:
University Physics volumes 1, 2 & 3, (2016 September), OpenStax College.
Volumes available from: https://openstax.org/

Instructional format
This course follows the Problem-Based Learning (PBL).
Each week of this course consists of a lecture and two tutorial meetings. In each of the tutorial meetings we will conduct a PBL discussion and work in teams to solve exercises. In parallel to these there will also be other materials provided online for the purpose of self-study.

Assessment
- Summary of PBL session communicated in a medium of the students choosing;
- Weekly Quizzes;
- Final examination.

PHY2001 Classical Mechanics

Course coordinator
Dr. Ronald Westra, Faculty of Science and Engineering, Department of Knowledge Engineering.
Contact: westra@maastrichtuniversity.nl

Pre-requisites
- ✓ MAT2006 Calculus

Recommended
- ✓ MAT2004 Linear Algebra

Co-requisites
- ✓ None

Objectives
- To acquaint the student with the foundations of Classical Mechanics;
- To acquire general understanding of theoretical and practical methods in Classical Mechanics;
- To serve as sufficient basis for future education in physical sciences;
- To be able to apply this knowledge to concrete practical problems;
- To be able to read texts that build on the subjects of this course.

Description of the course
Classical mechanics forms the starting point for all physical science and engineering. The course aims at understanding the fundamental principles of Classical Mechanics and how to apply them in specific situations. The major topics in this course are: Single particle dynamics, Mechanical Energy, Collisions and Momentum, Rotational Motion, Angular Momentum, Rigid body dynamics, and Analytical Mechanics. The course address: statics and kinematics, Newton's laws, work and energy, momentum and collisions, rotational dynamics, and gravitation. Each of these subjects is taught on a theoretical level as lecture, and trained on a practical level with exercises and practical training sessions. Associated (but not co-required) to this course are the Physics skill courses Physics Laboratory PRA1003, PRA2007, PRA3002, involving experimental practical training sessions.

Literature
- **University Physics With Modern Physics**, Authors: HD Young, RA Freedman, Pearson Education (US), 13th International edition, May 2011;
- **Classical Mechanics, an undergraduate text**, R. Douglas Gregory, Cambridge University Press 2006, ISBN-13 978-0-521-82678-5.

Instructional format
Each week of this course is devoted to a major subject of Classical Mechanics, and consists of a plenary lecture, and two discussion group meetings. The first meeting starts with reviewing several discussion questions and practical exercises in PBL (Problem-Based Learning) format, followed by assigning some challenging assignments to student teams. In the second meeting each student team present their solution to their challenge problem. The grading of the course consists of the averages of the student presentations and the two written exams.

Assessment
- In week 4 there is a written midterm exam (MTE);
- In week 7 there is a written final exam (FE).

The final grade is based on the averages of the student presentations, the MTE, and the FE.

PHY2002 Thermodynamics and Statistical Physics

Course coordinator

Dr. Jessica Steinlechner, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.

Contact: jessica.steinlechner@maastrichtuniversity.nl

Pre-requisites

- ✓ None

Recommended

- ✓ PHY1001 Elements of Physics or PHY1101 Introduction to Physics

Objectives

- To acquire general understanding of theoretical and practical methods in Thermodynamics and Statistical Physics;
- To be able to apply this knowledge in analysis and resolution of practical problems;
- To develop an understanding and interest in state of the art research in this field;
- To connect concepts and ideas from throughout the course to build skills in applying knowledge to new and novel concepts.

Description of the course

Thermodynamics is the study of many-particle systems in terms of their macroscopic quantities such as temperature, heat, energy, and entropy. Statistical Physics relates these macroscopic quantities to the microscopic properties such as kinetic and rotational energy and vibrations, using statistics. In this course, participants will achieve comprehension of the fundamentals of Thermodynamics and StatisticalPhysics. We cover the major elements of this subject: temperature and heat, thermal properties of matter, the laws of thermodynamics, entropy, enthalpy and free energy, the relation between macroscopic parameters and microscopic dynamics, and the statistics of thermodynamic ensembles. Each of these subjects is taught on a theoretical level as lectures, and trained on a practical level with exercises and by using knowledge in applied situations in PBL tasks.

Literature

Concepts in Thermal Physics by Blundell and Blundell, Oxford University Press 2009.

Instructional format

This course follows the Problem-Based Learning (PBL) method. Each week of this course consists of a lecture and two tutorial meetings. In the tutorial meetings we will conduct PBL pre- and post-discussions and discuss the solutions to individual exercises.

Assessment

- Written or oral presentations about course content;
- Written examination.

PHY2003 Vibrations and Waves

Course coordinator
Dr. Sebastian Steinlechner, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.

Contact: s.steinlechner@maastrichtuniversity.nl

Pre-requisites
- ✓ PHY2001 Classical Mechanics

Co-requisites
- ✓ None

Objectives
- To acquaint the student with the fundamental principles of vibrations and waves as they apply to all systems;
- To develop an understanding of damped and forced vibrations, as well as normal modes;
- To identify and be able to use appropriate mathematical methods to solving problems relating to these phenomena, such as complex notation, differential equations, eigen modes and Fourier analysis;
- To understand wave characteristics such as standing waves, beats and wave packets.

Description of the course
Vibrations and waves covers the behaviour of many physical systems, be it mechanical, acoustic, electromagnetic or optical oscillations. We will investigate simple harmonic oscillators and derive a differential equation that will allow us to use the same mathematical framework for any oscillating system. Oscillations can experience damping or can be driven by external forces. An investigation of coupled oscillators will lead us to normal modes, and furthermore to oscillations that propagate – we call those waves! Waves can overlap (interfere) with each other, leading to phenomena such as standing waves and wave packets, which are fundamental for optics as well as electromagnetism.

Literature
- The Physics of Waves, H. Georgi, available for free at http://www.people.fas.harvard.edu/~hgeorgi/new.htm (2015), CC BY-NC-ND 2.5 license;
- Optional: Vibrations and Waves, G.C. King, Wiley, 2nd edition (2009).

Instructional format
Each week of this course consists of a lecture and two tutorial meetings. During the lecture, we will develop together our physical and mathematical understanding of oscillating systems. In the tutorials, we will be revisiting the contents of the lecture and deepen our understanding through exercises and example calculations. The tutorials and lectures will also contain practical demonstrations as well as computer simulations, and we will look at real-world phenomena in openly posed PBL-style problems. In parallel to these there will be individual exercises to be completed outside of the classroom.

Assessment
In accordance with the intended learning outcomes, there will be two points of assessment:

- The mid-term assessment will require you to demonstrate that you can identify and explain oscillation and wave phenomena in an experiment that you will be documenting in a video;
- The final assessment will be in the form of a written exam, where you will be able to demonstrate that you understood and can apply the mathematical framework of the course.

PHY2004 Electromagnetism

Coordinator

Prof. Dr. Benedikt Poser: Faculty Psychology and Neurosciences, Maastricht University

Contact: benedikt.poser@maastrichtuniversity.nl

Pre-requisites

- ✓ MAT2009 Multivariable Calculus

Recommended

- ✓ MAT1002 or MAT2004 Linear Algebra, PHY1001 Elements of Physics

Co-requisites

- ✓ None

Objectives

- To acquaint the student with the basics of electromagnetism;
- To acquire general understanding of theoretical and practical methods in electromagnetism;
- To serve as sufficient basis for future education in physical sciences;
- To be able to apply this knowledge to concrete practical problems;
- To be able to read texts that build on the subjects of this course.

Description of the course

Electromagnetism, also known as Maxwell theory, is the science of one of the four fundamental forces in Nature and deals with the effects of electrical charge and the associated force fields and energies. Electromagnetism unites the concepts of electricity and magnetism. These two concepts and their relations form the core of this course, which ultimately can be expressed in the four fundamental laws of electromagnetism: Maxwell's equations. Important components of the course are:

1. Electrostatics (week 1 and 2);
2. Electric Field in Matter (week 3);
3. Magnetostatics (week 4 and 5);
4. Magnetic Fields in Matter (week 6).

These topics are divided over the six lecturing weeks of the course. In addition, there will be exercises on Vector Analysis during the tutorials and as homework.

Literature

The course will closely follow the book *Introduction to Electrodynamics* by David J Griffiths, chapters 1 – 6.

Instructional format

This course follows a classic teaching format with elements of Problem-Based Learning (PBL). Each week of this course is devoted to a major subject of electromagnetism, and consists of a plenary lecture of two hours, and two discussion group meetings – each of two hours. The first tutorial meeting starts with reviewing several 'Discussion Questions' followed by the more conceptual assignments and exercises that can be studied jointly in the group. Next to these there are also "individual Exercises" to be prepared s homework for the second tutorial.

Assessment

In week 7 there is final exam (FE), which each count for 80% of the final course grade. There is a participation score that will be issued after Week 6 that counts for 20% of the total course grade.

PHY2005 Quantum Theory

Course coordinator
Dr. Keri Vos, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.
Contact: k.vos@maastrichtuniversity.nl

Pre-requisites
- ✓ MAT2004 Linear Algebra

Note: Following Linear Algebra simultaneously to PHY2005 allows for a waiver.

Co-requisites
- ✓

Recommended
- ✓ MAT2006 Calculus
- ✓ PHY2001 Classical Mechanics

Objectives
At the end of the course, students will be able to:
- Understand the foundations underlying Quantum Mechanics;
- Solve Schrödingers wave equation for analytically solvable potentials;
- Calculate QM expectation values of physical observables and their time evolution;
- Use the operator and vector space notation in calculations;
- Calculate the non-classical behavior resulting from the postulates of QM;
- Understand the modern orbital atomic model of Hydrogen and calculate the corresponding wave functions.

Description of the course
This course is an introduction to Quantum Mechanics, aimed at interested physics or chemistry students. Some prior knowledge of classical physics, linear algebra and infinitesimal calculus will help in looking through the equations and understand what is going on. When looking at the world at very small scales, classical physics (classical mechanics, electromagnetism, thermodynamics) is no longer sufficient to explain our observations. In order to describe the phenomena at these scales, we will enter the strange world of wave functions, probabilities of reality and Schrödingers equation.
Starting from the failings of classical physics, we will see the necessity of describing the world in a different way, and try to make sense of it in terms of classical variables like position and momentum. We will calculate the quantized energy states of various analytically solvable systems like the square- well potential and the harmonic oscillator, before turning to the proper linear-algebraic description of quantum mechanics. We will explore things like commutation relations of operators, Heisenberg's uncertainty principle, Pauli's exclusion principle and spin. Finally, we will do a proper treatment of the hydrogen atom in 3D and its orbitals.

Literature
"Introduction to Quantum Mechanics", David J Griffiths.

Instructional format
Lectures and tutorial group meetings.

Assessment
- Problem sheets;
- Midterm exam;
- Final exam.

PHY2006 Electronics

Coordinator
Dr. Bart van Grinsven: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: bart.vangrinsven@maastrichtuniversity.nl

Pre-requisites:
- ✓ None

Co-requisites:
- ✓ PRA2006 Electronics

Objectives
- Identify various electronic components and describe their basic functions in DC or AC circuits;
- Apply Ohm's law and Thevenin's theorem to circuits determining a range of different resistance, voltage and power values in different configurations;
- Apply basic magnetic principles to the process of AC power generation and DC motors;
- Explain the different mechanisms for conduction in various semiconductor types and how these differ from conductors and insulators;
- Sketch band-gap diagrams and IV characteristics of various materials and semiconducting components and describe how these change under different biasing conditions;
- Describe a variety of different uses for semiconductors and specify the functioning of some semiconducting devices;
- Sketch and calculate the output voltages of op-amps when in open-loop or controlled-gain circuits, when given information about the input voltages (or vice versa);
- Perform conversions and calculations in base 2 (binary), draw and simplify logic gate circuits, write out their truth tables and use Boolean algebra, de Morgan's laws and Karnaugh maps to simplify Boolean expressions and logic circuits;
- Calculate correct sampling frequencies in signal processing, resolutions for DAQ and optimal amplifications of signals;
- Apply DAQ theory to hypothetical problems solely based on the specification sheets of a DAQ card and proper description of a signal.

Description of the course
In this course you will learn the fundamentals of electronics beginning with simple electrical theory. You'll explore the role of different components and devices, learn the laws governing their behaviours and should develop an understanding of basic circuitry. You will learn about Ohm's and Kirchhoff's laws, resistances, voltages, DC and AC currents, capacitors, inductors, diodes, junctions and transistors. You'llalso cover the basics of digital electronics (logic gates and Boolean algebra). We will look at how combinations of discrete devices can be used to build up more complex circuitry and you will have the opportunity to see how electronics can be used to build up the technology which we are most familiar today from flat-screen TVs and smartphones. Nearly everything we use in this day and age relies on electronics. We hope that throughout this course you learn to appreciate how the technology around youfunctions and we hope to pull apart some electronic devices to explore their inner workings.

Literature
To be confirmed.

Instructional format
1 x 2 hour lecture per week.2
x 2 hour tutorial per week.

Assessment
- Presentation;
- Tutorial contribution grade;
- Final exam.

PHY2007 Optics

Course coordinator
Dr. Stefan Hild, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.
Contact: stefan.hild@maastrichtuniversity.nl

Pre-requisites
- ✓ PHY1001 Elements of Physics or PHY1101 Introduction to Physics

Recommended
- ✓ PHY2003 Vibrations and Waves

Objectives
- To acquire an understanding of optical systems and how they behave in nature;
- To be able to apply this understanding appropriate situations and correctly evaluate numerical solutions;
- To design imaging systems and evaluate their resolution, field of view and magnification;
- To understand the limitations and aberrations in optical systems;
- To understand and be able to apply interference and diffraction theory to a range of problems.

Description of the course
The study of optics begins with a geometrical approach, modelling light as rays which can travel accordingto specific rules. Essentially optics treats all rays as travelling in straight lines until such a point that theyreach an optical device such as a mirror, lens or obstacle. Based on these principles, we can assess thebehavior of optical devices (telescopes, microscopes, cameras for example) but also begin to understandoptical phenomena which occur in everyday life (i.e. rainbows etc.). After the geometrical approach, wewill move forward to physical optics where light is considered to be a wave. In this part more complex phenomena like polarization, interference, diffraction and their application (e.g. non-reflective coatings,Michelson interferometer,…) will be described.

Literature
To be confirmed.

Instructional format
This course follows the Problem-Based Learning (PBL) method. Each week of this course consists of an interactive lecture and two tutorial meetings. In each of the tutorial meetings we will conduct a PBL post-discussion and a PBL pre-discussion. In parallel to these there will also be ‘individual exercises’ to be completed outside of the classroom.

Assessment
- Written coursework;
- Final examination.

PHY2008 Solar System Astronomy

Course coordinator
Mr. Chad Ellington: Faculty of Science and Engineering, Maastricht Science Programme.

Contact: chad.ellington@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Objectives
- Introduce the electromagnetic spectrum and usefulness of spectroscopic observations, including: blackbody thermal radiation, emission/absorption spectra and how they can determine relative radial velocities, surface temperatures and chemical composition of objects throughout our universe;
- Interpret historical observations of planetary positions and their influence on early models of solar system motions;
- Understand the currently accepted formation scenarios of the solar nebula and how it accounts for the locations of the various planetary types; as well as the retinue of minor bodies and their locations / orbital parameters;
- Introduce scientific understanding of our solar system, including the planets, their moons, asteroids, comets and dwarf planets;
- Describe mechanisms that modify the surfaces of terrestrial planets: such as volcanism, impact cratering, tectonism (including geomagnetism) and erosion;
- Compare and contrast characteristics alongside the capabilities of various solar system bodies to retain various atmospheric constituents;
- Summarize physical properties and orbital characteristics of minor bodies, assessing whether their orbits deem them as being potential hazardous to Earth.

Description of the course
This course begins with an overview of information available by studying the spectrum of light from objects within our universe. Then we transition to historical observations of planetary motions within oursky, how it affected models of our solar system and our eventual increased understanding of the planetary laws of motion. We continue with in-depth investigations into the formation of our solar systemas well as physical characteristics (including surface/interior/atmospheric modification) of numerous solar system bodies; including: terrestrial planets, gas/ice giants & minor planet constituents such as satellites, asteroids, comets & dwarf planets.

Literature
- Ryden, B. & Peterson, B. (2020). Foundations of Astrophysics (1st ed.). Cambridge;
- Astronomy, OpenStax College. Retrieved via: https://openstax.org/details/books/astronomy;
- Selected articles and materials will be referenced/provided to the students.

Instructional format
Each week of this course focuses on various topics within our solar system, consisting of overview lectures and discussion group meetings. The first meeting will introduce the weekly group assignments/exercises with discussion questions where results with further discussions occurs in the subsequent tutor group meetings. There may occasionally be mathematical individual exercises, which may include independent research and/or observations.

Assessment
- Online assessments/surveys;
- Contributions to tutorial group meetings;
- Tutorial exercises/proposal;
- Midterms;
- Independent research/observational reports with presentation;
- Conceptual & computational final examinations.

PHY2009 Stellar Astronomy

Course coordinator
Mr. Chad Ellington: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: chad.ellington@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Objectives
- Review the electromagnetic spectrum and usefulness of spectroscopic observations, including: blackbody thermal radiation, emission/absorption spectra and how they can determine chemical composition, relative radial velocities, surface temperatures and luminosities of objects throughout our universe;
- Identify the overall structure of our Sun from core to corona, covering: nuclear fusion, highlighting structures/processes of energy transfer & how each region can be studied;
- Describe the conditions under which stars form & why their formation mass is so important;
- Synthesize apparent magnitude, surface temperature & parallax to determine information such as: stellar luminosity (absolute magnitude), distance & stellar size…comparing/contrasting with our own Sun & applying to more distant stars for which parallax information is lacking;
- Recognize spectral types of stars, being able to identify them based on surface temperature (color), spectral features, stellar mass and/or luminosity class;
- Differentiate types of binary stars and utilize observational data to find their physical properties, such as combined mass, individual mass, physical size and orbital separation (as applicable);
- Illustrate color-magnitude (H-R) diagrams, locating major types of stars as well as explaining differences for young versus old star clusters…identifying the turn-off point and how/why it is utilized to determine star cluster ages;
- Understand the importance of intrinsic variable stars, especially pulsating and cataclysmic variables and their contributions towards the cosmological distance ladder, being able to identify types based upon light curve and spectroscopic observations;
- Apply the cosmological distance ladder to determine distances to particular types of stars;
- Discuss stellar changes from formation to death, highlighting differences of low versus high mass stars from that of our Sun and how their remnants contribute to future star formation and planet formation.

Description of the course
This course begins with an overview of information available by studying the spectrum of light from objects within our universe. We then look at our own star, the Sun, covering what humanity has learned thus far about its interior structure/composition. Next, we study properties of other stars including: how they form, their 'lifetimes', 'evolution' & the many remnants they leave behind.

Literature
- Ryden, B. & Peterson, B. (2020). Foundations of Astrophysics (1st ed.). Cambridge;
- Astronomy, OpenStax College. Retrieved via: https://openstax.org/details/books/astronomy.

Instructional format
Each week of this course focuses on various topics concerning stars and stellar evolution, consisting of overview lectures and discussion tutorial group meetings. The first meeting may introduce the weekly group assignments/exercises with discussion questions where results with further discussions occurs in the subsequent tutor group meetings. There may be mathematical individual exercises, which may include independent research and/or observations.

Assessment
- Online assessments/surveys;
- Contributions to tutorial group meetings;
- Tutorial exercises/proposal;
- Midterms;
- Independent research/observational reports with presentation;
- Conceptual & computational final examinations.

PHY2010 Galactic Astronomy

Course coordinator
Mr. Chad Ellington: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: chad.ellington@maastrichtuniversity.nl

Recommended
- ✓ PHY2009 Stellar Astronomy

Objectives
- Illustrate the size/structure of our Milky Way Galaxy, how we are able to measure motions of stars/gas clouds, map its overall structure and determine our place within which;
- Compare/contrast the shapes, sizes & compositions of: spiral, elliptical, peculiar & irregular galaxies; being able to classify to which type they belong based upon imagery, orbital motions of bodies within which and/or physical content descriptions. Furthermore, evaluate the likelihood of various astrophysical objects being found within the above galaxy types;
- Evaluate observational evidence to differentiate between the top-down and bottom-up models describing galactic formation;
- Discuss competing models explaining the presence of galactic spiral arms;
- Explain the methods of determining distances to galaxies within the cosmological distance ladder, applying them to various galactic structures;
- Breakdown the historical classifications of active galaxies into the subcategories of: radio galaxies, Seyfert galaxies, quasars & blazars; understanding their impact on galactic evolution and why they are observed only at cosmological distance;
- Describe the various pieces of evidence for dark matter within most galaxies and clusters of galaxies, computing galactic masses when possible;
- Relate how observations of distant supernovae led to the discovery that our universe is accelerating in its expansion rate;
- Identify the key observations supporting the Big Bang as well as how problems with this model led to the inflationary hypothesis & the problems inflation solves;
- Summarize the eras of our universe after the Big Bang, identifying various processes that occurred within each and/or differentiated them from each other.

Description of the course
This course begins with an exploration of our Milky Way Galaxy, identifying its overall structure and our Sun's place within which. Continuing outward, we study properties of other galaxies, highlighting properties of varying types, how they form and change with time. Finishing up with how large scale observations lead us to the initial conditions of our universe and the Big Bang theory itself.

Literature
- Ryden, B. & Peterson, B. (2020). Foundations of Astrophysics (1st ed.). Cambridge;
- Astronomy, OpenStax College. Retrieved via: https://openstax.org/details/books/astronomy.

Instructional format
Each week of this course focuses on various topics concerning our Milky Way, other galactic types, large-scale structure of our universe and conditions in the early universe, consisting of overview lectures and discussion group meetings. The first meeting may introduce the weekly group assignments/exercises with discussion questions where results with further discussions occurs in the subsequent tutor group meetings. There may be mathematical individual exercises, which may include independent research and/or observations.

Assessment
- Online assessments/surveys;
- Contributions to tutorial group meetings;
- Tutorial exercises/proposal;
- Midterms;
- Independent research/observational reports with presentation;
- Conceptual & computational final examinations.

PHY3001 Quantum Mechanics

Course coordinator
Dr. Stefan Danilishin, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.

Contact: stefan.danilishin@maastrichtuniversity.nl

Pre-requisites
- ✓ PHY2005 Quantum Theory

Co-requisites
- ✓ None

Recommended
- ✓ MAT2006 Calculus
- ✓ MAT2004 Linear Algebra

Objectives
- To deepen and broaden the understanding of the theoretical and practical principles of Quantum Mechanics;
- To use this knowledge to study, model, and understand quantum phenomena in real physical systems;
- To serve as basis for future students who want to specialize in these topics;
- To be able to apply this knowledge to practical problems;
- To be able to read scientific texts that build on the subjects of this course.

Description of the course
This course addresses some advanced concepts in Quantum Mechanics and builds on the introductory course PHY2005 Quantum Theory. The course is organized around the following topics: quantum tunnelling, approximation methods such as the variational principle and time (in)dependent perturbation theory, state transitions, quantum entanglement and quantum fluctuations. Each of these subjects is taught on a theoretical level as lecture, and on a practical level with exercises.

Literature
- "Introduction to Quantum Mechanics", David J Griffiths;
- "Modern Quantum Mechanics", J.J. Sakurai;
- Handouts on specific texts during the lectures.

Instructional format
The tutorials will consist of highly interactive sessions, in which we will solve and discuss exercises in a group-effort, where the focus lies both on the mathematics as the physical interpretation of the results. In parallel to these group-exercises there will also be 'individual exercises' to be completed outside of the classroom.

Assessment
- Midterm exam;
- Final exam;
- Participation in the course.

PHY3002 Theory of Relativity

Course coordinator
Dr. Gideon Koekoek, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.
Contact: gideon.koekoek@maastrichtuniversity.nl

Pre-requisites
- ✓ PHY2001 Classical Mechanics

Co-requisites
- ✓ None

Objectives
- To acquaint the participants with the entirety of Special Relativity;
- To build up Special Relativity in the historical way (by means of thought experiments) as well as from rigid mathematical foundations;
- To understand 4-vectors and the mathematics of Minkowksi-spacetime as a complete description of Special Relativity, and apply them correctly in solving exercises;
- To be able to read and create Minkowski spacetime diagrams, and apply them correctly in solving exercises;
- To acquaint the students with the Lagrangian formalism of Nature, and to apply it in relativistic setting to derive relativistic physical laws;
- To be able to identify and solve the misconceptions and paradoxes in Special Relativity.

Description of the course
This course focuses on one of the two variants of Einstein's Theory of Relativity, that is known as Special Relativity, which is a complete description of space and time at the most fundational level of Nature. Most notably, the Theory of Relativity posits that space (lengths) and time (durations) are not separate entities, but are intimately entwined with each other; it also posits that these are not fixed but depend on the inertial system of the observer. This makes for a rich and interesting underlying structure of space and time. Building up this structure and learning how to apply it to exercises and physical situations, is the main goal of the lecture series.
We will start our series by identifying, historically, how Special Relativity was discovered and how it followed naturally from the laws of electromagnetism; we will then build up its laws and relationships in the historical (but limited) way of Gedankenexperiments, followed by the rigorous (but complete) way of Minkowski-geometry. We will introduce Lagrangian formalism of theoretical physics to derive the laws of special-relativistic mechanics. We will apply the theory in numerous exercises, for which we will also find graphical ways of getting insight in their solutions.
Finally, we will study the paradoxes and misconceptions; Special Relativity is a theory that is easy to misunderstand, and it is important that we study which misconceptions there are, how to identify them, and how to remedy them.

Literature
Special Relativity, T.M.Helliwell, University Science Books (US), First edition 2010.
Relativity: A very short introduction, Russell Stannard, Oxford University Press (UK), First edition, 2008.

Instructional format
The tutorials will consist of highly interactive sessions, in which we will solve and discuss exercises in a group-effort, where the focus lies both on the mathematics as the physical interpretation of the results. In parallel to these group-exercises there will also be 'individual exercises 'to be completed outside of the classroom.

Assessment
- Midterm exam;
- Final exam.

PHY3004 Elementary Particle Physics

Course coordinator

Prof. Marcel Merk and Dr. Jacco de Vries, Gravitational Waves & Fundamental Physics, Faculty of Science and Engineering

Contact: m.merk@maastrichtuniversity.nl and jacco.devries@maastrichtuniversity.nl

Pre-requisites

- ✓ PHY2005 Quantum Theory

Co-requisites

- ✓ None

Recommended

- ✓ MAT2004 Linear Algebra
- ✓ MAT2006 Calculus
- ✓ PHY3001 Quantum Mechanics
- ✓ PHY3002 Theory of Relativity

Objectives

- To acquire a general understanding of key concepts in elementary Particle physics;
- To be able to apply this knowledge to numerical calculations;
- To be able to read scientific texts that build on the subjects of this course.

Description of the course

This course provides an overview of the key concepts in elementary particle physics and serves as a preparatory course for a subsequent master study on Particle Physics.

Particle Physics provides us with an understanding of the fundamental particles in the universe and the interactions between them. Students will be taught which fundamental particles exist, what their properties are, and how they interact through the three fundamental forces, with the theories of Quantum Electrodynamics, the weak force, and Quantum Chromodynamics. We will use Feynman diagrams and Fermi's golden rule to calculate interaction cross-sections for a simple toy model. In addition, we will explore the beautiful concept of symmetry in nature, and its spontaneous breaking via the Higgs mechanism. The course consists of six lectures and related tutorials: particles, forces, waves, symmetries, scattering and detectors. In the lectures the material will be presented, while skills will be applied to exercises in the tutorial classes. In the last weeks, time will be reserved to work on specific topics for the group projects. A seminar will be organized to present the group work to each other.

This course requires a good understanding of Quantum Mechanics. Special relativity is also inherent in Modern Particle Physics, however for this course any necessary concepts will be taught in the lectures.

Literature

"Introduction to Elementary Particles", David J Griffiths

Instructional format

Lectures and PBL tutorial group meetings.

Assessment

- Group project and presentation (peer-reviewed);
- Final exam;
- Tutorial exercise presentations.

PHY3005 Relativistic Electrodynamics

Course coordinator
Dr. Stefan Danilishin, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.
Contact: stefan.danilishin@maastrichtuniversity.nl

Pre-requisites
- PHY2004 Electromagnetism
- PHY3002 Theory of Relativity

Objectives
- To acquire general understanding of electrodynamics;
- To be able to use Maxwell equations to solve practical problems;
- To get well-acquainted with the mathematical apparatus of field theories and potentials;
- To rewrite electrodynamics in the language of 4-vectors, so as to make its relativistic character explicit;
- To understand the importance of gauge invariance and Lorentz invariance in field theories.

Description of the course
Electrodynamics is the theory that describes all (non-quantum) aspects of electric and magnetic fields and their interaction with charged matter; most notably is describes the dynamics of these fields in time. The basic rules of Electrodynamics are laid out by the famous Maxwell Equations, that were covered in the prerequisite course Electromagnetism (PHY2004).
Maxwell's Equations reveal, when written in the appropriate mathematical language of scalar and vector potentials, that the theory of Special Relativity is fully embedded in Electrodynamics from the get-go, without having to artificially build this in. In fact, it can be shown that Electrodynamics would be mathematically inconsistent if the laws of physics had not obeyed the rules of Special Relativity. In this course, the goal is to make this intimate connection between Electrodynamics and Special Relativity explicitly clear.
The course will start with an overview of Maxwell's Equations and their qualitative meaning, starting from a few experimental facts (Gauss' Law and Biot-Savart's Law). Taking Maxwell's Equations as the foundation of the rest of the course, we will reformulate them in terms of scalar and vector potentials and show that there is a mathematical freedom in choosing these potentials without affecting the resulting physics. We will then find the equations that the potentials obey, and write down the general solution to them. It will next be discussed how one can take into account the time delay that occurs when sources and particles on which the act are a sizeable distance away. Finally, after an overview of 4-vectors, Lorentz-transformations, Minkowski-spacetime and tensors has been provided, the theory will be cast into the language of 4-vectors to make explicit the deep connection Electrodynamics shares with Special Relativity. The course ends with the introduction of the Principle of Least Action and the derivation of the entire classical field theory in covariant form from this principle. The concept of gauge transformation and gauge invariance is explained in application to electromagnetic fields and charged particles.

Literature
"Introduction to Electrodynamics", David Griffiths, 4th Edition (or higher).

Instructional format
The tutorials will consist of highly interactive sessions, in which we will solve and discuss exercises in a group-effort, where the focus lies both on the mathematics as the physical interpretation of the results. In parallel to these group-exercises there will also be 'individual exercises' to be completed outside of the classroom.

Assessment
- Midterm exam;
- Final exam;
- Participation in the course.

PHY3006 General Relativity

Course-coordinator
Dr. Gideon Koekoek, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering
Contact: gideon.koekoek@maastrichtuniversity.nl

Pre-requisites
- ✓ PHY2001 Classical Mechanics
- ✓ PHY3002 Theory of Relativity

Co-requisites
- ✓ None

Objectives
- To understand the theory of Special Relativity as a tensor theory;
- To reformulate gravity as curvature of spacetime;
- To understand tensor algebra as a mathematical apparatus;
- To be able to calculate spacetime curvature in the presence of mass and energy;
- To be able to calculate motion in curved spacetime;
- To understand black holes, cosmology, and gravitational waves as specific examples of the theory learned.

Description of the course
General Relativity is the best theory of gravity that we have. It refines and supersedes the classical Newtonian theory of Universal Gravitation, and leads to many interesting and exotic predictions about the Universe and objects within it. In this course, we will build up the General Theory of Relativity, the relation between curved spacetimes and matter and energy, study the mathematics needed to do the necessary calculations, and apply it to some interesting cases. Among those are Schwarzschild black holes, Friedmann-Robertson-Walker Universes, and gravitational waves.

Literature
- Lecture Notes by the lecturer (available as download);
- Recommended: "Gravity", by James B. Hartle;
- Recommended: "Gravitation & Cosmology", by Stephen Weinberg (note: this text is mathematically advanced).

Instructional format
The tutorials will consist of highly interactive sessions, in which we will solve and discuss exercises in a group-effort, where the focus lies both on the mathematics as the physical interpretation of the results. In parallel to these group-exercises there will also be 'individual exercises' to be completed outside of the classroom.

Assessment
- Midterm exam;
- Final exam.

PHY3007 Advanced Mathematical Techniques of Physics

Course coordinator
Dr. Gideon Koekoek, Gravitational Waves and Fundamental Physics, Faculty of Science and Engineering.
Contact: gideon.koekoek@maastrichtuniversity.nl

Lecturers:
Dr. Gideon Koekoek & Prof. Dr. Jo van den Brand
Contact: j.vandenbrand@maastrichtuniversity.nl

Pre-requisites
- ✓ MAT2004 Linear Algebra
- ✓ MAT2009 Multivariable Calculus

Objectives
To provide students training and fluency in the following mathematical techniques of physics:

- Fourier series
  Theorem of Riemann-Lebesque, Dirichlet conditions, Jordan's Lemma, Cauchy series;
- Laplace transformation
  Complex function theory, *s*-plane, initial value problems for (partial) differential equations;
- Fourier integrals
  Hilbert space; Schwarz inequality, Parseval relation, connection to Heisenberg uncertainty relation;
- Sturm-Liouville Theory, with as main examples Bessel and Legendre functions
  Complete sets of orthonormal functions, Frobenius Method, Fourier-Bessel series, Spherical Harmonics and their application in physics;
- Green's functions
  Solving of potential equations, Dirichlet and von Neumann boundary conditions, Wronskian determinant.

Description of the course
The Italian physicist Galileo already remarked in the 16th century that "the book of nature is written in mathematics". In the centuries and development of physics since, this has become true to the point that advanced mathematics is inseparably entwined with physics. Indeed, for a professional career in physics research, a rigorous training in advanced mathematical techniques is a necessity. In this course, we will provide a number of the most important topics needed in active research in physics. Topics include integral transforms, techniques of solving partial differential equations, finding particular solutions by Green's function techniques, complete sets, Fourier analysis and its relationship to data-analysis and quantum mechanics, and variational calculus. In all cases, the mathematics will be practiced in the context of real-life examples of fundamental theories of physics, such as quantum field theory and relativity.

Literature
- Arfken & Weber & Harris: *Mathematical Method for Physicists*, 7th edition or higher.
  ISBN 978-0-12-384654-9;
- lecture notes by Jo van den Brand & Gideon Koekoek.

Instructional format
Lectures and tutorial group meetings.

Assessment
- Midterm exam;
- Final exam.

PHY3008 Cosmology

Course coordinator
Dr. Lorenzo Reverberi, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: l.reverberi@maastrichtuniversity.nl

Pre-requisites
- ✓ MAT2006 Calculus
- ✓ At least one Astronomy course (PHY2008/PHY2009/PHY2010)
- ✓ Waivers possible for students who took several 2000-level PHY or MAT courses

Recommended
- ✓ PHY3002 Theory of Relativity

Co-requisites
- ✓ None

Objectives
- Summarise the basic mathematics of spacetime and general relativity, and apply them to homogeneous and isotropic cosmological models (FLRW metric);
- Remember the Friedmann equations and use them to derive the cosmological expansion history given the nature and amount of energy/matter in the Universe;
- Explain light propagation in an expanding Universe, ages, redshift, horizons and the cosmic distance ladder and apply these tools to cosmological observables;
- Outline the main epochs and topics in the cosmological history, including inflation, Big Bang Nucleosynthesis, recombination, structure formation, late-time cosmic acceleration;
- List the main theoretical and observational evidence for the ΛCDM model and in particular for the existence of Dark Matter and Dark Energy.

Description of the course
This course will cover the basic topics in theoretical and observational cosmology. A background in (General) Relativity and Astronomy is useful but not strictly mandatory, but a solid understanding of calculus and algebra is assumed.
We will begin with a brief introduction to the mathematics of spacetime and General Relativity, and apply it to homogeneous, isotropic (FLRW) cosmological models. We will then study light propagation in an expanding Universe, discuss the cosmic distance ladder and the basics of observational cosmology.
After that, we will outline the cosmological expansion history and investigate in some depth the various epochs, their observational status and the underlying physical laws: the Big Bang, inflation and the generation of primordial fluctuations; the thermodynamics of the early Universe and Big Bang Nucleosynthesis (BBN); recombination and the Cosmic Microwave Background (CMB); structure formation and Dark Matter; the late-time cosmic acceleration and Dark Energy.
At the end of the course, you should be able to outline the basic theoretical motivation and observational support in favour of the ΛCDM model, the concordance cosmological model.

Literature
There is no official textbook for the course. All necessary study material will be provided and/or indicated during the course. For more advanced and in-depth reading, the interested student is referred to one or more of the excellent books on the subject, for instance:

[1] S. Dodelson, *Modern Cosmology*, Academic Press (2003);
[2] E.W. Kolb, M.S. Turner, *The Early Universe*, Avalon Publishing (1994);
[3] A. Liddle, *An Introduction to Modern Cosmology*, Wiley (2003);
[4] P.J.E. Peebles, *Principles of Physical Cosmology*, Princeton University Press (1993).

Instructional format
The course will follow the PBL system, with tutorials involving both group exercises building on the lecture content of the week, and independent research to be carried out at home.

Assessment
- Weekly quizzes/projects;
- Final examination.

PRA1101 Introduction to Scientific Research I

Dr. Erik Steen Redeker & Dr. Chris Pawley, Faculty of Science & Engineering, MaastrichtScience Programme.
Contact: erik.steenredeker@maastrichtuniversity.nl or c.pawley@maastrichtuniversity.nl

Co-requisites
- ✓ CHE1101 Introduction to Chemistry
- ✓ PHY1101 Introduction to Physics

Objectives
- Explore the different natural sciences in a laboratory setting;
- To prepare for a lab from a safety perspective;
- To understand the handling of materials and solutions and disposal of waste material;
- How to work safely in a laboratory environment;
- To be able to relate a research question to a scientific theory and a research experiment;
- Design and setup a simple research plan to answer the research question;
- Understand the use of control samples, reference values, blanks, standards in experimentation;
- To be able to perform and record basic laboratory research experiments in a safe and scientifically valid way;
- Generate valuable data from a scientific experiment;
- Learn the basics of writing lab reports.

Description of the skill
The academic world has its own strict set of rules with respect to collecting data, analyzing the data, and writing and reporting about it. 'Introduction to Scientific Research' focuses on designing and performing scientific research experiments in the lab. It will teach you some basic laboratory skills commonly usedin chemical, biological and physics research. Students will gain experience in how to design and set up an experiment in order to answer a specific scientific question. During the laboratory sessions, students will execute experiments, learn how to record the methods and observations, and perform the necessary measurements to generate valuable data with the final goal to answer the scientific question. You will conduct basic data analysis, interpret the analysis, and report the findings.
Basic practical techniques will be taught, such as the accurate weighing, preparing solutions and dilutions, working with pipettes and volumetric glassware, performing simple analysis, ...
In PRA1101 Introduction to Scientific Research I, students will start with learning how to work in a safe manner in a laboratory environment, with respect for themselves, others, and the environment. You will learn how to design an experiment in order to generate valuable data. You will perform experiments and learn the basics of documenting procedures and observations and how to write specific parts of a lab report.
This skills course continues with PRA1102 Introduction to Scientific Research II in which you will focus more on how to analyze and interpret the data generated in the experiments and how to report the conclusions and findings.

Literature
Course manual and online instructions on the Student Portal.

Instructional format
This skills training will consist of several interactive sessions, practical lab work, and sessions on experimental design, research ethics, data analysis, and reporting of data.

Assessment
- Pre-lab;
- In-lab;
- Written lab assignments.

PRA1102 Introduction to Scientific Research II

Course coordinators

Dr. Linnea van Griethuijsen: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: l.vangriethuijsen@maastrichtuniversity.nl

Dr. Stefan Jongen: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: stefan.jongen@maastrichtuniversity.nl

Co-requisites

- ✓ BIO1101 Introduction to Biology
- ✓ INT1101 Introduction to Liberal Arts and Sciences

Objectives

At the end of this skills module, you will be able to …

- Explore the different natural sciences in a laboratory setting;
- Relate a research question to a scientific theory and a research experiment
- Design and setup a simple research plan to answer the research question;
- Understand the use of control samples, reference values, blanks, and standards in experimentation;
- Perform and record basic laboratory research experiments in a safe and scientifically valid way;
- Evaluate scientific fraud and evaluate resources critically;
- Generate valuable data from a scientific experiment;
- Conduct basic data analysis;
- Interpret and discuss experimental results;
- Write a basic lab reports.

Description of the skill

The academic world has its own strict set of rules with respect to collecting data, analyzing the data, and writing and reporting about it. 'Introduction to Scientific Research' focuses on designing and performing scientific research experiments in the lab. It will teach you some basic laboratory skills commonly usedin chemical, biological or physics research, such as the accurate weighing, preparing solutions and dilutions, working with pipettes and volumetric glassware and performing simple analyses. Students will gain experience in how to design and set up anexperiment in order to answer a specific scientific question. During the laboratory sessions, students willexecute experiments, learn how to record the methods and observations, and perform the necessary measurements to generate valuable data with the final goal to answer the scientific question. You will conduct basic data analysis, interpret the analysis, and report the findings in partial lab reports.
PRA1102 Introduction to Scientific Research II builds on PRA1101 Introduction to Scientific Research I and you will gain more experience in how to design and set up an experiment in order to answer a specific scientific question.

Literature

Course manual and online instructions on the Student Portal.

Instructional format

This skills training will consist out of several interactive sessions and practical lab work on experimental design, data analyses, and reporting of data.

Assessment

- Pre-lab;
- Post-lab assignments.

PRA1003 Basic Physics Laboratory

Course coordinator
Dr. Chris Pawley, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: c.pawley@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
- To acquire understanding of practical methods in experimental physics;
- Being able to solve technical problems in a physical experiment;
- To be able to relate the experiment to the relevant physical theory;
- To be able to process empirical data in relation to the theoretical physical predictions using the adequate statistical and graphical tools;
- To be able to properly describe the experimental methods and results in technical reports.

Description of the skill
The aim of this skill is for participants to understand what physics means by performing instructive physical experiments that reveal fundamental physical principles, and to attain a level of dexterity with experimental devices. Physics is an empirical science and not a mere collection of mathematical laws. In this sense, this practical is an appropriate counterpart for the more theoretic and mathematicalphysics courses. Moreover, the aim of this training is to improve your ability to report and summarize your experimental work in a few pages. The skill consists of a collection of 7 different experiments. Students cooperate in pairs and each week performs a different experiment. Each week requires the participants to learn the theory, design and plan an appropriate experiment, collect and analyse their data to understand the physical principles contained within. These experiments are supplemented with a full day of training at the beginning regarding various “tools” used in practical physics, which can be applied during this skill.

Topics:
Mechanics: Newton's Laws Experiment, Conservation of momentum and impulse, Projectile Motion, Mechanical waves, Harmonic Motion.
Thermodynamics: Thermal Energy, Equilibrium Temperature, Specific Heat, Ideal Gas Law
Optics: Michelson’s interferometer.

Literature
There is no book directly associated to this module. Information on the individual experiments is providedin this syllabus and in separate detailed experiment descriptions. A suitable textbook for this module is: University Physics with Modern Physics, H.D. Young & R. A. Freedman, Pearson Education (US), 13th International edition, May 2011. For the underlying physical principles of the experiments we refer to any general physics textbook.

Instructional format
This module takes place in the physics laboratory. Students work in small teams during the skill. Each week each couple jointly studies a different experiment, i. perform measurements, ii. process the experimental data, and iii. write a report. The final grade is partly based on these reports. During the modulestudents also learn more about the basis theory of Experimental Physics, like sources of errors and errorpropagation.

Assessment
Evaluation of student performance will be based on:

- Lab reports;
- In-lab assignments.

PRA1005 Data Collection Techniques in the Neurosciences

Course coordinator

Dr. Mark Roberts: Faculty of Psychology and Neuroscience, Department of Cognitive Neuroscience. *Contact:* mark.roberts@maastrichtuniversity.nl

Pre-requisites

- ✓ Laptop computer
- ✓ headphones

Co-requisites

- ✓ None

Objectives

This skill has the aim of familiarizing students with basic techniques for data collection and analysis in neuroscience for behavioural and electrophysiology data.

Description of the skill

Neuroscience uses a range of techniques to make inferences about the workings of the brain and its relationship to perception, behaviour, health and disease. This skill course will introduce the fundamentals of experimental design, data collection, analysis and interpretation, covering methods for measuring behaviour, perception and electrophysiology (the electrical activity of the brain). To make the knowledge concrete, students will perform experiments and data analysis, and write a report comparing methods used to measure perceptual sensitivity. In addition, to build a wider appreciation of field, students will read and present a journal article.
Computer programming is an essential skill for modern neuroscience, used to run experiments and perform data analysis. This skill forms a large portion of the course, you will learn the basic functionalityof MATLAB and the Fieldtrip toolbox. No previous programming experience is expected.

Literature

Hand-outs and relevant literature will be provided by coordinator.

Instructional format

Lectures, Group meetings and computer meetings.

Assessment

- Intermediate assignment based on group work;
- Presentation of a selected journal article;
- Lab report based on practical sessions.

PRA2002 Chemical Synthesis

Course coordinator
P1: Dr. Matt Baker: Faculty of Health, Medicine and Life Sciences, MERLN.
Contact: m.baker@maastrichtuniversity.nl

P4: Dr. Hanne Diliën: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: hanne.dilien@maastrichtuniversity.nl

Pre-requisites
- ✓ PRA1001 Research methods or PRA1101 Introduction to Scientific Research I
- ✓ PRA1002 Research, Data Analysis and Presentation Academic Skills or PRA1102 Introduction to Scientific Research II

Co-requisites
- ✓ CHE2001 Organic Chemistry

Objectives
- To be able to perform organic synthetic experiments in a structured and safe manner;
- To understand specific separation and purification techniques commonly used in organic chemistry;
- To gain a practical understanding of the impact of the choice of reagents, solvents and conditions on the outcome of an organic reaction;
- To gain further skills in scientific research reporting.

Description of the skill
This skills focuses on the development of a clear understanding of the synthesis of organic chemical compounds. It is important for the students to learn how to convert their theoretical knowledge on chemical reactivity to actual design and execution of synthetic chemical reactions. Typical topics, which will be covered in this skills training are:
- Safe handling of organic reagents and safe execution of organic experiments;
- Commonly used organic synthetic laboratory techniques;
- Synthetic chemistry of various organic reaction types (*e.g.* nucleophilic substitutions and eliminations, electrophilic reactions and radical chemistry);
- Stereochemistry in organic synthesis;
- Purifications and separations in chemistry;
- Spectroscopy and characterization of organic compounds.

Literature
- Practical laboratory instructions;
- For students intending on continuing and specializing in organic chemistry, a practical book, such as "Multiscale Operational Organic Chemistry" by John W. Lehman (Pearson, 2nd edition, 2009) may be interesting.

Instructional format
This training is organized as a series of laboratory sessions. The students will have to prepare short reports on the various laboratory activities of this training. The theory required for the skills is introducedduring the tutorial group meetings of the co-requisite course: CHE2001 Organic Chemistry.

Assessment
- The laboratory notebook with developed protocols;
- Pre-lab online assessment;
- Lab reports.

PRA2003 Programming

Course coordinator

Cameron Browne, Faculty of Science and Engineering Department of Data Science & Knowledge Engineering.
Contact: cameron.browne@maastrichtuniversity.nl

Pre-requisites

- ✓ MAT1004 Imperative Programming or MAT2007 Introduction to Programming

Co-requisites

- ✓ None

Objectives

To familiarise students with the practical skills required in computer programming.

Description of the skill

The hands-on course is intended to introduce students to more practical concepts involved with computer programming. The students will gain experience implementing these concepts in programming tasks during weekly labs and an assignment. Topics include:

- Elements of Java programs;
- Efficiency and coding style;
- Object-oriented programming;
- Recursion;
- Basics of graphical user interface (GUI) programming;
- Exceptions and error handling;
- File input and output;
- Threads and multithreading.

Literature

No specific text book is required, although students are referred to the online book Introduction to Programming Using Java by David J. Eck (http://math.hws.edu/javanotes/). Relevant literature will be available online and referred to in the lab handouts as needed.

Instructional format

The course will be taught in a computer lab. Each session will start with a short lecture to introduce the week's topic, followed by short programming tasks that demonstrate practical applications of the topic,to be completed during the session. Students should bring their own laptop with a Java SDK installed (Eclipse preferred) ready to write and run Java programs.

Assessment

The assessment will be based on:

- The programming tasks;
- A larger take-home assignment.

PRA2004 Inorganic Synthesis

Course coordinator

Dr. Giuditta Perversi, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: g.perversi@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA1001 Research methods or PRA1101 Introduction to Scientific Research I
- ✓ PRA1002 Research, Data Analysis and Presentation Academic Skills or PRA1102 Introduction to Scientific Research II

Recommended:

- ✓ CHE2001 Organic Chemistry
- ✓ PRA2002 Chemical Synthesis

Co-requisites

- ✓ CHE2002 Inorganic Chemistry

Objectives

- To implement principles seen in class in a laboratory setting;
- To learn the basic synthetic techniques in inorganic chemistry;
- To synthesize and study a range of inorganic compounds;
- To understand the scientific approach to characterization of products;
- To refine the scientific reporting skills on data presentation, analysis and discussion.

Description of the skill

This skills will focus in the synthesis and analysis of inorganic compounds, focusing primarily on coordination compounds and their spectroscopy.
The students will be expected to become familiar to how to gather methodological and characterization results, and reported in a scientific manner adequate for further training.

Literature

Girolami, Rauchfuss, Angelici: Synthesis and Technique in Inorganic Chemistry (University ScienceBooks).
Woollins: Inorganic Experiments (Wiley VCH).

Instructional format

Laboratory sessions.

Assessment

Assessment may include but may not be limited to:

- Laboratory participation;
- Laboratory notebook;
- Written laboratory reports;
- Pre- and post-laboratory problem sets;
- Practical or theoretical exams.

PRA2005 Advanced Molecular Laboratory Skills

Course coordinator
Dr. Erik Steen Redeker, Faculty of Science and Engineering, Maastricht Science Programme
Contact: erik.steenredeker@maastrichtuniversity.nl

Pre-requisites:
- ✓ PRA1101 Introduction to Scientific Research I

Co-requisites:
- ✓ None

Objectives
- To be able to efficiently plan experiments related to molecular research in chemistry, biology and biochemistry;
- To understand and execute protein extraction, separation and analysis tools frequently used in a (bio)chemical and biological laboratory;
- To be able to accurately follow and develop scientific protocols and procedures;
- To be able to correctly use a lab notebook and do scientific reporting in the form of scientific reports.

Description of the course
This course focuses on experimental research methods and reporting. The main goal is to provide students with sufficient laboratory skills to successfully complete more advanced skills and projects in chemistry and biology/biochemistry related to (bio)molecular laboratory research. During the lab days, students will perform a set of biology and chemistry experiments. The different experiments areconnected and form one integrated experiment. Parts of the experiments have an emphasis on biologicalor biochemical aspects of molecular research, while other experiments focus more on some chemical aspects. For the final lab day, students have to design their own protocol for an experiment in which the results of the earlier experiments will be combined. The course will be structured in the Research Based Learning (RBL) format, with room for student initiatives and ideas.

Literature
Lab manual. Useful additional literature: "Practical skills in Biomolecular sciences" by Reed, R., Holmes,D., Weyers, J., Jones, A. (Pearson).

Instructional format
PBL/RBL, work in subgroups, research experiments, assignments

Assessment
- Pre-lab preparation and lab book use;
- Protocol development;
- Scientific reports.

PRA2006 Electronics Lab

Coordinator
Dr. Bart van Grinsven, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: bart.vangrinsven@maastrichtuniversity.nl

Pre-requisites:
- ✓ None

Co-requisites:
- ✓ PHY2006 Electronics

Objectives
By the end of this course you will be able to:
- Follow a circuit diagram and built a circuit on a breadboard by identifying and using the correctcomponents, supplies and measurement devices to check the circuit;
- Collect experimental readings using multimeters and oscilloscopes to fault find and comparedevice function to theory in DC and AC configurations;
- Plot and analyse graphs of results and perform calculations of resistances, power, currents and (various types of (average/RMS)) voltage drops across various sections of circuits or components;
- Build and analyse RC filters while calculating their gain, time constants and cut-off frequencies;
- Build diode rectifying circuits and identify the benefits of full/half wave/smoothing circuits;
- Use op-amps in various configurations to amplify weak signals by calculating and selecting theappropriate resistors and use op-amps as comparators for digital conversion;
- Programme and wire up an Arduino using the software to control various circuit devices as inputs and outputs;
- Write clear reports outlining experimental observations and how they compare to theory;
- Keep clear notes which contain enough information for someone to be able to repeat and test the experiments and builds which you undertook.

Description of the skill
This practical addresses the basic concepts essential for mastering the principles of electronics applicableto direct current (DC) and alternating current (AC) circuit analysis. The emphasis is on the basic physics behind electronics, the application of the fundamental laws of electronics to discrete electrical components, and the network theorems used in circuit analysis. The first weeks involve schematic reading, the mathematics behind electronics, and elementary circuit analysis. Here the students acquire the fundamental concepts of DC and AC theory and progresses through capacitive circuits with emphasison AC circuit analysis, with special emphasis on sinusoidal waveforms, filters and rectifiers.
The practical continues with semiconductor physics, namely diode and transistor characteristics and their applications, most notably operational amplifiers (and comparators).
The next part of the practical entails the study of digital logic, its operations, principles and applications. The course concludes with an introduction to microprocessor circuits and techniques using the Arduino microcontroller.

Literature
A course manual and detailed experiment descriptions will be provided during the practical.

Instructional format
Laboratory sessions.

Assessment
The final assessment is based mainly on lab reports by students but some lab days will also require the completion of pre-lab quizzes.

PRA2007 Physics Laboratory

Course coordinators

Dr. Chris Pawley, Faculty of Science and Engineering, Maastricht Science Programme.
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Dr. Lorenzo Reverberi, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: l.reverberi@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA1003 Basic Physics Laboratory

Note: Waivers are unlikely to be granted unless applicants can show their experience in experimental physics is equivalent to that of PRA1003.

Co-requisites

- ✓ None

Objectives

This practical aims for students to obtaining a deeper understanding of physics by performing various key experiments in the areas of Classical Mechanics, Quantum Mechanics, and Electromagnetism. Examples are the photoelectric effect, blackbody radiation, angular momentum, Faraday's law, and Coulomb's law. The focus will be on the design and execution of the experiments and their relation to the fundamental laws and principles of physics. Another objective is the further training of physics laboratory techniques and procedures. Furthermore, attention will be paid on data analysis and reporting.

Description of the skill

This skill will educate you on the following:

- Design, use and measurement in physics experimentation;
- Gathering data using automated processes;
- Data manipulation and analysis using modern tools;
- Experiments in mechanics (Gyroscope dynamics, Driven Damped Harmonic Oscillator), Quantum Physics (Photoelectric Effect, Blackbody Radiation, Atomic Spectra), and Electrodynamics (Coulomb's Law, Faraday's Law of Induction Experiment).

Literature

- University Physics with Modern Physics, H.D. Young & R. A. Freedman, Pearson Education (US), 13th International edition, May 2011;
- Practical Physics, G.L. Squires, Cambridge University Press, 4th edition, September 2001;
- Measurements and their Uncertainties: A practical guide to modern error analysis,
  I. Hughes & T. Hase, Oxford University Press, August 2010.

Instructional format

In this skill participants work together in a small team and each of the weeks perform a different physics experiment. Each experiment is thoroughly planned, executed, and analysed by the team, and each week a report is submitted. The final grade is based on these reports. Participants are expected to more independent than in PRA1003 Basic Physics Lab, but staff are available for support.

Assessment

The grade is based on:

- The submitted laboratory reports;
- The ability of the team members to design and execute a suitable experiment in physics asassessed through proposals.

PRA2008 Physical Chemistry

Course coordinator
Dr. Veaceslav Vieru, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: v.vieru@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Recommended
- ✓ CHE2003 Physical chemistry

Objectives
For the course, students are expected to perform various physical chemistry experiments and analyse the obtained data, involving *inter alia* kinetics analysis, thermodynamics analysis and spectroscopy analysis.

Description of the skill
During this practicum, we will investigate how physical data is extracted from different experiments. Each week, students will perform different experiments focusing on the different aspects of physical chemistry (thermodynamics, kinetics, spectroscopy). Students are expected to work out different constants or information from the data they collected from experiments. Error analysis will also take a large part in the training as it is completely inherent to physical chemistry.

Literature
Atkins, Peter. *Physical chemistry* (any edition). Oxford University Press.

Instructional format
Weekly practical sessions.

Assessment
Assessment will be based on:
- The quality of the lab reports;
- Lab notebooks;
- Results obtained;
- Error analysis;
- As well as answers to post-lab questions.

PRA2009 Field Skills in Biology

Note: You cannot take this skill if you have done PRA2501 Practical Organismal Ecology.

Course coordinator

Dr. John Sloggett: Faculty of Science and Engineering, Maastricht Science Programme.

Contact: j.sloggett@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA1002 Research Data Analysis and Presentation Skills or PRA1102 Introduction to Scientific Research II

Co-requisites

- ✓ BIO2002 Ecology

Objectives

For an ecologist, the field is a much less controlled, though much more realistic environment than the lab, and a completely different set of practical skills are required. In this course you will learn how to generate well controlled reliable, results in the field. You will be shown a diversity of methods to collect,count and identify animals and plants. You will learn how to measure important environmental variables that can determine the results you get, and most importantly some basic means to plan for and interpretall that complex data.

Description of the skill

This skills will include:

- Use of GIS computer mapping tools;
- The means to identify species or higher taxa of certain environmentally or taxonomically important groups or indicator species in the field or lab;
- Methods to collect or count organisms in the field;
- Planning of field experiments;
- Interpretation of field results, including some statistical work and spatial analysis;
- How to represent spatial data on an appropriately formatted map.

Literature

Wheater, C.P., Bell, J.R. & Cook, P.A. (2021). *Practical Field Ecology: A Project Guide*, 2nd edition John Wiley & Sons (Not obligatory but useful).

Instructional format

Practical classes outdoors. This means that appropriate clothing is needed such as Wellingtons, trousers that can get dirty, rain clothing, a watertight back-pack etc. Classes will take place even when it is raining.

Assessment

Practical exercises online and in the field.

PRA2010 Synthetic Biology

Course coordinator

Dr. Erik Steen Redeker, Faculty of Science and Engineering, Maastricht Science Programme

Contact: erik.steenredeker@maastrichtuniversity.nl

Pre-requisites:

- ✓ PRA2005 Advanced Molecular Lab Skills
- ✓ PRA2014 Genetics

Co-requisites:

- ✓ None

Objectives

- Understand synthetic biology concepts;
- Understand engineering concepts of design, build and test;
- Practical application of synthetic biology concepts;
- Learning and implementing basic molecular biology lab skills;
- Collect and analyze experimental data.

Description of the course

This course explores the relatively new and rapidly growing field of synthetic biology. Synthetic biology aims to construct genetic systems, change biological systems or even (re)design organisms, to solve real-life issues in, for example, environment, health, nutrition, … This is done by looking at biology from an engineering point-of-view and by using molecular biology, genetic engineering and microbiology methods. This engineering approach focuses on four important principles: abstraction, modularity, standardization andmodelling. In this way it is possible to extend and apply genetic techniques to real-world applications. The goal of this practical course is to design, build, and experiment with biological systems using molecular biology techniques relevant to the field of synthetic biology in combination with engineering concepts. Students will gain experience in growing and analysing microbial cell cultures (plates/liquid cultures), perform some genetic engineering and cloning techniques and DNA analysis tools.

Literature

Course manual

Instructional format

This practical course is organized as a series of laboratory sessions.

Assessment

The assessment will consist of short reports on the various laboratory activities of this training and an individual essay. The exact format will be announced during the course.

PRA2011 Exploring the World of Plants

Course coordinator
Dr. Roy Erkens, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: roy.erkens@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ BIO2003 General Botany

Objectives
In this skills-training you will get an overview of the characteristics of one of the most important lineages of life: land plants. At the end of this skills-training you should have insight into the most important aspects of the biology of mosses, ferns, gymnosperms and angiosperm and be able to explain their characteristics. Furthermore, you gain specifically insight into the flowering plants and their mode of reproduction.

Description of the skill
There are currently between 300.000 and 350.000 species of land plants known. These vary tremendously in terms of their characteristics and diversity. Several groups have only one to a few species while the flowering plants constitute the majority of species. This group is also by far the most important plant group for humans in terms of food, health, and economic value.
In this skill, you will first study the evolutionary history of four groups (the 'mosses', ferns, gymnosperms and angiosperms). You will focus on the life cycle of these groups and learn how the differences in life cycles are related to adaptations that are connected to water availability. Then you will focus mainly on flowering plants. You learn what the vegetative plant body looks like and why, with a special emphasis on secondary growth (a.k.a. wood). After this, you focus on the reproductive strategies of angiosperms and look at flowers, fruits and seeds.

Literature
Botany, an introduction to plant biology. J.D. Mauseth, 7th ed. 2021. Jones & Bartlett Learning. ISBN: 978-1-284-15735-2;
Campbell Biology. J.B. Reece et al. Pearson (edition that you used in the Core).

Instructional format
Weekly laboratory exercises, drawings, microscope work and studies of living material.

Assessment
There will be several points of assessment:
- Worksheets for lab 1 and 2;
- A group poster assignment on lab 3-4;
- Participation in and exercises related to four DIY field excursions.

PRA2013 Practical Zoology

Course coordinator

Dr. John Sloggett, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: j.sloggett@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA1002 Research, Data Analysis and Presentation Skills or PRA1102 Introduction to Scientific Research II
- ✓ BIO2004 General Zoology

Objectives

The skills will include:

- Carrying out experiments on physiology, behaviour, biodiversity and other aspects of zoology.
- Analysing zoological data;
- Writing up zoology experiments.

Description of the skill

The skill aims to provide a greater insight into the different aspects of zoology and how they are studiedin the laboratory. You will learn different experimental approaches used in zoology in including physiological testing, behavioural analysis and measures of animals diversity. We aim to provide you with better skills in handling both live and dead animal samples and in interpreting what you see in a biologically relevant way.

Please note that in this course you are required to carry out experimental work with live (invertebrate) animals, which may harm them.

Literature

Recommended is the book used for course BIO2004 General Zoology.

Instructional format

One whole-day (lab) instruction per week; museum visit

Assessment

- Lab performance;
- Data presentation;
- Reports.

PRA2014 Genetics

Course coordinator
Servé Olieslagers: Faculty of Health, Medicine and Life Sciences, Maastricht University.
Contact: s.olieslagers@maastrichtuniversity.nl

Pre-requisites
- ✓ Core 1000 level courses

Co-requisites
- ✓ BIO2007 Genetics

Objectives
- To experience the basic molecular tools that cover the genetic dogma;
- To be able to purify genomic DNA from eukaryotic cells and plasmid (circular) DNA from prokaryotic cells and perform quantitative and qualitative analyses nucleic acid products;
- To isolate RNA from eukaryotic cells and apply reverse transcription to generate copy DNA;
- To perform and comprehend polymerase chain reaction (PCR) analysis;
- To study specific proteins from tissue by Western immunoblotting;
- To present in-depth knowledge in an essay on predefined genetic concepts.

Description of the skill
The course discusses the principles of technical genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms, including humans. The skills trainings are aimed to obtain a basic introduction to techniques and methods in modern Genetics. The skills take place at a designated skills laboratory at DUB30; subsequently group presentations form the integration of theoretical and practical information.

Literature
- A reader is provided at the start of the course. Other recommended literature will be announced later;
- "Introduction to Genetic Analysis" by Griffiths, Wessler, Carrol, Doebley (Palgrave Macmillan, 11thedition, 2015. ISBN-13: 9781464109485). (Co-requisite).

Instructional format
Skills group meetings.

Assessment
- Attendance to the skills meetings is required (cf. Rules and Regulations);
- A written skills exam;
- Group presentation.

PRA2015 Advanced Academic Skills

Course coordinator
Dr. Kyle Jazwa: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: k.jazwa@maastrichtuniversity.nl

Pre-requisites
- ✓ PRA1002 Research, Data Analyses and Presentation Academic Skills or PRA1102 Introduction to Scientific Research II

Co-requisites
- ✓ None

Objectives
- To improve your grammar and prose style;
- To improve your presentation skills;
- To improve your ability to write for different genres;
- To improve your time management skills in academic environments;
- To improve your ability to give and receive feedback;
- To improve your group work skills.

Description of the skill
A good researcher not only knows a lot about their specific topic of study; they are also able to communicate their findings clearly and concisely to others. Advanced Academic Skills will improve your ability to do just this by focusing on you prose style, (written) organization, and argumentation. The course picks up where PRA1102 left off by asking you to develop your writing for various genres, including the Abstract, Literature Review, Research Proposal, and Research Paper. At the same time, you will collaborate with your classmates for peer review exercises and didactic presentations.

By the end of the course, you will be better prepared to complete your BTR thesis writing and participate in a scientific/academic career beyond MSP. Thus, Advanced Academic Skills is particularly suitable for students who are generally interested in the process of scientific communication and/or intend to continue their science education beyond the undergraduate level.

Literature
A selection of readings, videos, and “podcasts” will be assigned each week. All course materials are currently accessible (for free) online, via Canvas, or through the UM Library webpage.

Instructional format
Short, interactive lectures; assisted individual work/exercises; peer review

Assessment
- Written Abstract [solo];
- Literature Review [solo];
- Research Proposal [group];
- And other minor writing assignments;
- Students will also design and make a didactic group presentation.

PRA2017 NanoBiology

Coordinator
Dr Raimond Ravelli: M4I Nanoscopy, Faculty of Health, Medicine and Life Sciences.
Contact: rbg.ravelli@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Recommended
- ✓ CHE2006 Biochemistry
- ✓ BIO2001 Cell Biology
- ✓ Some aptitude to work with computers will be helpful, but no programming experience is required.

Objectives
- Learn about the principles of NanoBiology and the complexity of living systems at the nanometre-scale;
- Learn about the relationship between structure & function in biology, in a practical way;
- Learn about the functioning of complex biomolecular nano-machines of the electron transport chain;
- Learn to use literature to understand the molecular mechanism of green biofuel production;
- Learn to use bioinformatics databases such as UniProt and the Protein Data Bank (PDB);
- Learn to use software to visualise, analyse and animate biomolecular structures (UCSF Chimera);
- Learn to use software to depict and animate cellular scenes (CellPAINTv2);
- Learn to create a full-length animation with a coherent story from multiple individual clips.

Description of the skill
How does life work at a molecular scale? In this skill, you will work in teams to visualise life at the level of individual molecules and atoms. How are proteins born, how do they fold, where do they travel to within the cell, and how do they act together? What goes wrong when an efficient pathogen starts to kidnap the cell's machinery for its own advantage? In this practical skill, you will try to answer these questions using the tools of NanoBiology!
The skill will consist of two parts: (i) the morning sessions, where you will learn the techniques and the (applied) theory of Nanobiology; (ii) the afternoon sessions, where you will work in a team to create an animation describing the infection cycle of a human pathogen with the tools of Nanobiology.
In the morning sessions, you will be trained in bioinformatics skills to find and analyse protein and DNA sequences. You will learn about the protein data bank (PDB) and how to download from it the three-dimensional (3D) structures of proteins, DNA, RNA, and complexes thereof. You will learn how to use software packages -such as UCSF Chimera- to inspect these structures and their physicochemical properties, and how to make them 'alive' into 4D animations. You will also get acquainted with CellPAINT, a software which allows you to easily paint beautiful and realistic pictures of cellular landscapes, either healthy or infected by a pathogen.
During the afternoon sessions, the real investigative work will happen! As a team, you will work together to shed light on the cellular and molecular mechanisms related to a global health issue. Previously, we worked on Covid19 as well as Tuberculosis: this year, we will work on Climate Change. You will study the electron transport chain, the molecular mechanisms by which bacteria can produce hydrogen and/or methane gas, and propose new schemes to produce green energy. The work, which can be divided among team members, will include literature research and study, writing of a movie script, data collection from bioinformatics databases, data analysis and animation, and the making of a presentation. At the end of the course, each team will present the animation they created, as well as a power point presentation in which the technical background as well as the choices made during the making of the animation can be explained.
This skill is designed for students interested in biology and chemistry (and animation!), but with no previous experience in structural biology or computational chemistry. It progresses rapidly to powerful tools that will be of interest to interdisciplinary students who wish to specialise in protein structure and bioinformatics.

Literature
Each year, we will cover a different threat to human health. In 2020, the students made animations of the cellular infection of the SARS-CoV-2 virus, whereas in 2021, the students studied mycobacterium tuberculosis. These movies can be seen at the youtube channel of Maastricht4Imaging:
https://www.youtube.com/channel/UCurg8uv6dpsaAeYcGbHGUOQ/featured

Instructional format
This skill is organised as a series of lectures, computer practical sessions and tutor group sessions.

Assessment
Students will be assessed on:
- Weekly individual exercises, quizzes and home assignments on the tools and techniques learned;
- Final group animation;
- Final group presentation;
- Peer-review of the group.

PRA2018 Capita Selecta in Life Sciences

Coordinators
Prof. Dr. Peter Peters, M4I Nanoscopy, Faculty of Health, Medicine and Life Sciences.
Contact: pj.peters@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
- The objective of this skill is to acquire insight into trending topics;
- Critical reading (literature);
- To quickly comprehend and discuss a new topic;
- Debate the news coverage (objectivity, bias, fear spreading, prediction models);
- Predict effects in the near future based on current insights;
- Obtain some hands-on experience in a trending topic;
- Laboratory visit or field trip to places that work on the topic. Examples: MUMC+ coronavirus testing or Brightlands CryoSol startup company.

Description of the skill
Capita Selecta is unique and addresses trending topics in the (bio)chemical, biotechnology or the imaging field. For example, it may cover a recent virus outbreak or a profound breakthrough in biotechnology, such as CRISPR, or the latest Nobel prize in Chemistry, Physiology or Medicine. Studentswill quickly explore a 'hot topic'. Students will acquaint themselves with the theoretical basis of the subject. If possible, they will critically investigate news coverage (from scientific papers to popular newsflashes) and discuss the media reports. To acquaint the students better with the current trends and research, there will be visits to companies/laboratories that are involved.

Literature
As the nature of this skill is a 'hot topic', the literature recommendation are of a digital nature; 'trending topics' related to biochemistry, biotechnology and imaging in the news, such as:
- https://www.nature.com;
- https://www.bbc.com/news/health;
- https://www.ncbi.nlm.nih.gov/pubmed/trending/;
- https://www.sciencemag.org;
- https://www.sciencedaily.com/news/plants_animals/biochemistry/;
- https://crosstalk.cell.com/blog/topic/trends-in-biochemical-sciences;
- https://www.medicalnewstoday.com/categories/biology-biochemistry

  At the start students will be provided with a list of literature, relevant to the topic.

Instructional format
We will start with an introductory lecture and continues with specialized journal clubs. In addition, it will include several lab visits inside and outside the University, including industries/companies. Students will also be arranged in the lab to get hands-on experiences on techniques related to these 'hot topics'.

Assessment
The students will be assessed individually by:
- Peer review;
- Pecha Kucha presentations;
- Verbal group exam.

PRA2019 Natural Science Illustration

Course coordinator
Dr. Jessica Nelson: Faculty of Science and Engineering, Maastricht Science Programme.
Contact: jessica.nelson@maastrichtuniversity.nl

Pre-requisites
- ✓ None

Co-requisites
- ✓ None

Objectives
After this skill, students should be able to:
- Accurately draw biological (or other scientific) subjects;
- Apply arrangement guidelines to produce pleasing compositions for illustrations;
- Produce illustrations in graphite and ink;
- Digitize illustrations and use them to construct scientific figures.

Description of the skill
This skill will introduce you to natural science illustration and train you in drawing techniques used in this field. No artistic experience is assumed for students entering this practical and drawing techniquesfor technical illustration differ from those taught in many art classes, so instruction will start with basic drawing. You will then explore techniques using pencil and ink, as well as guidelines for composition. You will also get experience digitizing and digitally editing illustrations to construct scientific figures for publications. Your final project for the course will be to produce a full illustration in either of the introduced media.

Literature
Course manual and weekly instructions.

Instructional format
One class per week to practice techniques.

Assessment
- Weekly drawing assignments;
- Short writing assignments;
- Final illustration project.

PRA2020 Practical Mass Spectrometry

Course coordinator

Prof. dr. M. Honing: Faculty of Health, Medicine & Life Sciences.
Contact: m.honing@maastrichtuniversity.nl

Pre-requisites

INT2010 Principles of Mass Spectrometry

Objectives

- Familiarization and practical experience with ionization techniques; ESI, MALDI and APPI;
- Basic understanding of ion physics and ion trajectories in mass spectrometers;
- Basic training in the application of tandem mass spectrometry (MS/MS) for biology and chemistry relevant molecules, the use of MS/MS prediction software;
- Ability to utilize ion mobility spectrometry (IMS) for three chemistry relevant molecules for molecular shape analysis;
- Understanding of the assessment of the native structures of proteins by MS;
- Basic understanding on the application of vacuum systems, optimization of detectors, ion optics, electronics.

Description of the course

This course focusses on gaining practical experience with a variety of MS and ion mobility spectrometry. A variety of ionization technologies, including MALDI, ESI and APPI will be used for the structural identification of biological relevant molecules like, proteins or small molecule hormones. The optimization of ESI, by varying e.g. ion-focusing lenses and electrical field strength, willgive the student an introduction in the practical aspects of ion-physics. Likewise, optimization of MS/MS methodologies will allow the students to recognize the importance of the physical foundations of gas- phase molecular collisions, the assessment of molecular structures. By developing MS imaging methodologies, physical chemical processes at the surface of tissues or biomedical materials will be gained. As MS plays an essential role in many R&D laboratories, a broad field of applications, including human tissues, endogenous compounds such as lipids and proteins, pharmaceutical drugs, biomedical materials such as orthopedic implants will be used. The students will gain basic experience with MS (ionization and separation instruments) and IMS based technologies.

Literature

Mass Spectrometry Principles and Applications, de Hoffman, power point slides, articles to be distributed.
Students are requested to search literature for specific manuscripts.

Instructional format

This practical course is organized as a series of hands-on experiments, analyzing different small and larger molecules with various MS techniques. The students(in small groups) will work as a team, taking care that all participant will have worker with the technologies.

Assessment

The assessment on individual level will be based on:

- The resolution of an "molecular structure" and MS analysis puzzle;
- The quality of the individual notebooks (template provided by instructors);
- Laboratory reports.

PRA2021 Historical Pigments Synthesis

Course coordinator
Dr. Giuditta Perversi, Maastricht Science Programme, Faculty of Science and Engineering.
Contact: g.perversi@maastrichtuniversity.nl
Kate Seymour, Stichting Restauratie Atelier Limburg (SRAL)
Contact: k.seymour@sral.nl

Prerequisite
None

Recommended
- ✓ PRA1001 or PRA1101 Introduction to Scientific Research I
- ✓ PRA1002 or PRA1102 Introduction to Scientific Research II

Objectives
- To become acquainted with pigments used historically (pre-Industrial Revolution) by artists;
- To become acquainted with the preparation of such minerals for use as a pigment;
- To become acquainted with synthesis methods to reproduce historical (pre-Industrial Revolution) pigments, and obtain practical experience with some of these techniques;
- To answer research questions connected to use of these pigments by artists;
- To further develop hands-on experience with the laboratory practices of extraction pigments from minerals or synthesising them.

Description of the course
Have you ever wondered where the beautiful bright colours used by artists come from? This skills module will allow you to experience the process first-hand. The aim of the skills training is to introduce how a variety pigments were made, using the same chemistry as in the 17th century and comparing this to modern chemical processes. The identification ofchemical and morphological composition will be covered. Ultimately, the produce pigments can be mixed with traditional binding media to create a paint. After a general introduction, the students will work in pairs to produce pigments, organic and inorganic in nature (sometimes in small the group subgroups with a particular focus). Practical and research problems will be addressed, such as:

- Extraction of the colour aspect from the mineral or rock or plant;
- Complex synthesis to create the pigment from the source materials;
- (Theoretical) comparison between historical making processes and modern production processes.

Relevant literature on artistic materials will be studied and used to support findings. The course is mostly based at the Dub30 laboratories, but will involve visits to the Stichting Restauratie Atelier Limburg (SRAL). Supervision will be by both SRAL and MSP staff.

Literature
Selected articles and chapters will be provided to the students.

Instructional format
Practical work, group discussions, laboratory visits and literature research.

Assessment
The student’s performance will be assessed with:

- Weekly assignments on the experimental work performed in the lab;
- A final examination (power point presentation on research design);
- Lab notebook keeping and contribution to the collective practical work.

PRA2022 Integrated Assessment Modelling of Climate Change

Course coordinator
Prof. Dr. Pim Martens, University College Venlo.
Contact: *p.martens@maastrichtuniversity.nl*

Prerequisite
- ✓ None

Objectives
- Understand the climate system, its dynamics and feedback loops;
- Understand climate and climate impacts models;
- Understand how the models are used to predict future changes;
- Be able to design your own (conceptual)climate impact model;
- Improve your communication and debating skills on climate change.

Description of the course
Climate change poses serious challenges for humans around the world. Global warming is perceived as one of the biggest global health risks of the twenty-first century which could have a range of effects. In this skills course, we'll take an integrated (modelling) approach to climate change. This course ranges from the fundamental science of the atmosphere to the social, economic and political consequences of climate change. We'll start with an introduction of integrated assessment modelling, followed by an overview of the climatic system, how it's changed over time and how it's predicted to change in future. Then, we'll focus on the impact of climate change on our lives.

Theory is mixed with practice through discussions, modelling sessions and games.

Literature
All material (problem descriptions and supporting literature) will be provided during the course and made available through the Student Portal. There is no specific textbook.

Instructional format
Presentation and computer-based group practicals, research-based learning, excursions.

Assessment
- Final report;
- Graded laboratory exercises.

PRA2023 Astronomical Observing Techniques

Course coordinator
Mr. Chad Ellington, Faculty of Science and Engineering, Maastricht Science Programme.
Contact : chad.ellington@maastrichtuniversity.nl

Prerequisite
- ✓ PHY2008 Solar System Astronomy OR
- ✓ PHY2009 Stellar Astronomy OR
- ✓ PHY2010 Galactic Astronomy

Objectives
This skill will prepare students to:
- Design, use and perform measurements in observational experiments;
- Manipulate and measure light;
- Carry out data reduction/analysis of astrometric, photometric and spectroscopic observations;
- Learn basics of various software routines for processing data and assembling figures;
- Communicate processes and findings to others;
- Productively collaborate and critique.

Description of the course
This practical is aimed at learning various aspects of observational astronomical techniques. This will be accomplished via hands-on exercises, laboratory experiments/analyses and via computer-based exploration. This practical will hopefully begin to prepare you for continuing to more professional astronomical instruments. Students in this practical will perform some observations on their own: beginning with simple naked eye observations and their interpretations, understanding optical systems of telescopes, move on to acquiring, processing & analyzing imagery acquired with CCD or CMOS cameras, acquire & analyze radio telescope observations of 21cm radiation within our Milky Way galaxy and finish up with the multimessenger-era of astronomy to better understand gravitational wave observations. Sub-topics may include learning about: celestial coordinate systems, celestial navigation,blackbody radiation, spectroscopy, image formation, diffraction, active/adaptive optics, various telescope types, tracking mounts, image acquisition (bias, flats, darks & science images), image processing, photometry, light curves, radio observations and interferometry.
Due to uncertain weather conditions and that some observations will need to be performed outside regular practical hours, some observations may be left up to students to perform on their own or will beof a simulated nature. If weather conditions indicate it was clear and students did not perform their observations nor figure out how to perform them virtually, this will certainly be reflected in practical performance.

Literature
- To Measure the Sky (An Introduction to Observational Astronomy), F.R. Chromey, Cambridge University Press, 2010;
- AAVSO Observing Manuals, https://www.aavso.org/observing-manuals;
- AstroImageJ, https://www.astro.louisville.edu/software/astroimagej/;
- ISIS (Integrated Spectrographic Innovative Software), http://www.astrosurf.com/buil/isis-stoftware.html (Windows only though!).

Instructional format
In this skill, participants work together in small teams as well as individually and will perform different observations/laboratory exercises each week. Each observation is thoroughly planned, executed, and analyzed by the team, with summary reports submitted. The final grade is partially based on these reports as well as other assessments.

Assessment
The overall practical grade is based on:
- Pre- and post- diagnostic assessments;
- In-practical assignments;
- Laboratory reports;
- Evaluation of an observing logbook;
- A final presentation and/or examination.

PRA2024 Geology

Course coordinator
Dr. Jesse Hennekam, Faculty of Science & Engineering, Maastricht Science Programme
Contact: j.hennekam@maastrichtuniversity.nl

Prerequisite
- ✓ INT1007 Introduction to Earth Sciences
- ✓ A bike to make field trips

Objectives
With its elevated landscape, prominent Pleistocene glacial deposits, and world-famous Cretaceous outcrops, Maastricht and its surroundings are situated in an exceptionally interesting geological environment. Furthermore, it marks a transition zone between the Ardennes in the south and the Rhine-Meuse delta in the north. The objective of this geology training course is to learn and utilise specific field skills, enabling you to investigate and understand the geology and geological history of an area.

Description of the course
Ever wondered why the south of Limburg is so distinctly different from the rest of the Netherlands? Being uniquely situated between foot of the Ardennes mountain range and the river delta in the low lands, Maastricht and surroundings are very interesting from a geological point of view. Moreover, the presence of the Maastrichtian Stage, a period demarking the end of the era of the dinosaurs, highlights the global importance of south Limburg to the study of geology. Millions of years of climatic variation, sea level changes, mountain building and erosion have formed the Limburg landscape into its current shape. This geological history has also a huge impact on the development of the area. The hills in the Limburg surroundings and their loess deposits, resulting in fertile grounds; the effects of the Meuse, dividing the city of Maastricht; and the ENCI quarry, excavating ancient sea deposits in order to provide building resources. During this course we will use various field techniques to investigate how these structures came into existences and how they have developed since. You will read and create geological maps, draw and measure outcrops, identify specific types of rock and learn how to look at a landscape in order to understand its geological past.

Literature
No textbook is required, although the literature used in the INT1007 Introduction to Earth Sciences course will be useful.

Instructional format
During this course we will go outside on multiple occasions. Most excursions will be in and around Maastricht city, for which a good bike will be necessary to reach the sites.

Assessment
- Field assignments;
- Field report.

PRA3001 Advanced Organic Synthesis

Course coordinator
Dr. Hanne Diliën, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: hanne.dilien@maastrichtuniversity.nl

Pre-requisites
- ✓ PRA2002 Chemical Synthesis

Co-requisites
- ✓ CHE3001 Organic Reactions

Objectives
The main objective of this skill is to provide a solid foundation in multi-step organic synthesis. Most organic compounds cannot be prepared in a single step. Instead, a sequence of reactions has to be designed to obtain these materials. Some of these steps may require complex chemistry, very reactiveintermediates or inert atmospheres. This course focuses on these special situations.

Description of the skill
This skill will contain:
- Advanced synthetic chemistry of various organic reaction types;
- Multi-step organic synthesis;
- Synthesis and handling of reactive compounds under inert atmosphere;
- Extensive use of spectroscopic characterization (therefore it is recommended to already have experience in operating the IR and NMR in the chemelot labs).

Literature
- Practical laboratory instructions;
- For students intending on continuing and specializing in organic chemistry, a practical book, such as “Multiscale Operational Organic Chemistry” by John W. Lehman (Pearson, 2^{nd} edition, 2009) may be interesting.

Instructional format
This training is organized as a series of laboratory sessions. The students will have to prepare short reports on the various laboratory activities of this training. The theory required for the skills is introducedduring the tutorial group meetings of the co-requisite course: CHE3001 Organic Reactions.

Assessment
- The laboratory notebook with developed protocols;
- Lab reports;
- Pre-lab assignments.

PRA3002 Advanced Physics Laboratory

Course coordinator
Dr. Chris Pawley, Faculty of Science and Engineering, Maastricht Science Programme.

Contact: c.pawley@maastrichtuniversity.nl

Pre-requisites
- ✓ PRA1003 Basic Physics Laboratory
- ✓ PRA2007 Physics Laboratory

Note: Waivers are unlikely to be granted unless applicants show significant expertise in experimental physics or similar subject (equivalent to the two pre-requisite skills).

Co-requisites
- ✓ None

Objectives
- To acquaint the participants with an overview of the main areas in experimental physics;
- To illustrate the relationship between observation, experiment and hypothesis;
- To give the participants a better understanding of the laws of physics;
- To hone the skills required for planning and conducting experimental physics;
- To develop the skills of experimental design and the impact this has on the outcome.

Description of the skill
This skill is the culmination of the physics laboratory modules, and requires participants to use the skills that they have acquired in their previous lab experiences to good effect in order to design and conduct suitable experiments. The participants will have the opportunity to conduct experiments in material science, thermodynamics, optics, nuclear and particle physics and chaotic dynamics. During this skill, the participants will design experiments to test hypotheses in a variety of fields, ensuring that the datathat they gather is sufficient to address pertinent questions in this field. Unlike the prerequisites, the participants will not be given step-by-step instructions for each experiment - a certain level of independence is both expected and required.

Literature
- University Physics with Modern Physics, H.D. Young & R. A. Freedman, Pearson Education (US), 13th International edition, May 2011;
- Practical Physics, G.L. Squires, Cambridge University Press, 4th edition, September 2001;
- Measurements and their Uncertainties: A practical guide to modern error analysis, I. Hughes & T. Hase, Oxford University Press, August 2010.

Instructional format
This skill is taught in a 'carousel' style – participants work in small teams (2 or 3 per team) with each team working on a different experiment during the session. During each subsequent week the team conducts a different experiment, this provides the opportunity for each team to perform experiments in diverse areas of physics during the entire module.

Assessment
Assessment consists of:
- Contribution within the lab;
- Quality of lab notes kept plus individual lab reports written following the laboratory session.

Each participant produces lab reports for the duration of the module. These are marked considering the quality of the experimental design as well as the report itself.

PRA3003 Molecular Biology

Course coordinators

Servé Olieslagers, Faculty of Health, Medicine and Life Sciences, Maastricht University.
Contact: s.olieslagers@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA2014 Genetics

Co-requisites

- ✓ BIO3001 Molecular Biology

Objectives

- To be able to investigate protein/nucleic acid interactions via an electrophoretic mobility shift assay (EMSA);
- To perform and comprehend a cytological staining and to visualize and interpret the results;
- To apply basic cloning tools in order to manipulate nucleic acids;
- To isolate proteins from cells and perform protein quantification;
- To perform an immunoprecipitation (IP) and interpret the final results by Western immunoblotting;
- To put together a research grant proposal plan based on previously published research; to present and defend it towards peers and tutors.

Description of the skill

The general aim of this skills course is to obtain detailed knowledge about the techniques that can be applied to address molecular processes in mammalian biology. Topics include the intracellular signaling pathways; cellular responses; Nucleic acid vs protein interactions; and the culmination of the above elements in an essay and assignment to indicate active understanding of the above processes. The skills days are designed to provide a perspective of how molecular biological techniques are applied to tackle major research questions in modern biomedical research.

Literature

A reader is provided at the start of the course. Other recommended from pre- and co-requisites.

Instructional format

Skills group meetings.

Assessment

- Attendance to the skills meetings is required. A final evaluation on skills attendance and active participation is scored by result analysis;
- A written skills;
- A student group scientific proposal writing activity and group presentation.

PRA3005 Polymer Processing

Note: This skill will require students to arrange their own travel to the Geleen Chemelot campus to attend laboratories.

Course coordinator

Cyriel Mentink PhD, Chemelot Innovation and Learning Labs.

Contact: cyriel.mentink@chillabs.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry

Co-requisites

- ✓ None

Objectives

- To have the skills to determine the physical and mechanical properties of polymers and to increase the understanding of the underlying analytical methods;
- To obtains skills in the processing of polymers e.g. (film)extrusion and injection moulding,compounding, etc.;
- To obtain an understanding of the processing of different polymers like thermoplastic, and elastomeric polymers.

Description of the skills

In this practical course the processing and mechanical testing of polymers will be explored. The course will exist of three different experiments. In these experiments the processing and testing of a specific polymer will be conducted.
Thermoplastic polymers will be processed with blown film extrusion. Mechanical tests will be conducted on the produced films to get a better understanding of the effects of the processing on the properties of the material.
Thermoplastic polymers with fillers will be processed via twin screw extrusion. These materials will be used in the next experiment for injection molding.
By the use of injection moulding standard dog bones will be made for mechanical testing. Mechanical and physical properties of the product will be determined by tensile and bending strength analysis, Melt Flow Index (MFI) and a notched test bar impact test.

Literature

Practical Manual and SOP’s of the used equipment.

Instructional format

Practical course.

Assessment

- Assessment of the motivation;
- Assessment of the practical skills;
- A written lab report at the end of every experiment.

PRA3006 Programming in the Life Sciences

Course coordinators

Dr. Rianne Fijten [1], Dr. Egon Willighagen [2] & Prof. Dr. Chris Evelo [2,3]

1. Department of Radiotherapy, FHML
2. Department of Bioinformatics – BiGCaT, FHML
3. Maastricht Centre for Systems Biology (MaCSBio), FSE

Contact: r.fijten@maastrichuniversity.nl

Pre-requisites

✓ MAT2007 Introduction to Programming **or** PRA2003 Programming

Objectives

- To have the ability to recognize various classes of biological entities and to understand how they link to human health;
- To know the programming concepts related to data processing and web services;
- To be familiar with technologies for web services and querying resources in the life sciences;
- To obtain experience in using such web services with a programming language;
- To be able to select web services for a particular biological or medical research question;
- To be familiar with modern software development practices;
- To have the ability to visualise data retrieved from web services.

Description of the course

In the life sciences the physical interactions between chemical and biological entities, like genes, RNA, proteins, metabolites, and drugs, is of key interest to human health. Not only do these interactions play an important role in the regulation of gene expression, inhibition of proteins, and they basically define all cellular processes and therefore life itself. For example, pharmacology studies the action of drugs on protein, metabolism depends on the interactions of small molecule substrates with enzymes, and coronaviruses reorganise the normal function of cells after entry into the cell.
With the increasing amount of knowledge and data in the life sciences, automation becomes increasingly important. The data, whether large or small and complex, have challenges to integrate data from different experiments and data sources. Many core life sciences databases provide SPARQL endpoints to their knowledge, while Wikidata is a spider in this web of semantic data. In this course, you will learn to use how to interact with SPARQL endpoints with JavaScript and visualise the results graphically with a library like d3.js or Cytoscape.js.

Literature

- "JavaScript & jQuery: The Missing Manual" by D.S. McFarland (O'Reilly, 2nd edition, 2011);
- "Wikidata as a knowledge graph for the life sciences" by A. Waagmeester et al. eLife, 2020, https://doi.org/10.7554/eLife.52614;
- "WikiPathways: a multifaceted pathway database bridging metabolomics to other omics research" by D. Slenter et al. NAR, 2018, https://doi.org/10.1093/NAR/GKX1064;
- "Semantic Web programming" by J. Hebeler. 2009. UB Library. https://maastrichtuniversity.on.worldcat.org/oclc/428142652;
- "Semantic Web for the working ontologist: effective modeling in RDFS and OWL" by D. Allemang, J.A. Hendler. 2011. UB Library. https://maastrichtuniversity.on.worldcat.org/oclc/733936673;
- "Git from the Bottom Up" by J. Wiegley. https://jwiegley.github.io/git-from-the-bottom-up/.

Instructional format

Five hands-on practicals, literature review, and home assignments. Students should bring their own laptop.

Assessment

- A final product consisting of working source code and documentation (group assessment);
- A final presentation describing the product, research question, results, and conclusions (group assessment);
- Individual written or oral assessment.

PRA3008 Transition Metal Chemistry

Course coordinator:
Dr. Burgert Blom, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: burgert.blom@maastrichtuniversity.nl

Pre-requisites:
- ✓ PRA2002 Chemical Synthesis
- ✓ PRA2004 Inorganic Synthesis
- ✓ CHE2004 Spectroscopy

Recommended:
- ✓ CHE3001 Organic Reactions
- ✓ PRA3014 Spectroscopic Methods

Co-requisites:
- ✓ CHE3002 Transition Metal Chemistry

Objectives
- To adapt common synthetic techniques towards inorganic and organometallic compounds;
- To learn Schlenk-line and glovebox techniques in order to work with air-sensitive transition metal compounds;
- To apply the theoretical knowledge gained in CHE3002 in a laboratory setting;
- To use diverse analytical techniques to explore the physical, electronic and spectroscopic properties of the transition metal complexes synthesized;
- To experimentally perform catalytic reactions to test the complexes synthesized.

Description of the skills
This skill is devoted to the multi-step synthesis, characterization and further exploration of organometallic complexes. These complexes allow for an introduction to organometallic (coordination) chemistry, geometrical distortions, ligand isomerism, back-bonding interactions, and catalysis. Each week a different class of compound will be synthesized including arene complexes, carbonyls, ferroceneand its derivatives, complexes with metal-metal multiple bonding, coordination complexes with phosphane ligands etc. Synthesis and detailed data analysis via spectroscopy are the cornerstone of thisskill and learning to work with complexes under inter conditions (under nitrogen).
Concepts from the Transition Metal Chemistry Lecture (CHE3002) can be related back to this practical, and provide a foundation that can be utilized in order to successfully complete this course.

Literature
- TBA.

Instructional format
This practical course is organized as a series of laboratory sessions.

Assessment
- Research paper on one of the experiments (40 %);
- Weekly questions and spectral data to be handed in for grading (60 %).

PRA3010 Microbiology

Course coordinator

Frank Stassen, Faculty of Health, Medicine and Life Sciences.

Contact: f.stassen@maastrichtuniversity.nl

Pre-requisites

- ✓ BIO2001 Cell Biology
- ✓ BIO2007 Genetics

Co-requisites

- ✓ BIO3003 Microbiology

Objectives

In this skill training you will perform microbiological tests such as a variety of biochemical and molecular methods that enable you to identify an infectious agent and genetic relatedness in case of an outbreak.

Description of the skill

Medical Microbiology is concerned with the diagnosis, treatment and prevention of infectious diseases. For identification and treatment of an infectious agent patient samples are analyzed in a medical microbiology laboratory. In the first three weeks of this skill training you will get acquainted with the basic microbiological techniques such as, microbial culture, biochemical tests, antimicrobial resistance, and molecular characterization. In the subsequent weeks, you will each analyze a potential outbreak forwhich you will need to determine the infectious agent, analyze the antimicrobial resistance pattern to propose therapy as well as the genetic composition of the micro-organism in order to determine geneticrelatedness. For this you will use the techniques that you have learned in the previous weeks. Finally you will need to present your results in a practical report.

Literature

- Murray, *Medical Microbiology* (8^{th} ed.), Elsevier Mosby;
- Primary literature.

Instructional format

Weekly laboratory experiments.

Assessment

You will be marked on the quality of

- Your written research plan (week 3);
- A poster presentation on the outbreak analyses (final week).

PRA3011 The Limburg landscape

Course coordinator

Dr. Roy Erkens: Faculty of Science and Engineering, Maastricht Science Programme

Contact: roy.erkens@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA2009 Field Skills in Biology
- ✓ A good quality bike to make field trips

Co-requisites

- ✓ None

Objectives

The landscape of Limburg is unique in the Netherlands, especially the Southern part. In terms of botanical and geological diversity but also in terms of elevation the province has a clearly distinct profile from the other provinces in the Netherlands. It is also this landscape you see on a daily basis while studying at Maastricht University. The main objective of this skills training is to familiarise you with the biological characteristics and geological history of the province so you can understand the evolution of its natural landscape.

Description of the course

The landscape of Limburg, like any other landscape, displays a variety of features. Some of these reflect man's ongoing endeavour to adapt the landscape to its needs. For instance, there has been a clear impact of human behaviour in the province from the moment that Neolithic farmers arrived in these parts around 4000 BC. Other features represent a natural evolution of the landscape on a scale of (tensof) millions to several thousands of years to very recent. Distinct features are the geology, the variety in landforms and different climatic conditions. This combination of geological, geomorphological and climatic factors has endowed the province with its own characteristic wealth of especially botanical variety but also explains the findings of for instance Mosasaurs. Topics covered in this skills training are the geological history of Limburg, characteristics and management of the riverine landscape of the Maas,the practice of nature conservation and the ecology of different types of South Limburg forests. As partof this skill, you will also gain more in depth knowledge of the use of Geographical Information Systems(GIS) software.

Literature

This skill will use solely primary literature as a basis for the tasks. No text book is required.

Instructional format

Every week a major topic will be addressed (e.g. geology and paleobiology, river biology, fungal biology, nature conservation). During the weeks you will visit several field sites by bike or bus. Parts of some days will be devoted to learning GIS analyses. The bus will be arranged by MSP but you are responsible for having a proper bike available (e.g. proper brakes etc.). On some days we might bike substantial distances in an elevated landscape so also make sure you are in good health.

Assessment

The assessment includes several assignments:

- Individual GIS assignments;
- An individual review report on one of the excursions;
- A group review report on one of the excursions;
- Optional GIS project.

PRA3012 Advanced Electronics

Coordinator

Dr. Bart van Grinsven, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: bart.vangrinsven@maastrichtuniversity.nl

Prerequisites

- ✓ PRA2006 Electronics Lab
- ✓ PHY2006 Electronics

Objectives

- To appreciate the theory behind digital (Boolean) logic and logic gate applications and to develop an insight into how computers function;
- To design, study and build circuits involving adders, flip-flops, counters and sequential logic and understand how these devices can be used in everyday electronics;
- To understand how an electrocardiogram (ECG) measures the heart's electrical pulses and translates these into an analogue waveform;
- To build an ECG generator and detector and collect measurements using these;
- To use impedance spectroscopy to distinguish between different samples and understand the principles behind this technique.

Description of the skill

The course builds on the introductory electronics lab and is split into three, two-week long projects covering the following topic areas:

- **Digital electronics for computing:**
  This project covers the basics of binary number systems, Boolean algebra, and logic devices. You will build a digital clock to provide an appreciation of how digital devices can perform different functions. A similar device will be built using the Arduino microcontroller to better understand how an integrated microcontroller can achieve the same functions of many discrete logic components;
- **Analogue electronics with bioengineering applications:**
  In this project you will build an ECG generator and measurement unit using analogue components with the aim of better understanding analogue electronics and their potential applications in biomedical engineering. Students will gain a more detailed insight into the charging and discharging characteristics of biological and technological capacitors as well as understanding the function of amplifiers, filters and counters;
- **Electrochemical impedance measurement and biosensor technology**
  Impedance spectroscopy is an electronic read-out technology which emerged in the Nazi era, used to investigate the structural quality of U-boats. Through the decades the technology was optimized and is now an established technology, implemented in (bio) medical research. It has been used for the detection of proteins, neurotransmitters and even the detection of single nucleotide polymorphisms in DNA sequences. In this project you will mimic this last experiment and try to delineate impedimetric signals in way that DNA melting times can be calculated and based on this information you will try to distinguish between a full matching DNA sequence and a mutated DNA sequence.

Literature

A course manual and detailed experiment descriptions will be provided during the practical.

Instructional format

Laboratory sessions: students working in small teams working on a different project every two weeks.

Assessment

Assessment is based on:

- Question sheets to be completed within the lab;
- Lab reports;
- An oral assessment.

PRA3014 Spectroscopic Methods

Course coordinator

Dr. Chris Bahn, Faculty of Science and Engineering, Maastricht Science Programme.
Contact: chris.bahn@maastrichtuniversity.nl

Pre-requisites

- ✓ CHE2001 Organic Chemistry
- ✓ CHE2004 Spectroscopy

Co-requisites

- ✓ None

Objectives

- Learn to identify chemical compounds using a variety of available analytical techniques;
- Have a basic understanding of the theoretical background of the measurement principles typically used in spectroscopy and spectrometry;
- Be able to develop an analytical strategy to identify an unknown compound;
- Be able to operate typical spectroscopic instruments.

Description of the skill

This course focuses on several topics in analytical chemistry and will contain:

- Identification and structure elucidation of molecules and materials with advanced spectroscopy and spectrometry;
- UV-Vis spectroscopy;
- FT-IR spectroscopy;
- ^{1}H, ^{13}C, ^{19}F, ^{31}P, COSY spectroscopy;
- Mass spectrometry using GC and LC;
- Possible module on Differential Scan Calorimetry and Thermogravimetric Analysis.

Literature

- The textbooks from the pre-requisite courses;
- Manuals of the different instruments will be provided.

Instructional format

Interactive laboratory sessions.

Assessment

- Lab reports, including theoretical background, procedures, data presentation and discussion;
- Laboratory notebook and lab safety;
- A chemical analysis project.

PRA3017 Applied Cell Biology

Course coordinator

Prof. Martijn van Griensven: Dept. cBITE, MERLN Institute for Technology-Inspired Regenerative Medicine; Faculty of Health Medicine and Life science, Maastricht University.

Contact: m.vangriensven@maastrichtuniversity.nl

Pre-requisites

- ✓ PRA2014 Genetics

Co-requisites

- ✓ None

Objectives

The main objective of this course is to provide a practical introduction into molecular and cell biology. We will use osteoblasts to study the effects of a hypoxia mimic on programmed cell death. A variety of experiments will be performed to study the effects on RNA and protein level. Cell Profiler will be used for image/data analysis.

Description of the skills

These skills will contain:

- Immunohistochemistry (IHC) on HIF translocation in hypoxia/DFO treated and untreated cells;
- RT-qPCR using Sybr Green for anti- and pro-apoptotic markers;
- Metabolic assays (LDH assay);
- Microscopy;
- Computational analysis of obtained data (Use of CellProfiler to analyse IHC data).

Literature

- Course manual;
- Oxygen-distribution within 3-D collagen I hydrogels for bone tissue engineering (P Wolff, Materials Science & Engineering C95 (2019) 422-427).

Instructional format

This training is organized as a series of laboratory sessions. The students will have to prepare short reports on the various laboratory activities of this training.

Assessment

- Attendance to skills meetings is required (cf Rules and regulations);
- Mini quizzes regarding the technique will be given before the start of a practical topic to make sure students come prepared to the course;
- At the end of week 4 a written skills exam will be provided. This exam will contain ±25 questions related to the practical techniques and information received during the first 4 weeks of the course;
- Keeping an organized laboratory notebook;
- Practical reports.

PRA3018 Molecular Modeling

Course coordinator
Dr. Veaceslav Vieru: Faculty of Science and Engineering, Maastricht Science Programme.

Contact: v.vieru@maastrichtuniversity.nl

Pre-requisites
- ✓ CHE3006 Quantum Chemistry

Co-requisites
- ✓ None

Objectives
- To demonstrate as to what can be achieved using molecular modelling software;
- To identify the most appropriate basis sets for solving different problems;
- To extract via calculations a variety of measurable properties (HOMO/LUMO, transition states, energies, electron densities…);
- To interpret the results of calculations and draw conclusions as to how a reaction will proceed;
- To study transition states and their relevance in chemistry.

Description of the skills
This practicum will introduce students to the basics of computational chemistry via a series of different calculations carried out with Gaussian software. Among others, students will learn how to run Hartree-Fock and Density Functional Theory (DFT) single point calculations and how to include the electron correlation energy via Møller–Plesset second-order perturbation theory. Equally, they will learn to optimize the geometry of molecules, calculate infra-red spectra, study reaction paths and finding the transition states. Moreover, they will be instructed to compute potential energy surfaces, consider solvent effects, and calculate rate constants.

Literature
Cramer, Christopher J. *Essentials of Computational Chemistry*: *Theories and Models* (2nd ed.) Wiley.

Instructional format
Practical sessions.

Assessment
Assessment will be based on the quality of lab reports and results obtained.

PRA3020 Analytical chemistry in the Art World

Note: this course replaces PRA3007 Conservation Science Skills. If you have successfully completed PRA3007 you may not participate in PRA3020.

Course coordinator

Dr. Giuditta Perversi: Faculty of Science and Engineering, Maastricht Science Programme.
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Pre-requisites

- ✓ CHE2001 Organic chemistry

Co-requisites

- ✓ INT3010 Science and the Visual Arts

Objectives

- To become acquainted with various analytical techniques used for the investigation of paintings and other works of art, and of artists' materials;
- To obtain practical experience with some of these techniques;
- To answer research questions connected to works of art and artists' materials;
- To further develop hands-on experience with the laboratory practices of discovering fraud and forgery, as well as of supporting fine arts conservation.

Description of the skills

Over the last decades the field of conservation science has evolved in parallel with that of forensic science. Many non-destructive (NDT) and non-invasive analytical techniques are used, hand-in-hand with more traditional photographic methods, for the identification and detection of fakes and forgery. These same techniques are also indispensable in the decision-making processes used by conservators to determine treatment protocols for individual art works. Modern instrumental techniques make it possible to extract a whole array of 'big data' from a 'grain of original material'. This skills training module is intended to be a first practical introduction to this highly interesting, broad and quickly expanding field. The course will take place predominately in the conservation studios of the Stichting Restauratie Atelier Limburg (SRAL) and the training will be mainly given by the SRAL staff. Actual artworks, often undergoing conservation treatment, will provide the source material for study. Laboratory work will take place both at the SRAL (Maastricht) and at DUB30.
After a general introduction, the group will be divided into small subgroups that will work on the different practical and research problems, such as:

- The analysis of paint cross-sections from (authentic) paintings, using different analytical techniques for the identification of pigments, binding materials, varnishes…;
- The complex synthesis of an old pigment, via different routes, followed by the analytical identification of the different colourful reaction products;
- The analysis of several pigments and resins used in the past.

A large number of different techniques will be employed, including: optical and UV microscopy, UV spectroscopy, FTIR, SEM/EDX, etc. The difficulty in interpreting results and the relevance of these outcomes for the scientific research and investigation of fine art paintings (such as dating, proof of authenticity, attribution, etc) will be discussed. Relevant literature on artists' materials and research methods will be studied and used to support findings.

Literature

Selected articles and chapters will be provided to the students.

Instructional format

Practical work, group discussions, laboratory visits and literature research.

Assessment

- A mid-term examination, which consists of a research paper;
- A final examination (power point presentation on research design);
- The contributions to the collective practical work.

PRA3021 Topics in Scientific Computing

Course coordinators

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Pre-requisites

- ✓ MAT2004 Linear Algebra
- ✓ MAT2006 Calculus

Pre/Co-requisite

- ✓ MAT2007 Introduction to Programming

Recommended

- ✓ KEN1540 Numerical Mathematics

Objectives

- To learn some important algorithms for scientific computing;
- To know the assumptions for and rationale behind these algorithms, understand where they can be applied, and where they may fail;
- To gain experience implementing algorithms and applying them to scientific problems.

Description of the skill

Scientific computing concerns the use of computers to analyze and solve problems arising in biology, chemistry and physics. This generally involves the construction of a mathematical model of the scientific problem, and solving the mathematical problem using computational algorithms. The purpose may be to improve the understanding of natural phenomena or to make predictions of behaviour under different conditions.
A broad range of scientific problems can be tackled computationally, including simulation methods (for dynamic systems); transform methods (for processing data and images) and optimisation methods (for learning models from data and improving technological processes).
This course will focus on well-established algorithms, which will each be applied to a realistic scientific case study. The methods are frequency-domain Fourier/wavelet analysis (for signal processing and quantum physics), linear regression, principal component analysis and clustering algorithms (for classification and data analysis), integrators for ordinary differential equations (for simulation and control of dynamic systems), finite-difference solvers for partial differential equations (for investigating pattern formation).
The course will be entirely based on the use of Matlab, a high-level scientific programming language and interactive environment for numerical computation, visualization, and programming. This course is complemented by KEN1540 Numerical Mathematics, in which students learn in more depth the basic algorithms of scientific computing.

Literature

All material (problem descriptions and supporting literature) will be provided during the course and made available through the Student Portal. There is no specific textbook.

Instructional format

Lecturing, computer-based practicals, problem-based learning.
There are no separate tutor groups for this course.

Assessment

- Computer practical reports;
- Class participation. There is 100% attendance requirement.

PRA3022 iGEM Project

Note: this project runs from period 4 to period 2 in the following academic year. Registration can only be done for period 1.

Course coordinator

Dr. Erik Steen Redeker, Faculty of Science and Engineering, Maastricht Science Programme
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Pre-requisites:

- ✓ PRO3022 iGem Project

Co-requisites:

- ✓ None

Objectives

Students will acquire an in-depth view of the scientific process of the design, build and test cycle of a synthetic biological system. They will not only get experience in the practical application of molecular biology techniques, but will experience the full cycle of a research project.

Description of the course

The iGEM competition is a prestigious international student competition on synthetic biology and is organized yearly by the Massachusetts Institute of Technology (MIT). In this competition student teams from all over the world try to tackle real-world problems by using synthetic biology. In this project, several important aspects of science will be experienced.
Students will brainstorm and decide on their own biological design. This design will then be modelled and built by using standard, interchangeable parts. In addition to the practical aspects, students will also be responsible for project management, funding, media attention and communication to the general public. At the end of the competition, the team will present the project at the iGEM jamboree (either online or in Paris) in a poster session and by giving an oral presentation.

Literature

This skill requires self-study and literature research as a basis. No text book is required.

Instructional format

A combination of group meetings, self-study, brainstorm sessions, participation in local iGEM team meet-up and workshops.

Assessment

Students will be assessed with a peer-review grade and with a supervisor grade that will be a combination of:

- The overall participation and contribution in the iGEM team (based on input in brainstorm sessions and project meetings);
- Practical work on the design and building of the biological system and the contribution to scientific presentations (oral and poster).

PRA3023 Plant Physiology and Microbiomes

Course coordinator

Dr. Jessica Nelson: Faculty of Science and Engineering, Maastricht Science Programme.
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Pre-requisites

- ✓ BIO2003 General Botany
- ✓ MAT1006 Applied Statistics OR MAT2005 Statistics

Co-requisites

- ✓ None

Objectives

After this practical, students should be able to:

- Conduct an experiment on plant growth and physiological responses to microbes;
- Contextualize their experiments with knowledge of plant microbiome research and its applications in agriculture and ecology;
- Perform sterile techniques for growing plants and microbes;
- Measure plant responses to biotic and abiotic stimuli;
- Correctly apply statistical tests to analyze a plant growth experiment;
- Use ImageJ to measure data images.

Description of the skill

As research on microbes living in and on plants has accumulated in recent years, it has become increasingly clear that plants' success and responses to their abiotic environment are mediated by their microbial communities or microbiota. Therefore the study of plant physiology is now increasingly linked to microbiology. In this skill, you will practice techniques for measuring physiological responses of plants to biotic and abiotic changes in their environments. This will include observing and quantifying common plant-microbe symbioses, measuring plant functional traits, and practicing techniquesfor sterile plant and microbe propagation.

Literature

Various primary literature articles and the course manual.

Instructional format

One laboratory session per week.

Assessment

- Reports on laboratory exercises;
- Laboratory notebooks;
- Research paper on the results of a growth experiment.

PRA3024 Analysis of Big Data in Physics

Course coordinator

Dr. Jacco de Vries, Maastricht Science Programme, Faculty of Science and Engineering.

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Pre-requisites

- ✓ MAT2007 Introduction to programming

Recommended

- ✓ At least a handful of physics courses at level 3000.

Objectives

At the end of the skill, students will be able to:

- Experiment with code in python in a notebook-like setup;
- Recognise the basic concepts of data analysis in physics;
- Compare and Evaluate various types of data;
- Perform statistical analysis on a variety of physics data sets, in order to extract meaningful physical parameters;
- Perform a proper analysis of errors, correlations and significance;
- Demonstrate awareness of the concept of false positives in data.

Description of the skill

As the world is digitizing, data is being generated by the terabytes per second. As such, there is a great need for people who can make sense of all these data and extract meaningful conclusions. In physics, the last 20 years has seen movement away from individuals working in research groups, towards large, international collaborations. Within these collaborations, data gathering and handling are essential for the successful completion of the experiments. Typical examples are through telescope observations, gravitational wave detectors or particle accelerators.

This skill is a general introduction to analysis of data from physics experiments. We will learn the systematic treatment of data - following logic and statistics - to reach answers to our questions and assess their significance. We will change datasets (and teachers) every week, which will consist of LIGO/Virgo data, CERN/LHCb data and astrophysical datasets. This skill will introduce modern computingskills for data handling such as artificial intelligence, data mining and scalability through (for example) parrallelization. We will make use of Jupyter notebooks running on a server at MSP, for which you just need to bring your laptop with a browser. The first week will cover an introduction to the python programming language.

At the end of the skill we hope to have provided you with a diversity of perspectives on data within physics as well as the skill to interpret and analyse such data.

Literature

TBD

Instructional format

Full-day practical setup, bring your own laptop.

Assessment

- Lab Reports;
- Code Review;
- Peer-to-Peer feedback.

PRA3503 Microbiome Analysis

Course coordinator
Dr. Jessica Nelson: Faculty of Science and Engineering, Maastricht Science Programme.
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Pre-requisites
- ✓ BIO2007 Genetics OR INT3007 Systems Biology OR MAT2007 Introduction to Programming

Co-requisites
- ✓ None

Recommended
- ✓ Basic familiarity with computer programming and command line interfaces
- ✓ BIO3003 Microbiology and/or BIO3010 Genomics and Proteomics

Objectives
After this practical, students should be able to:
- Process and analyze microbiome data from high-throughput sequencing;
- Correctly interpret microbiome data analyses;
- Assess the methodologies used in microbiome research publications;
- Contextualize their data analyses with knowledge of microbiome research and its applications in medicine, agriculture, and ecology.

Description of the skill
In the past decade, research has increasingly revealed that the success of macro-organisms like plants and animals is dependent on complex communities of micro-organisms living inside and on them—their microbiota. The collected genetic material of all these microbes is called a microbiome and can extend the genetic resources available to the host organism. Next generation DNA sequencing technologies have accelerated these discoveries by allowing identification of the many members of diverse microbiomes simultaneously. Such sequencing methods have generated large amounts of data which have required new bioinformatic methods. In this skill, students will learn how to analyze microbiome datasets. They will also familiarize themselves with the literature in this field in order to explain the applications and importance of microbiome research.

Literature
Various primary literature articles and the course manual.

Instructional format
One computer laboratory session per week.

Assessment
- Data analysis training exercises;
- Proposal and final paper for microbiome data analysis group project.

PRA3504 The Academic Life Cycle

PLEASE NOTE: This course only runs in alternate years (even). It will run in academic year 2022-2023 but not in 2023-2024.

Course coordinators

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Pre-requisites

- ✓ None

Recommended

- ✓ None, but students should have already written a university-level paper.

Objectives

At the end of the skill, students will be able to:

- Participate in all stages of the academic lifecycle: from idea to publication to publicization;
- Engage expert and non-expert audiences with your work/research;
- Network and communicate with peers, colleagues, and others;
- Identify relevant funding sources and publication venues for their research;
- Provide helpful feedback via the peer review process;
- Present their research in different venues and in different time limits;
- Convince outside stakeholders to support and fund their work.

Description of the skill

This skills course will complete the student's exploration of the academic life cycle – from idea to publication to publicization. Its coverage includes: writing grant proposals, submitting academic papers for publication in scientific venues, peer reviewing and assessing the work of other scientists, and developing the essential (and often untaught) interpersonal skills that are integral for professional and academic interactions. By performing and recreating many of these steps, students will gain the confidence and self-certainty to become well-rounded participants in professional, scientific arenas.

Particular emphasis will be placed on three specific moments in the academic sequence: grant writing, journal submission/review process, and outreach. After having completed this course, PRA2015, and PRO1101, therefore, the MSP student will have practiced virtually all important steps in the Academic Lifecycle.

Literature

All assigned readings and other materials are available (free of charge) via the course Canvas page and/or the UM library webpage.

Instructional format

A combination of in-person meetings/tutorials, asynchronous activities, and flexible group work. The in-person meetings will often feature guestspeakers and discussion sessions.

Assessment

Several small assignments and activities, including:

- Writing a (fictional) grant proposal;
- Mock submitting a revised/formatted paper to a journal;
- Peer review activity;
- Advertising your research over social media;
- Short presentations.

Courses Available at University College Maastricht

MSP students are welcome to register for the following courses, provided they meet the prerequisites, via the online course registration form. These requests will be automatically approved by the MSP Board of Examiners, pending scheduling conflicts. Students wishing to take courses at UCM not listed in this appendix should follow the full external education request procedure. Their motivated requests will be evaluated by the Board of Examiners. More details on UCM courses are available in the UCM course catalogue.

Course	**Title**	**Period**
SCI3007	Endocrinology	1
SCI3005	Metabolism, Nutrition and Exercise	2
SCI3050	Advances in Biomedical Sciences	2
HUM2022	Digital Media	2
HUM2051	Philosophical Ethics *Note: this course fulfils the LAS topic requirement.*	4
SCI2031	Immunology	5