Faculty of Science

Prospectus 2008 - 2009

Natural Science

Master

Radboud University Nijmegen

Preface

This prospectus provides information on courses as well as on research departments that are relevant to Master students Natural Science.

The goal of a Masters study is quite simple: Find joy in becoming an expert in a field that you like to work in, whether that be biophysical chemistry, theory of solid state physics, or science communication, every student here has a chance to study in a top-research environment, follow state-of-the art courses and participate in front-line research with world class researchers. Master students of Natural Science choose to become experts on the interface between disciplines, the surface where scientific development finds new ways. A Master in Natural Science is able to work with concepts and methodology of two trades. This prospectus offers a sample of subjects available at the Radboud University. But be sure to also venture out further in the information provided by other tracks, faculties and other universities.

The three non-research variants that resulted from the Beta-convenant have been getting a clear shape and programme so that there are now 4 choices for the starting master student: Research (O), Communication (C), Management (MT), and Education (E). All of these are described in this Masters Study Guide/Brochure.

Although the master Natural Science is intended to offer an all english curriculum, some information may still be available only in Dutch.

More information, and the most recent education and examination regulations (OER) can be obtained from the web-sites www.ru.nl/natuurwetenschappen and www.ru.nl/moleculairewetenschappen.

Important information about being a student in Nijmegen is available through the *Vademecum* that is available as a booklet for every student as well as on the internet www.ru.nl/students/general .

The contents of this guide were made and assembled with great care, however, errors and inaccuracies cannot be ruled out and no rights can be derived from this document. Suggestions for improvement and corrections are warmly welcomed.

July 2008,
Dr. L.J.J. Laarhoven, email: L.Laarhoven@science.ru.nl
Ms. E.A.M.L. Meijer

Contents

1 Introduction

1.1 Introduction

Master in Natural Science

Radboud University Nijmegen (RU) offers a Master of Science programme in Natural Science. This is the official master that follows the bachelors programme 'Natuurwetenschappen' at this university. These bachelor and master are unique in The Netherlands; they offer a programme that is both broad and in-depth in the three main disciplines of Science: Physics, Chemistry and Biology.

The master comprises a theoretical component and extensive practical training, which prepares the student for a PhD-position or a career in fundamental or applied research in industry or institutions. Also the training for a teaching position with a first-degree licence is possible in the second year. The master Natural Science even offers the possibily to obtain a double licence for chemistry and physics. Aside from these classic masterprogrammes there are two other possibilities: Communication and Management.

Admission

Both the bachelor and the master of the Natural Science study in Nijmegen are intended to train the student broadly, but deeply into the three disciplines Chemistry, Physics and Biology and specifically the boundaries between these. For this reason admission to the master programme is limited: Students have to have a thorough background in all disciplines to start the master.

For admission a Bachelor degree in Natuurwetenschappen is required, or a mostly completed curriculum of the first three years in the doctoral programme in Natural Science from Radboud University. In some cases bachelor students Natuurwetenschappen may enter the master programme before graduating, but only after approval of the examination board.
Students with a BSc in Chemistry or Physics from Nijmegen or other universities may be admitted after a check of their curriculum, and will usually have to follow some additional courses (max. 30 ec) to relieve deficiencies. Bachelor students who wish to enrol in the master Natural Science are advised to contact the study advisor timely. It is usually possible to limit deficiencies by choosing the right electives during the bachelor programme.

Bachelors in related subjects (Chemistry, Physics) from foreign universities will be checked for their level of knowledge in the three core disciplines before they can be admitted.

Students with a BSc in Biology, Molecular Life Sciences, or graduates from HBO Physics or Chemistry cannot enrol the master Natural Science. Their deficiencies exceed 30 ec. They may however be able to follow a shortened bachelor education track.

Structure of the Masters programme

The master programmes at the Science Faculty of Radboud University are offered in four variants: a research (O) variant, a communication (C) variant, an education (E) variant, and a management and technology (MT) variant.

The masters programme aims at specialization in a particular field between Physics, Chemistry and Biology. Students will have to take courses and one or two internships such that multidisciplinarity is obvious. At Radboud University many research groups of various denomination in science cooperate and there is ample opportunity to enter a multidisciplinary research specialisation of choice.

This prospectus

This prospectus describes the various master programmes and offers a choice of elective courses. Students are encouraged to venture into other study guides as well and look outside the boundaries of the Faculty. An extensive description of multidisciplinary research going on in the various research groups is given in Chapter 4.
At the end some practical information is supplied.

2 Master Programme

2.1 Masters programme

All master programmes at the Faculty of Science offer four variants: Research (O), Communication (C), Education (E), and Management (MT). Common aspects in all variants are a Natural Science programme consisting of elective and specialization courses and one or two research internships. In this chapter the different variants are described. The next chapter offers descriptions of the courses for C and MT variants, and a number of courses from Physics, Chemistry and Biology that may function as electives for the Natural Science programme. Bachelor students Natuurwetenschappen have graduated in one of three specializations:

- physical-chemical,
- biological-physical, or
- chemical-biological

In the master Natural Science, students can continue into the same direction of specialization, but this is not strictly required. Students entering the master with a different bachelor for instance will not have specialized according to these three yet. Students do have to make a choice, though, in any variant (O, C, E, MT) it is important to find a specialization for graduation and, accordingly, a matching programme of courses. Electives can be chosen freely, but the total package has to be approved by the examination board. The direction of internship determines which courses are compusory and with which specialization a graduate enters the job-market.

Always a specialization on the interplay of Physics, Chemistry and Biology must be chosen and every Natural Science internship (major, minor or within the variants) has to be approved by the Programme's board (see Chapter 5).

The Variants:

- The Research Variant (O-variant), trains students for fundamental and applied research and is required for people persuing a PhD position or a position in industrial or institutional research. The programme offers two research internships part of which can be fulfilled externally
- The Communication Variant (C-variant), trains students in the direction of communication of science. The programme consists of one research internship in science, and one project in communication
- The Education Variant (E-variant), educates students toward becoming a first-degree teacher in Chemistry, Physics, or both. During the first year a Natural Science internship is taken, the second year is completely education oriented
- The Management and Technology Variant (MT-variant), prepares students for a management position as an academic professional. Again: one Natural Science internship and one MT-project

2.2 O - Research Variant

Masters programme

Basically, the master programme for the research variant contains 6 months of elective and specialization courses, a Philosphy course, 6 months for a Minor and 1 full year for a Major specialization.
Minor and Major comprise an internship and a number of specialization courses/capita. Requirements are that Major and Minor are within research groups from different disciplines (Chemistry, Physics, Biology) and that both are multi-disciplinary. Approval regarding this has to be obtained from the Examination board for both.
The Research Variant comprises:

- Philosophy II 3 ec
- Science Electives at least 12 ec
- Electives 15 ec
- Minor 30 ec, including max 6 ec of specialization courses
- Major 60 ec, including max 12 ec of specialization courses

Requirements for internships

Internships need to be taken in two different disciplines along the lines of the chosen specialization. The subject of both Minor and Major internship will have to be approved for interdisciplinarity by the Steering Board of Natural Science. A form can be obtained at the study coordinator or on the website: www.ru.nl/natuurwetenschappen.

Internships can also be taken abroad, or at a company, but always under supervision of a professor at the university. For internships or courses abroad funding bodies are available such as the Erasmus programme. If you want to pursue an external internship, contact the study coordinator.

Written approval has to be obtained before starting an internship

See also the regulations in Chapter 5 of this study guide.

Most research groups will require certain courses to be taken before starting an internship, and some courses to be taken during, or as a part of the internship. It may also be possible that a literature sudy has to be made. Make sure you inquire timely with the leader of the group of choice.

Generally the duration and order of internships is: Major of 60 ec first, then Minor of 30 ec, both including specialisation courses. However, after consulting the Examination Board, alternatives are possible, such as a combined internship on an interdisciplinary subject at two research groups (from different disciplines). A list and descriptions of research groups with multi-disciplinary research can be found in Chapter 4 of this guide.
Both Major and Minor internship will entail participation in a research project. Usually under supervision of a PhD-student or a post-doc.

Internships are always concluded with a report an oral presentation. **You are required to hand a (digital) copy of the research reports and thesis to the study coordinator.** These will be needed for the examination board and education assessments by the government.

Electives
Electives can be chosen from all the courses given within and outside the faculty of science. Requirements are that there should be some cohesion bewteen at least part of the electives and that the level is sufficient.
The total package of electives should be approved by the examination board, preferably together with an indication of the intended internship. Usually this causes no problems, but when in doubt about the applicability of certain courses, make sure to check with the coordinator and the examination board before entering.
At the secretariat and with the coordinator a form to submit the master programme can be obtained.

2.3 C, E, and MT variant

C, E, and MT-variant
In the **C** and the **MT** master programmes, the first year and a small part of the second are used to finalise the Natural Science education with 9 ec in Science electives and one internship of 45 ec.
The variant-specific courses are mainly given in the second year and the master is concluded with a C or MT project or internship. This internship cannot be started before the science courses are taken and the science internship is completed.

In the **E** master programme the entire second year is dedicated to education training with courses and two internships in a school. This means that the whole Natural Science education should be *finished* in the first year. Students who wish to obtain two teaching licences (for phyiscs and for chemistry) will recieve an additional training of 15-30 ec after the second year. If you wish to pursue a teaching licence, be sure to contact the ILS that organises this training in time.

Only one science internship
In these three programmes there is only one Natural Science research internship of 45 ec, to be fulfilled in a research department at the university on an interdisciplinary subject. The same requirements apply as for the internships in the research variant.

This internship must be approved by the Examination Board. For further details see the regulations in Chapter 5.

C - Communication
the C-programme:
- Philosophy II 3 ec
- Electives 15 ec
- Natural Science internship 45 ec
- Communication courses 57 ec:

Communication courses in the first year are:
Introduction Science Communication 3 ec
Science & Societal interaction 3 ec
Risk Communication 3 ec
Boundary Work 3 ec

Communication courses in the second year are:
Framing Knowledge 3 ec
Knowledge Society 3 ec
Science, Media, and Strategy 3 ec
Electives 6 ec
Project 30 ec

Electives in the communication programme should be chosen after consulting the C-coordinator, the total master-programme should be approved by the Examination Board of Natural Science. More information and contact adresses can be found via www.betacom.science.ru.nl/

E - Education

The E-programme:
- Philosophy II 3 ec
- Electives 15 ec
- Natural Science internship 45 ec
- Education programme 57 ec
- Optional 15 ec extra for second licence

Note that the whole natural science education, certainly the research internship should be completed before the Educational programme can be started.
The educational programme is completely organised by the ILS, the Instituut voor Leraar en School and will be entirely in Dutch. The programme starts in September and in January. This training is part of the master programme and the Science Faculty is responsible for this variant. Students who wish to obtain a licence in both chemistry and physics will have to take an additional 15 ec (approximately) of internship and courses after the second year.

Alternatively, it is also possible to enrol in the education training ***after*** completion of the masters programme (O, C, or MT). Students with a master in Natural Science can enter the ILS for a 1 year training to obtain a licence. Again, 15 more ec of training should be added for a double licence. This training is independent from the Faculty of Science and coordinated entirely by the ILS.

Enrolling in the E-programme
Natural Science students should consult the ILS at an early stage, in order to check their programme for deficiencies.
The Physics education track is open to Natural Science students with a Phpysical-Chemical or a Biological-Physical specialization. Additionally, the following courses should be taken in Bachelor or Master:
- NP007B Speciale Relativiteitstheorie, 3 ec, prof. dr. S. de Jong
- NB042B Optica: de manipulatie van licht, 3 ec, dr. F. Harren
- NP024B Newtoniaanse kosmologie, 3 ec, dr. G. Nelemans
- NB 007C Deel: experiment Röntgenstraling, 1 ec, ir. R. van Haren

The address of the ILS is:

Secretariaat Instituut voor Leraar en School
Erasmusplein, tel. 024-35 15572
www.ru.nl/ils

MT - Business and Management

The MT-programme

- Philosophy II 3 ec
- Electives 15 ec
- Natural Science internship 45 ec
- Management programme 57 ec:

Obligatory MT courses:
Business & Society (5 ec)
Organization Theory (5 ec)
Innovation management (5 ec)
Strategy & Marketing (5 ec)
Finance & Accounting (5 ec)

Elective MT courses:
Science and entrepreneurship (3 EC)
Research strategy & Management (3 EC)
Industrial chemistry (3 EC)
Algemene managementvaardigheden (2 EC)

Electives in the MT programme should be chosen after consulting the MT-coordinator, the total master-programme should be approved by the examination committee. More information can be found in Chapter 3.

The MT-variant is coordinated by:

Prof.dr. B. Dankbaar (b.dankbaar@nsm.ru.nl)

3 Courses

3.1 Research Variant

Electives

The following section gives a *sample of elective courses* from Physics, Biology and Chemistry available to Master students in Natural Science. There are many more possibilities, be sure to check the other masterprospectuses (www.studiegids.science.ru.nl/2008/science).

Most research groups offer topical courses (Capita Selecta) alongside your internship.
Other faculties and other universities also offer interesting courses that are not available in Nijmegen.

Master courses are often scheduled on demand. The usual procedure is to contact the teacher or the group's secretariat to show your interest. If you encounter problems, contact your study coordinator.

Each student's programme, including electives and internships has to be approved by the Examination Board. A form can be downloaded at www.ru.nl/natuurwetenschappen.

Before starting an internship it requires approval as well. Failing to get approval may result in losing time!

Physics - elective courses

Brain and Behaviour 2
Course ID: **NM050B** *6 ec* second semester prof. dr. C.C.A.M. Gielen

Website
www.mbfys.ru.nl/~stan/

Teaching methods
- 28 hrs lecture

Prerequisites
Brain and Behaviour 1

Objectives
- The student is familiar with the main problems in the field of visual perception and motor control
- The student is familair with Information Theory (Mutual information and maximum log likelyhood estimator) to estimate information transfer
- The student can apply deterministic optional control (including Hamilton-Jacobi-Bellman equation and Pontryagin Maximum Principle)
- The student has the mathematical skills to develop advanced models to explain recent experimental data in a unified conceptual frame work

Contents
This course will present general principles of neuronal information processing. These principles are illustrated by discussing the functional characteristics of the visual system and motor system in man.

Subjects
- Control Theory
  - Conditions of stability of nonlinear systems
  - Conditions for stable control
  - Algorithms for optimal control
- Information Theory
  - Entropy; mutual information
  - Efficiency of information coding
  - Parameter estimation principles
- The visual system
  - Organisation of the visual system
  - Efficiency of visual information processing
- The motor system
  - Organisation of the motor system
  - Optimal control of the motor system
  - Control of redundant manipulators

Literature
- Lecture notes (For sale at secretary's office of Biofysica room 0.20 M244, Geert Grooteplein-Noord 21)

Examination
Written examination

Computational Neuroscience

Course ID: **NM047B** *6 ec* first semester prof. dr. C.C.A.M. Gielen
prof. dr. H.J. Kappen

Website
www.mbfys.ru.nl/~stan

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Course Inleiding Biofysica

Objectives
This course deals with the mechanisms underlying the communication by and between cells in the central nervous system. It begins with the dynamics of changes in the configuration of proteins that are responsible for the transport of ions (sodium, potassium, chloride, etc.) through the outer cell membrane, and a biophysical model of the nerve cell is developed. Then, neuronal information processing and information storage within the CNS is treated, and how self organisation of the CNS can be understood from basic principles about development and learning.
After successful completion of the course
- the student is able to calculate the response of a neuron or of a network of neurons to various inputs, both analytically and by computer simulations
- the student should be able to apply basic principles from Information Theory and Non-linear Systems analysis to quanitfy information processing bu networks of neurons and to determine the attraction domain and stable states of a network of neurons.

Contents
The aim of this course is to give a theoretical description of the neuronal dynamics at the level of a single neuron and at the population level. The theoretical model will be used to explain the information processing and the storage and retrieval of information by populations of neurons.

Subjects
- Structure, function and properties of ion channels. This part is a further elaboration on the Hodgkin-Huxley model as dealt with in the Introduction to Biophysics course (Bachelors program).
- Biophysical models of the neuron:
  - Integrate-and-fire model
  - Fitz Hugh-Nagumo model
  - First passage time model
  - McCullock Pitts model
- Phase-space analysis of neuron dynamics: stable states and convergence criteria
- Information coding by firing rates (Poisson model) and coincidence detection
- Physical properties of synapses; the inhibitory and excitatory synapse

- Feedforward and recurrent neurale networks
- Markov processes for binary neural networks and ergodicity
- Learning and memory within recurrent neural networks
- Selforganisation in neural networks

Literature

- Reader with chapters from *Handbook of Biological Physics*, Vol.4: Neuro-Informatics and Neural Modeling. Editors: Gielen and Kappen, Elsevier, 2001 (For sale at secretary's office of Biofysica, room 020 M244, Geert Grooteplein-Noord 21)

Examination

Written exam

Electronic Structure of Materials

Course ID: **NM038B** *6 ec* second semester prof. dr. R.A. de Groot

Teaching methods
- 32 hrs lecture

Objectives
This course gives insight in the (im)possibilities of calculating electron structure in solid states

Contents
Tutorials involve the calculation of electron structure of:
- Simple metals
- Magnetic metals
- A semiconductor
- A relativistic material

all with the use of existing computer programs.

Subjects
- Reciprocal space, Brilliouin zones and group theory associated to electron structure calculations
- Basic sets, pro's and con's
- Density functional theory
- APW, ASW and LSW methods in some detail

Literature
- Lecture notes and references given during the lectures

Examination
Oral exam

Electrodynamics 1

Course ID: **NM001B** *3 ec* first quarter dr. ir. G.A. de Wijs

Teaching methods
- 16 hrs lecture
- 16 hrs problem session

Prerequisites
Bachelors course electromagnetism or equivalent.

Objectives
- The student has a thorough understanding of classical radiation theory
- The student is capable to solve the exercises of the treated subjects at the level of Jackson's 'Classical Electrodynamics'

Contents
The subject of this course is electromagnetic radiation. The course opens with a derivation of the retarded Green function from Maxwell's equations. This Green function is used to derive the potential (Lienard-Wiechert) and radiation from an accelerated charge. The special case of a constant velocity larger than the speed of light in a medium leads to a qualitative description of Cerenkov radiation. The case of uniform circular motion is worked out to the point of a qualitative treatment of the power spectrum of cyclotron and synchrotron radiation. Other important examples that are treated in the course are radiation from scattering of light to a free electron. (Thomson and Compton scattering) and radiation from a collision of two charges (Bremsstrahlung). Finally the radiation of an oscillating charge distribution is treated in a multipole expansion up to the quadrupole term. An application is Rayleigh scattering and the structure function of a material. Level: Introduction to Jackson: 'Electrodynamics'

Literature
Necessary:
- J.D. Jackson, *Classical Electrodynamics,* 1998, ISBN 0-4713-0932-X

Examination
Written examination

Electrodynamics 2

Course ID: **NM002B** *3 ec* second quarter dr. ir. G.A. de Wijs

Teaching methods
- 14 hrs lecture
- 14 hrs problem session

Prerequisites
Electrodynamics 1

Objectives
The student is capable to solve and answer the exercises and questions concerning the treated subjects at the level of Jackon's '*Classical Electrodynamics*'.

Contents
The course starts with a more precise treatment of Cerenkov radiation leading to the Frank-Tamm formula for the energy loss. The next issue is a mathematical more precise derivation of the power spectrum of synchrotron radiation. The remainder of the course is devoted to more fundamental issues. First the Hamilton and Lagrange equations for a charge in an electromagnetic field are derived both classically and relativistically. The quantum case leads to a discussion of Dirac monopoles. Secondly the field equations are derived from the EM Lagrangian and the Minkowski stress tensor is discussed. The covariant Green's function is derived. Finally the reaction force is discussed in the context of the Abraham-Lorentz model.

Literature
Necessary:
J.D. Jackson, *Classical Electrodynamics,* 1998, ISBN 0-4713-0932-X

Examination
Written examination

Experimental Techniques

Course ID: **NM004B** *3 ec* first semester dr. S.A.J. Wiegers

Teaching methods
- 12 hrs lecture
- 12 hrs problem session

Prerequisites
- Bachelor Program Laboratory Courses

Objectives
- The student understands the experimental and physical background of achieving high vacuum, of operating lasers, achieving low temperaturs and using electronic lock-in signal techniques
- The student is able to translate a scientific question into an experimental design/realisation

Contents
Modern physics depends heavily on advanced experimental techniques. The technological fields of vacuum technology, laser technology, cryogenic technology and electronics are essential when translating a scientific question into an instrument including the collection and use of the observations. In this course, we want to stay close to the technology, pumps, lasers, coolers, lock-in amplifiers explaining their physical and practical operating principes. Next to making series of problem sets on the different topics, a self-chosen scientific problem and its experimental solution will be described and presented.

Literature
- Lecture notes

Examination
- Take home experimental construction problem
- Oral presentation

Materials Science

Course ID: **NM020B** *6 ec* second semester dr. P.R. Hageman

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
This course aims at master students physics, chemistry or natural sciences

Objectives
- The student has knowledge of the concepts and theory from material science as presented in the course
- The student can apply the presented concepts and theory in order to interpreted correctly scientific literature in the area of material science
- The student is capable to reduce the information from the scientific literature to the core problems
- The student is capable to solve these core problems using the presented theory and concepts or can present a different solution method

Contents
Understanding of the fundamental nature of materials during the last century has led to the development of materials science and engineering. Within this field traditionally the relation between the microscopic structure and macroscopic properties of bulk materials such as metals, semiconductors, ceramics and polymers is studied. Recent developments concentrate on the processing and performance of materials in the form of thin films, as these have become increasingly important in our daily life.

This material science course handles the relationship between material structure and the resulting mechanical, electrical, chemical, optical and magnetic properties of materials in general and thin films in particular. Enveloping this relation special emphasize is given to methods for thin film deposition (MOCVD, MBE, Sputtering) and their final performance. The processing -> structure -> properties -> performance interactions will be illustrated by the discussion of recently developed materials such as gallium-nitride and synthetic diamond coatings as well as specialized applications such as high efficiency solar cells and magnetic multi-layers.

Literature
Hand outs will be distributed during the course. No specific book is required.

Examination
The students write independently a paper about a subject dealing with materials science on basis of distributed scientific literature. In this paper the student has to apply the knowledge learned in the course.

Nano Magnetism

Course ID: **NM044B** *6 ec* second semester dr. A.I. Kiriliouk

Teaching methods
- 28 hrs lecture

Prerequisites
Quantum mechanics; Introduction to Solid State Physics

Objectives
- The student should be able to understand the recent discoveries in the area of magnetism
- The student is able to read and understand the articles in leading scientific journals

Contents
Magnetism is a phenomenon that has intrigued mankind since millennia and has found a large variety of applications ranging from the compass to hard disks. Modern preparation techniques have allowed the fabrication of magnetic structures with typical dimensions that are small compared to fundamental **length scales** such as exchange length, mean free paths or spin diffusion length, which have led to exciting new effects like giant magneto-resistance and spin injection. The importance of such phenomena has been recognized in the Nobel prize 2007. This course will cover several topics of magnetism in **nanodimensions**, starting from basics. Special attention will be on the formation of the magnetic moments as well as on various aspects of magnetization dynamics. It will also include a review of experimental approaches.

Subjects
- quantum mechanics: spin-spin and spin-orbit interactions
- exchange and anisotropy
- magnetic order: ferro-, ferri, and antiferromagnets - dimension dependence
- superparamagnetism
- spin waves in nanoelements
- magnetization dynamics: domain wall, spin precession, spin heating, etc.
- magnetic quantum phenomena
- preparation and magnetic and structural characterization techniques
- magneto-optics as important tool for ultrafast dynamics studies
- utilization: are we going to have a magnetic computer?

Literature
Lecture notes are handed out at every lecture
As extra reading:
- S.V. Vonsovskii, *Magnetism,* John Wiley & Sons, New York, 1974
- S. Chikazumi, *Physics of Ferromagnetism,* Clarendon Press, Oxford, 1997
- D. Craik, *Magnetism: Principles and Applications,* John Wiley & Sons, New York, 1995
- D.C. Mattis, *The theory of magnetism,* Harper & Row, New York, 1965
- J. Stöhr and H.C. Siegmann, MAgnetism: from fundamentals to nanoscale dynamics, Springer, 2006

Examination
Combination of a written short report, 15 minutes oral presentation on a selected subject, and the work during the semester

Solid State Physics

Course ID: **NM009B** *6 ec* first semester prof. dr. ir. J.C. Maan

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Inleiding in de Vaste Stof Fysica en/of Structuur der Materie

Objectives
- The student will have an understanding of formal transport theory
- The student will have an understanding of mesoscopic phenomena
- The student will have an understanding of semiconductor and heterojunctions
- The student will have an understanding of superconductiviy
- The student will have an understanding of magnetism in solids
- The student will have an understanding of important quantum phenomena of solids in magnetic fields

Contents
This course assumes a working knowledge of key concepts and methods in solid state physics: the consequences of crystal symmetry, the notion of quasi-particles and the Fermi-particle character of the electrons, as obtained in a course like 'Inleiding Vaste Stof Fysica', and/or 'Structuur der Materie' and the student should have cursory understanding of energy bands and Fermi surfaces, and the consequences of band filling for metals, semiconductors and insulators. The importance electron-electron interaction and the concept of quasiparticles to describe impotant phenomena like superconductivity and magnetism will be emphasized. Furthermore the effect of the discrete electron charge and wave character electron for small systems (mesoscopic physics) will be treated. The course aims at building a bridge bridge between the basis concept dveloped in the last fifty years to understand solid state physics and the new phenomena discovered in the last decades which are based upon this understanding.
The course material roughly covers chapters 8-13, 17 and 18 from Kittels book.

Subjects
- Formal transport theory in bulk and low dimensional (semiconductor) systems where mesoscopic phenomena play a role. Semiconductors and heterostructures will be treated more thoroughly than in the introductory course
- Superconductivity which from a phenomenological point of view while also an introduction to the BCS theory is given
- Magnetism (paramagnetism, diamagnetism and ferromagnetism) both from an experimental as a theoretical point of view
- Important quantum effects in magnetic fields, like the Shubnikov-deHaas, deHaas van Alphen, Magnetic resonances, Quantum Hall effect and fractional quantum Hall effect will be presented

Literature

Necessary:

- Charles Kittel, *Introduction to Solid State Physics*, Wiley 2005, ISBN 0-471-680057-5, (8th edition or later)

Recommended:

- Luthj and Ibach, *Solid State physics*, 2nd edition, Springer Verlag

Examination

Written exam and 1 point credits by joining the tutorial

Turbulence

Course ID: **NM035B** *6 ec* first semester prof. dr. ir. W. van de Water

Teaching methods
- 40 hrs lecture

Objectives
- Understanding the phenomenology of turbulence in two- and three dimensions
- Mastering the various statistical quantities, such as spectra and correlations, needed to qualify turbulence
- Being able to arrive at estimates of the relevant turbulence parameters in situations of practical interest
- Being able to device models for turbulence that can short-circuit this last unsolved problem of classical physics

Contents
Turbulence is the disordered flow of fluids. Understanding turbulent flow is of enormous practical relevance, as most flows around us are turbulent. Turbulence is also a fundamental problem of classical physics that is still unsolved. Turbulence starts with an instability and we will dwell on the description of instabilities that are ubiquitous in fluids. At this point we will be close to the theory of chaos. However, in real world turbulence the number of degrees of freedom is so large that a statistical description is called for. We will discuss such a description, in which exotic phenomena such as fractals play a role. In turbulence there are a few exact results, but there is a plethora of models that are used in practical calculations. We will critically discuss these models and finally dwell upon the surprising phenomenology of turbulence in two dimensions.

Literature
Necessary
- U. Frisch, *Turbulence*, Cambridge, 1995
- Lecture notes

Examination
Presentation

Scanning Probe Microscopy

Course ID: **NM070C** *3 ec* first semester prof. dr. S.E. Speller

Website
www.evsf2.science.ru.nl/speller/materialen/spm

Teaching methods
- 30 hrs lecture

Prerequisites
Solid State Physics

Objectives
The student is able to follow and participate in discussions in scanning probe microscopies for solid materials, organic molecules, and biological systems

Contents
Nanosystems are aperiodic and inhomogeneous and require local visualization and manipulation in real space on nanoscale, which is provided exclusively by Scanning probe microscopy (SPM) so far. The nanoprobe usually does not physically touch the surface. This is managed by mounting the probe on actuators, capable of nanometric precision. These are adjusted according to a signal stemming from a local interaction between tip and sample. The nanoprobe is scanned over the surface and the signal is maintained constant by means of a feedback circle. In this way, surface characteristics, for instance, the topography of a surface is mapped showing terraces steps, and atoms. Probes can be rendered specific for a wealth of interaction types, and several nanomanipulation modes have been developed. This course is an introduction to:
- Scanning Tunneling microscopy
- Atomic Force microscopy
- Nano-Optical microscopy

The methods are illustrated and discussed by means of example objects from solid state surfaces, molecular layers, and bio-molecular systems.
Nijmegen has a long tradition in the development of Advanced Scanning Probe Microscopy and spectroscopy modes. For some of the more specific modes under development like Magnetic Resonance Force Microscpy (MRFM), a combination of Atomic force microscopy and Nuclear Magnetic Resonance, the lectures will be given by a docent of the resepective research group of the Institute for Molecules and Materials (Prof APM Kentgens, a.o.).

Literature
On website during the course

Examination
Presentation

Biology - elective courses

Capita selecta: Adaptation physiology

Course ID: **BM010B** *3 ec* december 5, 2008 - march 13, 2009 prof. dr. G. Flik dr. P.H.M. Klaren

Teaching methods

- 26 hrs lecture
- 54 hrs individual study period

Prerequisites

Acquaintance with the content of the Bachelor courses 'Adaptation Phyiology' and 'Endocrinology' is highly recommended, but not a strict requirement.

Objectives

Increased insight in dedicated aspects of the broad field of adaptation physiology through interactive lectures on recent developments in this research field.

Contents

This series of lectures focuses on organismal physiology: regulatory mechanisms in the intact animal are addressed (Integrative Physiology). The central theme is how animals (including the human being) have adapted to realise a dynamic interaction and to cope with continuously changing environmental conditions. Homeostatic and allostatic principles are discussed. Two internal systems are predominantly involved in this adaptation: the nervous system and the endocrine system. Together these systems control the activity of peripheral endocrine and non-endocrine targets, resulting in a functional adaptive response. In this regulation the hypothalamus and pituitary gland are pivotal as relays between the central nervous system and peripheral organs; in the hypothalamus signals from central and peripheral sensors are integrated with peripheral (endocrine) signals from e.g. the immune system and gastro-intestinal tract. The intensive interaction of the immune system and the neuroendocrine system is illustrated with the stress response, based on ongoing recent research towards the neuroendocrine mechanisms at the basis of active and passive coping strategies in animal models. Attention is also given to a selection of concepts and adaptive strategies relating to cyclical changes (diurnal, mensal, circannual), biological clocks, feeding and endocrine mechanisms underlying (sleep) activity, temperature, digestion strategies. Some lectures will be dedicated to topics that received attention in recent papers and science sections of news papers.

Literature

The lectures will be published as power points (without subtexts!) on Black Board.
Eckert and Randall: Animal Physiology
Sherwood et al: Animal Physiology. From genes to organisms.
Science pages of NRC, Volkskrant

Examination

The written exam consists of a selection of open questions on different topics.

Extra information

contact: Mrs. D. Maurits (d.maurits@science.ru.nl)

Capita selecta: Apoptosis

Course ID: **BM004B** *3 ec* september 12 - november 28, 2008 dr. F. van Kuppeveld, dr. W.C. Boelens, dr. H. Dolstra

Teaching methods
- 20 hrs lecture

Prerequisites
Biochemistry and Molecular Biology II (BMB-II)

Objectives
After completing the course the student should be able to understand what apoptosis is, how it is regulated and in which way it is involved in the many different cellular processes. Apoptosis is a highly regulated process that is needed to kill a cell clean and neatly. For a very long time the process was neglected, but now the importance of the process is generally accepted. Apoptosis is involved in many different aspects of life, such as embryonic development, tissue homeostasis and regulation of the immune response. Deregulation of the apoptotic process plays an important role in the development of autoimmune diseases, cancer and viral infection.

Contents
- Introduction Molecular Aspects of Apoptosis
- Apoptosis and Cancer
- Apoptosis and Stress
- Suppression and Induction of Apoptosis by Viruses
- Apoptosis and Inflammation

Literature
Hand-outs, distributed via blackboard

Examination
Written exam.

Extra information
contact: dr. W. Boelens, phone 36 16753, e-mail: w.boelens@ncmls.ru.nl

Capita selecta: Molecular and cellular neurobiology

Course ID: **BM001B** *3 ec* march 27 - july 3, 2009 dr. B.G. Jenks
prof. dr. E.W. Roubos
prof. dr. G.J.M. Martens

Website
www-celcom.science.ru.nl

Teaching methods
- 20 hrs lecture

Prerequisites
Bachelor level Cell Biology, Molecular Biology and Neurobiology

Objectives
The aim of this course is to give students an appreciation of current issues in Neurobiology, particularly molecular and cellular aspects and how these can impact on neurodgenerative diseases and behavior.

Contents
This course considers advanced topics of molecular and cellular aspects of neurobiology. Particular attention is given to where such mechanisms impact on behaviour. Among the topics covered in recent years are: Hypothalamic Control of Feeding; Oxytocin: a Multifunctional Behavioral Neuropeptide; The Neurobiology of Fear; Adult Neurogenesis; The Molecular and Cellular Mechanisms involved in Neurodegeneration; Genetic and Epigenetic Mechanisms underlying Neurodevelopmental Disorders. A selection of these, or similar topics will be presented in the course. Instructors for the course are: Bruce Jenks (10h of lectures), Gerard Martens (8h) and Eric Roubos (2h). The lectures are in English (Exam can be in English or Dutch).

Literature
Study material (readers, CD ROMs etc) are made available at the first lecture.

Examination
Written exam

Capita selecta: Microbiology

Course ID: **BM014B** *3 ec* december 5, 2008 - march 3, 2009 prof. dr. ir. M.S.M. Jetten
dr. H.J.M. op den Camp

Teaching methods
- 48 hrs individual study period
- 22 hrs lecture

Prerequisites
1st year course 'Biologie van micro-organismen' (Biology of microorganisms) and preferably the bachelor courses 'Fysiologische microbiologie' (Physiological Microbiology) and 'Ecologische microbiologie' (Ecological Microbiology).

Objectives
The lectures and literature evaluations aim to give students insight in the newest developments within selected research fields of microbiology.

Contents
The topic of this caput varies each year. The past years the following topics were selected:
- Microorganisms and symbiosis
- The microbiology of the geochemical cycles
- Extremophiles
- Microbial interactions in ecosystems

Literature
Literature will be distributed at the start of the course.

Examination
By oral exams.

Capita selecta:
Molecular biology: Gene expression, chromatin and disease

Course ID: **BM009B** *3 ec* december 05, 2008 - march 13, 2009

C. Logie
dr. G.J.C. Veenstra
dr. M.A.E. Lohrum

Teaching methods
2x12 hrs of lectures, 2x28 hrs study time

Prerequisites
Biochemistry and Molecular Biology II and Functional Genomics courses. This prior knowledge can be found in Lodish 6th edition, Chapters 4, 6, 7, 8, 20, 21.

Objectives
This course aims to showcase current insights in the role of gene expression with respect to cancer, congenital disease, embryonic development and establishing cellular identity. Special emphasis will be on epigenetics (heritable modifications of chromosomes), transcription factors and the molecular biology of tumor suppressors.

Contents
1. Introduction chromatin structure and function
2. Epigenetics as molecular memory
3. Chromatin and cancer
4. Imprinting and imprinting syndromes
5. Animal models for the pathology of chromatin dysfunction

Literature
Literature: Lectures, PowerPoint print-outs

Examination
Written Essay

Extra information
Contact person: dr. Logie tel: 3610525, c.logie@ncmls.ru.nl

Capita selecta: Signal transduction and transport

Course ID: **BM016B** *3 ec* march 27 - july 3, 2009 dr. P.H.G.M. Willems
dr. A.P.R. Theuvenet

Teaching methods

- 20 hrs lecture
- 60 hrs individual study period

Objectives

Students gain knowledge and insight into the biophysical aspects of signal transduction by polypeptide growth factors, neurotransmitters and hormones. Emphasis lies on the use of patch-clamp and cellular imaging techniques in biomedical research. Lectures will be based on most recent scientific papers.

Contents

Part A.'Electrical aspects of Signaltransduction' (Coordinator Theuvenet, a.theuvenet@science.ru.nl, 3652013)

1. Bioelectricity and cellular growth regulation
2. Cell communication via gap junctions and cancer
3. Ion channels as signal transducers
4. Ion channels and apoptosis
5. Ion channels and disease, channelopathies

Part B.'Cellular Imaging in Four Dimensions' (Coordinator Willems, p.willems@ncmls.ru.nl, 3614589)

I. Principles of fluorescence and electron microscopy

1. Introduction in microscopy
2. Genetically-encoded green fluorescent proteins

II. Microscopy: Applications in biology and medicine

3. Imaging of Intracellular Protein Routing in Health and Disease
4. Imaging of Cellular Ion Homeostasis in Health and Disease
5. Imaging of Mitochondrial Plasticity in Health and Disease

Examination

The final written exam includes both parts of the course.

Extra information

contact: mrs. J. Rullmann, 3652701, j.rullmann-freriks@science.ru.nl

Capita selecta: Metabolism, transport and motility

Course ID: **LM011** *3 ec* 12 september - 28 november 2008 dr. L.P.W.J. vanden Heuvel
dr. P.M.T. Deen
mw dr. R. Masereeuw
prof. dr. B. Wieringa

Teaching methods
- 20 hrs lecture
- 60 hrs individual study period

Prerequisites
recommended: 'Biochemie en moleculaire biologie II' and 'Celbiologie der dieren'

Objectives
Make students familiar with the biomedical significance of energy and metabolites in the "small molecular world"and how the role of these compounds is integrated in the larger cellular network for metabolism, transport and motility. Specifically, students should be able to
- appreciate the significance of 'metabolic, transport and motion research' for molecular life sciences
- recognize current possibilities and developments in the field
- implement the newly obtained knowledge in future research activities

Contents
Students will be offered a comprehensive series of introductory lectures on the topics of interest that go beyond basic (bachelor) knowledge of biochemistry and cell-biology textbooks. They will be asked to read background literature and use information at websites to make themselves familiar with knowledge on the significance of metabolite profile analysis, the role of energy and redox metabolism in cell viability and mobility control, (reverse) genomics and proteomics for the study of transport proteins, channelopathies, mitochondrial diseases, and multifactorial disorders. Emphasis will be on the value of multi-disciplinary approaches.

Subjects
- The essence of metabolic investigations
- Multifactorial disorders
- OXPHOS system diseases
- Proteomics and human pathology
- Water channels
- Body water homeostasis
- ABC transporters and solute carriers
- Regulation of drug transporters in health and disease
- Coupling of energy/redox metabolism to cell viability and motility control
- Biochemical adaptation to energy and redox stress

The course will be focused on aspects of metabolism, transport and motility in muscle, brain, kidney disease and cancer and other related health problems.

Literature
Literature assignments and hand-outs are distributed during the lectures

Examination
written examination

Extra information
Contact: Dr. L. van den Heuvel (024-3617983 ot 024-3614428),
B.vandenHeuvel@cukz.umcn.nl

Adaptatiefysiologie

Vakcode: **BB020B** *6 ec* 6-4 t/m 8-5-2009 prof. dr. G. Flik

Werkvormen
- 28 uur hoorcollege
- 27 uur practicum
- 42 uur werkcollege
- 63 uur zelfstudie

Vereiste voorkennis
Voorkennis en gedegen interesse van fysiologie van dieren is een pre, evenals basale histologie.

Leerdoelen
In deze cursus staan de structurele, fysiologische en gedragsadaptaties centraal die het dieren mogelijk maken om zich aan te passen aan dynamische veranderingen in hun omgeving.

Beschrijving
- Eerst wordt ingegaan op structuur en functie van het neuro-endocriene systeem, dat een belangrijke rol speelt bij adaptaties aan dynamische veranderingen in de omgeving van het dier: de hypothalamus-hypofyse-bijnier-as, die een essentiële rol speelt bij stressadaptatie. Vervolgens wordt een aantal thema's uit de adaptatiefysiologie behandeld: aanpassingen aan land en water, aan cyclische veranderingen (dagritmiek, jaarritmiek) en aan bedreigende veranderingen (stressoren). Deze thema's worden zoveel mogelijk geplaatst in een evolutionaire context, in het bijzonder de evolutie van de vertebraten.
- De betekenis van de stressfysiologie voor aquacultuur van vissen en aspecten van osmoregulatie in ongewervelden (i.h.b. crustacea) worden belicht in twee series gastcolleges door collega's uit Cadiz en Montpellier.
- Het practicum behelst vergelijkende histologie van de stress-as, simulatiepractica stressfysiologie en calciumhuishouding van vissen, analyse van een researchartikel, toepassing van moleculaire biologie in de fysiologie en een thema. In het themaonderdeel krijgen de studenten de opdracht om een onderwerp te bestuderen uit de adaptatiefysiologie, hierover een verslag te schrijven en een voordracht te presenteren aan het einde van de cursus. De cursus wordt afgesloten met een bijeenkomst op de afdeling waar de beste voordracht met een prijs wordt beloond op basis van een juryrapport.

Literatuur
- Leerboek: Eckert Animal Physiology, 5e druk, Randall et al. ; E 65
  of:
- Sherwood et al. Animal Physiology. From genes to organisms.
- Syllabus en practicumhandleiding

Tentaminering
Door een schriftelijk tentamen bestaande uit een tiental vragen (essay/open ending) die het geheel der in colleges en practica behandelde stof beslaat (telt voor 60% mee), het maken van practicumverslagen en het houden van een voordracht (telt voor 40% mee).

Bijzonderheden
contact: mw. D. Maurits, d.maurits@science.ru.nl

Endocrinologie

Vakcode: **BB048B** *6 ec* 09-03-2009 t/m 03-04-2009 dr. P.H.M. Klaren
prof. dr. G. Flik

Werkvormen
- 32 uur hoorcollege
- 8 uur werkcollege
- 12 uur practicum

Vereiste voorkennis
Er wordt een basiskennis van de moleculaire biologie, celbiologie en dierfysiologie verondersteld op grond van de eerstejaars cursussen.

Leerdoelen
De differentiatiecursus: 'Endocrinologie' is gepland in het begin van de tweede helft van de bachelors-fase en is bedoeld voor studenten Biologie met een zoölogische/fysiologische interesse en studenten Medische Biologie. De cursus Endocrinologie kenmerkt zich door een hoog aantal gastdocenten van buiten FNWI, en het intensieve gebruik van de digitale leeromgeving Blackboard. Studenten leggen een mini-portfolio aan en maken abstracts van hoorcolleges, waarmee wordt nagestreefd dat studenten, naast het vergaren van endocrinologische vakinhoudelijke informatie, zich ook algemene academische vaardigheden als integreren en ordenen van deze informatie eigen maken. De cursus omvat effectief vier weken met vijf werkdagen elk. 's Ochtends vinden hoorcolleges plaats (twee uur per ochtend), 's middags zijn practica (histologie, computersimulaties), zelfstudie en literatuurdiscussies. De literatuurdiscussies vinden plaats in kleine werkgroepjes waarin studenten kunnen oefenen in het lezen van review- of researchartikelen.

Onderwerpen
De onderwerpen die in de cursus aan bod zullen komen hangen in belangrijke mate af van de deelnemende gastdocenten en hun wensen en expertise. Er wordt naar gestreefd om in elk geval aan de orde te laten komen:
- moderne endocrinologie (nieuwe concepten)
- histologie van endocriene klieren
- hypothalamus - hypofyse - bijnier as (humaan en vergelijkend)
- hormonen van de bijnier
- schildklier-as (humaan en vergelijkend)
- endocriene pancreas
- (vrouwelijke) voortplantingsendocrinologie
- calcium-regulerende hormonen
- groei en groeihormoon
- hormonen van de digestietractus
- tumormerkstoffen
- het immuunsysteem als endocrien systeem

Literatuur
De studiewijzer bevat researchartikelen voor besprekingen. PowerPoint-bestanden van de colleges worden, indien mogelijk, via BlackBoard beschikbaar gemaakt. De belangrijkste literatuur wordt echter gevormd door het persoonlijke portfolio.

Tentaminering
Schriftelijk tentamen (waarbij het portfolio geraadpleegd mag worden) en uitvoering portfolio.

Bijzonderheden
Zelfstudie dient besteed te worden aan schrijven van abstracts direct na de colleges, voorbereiden literatuurbespreking en het maken van portfolio. Bijhouden van het aangeboden studiemateriaal is een vereiste gezien het hoge tempo van deze cursus en de belangrijke plaats die zelfstudie in de cursus inneemt.

Fysiologie van micro-organismen

Vakcode: **BB024B** *6 ec* 09-03-2009 t/m 03-04-2009 dr. J.T.M. Keltjens

Werkvormen
- 20 uur hoorcollege
- 10 uur werkcollege
- 48 uur practicum
- 80 uur zelfstudie
- 8 uur presentatie door studenten

Vereiste voorkennis
De cursus bouwt voort op de basiskennis die verworven is in de eerdere curriculumonderdelen (energietransformatie in de cel, biologie van micro-organismen, fysiologie van planten en dieren).

Leerdoelen
Na afloop van de cursus is de student in staat te analyseren en te verklaren, hoe (anaërobe) micro-organismen onder gegeven specifieke omstandigheden hun energie voor de groei winnen en hoe dit metabolisme ten grondslag ligt aan samenwerkingsverbanden en concurrentieverhoudingen in microbiële ecosystemen.

Beschrijving
De cursus behandelt twee centrale thema's uit de fysiologie van micro-organismen: (1) hoe leggen de organismen hun energie vast, en (2) hoe worden de celprocessen op moleculair niveau geregeld, als de omgevingscondities (m.n. het aanbod van energie substraten) veranderen. Uitgaande van deze moleculaire basis proberen we tot een fundamenteel inzicht te komen in het gedrag van micro-organisme in hun natuurlijke milieu. Specifieke onderwerpen die behandeld worden zijn de volgende:
1. Metabolisme en bio-energetica van anaërobe micro-organismen
2. Metabole interacties tussen anaërobe micro-organismen: concurrentie en samenwerking
- De centrale rol van waterstofgas in anaërobe systemen
- 'Interspecies-substrate transfer'
- Toepassingen van anaërobe processen

De centrale rol van waterstofgas in anaërobe systemen
3. Regelmechanismen in anaërobe micro-organismen: aanpassing aan veranderende leefomstandigheden
- Algemene principes van regelmechanismen in micro-organismen
- Regulering van anaërobe metabole processen
- Respons op stress situaties

Nieuwe ontwikkelingen in het vakgebied worden in werkgroepen verder bestudeerd, waarbij de studenten hun verworven kennis overdragen in een afsluitend colloquium.
Centraal in de cursus staan de anaërobe micro-organismen. Met deze onderwerpkeuze wordt de grondslag gelegd voor de cursus Ecologie van Micro-organismen die later in deze fase gegeven wordt, alsmede voor het onderzoek en onderwijs in de masterfase van de afdeling Ecologische Microbiologie.

Literatuur

- Leerboek (**verplicht**): Madigan et al., 'Brock Biology of Microorganisms', 11e druk, 2006, Prentice Hall (prijs ca. € 75,-)
- Syllabus (dictatencentrale, prijs ca € 8).
- Practicumhandleiding (verkrijgbaar tijdens practicum, prijs ca € 2,50); denk aan: witte labjas en veiligheidsbril

Tentaminering

Schriftelijk tentamen (telt voor 60% mee), deelname practicum + verslaglegging (telt voor 30% mee), bijdrage aan het studentcolloquium (telt voor 10% mee).

Ontwikkelingsfysiologie van met name het zenuwstelsel

Vakcode: **BB039B** *6 ec* 2-2 t/m 6-3-2009 dr. F. van Herp
prof. dr. G.J.M. Martens

Werkvormen
- 12 uur hoorcollege
- 9 uur responsie-college
- 12 uur practicum
- 34 uur werkcollege
- 8 uur presentatie door studenten
- 87 uur zelfstudie

Vereiste voorkennis
Kennis van de beschrijvende embryologie is wenselijk.

Leerdoelen
Uitgaande van een bevruchte eicel is de ontwikkeling van een meercellig organisme een prachtige triomf van de evolutie. Tijdens de embryonale ontwikkeling deelt de eicel tot miljoenen cellen die samen zeer complexe orgaansystemen samenstellen. De beschrijvende embryologie heeft ons in de vorige eeuw een overzicht gegeven van de vormveranderingen die een organisme doormaakt vanaf zijn ontstaan tot aan zijn volwassen toestand. In deze eeuw gaat de ontwikkelingsfysiologie een opwindende periode tegemoet omdat de moleculaire achtergronden van de ontwikkelingsprocessen steeds duidelijker worden. In deze cursus wordt ingegaan op de wisselwerkingen tussen de morfogenen die een rol spelen bij de opbouw van een meercellig organisme en wordt met name dieper ingegaan op de ontwikkeling van het zenuwstelsel.

Beschrijving
Na een kort overzicht van de morfologische aspecten (herhaling uit thema's van de algemene fase), wordt in deze cursus dieper ingegaan op de moleculair-ontwikkelingsfysiologische regulatiemechanismen. Hierbij staan aspecten betreffende de ontwikkeling van het zenuwstelsel centraal. Aan de hand van laboratorium- en simulatie-experimenten krijgt men een indruk van het onderzoek naar de mechanismen die ten grondslag liggen aan ontwikkelingsbiologische processen. Tevens worden computergestuurde simulatie-experimenten uitgevoerd, waarbij aandacht wordt besteed aan moderne methodieken die in het ontwikkelingsfysiologisch onderzoek worden gebruikt. De cursus wordt afgerond met een literatuurstudie van een recent ontwikkelingsfysiologisch onderzoek die verwerkt wordt tot een mondelinge presentatie en een voorstel voor een onderzoeksproject in het Engels.

Literatuur
Syllabus incl. practicumhandleiding zal beschikbaar zijn via Blackboard
Leerboek: Scott F. Gilbert 'Developmental Biology' 2006, 8e druk, Sinauer Associates, Inc., ISBN 0-87893-250-X (**verplicht**); E 70,-

Tentaminering
Tussentijds schriftelijk tentamen (telt voor 60% mee) en het maken van verslagen, het houden van een presentatie en het maken van een onderzoeksvoorstel (telt voor 40% mee). Let op: omdat het schriftelijk tentamen wordt afgenomen direct na het theoretische deel van de cursus (na de eerste 2 weken), dient men zich tijdig in te schrijven voor het tentamen!
Het maximaal aantal studenten dat kan deelnemen is 40.

Bijzonderheden
contact: dr. F. van Herp, 3610566, f.vanherp@ncmls.ru.nl

Course on Laboratory Animal Science

Course ID: **BM024D** *3 ec* several times in 2008-2009 dr. ir. P.P.A.M. Leenaars

Website
www.umcn.nl/cdl

Teaching methods
Lectures, practical work, demonstrations, individual and group assignments. Several (external) guest lecturers will appear.

Prerequisites
The course is only open for students who have at least 500 study hours in basic biology. At least 200 study hours anatomy/zoology and 200 study hours animal physiology should be part of this 500 study hours in basic biology.
For MLW an NW students this means:
- part of the first year biology course "Ontwikkeling en evolutie in de bouwplannen van dieren" (BP004B). For detailed information contact the coordinator of this course: dr. F. van Herp (f.vanherp@ncmls.ru.nl)
- one or both of the following courses from the bachelor biology: "Endocrinologie" (BB048B) or "Adaptatiefysiologie" (BB020B)
- one or both of the following capita selecta from the master of biology "Endocrinology" (BM048B) or "Adaptation Physiology" (BM010B)

Objectives
The course has the aim to gain knowledge and insight into the design of an animal experiment in a scientific and ethically justified manner, taken into account that alternatives (refinement, reduction, replacement) are not possible.
The program of the course on laboratory animal science comprises the requirements cited in article 9 of the Wet op de dierproeven (Experiments on Animals Act) and the (European) FELASA category C demands. The certificate of completion of the course together with an academic degree in biomedical science will lead to a legal recognition to design animal experiments in the Netherlands.

Contents
The objective of the course an laboratory animal science is to present basic facts and principles that are essential for the humane use and care of laboratory animals and for the quality of research. The course will focus on:
the responsible and appropriate use of animals in scientific experiments in which alternatives (refinement, reduction, replacement) play an essential role.

The student:
- will be able to make an ethical argumentation whether the use of laboratory animals in a specific experiment is acceptable (the benefits outweigh the expected adverse effects)
- has insight into the consequences of the animal experiment on the welfare/distress of the laboratory animal and how to effectively tackle this
- will form a critical attitude towards the use of animals in scientific research

- will be able to design an appropriate animal experiment which meets the legal requirements and scientific demands (statistics for example)
- has insight into the possibilities for alternative methods (reduction, refinement and replacement).

Literature

- Textbook in Dutch: L.F.M. van Zutphen, V. Baumans en A.C. Beynen (Eds.), 2003. Handboek Proefdierkunde; proefdieren, dierproeven, alternatieven en ethiek. Elsevier gezondheidszorg, Maarssen. Vierde (niet herziene) druk. ISBN 9789035226159.
- Textbook in English: L.F.M. van Zutphen, V. Baumans and A.C. Beynen (Eds.) (2001). Principles of Laboratory Animal Science. A Contribution to the humane use and care of animals and to the quality of experimental results. Elsevier, Maarssen, Second (Revised) Edition. ISBN 13: 978-0-444-50612-2.
- A module guide will be available.

Examination

The examination is based on a written exam and the evaluation of the groupwork (design of an animal experiment; critical analysis of an article).

Extra information

The course is not an obligatory part of the study Biology.
The course on Laboratory Animal Science is organised by the Central Animal Laboratory (www.umcn.nl/cdl). The course is lectured in English.

The course is scheduled for:

- September 1th - 19th, 2008
- October 27th - November 14th, 2008
- January 5th - 23th, 2009
- March 2th - 20th, 2009

The application form can be found on: www.umcn.nl/cdl
You can apply by emailing the application form to info@cdl.umcn.nl
Requests for further information may also be sent to info@cdl.umcn.nl

Chemistry - elective courses

Chemometrics II

Course ID: **SM103** *4 ec* in mutual agreement with student(s) prof. dr. L.M.C. Buydens

Teaching methods

- 10 hrs lecture
- 10 hrs problem session

Prerequisites

chemometrie 1

Contents

Students are given one subject, typically a lesser known chemometrical technique, which they have to study and apply. They should present the technique, and the results of applying them, in a classical lecture. Also the comparison with other alternatives is important. The course aims at deepening the knowledge in the field of chemometrics.
Subjects: modern chemometrical techniques.

Literature

Relevant references will be handed out.

Examination

Presentation.

Capita selecta: Analytical Chemistry

Course ID: **SM104** *3 ec* in mutual agreement with student(s) prof. dr. L.M.C. Buydens

Teaching methods
- 8 hrs lecture
- 8 hrs problem session

Prerequisites
Chemometrie 1

Objectives
After completing the course, the student should be able to
- critically assess the content of scientific papers and lectures
- summarise the main points of scientific papers
- present these clearly and concisely in a lecture

Contents
Students are given three recent overview papers on one subject from analytical chemistry, and present these in two lectures. The course aims at broadening the background in analytical chemistry.
Subjects:
- modern analysis techniques
- new applications of analysis techniques

Literature
Relevant papers will be handed out.

Examination
Presentation, and participation in discussion.

Computational drug discovery

Course ID: **CMBI101** *4 ec* Spring prof. dr. J. de Vlieg
dr. G. Schaftenaar

Teaching methods
- 17 hrs lecture
- 25 hrs computer course

Prerequisites
Basic bioinformatics and (medicinal) chemistry knowledge; preferentially specific knowledge on 3D protein structures and ligands

Objectives
- The course will improve the participants understanding of how drugs are discovered, and the crucial role played by computational methods in this process.
- After attending this course students will be able to better understand why drug-receptor interactions and other physical-chemical characteristics are important to drug efficacy.
- Finally the course will provide a basic practical understanding of a number of standard and advanced computational drug design tools, such as applied molecular modelling, gene expression analysis, virtual screening, QSAR/CoMFA, molecular dynamics computer simulations, structure-based drug design, homology modeling, and so on.

Contents
It is the intent of the course to describe some of the recent advances in drug discovery informatics, with a focus on the application of *e-science* to real life problems. Topics include the process of in-silico gene hunting, toxicogenomics, pharmacogenetics and structure-based molecular design. Also, the tools and scientific concepts that are part of the modern genomics-based drug discovery pipeline from target discovery and validation to lead discovery and optimization will be discussed. The several hands-on sessions will provide participants with the opportunity to work with the various *in silico* tools and databases available to a modern *in silico* drug hunter. The course is given in close collaboration with the pharmaceutical company NV Organon, part of Schering-Plough corporation.

Literature
Material is handed out during the course.

Examination
Presence at lectures and practicals mandatory.
Team presentation for those who do the 3.0 ec variant.
After completing the course, there is a supplement of 1.0 ec; examination is a presentation (code CMBI102).

Bioinformatics of protein structure

Course ID: **CMBI103** *4 ec* Spring prof. dr. G. Vriend

Teaching methods
- 24 hrs lecture

Prerequisites
- basic bioinformatics knowledge, i.e. 'Methoden: bioinformatica'
- structuur, functie en bioinformatica (SB113B)

Objectives
- After this course the student will have a good impression of fundamental bioinformatics research.
- The student will be able to use (very) advanced bioinformatics tools.
- The student will have a good impression about the entire cycle of a fundamental bioinformatics project: Question -> Plan -> Method -> Results -> Interpretation -> Answers -> New Question.

Contents
The topic of the project will be discussed with the students. The topic will be a fundamental, protein structure related bioinformatics question.

Literature
Material is handed out during the course, and will normally consist of some articles that relate to questions underlying the research topic.

Examination
Written report.

Instrumental analysis for molecular chemistry

Course ID: **SM015A** *3 ec* Autumn dr. M.C. Feiters

Teaching methods
- 16 hrs problem session
- 10 hrs lecture

Prerequisites
- SRM4
- organische chemie 1
- magnetic resonance I (recommended)

Objectives
Independent interpretation and evaluation of NMR and mass spectra, independent planning of strategy for purification by chromatography.

Contents
Important techniques for the characterization of compounds by instrumental analysis are treated. The emphasis is on NMR and mass spectrometry of organic compounds; in the integrated problems IR and the results of elemental analysis are also included. Furthermore chromatography is treated.

Literature
Handouts and papers will be distributed during the course.

Examination
Written examination.

Industrial Chemistry

Course ID: **FMT013A** *3 ec* will be scheduled every other year in May-June starting 2009 prof. dr. P.H.H. Hermkens

Teaching methods
- 30 hrs lecture

Contents
This course will focus on pharmaceutical aspects of industrial chemistry. In the process of drug development, several phases can be distinguished: From therapeutical concept to molecule (drug discovery) and from molecule to registered product (development) different chemistry disciplines and concepts play an important role. During the course these disciplines and concepts will be addressed in a process related order:
- Chemistry-driven hit discovery with topics such as combinatorial chemistry, library design, compound collections, synthetic chemistry, natural product chemistry, lab automation, desired properties
- Chemistry-driven lead optimization with topics such as synthetic chemistry & small molecules, chirality, enabling technologies (i.e. parallel chemistry, lab automation), physical chemistry & desired properties (aqueous solubility, pKa, lipophilicity), DMPK parameters, analytical chemistry
- Chemistry-driven development with topics such as process chemistry, lab automation (HTE, experimental design) , radiolabeling, salt selection, polymorphism, formulation, analytical chemistry

This course which will be provided every other year and is intended for MSc- as well as PhD-students. This course consists of 25-30 hrs interactive teaching, followed by a written exam, spread over a period of two weeks.

Examination
Written examination.

Extra information
25-30 hrs interactive teaching and training during 1 week.
The lecture series are obligatory for students taking the minor Industrial Chemistry. The series can be part of the master programme in organic chemistry. The series can also be part of the variant Management and Technology.

Application of metal-catalysis in natural product synthesis

Course ID: **SM018A** *3 ec* March/April 2009 prof. dr. F.P.J.T. Rutjes

Teaching methods
- 16 hrs lecture

Prerequisites
SRM1, SRM2, SRM3, Syntheseconcepten 2, Organische Chemie 1, or the equivalent thereof.

Objectives
After completing the course, the student can apply a variety of metal-catalyzed transformations for the stereoselective formation of CC-, CN- and CO-bonds. Furthermore, the student has developed a basic feeling for the general strategies that one can apply for the construction of complex molecular scaffolds that are present in natural products.

Contents
Topics:
Transition metal-catalyzed reactions are becoming increasingly important tools to the synthetic organic chemist. Various metals, combined with suitable organic ligands, provide catalysts that can be efficiently used for the formation of CC-, CN- and CO-bonds in functionalized organic molecules. In this course, an overview will be provided of recently developed transition metal-catalyzed reactions (involving a.o. Pd, Ru, Cu, Mn and Ti). Furthermore, an important aspect of this course is the application of these reactions in total syntheses of natural products and biologically active compounds of which various examples will be highlighted.

Literature
Lecture notes and scientific papers.

Examination
Assignment: writing a scientific proposal for natural product synthesis

Polymer chemistry

Course ID: **SM019A** *3 ec* January-February 2009 prof. dr. ir. J.C.M. van Hest
prof. dr. E.W. Meijer

Teaching methods
- 18 hrs lecture

Objectives
After completing the course the student will be able to understand the most important polymer chemistry definitions and methodologies, of which synthesis and molecular aspects will receive most attention. The student can relate polymerization mechanism to polymer properties. Furthermore, with the aid of special topics, the student will become familiar with recent trends in polymer chemistry.

Contents
The first part of the course Polymer Chemistry will give an introduction into different aspects of this multidisciplinary area, such as history, properties and applications of polymers. The preparation of the most common polymers will be discussed from a molecular point of view. The relationship between synthetic methodology and macromolecular properties and, as a result, between synthesis and applications will be emphasized. The second part deals with some special topics of recent developments in the field of polymer chemistry.

Subjects
- chain polymerization
- radical polymerization
- ionic polymerization
- coordination polymerization
- step polymerization
- ring opening polymerization

Special topics, such as
- controlled polymerization mechanisms
- dendrimers
- biopolymers

Literature
- Hand-outs and lecture notes (handed out during the course).
- Recommended: 'Polymers', Walton and Lorimer, Oxford Chemistry Primers, Oxford University Press, ISBN 019850389X.

Examination
Written examination.

Magnetic resonance II

Course ID: **SM023C** *5 ec* second semester prof. dr. A.P.M. Kentgens
prof. dr. S.S. Wijmenga

Teaching methods
- 30 hrs lecture
- 10 hrs question session

Prerequisites
Mandatory: Magnetische Resonantie I
Advised: Structuur Biomoleculen, Structuur Functie en Bio-informatica, Vaste Stof Chemie

Objectives
At the end of this course the student knows the basic theory behind modern techniques for Biomolecular and Solid-State NMR. On the basis of this knowledge he/she can predict the outcome of NMR pulse sequences employed in modern liquid state NMR of moderately complex spin systems. The student recognizes the basic manifestations of single crystal and powder NMR spectra in the solid-state and can extract and interpret the interaction parameters contained in the spectra.

Contents
This course treats the basics of modern techniques for Biomolecular and Solid-State NMR. Various topics will be treated in view of advanced applications of NMR in Life Science and Materials Science. The themes that will be addressed are:
- Reprise: Larmor precession, rotating frame, Bloch equations;
- Basic NMR hardware and principle of the measurement;
- The density operator concept, QM approach of the rotating frame;
- The Operator Formalism, in order to be able to analyze the effect of NMR pulse sequences on coupled spin system;
- The nuclear spin Hamiltonian and its spectral manifestation in liquids, liquid crystals (alignment), single crystals and powders;
- Use of spherical tensor operators;
- Motion (coherent and incoherent): averaging, exchange;
- The mechanisms of spin-spin and spin-lattice relaxation;
- multi-dimensional NMR;
- phase cycling, selection of coherences, canceling unwanted signals;

Literature
- M. Levitt, 'Spin dynamics'.
- J. Cavanagh, 'Protein NMR Spectroscopy. Principles and Practice'.

Examination
Written examination, open book.

Magnetic resonance IIIa, Advanced biomolecular NMR

Course ID: **SM024** *3 ec* Spring prof. dr. S.S. Wijmenga

Teaching methods
- 30 hrs lecture

Prerequisites
Structuur Biomoleculen, Magnetische Resonantie I, Structuur Functie en Biomoleculen, Magnetische Resonantie II

Objectives
After the course the student *knows about* advanced applications of NMR in the field of Structural and Functional Biology. The student *knows* how advanced structure determination of biomolecules is carried out and knows its practical implementation. The student *knows about* advanced applications of NMR to study the dynamics and interactions of biomolecules.

Contents
This course treats the practical aspects of the application of advanced multidimensional NMR to the study of biomolecular structure, function, and interactions. This includes structure determination of proteins and nucleic acids (spectral assignment, structure calculation, and structure validation). Recent novel BioNMR methods will be treated such as application of residual dipolar couplings and the study of dynamics. Also, the use of NMR in the characterization of interaction cellular processes will be discussed. In as far as the NMR background is concerned the course largely builds on Magnetic Resonance I and II and 'Structuur biomoleculen'. For students with a Molecular Life Sciences background and who have not followed Magnetic Resonance II, a differentiation can be set up.

Literature
Articles and reference books.

Examination
Written examination, open book.

Magnetic resonance IIIb, Solid-state NMR

Course ID: **SM044** *3 ec* second semester prof. dr. A.P.M. Kentgens

Teaching methods
- 30 hrs lecture

Prerequisites
Magnetic Resonance I and Magnetic Resonance II

Objectives
After completing this course the student has an in-depth theoretical knowledge of advanced solid-state NMR as applied in contemporary materials science. The student is able to predict the outcome of complex experiments from first principles and knows when to resort to numerical simulations to fully describe the spectra and extract all meaningful interaction parameters. The student is capable of chosing the right approach to eliminate or enhance specific NMR interactions and is aware of the field of application of these techniques.

Contents
Based on the knowledge acquired in the courses Magnetic Resonance I and II, this course will give an in-depth treatment of a number of experiments which are at the heart of Solid State NMR and its applications in materials science and the study of bio(mimicking) materials. Themes will be:
- The nuclear spin Hamiltonian (in spherical tensors operators) and its spectral manifestation in single crystals and powders; homogeneous vs. inhomogeneous line broadening.
- Manipulation of spin Hamiltonians in real and spin space (sample spinning and multiple pulse techniques); Average Hamiltonian Theory.
- Study of molecular motions; line narrowing; multidimensional exchange spectroscopy.
- Double resonance; Cross-Polarization, SEDOR, REDOR.
- Homo- and heteronuclear correlation spectroscopy; recoupling of dipolar interactions under Magic Angle Spinning.
- Getting isotropic spectra for quadrupolar nuclei; DOR, DAS, MQMAS, STMAS.
- Power averaging; Herzfeld and Berger analysis.
- Numerical simulations using the SIMPSON simulation package.

Literature
- M. Duer, 'An introduction to solid-state NMR'.
- M. Levitt, 'Spin dynamics'.
- K. Schmidt-Rohr, H.W. Spiess, 'Multidimensional solid-state NMR and polymers'.

Examination
Written examination, open book.

Moleculaire quantummechanica

Vakcode: **SB110B** *4 ec* voorjaarssemester dr. ir. G.C. Groenenboom

Website
www.theochem.ru.nl

Werkvormen
- 24 uur hoorcollege
- 100 uur zelfstudie

Vereiste voorkennis
Quantummechanica en chemische binding 1, 2 en 3

Leerdoelen
De student heeft na afloop van dit college breder en dieper inzicht verworven in quantummechanische theorieën.

Beschrijving
Het deel van de quantummechanica dat nodig is voor het begrijpen van het gedrag van electronen in moleculen en molecuulparen wordt ingevoerd. De Hartree-Fock methode om moleculaire orbitals te berekenen wordt afgeleid, evenals de theorie van F.W. London voor Van der Waals krachten. Doelstelling van deze meer wiskundige afleidingen is dat de studenten een breder en dieper inzicht verwerven in quantummechanische theorieën die eerder al gedeeltelijk, en minder formeel, behandeld zijn in de colleges quantummechanica en chemische binding.

Subjects
- Quantummechanica: Hilbert ruimtes en postulaten
- Benaderingsmethoden: Variatierekening en (ontaarde) Rayleigh-Schroedinger storingstheorie
- Hartree-Fock theorie: Slater determinanten, LCAO benadering, Roothaan vergelijking
- Intermoleculaire krachten: tensoren in het algemeen, multipool- en polarizeerbaarheid-tensoren in het bijzonder, Van der Waals krachten

Literatuur
Dictaat 'Moleculaire quantummechanica', P.E.S. Wormer en A. van der Avoird, te downloaden van www.theochem.ru.nl

Tentaminering
Tentamen op afspraak.

Bijzonderheden
website: www.theochem.ru.nl/molquant

Molecular Materials

Course ID: **SM292A** *3 ec* May-June 2009 prof. dr. A.E. Rowan
dr. R. de Gelder
dr. P.H.J. Kouwer

Teaching methods
- 30 hrs lecture

Prerequisites
Organic chemistry 3, Supramolecular chemistry

Objectives
To acquire a basic knowledge of the relationship between function and architecture of materials with particular emphasis on self-ordered systems and polymers for applications in OLEDS, OFETS, liquid crystal devices and nanoelectronics.

Contents
The basic concepts and chemistry of optoelectonic devices such as OFET (organic field effect transistors), solar cells, liquid crystalline devices will be discussed. The properties and synthesis of conductive materials viz. bucky balls, carbon nanotubes and organic polymers will be described. As part of the course expert guest speakers from companies and other universities will discuss the applications of these materials in house hold devices.

Literature
Handouts and scientific papers.

Examination
written examination, scientific report and presentations

Group theory for physical chemists

Course ID: **SM124** *5 ec* Spring or Autumn in mutual agreement with student(s) dr. ir. G.C. Groenenboom

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
lineaire algebra

Objectives
Recognition of molecular symmetry and its use in solving the Schrodinger equation.

Contents
- Introduction to point groups and their irreducible presentations
- Application to molecular orbital theory
- Concept of feasible permutations and the permutation-inversion group

Literature
- F.A. Cotton, 'Chemical applications of group theory', 3rd ed., 1990, Wiley.
- P.R. Bunker, P. Jensen, 'Molecular symmetry and spectroscopy, 1998, NRC Research Press.

Spectroscopy and theory of molecular vibrations and rotations

Course ID: **SM124A** *5 ec* Spring or Autumn in mutual agreement with student(s) dr. ir. G.C. Groenenboom

Teaching methods
- 15 hrs lecture
- 15 hrs problem session

Prerequisites
quantummechanica en chemische binding 1, 2, 3

Objectives
A deeper understanding of the relation between nuclear motion and spectra.

Subjects
- Spectroscopy of igid rotor and harmonic oscillator.
- Wilson's GF method.
- Eckart conditions and Watson's hamiltonian.
- Extension to floppy molecules and their large amplitude motion.

Literature
D. Papousek, M.R. Aliev, 'Molecular vibration - rotational spectra', 1982, Elsevier.

Chemical Biology

Course ID: **SM025A** *6 ec* 4 weeks

dr. F.L. van Delft
prof. dr. F.P.J.T. Rutjes
dr. J.J.L.M. Cornelissen
dr. D.W.P.M. Lowik
dr. W.C. Boelens
Prof.dr. R. Brock

Teaching methods
- 20 hrs lecture
- 16 hrs problem session
- 80 hrs laboratory course

Objectives
After completing the course, the student will be able to deal with theoretical and practical aspects in the field of chemical biology. He has a comprehensive overview of current trends and important developments in this field, and is able to apply them in practice.

Contents
The growth of research at the interface of chemistry and biology has emerged into an interely new scientific research field termed chemical biology; chemical tools and strategies are applied to approach biological problems or biological knowledge is used to inspire the development of new chemistry. As such, chemical biology is a highly interdisciplinary field that requires chemists and biologists to pool their skills and knowledge to maximize their ability to solve interesting problems.
The fundamental concept underlying this course involves the application of chemical tools to interfere with biology. In other words, how can we apply our chemical knowledge to influence or monitor biochemical processes, *in vitro* and even *in vivo*. Specific topics that will be discussed: 1. Chemical genetics and chemical ligation, 2. Fusion proteins and detection, 3. Molecular imaging and virus chemistry, 4. Fluorescent probes, 5. Protein engineering.

Literature
Handouts, scientific articles.

Examination
Presentations (both case studies and research project), as well as the practical work during the research project.

Extra information
The full course covers a whole months that can be divided into two weeks of theory and two weeks of hands-on experience. The theoretical part consists of 5 cycles of 2 days, that begin with a lecture on a chemical biology topic, followed by case studies based on recent literature publications by two students (in groups of two). At the end of the second day, the case studies will be plenary presented.
Following the theoretical part, practical experience with chemical biology will be obtained by working individually 8 days on a chemical biology project of choice in one of the contributing research groups.
The course will be concluded by plenary presentations of the research projects.
Grading will involve the presentations (both case studies and research project), as well as the practical work during the research project.

Advanced organic chemistry

Course ID: **SM024A** *6 ec* September 2007-June 2008

dr. M.C. Feiters
prof. dr. F.P.J.T. Rutjes
dr. F.L. van Delft
dr. J.J.L.M. Cornelissen

Teaching methods

- 170 hrs problem session

Objectives

After completing the course the student will be able to solve independently and critically most of the organic chemistry problems that they may come across during the master program in organic chemistry, in particular those relating to mechanisms of important and complex reactions in organic chemistry and their regio-, stereo- and enantioselectivity.
Furthermore, the students will be familiarized with more advanced physical organic chemical principles, such as free energy relations, kinetic analyses and the hydrophobic effect.

Contents

Main focus of the course advanced organic chemistry is to lift organic chemistry mechanisms and principles from a passive knowledge and perception to a level of thorough understanding and active application. To this end, you will be taught to solve organic chemistry problems by combining an increasing knowledge of organic chemistry principles with common sense. The instructor will help you whenever necessary, both in classical form and on an individual basis.
Two specific approaches can be distinguished for the course. The first part involves a thorough repetition of the most important contemporary organic chemistry transformations as well as the physical organic principles underlying these reactions. Specific contents of the course will be highly dynamic, based on recent literature publications as well as on Anslyn and Dougherty.
The second part of the interactive lecture discusses organic chemistry mechanisms and principles on the basis of chapters and problems of Clayden, with an emphasis on chapters 31 to 42.
Before the course, the students are expected to familiarize themselves with chapters 1-30 of Clayden, which are considered to discuss the topics already covered in the bachelor phase.

Literature

Clayden, Greeves, Warren and Wothers, Organic Chemistry', Oxford University Press 2001.
Anslyn & Dougherty 'Modern Physical Organic Chemistry', University Science Books, 2006.

Examination

Written examination. Workshops and lectures are a preparation for the bimonthly exams. A minimum of 3 passed exams is required to pass the course.

Pattern recognition for the natural sciences

Course ID: **SM114** *6 ec* Fall/Winter dr. H.R.M.J. Wehrens
prof. dr. L.M.C. Buydens

Website
www.webchem.science.ru.nl/PRiNS

Teaching methods
- 20 hrs lecture
- 32 hrs computer course

Prerequisites
- Introductory statistics
- Basic knowledge of R (www.r-project.org)
- Basic linear algebra

Objectives
The students should be able to
- Visualize multivariate chemical data to maximize the information content of plots
- Formulate real-world research questions in terms of pattern recognition problems
- Select and apply the appropriate technique(s) for a specific case
- Apply these techniques using appropriate software
- Interpret the results using both domain knowledge and statistical insight
- Validate the results

Contents
The aim of the IMM is to conduct research in the field of functional molecular structures and materials. There is an emphasis on understanding and controlling complexity in order to be able to design new functionality in these systems. One of the focus areas of the IMM is the development and use of a host of spectroscopic techniques such as optical spectroscopy, scanning probe microscopies and nuclear magnetic resonance. This leads to increasingly complex data streams. In the analysis and interpretation of these data pattern recognition plays an increasingly important role. This will be illustrated by numerous examples, such as analysis of data from chemical sensors, clustering of microarray data, image segmentation of remote sensing images (for detecting and classifying tumours based on MRI data), efficient data processing and preprocessing in high-throughput analysis (e.g. in proteomics or metabolomics), data mining of large databases of chemical structures, etcetera.
Students will apply the theory by means of exercises and actual case studies from different departments. In this way, students should be able not only to grasp the principles and ideas behind the mathematics, but also to recognize and solve pattern recognition problems in an appropriate research setting.

Literature
- Reader, available from the course website
- "The Elements of Statistical Learning", Hastie, Tibshirani and Friedman (Springer 2003)

Examination
Written exam.

Physical organic and supramolecular chemistry

Course ID: **SM023B** *3 ec* November-December 2008 prof. dr. R.J.M. Nolte
dr. J.J.L.M. Cornelissen

Teaching methods
- 18 hrs lecture

Contents
This course gives an overview of modern developments in physical organic and supramolecular chemistry, and is meant as an extension of the 'Advanced Organic Chemistry' course. The topics are based on the recent literature. Subjects that will be discussed include self assembling molecular systems, host-guest chemistry, supramolecular materials and biomimetic catalysis.

Literature
Lecture notes and original literature.
Anslyn & Dougherty 'Modern Physical Organic Chemistry', University Science Books, 2006

Examination
Written examination.

3.2 C-variant

Science & Societal interaction

Course ID: **FC002B** *3 ec* third quarter dr. J.G. van den Born
P.H.T. Scholten

Website
www.betacom.science.ru.nl

Teaching methods
- 14 hrs lecture
- 1 hrs personal study counseling
- 69 hrs individual study period

Prerequisites
Basic articles from the reader of the course: 'Introduction Science communication'.

Objectives
The student:
1. develops knowledge and understanding in the field of public participation, regarding natural-scientific topics in societal processes.
2. applies this knowledge by developing a participation-plan. Attention is paid to different levels of participation and methods and tools of participation. Also, a distinction of the different stakeholders is made, and ways to reach them are explored.
3. is introduced in and applies the methods and tools for the design of an objective and research questions of a research plan.
4. is able to formulate an advice by means of a group discussion and to present and argue this advice in front of experts in the field of participation.

Contents
Science communication is usually not a linear process, but comes into being through interaction. In this course is dealt with ways to involve citizens and other stakeholders in an interactive process when scientific topics are on the agenda. Questions as why would you involve stakeholders and why not, who would you involve and on which level are under discussion. With regard to the question who to involve it is important to get a grip on 'the public'; who will and can be involved? And what are the benefits for people to participate in such a process? Finally, we learn about the different methods and tools that can be used in the planning of a participation project, such as debates and focus groups.
In this course the students are introduced in the basic principles of stakeholder participation, students design a participation plan themselves and debate with experts on the field of participation on an actual case.

Literature
Literature will be made available on Blackboard

Examination
An assignment.

Extra information
Thursday 15.30-17.30

Risk Communication

Course ID: **FC003B** *3 ec* second quarter dr. J.G. van den Born
S.A.J. Segers

Website
www.betacom.science.ru.nl

Teaching methods
- 20 hrs problem session
- 1 hrs personal study counseling

Prerequisites
The course builds on previous courses from the Mastertrack Science Communication, and is part of the obligatory part of the Mastertrack. In addition, the course is open as an optional course for all MSc. Students.

Objectives
- Students are familiarised with the specific characteristics of Risk Communication in relation to Science Communication
- Students are familiarised with actual cases and practices in Risk and Uncertainty Communication
- Students are familiarised with determinants of public perception of Risk and Uncertainty
- Students are familiarised with the role of the different actors and stakes in Risk Communication (for instance companies, government, local population) and how to position themselves among these actors

Contents
Present day society has been characterised as a Risk Society. The communication of risk and the public understanding of risk have become important issues in Science Communication. The course aims to prepare students to actively engage in risk communication and to analyse, reflect on and assess risk communication practices.
The course combines a practical and theoretical component. Discussions among students, teachers and guest speakers are matched with analyses of current scientific insights on issues of risk communication, risk perception and uncertainty.

Literature
Literature will be made available on Blackboard

Examination
To be announced

Extra information
Thursday 15.30-17.30

Boundary-Work:
The Tension between Diversity and Sustainability

Course ID: **FC0041C** *3 ec* fourth quarter

prof. dr. F.W.J. Keulartz
drs. I.E.M. Dankelman
S.A.J. Segers

Website
www.betacom.science.ru.nl

Teaching methods
- 4 hrs personal study counseling
- 20 hrs lecture

Objectives
Students should gain some basic insights in the tension between the heterogeneity of actors that (should) have a stake in natural resources management on the one hand and the need for an integrated approach and close cooperation among these various stakeholders on the other. They should be able to specify and discuss general strategies of so-called ‘boundary work' to deal with this tension between diversity and sustainability.

Contents
Climate change, air pollution, deforestation, loss of biodiversity, stratospheric ozone depletion, land and freshwater degradation - all these environmental problems have effects that transcend national boundaries; they cannot be solved by the unilateral decisions of individual states but require international cooperation. Moreover, these problems are interconnected and cannot be solved in isolation. For instance, climate change can lead to depletion of the ozone layer, loss of biodiversity, land degradation, desertification, and alteration of the global hydrological cycle. These negative impacts in turn reinforce each other through feedback loops, which results in a serious threat to land productivity, food supply, and freshwater availability. Because they are so closely connected, these global environmental threats require an integrated approach. But such an approach is frustrated by the existing multiplicity of communities with diverse and sometimes diverging ethical visions and moral vocabularies. So, there is a strong tension between on the one hand the diversity of actors that have a stake in sustainable development and on the other hand the need for a close cooperation between these various stakeholders. This tension between sustainability and diversity can only successfully be resolved through processes of communication, conflict management and consensus building across the lines that separate communities and their social and moral worlds. Such ‘boundary work' is the central topic of this course.

Literature
J. Keulartz: Werken aan de grens - een pragmatische visie op natuur en milieu. Damon, 2005.

Examination
Students should study the literature, participate in discussions, make at least one presentation, and write a brief essay.

Extra information
Thursday 13.45-15.30

Introduction Science Communication

Course ID: **FC001B** *3 ec* first quarter dr. J.G. van den Born

Website
www.betacom.science.ru.nl

Teaching methods
- 14 hrs lecture
- 70 hrs individual study period

Prerequisites
This is the first course of the Mastertrack Science Communication. It is part of the obligatory programme of the Mastertrack. In addition the course is open as an optional course for all MSc. students.

Objectives
- Students are familiarised with science communication practice
- Students are familiarised with science communication theory
- Students are trained by a professional in presentation techniques

Contents
Nowadays every scientist gets involved in science communication in his or her professional life. In this course we give an overview of science communication strategies and of seminal views on science communication practices and theories.
Focus is on communication with the public and with target groups within the general public on issues that involve scientific knowledge. Scientific communication (communication among scientists for instance at scientific meetings) is not the main issue, although the training in presentation techniques applies to those communication practices as well.
Students will also study and present classic examples of succesful popularization of scientific insights, in the shape of TV documentaries, films, fiction and non-fiction books, and 'visitables'.

Literature
Literature will be made available on blackboard

Examination
Written exam, participation and presentation

Extra information
This course will be taught in Dutch.
Thursday 15.30-17.30

Framing Knowledge

Course ID: **FC0010C** *3 ec* first quarter dr. J.G. van den Born

Website
www.betacom.science.ru.nl

Teaching methods
- 14 hrs lecture
- 70 hrs individual study period

Prerequisites
The course 'risk communication' is recommended.

Objectives
The student:
- will be introduced in the field of cognitive psychology (knowledge)
- will have insight in the role of perceptions, interests and strategies in conflict situations (knowledge)
- can cooperate in a group of fellow students with regard to the assignment (skills)
- can design an interview guide, learn to interview, and to work out and interpret the interview results (skills)
- can debate (skills)

Contents
Framing knowledge is an introduction into perceptions; frames that individuals use to look at and understand the world around them. It is important to be conscious of the fact that everyone has their own background and patterns of thought. For example, a farmer has a different idea of what nature is than a city dweller, and a scientist has a different perception of a laboratory animal than an ethicist.
When looking closer at laborious and failed negotiations, it is not impossible that different perceptions are underlying the whole matter, perceptions the stakeholders are often stuck to. To recognize these frames is the first step of understanding and solving a conflict. Connected to these frames are individuals (or groups) interests and strategies to act and negotiate.
In this course the students are also introduced to the basic principles of interviewing, they learn to design an interview guide and finally interview a stakeholder in the case we investigate during the course.

Literature
Literature will be made available on Blackboard

Examination
An assignment.

Extra information
This course will be taught in Dutch
Thursday 13.30-15.30.

Knowledge Society

Course ID: **FC0011C** *3 ec* third quarter dr. J.G. van den Born
S.A.J. Segers

Website
www.betacom.science.ru.nl

Teaching methods
- 7 hrs lecture
- 7 hrs problem session
- 20 hrs personal study counseling

Prerequisites
The course builds on previous courses from the Mastertrack Science Communication(especially Risk Communication) , and is part of the obligatory part of the Mastertrack. In addition, the course is open as an optional course for all MSc. Students.

Objectives
- Students are familiarised with the different roles of scientists in the Knowledge Society
- Students are familiarised with the implications for science communication
- Students are familiarised with shifts in the knowledge infrastructure and with techniques and strategies to analyse these shifts
- Students are familiarised with the pro's and con's of multi-, inter-, and transdisciplinary-settings they will encounter in professional contexts
- Students are trained in essay-writing

Contents
Present day society has been characterized as developing towards a 'Knowledge Society'. Scientific knowledge has become more important and new technologies have a sometimes unprecedented impact. At the same time, the position of (academic) science is under pressure and apparent shifts take place in the role and authority of science in society. Knowledge is an issue.
In this course we reflect on these changes, and discuss the possible implications of these shifts for MSc. students in their future professional life. We ground these discussions in actual working practice brought to the classroom by guest speakers, and complement these by models and approaches that are currently used in assessments of the Knowledge Society.
The course combines a practical and theoretical component. Discussions among students, teachers and guest speakers are matched with analyses of current scientific insights on the Knowledge Society. A professional training in essay-writing completes the course.

Literature
Literature will be made available on Blackboard

Examination
Essay

Extra information
The course is taught Thursday 13.30-15.30

Science & Media: strategies and trends

Course ID: **FC0013C** *3 ec* second quarter H.M. Dresen
drs. R.P.M.M. Welters

Teaching methods
- 1 hrs personal study counseling
- 20 hrs problem session
- 63 hrs individual study period

Prerequisites
This course is part of the Mastertrack Science Communication, and also open as optional course for all MSc. students.
In either case, finishing the course **Introduction Science Communication is a pre-requisite for taking part in this course.**

Dutch language:
Part of this course (i.e. the training in media-oriented writing) will be given and examined in Dutch, as it is aimed at gaining access to the Dutch media landscape. Participants who do not write Dutch need to register six weeks in advance of the start of this course by sending an email to the coordinating lecturer of this course (H.M. Dresen) asking for an English language arrangement.

Number of participants:
The number of participants for this course is limited, due to the character of the training in media-oriented writing. Students will be accepted in the order of their registration. Students of the Science Communication mastertrack have priority in placement, if they register six weeks in advance of the start of this course.

Two versions of media-oriented writing
The training in media-oriented writing will be offered in two different versions, to cater for different levels of previous training among students (esp. whether 'Effectief Schrijven' within CEM has been followed or not). Please read the details that will be given about this on Blackboard six weeks in advance of the start of the course, so that you may be placed in the appropriate group.

Objectives
- students will increase their abilities in media-oriented writing, and will be shown ways how to further increase these abilities in the near future.
- students will increase their knowledge of the strategical considerations and ethical codes involved in the process of transmitting information from the academic to the public arena.
- student will gain understanding of a) the current state of science reporting in the media and b) ways in which the representation of science and technology in the media has changed over the last few decades.
- students will get acquainted with several methodological alternatives for studying trends in science reporting in the media (as a subfield within the Social Studies of Science)

Contents
The course consists of two interrelated parts:
1. A training in media-oriented writing (given in Dutch), which will adress both the process of writing itself and the broader strategical and ethical considerations involved in the process of transmitting information from the academic to the public arena.
2. An introduction to the academic field of studying Science-in-the-Media, as a subfield within the Social Studies of Science. The examples we will study are intended to increase the students understanding of the current state of science reporting in the media. While studying these examples, the students will also get acquainted with different methodological alternatives for studying trends in how the media represent scientific expertise.

Literature
- Handbook on media-oriented writing (can be bought, or library copies can be used in the FNWI library)
- Additional reading material will be made available at the start of the course

Examination
Journalistic writing assignment & analytical assignment

Extra information
Classes once a week, Thursday 13.30-15.30 from november 13 2008 till january 29 2009.

Visible Scientists

Course ID: **FC0040B** *3 ec* fourth quarter dr. B. Smelik
S.A.J. Segers

Website
www.betacom.science.ru.nl

Teaching methods
- 26 hrs lecture

Objectives
After the course the student will be able to
- substantiate the terms 'visible' and 'invisible' in the framework of this course
- identify important scientists and to identify 'visible' and 'invisible' scientists in his own field of study and to argue why they are (in)visible.
- understand the way visibility works
- have a basic knowledge of network theory
- substantiate benefits and restraints of visibility in the academic world (f.e. by addressing the reliability and relevance of research) and gain insight in the problematic nature of societal interaction
- find primary and secondary sources on scientists.

Students will be required to read carefully, to formulate clearly and unambiguous, to present the material in a systematic manner and to unfold a good solid argumentation. These academic skills will be involved when reading, writing and presenting research results during the course.

Contents
A highly influential stereotypical view of scientists depicts them as invisible laboratory researchers, working silently and at a safe distance from their societal and cultural environment, communicating their findings to a small circle of fellow experts. Reality is often completely at odds with this stereotypical view. Quite often, prominent scientists are acutely aware of the importance of societal communication and interaction, and sometimes they are quite good at it and / or invest a substantial amount of time in this aspect of their work. They know how to involve broad audiences in this research, how to gain public attention, how to raise public support. On the other hand, visibility may backfire on the scientists or make their involvement in societal interaction less or even counter productive. Societal interaction may also greatly affect the course of their research activities and the development of their research agenda. We will take a more or less biographical approach, focusing on the research as well as the societal communication of particular scientists, and the benefits and restraints of using (in)visible scientists in science communication.

Examination
Essay & 2 ppt presentations
This is an elective course within the Science Communication track, but can be chosen in any master as elective course.

Research project (Masterthesis) Mastertrack Science Communication

Course ID: **FC0006B** *30 ec* dr. J.G. van den Born

Prerequisites
Students who want to start with their research project, must have finished all seven obligatory courses of the Science Communication mastertrack and their (beta) bachelor thesis.

Contents
For more information see: www.betacom.science.ru.nl .

3.3 E-variant

Familiarisation traineeship Education

Course ID: **FE0001B** *3 ec*

Teaching methods
- Traineeship secondary education 60 hours
- Preparations/traineeship assignments/report 20 hours

Objectives
The 'Work experience E-orientation' offers students the opportunity to further familiarise themselves with the E(ducation)-orientation during the master phase (following the CEM-course as part of the bachelor phase).

Contents
Planning: The traineeship at a secondary education institute does not only involve working alongside the teacher and observing, but also teaching a class yourself (8 lessons) and discussing these with the supervisory school teacher.
Experience shows that you will need to be at school 2 days per week for a period of 4 to 5 weeks in order to acquire the necessary experience. However, the student is free to make other arrangements in consultation with the traineeship school concerning some other schedule.
The schools offer two possible periods for the purpose of this work experience, namely from October 1st until December 1st and from February 1st until April 1st. This periods are generously scheduled in order to give the student and the school the opportunity to flexibly plan the traineeship in the course of the fourth year of one's studies.
Supervision: The university provides supervision in the form of a teaching methodologist from the Institute for Teachers and School (ILS). This institute teacher arranges an introductory meeting, maintains contacts with the schools, provides literature and assignments and assesses the report. The institute teacher visits the traineeship school once for consultations on location, supplemented with a lesson observation, if desired.
Secondary school teachers supervise at school.

Extra information
This work experience traineeship is not mandatory, but it is certainly advisable for everyone who wishes to be a fully-qualified teacher. The traineeship can be flexibly scheduled.
Contact: secretariat of the Institute for Teachers and School, Erasmusplein 1, 6525 HT Nijmegen, tel. 024-3615573 of 3615572.
The traineeship department of the ILS makes arrangements for trainee posts based on the applications pertaining to this particular form of traineeship. Please keep in mind that it may prove necessary to use a weekly rail pass.

3.4 MT-variant

Master-thesis Management & Technology-track

Course ID: **FMT010B** *27 ec* prof. dr. B. Dankbaar

Teaching methods
- 50 hrs personal study counseling

Prerequisites
- The master thesis for the MT-track is the final part of the Master curriculum for Master-students from the Faculty of Science of the Radboud University
- who have finished the required courses and 'master-research' in their own discipline; and
- who have successfully completed the required courses of the MT-track: Business & Society, Organization Theory, Innovation Management, Strategy & Marketing, and Finance & Accounting.

Contents
The master-thesis consists of performing a research project on the interface of science, technology, society and organization. This research project will be performed in a profit or non-profit organization. It is important that the student is performing research contributing to the solution of an organizational or practical problem for which a combination of knowledge from natural science and management science is required or at least useful. The duration of the project should normally not exceed six months, from the start until final presentation of the thesis.

Examples of research topics are:
- Diagnosing the implementation of technological innovation in organizations;
- Developing a business plan for a new product;
- Doing market research for a high tech product;
- Developing and/ or evaluating instruments for assessing and developing HRM-policy in R&D departments;
- Developing instruments to improve collaboration between university and companies;
- Developing en/ or evaluating public policy-instruments on innovation, science, and environmental issues;
- For inspiration, see also the MICORD-research program (see ISIS- web site)

Project stages:
The project consists of the following stages, which are all closed with a specific activity:
- Preparation of research, resulting in a research proposal
- Performing research, resulting in a research report
- Presenting the results of your research at the organization involved
- Defending your research report at the university

Literature

- Guidebook of the final MT research project (presently only available in Dutch), see the MT- web site

We advise you to use books about how to do business research, for example:

- Saunders, M. et al. (2003), ***Research Methods for Business Students*** *(3th ed.).* Harlow: Prentice Hall.
- Cooper, R., Schindler, P., S. (2006) ***Business Research Methods*** *(9th ed.), McGrawhill, New York*

Examination

- See guidebook

Algemene managementvaardigheden

Course ID: **FMT014A** *2 ec* Coursedate: June-July drs. J.G.J. van den Broek

Teaching methods
- Vaardigheidstraining (32 uur), zelfstudieopdrachten (24 uur)
  Inleidingen, zelfstudieopdrachten, vaardigheidstrainingen, presentaties
- Cursusdata in studiejaar 2008-2009
  18/06 (nm), 25/06 (nm), 29/06 (hele dag), 30/06(hele dag) en 01/07 (hele dag)

Prerequisites
Deze cursus heeft het karakter van een training. Hierbij is de nuance in de interactieve processen cruciaal. Voor de diepgang en kwaliteit vereist dit van alle betrokkenen taal op het niveau van "native speaker". Daartoe bedienen we ons bij dit keuzevak van de *Nederlandse taal*.
Voor studenten uit de afstudeervariant Management & Toepassing (afstudeervariant MT) kan deze cursus gelden als een keuzevak.

Maximale groepsgrootte: inschrijving en plaatsing
In verband met de vaardigheidstrainingen kunnen slechts 14 studenten per cursus deelnemen. Plaatsing geschiedt aan de hand van de volgorde van inschrijving. Studenten uit de afstudeervariant MT krijgen voorrang.

Objectives
De training beoogt een aantal vaardigheden (zie Inhoud) verder te ontwikkelen.
Studenten leren strategieën en technieken, die toepasbaar zijn in diverse professionele situaties.

Contents
- Strategisch denken en handelen
- Problem solving
- Projectmatig werken
- Adviesvaardigheden
- Het creëren van win-win situaties
- Onderhandelen
- Omgaan met weerstanden en conflicthantering
- Vergadertechnieken
- Zelfreflectie en het persoonlijke ontwikkelingsplan van de startende academicus

Examination
Actieve participatie vaardigheidstrainingen en schriftelijke eindopdracht.

Business & Society

Course ID: **FMT001B** *5 ec* fall semester dr. G.A.N. Vissers
prof. dr. B. Dankbaar

Teaching methods
- 28 hrs lecture

Prerequisites
Master student FNWI

Objectives
The aim of this course is for students to:
- Develop an understanding of the processes of mutual influence that exist between science, technology, economy, and society, and get acquainted with concepts and theories from economics and social sciences that seek to explain these processes.

Contents
Of the courses within Management & Technology curriculum, Business & Society is the first to be given. The course will provide students with an overview of theories and perspectives concerning the position and the functioning of firms and industries in the wider economy, national and international, and in society. In particular, themes from industrial history and industrial economy will be explored, but also issues related to current concepts like 'knowledge economy' and 'globalization'. These subjects will be discussed, partly on the basis of project assignments, and their implications for the university, firms, and government will be considered.

Subjects
- Economic history, especially industrial development in the 19th and 20th century
- Industrial revolutions and economic change
- National and regional differences within and between market economies
- National and sectoral systems of innovation
- The interactions between technology and organization
- The interactions between politics, society, and economic developments

Literature
Thomas K. McCraw (ed.), Creating Modern Capitalism. How Entrepreneurs, Companies, and Countries Triumphed in Three Industrial Revolutions, Harvard University Press, 1997

Examination
Written assignment and group presentation

Finance & Accounting

Course ID: **FMT005B** *5 ec* spring semester drs. R.A. Minnaar

Teaching methods
- +/- 15 lectures (see for detail Black Board)
- practices

Prerequisites
Master student FNWI

Objectives
The financial accounting part should give you a firm understanding and working knowledge of:
- The basic accounting terminology and the process for recording, summarizing and reporting economic events of a business enterprise;
- The interpretation and analysis of financial statements as a basis for business decisions.

The management accounting part is to develop the student's knowledge of the process of evaluating performance and decision making using accounting information as a basis. After taking this course you should be able to interpret, use and evaluate internal accounting information.

Contents
Accounting information is an integral part of the business environment and an understanding of accounting information is an essential tool in the process of making business decisions. The primary objective of this course is to develop the student's knowledge of accounting as a tool in making business decisions. The emphasis in this course will be on both the user and the preparation of accounting information in a business context.

This course consists of two parts. Financial- and management accounting.
In the financial accounting part, you will be introduced to accounting theory and practice using the models of sole proprietorships and corporations, with an emphasis on merchandising companies. The emphasis and focus of financial accounting is on financial information used by parties' external to the firm. Specific topics will include: the definition and scope of accounting; systems used to account for and control transactions; inventory costing; the measurement of income and equity; and a special emphasis on financial reporting and the analysis of financial statements.

The management accounting part of this course emphasizes the use of accounting information for internal planning and control purposes. As business managers, you will be involved in a variety of management decisions. Some examples of the issues that you might encounter include: "How much should we charge for this product or service?"; "What elements contribute the most to this business?"; "How is my company doing compared to the competitors?"; "Is this person a good manager?"; "Are my costs under control?" "Does this capital investment make sense?" A range of information may influence such decisions and management (internal) accounting information is among the most significant.

In this part, the fundamentals of managerial accounting, profit and cost accumulation are introduced. Specific topics covered include: cash flows, capital budgeting, cost allocation, product costing, differential costing for short and long-term decisions, performance evaluation, and the concepts related to the time value of money.

Literature

Needles, Powers & Crosson; Principles of Accounting 2008e, Tenth Edition; Houghton Mifflin; ISBN 0-618-73661-1989-4

Examination

- A final written 3 hour exam with open questions.
- Bonus points based on assignments, cases, participation and mid-term test.

Innovation management

Course ID: **FMT003B** *5 ec* fall semester ir. L.J. Lekkerkerk

Teaching methods
- +/- 15 interactive lectures, or workshops (see for detail Black Board)
- assignments

Prerequisites
- Master student FNWI
- BEM & Organisatiekunde in completion with a minimum of a 6

Objectives
The purpose of the course is for students to :
- Acquire knowledge in the field of innovation management including Research and Development and New Product Development
- Apply this knowledge in theoretical cases, eventually acquire sufficient knowledge to apply this knowledge in 'real life' settings
- Judge the value of scientific knowledge in the field of innovation management including Research and Development and New Product Development
- Learn how to design a research project in this field

Contents
Innovation determines the dynamics of the economy. Organizations innovate to stay viable. This course focuses on issues of innovation from a management perspective. The main issues concern the dilemmas of innovation management and innovation enhancement: how (and to what extent) are these processes manageable? In these processes different factors play an important role, such as creativity, enterpreneurship, structure, linkages, and a bit of luck. This course offers the student knowledge about the structure and nature of the innovation process (product as well as process innovation). Furthermore, it offers the students instruments to cope with the different dilemmas of innovation management.

Subjects
- Managing for innovation
- Strategy
- Establishing effective external linkage
- Building effective implementation mechanisms
- Creating the innovative organization
- Assessing and improving innovation management

Literature
To be determined (See Black Board)

Examination
assignments and a written exam

Organization Theory

Course ID: **FMT002B** *5 ec* spring semester prof. dr. B. Dankbaar

Teaching methods
- 30 hrs question session

Prerequisites
MT Course Business & Society

Objectives
- Students acquire knowledge of the main concepts and approaches in organization theory
- Students are able to apply this knowledge to issues of organizational design and change

Contents
This course offers an introduction into the fundamental insights of organization theory dealing with questions like: What are organizations? How are they structured? How do they interact with their environment? What is organizational culture? And how are organizations designed and managed? Organizations are complex systems and consist of people with different interpretation-schemes. As a result, organizations have to deal with a variety of problems and dilemmas. The course offers students methods and instruments to diagnose organizational problems and to deal with the problems and dilemmas of organizing.

Apart from studying and discussing a text on organization theory, the students will make presentations of their analysis and views on selected business cases

Literature
Gareth Jones, Organization Theory, Design and Change, 5th edition

Examination
Written examination and discussion of a business case

Strategy & Marketing

Course ID: **FMT004B** *5 ec* fall semester dr. P.E.M. Ligthart
dr. ir. N.G. Migchels

Teaching methods
- 30 hrs question session

Prerequisites
- Master student FNWI
- BEM & Organisatiekunde in completion with a minimum of a 6 ECTS

Objectives
After completion of the course, students are familiar with market oriented views of innovation and with several important forms of market research; they are able to describe the circumstances in which market orientation will influence innovation processes and to discuss the nature of such influence for business and product development. Students will also be familiar with strategy formation, with different types of strategy and the related perspectives, and with the relationships between general business strategy and innovation strategy.

Prime course objectives are that:
- participants acquire updated insights regarding challenges and opportunities in high-tech markets
- participants understand the virtue and limitations of traditional strategic marketing thinking and tools in emergent, high-tech markets, and
- participants apply their understanding of strategy and marketing concerning High-Technology to develop a well-founded business plan within their own technological discipline.

Contents
Marketing is the business function that deals with discovering and meeting customers' unfulfilled needs and wants. Strategy underlines the need to align this function to the objectives of the business, the other business activities and -last but not least- to the external market environment of the firm. Strategic marketing in high technology environments poses its own unique challenges due to the complexity and novelty of the technology. Some of those challenges include articulation of the value proposition, decision making with limited information on customers, and coordination with other market players. In order to succeed in this environment, firms need to be able to understand unarticulated needs, forecast the development of nascent markets, and position themselves appropriately in the competitive landscape.

High-tech firms operate under conditions characterized by high degree of market and technological uncertainty. Technological changes can occur rapidly. Products offered are novel and for buyers often difficult to evaluate. Moreover, high-tech firms often operate in emergent industries with "fuzzy"and rapidly changing industry boundaries. Such conditions -deviating from those captured in most marketing texts- represent specific challenges for high-tech firms to survive and prosper. It should also be noted that the rapid developmentes in modern technologies within science (e.g. biotechnics, informatics, chemics, mathematics, etc.) exert influence on markets and marketing practices only superficially dealt with in traditional

strategic marketing textbooks. The "driving question" that arises form the situation described above is: "Provides strategic marketing added value for firms operating in high-tech markets?"And, if so, "why and how ?"

The focus of this course will be on the strategic marketing to accompany a technology and not on the technical or scientific aspects of the high-tech products. Besides lectures, students will work on a group project (i.e. to set up a High-tech Business Development Plan) throughout the term to analyze the marketing strategy for a technology-based product or service. This course focuses on issue related to strategy and marketing of firms, such as:

- Technology and market
- Relation between R&D and Marketing
- Business strategy and product strategy
- Market research
- Relation with customers
- Distribution, supply chain and pricing

Literature

Mohr, Sengupta, Slater (2005) **Marketing of High-Technology Products and Innovations** (2nd international edition) Pearson Prentice Hall, ISBN 0-13-123023-9
Reader (links of articles will be published at Blackboard)

Examination

- Written exam (literature)
- Business Development Project (presentation and report)

Research Strategy and Management

Course ID: **FMT011A** *3 ec* spring semester prof. dr. J. de Wit

Teaching methods
- 20 hrs question session

Prerequisites
Master student FNWI

Objectives
The student will be informed on the following aspects of Research Strategy and Management:
- career development possibilities
- industrial strategies
- research strategy and management (from 1st to 4th generation)
- organization of research
- project management
- knowledge management
- cooperation between university and industry
- case studies on radical innovation
- the Balanced Score Card method
- project selection methods
- roadmapping
- measurement of R&D performance
- innovation and venturing
- sustainable development in the 3rd world

All information will be illustrated with examples from the practical experience of the teacher during more than 20 years in industrial research management.

Contents
Research Strategy and Management is an important discipline in many forms of research. It is the intention to inform Master students and junior researchers on all aspects of R&D management in relation to business strategies. The class is mainly intended for students who want to start a research management career relatively soon after getting their MSc or PhD diploma and therefore follow the MT variant as their Master education. This career can start in industry but also in government, a consultancy firm or as owner of a private company. The class is also suited for students whose first choice is not the MT variant but still want to receive general information on the aspects of modern R&D management

Literature
After each lecture a task is formulated consisting of usually 3 questions. To answer the questions use can be made of Internet or of a list of books that will be given during the first lecture of the series. Other forms of knowledge gathering are of course also possible.

Examination
One week after the last lecture a written examination is given. This examination takes 3 hours. One month later there is an oral exam of about 1 hour for those who failed the written exam.

Science and Entrepreneurship

Course ID: **FMT012A** *3 ec* spring semester prof. dr. J.T.P. Derksen

Teaching methods
- 20 hrs lecture
- 60 hrs individual study period

Prerequisites
Minimum of three years of academic training in one of the sciences

Objectives
The goal of the course is to provide insight in aspects of the commercial utilization of results from scientific research to advanced (3rd year or higher Bachelor, Master or PhD) students. The course has a particular emphasis on issues around starting up a commercial (high-tech) enterprise. Also various entrepreneurial skills are addressed. At the end of the course students will be able to write a concise business plan.

Contents
For a knowledge-driven economy, such as the EU, it is of prime importance to apply scientific findings and new technologies as starting-points for commercial activities. Evidently, also research results from universities can contribute to the economic growth of our society. How this commercialization and valorization of knowledge can be realized in practice is the main topic of this course.

Subjects
- Research and development in academic versus industrial setting
- Entrepreneurship ("unique selling proposition", business plans, legal and financial aspects of start-up companies, entrepreneurial skills and mentality)
- Market-orientation (marketing plan, sales pitches, how to find customers, pricing of products & services)
- Funding of start-up companies (ROI, (inter-)national government funding programs, venture capital, informal investors, banks)
- Intellectual property rights (patents, confidentiality and pitfalls)
- Help in Nijmegen (financial and other support specifically for Radboud spin off companies, coaching)

Literature
During the lectures hand-outs of the presented subjects will be supplied.

Examination
- At the end of course students will be required to submit a business plan on an idea of choice. This proposal will be judged primarily on how convincing it is, but also on originality and thoroughness
- Written assignment

Extra information
- Training exercises in various commercial skills
- Internet desk studies on business-related issues
- This course will be taught in Dutch only

4 Research

4.1 Multidisciplinary Research at the Faculty of Science

This chapter gives an overview of the multidisciplinary scientific research taking place at the Radboud University or in corporation with the RU. More and more interdisciplinary projects are carried by two or more research groups. Natural Science students can combine their Major and Minor internship into one interdisciplinary project shared by two research groups.

In this chapter a selection is made of research groups ('leerstoelgroepen', chairs) that are relevant for the Natural Science Master program. For an even more complete overview of all existing research groups we refer to the Prospectuses of Physics and Astronomy, Chemistry, and Biology that can be found at: www.studiegids.science.ru.nl/2008/science.

Most descriptions here are updated annually, but research projects change over time and new projects start. It is always best to go and talk with researchers in the department about their research and current possibilities.
Every researcher likes to talk about his work, do not hesitate to ask.

The large variety in subjects and experimental techniques makes it possible for every student to follow their interest. The traineeship can completely or partly take place outside the Faculty, for instance in industry or abroad.
Every internship should take place under ultimate supervision of a professor from the Faculty of Science.

During an internship, students get ample opportunity to participate in research. This can be on an individual basis by setting up and performing a short-term independent research under the supervision of a PhD-student or a senior staff member. In this case one can often lay the foundation of a possible PhD career. Another possibility is to do a bigger project with other students or in direct corporation with a PhD-student.
Concerning his/her more independently performed part in the research, the student is expected to write a graduate-report and to give a departmental colloquium.
Furthermore, in many cases, the student must write a thesis on a literature subject.

Note: Not all research projects in the selected departments are multidisciplinary and not all multidisciplinary research is suitable for the Natural Science Master program!
It could also be that multidisciplinary research is performed in a department that is not (yet) mentioned here. It is possible that such research could also be very suitable as a subject of a traineeship.

Internships should get approval BEFORE starting.
A form for planning and approval can be obtained from the study coordinator.

The two internships for the research variant must be taken in different groups and focus on different disciplines. This is the only way to get fully acquainted with concepts and methodology of different disciplines.

Relevant Research Institutes (See their respective websites)**:**

Institute for Molecules and Materials (IMM)
Institute for Water and Wetland research (IWWR)
Institute for Neuroscience (IfN) – Donders Institute
Institute for Molecular Life Science (NCMLS)
FC Donders-center
UMC St. Radboud

4.2 Condensed Matter Science and High Field Magnet Laboratory - HFML (IMM)

Head:	Prof.dr. Ir J.C. Maan
Scientific staff:	Dr. J.A.A.J. Perenboom, Dr. P.C.M. Christianen, Dr. S.A.J. Wiegers, Dr. U. Zeitler, Dr. H. Engelkamp
Secretariat:	Ms H.E.M. Verhaegh-Peeters, HFML 02.15, tel. 3652087, hfmlsecr@science.ru.nl
Website:	www.hfml.ru.nl

Research

- Connection with high magnetic fields
- Interdisciplinary research

Description of research

Connection with high magnetic fields
In condensed matter physics the application of high magnetic fields is widespread. A (high) magnetic field changes the thermodynamic state of any system and a study of this change provides new and unique information. In some cases new states of matter (suppression superconductivity, quantum Hall effects, etc.) are discoverd.
In the area of the fundamental properties of matter the main emphasis is on nanostructures ranging from, those made from lithographically etched semiconductor to self-assembled supramolecular structures. Pioneering scientific discoveries are often done in the highest magnetic fields, which are available at HFML.

Interdisciplinary research
Magnetic fields also find applications in chemistry or biology related research. These applications comprise instrumental developments like high field Electron or Nuclear Magnetic Resonance (ESR and NMR) but also ordering of mesa molecular systems in high magnetic fields. Finally there are also research activities in magnet technology.

Opportunities for students

Many experiments can be done in the laboratory. Ranging from low temperature (mK) experiments, laser spectroscopy, far infrared spectroscopy, magnetostriction, magnetisation, susceptibility and transport experiments. Much research is performed in collaboration with other groups both within the university and other (European) research departments. This open and international character provides a broad orientation for the students. Research done at HFML provides an excellent training as experimental physicist, which is highly appreciated on the labor market (both in academia as in industry).

4.3 Scanning Probe Microscopy (IMM)

Head: Prof.dr. S. Speller
Secretariat: Ms H.E.J. Gommers, HG01.074, tel. 3653141, r.gommers@science.ru.nl

Research

- Nanophysics
- Nanoscopic electron physics
- Supramolecular structures
- Biomolecules
- Applied physics
- Imaging of catalytic reactions in a liquid STM

Description of research

In our research group we study the structure, excitations, and dynamics of nanoscopic/molecular materials on nanoscale.
In this regime quantum mechanical principles and surfaces and interfaces play a dominant role and may lead to surprising new results. The research is mostly done with Scanning Probe, while also new experimental methods are being developed. Close collaborations exist with the Computational and Theory groups, the Supramolecular Chemistry and the Biochemistry groups within the Institute of Molecules and Materials (IMM) of the Faculty of Science. In addition, close collaboration exists with a large number of international top laboratories and industries. The research is mostly done by PhD students and postdocs in collaboration with undergraduate students. The senior scientists supervise the various PhD and undergraduate projects and are also involved in short time pilot projects, that if succesfully, will later be integrated into the research programme.

1. *Nanophysics*
This field of research includes magnetic surfaces and interfaces and electronic and magnetic properties of low dimensional objects such as nano-wires, ultra thin films and multilayers. For this purpose new experimental methods are being developed and applied to study this exciting and challenging world.
One of the central themes is 'nanomagnetism', an area that combines fundamental challenges with a high potential of practical applications (sensors, datastorage). We use new Scanning Probe Methods that were partly pioneered in Nijmegen like Spin Polarized STM and STM in liquids. New future developments are the combination of these approaches to allow the study of matter with the highest spatial and spectroscopic resolution.
A new theme is 'magnetite' and its role in bio-navigation. Magnetite particles exist in many vertebrates and it is assumed that they are the key to the magnetic sense. In a multidisciplinary approach we study the structure and physical properties of biogenic magnetite nanoparticles and try to elucidate the mechanism in magnetotransduction. We use scanning probe microscopy, such as AFM/MFM and STM, electron microscopy, and collaborate with biologists and theorists. Our studies also include magnetite layers and ferrofluids, and also the histological environment of the magnetite.
Further subjects in nanophysics are electron transport through semiconductor nanodots studied by scanning tunneling spectroscopy, and atomic-scale signatures of magnetic transitions. An especially interesting subject is the development of scanning probe instruments for practical conditions, ie. in liquids and electrolytes. We apply these new methods to the study of liquid-solid interfaces and of reactions in organic molecules and proteins.

A 'third theme' is the development of new methods to 'create nanowires and nanodots' on surfaces using intrinsic and adsorbate induced stress on surfaces. The structure and electronic properties of these nano-materials are studied with STM and Electron spectroscopy.

2. *Nanoscopic electron physics*
   In this theme the properties of conduction electrons in extremely small geometries are studied. Examples are the conductivity of a single atom, single electron tunneling and the effect of adsorbed gasmolecules on the tunneling probability of electrons. Under these conditions (semi-) classical descriptions completely fail and only quantum mechanics will lead to a correct description.
3. *Supramolecular structures*
   In collaboration with the Organic Chemistry groups that are responsible for the synthesis of increasingly complex systems with tailor made properties, the physical properties of individual molecules and molecular aggregates are being studied with scanning probe methods. Processes such as self assembly and catalysis can be observed and triggered on nano scale.
4. *Biomolecules*
   Functional molecules are being prepared on surfaces where they are studied with Scanning Probe techniques. The goal is to measure specific interactions with protein molecules in order to gain more insight in the relation structure-properties of bio materials.
5. *Applied Physics*
   Many of the topics described above are at the interface between fundamental and applied research (a distinction that is often rather arbitrary). This is illustrated by the industrial collaboration often within European projects. These research projects are often monitored by an external advisory/user committee where researchers from industrial laboratories play an important role. This allows students to have contacts with industry and their approach to research at a quite early stage, which gives extra opportunities for students who desire a career in industry. There are also possibilities to do (part of) a research project in an industrial laboratory.
6. *Imaging of catalytic reactions in a liquid STM*
   The use of Scanning Tunneling Microscopy (STM) has opened the possibility to study chemical reactions at the single molecule level with (sub)molecular resolution. A few examples of visualization of such a reaction, which in many cases occurs under ultrahigh vacuum conditions, have already been described. Most reactions in industry or in biology, however, take place in a liquid. To be able to look at chemical reactions at a surface in this more realistic environment, we make use of a home-built liquid STM. The catalysts, which are immobilized at a solid-liquid interface, are metal-porphyrin molecules that are synthesised in the organic chemistry laboratory. This research is ideal for students who are interested to work on a cutting edge interdisciplinary research topic with great potential for understanding the way catalysts work at the single molecule level.
   Suitable profile: physical-chemical, physical
   (Collaboration with Organic Chemistry Department of Prof.dr. R.J.M. Nolte)

Opportunities for students

For students, there is ample opportunity to participate in the research of basically all the projects mentioned above. Our philosophy however is that the students should have their own, individual projects, that can but not necessarily have to be part of a larger project. Though not a necessary condition, many of these student projects lead to one or more publications in international journals. Supervision is usally done by one of the more senior group members

(PhD's, postdocs or faculty). There are also possibilities of joint projects (with other graduate or Phd students) and often the undergraduate projects may lead to a PhD project. Because of the large spectrum of projects there is ample choice for the students and if the facilities allow it, also projects of their own design belong to the possibilities.

4.4 Spectroscopy of Solids and Interfaces (IMM)

Head: Prof. Dr Th. Rasing
Scientific staff: Dr A. Kirilyuk, Dr A. Kimel
Secretariat: Ms M.L.G. van Breemen-de Wit, HG01.074, tel. 3653141, m.vanbreemen@science.ru.nl
Website: www.ru.nl/imm/ssi

Research topics

- Nanomagnetism
- (Sub)nanosized magnetic clusters
- Ultra fast carrier and spin dynamics, coherent control
- Nanophotonics
- Supramolecular structures
- Liquid crystals and polymers
- Applications

Mission: to understand the relation between properties and structure of condensed matter, in particular of nanoscopic, magnetic and molecular materials with a focus on phenomena occurring on ultra short time scales (femto seconds).In this regime quantum mechanical principles and surfaces and interfaces play a dominant role and may lead to surprising new results. For this research novel, advanced optical and scanning probe techniques are being developed and applied.

Description

Nanomagnetism
This field of research includes magnetic surfaces and interfaces and electronic and magnetic properties of low dimensional objects such as nano-wires, ultra thin films and multilayers. This exciting area combines fundamental challenges with a high potential of practical applications (sensors, datastorage). We use new Scanning Probe and Nonlinear Optical techniques that were partly pioneered in Nijmegen like Magnetization induced Second Harmonic Generation. New future developments are the combination of these approaches to allow the study of matter with the highest spatial (in-plane as well as out of plane) and temporal resolution.

(Sub)nanosized magnetic clusters
The goal is a comprehensive study of nanosized clusters of various oxides, both free and deposited on surfaces, that form the building blocks of new materials. Special attention is on the correlation between crystallographic structure, electronic states and magnetic properties. The combination of structural (infrared vibrational spectroscopy, SEM), electronic (UV ionization spectroscopy for free clusters, STM spectroscopy for clusters on a surface) and magnetic (Stern-Gerlach experiments for free clusters, magneto-optics and spin-polarized STM for the deposited ones) information will provide an unprecedented insight into the properties of these interesting strongly-correlated materials.

Ultra fast carrier and spin dynamics, coherent control
The dynamics of electrons and holes in semiconductors and metals (in the presence of electric and magnetic fields) can be studied using ultrashort femto-second (fs) laser pulses. In this way electron-electron, electron-phonon and electron-magnon interactions can be probed directly, in contrast to standard transport experiments that only probe time - averaged quantities. For example, an intriguing question is: how fast can the magnetization of a magnetic system be changed (reversed)? This is an exciting area of fundamental research with far reaching practical consequences for opto-electronics, spintronics and magnetic recording. We have pioneered novel methods to create very fast controllable magnetic field pulses (Th. Gerrits, Nature **418** (2002) and A. Kimel et al, Nature **435** 2005) and have also demonstrated the possibility to observe and exploit the ultrafast spin dynamics in anti-ferromagnetically ordered materials (A. Kimel et al, Nature **429** (2004)).
We are further exploring complete coherent optical control of spins in magnetic media that eventually could lead to purely optical switching.

Nanophotonics
The goal is to achieve the control of electronic and magnetic properties at femtosecond time scales with nanometer spatial resolution, where usual optical tools fail. Scattering-type near-field scanning-probe microscopy is being developed to achieve a resolution down to 10 nm. This, combined with femtosecond laser pulses, will allow the real-time observation of ultrafast nanometer-scale dynamics. On the other hand, plasmonic structures will be developed and used to concentrate electromagnetic optical waves in a sub-wavelength volume and achieve modification and amplification of opto-magnetic effects.

Supramolecular structures
In collaboration with the Organic Chemistry groups (Nolte, Rowan, van Hest) that are responsible for the synthesis of increasingly complex systems with tailor made properties, the physical properties of individual molecules and molecular aggregates are being studied with scanning probe and nonlinear optical techniques. This highly interdisciplinar field is a strongly growing research area with connections to biology.

Liquid crystals and polymers
These fascinating materials combine a large variety of interesting fundamental phenomena with a huge potential for application (LCD's: Liquid Crystal Displays and Biosensors). Topics of current research are light induced ordering, nano patterned surfaces, phase transitions and dynamics in very thin films. A new development is the exploration of the hierarchy of ordering in LC-cells (from the molecular nanoscale to the macroscopic scale of the LCD) for the application of LC cells as biosensors. This work is done in collaboration with Organic Chemistry (Nolte, Rowan).

Applications
Many of the topics described above are at the interface between fundamental and applied research (a distinction that is often rather arbitrary). This is illustrated by the industrial collaboration with for example Philips, Siemens, Thales, Hitachi Maxell, Seagate and others, often within European projects. Some of these applied research projects are monitored by an external advisory/user committee where researchers from industrial laboratories play an important role. This allows students to have contacts with industry and their approach to research at a quite early stage, which gives extra opportunities for students who desire a career in industry. There are also possibilities to do (part of) a research project in an industrial laboratory, both in the Netherlands and abroad.

Opportunities for students

The research is mostly done by PhD students and postdocs in collaboration with undergraduate students. The senior scientists supervise the various PhD and undergraduate projects and are also involved in short time pilot projects, that if succesfully, will later be integrated in the research programme.
For students, there is ample opportunity to participate in the research of basically all the projects mentioned above. Our philosophy however is that the students should have their own, individual projects, that can but not necessarily have to be part of a larger project. Though not a necessary condition, the past experience shows that most of these student projects lead to one or more publications in international journals. There are also possibilities of joint projects (with other graduate or Phd students) and often the undergraduate projects may lead to a PhD project. Part of the research internship can be done abroad as part of the Socrates Programme (for example Leuven, Oxford, Marseille) or within one of the many European collaborations.

4.5 Applied Materials Science (IMM)

Head: Prof.dr. E. Vlieg
Scientific staff: Dr. P.R. Hageman, Dr.ir. J.J. Schermer
Secretariat: Ms A.L.A.M. Hendriks, HG03.527, 53353, ams-secr@science.ru.nl
website: www.ru.nl/ams

Research

- Classical III-V semiconductors like GaAs, AlGaAs, GaInP, and AlGaInP (Dr.ir. J.J. Schermer)
- III-Nitrides like GaN and AlGaN (Dr. P.R. Hageman)

Description of research

The department is the centre of knowledge for crystal growth by Metal Organic Vapour Phase Epitaxy (MOVPE) in The Netherlands. The group is specialised in the deposition of crystalline materials as well as the study of their material properties by the use of microscopic techniques (SEM, TEM), X-ray diffraction and different spectroscopic techniques. The research focuses on two different groups of materials:

- Classical III-V semiconductors like GaAs, AlGaAs, GaInP, and AlGaInP
- III-Nitrides like GaN and AlGaN.

The study of the properties of these materials forms the fundament for application-oriented research on solar cells and substrates for large bandgap materials for which advanced processing techniques (photolithography, sputtering, reactive ion etching, etc.) are utilised at the department.
The research activities aim to increase the efficiency of III-V solar cells by the development of a monolithic InGaP/GaAs tandem cell, which utilises the solar spectrum much better than a single junction solar cell. Parallel to the research on efficiency increase, studies are performed to reduce the amount of material (thus costs) presently used by the production of high-efficiency III-V solar cells. Secondly, we try to develop GaN substrates which are currently not commercially available. The use of GaN substrates is expected to boost the efficiency of blue lasers and GaN based electronics considerably. Not only the deposition of thick GaN layers but also the development and modelling of suitable reactors is studied.
The application-oriented research is performed in close comparison with a number of industries and organisations as well as other universities in and outside of The Netherlands.

Opportunities for students
Suitable for Physical, Chemical and Physical-Chemical students.

Cooperation: with Applied Molecular Physics (Prof.dr. J.J. ter Meulen), Solid State Chemistry (Prof.dr. E. Vlieg), Spectroscopy of Solids and Interfaces (Prof.dr. T.H.M. Rasing), Scanning Probe Microscopy (Prof.dr. S.E. Speller), and Condensed Matter Science/High Field Magnet Laboratory (Prof.dr. J.C. Maan).

4.6 Molecular and Biophysics (IMM)

Professor: Prof.dr. W.J. van der Zande
Scientific staff: Prof.dr. W.L. Meerts, Prof.dr. M.J.J. Vrakking (FOM-Institute AMOLF)
Secretariat: Ms E. Gouwens, HG 01.712, 53010, e.gouwens-vanoss@science.ru.nl
Website: www.ru.nl/molphys

Research
- Biomolecular structure and function.
- Molecular detection and recognition.
- Electrons and molecules.
- Instrumental developments

Description
Biomolecular structure and function
Structure and functionality of biological molecules are strongly related. Biophysical processes take place at a well defined temperature. These molecules often change in structure during their reactions; hence stiffness and flexibility have to be accurately tuned. Laser spectroscopy and in particular high resolution laser spectroscopy is the most accurate tool to determine the structure of the molecules. Also the flexibility of these molecules is encoded in their spectra as a consequence of the rules of nature imposed by quantum mechanics. We use high resolution laser techniques to find very precise answers on the structure and flexibility of small size biomolecules with the long term aim to explore the limits of these techniques in the direction of 'real' biomolecules. Experiments are performed in close collaboration and in an exchange program with the Heinrich Heine University in Düsseldorf and in collaboration with the theoretical chemistry program at this university.

Molecular detection and recognition
Small molecules such as atmospheric species are easily recognized by their spectral structures. However, also these molecules have spectral features that are extremely weak, while at the same time these properties are highly relevant to atmospheric problems as a consequence of the enormous amounts of these molecules in our atmosphere. Using cavity ring down spectroscopy, absorption characteristics of small molecules are quantified in order to understand the effects of collisions and improve the use of these data. In the mid-infrared and far-infrared, large molecules reveal not only structure but also their internal flexibility. The study and generation of these spectra is a growing field in the group.

Electrons and molecules
In our upper atmosphere, molecules are often present as ions. The reaction of these ions with electrons is experimentally studied in a large scale storage ring experiment in Stockholm in collaboration with the University of Stockholm while we develop instrumentation and determine the properties of these reactions that are directly related to airglow and auroral phenomena in our upper atmosphere.

Instrumental developments
The group MBf is respossible for the design ansd constructor of a FIR or THz radiator source based on a free electrolaser. A large and ambitious project.

Opportunities for students
The world around us contains molecules in all shapes, forms and size. Molecular processes dominate daily life. The understanding of molecular behavior, the detection and recognition of molecular behavior and in particular the interaction between the molecular world and electromagnetic radiation is central in the research themes of this group.
Therefore all students are welcome to perform or to join the scientific program in the department in all phases of their university program.

4.7 Molecular and Laser Physics (IMM)

Head: Prof.dr. D.H. Parker
Scientific staff: Dr. F.J.M. Harren
Secretariat: Ms M. Speijers, HG01.719, tel. 52025, m.speijers@science.ru.nl
Website: www.science.ru.nl/mollaserphys

Research
- Molecular dynamics of atmospherically relevant processes
- Development of new lasers and molecular beam techniques
- Trace Gas Research

Description
Molecular dynamics of atmospherically relevant processes
Many processes are possible during a collision between a molecule and another molecule, electron or photon. Most simply, elastic scattering can take place, where the molecular internal energy remains the same but the velocity changes. Inelastic scattering is more interesting - here the rotational and vibrational energy changes, which can lead to non-equilibrium population distributions and even laser or maser action. Chemical reaction, the most complicated and important collision process, can also occur, often via a short-lived transition state complex. The same sort of transition state complex is directly prepared and probed in photodissociation studies of so-called 'half-collision' reactions.

In recent years quantum mechanical theory has been able to quantitatively describe a few of the simplest reactive and inelastic scattering processes. For the more complicated 'real-world' scattering systems laboratory work is essential. Experimental research on molecular scattering dynamics has blossomed worldwide in the last years due to new powerful laser- and molecular beam-based techniques, especially the velocity map imaging technique developed here in our group in Nijmegen.

A general theme of our research centers on the dynamics of molecular processes relevant to atmospheric processes. The central molecule in this theme is molecular oxygen. We continue to deepen our understanding of the surprisingly complex molecule and, most recently, of Van der Waals clusters containing molecular oxygen. Another related species of interest is the hydroxyl radical. We have an active and synergetic collaboration with the Theoretical Chemistry Institute in Nijmegen in all of these studies.

In our current research on molecular scattering we use velocity map imaging and also the laser induced fluorescence technique in studies of photodissociation, inelastic scattering and most recently, reactive scattering. We are studying, for example, inelastic collisions between the OH and CO molecules, which is a key process in atmospheric chemistry and in combustion. Molecular beams of the reactants are formed and cross each other in a small region that is probed using laser induced fluorescence. With laser spectroscopy the precise quantum state distributions of both species can be obtained before and after collision. The results obtained are used to improve the theoretical potential energy surfaces describing the collision complex. In another related project the photodissociation dynamics of OH are studied using velocity map imaging. In this technique a laser is used to selectively photoionize the O and H atom dissociation products without changing the energy obtained from the initial photodissociation step. Carefully designed ion optics guides the ions onto a two-dimensional detector in a way that uniquely 'maps' the nascent product velocity. The full three-dimensional product velocity distribution can then be calculated from the experimental two-dimensional ion image. Up to now no such measurements have been possible for OH, despite it being the most important free radical in atmospheric chemistry. In collaboration with Prof. Ubachs of the Free University of Amsterdam we plan to chart out OH dissociation pathways for the ultraviolet to extreme ultraviolet (300-100 nm) spectrum.

Development of new lasers and molecular beam techniques
Progress in both fundamental and applied experimental research relies on increasingly better diagnostic techniques. Technique development is thus an important research line on its own in the group.
As an example, two-dimensional velocity map imaging of ions and electrons has been improved over the last years and applied to the study of bimolecular collisions and photodissociation, surface scattering and chemical reactions.

An important drawback of present lasers systems in the infrared wavelength region is their lack of laser power and ability to generate every laser frequency in the infrared. The use of novel non-linear materials and the technique of parametric oscillation offer the possibility to avoid this and to generate continuous-wave, continuous tunable, narrowband radioation with high output powers at wavelengths between 2.5 and 10 micrometers.
Another state-of-the-art method under development includes proton transfer mass spectrometry with ion cyclotron trapping for signal enhanchement.

Trace Gas Research
The reliable sensing of minute quantities of trace gases in complicated gas mixtures is an innovative, highly important and most exciting task in practically all technical and life sciences. The Trace Gas Research Group is focused on the development and application of trace gas detection methods with lasers and mass spectrometers. For this we use laser spectroscopical methods such as photoacoustic spectroscopy, frequency modulation spectroscopy and cavity ring down spectroscopy, while within mass spectrometry proton transfer reactions are used to

gain high sensitivity for volatile organic compounds. The focus is, thereby, on state-of-the-art detection of substances at sub-part per billion (volume) concentrations, on-line, non-invasive, with high selectivity and detection speed. See also www.ru.nl/tracegasfacility
Next to the research group we operate a Life Science Trace Gas Facility, in which scientists from Biological, Chemical and Medical fields are supported to perform trace gas research for which 'conventional' equipment lacks adequate sensitivity. The facility operates unique state-of-the-art trace gas detectors that allow real time measurements at unprecedented detection levels. Research areas are covered ranging from plant-pathogen interaction to the effect of smoking on the lungs and the study of the effect of tuberculosis.

Opportunities for students

There are opportunities for students in fundamental molecular reaction dynamics, the development of new instrumental techniques with lasers and molecular beams or the trace gas research with applications in medical sciences. Much of the research is in cooperation with our research groups in Europe and the USA, at University level or with industry.

4.8 Applied Molecular Physics (IMM)

Head: Prof.dr. J.J. ter Meulen
Associate: Prof. dr. W. van de Water (TU/e)
Scientific staff: Dr. N. Dam
Secretariat: Ms E.A.M.L. Meijer, HG01.721, tel. 3652339, ine.meijer@science.ru.nl
website: www.ru.nl/appliedmolecularphysics/

Research

- Molecular collisions
- Deposition of ultra hard diamond films
- A black box: what happens inside a diesel engine?
- Molecules in flames
- Writing in air and the mystery of turbulence

The Applied Molecular Physics group focuses on the development and application of sensitive laser diagnostics for fundamental and applied research with the aim to study physical and chemical processes involving molecular dynamics. In addition, the group is involved in solid state research. There are several research projects where students can take part for their masters thesis work.

Description of research

Molecular collisions
In the European network "Molecular Universe" we investigate collisions of interstellar molecules by the use of laser techniques. Collaboration with Molecular and Laser Physics - IMM (Prof.dr. D. Parker).

Deposition of ultra hard diamond films
Investigation of the deposition of diamond with direct applications as ultra hard or heat conducting layers. Collaboration with Applied Materials Science - IMM (Dr. J. Schermer) and Solid State Chemistry - IMM (Dr. W. van Enckevort).

A black box: what happens inside a diesel engine?
Study of the formation of (nano)particles and nitric oxide inside a transparent diesel engine. Collaboration with TU/e and DAF

Molecules in flames
Nitric oxide influences the formation of ozone and causes smog and acid rain. Can we reduce its formation by adding hydrogen? Collaboration with Prof.dr.L. de Goeij (TU/e).

Writing in air and the mystery of turbulence
Investigation of turbulent gas flows by the use of laser detection techniques. Collaboration with Prof.dr. W. van de Water (TU/e).

Opportunities for students
Suitable for Physics, Chemistry and Natural Science students.

4.9 Electronic Structure of Materials (IMM)

Head: Prof.dr R.A. de Groot
Scientific staff: Dr. G. de Wijs
Secretariat: Ms J.P.M. Föllings, HG03.064, tel. 52981, a.follings@science.ru.nl
Website www.ru.nl/esm

Research
- Magnetism of transition metals, their compounds and multilayers
- Half-metallic materials and spin-electronics
- Materials for hydrogen storage
- Electronic, optic and mechanical properties of polymers and refractory superalloys
- Photovoltaics

Description
The main goal is to understand and design the physical properties of various new materials, including artificial nanostructures, from ab initio calculations.
Modern quantum-mechanical computations within Density Functional Theory (DFT) and extensions like GW and Bethe-Salpeter schemes allow to investigate the electronic, magnetic, optical and mechanical properties of interesting materials.
Although the work is theoretical in nature, and mainly involves large scale computer work, we aim for a close collaboration with experimental groups.

Opportunities for students
Several oppertunities exist for students to participate in the ongoing research of the group. A master student works on an identifiable subject. Subjects range from "theoretical" to quite applied. Usually his/her work results into a publication in an international journal. For qualified students industrial apprenticeships are possible.

4.10 Theory of Condensed Matter (IMM)

Head: Prof.dr M.I. Katsnelson
Scientific staff: Prof.dr A. Fasolino
Secretariat: Ms J.P.M. Föllings, HG03.064, tel. 52981, a.follings@science.ru.nl
Website: www.ru.nl/tcm

Research
- physical properties of solids
- physical properties of liquids
- essentially many-body character

Description of research
The aim of condensed matter theory is an explanation of physical properties of solids and liquids on the base of fundamental physical principles. A broad class of phenomena, from strength, plasticity, friction, to magnetism, superconductivity, and superfluidity, can be explained in terms of laws of quantum mechanics. However, in practice it is an extremelly difficult problem, first of all, due to its essentially many-body character. The Theoretical Solid State Physics group deals with this problem on different levels, such as model considerations of basic many-body effects for quantum and classical systems, realistic simulations of physical properties of specific materials, and phenomenological description of complicated phenomena such as equilibrium and nonequilibrium phase transitions.

Opportunities for students
The department of Theory of Condensed Matter offers several theoretical and/or computational research projects at the Bachelor and Master level. Students are advised to contact the head and members of the department to choose a project of mutual interest at the right level. Master projects are in general related to one topic of current interest of the group and aim at reaching some original scientific result.

4.11 Biophysics (IfN)

Head: Prof.dr. C.C.A.M. Gielen
Scientific staff: Prof.dr. H.J. Kappen, Prof.dr. A.J. van Opstal, Dr. J.A.M. van Gisbergen, Dr. H.H.L.M. Goossens (UMC), Dr. T.F. Oostendorp (UMC)
Secretariat: Ms M. van Pelt, Ms J. Fontaine, GG 21.16.0.20, tel. 3614244, mbfys@science.ru.nl
website: www.ru.nl/mbphysics

The Biophysics group is funded both by the Faculty of Science and the University Medical Centre and collaborates with the Dept. of Biophysics of the University Medical Centre.

Research
- Brain and behaviour
- Machine learning and artificial intelligence

Description of research

Brain and behaviour

The research focuses on the neuronal information processing by the central nervous system, in particular on the sensory coding of visual, auditory and vestibular information and on sensori-motor transformations which map the sensory information into motor commands (eye, head, and arm movements) for appropriate action. The studies include an experimental and a theoretical approach. With regard to experiments the group collaborates with researchers in the F.C. Donders Center (www.ru.nl/fcdonders/), which houses advanced equipment for measuring and imaging of neuronal activity, and with research groups in the University Medical Center St. Radboud.

The topic of neuronal information processing is addressed from different perspectives:

- Experimental research based on system-theoretical approach. By presenting various complex stimuli and by measuring responses to those stimuli, we aim to elucidate and to characterize the functional properties and hierarchical structure of processes involved in perception and action.
- Electrophysiological studies recording neuronal activity in primates and humans.
- Characterization of source location of brain structures that contribute to neuronal activing using the bioelectricity of brain (electro-encephalography, EEG and magneto-encepha-lography MEG) in collaboration with the department of Neurology and the F.C. Donders Center.
- Theoretical research modelling biological neurons and the information storage and retrieval by networks of neurons.

The theoretical research focuses on insight in information processing in neurobiological systems as well as on applications of knowledge using artificial neural networks. In the former, we develop models for complex biological neurons and investigate learning and communication between neurons, as well as the dynamics of self-organization and information storage by networks of neurons.

Machine learning and artificial intelligence

One day, we will have computers that can think and learn like humans. But this will be far in the future. Nevertheless, artificial intelligence research is producing useful methods that provide solutions in many branches of industry. At the department of Biophysics, there is an group of physicists that develop novel machine learning methods and that apply these methods to AI applications. In particular, methods that have a close resemblance to methods from statistical physics, such as mean field and Bethe approximations and Monte Carlo sampling, are developed by the group and are among the best methods world-wide. Applications are in the areas of medical expert systems, genetics, multi-agent control problems, and time-series forecasting. Soms of these applications are commercialized through spin-off companies or with industrial partners. Students that are interested to write their Master's thesis in this research direction are adviced to follow courses in statistical physics and the courses Introduction to Pattern Recognition, Machine Learning, and Computational Physics. See www.snn.ru.nl/nijmegen for more information.

Opportunities for students

The department of Biophysics offers several experimental and theoretical research projects for a Bachelor or Master project. Students are advised to contact the head of the Biophysics department or one of the members of the scientific staff for more details.

4.12 Supra Molecular Chemistry (IMM)

Head: Prof.dr. R.J.M. Nolte
Scientific staff: Dr. J.J..M. Cornelissen, Dr. M.C. Feiters, Prof.dr. E.W. Meijer
Secretariat: Ms D.D. van der Wey, HG03.028, 52676, d.vanderwey@science.ru.nl
website: www.molchem.science.ru.nl

Research

- Biohybrid amphiphiles
- Processive catalysts
- Molecular electronics
- Biomimetic chemistry

Description of research

Since the first synthesis of an organic molecule (urea) by Woehler in 1827 the size and complexity of molecular structures have increased steadily. Organic molecules and macro-molecules (polymers) are traditionally made by covalent synthesis. Since the introduction of Supramolecular Chemistry by Pedersen, Cram and Lehn (1970's) new routes have become available for the design and construction of large molecular structures, nowadays even reaching the nanometer range (1-500 nm). These large molecules are prepared by different techniques, an important one being self-assembly. Self-assembly, sometimes described as 'molecular programming', is a two-step process: the first step involves the synthesis of building blocks, which have specifically designed shapes and properties. In a second step these building blocks are (self)-assembled by using non-covalent interactions, e.g. hydrogen bonding, pi-pi stacking, electrostatic interactions, metal-ligand coordination bonds and van der Waals interactions. The outcomes of this process are amazing, complex architectures, which are reminiscent of the majestic structures found in Nature. They are studied in house with different techniques, including NMR, electron microscopy, atomic force microscopy, and scanning tunneling microscopy. The challenge is to optimize the design process in such a way that functional structures, e.g. having special materials properties or specific catalytic properties, are obtained.

Projects that are currently in progress include:

- *Biohybrid amphiphiles*. Amphiphiles are molecules that possess both a hydrophilic and a hydrophobic part. Well-known examples are the phospholipids molecules, which are components of cell membranes. In this project so-called super-amphiphiles and giant amphiphiles are synthesized. These molecules are composed of a hydrophobic polymer (polystyrene) and a hydrophilic polypeptide or a protein (enzyme). When dispersed in water a self-assembly process takes place leading to nanostructures, e.g. fibers, complex helical structures and spheres. The latter structures can encapsulate enzymes and are used as nano-reaction vessels (artificial cells).
- *Processive catalysts*. DNA polymerases are complex enzyme systems that are used by Nature to make copies of DNA. Many of these 'processive' enzymes have a toroidal shape and completely enclose the biopolymer while moving along its chain. The overall architecture of these systems resembles that of rotaxanes, in which a long molecule is threaded through a macromolecule. We have taken this example from Nature as a source of inspiration to design synthetic catalytic systems that can bind to polymer chains and make changes in this chain (e.g. addition of oxygen atoms) while moving along it (artificial motors)

- *Molecular electronics.* Electronic devices are becoming increasingly smaller and chip structures are approaching the limits of what is possible by top-down lithographic techniques. A new strategy is to design and construct electronic components by bottom-up self-assembly techniques. In this project molecules (e.g. special types of phthalocyanine and porphyrin dyes), that spontaneously self-assemble to form micrometer-long cables and ring-like structures, are designed and synthesized. They are studied with respect to their energy and electron conducting properties by different physical techniques (in collaboration with the Department of Physics and the HFML institute in Nijmegen).
- *Biomimetic chemistry*. Cationic lipids are developed for condensation with DNA and applied in gene therapy, an approach to replace or add a functional copy of a defective gene to a cell in a diseased organism. Cyclodextrins, water-soluble cavity-containing molecules, are functionalized for the development of unidirectional molecular wires, to be applied in a synthetic self-assembled system for photocatalysed hydrogen evolution.

Opportunities for students
Suitable for Chemistry and Natural Science students.

Mandatory course: Organic chemistry 1
Recommended courses: Organic chemistry 2, Metal organic chemistry, Synthetic practical courses

4.13 Bio-Organic Chemistry (IMM)

Head: Prof.dr.ir. J.C.M. van Hest
Scientific Staff: Dr. D.W.P.M. Löwik
Secretariat: Ms J. Versteeg, HG03.028, tel. 3653389, j.versteeg@science.ru.nl
website: www.molchem.science.ru.nl

Research
Within the bio-organic chemistry group four lines of research are carried out: hybrid polymers and polymersomes, micro-reactors, peptides and amphiphiles, and protein-based materials.

Description of research
Research within the bio-organic chemistry group is positioned at the interface of three disciplines: organic chemistry, polymer chemistry and molecular biology. Inspired by concepts found in Nature, we develop biomimetic materials and processes by application of advanced synthetic techniques.
Within our group we use different methods to prepare smart polymers. We combine polymer chemistry with organic and peptide chemistry to connect biomolecules to synthetic polymers. These hybrid polymers are applied as antimicrobial coatings and are assembled into capsules, which find their application in the biomedical field.
Micro-reactors are synthetic devices which are much smaller than regular reaction vessels, such as round bottom flasks. The big advantages of micro-reactors are that reactions are much better controlled in a miniaturized environment, due to improved heat and mass transfer. Furthermore, only small amounts of reagents and catalysts are needed if you want to screen reaction conditions. Micro-reactors are becoming more and more important in the chemistry labs and therefore it is very interesting to get acquainted with this new type of technology.

Another area of research is peptide amphiphiles. By changing the hydrophobic-hydrophilic balance of a peptide its ability to fold and assemble will change drastically. This is then used to control both its functionality and/or structure. Via this approach we can make peptide fibres that can be perfectly aligned in magnetic fields. Switchable peptides can be used for targeted drug delivery. Also peptides are combined with polymers which provide us with new designer materials with adjustable properties.
Proteins are functional biomolecules which are designed by nature to perform specifically dedicated tasks. Within our group we want to extend the natural function of proteins by introducing additional functionality. By combining molecular biology (protein engineering) tools with organic chemistry methods, we develop smart self assembling enzymes and virus capsids as novel nano-containers. More information on: www.ru.nl/bio-orgchem.

Opportunities for students

The student projects are interesting for every student who wants to be active at the interface of chemistry and biology. The work varies from synthesizing compounds, (physical) characterization studies, to both molecular and chemical biology type of experiments. Hence the research is suitable for Chemistry, Molecular Life Science and Natural Science students. Find more information on: www.ru.nl/bio-orgchem/education/student_projects.

Mandatory course: Organic chemistry 1
Recommended course: Synthetic practical courses, Organic chemistry 2 and Metal-organic chemistry

4.14 Synthetic Organic Chemistry (IMM)

Head:	Prof.dr. F.P.J.T. Rutjes
Scientific staff:	Dr. F.L. van Delft
Secretariat:	Ms M. Versteeg, HG03.028, tel. 3653389, j.versteeg@science.ru.nl
website:	www.molchem.science.ru.nl/rutjes

Research

Main focus of the research is the synthesis of existing or newly designed molecules with specific desired (biological) properties by application of modern organic synthesis techniques or, if required, by development of novel methodology. Molecules of interest are usually applied in multidisciplinary research projects such as:

- RNA-targeting based on naturally occurring aminoglycosides
- Development of new drugs against rheumatoid arthritis (with NCMLS, Prof. Pruijn), LUMC (Dr. Drijfhout), Chiralix and ModiQuest.
- Synthesis and biological evaluation of carbohydrate building blocks as 'chain stoppers' in anticancer therapy (with NCMLS, Dr. van Kuppevelt)
- Synthesis and evaluation of pan-cholecystokinin (CCK) receptor binding ligands for radionuclide targeting of CCK-receptor positive tumors (with UMC St Radboud, Prof. Boerman, Dr. Laverman)
- Development of bioorthogonal ligation methods (with Dr. Cornelissen)
- Design and synthesis of germination stimulants (with Prof. Zwanenburg and Prof. Bouwmeester (WUR))

Description of research

The research focuses on the synthesis of enantiopure, multi-functionalized heterocyclic molecules, predominantly amino acid-based structures and carbohydrate derivatives. Emphasis lies on the development of new 'chemical tools', with particular focus on catalytic methods under sustainable and mild reaction conditions. This includes the following areas:

- Biocatalysis: use of enzymes as mild and environmentally benign catalysts for modification of organic molecules. Besides application of hydrolytic enzymes (lipases, amidases, nitrilases, sulfatases), enzymes that are capable of forming synthetically useful carbon-carbon bonds are investigated, such as hydroxynitrile lyases and aldolases. Synthetic challenges lie especially in the generation of enantiomerically pure compounds from racemic or non-chiral molecules. Furthermore, collaborations with molecular biology groups result in modified enzymes which are obtained via genetic engineering.
- Transition metal catalysis: transition metal-based catalyst systems (involving Pd, Ru, Cu, W, Ti) are applied in the functionalization and/or cyclization of highly functionalized molecules. For example, ring-closing metathesis is studied as a viable method for the synthesis of fluorinated building blocks, unnatural sugars, or conformationally constrained peptides. Pd-mediated processes are used for the synthesis of unnatural amino acids, and Cu-mediated reactions are explored to prepare triazole building blocks.
- Organocatalysis: in addition to bio- and metal-catalysts, also chiral amines (e.g. proline) can act as a catalyst to create enantiopure compounds. These types of reactions are being explored in a stereocontrolled approach to synthesize all possible stereoisomers of 1,3-aminoalcohols and diamines.

Technology development:

- Parallel synthesis: within our group, a fully automized synthesis robot and a semi-automated, modular parallel synthesis facility (in collaboration with the company Chiralix) are available for combinatorial synthesis development
- Synthesis in microreactors: in collaboration with the Bio-organic chemistry group, a microreactor platform has been established that can be used for reaction screening and optimization
- High pressure-mediated synthesis: dedicated high pressure equipment has been developed that can be used for exploring new reactions in a parallel fashion at a pressure of 15.000 bar

Opportunities for students

Any of these topics, as well as additional projects, are open to Master students in Chemistry, Molecular Life Science or Natural Science. For additional information contact the secretariat or visit our website.

mandatory course: Organic chemistry 1
recommended courses: Synthetic practical courses, Organic chemistry 2 and Metal-organic chemistry

4.15 Biophysical Chemistry (IMM)

Head: Prof.dr. S.S. Wijmenga
Scientific staff: Dr. H.A. Heus, Dr. M. Tessari
Secretariat: Ms M. de With, HG03.344, tel. 3652678, m.dewith@science.ru.nl
website: www.ru.nl/physchem

Research

- Structural and functional biology of regulatory RNA (e.g. riboswitches, HIV, HIV, poliovirus) by NMR, AFM and other biophysical methods
- Structural and functional biology by NMR of lipid-binding proteins (e.g. ApoA, C,E) and mis-folding proteins like Alzheimer peptide
- Metabolite and protein screening of body fluids and identification of liver metabolized medicines
- Developing of methods for improved structure determination of nucleic acids, proteins and metabolites

At the laboratory of biophysical chemistry NMR and other biophysical techniques are employed to study the structure and function of biomolecules, in particular RNA and proteins. In addition, the NMR methodology is further developed. NMR is ideally suited for functional studies, because it is the only method that can provide information at atomic detail on the three-dimensional structure, dynamics, and the interaction of biomolecules in solution under physiological conditions. It can also be used to identify and characterize small biomolecules in complex mixtures.

The main objective is to learn about biomolecular research, what it is and how it is done and at the same time learn the methods and techniques used in the field of Biophysical Chemistry. This is achieved by actively participating in one of the research projects at the department. Depending on your interest your own project can be more biologically oriented (e.g. expression and characterization of proteins or RNAs) or biophysically oriented (e.g. structural NMR) or even focused on methodology development (e.g. NMR methodology or developing computational methods for faster structure determination etc). Your research is usually under direct supervision of one of the PhD students or post-docs with regular discussion of progress to one of the principal investigators, who is ultimately responsible for the project. As a member of the department you are expected to participate in all its activities, which includes drinking coffee or 'tea' and joining work meetings. There is an open collaborative atmosphere in the group so that anyone can be approached for help and there are technicians who can help with lab work or with the NMR.

More information can be found at our website: www.ru.nl/physchem

Opportunities for students

It is our objective that students with a Chemical or Physics background as well as students with a Molecular Life Science background can successfully complete an internship at the laboratory of Biophysical Chemistry. A separate defined Molecular Life Science track has therefore been set up. Also students with a Biology background are welcome, but may require some extra training in chemical and physical subjects.

mandatory course*:* magnetic resonance I *or* structure biomolecules
recommended courses*:* structure biomolecules *or* magnetic resonance I, *and/or* structure, function and biomolecules

4.16 Solid-State NMR (IMM)

Head: Prof.dr. A.P.M. Kentgens
Scientific staff: Dr. P.J. van Bentum, Dr. E.R.H. van Eck
Secretariat: Ms M. de With, HG03.344, tel. 3652678, m.dewith@science.ru.nl
website: www.ru.nl/physchem

Research
Solid-state nuclear magnetic resonance

Description of research
Research goals: The overall aim of our group is to develop new solid-state NMR methods to study structure and dynamics of both crystalline and non-crystalline materials and to apply these methods in various materials science studies. We are active in a variety of fields studying functional materials e.g. in relation to energy conversion and storage, furthermore we investigate the structure of bio(mimetic) materials as developed within the Institute for Molecules and Materials (IMM). We use state of the art solid-state NMR equipment and techniques. A challenging goal is to enhance the sensitivity and resolution of our experiments while at the same time exploiting the information content contained in the anisotropic interactions encountered in the solid-state .

Opportunities for students
Within the research group there are always opportunities for students to participate in one of the research projects discussed above. The research has a strong multidisciplinary character; physical tools are used to study chemically or biologically relevant materials and processes. The work involves experiments, computer simulations and theory. Depending on the students' background it is possible to give more emphasis to either experiment or theory. Furthermore, one can decide to focus more on the chemical or physical aspects of the research.
Students are treated as full members of the research group and are expected to carry out their assigned research task with an important individual contribution. Personal initiative and creativity are therefore highly valued. Depending on the project the work is carried out under the direct supervision of a Ph.D. student, post.doc. or docent. There is an open atmosphere in the group where everyone is available to give support

Mandatory course: Magnetic resonance I
Recommended course: Atom and molecular spectroscopy, Molecular quantummechanics

4.17 Solid State Chemistry (IMM)

Head: Prof.dr. E. Vlieg
Scientific staff: Dr. W.J.P. van Enckevort, dr. H.L.M. Meekes
Secretariat: Ms E. Salem, HG03.629, tel. 3653323, e.salem@science.ru.nl
website: www.vsc.science.ru.nl

Research
The central research theme is crystal growth. Our goal is to obtain a fundamental understanding of the processes that occur during growth (or etching) of crystals and to apply this under-

standing to the prediction and control of crystal morphology and perfection. We use a wide range of topics (from academic to industrially relevant), materials (from diamond to steroids) and use a strong interaction between theoretical, computational and experimental methods.

Description of research

The specific research topics vary from year to year; detailed examples can be found in the publication list on our website and include chiral separation, III-V nanowires, etching of silicon and the structure and growth of pigments. Some typical current activities are:

Modelling of crystal growth: In order to understand crystal growth it is important to make simplified models that allow a detailed analysis of the elementary growth processes. At the same time, we have developed software that allows the simulation of crystal growth of realistic crystals, in which the full complexity of bonding topology can be included. Computer simulations are used extensively in this research topic.

In situ observations: The most powerful means to test growth models is to perform in situ observations. We use advanced optical microscopy and atomic-force microscopy in order to observe the growth of crystals from the mm length scale down to the molecular scale.

Templates: Templates (both inorganic and organic) offer the possibility to control the nucleation and growth of crystals by providing an ordering field with a specific periodicity and with specific interactions. In collaboration with organic chemistry, we use self-assembled supramolecular templates for the growth of (2D) protein crystals.

Proteins: Protein crystallography is the standard method to derive the structure of proteins, but its main bottle-neck is the requirement of high-quality protein crystals. Several space-based research projects aim to grow better protein crystals under microgravity conditions where convection is absent. We have developed two earth-based methods that allow also growth without convection, but that are cheaper and far more convenient. One is based on high magnetic fields (in collaboration with the HFML) and one is based on a special growth geometry.

X-ray diffraction of interfaces: Using the intense X-ray beams from the synchrotron radiation facility ESRF in Grenoble, France, we apply X-ray diffraction to determine the atomic-scale structure of the growth interface. In the case of solution growth, the ordering of the interfacial liquid is of specific interest.

Opportunities for students

The possibilities for practical work for undergraduate students follows the research topics of the group and covers theory, computer simulations, experimental work or a combination of these. In many cases the results lead to a publication in the scientific literature. A specific research topic is selected based on the interest of the undergraduate student and can vary from fundamental to applied. The research theme or the group is in the realm of physical chemistry, and thus the topics are most suitable for students in Chemistry, Natural Science and Physics. The course "inleiding in de kristalgroei" is mandatory, while the courses "practicum condensed matter", "advanced crystallography" and "materials science" are recommended.

4.18 Molecular Materials (IMM)

Head: Prof.dr. A.E. Rowan
Scientific Staff: Dr. R. de Gelder , Dr. J.T.V. Hoogboom, Dr. P. Kouwer
Secretariat: Ms P. Willems, HG03.012, tel. 3653421, Paula.Willems@science.ru.nl
website: www.molchem.science.ru.nl

Research

- synergetic materials
- organo and bioelectronics
- magnetic materials
- chemical crystallography

Description of research

The Molecular Materials group focuses on the construction of a variety of functional systems for application in the fields of:

- catalysis (organic and inorganic)
- molecular electronics (bio & organic)
- liquid crystals
- optoelectronic, conductive and magnetic materials.

The aim of the group is the design and synthesis of novel polymers, self-organizing molecules and ordered crystals and the subsequent investigation of their properties. The relationship between the molecular structure and architecture at the nanometer level and the material properties are studied. The group is divided into four overlapping themes.

Synergetic materials:
Synergetic materials are materials in which the properties are more than the sum of the individual components. For example, a reaction on one side of the molecule directly influences the reactivity on the other side.
Research in this area is divided into three areas:

- allosteric materials (can we transfer information between molecules?)
- molecular machines (can we mimic cascade enzymes or DNA polymerase?)
- single molecule studies (how does an enzyme work?)

Organo and Bioelectronics:
Organic: The development of conducting polymers, light emitting systems and energy transfer materials are all fundamental requirements for the construction of working photovoltaics, OLEDs, OFETs and molecular wires. The arrangement of the building blocks in such polymers and materials has been found to be one of the governing factors of the resulting properties of the material. In order to correctly order and position these units a variety of approaches is being investigated.
Bio: A biofuel cell uses biocatalysts (like enzymes or bacteria) for the conversion of chemical energy to electrical energy. In this project we are trying to further explore this concept by confining redox enzymes inside conductive polymer spheres called vesicles. Because the enzymes are inside conductive vesicles, they should be able to transport their generated electrons across the vesicle membrane, thereby creating a current. These functional vesicles might then be applied in a nano biofuel cell.
The materials above will also be investigated for functionality in sensor devices.

Magnetic materials:
The challenge is to use light for switching between either a paramagnetic (on) and a diamagnetic (off) state, or coupled spin states to give a prototype spintronics device. The department is developing a new type of molecular switch based on two coupled redox systems.

Chemical Crystallography:
Knowledge of the three-dimensional structure of molecules and materials is of crucial importance in many fields of chemistry and physics. The accurate determination and detailed atomistic understanding of the interactions that play a leading role in the formation of molecular assemblies is an essential step in the process of design and synthesis of new (supra)molecular compounds and materials. The chemical crystallographic research is focused on the determination of molecular structures and ordering in the solid state by X-ray diffraction methods and on the development of methods which translate structural information into new directions for design and synthesis of new compounds and materials.

Opportunities for students
The department is highly interdisciplinary in research. Cooperation with groups in Nijmegen and abroad entail a wide choice in research subjects for undergraduate students, from all subdivisions. We will tailor the internship to suit the needs of the student and will draft a specific educational plan for each individual. A whole host of techniques, ranging from chemical synthesis to single molecule experiments, scanning probe microscopy, electron microscopy etc. is employed in the research into new materials. Students interested in one of the projects should contact the secretary in advance.

mandatory course: Organic chemistry 1 or Metal-organic chemistry
recommended course: Synthetic practical courses, SRM4 and Organic chemistry 1

4.19 Biomolecular Chemistry (IMM - NCMLS)

Head:	Prof.dr. G.J.M. Pruijn
Scientific staff:	Dr. W.C. Boelens, Prof.dr. N.H. Lubsen, Dr. J.M.H. Raats
Secretariat:	Ms E. van Genne, NCMLS 2.95, tel. 3614254, e.vangenne@ncmls.ru.nl
website:	www.biomolecularchemistry.nl

Research
- Molecular aspects of autoimmunity: autoantigens and autoantibodies
- Cellular stress response: small stress proteins

Description of research
Characterisation and function of autoantigens (Pruijn/Raats)
Patients who suffer from a connective tissue disease, such as rheumatoid arthritis, often show the phenomenon of autoimmunity. These patients produce antibodies to self-proteins, which are referred to as autoantigens. In general, such autoantigens are macromolecules which have important cellular functions. We primarily study the structure and function of autoantigens involved in the synthesis and degradation of RNA and proteins. Next to that we are interested in posttranslational modifications of proteins (phosphorylation, citrullination), because we believe that these play an important role in the initiation of autoimmunity. In this respect, we are also studying the mechanisms that lead to the breaking of immunological tolerance to self-proteins in autoimmune patients. Finally, we apply the knowledge obtained on the structure of autoantigenic molecules for the development of autoimmune diagnostics.

Small stress proteins: structure, function and pathology (Boelens/Lubsen)
The cell protects itself against stress, like heat, radicals or radiation, by synthesizing a set of special proteins, amongst which the 'small heat-shock proteins' (sHsps). The sHsps have *in vitro* chaperone activity: i.e., they prevent the aggregation of other proteins. *In vivo,* they enhance the stress-tolerance of cells. Man has ten different sHsps, which are most abundant in the eye lens, in heart and muscles. In the brain they become induced in Alzheimer's disease and multiple sclerosis. The three-dimensional structures and working mechanisms of the various sHsps are poorly understood. Our group explores by means of mutagenesis, protein-interaction studies, and cell biological approaches the structure, chaperoning mechanism en cytoprotection of the sHsps, and their roles in diseases, ageing and apoptosis.

Opportunities for students

In the aforementioned research topics several projects are available for (Medical) Biology, Chemistry, Molecular Life Science and Natural Science students. As a result of the ongoing research projects are constantly reformulated. We assign an experienced supervisor (PhD student; post-doc) to each individual student.
In our work we use modern (biochemical, molecular and cell biological) techniques such as recombinant DNA, selection of recombinant (human) antibodies by phage display, various proteomics techniques, DNA and protein microarrys, cell culture, RNA interference, the mammalian two-hybrid system, RNA-protein interactions, confocal microscopy etc.

Compulsory courses for major, choose from the following:
- Apoptosis
- Chemical Biology
- Molecular aspects of host defense, tissue destruction and repair
- Post-transcriptional regulation in health and disease
- Signal transduction and transport

Mandatory course: biochemie-moleculaire biologie II (BB017C)
Recommended courses: celbiologie van dieren (BB023B), structuur biomoleculen (SB101B) and immunologie (BB019B).

4.20 Biochemistry (NCMLS, UMC St. Radboud))

Head:	Prof. dr. R. Brock
Scientific Staff:	Dr. G.J.C.G.M. Bosman, Dr. W.F. Daamen, Prof. dr. W.J. de Grip, Dr. W.J.H. Koopman, Dr. T.H. van Kuppevelt, Dr. P.H.G.M. Willems
Secretariat:	Ms C. Teunissen, tel. 3614259, c.teunissen@ncmls.ru.nl
website:	www.ncmls.ru.nl

Research

- signal transduction in T lymphocytes
- molecular aging in erythocytes
- cellular molecule import
- signal transduction and ion transport
- molecules of the extracellular matrix
- tissue engineering
- G protein-coupled receptors

Description of research

Biochemistry of Integrated Systems (Bosman, Brock, tel. 365390 resp. 3666213; www.ncmls.nl/biochemistry/Integrated/index.html)
This group joins two lines of research: (i) The molecular analysis of cellular signaling and (ii) the cellular import of molecules to specifically inhibit molecular interactions inside cells. In signaling, we address molecular signaling networks in T-lymphocytes as well as plasma membrane-located signaling mechanisms that regulate and mediate aging of the human erythrocyte. These activities relate to the development of new therapeutic approaches for autoimmunity and cancer, erythrocyte-related pathologies and the relationship of these processes with molecular and cellular aging and cancer. The activities are tightly connected to the other lines of research in the department: In the analysis of T-cell activity, there is increasing awareness of the role of energy metabolism. The interaction of drug molecules with glycoproteins and the extracellular matrix is a critical step controling their cellular uptake and bioactivity.

Matrix Biochemistry (Daamen, Kuppevelt, tel. 3614303 resp. 3616759; www.ncmls.eu/biochemistry/matrix/frames_1.html)
This group focuses on two lines of research (i) The biochemical analysis of extracellular matrix molecules and their role in pathological cascades, and (ii) the construction of biomatrices to induce tissue formation (tissue engineering). With respect to the biochemistry of the extracellular matrix, focus is on the sequence and function of glycosaminoglycan domains and their involvement in pathologies such as cancer and nephropathies. With respect to tissue engineering, focus is on the construction of "smart" scaffolds, which induce tissue/organ formation *in vivo* (skin, urogenital tissue, blood vessels).

Membrane Biochemistry (Koopman, Willems, tel. 3614589; www.ncmls.nl/biochemistry/membrane/index.html)
lassically, mitochondria are famous for their role as powerhouses of the cell. What may be less known is, that mitochondria are also crucially involved in the cell's ability to cope with a variety of stress situations. This group uses a combination of biochemistry, molecular biology and high-content live cell imaging to get mechanistic insight into the relationship between mitochondrial structure, localization and function. Emphasis lies on the coupling between cellular calcium homeostasis and mitochondrial energy production. As a second line of research, we study the cell biological consequences of life-threatening mutations in the oxidative phosphorylation system with the final aim to uncover targets for therapeutics that can improve the clinical condition.

Visual mechanisms (De Grip, tel. 3614263)
This research group addresses molecular mechanisms of selected G protein-coupled receptors, in particular photoreceptor proteins from the retina. For this purpose biotechnological production methodology, i.e. large-scale expression using recombinant baculovirus and his-tag based purification are employed.

Opportunities for students

Suitable for students with Biology, BMW, MLW and Chemistry background

4.21 Analytical Chemistry (IMM)

Head: Prof.dr. L.C.M. Buydens
Scientific staff: Dr. H.R.M.J. Wehrens, Dr. W. Melssen, Dr. G. Postma
Secretariat: Ms. B. Loozen, HG02.722, tel. 3653180, b.loozen@science.ru.nl
website: www.cac.science.ru.nl

Research

Examples of current projects at the department:

- Developing methods to extract chemical and diagnostic information from Magnetic resonance spectroscopic (MRS) images to diagnose brain tumours (European Community project also in collaboration with UMC, department of radiology).
- Applying chemometrical techniques to the analysis and interpretation of DNA-micro-array data.
- Investigation of relations between molecular structure and biological or physical properties.
- Development and further optimisation of novel statistical modelling techniques.

Description of research

The research in the department of analytical chemistry focuses on chemometrics. Chemometrics is the discipline within Chemistry that develops methods to obtain relevant information from chemical data, by applying techniques such as multivariate statistics, neural networks and genetic algorithms. Increasingly, chemometrical methodologies and techniques are also applied in the optimization of molecular structures with respect to their properties and (bio)chemical activity and in the processing and interpretation of (medical) multivariate images. The research in this department is centred around three main research lines:

- Methodological chemometrics: methodological research on chemometrical techniques like global optimisation methods, neural networks and multivariate statistics
- Spectroscopic image analysis: linking pixel-based quantification or classification techniques to image processing techniques
- Molecular chemometrics: applying chemometrics to the analysis, optimisation and determination of molecular structure

Opportunities for students

Students are assigned to individual projects and work on their project under the guidance of a direct supervisor, typically a PhD student. On a regular basis, progress of the research is reported orally to the staff and other students. All students are encouraged to participate in an active way to these presentations and discussions. Depending on the specific apprenticeship of a student, specific courses (like 'Chemometrics II' and 'Capita Selecta') are included in the practical training. Finally, a comprehensive report must be written and an oral presentation (colloquium) should be given.
Suitable profile: Chemistry, Physical-Chemistry and Chemistry-Biology.

Mandatory course: Chemometrics I

4.22 Theoretical Chemistry (IMM)

Scientific staff: Dr.ir. G.C. Groenenboom
Secretariat: Ms P. Willems, HG03.012, tel. 3653421, Paula.Willems@science.ru.nl
website: www.theochem.ru.nl

Research

- Computation of intermolecular potentials
- Dynamics of molecular clusters and collision processes
- Theory of chemical reactions

The Theoretical Chemistry group extracts information from the solution of the Schrödinger equation that can be confronted with experiment. To be able to pursue this research, one needs knowledge of numerical and applied-mathematical methods, and a sufficient grasp of the experiment as well. The latter is necessary to understand and interpret the measured results. In particular the research of the group is aimed at (i) the computation of interactions between molecules that (ii) can be bound by van der Waals forces, (iii) can exchange energy by collisions, or (iv) can react chemically.

Description of research

Computation of intermolecular potentials:
With the aid of modem quantum chemical computer methods, such as 'symmetry adapted perturbation theory', 'coupled cluster theory', 'many body perturbation theory', etc., the van der Waals forces are calculated between two or more molecules.
They may be closed- or open-shelI molecules. The concept of the van der Waals force is very broad, it comprises: long range attraction, Born (steric) repulsion and hydrogen bonding. The aim of the work is a reliable analytic description of these forces as a function of the relative orientation and distance of the molecules. These so-calIed potential energy surfaces are used subsequently in project 2.

Dynamics of molecular clusters and collision processes:
Infrared spectra of van der Waals molecules can be computed from potential energy surfaces as input. By definition a van der Waals molecule is a cluster, bound by van der Waals forces, consisting of two or more ordinary molecules. Currently much experimental research is being performed on these infrared spectra, among others by mernbers of the department of Molecular and Laser Physics in Nijmegen. The main reason for this interest is that the IR spectra gauge very accurately the potential energy surfaces and therefore contribute to a fundamental understanding of the intermolecular forces. The van der Waals potentials are also applied in the computation of non-elastic collision cross sections. A cross section is a measure for the probability that a molecule makes a transition from one quantum state to another under the influence of the collision. Cross sections are measured in very many laboratories in the world, including the Molecular and Laser Physics Lab in Nijmegen.

The theory of chemical reactions:
Computer methods exist, and are being improved; these are tools in the study of chemical reactions at the level of molecular quantum states. This means that the reactive collision is studied between two atoms and/or molecules that are in known, well-defined quantum states. The probabilities are computed that the reaction products appear in certain quantum states after the reaction is finished.

The time-dependent, as well as the time-independent, Schrödinger equation yields this probability. However, under certain circumstances the 'semi-classical' methods (a mixture of quantum and classical mechanics) can be applied very fruitfully as well.
This project also contains the study of photodissociation: the 'reaction' of a molecule and a photon leading to the dissociation of the molecule. The photodissociation of molecules by sunlight is of crucial importance in atmospheric chemistry. In Amsterdam and in Nijmegen experiments are being performed on photodissociation reactions that are important for the atmosphere. In close cooperation with these groups the theoretical chemistry department works on the interpretation and explanation of the measured results.

See www.theochem.ru.nl for recent references giving more details on the subjects mentioned above.

Opportunities for students

The students participate in the projects mentioned above. They collaborate with a faculty member and a Ph.D student (AIO/OIO). The work is usually computer oriented. The group owns six 4 processor Linux workstations. Further the group has access to the national supercomputing center in Amsterdam.
The student is expected to have knowledge of quantum mechanics and some knowledge of mathematics, which must be apparent from succesfully taken exams.
For each research project it is judged whether it is suitable for the Chemical/Chemical-Physical profile of the science curriculum.

mandatory course: molecular quantummechanics
recommended courses: Quantummechanica 1b, Introduction group theory, Linear algebra 2, Computer programming (all 2nd year physics)

4.23 Bioinformatics

Head:	Prof.dr. G. Vriend
Scientific staff:	Dr. C. van Gelder, Prof.dr. M. Huijnen, Dr. G. Schaftenaar, Prof.dr. R. Siezen, Prof.dr. J. de Vlieg
Contact for education:	Dr. C. van Gelder, c.vangelder@cmbi.ru.nl
Secretariat:	Ms B. van Kampen, NCMLS 010, 19390, b.vankampen@cmbi.ru.nl
website:	www.cmbi.ru.nl

Research

- Bioinformatics of protein structures
- Bacterial Genomics
- Comparative Genomics
- Computational Drug Discovery

Description of research

Bioinformatics of protein structures (Prof. dr. G. Vriend, G.Vriend@cmbi.ru.nl)
Proteins are very complex molecules. Despite many years of research every day something new is discovered about their structure or function. We work on sequence - structure - function relation analyses of proteins, and on methods for gathering, disseminating, validating and

mining data related to proteins (structures, sequences, mutations, ligand binding, expression profiles, etc). The prediction of protein structures and the effects of mutations as well as molecular visualisation are important aspects of our work. We often collaborate with biologists and medics to solve real problems with a real biomolecular origin, like a disease.

Bacterial Genomics (Prof.dr. R.J. Siezen, R.Siezen@cmbi.ru.nl)
Gram-positive bacteria play an important role in different aspects of food fermentation, ingredient production, food safety and health. In collaboration with NIZO food research (Ede) and the Top Institute Food and Nutrition (Wageningen), bioinformatics tools are being used to analyse and compare complete genomes of food-relevant gram-positive bacteria. Emphasis is put on the positive attributes of lactic acid bacteria (Lactococcus, Lactobacillus, Streptococcus) and the negative attributes of pathogenic and spoilage bacteria (Listeria, Bacillus cereus, Clostridium).

Comparative Genomics (Prof.dr. M. Huynen, M.Huynen@cmbi.ru.nl)
The -omics era is characterized by tremendous amounts of data (genome sequences, single nucleotide polymorphisms, gene expression data, proteomics data, metabolite concentrations data), and by (relatively) little understanding of these data or of their value for biology. Within the computational genomics group we try to bridge the gap between experimental data and biological knowledge. We focus specifically on prediction of protein function, and protein-protein interactions such as observed in protein complexes or biochemical pathways. In doing that we are not only interested in the functions of the proteins and their interactions in man, but also how these interactions have evolved.

Computational Drug Discovery (Prof.dr. J. de Vlieg, e-mail:jacob.devlieg@organon.com and Dr. G. Schaftenaar, G.Schaftenaar@cmbi.ru.nl)
Key goal of the Computational Drug Discovery (CDD) Group is to develop computer-based techniques for structure-based drug design and translational medicine. The CDD group is working closely together with the Department of Molecular Design & Informatics (MDI) of Schering-Plough, forming a unique collaboration between academic research and applied research. Computational techniques have created many opportunities to accelerate and rationalize the multidisciplinary drug discovery process, and provide novel approaches to the design of drugs. In silico technologies play a critical role in catalyzing the intensive "wet-dry" cycle that characterizes modern drug design. At CDD a variety of scientific methods are developed including micro array analysis, structure-based molecular design and simulation technologies.

Opportunities for students

Suitable for Molecular Life Sciences, Chemistry and Natural Sciences students.

- For internships in the groups of Prof. Siezen or Prof. Huynen the course Vergelijkende Genoomanalyse (SB116B) is mandatory.
- For internships in the group of prof. Vriend the course Structuur, functie en bioinformatica (SB113B) is recommended.
- For internships in the group of prof. de Vlieg the courses Structuur, functie en bioinformatica (SB113B) and Computational Drug Discovery (CMBI101) are recommended.

4.24 Cellular Animal Physiology (IWWR)

Head: Prof.dr. E.W. Roubos
Scientific staff: Dr. B.G. Jenks, Dr. W.J.J.M. Scheenen, Dr. L.T. Kozicz
Secretariat: Ms G. Hulzebos, HG02.022, tel. 3652702, g.hulzebos@science.ru.nl
website: www.celanphy.science.ru.nl

Research
The neural and endocrine mechanisms that control adaptation of animals and man to their continuously changing environment.

Description
The research focuses on the neural and endocrine mechanisms that control adaptation of animals and man to their continuously changing environment.
Attention is on two collaborating brain control centres: the hypothalamo-hypophyseal axis and the Edinger-Westphal system. These systems are studied from the gene up to the organismal level, with the skin colour background adaptation system of the frog *Xenopus laevis* as model to obtain more insight into fundamental cellular communication mechanism. Particular attention is being given to various aspects of the functioning of neuronal and endocrine (melanotrope) cells and to the mechanisms responsible for the production, secretion and specific binding of inter- and intracellular signal molecules such as neurotransmitters, neuropeptides and neuronal growth factors, and the translation of these signals into cellular, physiologically meaningful, responses.
This fundamental knowledge is applied in the biomedical and clinical area, in studies on rodent and man, to assess the significance of the adaptation systems for the proper functioning of the mammalian and human brain during acute and prolonged stress. In the latter respect, emphasis is on chronic depression and suicidal behaviour, gender-differences in the stress response, chronic pain, and antidepressant drug targeting.
Techniques include light and electron microscopy, immunocytochemistry (fluorescence, double and triple staining), confocal laser scanning, videoimaging, quantitative RT PCR, siRNA techniques, transgene *Xenopus*, biochemical techniques, patch clamp, morphometry, *in situ* hybridisation, radio-immuno-assay, cell culture, radio labelling, and single cell secretion measurement.

Opportunities for students
BSc students in Chemistry, Molecular Life Sciences and Natural Sciences.
Obligatory entry level: Course in Neurobiology (leader: Dr B.G. Jenks)

4.25 Organismal Animal Physiology (IWWR)

Head: Prof.dr. G. Flik
Scientific staff: Dr. P.H.M. Klaren
Secretariat: Ms Y.D. Maurits, tel. 3653244, d.maurits@science.ru.nl
website: www.organphy.science.ru.nl

Research
- Stress-adaptation in fish

Description of research

Mission: The research of the group focuses on the regulation of adaptation to stress and the role of communication between neuroendocrine systems (hypothalamus-hypophysis-interrenal and hypothalamus-hypophysis-thyroid axes) and the immune system. Stressors such as crowding or changes in temperature often have negative influences on growth and overall performance and may induce increased susceptibility for diseases due to immune suppression. Hormones from hypothalamic, pituitary, thyroidal and interrenal sources (CRH, TRH, prolactin, growth hormone, ACTH, MSH, endorfines, T3/T4 en cortisol) as well as from the innate immune system (interleukins, TNF's etc.) play an important role in the response of vertebrates to a stressor to reach tolerance or realise adaptation. The dynamic interaction of an animal with its environment basic to adaptation is studied in the largest group of vertebrates, the bony fish, that offer wonderful models to study this broad research topic. Studies are performed on adult fish as well as on their early (and sensitive) developmental stages; emphasis is given to structure function relationships in both central (brain, hypophysis) and peripheral (gills, gut, kidney, immune system components) organs during the adaptive response. The research approaches include molecular biology, cellular, organ and organismal physiology.

Methods/techniques: In our research techniques are secundary to the research questions we formulate, but essentially every modern technique can be implemented from molecular biological tools to intact animal studies; imaging-techniques are key to many lines of research and in this context light and electron microscopy, confocal laser-scanning microscopy and functional MRI are operational. Immunocytochemistry and in-situ-hybridisation are important methods within the imaging program.

Collaboration: Part of the research of the department is carried out in close collaboration with the departments of Cellular Animal Physioogy (Prof. dr. E.W. Roubos) and of Animal Ecophysiology (Prof.dr. S.E. Wendelaar Bonga); a collaboration with the department of Pharmacology (Prof.dr. F Russel/ Dr. R. Masereeuw) focuses on multidrug resistance proteins in fish kidney and brain capillaries. Outside Nijmegen intensive formalised collaborations have been established with the Interuniversity Reactor Institute (Delft TU), the department of Cell Biology and Immunology, the department Fish Culture and Fisheries (Wageningen University), research institutes in Antwerpen (RUCA, fMRI), Canada (i.a. Antigonish, Ottawa, Edmonton, Hamilton, Vancouver), USA (Berkeley and Hawai'i), Japan (Tokyo and Osaka) and (in EU context) laboratories in Norway, Portugal, Spain, France and Greece. Research in EU context concerns the role of PTHrP (parathyroid hormone related protein, a hypercalcemic hormone in fish) in calcium metabolism, growth and development of seabream, effects of food supplements (unsaturated fatty acids and vitamin-D metabolites) on growth and development of seabream, sea bass and salmonids, ecofysiological effects of parasites (salmon lice) and temperature variation as stressors in fish in the wild and in aquaculture settings.

Opportunities for students

The department offers several possibilities to carry out research. At the transition of the batchelor's /master's phase, there is the possibility for a 10-weeks "ministage" to learn to know the style of research and the mentality and atmosphere of the department. In the master's phase, we prepare an outline of a personal program for a research (6 -9 month) focused on the individual wishes for techniques and model systems. There are ample possibilities to carry out research abroad; in that case we generally advise to carry out part of the work in Nijmegen as a training and preparation for the research to be carried out in the institute abroad.

4.26 Molecular Animal Physiology (IWWR)

Head: Prof.dr. G.J.M. Martens
Scientific staff: Dr. F van Herp
Secretariat: B. Portier, NCMLS 6.93, tel. 3610564, b.portier@ncmls.ru.nl
website: www.ru.nl/molanphys

Research

- The molecular basis of psychiatric disorders
- The molecular regulatory mechanisms in the regulated secretory pathway of neuroendocrine cells
- Linking behavioral somatosensory learning in rats with gene expression profiles (in collaboration with Dr. Peter De Weerd, University of Maastricht)

Description of research

The Department of Molecular Animal Physiology is part of the Donders Centre for Neuroscience and the Nijmegen Centre for Molecular Life Sciences (NCMLS). Examples of our current research activities and possibilities for student projects are:

The molecular basis of psychiatric disorders: effects of (epi)genetic and environmental (early-life stress) factors on brain development
Early pre- or postnatal stress together with genetic background may play an important role in the development of psychiatric disorders such as schizophrenia. To study gene x environment interactions, we examine a rat model, the so-called APO-SUS and APO-UNSUS rat lines; APO-SUS rats display deficits observed in schizophrenia. We explore differences in the (epi)genetic make-up and brain mRNA/protein expression profiles between the APO-SUS and -UNSUS rats. We try to link the (epi)genetic and expression differences to molecular pathways responsible for the behavioural phenotypes. Furthermore, we study genetic variations in genomic DNAs from schizophrenic patients to obtain insight into susceptibility pathways for psychosis. Our research may lead to a better understanding of the highly complex mechanisms underlying schizophrenia and related complex neurodevelopmental disorders.

The molecular regulatory mechanisms in the regulated secretory pathway of neuroendocrine cells
We explore the physiological roles of a number of proteins of unknown function, including proteins of the secretory pathway. The studies include the generation and analysis of transgenic *Xenopus* with intermediate pituitary (neuroendocrine) cell-specific transgene expression. In addition, we apply biochemical +/- approaches (differential display proteomics) to identify novel neuroendocrine proteins.

Linking behavioral somatosensory learning in rats with gene expression profiles (in collaboration with Dr. Peter De Weerd, University of Maastricht
We are interested in characterizing gene expression during the acquisition of skills. We use the whisker system in the rat as a model system because it permits the controlled delivery of stimuli in somatosensory cortex (barrel cortex). This research fits in a larger program where links are sought between gene expression, molecular pathways and cognitive processes, for both rats and primates, with the ultimate goal of influencing learning through anti-sense or other techniques..

Techniques used
include gene transfer approaches (such as microinjection of DNA to generate transgenic *Xenopus* frogs), (2-D) protein separation, proteomics, mass spectrometry, (real-time quantitative/arbitrarily primed)-PCR, microarray analysis (mRNA expression profiling), mutagenesis, SNP/CNV genomic analysis, cell culture, electron/fluorescence microscopy, (live) imaging, and behavioral tests (operant conditioning, psychophysics, staircase threshold measurements).

Opportunities for students
Suitable for students Molecular Life Sciences, Chemistry, Natural Sciences; project C: strong cognitive/behavioral interest (for the operant conditioning and training of the rats) and/or chemical/biological profile (for the molecular analysis).

4.27 Microbiology (IWWR)

Head: Prof. dr. ir. M.S.M. Jetten
Scientific staff: Dr. J.T.M. Keltjens, Dr. H.J. Op den Kamp, Dr.ir. M. Strous, Dr. A. Pol
Secretary: Ms M. Uijt de Haag, HG02.404, 52940, m.uitdehaag@science.ru.nl
website: www.microbiology.science.ru.nl

Research
The Department of Microbiology studies the diversity and activity of microorganisms in their natural environment, their mutual interactions and their survival strategies. We focus on the microbial ecology of freshwater systems, in particular on the microbial processes at the very dynamic oxic/anoxic interface between the sediment and the water column. The research is polyphasic: (1) identify the main reactions/ key players in a particular process, (2) enrich and isolate the microorganisms that perform the reactions, (3) characterize these by a molecular toolbox, (4) study their physiology and elucidate their metabolism at the molecular level. On this basis of this knowledge we return to Nature: how biochemistry and cell biology determine the ecological niche differentiation of the bacteria and which environmental factors determine the qualitative and quantitative output of the products to biogeochemical cycles. And last but not least (5), develop a biotechnological application, for instance in waste water treatment. The approach is applied on three fields:
- microbial conversions in the nitrogen cycle
- microbial conversions in the sulfur cycle
- microbial conversions in the carbon cycle

Description of research
Microbial conversions in the nitrogen cycle
A major research topic is the microbial nitrogen cycle and more specifically, the 'chemolithoautotrophic' bacteria active in this cycle: anaerobic ammonium oxidizers ('anammox') in particular, but also aerobic ammonium- and nitrite oxidizers. The microbiological research of anammox, in which ammonium and nitrite are converted to dinitrogen gas with hydrazine as an intermediate, is unique in the world.

Microbial conversions in the sulfur cycle
Volatile sulfur compounds are very malodorous and often toxic. In addition, the compounds

may have an impact on global warming and acid precipitation processes. The sulfur compounds are formed during anaerobic biodegradation and may also result from industrial processes. Certain types of bacteria are capable of degrading to compounds, notably to sulfuric acid. We are particularly interested in the "acidophilic" species, micro-organisms that can live at very low pH.

Microbial conversions in the carbon cycle, the degradation of methane
Methane is a potent greenhouse gas. It is produced in large amounts by methane-forming micro-organisms in wetlands and other freshwater systems. However, methane can be effectively degraded by methane-oxidizing bacteria ('methanotrophs'). In our Department we study three groups of methane-oxidizing bacteria, quite unique organisms from solfataric fields that can live at high temperature and low pH, methanotrophs that live in symbiosis with *Sphagnum* mosses, and an even unique type of bacteria that is capable of "burning" methane under anaerobic conditions, viz. in the absence of oxygen.

As mentioned, the approach is polyphasic in all three research fields and comprises ecophysiology, molecular ecology, biochemistry, cell biology and environmental genomics. Techniques used include newly developed enrichment and continuous culture techniques of relevant bacteria in laboratory bioreactors, fluorescent in situ hybridization (FISH), PCR amplification, DNA sequence analysis, bioinformatics, denaturing gradient gel electrophoresis (DGGE), 2D-gel electrophoresis, MALDI-TOF mass spectrometry, stable isotope probing, gas chromatography, HPLC analysis and a variety of protein purification methods. For more detailed information on the research, we would like to refer to our website (www.microbioloy.science.ru.nl).

Opportunities for students

In all of the aforementioned research topics projects are available for Chemistry, Molecular Life Science and/or Natural Science students. Since research is constantly evolving, projects can not be specified here. The student is supervised by a PhD student, post-doc or staff member. In the first part of the internship, guidance will be extensive: regularly with the supervisor, weekly sessions with the other members of the Department. During this period the student will be introduced to literature and the relevant research techniques. In the second part of the internship more initiative is expected from the student in planning, designing and performing of the experiments. At the end, a research report will be written and the work is presented in a seminar. In addition, a literature thesis has to be written on a subject not related to the own research. The theoretical examination consists of capita selecta of modern microbiology; the student will be consulted with respect to the choice of the material.

Requirements:
To start with the internship, one of the specialized Microbiology courses ('Fysiologie van Micr-organismen', 'Ecologische Microbiologie') is recommended. As an introduction to the internship, the BSc-level research practical is very useful. Contact Dr. H.J.M. Op den Camp for further information.

4.28 Experimental Plant Ecology (IWWR)

Head: Prof.dr. J.C.J.M. de Kroon
Scientific staff: Dr. H. Huber, Dr. J.F. Stuefer, Dr. E.J.W. Visser
Secretariat: Ms J.J.M. Broekmans, HG01.021, 52410, j.broekmans@science.ru.nl
website: www.ecostages.science.ru.nl

Research

- study of functional responses of plants to environmental heterogeneity
- study of clonal plant species
- study of riverine grasslands

Description of research

Natural habitats are not homogeneous but heterogeneous. Essential resources for plant growth (such as water, mineral nutrients, light) and biotic factors (such as pathogens and herbivores) are not evenly distributed in natural environments. On the contrary, field research has shown that all natural habitats show a patchy distribution of resources and other abiotic and biotic environmental factors, and that this variation is expressed at different scales in space and in time. As a research group, we focus on the study of **functional responses of plants to environmental heterogeneity**. In other words, we are interested in the general ecological question of how plants can cope with a variable environment, and what traits they have developed to maximize their performance in a spatially and temporally heterogeneous environment.

Plants have developed a broad array of adaptive mechanisms to increase resource extraction from patchy habitats. These traits are often referred to as **foraging behavior**, because they are analogous to the search behavior of browsing animals. Plant foraging by roots and shoots relies mainly on morphological and physiological adjustments which are triggered by environmental factors, and which are internally coordinated by hormonal signaling. Such inducible responses are also called **phenotypic plasticity** and they play a central role in our current research program. We are mainly focusing on the mechanisms behind the expression of plasticity (e.g., petiole elongation in response to shading, root proliferation in response to patchy nutrient supply), on genetic diversity in these mechanisms, and on ultimate costs and benefits of plastic adjustments to environmental conditions.

A significant portion of our research is devoted to the study of **clonal plant species**. They can produce genetically identical copies of themselves by the formation of little offspring plants on horizontally growing stems. This mode of growth results in the formation of potentially extensive networks of plants which are physically linked to each other. We are mainly interested in ecological implications of these connections, as they allow for the transport of resources to young plants (post-natal care), they allow for a division of labor in resource capture within the network, and they enable **plant communication** about the presence of herbivores and pathogens. We are currently studying the role of plant-connections for transmitting defense induction signals (**early warning system**) upon herbivore attack, and their role as vectors for diseases. In analogy to electronic networks, viruses and other pathogens can use the network infrastructure to locate new hosts and potentially disperse very quickly within plant populations.

Riverine grasslands form an ideal model system a fascinating ecological arena for our main research activities. These systems can be found along large water streams (e.g. river Waal) and its vegetation is characterized by a strong gradient in species composition ranging from flooding-tolerant species near the water level to more drought resistant plants further uphill. Our group has a long tradition in studying the physiological causes and ecological consequences of variation in **flooding tolerance** within and between species, and this tradition (combined with questions of phenotypic plasticity and foraging) is continued in a number of ongoing projects. We are currently most puzzled by the unresolved question of what environmental factors and plant-specific characteristics determine the upper and the lower boundaries of species distribution on a flooding gradient.

In close connection to the above-mentioned questions, we are investigating the **micro-evolutionary dynamics** of a few model species (e.g. Trifolium repens) in riverine grasslands. In spite of very strong environmental selection pressures these species show extraordinarily high levels of genetic diversity. We aim at finding out how natural selection operates in the field (e.g., what favors and dis-favors certain genotypes) and what factors contribute to the generation, maintenance, and erosion of genetic diversity. We are using a combination of ecological, physiological and molecular techniques to study different aspects of selection and micro-evolution in the field.

Opportunities for students

Thesis research projects (contact: Dr. E.J.W. Visser, tel. 3653382, e.visser@science.ru.nl): A variety of projects is continuously available within the lines of research that are mentioned above. The work may comprise the collection of field data from experimental plots, the design, set-up and monitoring of experiments in our greenhouses and experimental garden, and/or the performance of ecophysiological experiments in the climate rooms and our lab.
Suitable profile: Projects are eligible mostly for students with a chemical-biological background.

4.29 Plant Cell Biology (IWWR)

Head: Prof.dr. C. Mariani
Scientific staff: Prof.dr. G. Angenent, Dr. W. Vriezen
Secretariat: Ms E. Schaberg, HG02.309, tel. 3652777, e.schaberg@science.ru.nl
website: www.pcb.science.ru.nl

Research

The research of the department is targeted to developmental processes that underlie flower and fruit development on a cellular as well as on a molecular level. Our current studies focus on the function of a class of homeotic genes in petunia flower development and on signaling events in tomato flower which lead to fruit development. In addition, we have a project in cooperation with 'The Centre for BioSystems Genomics' to identify new sources of resistance genes to *P. infestans* in wild accessions of Solanum.

Description of the research projects

Conservation and diversity in fruit formation of Arabidopsis and tomato
Floral organogenesis and fruit growth in angiosperms are controlled by regulatory networks in which transcription factors are interacting to promote or inhibit transcription of target genes.

Although these networks are largely conserved in flowering plants, the fruits of the model species Arabidopsis and tomato have a completely different morphology. In this project, we study the conservation and diversity in the transcriptional regulation of fruit formation and investigate how similar genes developed a different function during evolution. We focus on a few genes that belong to the MADS box transcription factor family. The expression patterns of these genes are investigated and the factors that determine the expression, like the cis-regulatory elements in the promoter will be identified. In addition, we aim to study which target genes are regulated by the transcription factors in the two species.

Characterization of type I MADS box genes in Arabidopsis
MADS-box genes are very important for plant development and especially for the formation of the flower. The MADS box family of transcription factors in plants can be subdivided into two classes: the MIKC-type genes, which play essential roles in flower formation, and the type I genes, which are functionally poorly understood. Recently, it has been shown that some type I MADS box genes play an important role in the formation of the female gametophyte (embryo sac). They are essential for a normal fertilization and for the formation of the endosperm. To learn more about the function of all 61 type I MADS box genes in Arabidopsis, we are investigating their expression patterns by promoter::reporter constructs. Subsequently, we want to study a few genes in more detail to unravel their function.

Hormonal regulation of fruit-set and early fruit development in Tomato
Tomato is one of the most important agricultural crops with a production of over 115 million tons a year. The ripening of tomato fruit has been studied for years but very little is known about the regulation of fruit set and early fruit development. It is known, however, that plant hormones are involved in these processes. Application of the plant hormones auxin or gibberellin to the pistil of a tomato flower is enough to induce fruit development without fertilization.

We do research on the role of hormones and their signaling pathways that switch on fruit development after fertilization. Transcript profiling experiments (cDNA-AFLP, micro arrays) are used to identify genes involved in gibberellin, auxin signaling pathways and suggested the involvement of other hormones. Based upon these data it is very likely that several plant hormones together regulate fruit set and early fruit growth. To understand the mechanism by which these hormones work together we analyze the function of the isolated genes in the flower. For this purpose we modulate their activity by making transgenic tomato plants, and analyze the effects on fruit set.

Another development under heat stress in tomato
Successful development of tomato fruits is strongly dependent on environmental conditions, especially temperature. Plants grown under high temperatures often have anthers without fertile pollen meaning that fruit set cannot occur. This is a considerable problem in fruit production in many parts of the world. The sensitivity to high temperature differs between different tomato cultivars. By comparing genome-wide gene expression of heat sensitive cultivars with that of heat tolerant cultivars, we try to identify genes that are important in the response to high temperature. The identity of these genes will be elucidated by DNA sequencing and their relation to heat tolerance by gene expression analysis. Finally, gene function will be analysed in transgenic plants as described above and in plants with mutations in the gene of interest.

Biodiversity: source of new traits
Species of the genus *Solanum* comprise wild plants but also many cultivated species such as tomato and potato. Wild species are often more resistant to biotic and a-biotic stress factors, which could be useful for many crops. For example, *Solanum dulcamara* (bittersweet), which grows indeed as weed in most of Europe and in the Netherlands grows often near to potato fields, shows clear resistance to diseases (in particular to *Phytophthora infestans*) and a good level of adaptation to various environments. We have previously made an extensive collection of various bittersweet ecotypes and we are using them to identify and clone new resistance genes (R-genes) against pathogens. This work implies the fine mapping of the R-genes in the genome of bittersweet (by syntheny with potato and tomato using AFLP markers) and their cloning (using map-based cloning and BAC libraries). Bittersweet is very well adapted to grow in wetlands, as it produces abundant adventitious roots after flooding. The physiological and molecular mechanisms of this fast root induction will be investigated under greenhouse conditions by hormone treatments and random mutagenesis, as well as by transcriptome analyses with cDNA-AFLP and microarray. Furthermore, we are currently collecting more species of the genus *Solanum* from Indonesia, in order to approach now the identification of R-genes against the bacterium *Ralstonia solanacearum*, the cause of brown-rot in potato. Also this work will imply mapping (AFLP) and cloning of the putative new R-genes.

Opportunities for students
Students can choose to participate in different fields of plant research using molecular, physiological and/or cytological approaches. Techniques used can be DNA/RNA analysis ((RT/Q-)PCR, (cDNA-)AFLP, *in situ* hybridization), microscopy (electron microscopy, CLSM) and/or physiological (analysis transgenic plants).

4.30 Aquatic Ecology & Environmental Biology (IWWR)

Head: Prof. dr. J.M. van Groenendael
Scientific staff: Dr. N.J. Ouborg, Dr. J.G.M. Roelofs, Dr. L. Lamers
Secretary: Ms J.J.M. Broekmans, HG02.204 , 52902, j.broekmans@science.ru.nl
website: www.eco.science.ru.nl/popbiol

Research
- Molecular ecology and ecogenomics (Dr. N.J. Ouborg)
  Transcriptional profiling of inbreeding depression and genetic erosion in threatened plant species
- Wetland biogeochemistry and ecology (Dr. L. Lamers, or Dr. F. Smolders)
  Sulphide and metal toxicity in wetlands

Description of research
Transcriptional profiling of inbreeding depression and genetic erosion in threatened plant species (Dr. N.J. Ouborg tel. 3652470, j.ouborg@science.ru.nl)
Habitat fragmentation, a process increasingly affecting nature, is known to lead to small, isolated populations of plants and animals. These small isolated populations are expected to 1) contain low levels of genetic variation and higher levels of inbreeding, 2) exhibit reduced average fitness of individuals as a consequence of inbreeding, and 3) to be more prone to extinction. Evidence for a correlation between population size and level of neutral marker (like microsatellites, AFLPs, ISSRs, etc.) variation has accumulated over the past years. However, no evidence is present for a reduction in sequence or expression variation of functional genes.

This research specifically focuses on 1) discovering the genes responsible for the inbreeding effects, 2) assessing the variance in gene expression as a function of population size, and 3) comparing impact of habitat quality with inbreeding effects on gene expression. The research is largely based on development and application of microarray and quantitative PCR methods. Part of the research is done in the greenhouse. Training combines ecological (inbreeding) experiments with advanced molecular biology techniques and bioinformatics analyses.
The research group is a highly cooperative mix of ecologists, molecular biologists and bioinformaticists. The aim of the project is to publish results in top-journals like Nature and Science.

Sulphide and metal toxicity in wetlands (Dr. L. Lamers tel. 3653014, or Dr. F. Smolders tel. 3652816)
Many freshwater wetlands suffer from sulphate and (heavy) metal pollution. Through the stimulation of sulphate pollution in wet soils and sediments, free sulphide may accumulate to levels toxic to characteristic plant and animal species. On the other hand, sulphide may sequester (potentially toxic) metals, thereby reducing their bioavailability. The water table strongly influences these processes. The research will focus on the interactions between water table, sulphur and metal dynamics, and their consequences for wetland ecosystems. The research training combining biogeochemical and ecophysiological studies, will comprise both laboratory- and fieldwork. The results will not only be interesting from a more fundamental scientific point of view, but they will also have important implications for wetland management.

Opportunities
Suitable for students with a Biological-Chemical profile. The department exists of a closely collaborating group of scientists: biologists, ecologists and a chemist. The research results are published in international scientific journals, but also in the form of reports and advice to various governmental institutions.

4.31 Cell Biology (IWWR)

Head: Prof.dr. E.J.J. van Zoelen
Scientific staff: Dr. A.P.R. Theuvenet, Dr. J.E.M. van Leeuwen
Secretariat: Ms J Rullmann-Freriks, HG02.204, 52701, j.rullmann-freriks@science.ru.nl
website: www.celbi.science.ru.nl

Research
- Development of EGF receptor antagonists
- Regulation of PDGF alpha-receptor expression in disease
- Propagation of calcium action potentials in NRK cells
- Intracellular targeting of ErbB receptors

Description of research
Research in the department focusses on the role of polypeptide growth factors in the control of proliferation of normal cells and tumor cells. Use is made particularly of cells grown in tissue culture, using a combination of cell biological, molecular biological, biochemical, biophysical and bioinformatical approaches. There are four lines of research in the department:

Development of EGF receptor antagonists
The mechanisms are being studied by which EGF-like growth factors are able to specifically bind their ErbB receptors and activate them by inducing receptor homo- and hetero-dimerisation. Many tumor cells overexpress ErbB receptors and produce EGF-like growth factors themselves. Based on the structure of the natural Drosophila EGF receptor antagonist Argos we are developing clinically relevant antagonists of human ErbB receptors in order to block autocrine growth stimulation of tumor cells.

Regulation of PDGF alpha-receptor expression in disease
PDGFRA plays an important role in neural development. We have detected multiple polymorphisms in the PDGFRA promoter region, based on which strong (H2a) and weak (H1) haplotypes can be identified. We have shown that the H1 allele predisposes to neural tube defects and the H2a allele to glioma brain tumors. Current studies focus on the expression regulation of PDGFRA in neural and glioma stem cells.

Propagation of calcium action potentials in NRK cells
Density-arrested normal rat kidney (NRK) fibroblasts show periodic action potentials, which are driven by multiple ion channels in the plasma membrane. The mechanisms of spontaneous action potential initiation and propagation in these cellular monolayers are being investigated by patch clamp techniques, in combination with molecular RNAi studies to control ion channel expression levels.

Intracellular targeting of ErbB receptors
After ligand binding ErbB receptors are internalised and degraded in proteasomes and lysosomes. Impairment of this proces can result in enhanced mitogenic activity and cancer. In our studies, emphasis is placed on the role of Cbl family adapter proteins, which control the ubiquitination and intracellular sorting of the internalised ErbB receptor.

Opportunities for students
Recommended for traineeships: 3rd year course Animal Cell Biology.

4.32 Applied Biology (IWWR)

Head: Prof.dr. E.J.J. van Zoelen
Scientific staff: Dr. K. Dechering, Dr. E. Piek
Secretariat: Ms J Rullmann-Freriks, HG02.204, tel. 3652701, j.rullmann-freriks@science.ru.nl
website: www.celbi.science.ru.nl/project3.htm

Research
- Osteogenomics: from stem cell to osteoblast

Description of research
Osteogenomics: from stem cell to osteoblast
Dr. Koen Dechering: 0412-663301, koen.dechering@organon.com
Dr. Ester Piek: 024-3652523, e.piek@science.ru.nl
Human mesenchymal stem cells (hMSC) are pluripotent cells which have the capacity to differentiate into several cell types, such as adipocytes, chondroblasts and osteoblasts. Bone morphogenetic proteins (BMPs) are growth factors which induce osteogenesis *in vivo*. *In vitro*, BMPs potentiate the osteoblast differentiation of hMSCs. Understanding the process of

osteogenesis and identifying genes that play key roles in osteoblast differentiation may contribute to the development of improved treatments for patients with bone disease, such as osteoporosis.
Microarray (DNA-chip) analysis is being used to identify those genes which are potential key regulators in osteoblast differentiation of hMSCs. The function of those genes and their role in osteoblast differentiation is established by overexpression of the corresponding cDNA or by selective knockdown of endogenous expression by RNA interference (RNAi). Several bioassays are being used to validate the role of the respective genes in osteoblast differentiation.
In addition to the osteogenomics project, chondrogenomics and adipogenomics projects are performed to identify and characterize genes that play a key role in cartilage and fat differentiation, respectively.
Techniques being used in our laboratory include:
Culturing of hMSCs, RNA extraction and cDNA synthesis, microarray analysis, bioinformatics/ statistical data analysis, Sybr Green quantitative RT-PCR analysis, cloning of cDNAs and RNAi oligos into mammalian expression vectors, transfection of cDNAs into mammalian cell lines, alkaline phosphatase assay, calcium release assay, von Kossa staining, Western blotting, cell sorting (FACS), etc.
The osteo-, adipo- and chondrogenomics projects are carried out in close cooperation with Organon scientists. A limited number of traineeships is available at the Target Discovery Unit of Organon Research in Oss.

Opportunities for students

If you are interested in a traineeship at our department it is recommended to follow the course Medical Biotechnology.

4.33 Cell Biology (NCMLS)

Head: Prof.dr. B. Wieringa
Scientific staff: Dr. J.A.M. Fransen, Prof.dr. P. Friedl, Dr. K. Wolf, Dr. W. Hendriks, Dr. C.E.E.M. van der Zee, Dr. D.G. Wansink
Secretariat: Mw M. Reawaruw, tel. 3614329, m.reawaruw@ncmls.ru.nl
Website: www.ncmls.nl/celbio

Research

Joint research of the Dept. of Cell Biology is aimed at understanding the pathobiological significance of

1. cellular energy and redox reactions,
2. coupling between energy and redox metabolism and actin-based cell shape dynamics and cell motility,
3. reversible protein phosphorylation reactions involved in the coupling between cell fate and growth regulation, actin cytoskeleton dynamics, and metabolic state,
4. the role of proteases and adhesion receptors in different types of cancer cell invasion, and
5. the mechanisms of cancer cell killing by cytotoxic T lymphocytes.

Study of these cellular reactions is important for a better understanding of health problems that are related to cancer cell growth and motility, neurodevelopment and neurodegeneration, or diseases like myotonic dystrophy and mitochondrial myopathies.

Description of research

Next to the transcriptome and the proteome, the metabolome forms the third level of organisation of the cell. Among the >5000 small compounds in mammalian cells, energy and redox metabolites like ATP, PCr and NAD/NADH or NADP/NADPH have a special position and are utilized in the core pathways of metabolism (glycolysis, PPP-pathway and TCA-cycle, OXPHOS). Not surprisingly, therefore, metabolites like ATP and NAD(P)(H) are involved in virtually all relevant interactions between micro- and macromolecular components of the cell. Distinctly different processes like the formation of projections by astrocytes and neurons, the development of podosomes and invadopodia by malignant cells, the formation of phagocytic cups by macrophages, or the generation of lamellipodial/filopodial extensions in motile cells, and even cytokinesis, share the hallmark that they are all actin-based and under temporal and spatial control of ATP or NAD(P)(H)-based reactions. Here, these reactions are involved in the dynamic coordination of actin polymerization behavior, force generation by myosin ATPases, or the local control of phosphorylation of proteins in upstream signaling pathways. Therewith, post-translational modification of cell cortical proteins and metabolic signaling effects of energy and redox metabolites are closely interrelated and vitally important for cell growth and viability control.
Currently central in our interest is how the local distribution of ATP, and activity of members of the protein tyrosine phosphatase (PTP) family or the Rho-kinase family member Myotonic Dystrophy Kinase (DMPK), couple to activity of actin-based machinery in the cell cortex and determines fate of neurons, macrophages, muscle and cancer cells in health and disease.

Opportunities for students

All MSc students with a chemical/biological, biological/physical or biomedical profile, with molecular biological and/or cell biological elements in their training program are invited to apply for traineeship opportunities. We assign an experienced supervisor to each individual student. Therefore, we have only a limited number of internship positions available at a given moment. For further information we refer to www.ncmls.nl/celbio/

4.34 Cell Physiology (NCMLS, UMC St. Radboud)

Head: Prof.dr. R. Bindels
Scientific staff: Dr. P. Deen, Dr. J. Hoenderop
Contact: Dr. J. Hoenderop, tel. 3610580, j.hoenderop@ncmls.ru.nl
Website: www.physiology-nijmegen.nl

Description of researchers

Regulation of electrolyte and water transport in kidney and intestine
The research groups Ion Transport and Osmoregulation from the department of Physiology in Nijmegen have a long long-standing reputation in the field of membrane transport, and, in particular, epithelial transport. Research at this department is focused on aquaporin water channels, epithelial calcium and magnesium channels and sodium-chloride cotransporters. One line of research is focused on the identification of novel ion transporters in kidney and small intestine. Using advanced molecular biological techniques we identified and characterized new ion and water transporters including aquaporin water channels and epithelial calcium and magnesium channels. Our research aims to clarify the cell biological consequences of mutations in the genes encoding for these renal transporters, which are the cause of diseases such as Nephrogenic Diabetes Insipidus, Bartter and Gitelman syndromes and disturbances in the calcium and magnesium homeostasis of the body. Another line of research aims to

understand the factors that determine the activity of epithelial transporters, which include phosphorylation, glycosylation, regulated trafficking and hormonal regulation. The obtained knowledge will not only substantiate the role of epithelial transporters under (patho)physiological conditions, but could ultimately also give way to the development of pharmacological strategies to treat ion en water-related mal(re)absorption disorders. For more information please also consult our website: www.physiology-nijmegen.nl

Methods and Techniques
Depending on the subject the student can obtain experience with a wide variety of techniques:
- Molecular-biology: recombinant DNA technology, Northern en Southern blots, real-time PCR, fusion proteins, siRNA.
- Maintenance of cell lines: transfection and culture of various cell lines.
- Biochemistry: enzyme and ion transport activity measurements, cell signaling techniques, pull-down assays, proteomics, yeast-two-hydrid assays, 2D-gel electrophoresis.
- Immunology: immunohistology, immunoblots, preparation of antibodies, immunoprecipitations.
- Imaging: real-time cytosolic ion concentration measurements with video and confocal microscopy.
- Miscellaneous: radio isotopes, animal research, electrophysiology, bioinformatics.

Opportunities for students
The department of Physiology is a dynamic, enthusiastic and internationally orientated research group with an excellent scientific track record. Students will be guided by senior PhD students or Post-doc researchers. Interested students with a background in (Bio)Chemistry, (Medical) Biology and Molecular Life Sciences are welcome to perform an internship at the department of Physiology. The projects are carefully planned and the amount of positions is limited so make sure you organize your internship in time.

4.35 Biological Psychology (Soc. Wet.)

Scientific staff: Dr. G. van Luijtelaar, Dr. R. Maes, Dr. E. Maris, Dr. C. van Rijn, Dr. M. Jongsma
Contact: Dr. G. van Luijtelaar, tel. 3615621, g.vanluijtelaar@nici.ru.nl
Secretariat: tel. 3612544
website: www.ru.nl/socialewetenschappen/nici/divisions/all_divisions/cognitive

Research
- Electrophysiological correlates of learning and memory processes
- Epilepsy and its modulation

Specific research topics addressed in ongoing research:
- neurophysiological mechanisms of recognition and expectation
- dynamic aspects underlying learning and memory formation
- perseveration and learned irrelevance in discrimination learning
- use and develop animal models for chronic pain
- electrophysiological correlates of somatosensory stimulus processing
- develop model for temporal lobe epilepsy
- early seizure detection
- develop behavioural-electrophysiological experiments in rats in the field of attention

Description of research

Electrophysiological correlates of learning and memory processes (supervisor: Dr. R. Maes, tel 3615992, r.maes@nici.ru.nl)

Numerous human and animal conditioning research has generated a number of experimental procedures, each of which is linked to well-developed theories on learning and memory. These procedures include single-stimulus paradigms prompting elementary forms of (associative) learning, such as habituation and perceptual learning, and more complex, multi-stimulus paradigms. The latter include simple classical conditioning, latent inhibition, extinction, and discrimination learning. Even more complex paradigms concern occasion-setting procedures in which behavioral responding to target stimuli is modulated by the presence or absence of other stimuli.

The research is directed at the neuro-electrophysiological correlates of these diverse forms of learning in rats and humans and constitutes a valuable tool for establishing the neurobiological substrates and nature of cognitive processes involved in learning and memory, both within healthy organisms as well as in models of distinct pathologies (e.g. epilepsy, chronic pain, and aging).

Rats and humans are subjected to procedures known to prompt simple and/or complex forms of learning, while measuring local field evoked potentials on the skull (humans), or on the dura mater or in sub-cortical regions (rats).

Epilepsy and its modulation (supervisor: Dr. Gilles van Luijtelaar, tel 3615621, g.vanluijtelaar@nici.ru.nl)

The cortico-thalamic network: its role in modulation The availability of a genetic rat model for absence epilepsy and recent discoveries of how specific parts of the cortex control spontaneous seizures allow the study of mechanisms involved in the control of these seizures. Moreover, it gives possibilities to study network interactions and plasticity in the cortico-thalamo-cortical network.

A closed loop system for prevention of limbic seizures Seizure control by drugs is poor in many epilepsy patients. Brain surgery is only an option for a limited number of patients. Research is aimed to develop various deep brain stimulation techniques and protocols in rats with temporal lobe epilepsy in order to treat them. Some deep brain stimulation techniques will induce plasticity, other techniques are aimed to block an ongoing seizure. Next, we will develop an early seizure detection technique, and, finally, a closed loop system that allows stimulating the rat brain after the onset of a seizure has been detected.

Opportunities for students

It is recommended that an interested student contacts the research coordinator minimally four months before the actual start of the experiments. Students (biological-physical profile) can participate in ongoing animal or human research, however, permission from the Animal Welfare officer must be obtained. The work placement offers the opportunity to acquire and combine knowledge from the field of electrophysiology and behavior (e.g. learning psychology). The student should have knowledge, or should acquire knowledge at short notice, of: a) working with laboratory animals (rats), if the work placement concerns animal research, b) using electrophysiological equipment, stimulators and equipment used to present the learning tasks (including programming), c) data analysis, d) recent developments within the field of animal and human leaning psychology, sensory perception, brain networks, specifically in the sub-domain of interest, and e) reporting experimental data.

5 Organisation

5.1 Coordination, Information and Advice

General

Coordination of the Master Natural Science
Natural Science is one of three Masters offered by the Institute for Molecular Sciences.
Director of the Institute is prof. dr. A.P.M. Kentgens.
The master Natural Science is coordinated by **Prof. dr. A.J. van Opstal**. He is chairman of the Steering board of the programme and responsible for the educational policy. Daily coordination is performed by **Dr. L.J.J. Laarhoven**. He is the main source of information for students, mediates in contacts with teachers and informs students about courses, schedules, planning, etc.

Coordinator:	Prof. dr. A.J. van Opstal (John)
room:	Medical and Biophysics, Geert Grooteplein-Noord 21, k 1.08
tel::	(024) 36 14251
e-mail:	J.vanopstal@science.ru.nl
Coordinator:	Dr. L.J.J. Laarhoven (Luc-Jan)
room:	HG01.061
tel:	(024) 36 53434
e-mail:	L.Laarhoven@science.ru.nl

Secretariat Molecular Sciences: Ms. Ine Meijer
room: HG01.060
tel: (024) 36 53429
e-mail: secromw@science.ru.nl

Information about schedules etc. can also be obtained from:
Ms. Wilma Philipse
room: HG01.059
tel: (024) 36 53173
e-mail: W.Philipse@science.ru.nl

Announcements
Announcements about courses, changes in schedules, etc., etc. are made mainly by email.
It is important to check your email on a regular basis.
Also **Blackboard** will play an important role in spreading information about courses by the teachers themselves. Make sure to be enrolled in courses (via KISS). (See next section).

Student advisor
Dr. Laarhoven functions as student advisor. He keeps an eye on results and can offer advice about courses and tracks and whenever problems arise. The members of the Steering Board offer research related advice. Do not hesitate to contact them:

Dr. A.J. van Opstal	(024) 36 14251	Geert Grooteplein-Noord 21, k 1.08	(physics)
Dr. W.J.J.M. Scheenen	(024) 36 52036	HG 02.010	(biology)
Prof.dr. S.S. Wijmenga	(024) 36 53384	HG 03.345	(chemistry)

Lecture and examination schedules
Schedules with chemistry, physics or biology courses are available before the start of each semester. There is no separate schedule for Master students natural science.
Some Master courses are scheduled on-demand (contact the teacher, or the secretariats of Biology, Physics or Chemistry). Electives from bachelor curricula can be found in the appropriate schedules and on KISS.
You can again contact the various secretariats, or ask for advise with the study coordinator.

Tentamens (written examinations) can be found in KISS. You need to register in KISS. For some Master's courses also oral examinations may be scheduled. For these you have to contact the teacher and register a 'testimonium' at the students administration.

You have to register for tentamens at least 5 working-days before the tentamen. See the appropriate section elsewhere in this prospectus.

Examination board
All Master's programmes must be approved by the examination board. Also requests for extra resits for an exam (4th try) must be directed to the examination board.

Dr. L.J.J. Laarhoven	(024) 36 53434	HG01.061	secretary
Dr. G.W. Vuister	(024) 36 18940	NCMLS 0.25	chairman

Students administration/examenbureau B-faculteiten (FSA)
The students administration can be found in room
HG00.134 ; tel. 36 53392 / 36 52247
Opening hours: Monday to Thursday 13.00 - 16.00 h, Friday 9.00 - 12.00 h

Blackboard

The Radboud University embraces the computer programme 'Blackboard', which creates a digital study and communication environment between teacher and student.
Every course has a spot on Blackboard where the teacher can place assignments, announcements, or extra information. More and more lecturer use Blackboard, so this will become an important medium.

Students have to enrol the courses they wish to attend or follow via KISS. At the start of each course, the lecturer will 'open' his or her blackboard-site and all students who enrolled via KISS automatically have access to this site.

Enroling courses in KISS is possible at all times, even when the course has already started. However, **when a practicum is part of the course** (e.g. in Biology courses), students have to sign up **at least 1 month in advance**. Otherwise participation might not be possible.

5.2 Final Qualifications Master Natural Science

The degree courses in Natural Science (Bachelor's and Master's) aim to educate and train students in the Natural Sciences, *i.e.* Chemistry, Physics and Biology, and the links between these disciplines, so that they are able to:
1) Work in interdisciplinary fundamental or applied research within the physical-chemical, chemical-biological or biological-physical fields
2) Work as "academic professionals" within management, communication or education.

Students should attain equal levels of knowledge, skills and academic attitude as their mono-disciplinary peers.
The objectives and final qualifications of the Natural Science program were set up by scientists involved in international, multi-disciplinary research in Physics, Chemistry and Biology, and correspond to the requirements made by scientists in mono-disciplinary and multi-disciplinary research.

Competences of the Master's Program

Master's graduates are expected to have the following supplemental skills to complement their Bachelor's competences:

1. specialized insight in at least one interdisciplinary field of natural sciences (i.e. one of the related fields, chemistry/biology, biology/natural sciences and natural sciences/chemistry)
2. sufficient knowledge in this specialized field to carry out scientific research under supervision
3. the ability to read scientific articles about their chosen specializations comprehensively, to master newly acquired knowledge within those fields of specialization and to integrate it into existing knowledge
4. the ability to formulate new definitions of questions and hypotheses within their chosen specializations and to select the correct paths and research methods for resolving these questions
5. the ability to follow general scientific developments within the chosen interface of natural sciences
6. the ability to adapt at a specialist level of another sub-specialization within the chosen interface of natural sciences
7. the ability, under supervision, to set up experimental or theoretical research, to treat systematically and critically interpret the research results and to formulate conclusions
8. the ability to present research results, both orally with clear delivery and, in written form, in a scientific article for professional colleagues and for a non-specific, expert audience
9. the ability to communicate about scientific knowledge at specialist level with professional colleagues working in the same discipline
10. sufficient knowledge of and insight in the societal significance of the natural sciences to be able to reflect on social problems based on the knowledge gained from the natural sciences

Graduate Master's students who have taken the **Research variant**, as a supplement to competences 1 to 10, are expected:

11. to have sufficient knowledge and skills to be able to conduct scientific research independently within at least one inter-disciplinary field of natural sciences
12. to be capable of critically analyzing the results obtained from research and, on this basis, explore new avenues of research.

Graduate Master's students who have taken the **Communication variant**, as a supplement to competences 1 to 10, are expected:

11. to have knowledge and skills derived from communication studies
12. to be capable of designing, conducting, delegating and supervising communication research, independently and methodically
13. to contribute to the analysis and approach to problems that occur in the interaction between science, technology and society
14. to have an overview of the interaction and communication processes that occur in social discourse
15. to be able to work effectively in a policy team with a broad composition (interaction between science, technology and society) and be open for other types of knowledge (intuitive and practical experience).

Graduate Master's students who have taken the **Education variant**, as a supplement to competences 1 to 10, are expected to be able to fulfill the following six instructor roles:

11. the classroom instructor
12. the expert
13. $the educationalist
14. the reflective professional
15. the instructor outside the classroom
16. the developer and researcher.

Graduate Master's students who have taken the **Business and Management variant**, as a supplement to competences 1 to 10, are expected:

11. to be familiar with the language of management, in addition to the language of their own natural-science specialization
12. to be capable of conducting research independently with regard to problems that occur at the interface of technology, organization and society
13. to be capable of contributing to the solution of management problems
14. to be capable of effectively cooperating and communicating in a multidisciplinary team.

5.3 Regulation of interim exams

Participation in interim exams (tentamens) is strictly regulated through the 'tentamenregeling' which can be found in the Education and Examination Regulation, OER.

Students are allowed three opportunities to pass an interim exam and are required to register for each tentamen (or other part of the final exam, such as practica). This is possible up to 5 working days before the tentamen using KISS.
Unregistring is likewise possible through KISS up to 5 working days. After that it has to be done in writing (email) with the responsible teacher.
Registered students that do not show at the tentamen, lose one opportunity.

If all three opportunities are 'used up' the student has to request a fourth, final, opportunity, in writing with the examination board.

5.4 Exams

Regulations for exams

All regulations for exams and the study programme are laid down in the 'Onderwijs en Examenregeling Master' (OER). This is available on the site of Natural Science and the faculty website: www.ru.nl/natuurwetenschappen, www.ru.nl/fnwi.
A copy, in Dutch, of the OER is reproduced in this prospectus. No rights can be derived from this reproduction.

For students who started their study before September 2002 (doctoral students), the older versions of the OER still apply. Also these can be found on the site.

The OER states for instance the exact educational programme for each cohort of students, regulations for tentamens and practica, and language criteria. Other exam-regulations, such as compensation and judicia are specified by the examination board and can be found elsewhere in this prospectus.

Appeal

If you disagree with the grade of an exam, or find yourself dishonestly treated, it is best to first contact the teacher and/or the student advisor and see if things can be worked out. Also the examination board can be asked to rule or advise. Ultimately, if matters cannot be agreed upon, it is possible to ask for a ruling of the Board of Appeal.
Such an appeal must be directed in writing to the Board, within four weeks after the disputed decision was made. The student deans (Decanen) at Comeniuslaan can assist in such a procedure.

College van Beroep voor de Examens
Comeniuslaan 4
Postbus 9102
6500 HC Nijmegen
tel. (024) 3612270
See also www.ru.nl/studenten/

Doctoral/Master Exam

The Exam comprises a number of interim exams (tentamen, practica, internship) with a total of at least 120 ec.
The composition of the exam requires approval of the examination board. Make sure you get this well in advance. The exam is passed if all components were graded 6 or higher
Dates for Bachelor/Master/Doctoral Exams in 2008/2009

Last day to register	**Date of the exam**
September 15, 2008	September 29, 2008
October 13, 2008	October 27, 2008
November 10, 2008	November 24, 2008
December 1, 2008	December 15, 2008
January 12, 2009	January 26, 2009
February 2, 2009	February 16, 2009
March 16, 2009	March 30, 2009
April 6, 2009	April 20, 2009
May 11, 2009	May 25, 2009
June 15, 2009	June 29, 2009
May 29, 2009	August 30, 2009

It is possible to register for an exam if all results of interim exams are registered in KISS.
After passing the exam you will receive a notification with which you can apply for your diploma at the central students administration (Comeniuslaan 4).
Every month diploma'a are presented in a ceremony.

Exception for August 30:
For the August 30 exam it is possible to register without all results being registered in KISS. This has to done before May 31st. The last results need to be registered by August 30.

To register for an exam you need to present:
- a valid Students card (collegekaart), both parts
- the approval of the examination board for your study programme
- A valid passport or ID-card. Drivers license is not sufficient
- students with a propedeuse/bachelor not from Radboud University: Your last diploma

When the exam is passed and approved by the examination board the Diploma will be made at the central administration (Comeniuslaan)

The graduation ceremony takes the following format:
1. The chaiman of the examination board introduces the ceremony
2. Each candidate gives a short presentation of his/her graduation work and receives the Diploma from his/her graduation professor
3. The ceremony is celebrated over drinks at the Faculty or at the Aula

If necessary it is possible to receive your diploma earlier than the official cermonies. Please contact the students coordinator in that case.

5.5 Regulation for internships

Learning outcomes

After completing an internship a student should be able to:

- locate and use relevant literature to solve a scientific problem
- be acquainted with multidisciplinary scientific research
- be able to set up a scientific experiment
- obtain, interpret and use the results of such an experiment
- communicate about his/her research written and in a presentation
- participate in a topical scientific discussion

In order to achieve these goals, the following aspects should be taken care of:

1. **Knowledge:** Before starting an internship the research practica (doctoral student), or bachelorstage (master student) should be fulfilled. If a subject is chosen that is outside the scope of the students bachelor specialisation, certain courses may be required by the research department chosen for the internship.
2. **Approval:** Each research internship should be approved for multidisciplinarity by two members of the Steering Board of Natural Science. For this, an **internship-form** must be filled out by the student together with, and signed by the aspired supervisor. The form should state the content and goal of the internship, the daily supervisor, the intended duration and, if needed, the required specialisation courses. **It must clearly describe the multidisciplinary aspects of the internship.**
3. **External:** External internships are supervised by a professor at one of the research departments of the faculty of science.
4. **Guidance:** each internship is performed under responsibility of a member of the scientic staff of the faculty of science. Daily guidance can be given by a knowledgable researcher at the department. These should be stated on the form mentioned above.
5. **Report:** An internship is always concluded by a written report and usually by an oral presentation. A (digital) copy of the report should be handed to the study-coordinator of Natural Science. This is for external reviewing purposes by the educational inspection.
6. **Conflicts:** In case a conflict arises between student and research supervisor the members of the stuurgroep (see colofon) can mediate. Ultimately any decision can be formally put before the 'college van decanen'. For this see the www.ru/nl/studenten.

Two internships

A Master in Natural Science should be at home in two disciplines. Therefore it is required to perform two internships in two different research groups of different disciplines. That is the only way to become truly acquainted with the concepts and methodology of both fields of science. It is possible to do a combined intership at two departments that cooperate on an interdisciplinary subject. Further information on possibilities and requirements are available from the study-coordinator.

Requirements

Different research groups, different disciplines work in different ways and may have different approaches toward internships. In any internship practical work, a written report and a presentation are required. As a theoretical part some groups offer the possibility to write a literature thesis, other groups have caput courses and monthly tests or require external courses to be followed.

The requirements for an internship should be agreed upon before starting and written down on the internship-agreement.

Research reports and theses

The student needs to produce a number of copies of research reports and theses.
The secretariat of Natural Science requires one (digital) copy for the examination board.

Marks

The supervisor and, if applicable, the leader of the research department will mark the internship and the report. In a mutual desicion with the student the duration of the internship and amount of ec's is agreed upon.
In cases of disagreement the study coordinator, or the students-advisor may mediate.
Ultimately there is the appeal procedure described in the vademecum and elsewhere in the study guide.

5.6 Committees and Board

Examination Board

Decides on admission, approval of exams, extra resits, extraordinary study-tracks, etc. Requests must be directed in writing to the chairman (possible via the secretary).

Chairman: Dr. G.W. Vuister	Secretary: Dr. L.J.J. Laarhoven
NCMLS 0.25 G.Vuister@nmr.ru.nl	HG 01.061 L.Laarhoven@science.ru.nl

Composition on July 1, 2008:
Dr. G.W. Vuister (Chairman)
Dr. L.J.J. Laarhoven (Secretary)
Dr. P.C.M. Christianen
Prof.dr. C.C.A.M. Gielen
Drs. W.J.J. Gielen
Dr. J.T.M. Keltjens
Dr. C. Logie

Programme Committee

Eight members (4 teachers and 4 students) monitor the curriculum and the quality of teaching, approves the examination regulation and advises the Programme Coordinator.
In the Natural Science Programme Committee at least one teacher from each of the disciplines is present. Email: olc-nw@student.science.ru.nl.

Composition on 1 September 2008:
Dr. H.L.M. Meekes (chairman)
Dr. L.J.J. Laarhoven (Secretary)
Dr. J.L. Peters (Biology)
Prof. Dr. H.J. Kappen (Physics)
Prof. dr. A.E. Rowan (Chemistry)
L. Janssen (student, Master)
R. Rammeloo (student, Master)
J. Boekhoudt (student, 3rd year)
J. Rotink (student, 3rd year)

Steering Board
Because of the broadness of the Natural Science programme a steering board assists the programme coordinator. Its members represent the three disciplines:

Prof. dr. A.J. van Opstal (Physics - programme coordinator and chairman)
Prof. dr. S. Wijmenga (Chemistry)
Dr. W.J.J.M. Scheenen (Biology)
Dr. L.J.J. Laarhoven - Secretary

Board of the Educational Institute Molecular Sciences
Director:
prof.dr. F. Rutjes (Floris)
tel.: 3653202
e-mail: f.rutjes@science.ru.nl
Room HG 03.024

Board:
Dr. H.R.M.J. Wehrens (Programme Coordinator Chemistry)
Prof. dr. E.J.J. van Zoelen (Programme Coordinator Moleculaire Levenswetenschappen)
Prof. dr. A.J. van Opstal (Programme Coordinator Natuurwetenschappen)
Secretary: Dr. L.J.J. Laarhoven

Advisory Board/Cluster Committee
The advisory board meets four times per year and consists of the programme coordinators, the student coordinators, three lectureres and three students.
On July 1, 2008:

Prof. F. Rutjes, dr. R. Wehrens, prof. J. van Zoelen, prof. J. van Opstal
dr. L. Laarhoven (Luc-Jan), mrs.drs. G. Coppens (Gerrie) en mrs. W. Philipse (Wilma), (study coordinators)
dr. W. Boelens (Wilbert), mrs.prof.dr. L. Buydens (Lutgarde) and dr. N. Dam (Nico) (lecturers)
Albert Konijnenberg, Roel Manning and Judith Rotink, (students)
secretary: dr. L. Laarhoven (Luc-Jan), e-mail: l.laarhoven@science.ru.nl

Coordinator international affairs for Molecular Sciences
dr. L. Laarhoven (Luc-Jan)
room HG01.061
tel.: 3653434
e-mail: l.laarhoven@science.ru.nl

5.7 Facilities

Libraries
The Faculty Library can easily be found in the new Huygens building. It houses the main part of the science collection and offers room for students to quietly study.
Every student also has access to the **University Library**, Erasmuslaan 36. Your university Collegekaart allows you to borrow books. Most of these are stored in a back-office.

Computerfacilities
Every student receives a personal login an email address. These can be used to work on the computers at the Faculty and are needed to register for examinations. The Huygens building houses a number of terminal-rooms that can be used by students, but may also be reserved for teaching. The builiding is equipped with a wireless network for laptops.

Selfstudy
In the Faculty library ample space for individual stuyding is available.

Studymaterial
Most books can be purchased via the students-association Leonardo. Readers are sold by the teachers or the secretariat, or at the Campusshop in Thomas van Acquinostraat.

Copying
To use the copymachines in the building a copycard is required. This can be purchased at the Library.

Service for students affairs
Is located at Comeniuslaan 4-6 and offers a number of services. For details and opening hours, please see www.ru.nl/studenten

Balie Studentenzaken and Central Students Administration
Registring as a student, study-information, student-counsellors, psychologists, courses in student management. These services can be very helpfull.

Comeniuslaan 4 and 6, Nijmegen
tel: (024)-3612345
email: balie@dsz.ru.nl (to make an appointment)

Studie Loopbaan Advies Groep
Offers an Infotheek that can be helfull with
- choice of study or profession
- training in jobapplication
- studying abroad

Faculty Students Administration

All results and administrative data are kept at the Faculty. Registring for interim exams and, e.g., change of address should be done electronically via KISS.
Applying for exams (propedeuse, Bachelor, Master) must be done in person, with your students card (Collegekaart) and, if applicable, foreign diploma's, at the Faculty Students Administration. Dates and deadlines of the exams can be found in this prospectus.

Studentenadministratie/examenbureau B-faculteiten (FSA)
Huygensgebouw room HG 00.134
tel. 3653392 / 3652247

Hours:
Mo - Thur 13.00 - 16.00 h
Friday 9.00 - 12.00 h

Leonardo da Vinci

Students club Leonardo da Vinci offers seminars, books and social events to Natural science students. The bar is located in the 'south cantina'.
Leonardo@science.ru.nl - www.ru.nl/leonardo

Information Channels at this university:

- Website R.U. Nijmegen: www.ru.nl
- Infotheek Dienst Studentenzaken
- email and blackboard
- VOX Magazine Radboud Universiteit Nijmegen

5.8 Preparing to find a job

Every year the 'BBB' organizes a job-market where companies present themselves to students. See www.bbb.science.ru.nl.

In connection to this day there are also possibilities to to have an appointment with recruiters and to participate in several workshops.
Stichting BBB-CarrièreBeurs, PO-box 9010, 6500 GL Nijmegen; tel. (024) 3652388, e-mail: bbb@science.ru.nl

The central students facility at Comeniuslaan 4-6 offers courses in presentation and has facilities for job-orientation.

5.9 The academic calendar

Semesters/Quarters

Courses may be planned according to quarters or semesters. Two quarters make one semester. These are:

first quarter:	Mo September 1, 2008 - Fri November 7, 2007
second quarter:	Mo November 10, 2008 - Fri January 30, 2009
third quarter:	Mo February 2, 2009 - Fri April 17, 2009
fourth quarter:	Mo April 20, 2009 - Fri July 10, 2009

Holidays in 2007-2008

Some holidays (vakantie) can be used for tentamens. Research does not really care for holidays.

Herfstvakantie (Autumn)	Mo October 13, 2008 - Fri October 17, 2008
Kerstvakantie (Christmas)	Mo December 22, 2008 - Fri January 2, 2009
Voorjaarsvakantie (Carnival)	Mo February 23, 2009 - Fri February 27, 2009
Goede Vrijdag (Good Friday)	Fri April 10, 2009
Tweede Paasdag (Easter Monday)	Mo April 13, 2009
Meivakantie (Springbreak)	April 27 - May 5, 2009 (including Queens Day and Liberation Day)
Hemelvaart (Ascensionday)	May 21 and 22, 2009
Tweede Pinksterdag (Whit Monday)	Mo June 1, 2009
Resit examination period	August 17 - 28, 2009

6 Examination regulations

6.1 Examination regulation OER (in Dutch)

Onderwijs- en examenregeling natuurwetenschappen - will become available in English in the online prospectus

Deel II - Masteropleiding

Paragraaf 1 Algemene bepalingen

Artikel 1.1 Toepasbaarheid van de regeling

Deze regeling is van toepassing op het onderwijs en de examens van de masteropleiding natuurwetenschappen, hierna te noemen: de opleiding.
De opleiding wordt verzorgd door het onderwijsinstituut Moleculaire Wetenschappen (hierna te noemen: het onderwijsinstituut) binnen de faculteit Natuurwetenschappen, Wiskunde en Informatica (hierna te noemen: de faculteit).

Artikel 1.2 Begripsbepalingen

De in dit reglement voorkomende begrippen hebben, indien die begrippen ook voorkomen in de Wet op het hoger onderwijs en wetenschappelijk onderzoek (WHW) de betekenis die deze wet eraan geeft.

In deze regeling wordt verstaan onder:
a. de wet: de Wet op het Hoger onderwijs en Wetenschappelijk onderzoek afgekort tot WHW en zoals sindsdien gewijzigd;
b. opleiding: de masteropleiding bedoeld in artikel 7.3a, lid 1 onder b van de wet;
c. student: hij of zij die is ingeschreven aan de Radboud Universiteit Nijmegen voor het volgen van het onderwijs en/of het afleggen van de tentamens en de examens van de opleiding;
d. bacheloropleiding: de opleiding, genoemd in artikel 7.3a van de wet;
e. practicum: een praktische oefening als bedoeld in art. 7.13, lid 2 onder d van de wet, in één van de volgende vormen:
- het maken van een scriptie;
- het maken van een werkstuk of een proefontwerp;
- het uitvoeren van een ontwerp- of onderzoekopdracht;
- het verrichten van een literatuurstudie;
- het schrijven van een computerprogramma;
- het verrichten van een stage;
- het deelnemen aan veldwerk of een excursie;
- het uitvoeren van proeven en experimenten;
- of het deelnemen aan een andere onderwijsactiviteit, die gericht is op het bereiken van bepaalde vaardigheden.

f. tentamen: een onderzoek naar de kennis, het inzicht en de vaardigheden van de student met betrekking tot een bepaalde onderwijseenheid, alsmede de beoordeling van dat onderzoek door minstens één daartoe door de examencommissie aangewezen examinator.

g. examen: toetsing, waarbij door de examencommissie wordt vastgesteld of alle tentamens van alle tot de master behorende onderwijseenheden met goed gevolg zijn afgelegd, voor zover de examencommissie niet heeft bepaald dat het examen tevens omvat een door haar zelf te verrichten onderzoek naar de kennis, inzicht en vaardigheden van de examinandus alsmede de beoordeling van de uitkomsten van dat onderzoek. (conform artikel 7.10 van de wet).
h. examencommissie: de examencommissie van een opleiding ingesteld conform artikel 7.12 van de wet. Zie ook Structuurregeling RU.
i. examinator: degene die door de examencommissie wordt aangewezen ten behoeve van het afnemen van tentamens, conform artikel 7.12 van de wet;
k. EC: studiepunten conform het European Credit Transfer System
l. werkdag: maandag t/m vrijdag m.u.v. de erkende feestdagen.
m. studiegids: de gids voor één van de opleidingen genoemd in artikel 1 bevattende de specifieke informatie voor de masteropleiding
n. instelling: Radboud Universiteit Nijmegen

Artikel 1.3 Doel van de opleiding
Met de opleiding wordt beoogd:
a. kennis, vaardigheid en inzicht op het gebied van de natuurwetenschappen, in het bijzonder op interdisciplinaire onderwerpen tussen de natuurkunde, scheikunde en biologie;
b. academische vorming;
c. management- en toepassingvariant (MT-variant), aanvullend aan het onder a en b genoemde: kennis, vaardigheid en inzicht op relevante terreinen van de bedrijfskunde en bestuurskunde;
d. communicatievariant (C-variant), aanvullend aan het onder a en b genoemde: kennis, vaardigheid en inzicht op relevante terreinen van de communicatie;
e. educatievariant (E-variant), aanvullend aan het onder a en b genoemde: het verwerven van competenties als docent.

Artikel 1.4 Vorm van de opleiding
De opleiding wordt voltijds verzorgd.

Artikel 1.5 De examens van de opleiding
1. In de opleiding kunnen de volgende examens worden afgelegd:
a. het master examen.

Artikel 1.6 Studielast
1. De studielast wordt uitgedrukt in ec. Eén ec is gelijk aan 28 uren studie.
2. Het masterexamen heeft een studielast van 120 ec.

Artikel 1.7 Taal
1. Het onderwijs wordt in het Engels gegevens en kan in het Nederlands worden gegeven indien de herkomst van de studenten geen Engelstalig onderwijs vereist.
2. Voor in het Engels verzorgd onderwijs is de Gedragscode vreemde taal van de RU Nijmegen van toepassing. (zie appendix)
3. Voor deelname aan het in het Engels verzorgde onderwijs en eventueel de tentamens is een voldoende beheersing van het Engels vereist. Aan deze eis is voldaan, als de student:
1. in het bezit is van een diploma voorbereidend wetenschappelijk onderwijs; of
2. in het bezit is van een diploma van voortgezet onderwijs, behaald aan een Engelstalige instelling van voortgezet onderwijs binnen of buiten Nederland; of
3. in het bezit is van een diploma hoger beroepsonderwijs, of

4. een van de onderstaande toetsen heeft afgelegd:
* de TOEFL met een score van 550 of hoger voor de papieren versie;
* de TOEFL met een score van 215 of hoger voor de computer versie;
* de IELTS met een score van 6 of hoger.

De examencommissie kan in voorkomende gevallen beoordelen of een student de Engelse taal in voldoende mate beheerst.

Paragraaf 2 De Masteropleiding

Artikel 2.1 Samenstelling masteropleiding (O-variant)
De masteropleiding Natuurwetenschappen O-variant behelst een specialisatie op een grensvlak tussen twee van de drie hoofddisciplines natuurkunde, scheikunde en biologie en omvat de volgende onderdelen met de daarbij vermelde studielast:
1. verplichte onderdelen:
a. hoofdvakstage (incl. max. 12 ec specialisatiecolleges): 60 ec
b. bijvakstage (incl. max. 6 ec specialisatiecolleges): 30 ec
2. natuurwetenschappelijke mastervakken: 12 ec
3. keuzeruimte, waarvan 6 ec volledig vrij: 15 ec
4. vakken met een wijsgerig karakter: 3 ec

De hoofd- en bijvakstage dienen in twee verschillende leerstoelgroepen, behorend tot de twee disciplines op het tussengebied waarvan de specialisatie plaatsvindt, te worden verricht. De specialisatiecolleges dienen betrekking te hebben op het onderzoeksgebied van de stage

De hoofdvakstage heeft een omvang van 60 ec inclusief maximaal 12 ec aan specialisatiecolleges, een verslag en een colloquium en/of een scriptie, in een vorm zoals gebruikelijk binnen het onderzoeksinstituut waar de stage wordt verricht.
De bijvakstage heeft een omvang van 30 ec inclusief maximaal 6 ec aan specialisatiecolleges, een verslag en een colloquium en/of een scriptie, in een vorm zoals gebruikelijk binnen het onderzoeksinstituut waar de stage wordt verricht.
Na goedkeuring van de examencommissie kunnen hoofd- en bijvakstage met afwijkende omvang worden afgelegd of een gecombineerde stage waarbij twee leerstoelgroepen als boven bedoeld bij betrokken zijn.

Artikel 2.2 Samenstelling masteropleiding (MT-variant)
De masteropleiding MT-variant behelst een specialisatie op een grensvlak tussen twee van de drie hoofddisciplines natuurkunde, scheikunde en biologie, gecombineerd met management-toegepast specifieke onderdelen en omvat de volgende onderdelen met de daarbij vermelde studielast:
1. opleidingsspecifieke onderdelen met een totale studielast van 54 ec:
a. hoofdvakstage (incl max. 9 ec specialiatiecolleges (45 ec)
b. keuzevakken op natuurwetenschappelijk gebied (9 ec)

De hoofdvakstage heeft een omvang van 45 ec inclusief maximaal 9 ec specialisatiecolletges, een verslag en een colloquium en/of een scriptie, in de vorm zoals gebruikelijk binnen het onderzoeksinstituut waar de stage wordt verricht.

2. MT-onderdelen met een totale studielast van 57 ec:
a. verplichte onderdelen:
- business & Society (5 ec),
- Organisation Theory (5 ec),
- Innovation management (5 ec),
- Strategy & Marketing (5 ec),
- Financie & Accounting (5 ec).

b. MT-keuzevakken (5 ec) te kiezen uit:
- Science & Entrepreneurship (3 ec)
- Research strategy & management (3 ec)
- Industrial Chemistry (3 ec)
- Algemene managementvaardigheden (2 ec)
- dan wel een onder goedkeuring van de voor de variant verantwoordelijke docent vrij te kiezen vak;

c. een afstudeerproject (27 ec)

3. vrije-keuzeruimte met een minimum omvang van 6 ec;
4. een of meer vakken met een wijsgerig karakter met in totaal een minimum omvang van 3 ec.

Artikel 2.3 Samenstelling masteropleiding (C-variant)
De masteropleiding C-variant behelst een specialisatie op een grensvlak tussen twee van de drie hoofddisciplines natuurkunde, scheikunde en biologie, gecombineerd met communicatie specifieke onderdelen en omvat de volgende onderdelen met de daarbij vermelde studielast:

1. opleidingsspecifieke onderdelen met een totale studielast van 54 ec:
a. hoofdvakstage (incl max. 9 ec specialiatiecolleges (45 ec)
b. keuzevakken op natuurwetenschappelijk gebied (9 ec)
De hoofdvakstage heeft een omvang van 45 ec inclusief maximaal 9 ec specialisatiecolletges, een verslag en een colloquium en/of een scriptie, in de vorm zoals gebruikelijk binnen het onderzoeksinstituut waar de stage wordt verricht.

2. C-onderdelen met een totale studielast van 57 ec:
a. Verplichte vakken in het eerste jaar:
- Science Communication (voorheen Inleiding Massacommunicatie) (3 ec)
- Science and Societal Interaction (voorheen Communicatie & Verandering) (3 ec)
- Risk Communication (voorheen Crisis- en risicocommunicatie) (3 ec)
- Boundary Work (voorheen Grenswerk) (3 ec)

b. Verplichte vakken in het tweede jaar:
- Framing Knowledge (voorheen Kaders en beelden) (3 ec)
- Knowledge Society (voorheen Kennis in context) (3 ec)
- Science, Media and Strategy (voorheen Strategieën in wetenschapscommunicatie) (3 ec)

c. C-Keuzevakken, goed te keuren door de voor de variant verantwoordelijke docent, met een totale studielast van 6 ec
d. Stage en verslaglegging (30 ec)

3. vrije-keuzeruimte met een minimum omvang van 6 ec;

4. een of meer vakken met een wijsgerig karakter met in totaal een minimum omvang van 3 ec.

Artikel 2.4 Samenstelling masteropleiding (E-variant)
Er is geen eerstegraads lerarenopleiding Natuurwetenschappen.
Met de juiste keuzevakken of een aanvullend programma kan het Instituut voor Leraar en School studenten Natuurwetenschappen toelaten tot de lerarenopleidingen Natuurkunde en/of Scheikunde.

De masteropleiding E-variant behelst een specialisatie op een grensvlak tussen twee van de drie hoofddisciplines natuurkunde, scheikunde en biologie, gevolgd door een opleiding tot eerstegraads onderwijsbevoegdheid en omvat de volgende onderdelen met de daarbij vermelde studielast:
1. opleidingsspecifieke onderdelen met een totale studielast van 54 ec:
a. hoofdvakstage (incl max. 9 ec specialiatiecolleges (45 ec)
b. keuzevakken op natuurwetenschappelijk gebied (9 ec)
De hoofdvakstage heeft een omvang van 45 ec inclusief maximaal 9 ec specialisatiecolletges, een verslag en een colloquium en/of een scriptie, in de vorm zoals gebruikelijk binnen het onderzoeksinstituut waar de stage wordt verricht.

2. E-onderdelen met een totale studielast van 57 ec: 2 stages met een totale studielast van 57 ec. Deze stages zijn integrale leertrajecten, waarin een continue wisselwerking van theorie, praktijk, intervisie en supervisie plaatsvindt.

3. vrije-keuzeruimte met een minimum omvang van 6 ec;

4. een of meer vakken met een wijsgerig karakter met in totaal een minimum omvang van 3 ec.

Artikel 2.5 Goedkeuring samenstelling master opleiding
De door de student gekozen samenstelling van de masteropleiding wordt vooraf ter goedkeuring voorgelegd aan de examencommissie.

Paragraaf 3 Tentamens en examens van de opleiding

Artikel 3.1 Volgorde van tentamens

1. O-variant: Aan de volgorde van de tentamens van de O-variant worden geen nadere eisen gesteld.

2. MT-variant:
Aan de tentamens van de onderdelen Innovatiemanagement en Strategie & Marketing kan niet eerder worden deelgenomen dan nadat de tentamens Bedrijf & Maatschappij en Organisatiekunde zijn behaald.

Het afstudeerproject van de MT-variant kan niet eerder worden verricht dan nadat
- er een voldoende resultaat behaald is voor en/of vrijstelling is verleend van onderdelen van de desbetreffende masteropleiding met een studielast van tenminste 45 ec waaronder de praktische werkzaamheden in het kader van de onderzoekstage van de opleiding;
- een voldoende is behaald voor het merendeel van de vijf MT-basisvakken zoals genoemd in artikel 2.2.

3. C-variant:
De stage van de C-variant kan niet eerder worden verricht dan nadat:
- er een voldoende resultaat behaald is voor en/of vrijstelling is verleend van onderdelen van de desbetreffende masteropleiding met een studielast van tenminste 45 ec waaronder de praktische werkzaamheden in het kader van de onderzoekstage van de opleiding;
- een voldoende is behaald voor het merendeel van de C-basisvakken zoals genoemd in artikel 2.3.

4. E-variant:
De stages van de E-variant kunnen niet eerder worden verricht dan nadat er een voldoende resultaat behaald is voor en/of vrijstelling is verleend van onderdelen van de desbetreffende masteropleiding met een studielast van tenminste 30 ec waaronder de praktische werkzaamheden in het kader van de onderzoekstage van de opleiding.

Artikel 3.2 Tijdvakken en frequentie tentamens
1. Tot het afleggen van de tentamens van de in de artikel 2.1 t/m 2.4 genoemde onderdelen wordt tenminste tweemaal per jaar de gelegenheid gegeven, met uitzondering van practica of het praktische gedeelte van onderdelen, welke slechts eenmaal per studiejaar kunnen worden afgelegd. Tentamens worden afgenomen aansluitend aan het onderwijs alsmede gedurende een nader te bepalen periode bij voorkeur direct voor het begin van het volgende studiejaar. De Regeling beperking tentamendeelname is hierbij van toepassing (zie appendix).
2. In afwijking van het bepaalde in het eerste lid wordt tot het afleggen van het tentamen van een onderdeel, waarvan het onderwijs in een bepaald studiejaar niet is gegeven, in dat jaar tenminste eenmaal de gelegenheid gegeven.

Artikel 3.3 Vorm van de tentamens
1. De tentamens van de onderdelen, genoemd in artikel 2 kunnen op de volgende wijze worden afgelegd:
a. schriftelijk en/of
b. praktische oefening + verslag en/of
c. computerpracticum en/of
d. computertentamen en/of
e. mondelinge presentatie.

2. Op verzoek van de student kan de examencommissie toestaan dat een tentamen op een andere wijze dan vorenbedoeld wordt afgelegd.
3. Aan studenten met een functiestoornis wordt de gelegenheid geboden de tentamens op een zoveel mogelijk aan hun individuele handicap aangepaste wijze af te leggen. De examencommissie wint zo nodig deskundig advies in alvorens te beslissen. Indien de betreffende studenten bij een tentamen bepaalde faciliteiten nodig hebben, dienen zij deze uiterlijk twee weken voor het tentamen bij de docent aan te vragen.

Artikel 3.4 Mondelinge tentamens
1. Mondeling wordt niet meer dan één persoon tegelijk getentamineerd, tenzij de examencommissie anders heeft bepaald.
2. Het mondeling afnemen van een tentamen is niet openbaar, tenzij de examencommissie of de desbetreffende examinator in een bijzonder geval anders heeft bepaald, dan wel de student daartegen bezwaar heeft gemaakt.

Artikel 3.5 Vaststelling en bekendmaking tentamenuitslag
1. De examinator stelt terstond na het afnemen van een mondeling tentamen de uitslag vast en reikt de student een desbetreffende schriftelijke verklaring uit.
2. De examinator stelt de uitslag van een schriftelijk tentamen vast binnen 30 dagen na de dag waarop het is afgelegd, of zoveel eerder als nodig is om 10 werkdagen voor de herkansings-datum bekend te zijn, en verschaft de administratie van de faculteit de nodige gegevens ten behoeve van de uitreiking van het bewijsstuk omtrent de uitslag aan de student.
3. Voor een op andere wijze dan mondeling of schriftelijk af te leggen tentamen bepaalt de examencommissie tevoren op welke wijze en binnen welke termijn de student een verklaring omtrent de uitslag zal ontvangen.
4. Op de verklaring omtrent de uitslag van een tentamen wordt de student gewezen op het inzagerecht, bedoeld in artikel 3.7, eerste lid, alsmede op de beroepsmogelijkheid bij het college van beroep voor de examens.
5. De termijn waarop studenten in beroep kunnen gaan bij het College van Beroep voor de Examens tegen een beslissing van de examencommissie is vier weken (zoals vastgesteld in de Structuurregeling RU).

Artikel 3.6 Geldigheidsduur
1. De geldigheidsduur van behaalde onderdelen is onbeperkt.
2. In afwijking van het bepaalde in het eerste lid kan de examencommissie voor een onderdeel aanvullende dan wel vervangende eisen stellen, indien naar haar oordeel de eisen met betrekking tot dat onderdeel aanzienlijk afwijken van die, gesteld ten tijde van het afleggen van het tentamen.

Artikel 3.7 Inzagerecht
1. Gedurende tenminste zes weken na de bekendmaking van de uitslag van een schriftelijk tentamen krijgt de student op zijn verzoek inzage in zijn beoordeeld werk. Tevens wordt hem op zijn verzoek tegen kostprijs een kopie verschaft van dat werk.
2. Gedurende de in het eerste lid genoemde termijn kan elke belanghebbende kennis nemen van vragen en opdrachten van het desbetreffende tentamen, alsmede zo mogelijk van de normen aan de hand waarvan de beoordeling heeft plaatsgevonden.
3. De examencommissie kan bepalen, dat de inzage of de kennisneming geschiedt op een vaste plaats en op tenminste twee vaste tijdstippen. Indien de betrokkene aantoont door overmacht verhinderd te zijn of te zijn geweest op een aldus vastgestelde plaats en tijdstip te verschijnen, wordt hem een andere mogelijkheid geboden, zo mogelijk binnen de in het eerste lid genoemde termijn.

Artikel 3.8 Vrijstelling
De examencommissie kan de student op diens verzoek, gehoord de desbetreffende examinator, vrijstelling verlenen van een tentamen, indien de student:
a. hetzij een qua inhoud en niveau overeenkomstig onderdeel van een universitaire of hogere beroepsopleiding heeft voltooid;
b. hetzij aantoont door werk- c.q. beroepservaring over voldoende kennis en vaardigheden te beschikken m.b.t. het desbetreffende onderdeel.

Artikel 3.9 Examen
1. Tot het afleggen van het examen wordt de gelegenheid geboden nadat de student voldoende bewijzen overlegd heeft van door hem behaalde onderdelen van dat examen.
2 De examencommissie stelt de uitslag van het examen vast, alsmede de regelen met betrekking

tot de wijze waarop de uitslag van het examen wordt vastgesteld.
3. Alvorens de uitslag van het examen vast te stellen kan de examencommissie zelf een onderzoek instellen naar de kennis van de student met betrekking tot een of meer onderdelen of aspecten van de opleiding, indien en voorzover de uitslagen van de desbetreffende tentamens haar daartoe aanleiding geven.

Artikel 3.10 Graad
1. Aan degene die het masterexamen met goed gevolg heeft afgelegd, wordt de graad 'Master of Science' verleend.
2. De verleende graad wordt op het getuigschrift van het examen aangetekend.
3. Aan degene die de O-variant als bedoeld in artikel 2.1 met goed gevolg heeft afgelegd, wordt aan de mastergraad de differentiatie Onderzoek toegevoegd.
4. Aan degene die de MT-variant als bedoeld in artikel 2.2 met goed gevolg heeft afgelegd, wordt aan de mastergraad de differentiatie Management & Toepassing toegevoegd.
5. Aan degene die de C-variant als bedoeld in artikel 2.3 met goed gevolg heeft afgelegd, wordt aan de mastergraad de differentiatie Communicatie toegevoegd.
6. Aan degene die de E-variant als bedoeld in artikel 2.4 met goed gevolg heeft afgelegd, wordt aan de mastergraad de differentiatie Educatie toegevoegd en wordt door het Instituut voor Leraar en School een eerstegraads docentbevoegdheid verleend.

Paragraaf 4 Vooropleiding

Artikel 4.1 Toelatingseisen masteropleiding

1 Tot de opleiding worden, onverlet het bepaalde in artikel 4.3, toegelaten:
1. degene die het afsluitend examen van de bacheloropleiding Natuurwetenschappen aan de RU Nijmegen met goed gevolg heeft afgelegd;
2. degene die in het bezit is van het bewijs van toelating, dat het College van Bestuur voor het desbetreffende studiejaar afgeeft (artikel 4.2).

Artikel 4.2 Bewijs van toelating
Voor het bewijs van toelating komt in aanmerking degene die:
1. in het bezit is van een getuigschrift dat ten minste gelijkwaardig is aan het diploma als bedoeld in artikel 4.1. onder a,
2. of anderszins naar het oordeel van de examencommissie blijk heeft gegeven van geschiktheid voor het volgen van de opleiding,
3. en het bewijs heeft geleverd van voldoende beheersing van de Engelse taal, zoals bepaald in artikel 1.7.

Artikel 4.3 Flexibele instroom in de masteropleiding
1. De examencommissie kan, voor zover de beschikbare onderwijscapaciteit dit toelaat, besluiten dat de student die is ingeschreven voor de bacheloropleiding natuurwetenschappen van de RU Nijmegen, kan worden toegelaten tot de masteropleiding natuurwetenschappen van de RU Nijmegen, voordat deze met goed gevolg het afsluitend examen van de bacheloropleiding natuurwetenschappen van de RU Nijmegen heeft afgelegd.
2. Toelating is alleen mogelijk, als de student voldoet aan de volgende voorwaarden:
a. er is voldoende resultaat behaald voor en/of vrijstelling verleend van de onderdelen van het bachelorexamen met een studielast van 162 ec;

b. in afwijking van het bepaalde in lid 2.a geldt voor studenten begonnen op 1 september 2002 dat toelating mogelijk is wanneer er voldoende resultaat is behaald voor en/of vrijstelling verlend van de onderdelen van het bachelorexamen met een studielast van 150 ec.

3. De student die krachtens dit artikel is toegelaten tot het onderwijs van de opleiding, dient uiterlijk een jaar na die toelating het afsluitend examen van de in het eerste lid bedoelde bacheloropleiding met goed gevolg te hebben afgelegd. Wanneer aan deze voorwaarde niet is voldaan wordt de student uitgesloten van deelname aan tentamens van de opleiding totdat het afsluitend examen van genoemde bacheloropleiding met goed gevolg is afgelegd.eeft niet het recht het afsluitend examen van de opleiding af te leggen zolang als hij niet in het bezit is van het getuigschrift van het met goed gevolg afgelegd afsluitend examen van de in het eerste lid bedoelde bacheloropleiding.

Paragraaf 5 Studiebegeleiding

Artikel 5.1 Studievoortgangsadministratie
1. De faculteit registreert de individuele studieresultaten van de studenten.
2. Zij verschaft elke student tenminste eenmaal per jaar een overzicht van de door hem behaalde studieresultaten.

Artikel 5.2 Studiebegeleiding
De opleiding draagt zorg voor de introductie en de studiebegeleiding van de studenten, die voor de opleiding zijn ingeschreven, mede ten behoeve van hun oriëntatie op mogelijke studiewegen in en buiten de opleiding.

Paragraaf 6 Overgangs- en slotbepalingen

Artikel 6.1 Tentamens en examens voor studenten begonnen voor 1 september 2002
1. Tot 1 september 2007 wordt aan studenten die voor 1 september 2002 zijn begonnen de gelegenheid geboden de tentamens alsmede het doctoraalexamen van de opleiding scheikunde af te leggen zoals vastgesteld in de OER die in werking trad op 1 september 2002.
2. In bijzondere gevallen kan de examencommissie aan andere studenten dan die bedoeld in het eerste lid, toestemming verlenen tentamens en examens af te leggen volgens de in het eerste lid bedoelde onderwijs- en examenregeling. Het bepaalde in het eerste lid blijft daarbij onverminderd van kracht.

Artikel 6.2 Overstap van ongedeelde opleiding naar bachelor/master structuur
Een student, als bedoeld in art. 6.1, kan onder de volgende voorwaarden deelnemen aan de opleiding krachtens deze onderwijs- en examenregeling:
a. behaalde studieresultaten kunnen worden gewaardeerd als vrijstelling voor overeenkomstige onderdelen 'nieuwe stijl';
b. deelneming staat open voorzover de gefaseerde invoering van het onderwijs en de tentamens volgens deze regeling dat feitelijk toelaten.

Artikel 6.3 Vaststelling OER/ Wijzigingen
(NB: zie ook Structuurregeling artikelen 11 en 18 en Reglement UGV en FGV artikel 3.3.1.)

1. Deze regeling en wijzigingen van deze regeling worden door de decaan, na advisering door de opleidingscommissie scheikunde en na instemming van de FGV, bij afzonderlijk besluit vastgesteld.

2. Een wijziging van deze regeling heeft geen betrekking op het lopende studiejaar, tenzij de belangen van de studenten daardoor redelijkerwijs niet worden geschaad.
3. Een wijziging kan voorts niet ten nadele van studenten van invloed zijn op enige andere beslissing, die krachtens deze regeling door de examencommissie is genomen ten aanzien van een student.

Artikel 6.4 Bekendmaking
1. De decaan draagt zorg voor een passende bekendmaking van deze regeling, van de regelen en richtlijnen die door de examencommissie zijn vastgesteld, alsmede van elke wijziging van deze stukken.
2. Elke belangstellende kan op het faculteitsbureau een exemplaar van de in het eerste lid bedoelde stukken verkrijgen.

Artikel 6.5 Inwerkingtreding

Deze regeling treedt in werking op 1 september 2008.

APPENDIX

Gedragscode vreemde taal, als bedoeld in artikel 7.2 sub c WHW (vastgesteld door het College van Bestuur)

Binnen de RU geldt de onderstaande gedragscode

Artikel 1
Binnen de Radboud Universiteit Nijmegen kan het verzorgen van onderwijs en het afnemen van tentamens en examens in een andere taal dan het Nederlands geschieden indien de specifieke aard, inrichting of kwaliteit van het onderwijs, dan wel de herkomst van de studenten daartoe noodzaakt.

Artikel 2
Een besluit tot het gebruik van een vreemde taal wordt genomen door de decaan van de desbetreffende faculteit, na advies ingewonnen te hebben van de opleidingscommissie. De decaan neemt daarbij de volgende uitgangspunten in acht:
- De noodzaak van het gebruik van een andere taal dan het Nederlands dient vast te staan;
- Tentamens en examens kunnen op verzoek van de student in het Nederlands worden afgelegd;
- Het gebruik van een vreemde taal mag niet leiden tot verzwaring van de studielast van de opleiding;
- Het anderstalig onderwijs voldoet aan dezelfde kwaliteitseisen als het onderwijs verzorgd in het Nederlands.

Artikel 3
In de onderwijs- en examenregeling van de opleiding wordt het besluit van de decaan verwerkt.

Artikel 4
De decaan van de faculteit brengt jaarlijks het College van Bestuur verslag uit van de door hem genomen besluiten.

Opleidingscommissie

Overeenkomstig art. 9.18 WHW is er een opleidingscommissie. Deze commissie heeft tot taak:
1. advies uit te brengen over de onderwijs- en examenregeling,
2. het jaarlijks beoordelen van de uitvoering van de onderwijs- en examenregeling, en
3. het desgevraagd of uit eigen beweging advies uitbrengen aan de onderwijsdirecteur en de decaan over alle aangelegenheden betreffende het onderwijs in de opleiding.

Regeling beperking tentamendeelname

Op alle tentamens van de binnen de faculteit verzorgde opleidingen is onderstaande Regeling beperking tentamendeelname van toepassing. Deze is op 7 januari 2004 vastgesteld door de faculteitsleiding na advies van het Onderwijsmanagementteam.

- Studenten mogen maximaal 3 keer aan een tentamen deelnemen. Studenten zijn verplicht zich voor het tentamen elektronisch aan te melden via KISS tot 5 werkdagen voor het tentamen. De surveillant dient e.e.a. te controleren en bijschrijvingen op de deelnamelijst worden niet toegestaan. De docent mag slechts tentamenopgaven uitreiken aan studenten, die vooraf aangemeld zijn.
- Studenten dienen zich af te melden als ze niet deelnemen aan een tentamen:
  - tot 5 werkdagen voor het tentamen in Kiss,
  - daarna tot 1 werkdag voor het tentamen wordt afgenomen.

Deze laatstgenoemde afmelding geschiedt uitsluitend schriftelijk/elektronisch bij de docent/ betreffend secretariaat. Als een student niet deelneemt zonder zich tijdig te hebben afgemeld, verspeelt hij/zij een tentamenkans (1 van de 3).

- Indien het tentamen na 3 keer nog niet is behaald, dient de student voor iedere volgende keer dat hij/zij aan het tentamen wil deelnemen een schriftelijk verzoek in te dienen bij de examencommissie van zijn/haar opleiding.
- De studentenadministratie is verantwoordelijk voor het registreren van het aantal keren, dat een student heeft deelgenomen aan een tentamen.
- Deze regeling betreft zowel mondelinge als schriftelijke tentamens.
- Deze regeling geldt voor alle studenten van de Faculteit Natuurwetenschappen, Wiskunde en Informatica.
- Indien de student kan aantonen door overmacht verhinderd te zijn geweest deel te nemen aan het tentamen dan wel zich niet tijdig heeft kunnen afmelden, kan de examencommissie besluiten de inschrijving niet als deelname te beschouwen.
- Deze regeling treedt in werking met ingang van 1 februari 2004 voor wat betreft tentamens waarvoor studenten zich na die datum voor de eerste maal inschrijven

6.2 Regels en richtlijnen van de examencommissie

Regels en richtlijnen van de examencommissie Natuurwetenschappen

Artikel 1 - toepassingsgebied
Deze regels en richtlijnen zijn van toepassing op de tentamens en examens in de bachelor en master opleiding natuurwetenschappen van de Radboud Universiteit Nijmegen, hierna te noemen 'de opleiding'.

Artikel 2 - begripsomschrijving
In deze regels en richtlijnen wordt verstaan onder:
- examenregeling: de onderwijs- en examenregeling voor de in artikel 1 genoemde opleiding vastgesteld door het faculteitsbestuur Natuurwetenschappen, Wiskunde en Informatica;
- examinandus: degene die zich onderwerpt aan een tentamen of examen;
- tentamen: het onderzoek naar en de beoordeling van kennis, vaardigheden en inzicht, ongeacht de vorm waarin dit onderzoek plaatsvindt;
- student: degene die als zodanig is ingeschreven voor de opleiding;
- examinator: examinator als bedoeld in artikel 7.12 lid 3 WHW.

Artikel 3 - samenstelling examencommissie
Leden van de examencommissie zijn docenten betrokken bij het onderwijs van de opleiding Natuurwetenschappen. Zij worden benoemd door het faculteitsbestuur NWI. Zorg wordt gedragen voor een evenwichtige verdeling van docenten over de disciplines die betrokken zijn bij de opleiding.

Artikel 4 - dagelijkse gang van zaken examencommissie
De examencommissie wijst uit haar midden een lid aan dat belast is met de behartiging van de dagelijkse gang van zaken van de examencommissie.

Artikel 5 - aanmelding tentamen
1. Conform de facultaire richtlijn mogen studenten maximaal 3 keer aan een tentamen deelnemen. Een volgende deelname kan slechts plaatsvinden na toestemming van de examencommissie.
2. Als tijdige aanmelding geldt een elektronische opgave tenminste 5 werkdagen voor het tijdstip waarop het desbetreffende tentamen zal worden afgenomen. De examencommissie kan in bijzondere gevallen toestaan dat een latere aanmelding niettemin als tijdig wordt aangemerkt.
3. Deelneming aan een schriftelijk tentamen kan pas plaatsvinden na deugdelijke en tijdige aanmelding bij de facultaire studentenadministratie.

Artikel 6 - cijfers
De cijfers die voor de beoordeling van de tentamens gebruikt mogen worden zijn uitsluitend:
10,0; 9,5; 9,0; 8,5; 8,0; 7,5; 7,0; 6,5; 6,0; 5,0; 4,0; 3,0; 2,0; 1,0;
of indien geen cijfer wordt gegeven: Voldaan. Cijfers 6,0 of hoger zijn 'voldoende'.

Artikel 7 - vaststelling uitslag examen
1. De examencommissie stelt de uitslag van het examen vast bij gewone meerderheid van stemmen.
2. Staken de stemmen, dan is de examinandus afgewezen.
3. Indien een tentamen meer dan eenmaal is afgelegd, neemt de examencommissie bij de vaststelling van de uitslag van het examen de hoogst behaalde beoordeling in beschouwing.

4. Men is dan en alleen dan geslaagd voor het propedeutisch examen natuurwetenschappen indien:
a. alle onderdelen van het examen met een voldoende (minimaal cijfer 6,0) zijn beoordeeld
of
b. alle onderdelen op één na voldoende. Die ene onvoldoende is een 5,0, en wordt gecompenseerd met minimaal een 7,0 voor een van de andere onderdelen.

5. Men is dan en alleen dan geslaagd voor het bachelor examen natuurwetenschappen indien de propedeuse natuurwetenschappen is behaald en:
a. alle onderdelen van de post-propedeuse met een voldoende (minimaal cijfer 6,0) zijn beoordeeld;
of
b. alle onderdelen van de post-propedeuse op één na voldoende. Die ene onvoldoende is een 5,0, en wordt gecompenseerd met minimaal een 7,0 voor een van de andere onderdelen. De bachelorstage dient voldoende te zijn beoordeeld.

6. Men is dan en alleen dan geslaagd voor het master examen natuurwetenschappen als alle onderdelen van het master-examen met een voldoende (minimaal cijfer 6,0) zijn beoordeeld.
7. In bijzondere gevallen kan de examencommissie afwijken van het hiervoor bepaalde.

Artikel 8 - judiciumregeling
Aan de examens kan door de examencommissie een judicium worden toegekend.
Daarbij worden in aanmerking genomen respectievelijk de onderdelen van de propedeuse, van de postpropedeuse (bachelorjaar 2 en 3) en van het masterprogramma.

Voor het propedeutisch examen en het bachelor-examen luidt het judicium:
- bij een gemideldde van 7,0 tot 7,5: 'met genoegen';
- bij een gemiddelde van 7,5 tot 8,0: 'met veel genoegen';
- bij een gemiddelde gelijk of hoger dan 8,0: 'cum laude'.
- Wanneer in de lijst een 5 staat, wordt het judicium 1 graad verlaagd.

Voor het master-examen luidt het judicium:
- bij een gemiddelde van 7,0 tot 7,5: 'met genoegen';
- bij een gemiddelde van 7,5 tot 8,0: 'met veel genoegen';
- bij een gemiddelde gelijk of hoger dan 8,0, waarbij het gemiddelde van de uitgevoerde stages tenminste 8,5 is: 'cum laude'.
- Wanneer in de lijst een 5 staat, wordt het judicium 1 graad verlaagd.

Artikel 9 - toelating tot afleggen van tentamens van het bachelor examen natuurwetenschappen
1. De toelating tot het afleggen van post-propedeuse tentamens van het bachelorexamen natuurwetenschappen wordt een student verleend
a. indien het propedeutisch examen natuurwetenschappen met goed gevolg is afgelegd;
b. danwel vrijstelling is verkregen van het afleggen van het propedeutisch examen natuurwetenachappen;
c. danwel tenminste 45 ec van de propedeuse voldoende (cijfer 6,0 of hoger) is afgelegd. De bachelorstage kan niet worden begonnen voordat de propedeuse en tenminste 60 ec van de postpropedeutische onderdelen zijn behaald.
2. In alle overige gevallen wordt de student geen toelating tot het afleggen van onderdelen van het bachelorexamen natuurwetenschappen verleend.

3. In bijzondere gevallen kan de examencommissie afwijken van het bepaalde in het voorgaande lid.

Artikel 10 - vrijstellingsverzoek
1. Een verzoek om vrijstelling van een tentamen of examen wordt schriftelijk en met redenen omkleed ingediend bij de examencommissie.
2. De examencommissie beslist binnen 3 maanden na ontvangst van het verzoek. De verzoeker wordt onverwijld in kennis gesteld van de beslissing.

Artikel 11 - overige verzoeken
Verzoeken tot goedkeuring van een studieprogramma of opname van een enkel vak daarin, alsmede verzoeken om na drie pogingen deel te nemen aan een tentamen, worden schriftelijk aan de examencommissie gericht.
De examencommissie neemt indien mogelijk eens per maand beslissingen over de liggende verzoeken. De beslissingen worden per omgaande meegedeeld aan de indiener.
Studenten krijgen in de regel na drie pogingen nog één extra tentamenkans. In overleg met de docent kunnen daarbij nadere eisen worden gesteld.

Artikel 12 - orde tijdens een tentamen
1. De examinator van een examenonderdeel zorgt dat t.b.v. de schriftelijke examinering surveillanten worden aangewezen die erop toezien dat het tentamen in goede orde verloopt.
2. De examinandus is verplicht zich op verzoek van de surveillant te legitimeren door middel van zijn collegekaart.
3. De examinandus is verplicht de aanwijzingen van de examencommissie c.q. de examinator, die voor de aanvang van het tentamen zijn gepubliceerd, alsmede aanwijzingen die tijdens het tentamen en onmiddellijk na afloop daarvan worden gegeven, op te volgen.
4. Volgt de examinandus een of meer aanwijzingen als bedoeld in het voorgaande lid niet op, dan kan hij door de examencommissie c.q. de examinator worden uitgesloten van de verdere deelname aan het desbetreffende tentamen. De uitsluiting heeft tot gevolg dat er geen uitslag wordt vastgesteld van dat tentamen en dat de examinandus wordt uitgesloten van deelneming aan dat tentamen. Voordat de examencommissie c.q. de examinator een besluit tot uitsluiting neemt, stelt zij de examinandus in de gelegenheid te worden gehoord.

Artikel 13 - fraude
1. Er is sprake van fraude wanneer als gevolg van handelen of verzuim van handelen van een examinandus het vormen van een juist oordeel omtrent zijn kennis, inzicht en vaardigheden geheel of gedeeltelijk onmogelijk wordt.
2. In geval van fraude tijdens het afleggen van een tentamen kan de examencommissie de examinandus uitsluiten van verdere deelname aan het tentamen.
3. De beslissing inzake uitsluiting wordt genomen naar aanleiding van door de examinator of surveillant geconstateerde of vermoede fraude.
4. In spoedeisende gevallen kan de examinator een voorlopige beslissing tot uitsluiting nemen op grond van zijn constatering danwel redelijk vermoeden of, indien van toepassing, een mondeling verslag van de surveillant. Desgevraagd draagt de examinator er zorg voor dat, binnen een redelijke termijn, het verslag van de geconstateerde fraude op schrift wordt gesteld en in afschrift aan de examinandus wordt verstrekt.
5. De examinandus kan aan de examencommissie verzoeken de uitsluiting ongedaan te maken.
6. Voordat de examencommissie een beslissing neemt op een verzoek, als bedoeld in het vijfde lid, stelt zij de examinandus en de examinator in de gelegenheid te worden gehoord.

7. Een uitsluiting heeft tot gevolg, dat geen uitslag wordt vastgesteld voor het in het tweede lid bedoelde tentamen.

Artikel 14 - wijziging regels en richtlijnen
Geen wijzigingen in deze regeling vinden plaats, die van toepassing zijn op het lopende studiejaar, tenzij de belangen van studenten hierdoor redelijkerwijs niet worden geschaad.

artikel 15 - onvoorzien
In gevallen waarin deze 'regels en richtlijnen van de examencommissie natuurwetenschappen' niet voorzien danwel twijfel bestaat over de interpretatie ervan, beslist de examencommissie natuurwetenschappen.

Artikel 16 - inwerkingtreding
Deze regels en richtlijnen treden in werking op 1 september 2006

Aldus vastgesteld door de examencommissie voor de opleiding natuurwetenschappen op 9 oktober 2006

6.3 List of lecturers

Name	Email	Phone	Room
Boelens, Dr. W.C.	w.boelens@ncmls.ru.nl	16753	NCMLS 3.93
Born, Dr. J.G. van den	r.vandenborn@science.ru.nl	52188	HG02.826
Brock, Prof.dr. R.	R.Brock@ncmls.ru.nl	66213	NCMLS
Broek, Drs. J.G.J. van den	j.vandenbroek@science.ru.nl	53346	HG00.109
Buydens, Prof. dr. L.M.C.	l.buydens@science.ru.nl	53192	HG02.721
Camp, Dr. H.J.M. op den	h.opdencamp@science.ru.nl	52657	HG02.407
Cornelissen, Dr. J.J.L.M.	j.cornelissen@science.ru.nl	52381	HG03.016
Dankbaar, Prof. dr. B.	b.dankbaar@fm.ru.nl	52684	HG02.809
Dankelman, Drs. I.E.M.	i.dankelman@science.ru.nl	52150	HG02.827
Deen, Dr. P.M.T.	p.deen@ncmls.ru.nl	17347	NCMLS
Delft, Dr. F.L. van	f.vandelft@science.ru.nl	52373	HG03.022
Derksen, Prof. dr. J.T.P.	h.derksen@science.ru.nl		HG02.831
Dolstra, Dr. H.	h.dolstra@chl.umcn.nl		
Dresen, H.M.	l.dresen@science.ru.nl	52269	HG02.814
Feiters, Dr. M.C.	m.feiters@science.ru.nl	52016	HG03.021
Flik, Prof. dr. G.	g.flik@science.ru.nl	53242	HG02.014
Gelder, Dr. R. de	r.degelder@science.ru.nl	52842	HG03.009
Gielen, Prof. dr. C.C.A.M.	s.gielen@science.ru.nl	14242	GG0.16 M244
Groenenboom, Dr. ir. G.C.	g.groenenboom@theochem.ru.nl	53034	HG03.044
Groot, Prof. dr. R.A. de	r.degroot@science.ru.nl	52211	HG03.065
Hageman, Dr. P.R.	p.hageman@science.ru.nl	53158	HG03.524

Hermkens, Prof. dr. P.H.H.			
Herp, Dr. F. van	f.vanherp@ncmls.ru.nl	10566	NCMLS 6.91
Hest, Prof. dr. ir. J.C.M. van	j.vanhest@science.ru.nl	53204	HG03.015
Heuvel, Dr. L.P.W.J. vanden	b.vandenheuvel@cukz.umcn.nl	17983	
Jenks, Dr. B.G.	b.jenks@science.ru.nl	53335	HG02.021
Jetten, Prof. dr. ir. M.S.M.	m.jetten@science.ru.nl	52941	HG02.406
Kappen, Prof. dr. H.J.	b.kappen@science.ru.nl	14241	GG0.12 M244
Keltjens, Dr. J.T.M.	j.keltjens@science.ru.nl	53437	HG02.342
Kentgens, Prof. dr. A.P.M.	a.kentgens@nmr.ru.nl	52078	HG03.343
Keulartz, Prof. dr. F.W.J.	j.keulartz@science.ru.nl	52851	HG02.823
Kiriliouk, Dr. A.I.	a.kirilyuk@science.ru.nl	53183	HG01.077
Klaren, Dr. P.H.M.	p.klaren@science.ru.nl	53245	HG02.011
Kouwer, Dr. P.H.J.	p.kouwer@science.ru.nl	52464	HG03.011
Kuppeveld, Dr. F. van	F.vanKuppeveld@ncml.ru.nl	17574	NCMLS
Leenaars, Dr. ir. P.P.A.M.	m.leenaars@cdl.umcn.nl	19379	M220.00.027
Lekkerkerk, Ir. L.J.	h.lekkerkerk@fm.ru.nl	11931	TvA1 01.35
Ligthart, Dr. P.E.M.	p.ligthart@fm.ru.nl	12020	TvA1 01.34
Logie, C.	c.logie@ncmls.ru.nl	10525	NCMLS 3.93
Lohrum, Dr. M.A.E.	m.lohrum@ncmls.ru.nl	10541	NCMLS 3.87
Lowik, Dr. D.W.P.M.	d.lowik@science.ru.nl	52382/53185	HG03.016
Maan, Prof. dr. ir. J.C.	jc.maan@science.ru.nl	53422	HFML 02.14
Martens, Prof. dr. G.J.M.	g.martens@ncmls.ru.nl	10564	NCMLS 6.95
Masereeuw, Mw dr. R.	r.masereeuw@ncmls.ru.nl	13730	NCMLS 7.030
Meijer, Prof. dr. E.W.			
Migchels, Dr. ir. N.G.	n.migchels@fm.ru.nl	11613	TvA1 01.53
Minnaar, Drs. R.A.	r.minnaar@fm.ru.nl	11765	TvA1 02.24
Nolte, Prof. dr. R.J.M.	r.nolte@science.ru.nl	52143	HG03.025
Roubos, Prof. dr. E.W.	e.roubos@science.ru.nl	52360	HG02.024
Rowan, Prof. dr. A.E.	a.rowan@science.ru.nl	52323	HG03.020
Rutjes, Prof. dr. F.P.J.T.	f.rutjes@science.ru.nl	53202	HG03.024
Schaftenaar, Dr. G.	g.schaftenaar@cmbi.ru.nl	19674	NCMLS 0.18
Scholten, P.H.T.	p.scholten@science.ru.nl	52427	HG02.829
Segers, S.A.J.	s.segers@science.ru.nl	53201	HG02.832
Smelik, Dr. B.	bsmelik@cs.ru.nl	52204	HG02.045
Speller, Prof. dr. S.E.	s.speller@science.ru.nl	52369	HG01.075
Theuvenet, Dr. A.P.R.	a.theuvenet@science.ru.nl	52013	HG02.205
Veenstra, Dr. G.J.C.	g.veenstra@ncmls.ru.nl	10541	NCMLS 03.87
Vissers, Dr. G.A.N.	g.vissers@science.ru.nl	52686	HG02.830
Vlieg, Prof. dr. J. de	j.devlieg@organon.com		
Vriend, Prof. dr. G.	g.vriend@cmbi.ru.nl	19521	NCMLS 0.27
Water, Prof. dr. ir. W. van de		33944	HG01.714
Wehrens, Dr. H.R.M.J.	r.wehrens@science.ru.nl	52053	HG02.730
Welters, Drs. R.P.M.M.	r.welters@honours.ru.nl	11354	
Wiegers, Dr. S.A.J.	s.wiegers@science.ru.nl	52947	HFML 01.08
Wieringa, Prof. dr. B.	b.wieringa@ncmls.ru.nl	14287	NCMLS
Wijmenga, Prof. dr. S.S.	sybrenw@science.ru.nl	53384	HG03.345
Wijs, Dr. ir. G.A. de	g.dewijs@science.ru.nl	52984	HG03.075
Willems, Dr. P.H.G.M.	p.willems@ncmls.ru.nl	14589	NCMLS 7.39
Wit, Prof. dr. J. de	j.dewit@science.ru.nl	52684	HG02.809

Index of courses