



Universiteit Leiden

# *Appendices to the Course and Examination Regulations Master's Programmes Faculty of Science*

valid from September 01, 2017

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e-Prospectus ..... [www.studiegids.leidenuniv.nl](http://www.studiegids.leidenuniv.nl)

# MSc Mathematics

**CROHO-number 66980**

The programme is taught in Leiden by the Mathematical Institute (MI).

Leiden University offers six specialisations of an MSc programme in mathematics. Three of these correspond to research specialisations in the Leiden Mathematical Institute. The remaining three specialisations combine research in mathematics with Science Based Business (SBB), Science Communication and Society (SCS) and Education (EDU).

The duration of each programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Mathematics, with specification of the specialisation, if applicable. Details are provided below. All specialisations have the same Director, the same Board of Examiners, and the same Department Teaching Committee. A Board of Admissions will advise on admissions. Exceptions to this are formed by the specialisations SBB, SCS, and EDU, which for the specialisation-specific part each have their own specialisation coordinator and a Board of Examiners appointed by the Faculty of Science.

The goal of each programme is to train the student as an independent researcher, and to develop the necessary skills and proficiency to advance their career.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Admission is possible throughout the year, but international students are strongly advised to start in September or February.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation. Individual combinations of the research programmes, with research projects from different groups, are possible in principle, depending on the decision by the Board of Examiners. The choice in optional courses in the MSc programme may be limited by the need to adapt the programme to the present knowledge of the candidate. This will be recorded in the student's study plan.

Students from any university in The Netherlands with a BSc degree in Mathematics or with a BSc major in Mathematics will be admitted to the MSc Mathematics programme. For students with a Dutch bachelor degree in a related field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Mathematics.

Students with a bachelor degree in Mathematics, or in a field related to Mathematics, at an international University can apply for admission. The Board of Admissions will evaluate whether their degree may be considered equivalent to a Dutch BSc in Mathematics, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.0
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

### **Specialisation**

## **Algebra, Geometry and Number Theory (ALGANT)**

### **Description**

The MSc programme Algebra, Geometry and Number Theory leads students to a high level of knowledge in this area. It consists of advanced courses from the field and a final research project including a master thesis and an oral presentation of it. Students with this MSc in Mathematics are admissible to a PhD programme. The programme is suited as preparation for an academic career, in particular via a subsequent PhD study, but also for a career as mathematical researcher outside the universities.

### **Programme**

For each student a programme will be tailored individually. It consists of a choice of advanced courses (at least 60 EC; at least 30 EC of these must be obtained via courses of the Dutch Master Programme in Mathematics) from algebra, algebraic and analytic number theory, algebraic and differential geometry, topology, cryptology, combinatorics, a research project in mathematics (at least 40 EC, including 7 EC for the thesis and an oral presentation), and a free choice of courses from any field (maximum 20 EC); required is a total of at least 120 EC.

### **Specialisation**

## **Applied Mathematics**

### **Description**

The MSc programme Applied Mathematics leads students to a high level of knowledge in this area. It consists of advanced courses from the field and a final research project including a master thesis and an oral presentation of it. Students with this MSc in Mathematics are admissible to a PhD programme. The programme is particularly suited as preparation for a career as mathematical researcher in industry, government and other institutions, but also for an academic career, in particular via a subsequent PhD-study.

### **Programme**

For each student a programme will be tailored individually. It consists of a choice of advanced courses (at least 60 EC; at least 30 EC of these must be obtained via courses of the Dutch Master Programme in Mathematics) on differential equations, dynamical systems, analysis of industrial problems, measure- and integration theory, probability theory, statistics, functional analysis, numerical analysis, operations research, a research project in mathematics (at least 40 EC, including 7 EC for the thesis and an oral presentation), and a free choice of courses from any field (maximum 20 EC); required is a total of at least 120 EC.

### **Specialisation**

## **Statistical Science for the Life and Behavioural Sciences**

Since September 2016 the new MSc programme Statistical Science of the Life and Behavioural Science has started. The programme of the specialisation Statistical Science for the Life and

Behavioural Science of the MSc programme Mathematics is identical to the MSc programme. For the description, qualifications of admission and programme of both the specialisation within Mathematics and the MSc programme Statistical Science for the Life and Behavioural Science, see page 6.

As of September 1, 2016 no new students will be admitted to the specialisation Statistical Science for the Life and Behavioural Science of the MSc programme Mathematics.

## **Specialisation Science Based Business**

### **Description**

The specialisation Mathematics and Science Based Business (SBB) offers students the possibility to combine mathematics with knowledge, insights and skills in the area of Management, Business and Entrepreneurship.

Students are encouraged to broaden their horizon, to form an opinion on and prepare for a career in industry and to enhance competences for pursuing entrepreneurial business opportunities created in science and research.

Students who complete the specialisation Mathematics and Science Based Business are admissible to a PhD programme.

### **Programme**

The Mathematics and Science Based Business (SBB) programme consists of:

- a research project in Mathematics<sup>1</sup> of 40 EC (incl. 7 EC for the master's thesis and an oral presentation) in one of the research groups of the Leiden Mathematical Institute;
- 20 EC of courses to be selected in correspondence with the research topic;
- a maximum of 20 EC of electives within either Mathematics or the SBB component; and
- the SBB Management or SBB New Technology Ventures track<sup>2</sup> as described on page 81.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## **Specialisation Science Communication and Society**

### **Description**

The specialisation Mathematics and Science Communication and Society (SCS) offers students the possibility to combine mathematics and science communication.

Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set.

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<sup>1</sup> For the programme Mathematics and Science Based Business the SBB internship should be connected to the research project in Mathematics.

<sup>2</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

Students who complete the specialisation Mathematics and Science Communication and Society are admissible to a PhD programme in mathematics or in science communication.

## Programme

The Mathematics and Science Communication and Society (SCS) programme consists of:

- a research project in Mathematics of 40 EC (incl. 7 EC for the master's thesis and an oral presentation) in one of the research groups of the Leiden Mathematical Institute;
- 20 EC of courses to be selected in correspondence with the research topic; and
- a maximum of 20 EC of electives within either Mathematics or the SCS component; and
- the Science Communication and Society component<sup>3</sup> as described on page 84.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

## Specialisation Education

### Description

The specialisation Mathematics and Education (EDU) prepares students for a career as mathematics (wiskunde) teacher qualified to teach in Dutch secondary education.

Students who complete the specialisation Mathematics and Education are admissible to a PhD programme.

### Additional qualifications for admission

In addition to the general admission requirements of the MSc programme in Astronomy, students must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden – gevorderd, met spreekvaardigheid minimaal een 7 ½).

## Programme

The Mathematics and Education (EDU) programme consists of:

- a research project in Mathematics of 40 EC (incl. 7 EC for the master's thesis and an oral presentation) in one of the research groups of the Leiden Mathematical Institute;
- 20 EC of courses to be selected in correspondence with the research topic; and
- the Education component as described on page 85.

The Mathematics component of the programme will be followed during the first year of study, the Education component will be followed during the second year.

When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced with 30 EC. The remaining 30 EC can be used for both the Mathematics and Education component of the MSc programme.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.

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<sup>3</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

# MSc Statistical Science for the Life and Behavioural Sciences

**CROHO-number 60957**

The MSc programme Statistical Science for the Life and Behavioural Sciences is taught in Leiden by the following institutes:

- Mathematical Institute;
- Department Medical Statistics and Bioinformatics – Leiden University Medical Center;
- Methodology and Statistics – Institute of Psychology – Faculty of Social and Behavioural Sciences;
- Biometris – Wageningen UR;
- Leiden Institute for Advanced Computer Science.

Leiden University offers two specialisations of the MSc programme Statistical Science for the Life and Behavioural Sciences. The first focuses on the Life and Behavioural Sciences, and the second focuses on Data Science.

The duration of each programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Statistical Science for the Life and Behavioural Sciences. The tracks have the same Director, the same Board of Examiners, and the same Department Teaching Committee. A Board of Admissions will advise on admissions.

The goal of each programme is to train the student as an independent researcher, to become a PhD candidate, and to develop the necessary skills and proficiency to advance their career as an applied statistician.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Admission is possible throughout the year, but students are strongly advised to start in September. Furthermore, the procedure to come to a decision for admission might take a month longer for starting dates other than September 1 or February 1.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students from any university in The Netherlands with a BSc degree in Mathematics or with a BSc major in Mathematics will be admitted to the MSc Statistical Science for the Life and Behavioural Sciences programme. For students with a Dutch bachelor degree in a related field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Mathematics.

Students with a wide range of other (international) bachelor degrees are also eligible for admission. Their academic programme must include at least one introductory course and one advanced course in statistics or probability. The Board of Admissions will evaluate whether their degree may be considered equivalent to a Dutch BSc Mathematics, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking

- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

## Specialisation Statistical Science

### Description

The MSc specialisation in the Life and Behavioural Sciences focuses on statistics in the broad sense, with biostatistics (for general medicine and life sciences) and statistics in the behavioural sciences. Some of the key words are longitudinal analysis, genomics, genetics, high dimensional ("big") data, medical imaging, psychometrics and sensory metrics. The emphasis is on application in multidisciplinary environments of the life and behavioural sciences.

Students will gain a thorough knowledge and understanding of statistical models, including their application and interpretation in a broad range of empirical research. They are able to critically study scientific research and develop new models and techniques.

Students learn practical skills such as statistical programming, statistical consultation, and written and oral presentation of analysis and research results.

### Programme

The nominal duration of the programme will be two years (120 EC). The programme consists of a core (53 EC), specialization courses (9 EC), elective courses (24 EC), an Internship (10 EC) and a Master's Thesis (24 EC). The Internship may be included into the Master's Thesis to form an Extended Master's Thesis (34 EC).

The courses from the core programme and the specialisation courses are compulsory and count for 62 EC. At least 12 EC should come from the elective courses within the programme, leaving 12 EC free of choice.

Students must have completed at least 45 EC of the program of compulsory courses to enrol in the "Statistical Consulting" course and the Internship. Students should have completed at least 74 EC to start their Master Thesis research.

<b>Core Programme</b>	<b>EC</b>	<b>Level</b>
Statistics and probability	9	400
Mathematics for Statisticians	3	300
Statistical Computing with R	6	400
Linear & Generalized Linear Models and Linear Algebra	9	400
Multivariate and Multidimensional Data Analysis	6	500
Bayesian Statistics	6	500
Mixed and Longitudinal Modelling	6	500
Statistical Consulting	5	500
Advanced Statistical Computing	3	500

### Specialisation Courses

Study Designs in the Life and Behavioural Sciences	6	400
Introduction to the Life and Behavioural Sciences	3	400
	<b>9</b>	

### Elective Courses

<i>Choose 4 out of the following 8 courses:</i>	<b>24</b>	
Statistical Learning Theory	6	500
Psychometrics and SEM	6	500
High-Dimensional Data Analysis	6	500
Statistical Genetics	6	500
Survival Analysis	6	500
Survey Data Analysis	6	500
Optional Course 1	6	
Optional Course 2	6	

### Internship, Thesis

Internship	10	600
Thesis	24	600
Extended Thesis	34	600
<i>Choose either the Internship and Thesis separate, or choose the Extended thesis:</i>	<b>34</b>	

**Total** **120**

## Specialisation

### Data Science: Statistical Science

#### Description

The MSc specialisation Data Science equips students with a broad basis in statistics combined with state-of-the-art knowledge in Data Science through collaboration between the Mathematical Institute and the Leiden Institute for Advanced Computer Science. Some of the key words are Databases, Advances in Data Mining, Networks, Pattern Recognition, and Deep Learning.

Students will gain a thorough knowledge and understanding of statistical models, especially in relation to Data Science, including their application and interpretation in a broad range of empirical research. They are able to critically study scientific research and develop new models and techniques.

Students learn practical skills such as statistical programming, statistical consultation, data base management and written and oral presentation of analysis and research results.

#### Programme

The nominal duration of the programme will be two years (120 EC). The programme consists of a core (53 EC), specialisation courses (27 EC), specialised electives (6 EC), an internship (10



EC) and a Master's Thesis (24 EC). The Internship may be included into the Master's Thesis to form an Extended Master's Thesis (34 EC).

The courses from the core programme and the specialisation courses are compulsory and count for 80 EC. Students choose 1 out of 2 specialised electives (6 EC).

Students must have completed at least 45 EC of the program of compulsory courses to enrol in the "Statistical Consulting" course and the Internship. Students should have completed at least 74 EC to start their Master Thesis research.

	<b>EC</b>	<b>Level</b>
<b>Core Programme</b>		
Statistics and probability	9	400
Mathematics for Statisticians	3	300
Statistical Computing with R	6	400
Linear & Generalized Linear Models and Linear Algebra	9	400
Multivariate and Multidimensional Data Analysis	6	500
Bayesian Statistics	6	500
Mixed and Longitudinal Modelling	6	500
Statistical Consulting	5	500
Advanced Statistical Computing	3	500
	<b>53</b>	
<b>Specialisation Courses</b>		
Databases	6	200
Introduction to Data Science	3	400
Statistical Learning Theory	6	500
High-Dimensional Data Analysis	6	500
Advances in Data Mining	6	500
	<b>27</b>	
<b>Elective courses</b>		
Bayesian Networks	<b>6</b>	500
Neural Networks	6	500
<i>Choose 1 elective</i>	6	
<b>Internship, Thesis</b>		
Internship	10	600
Thesis	24	600
Extended Thesis	34	600
<i>Choose either the Internship and Thesis separate, or choose the Extended thesis:</i>	<b>34</b>	
<b>Total</b>	<b>120</b>	

# MSc Computer Science

**CROHO-number 60300**

The Leiden Institute of Advanced Computer Science (LIACS) is the computer science institute of Leiden University. The LIACS offers six MSc specialisations within the computer science curriculum. The first two are the specialisations '*Computer Science and Advanced Data Analytics*' and '*Bioinformatics*'. The latter is in combination with Delft University of Technology. The third specialisation '*Data Science*' is in combination with the Mathematical Institute. The remaining three specialisations combine research in computer science with *Science Based Business* (SBB), *Science Communication and Society* (SCS), and *Education* (EDU). In addition, LIACS offers two Master programmes in *Media Technology* and in *ICT in Business*, which are described separately in this appendix.

The duration of each programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Computer Science, with a description of the specialisation. Details are provided below. All specialisations have the same Director, the same Board of Examiners, and the same Department Teaching Committee. A Board of Admissions will advise on admissions. Exceptions to this are formed by the specialisations SBB, and SCS, which for the specialisation-specific part each have their own specialisation coordinator and a Board of Examiners appointed by the Faculty of Science.

The goal of each programme is to train the student as an independent researcher, and to develop the necessary skills and proficiency to advance their career.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Students can start the programme in September or February (for the specialisation Data Science in September only).

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation. The choice of the specialisation courses in the MSc programme may be limited by the need to adapt the programme to the present knowledge of the candidate.

Students from any university in the Netherlands with a BSc degree in Computer Science or with a BSc major in Computer Science will be admitted to the MSc Computer Science programme. For students with a Dutch bachelor degree in a related field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Computer Science.

Students with a bachelor degree in Computer Science, or in a field related to Computer Science, at an international University are also eligible for admission. The Board of Admissions will evaluate whether their degree may be considered equivalent to a Dutch BSc in Computer Science, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA,

UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

## Specialisation

### Computer Science and Advanced Data Analytics

#### Description

The master programme Computer Science and Advanced Data Analytics offers future-oriented topics in computer science, with a focus on both foundations and applications of advanced algorithms and techniques in discovering meaningful patterns in data (= Data Analytics) via advanced data mining, optimization, and decision support techniques.

This specialisation of the MSc programme Computer Science is intended to provide students with a thorough computer science background that will allow them to pursue careers in research or industrial environments. The strength of the programme is its individual approach: for each student an individually tailored programme can be designed. This programme consists of courses and seminars, a research project and a Master's thesis research project.

The specialisation Computer Science and Advanced Data Analytics covers of three different areas: *Advanced Data Science* (with a focus on data mining, algorithmic aspects of data analysis, optimization algorithms, and social network analysis), *Algorithms and Software Technology* (with a focus on software engineering, software testing, parallel programming, component coordination, and algorithms inspired by nature), and *Computer Systems, Imagery and Media* (with a focus on multimedia systems, audio signal processing, visualization techniques, and embedded systems). Students with an MSc in Computer Science are admissible to a PhD programme.

#### Programme

The programme is 120 EC in extent, and consists of level-500 specialisation courses and seminars (first year; 60 EC in total), and two research projects in computer science (second year; 60 EC in total).

Components	Level	EC
Specialisation courses and seminars	500	60
Computer Science introductory research project	600	18
Computer Science master's research project (incl. 7 EC for a thesis and an oral presentation)	600	42

## Specialisation

### Bioinformatics

#### Description

The specialisation Bioinformatics is taught in Leiden and Delft by the Leiden Institute of Advanced Computer Science (LIACS) and the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) of Delft University of Technology. The main focus of this programme is on *Data Analysis and Modelling*, which represents the unique expertise of the different research groups of Leiden University and the Delft University of Technology participating in this *research oriented* specialisation. This expertise is used to address issues like

data capturing, data warehousing, data analysis and data mining that have become major challenges in the field of Bioinformatics due to the tremendous complexity and abundance of quantitative data in biology and medicine. On the other hand, bioinformatics heavily contributes to the identification of new fundamental computer science principles and the development of new informatics tools.

Bioinformatics offers a unique new synthetic approach for formulating hypotheses and solving problems in (molecular-) biology versus the classical reductionist approach.

## Programme

The programme is 120 EC in extent. The programme is outlined below.

<i>Core Programme</i>	<b>Level</b>	<b>EC</b>
Pattern Recognition	500	6
Databases and Data mining	500	6
Functional Genomics and Systems Biology	500	6
Computational Molecular Biology	500	6

Every student of the Bioinformatics specialisation has to complete the core programme.

## Specialisation Courses

500 24

A choice can be made out of different specialisation courses. The specialisation courses have level 500, and range from 3 - 6 EC. The total of 24 EC is indicative and depends on the extent of the student's support programme and research assignment. The selection of the specialisation courses takes place in coordination with the Bioinformatics specialisation study adviser.

## Support Programme

500 12

For each student a support programme will be defined by the Bioinformatics specialisation study adviser. The support programme consists of tutors or courses in Life Science, Computer Science, Mathematics, or of optional courses for deficiency programmes. The support programme will consist of a maximum of 12 EC.

## Research assignment

600 15

## Master's research project

600 45

(incl. thesis and oral presentation)

## Specialisation

### Data Science

#### Description

Data science is an interdisciplinary discipline at the border between statistical science and computer science aiming at discovering knowledge from typically large set of structured or unstructured data. To achieve this goal, data scientists use statistical methods and machine learning in combination with exploration and optimization algorithms from computer science. The MSc specialisation Data Science equips students interested in data analysis with state-of-the-art knowledge in the advanced statistical techniques, machine learning and algorithmic aspects of data analysis. The programme is a unique collaboration between the Leiden Institute for Advanced Computer Science and Mathematical Institute.

Students will gain a thorough knowledge and understanding of statistical models, including their application in Databases, Advances in Data Mining, Networks, Pattern Recognition, and Deep Learning. They will be able to critically study scientific research and develop new models and techniques.

## Programme

The programme is 120 EC in extent and consists of a selection of eight courses from a core programme (48 EC in total), five specialisation courses (30 EC), and a Master Thesis research in computer science (second year; 42 EC in total).

	EC	Level
<b>Core Programme (selection of eight courses)</b>	<b>48</b>	<b>500</b>
A choice of 8 courses can be made out of different specialisation courses. The specialisation courses have level 500 and are worth 6 EC. The selection of the core programme courses takes place in coordination with the study adviser.		
<b>Specialisation Courses</b>		
Advanced Statistical Computing	3	500
Introduction to Data Science	6	400
Linear & Generalized Linear Models and Linear Algebra	9	400
Multivariate and Multidimensional Data Analysis	6	500
Statistical Learning Theory	6	500
<b>Total</b>	<b>30</b>	
<b>Thesis</b>		
Computer Science master's thesis research (incl. 7 EC for a thesis and an oral presentation)	42	600
<b>Total</b>	<b>42</b>	
<b>Total</b>	<b>120</b>	

A selection of 8 courses from the core programme and all the specialisation courses are compulsory and count for 78 EC in total. Students should have completed at least 72 EC to start their Master Thesis research.

## Specialisation Science Based Business

### Description

The specialisation Computer Science and Business is designed for students who consider a career in industry. The specialisation teaches students analytical frameworks and skills for managerial decision making. Case-based teaching and practice-oriented sessions featuring senior managers from the Leiden Science Park and beyond are an integral part of the curriculum. In addition, students have the opportunity to gain experience working as an intern for a company.

Students who opt for the Leiden Business specialisation can choose from two tracks: A general Management track that focuses on managerial challenges of established organisations; A New Technology Ventures track focuses on the challenges involved in setting up novel entrepreneurial ventures around business opportunities created in science and research.

Students who complete the specialisation Computer Science and Business are admissible to a PhD programme.

## Programme

The Computer Science and Science Based Business (SBB) programme consists of:

- a research project in Computer Science of at least 42 EC (incl. 7 EC for the thesis and an oral presentation) in one of the research groups of LIACS;
- at least 18 EC of level-500 courses to be selected in correspondence with the research topic;
- a maximum of 20 EC of electives within either Computer Science or the SBB component; and
- the Science Based Business (either SBB Management or SBB New Technology Ventures) component<sup>4</sup> as described on page 81.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation Science Communication and Society

### Description

The specialisation Computer Science and Science Communication and Society (SCS) offers students the possibility to combine computer science and science communication.

Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set.

Students who complete the specialisation Computer Science and Science Communication and Society are admissible to a PhD programme in computer science or in science communication.

### Programme

The Computer Science and Science Communication and Society (SCS) programme consists of:

- a research project in Computer Science of at least 42 EC (incl. 7 EC for the thesis and an oral presentation) in one of the research groups of LIACS;
- at least 18 EC of level-500 courses to be selected in correspondence with the research topic;
- a maximum of 20 EC of electives within either Computer Science or the SCS component; and
- the Science Communication and Society component<sup>5</sup> as described on page 84.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

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<sup>4</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

<sup>5</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

## Specialisation Computer Science and Education

### Description

The specialisation Computer Science and Education (**EDU**) is offered as a joint programme with the Leiden University Graduate School of Teaching (**ICLON**). It prepares students for a career as computer science (in Dutch: ‘informatica’) teacher. This programme leads up to the so-called “eerstegraads-lesbevoegdheid”, qualifying the student to teach in Dutch upper secondary education.

Students who complete the specialisation Computer Science and Education are admissible to a PhD programme

### Additional qualification for admission

In addition to the general admission requirements of the MSc programme in Astronomy, students must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden – gevorderd, met spreekvaardigheid minimaal een 7 ½).

If there are deficiencies in the prior education of the student for a “eerstegraads-lesbevoegdheid”, a proposal will be made on how these can be solved.

### Programme

The Computer Science and Education (EDU) programme consists of:

- a research project in Computer Science of 30 EC (incl. 7 EC for the thesis and an oral presentation) in one of the research groups of LIACS;
- at least 30 EC of level-500 courses to be selected in correspondence with the research topic; and
- an Education component including courses on Educational Theory, Learning and Instruction, Teaching Methodology, and Teaching Practice.

The Computer Science component of the programme will be followed during the first year of study, the Education component will be followed during the second year.

When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced with 30 EC. The remaining 30 EC can be used for both the Computer Science and Education component of the MSc programme.

# MSc ICT in Business and the public sector

CROHO-number 60205

## Description

Over the last years, rapid changes in information and communication technology (ICT) and its applications have caused major changes for all kinds of organisations, industries, and individuals. The Internet, information systems, and communication technology in general, have radically impacted our professional and personal lives. They challenged our thinking on physical, geographical and industry boundaries, on distance, speed and communication. The MSc *ICT in Business and the Public Sector* aims at providing a deeper understanding of the issues, challenges and opportunities in this area, with a specific focus on the management and alignment of ICT in a business and/or governmental context. The programme builds on a foundation of Computer Science that students bring from their bachelor's education.

As of September 2017, the MSc *ICT in Business and the Public Sector* offers the following specialisations:

- ICT in Business
- ICT in the Public Sector

The specialisations Science-Based Business, Science Communication and Society, and Education are not available to students in the ICT in Business programme.

The duration of the programme, which is taught entirely in English, is two years (120 EC). The programme offers two opportunities to start, in September and in February. Courses can be organised in Leiden as well as in The Hague. Students who complete the programme receive the degree Master of Science in ICT in Business and the Public Sector.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. The admission process may include an interview with the Board of Admissions. Students can start their programme in September or February.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students with a BSc degree in Computer Science from Leiden University will be admitted to the MSc ICT in Business and the public sector programme. For students with a Dutch bachelor degree in a related field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Computer Science.

Students with a bachelor degree in a bachelor's degree in Computer Science or a closely related subject at an international University are also eligible for admission. The Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Computer Science, and whether their academic background, obtained grades, and (if applicable) work experience provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking



- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

## Programme

The master programme consists of 15 months of course-work, and a 38 EC thesis project, often based on an in-company project. The courses cover business or governmental foundations, ICT & Business topics, research methods and electives. The electives allow students to individualise their programme and accommodate special interests. In addition, there are possibilities to customise the programme through international exchange programmes. Courses are typically offered in a combination of interactive lectures, case studies, projects, company visits, and student presentations. Many activities are based on team work, whereas research colloquia strengthen the individual's research competence.

### Curriculum outline ICT in Business

The curriculum depends on the student's background. Students with a Leiden University bachelor in Computer Science, specialisation "Informatica & Economie" follow an alternative curriculum; all courses marked with an \* have to be replaced by electives. All the other students follow the main curriculum.

The main curriculum consists of the following courses:

<b><u>Main Curriculum for both specialisations:</u></b>	<b><u>EC</u></b>	
Global Business Game	1	400
Leading & Managing People	5	500
Strategy: Process, Content, Context	6	500
Behavioural and Analytical Decision Making	6	500
ICT Architectures	6	500
ICT Enabled Process Innovation	3	500
Accounting*	3	500
Process Modelling*	3	500
Research Methods	6	500
Software Engineering	3	500
System Development & Project Management	6	500
Applied Research Methodology	4	500
Business Intelligence*	3	500
Specialisation (see below)	18	500
Electives	9	500
MSc Research Project	38	600
<b>Total</b>	<b>120</b>	
 <b><i>Specialisation ICT in Business:</i></b>		
Marketing and Corporate Communications*	3	500
Managing the Digital Business	3	500
Finance*	3	500

Managing Innovation	3	500
Entrepreneurship	3	500
Capstone Cases	3	500

***Specialisation ICT in the Public Sector:***

Role of ICT in Public Administration	6	500
Digital Government-Citizen Interaction	3	500
Data-driven Policy Making	3	500
Working for the Government as ICT Expert	6	500

The electives need approval by the Board of Examiners *before* the courses can be taken. Without this preliminary approval we cannot guarantee these electives to be part of the curriculum.

**Programme for candidates with working experience**

A special programme is offered to professionals with at least three years of working experience. These professionals should have a BSc degree in Computer Science or equivalent to be able to participate in the following programme.

<b>Courses</b>	<b>EC</b>	
ICT Architectures	6	500
Strategy: Process, Content, Context	6	500
Behavioural and Analytical Decision Making	6	500
Leading and Managing People	5	500
Accounting	3	500
Research Methods	6	500
Specialisation courses**	33	500
Research Participation & Scientific Reporting	17	500
Master Thesis Research Project	38	600
	<b>120</b>	

\*\* If the specialisation ICT in the Public Sector is chosen then the following courses are obligatory:

***Specialisation ICT in the Public Sector:***

Role of ICT in Public Administration	6	500
Digital Government-Citizen Interaction	3	500
Data-driven Policy Making	3	500
Working for the Government as ICT Expert	6	500

The specialisation courses need approval by the Board of Examiners *before* the courses can be taken. Without this preliminary approval we cannot guarantee these courses to be part of the curriculum.

# MSc Media Technology

**CROHO-number 60206**

The programme Media Technology is taught in Leiden by the Leiden Institute of Advanced Computer Science (LIACS) and the Academy for Creative and Performing Arts.

The Media Technology MSc programme is a common initiative of the computer science institute (LIACS) within the Faculty of Science, and the Academy for Creative and Performing Arts. The duration of this programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Media Technology.

## Description

The Media Technology programme recognises creativity and playfulness as important factors in scientific innovation. It is a place where students and researchers are allowed to formulate their own scientific questions and are encouraged to translate their personal inspirations and curiosities into manageable and compact research projects.

To achieve this, the curriculum focuses on creative exploration and on the understanding of science and technology. Student projects often involve creating actual products: software, hardware, something made from sticky tape perhaps. We are convinced that by doing and creating, new insights into the underlying research question are encountered. The programme encourages its students to draw from the knowledge available throughout Leiden University's various faculties and the ArtScience programme of the Royal Conservatoire and the Royal Academy of Arts in The Hague.

Besides completing the curricular courses (see "Programme"), each student must successfully complete an individual Graduation Project guided by two supervisors. It aims to answer a student's personally developed scientific question, possibly by creating a product. A thesis is written, presented and publicly defended as part of the Graduation Project. The thesis generally takes the form of a scientific article, possibly augmented with alternative output such as a product, performance, book, installation, and etcetera.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Students can start their programme in September or February.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students with a BSc degree in Computer Science from Leiden University or a BSc major in Computer Science from Leiden University will be admitted to the MSc Media Technology programme.

Students holding a BSc, BA or equivalent degree can apply for admission, regardless of prior field of study and nationality. The Board of Admissions will evaluate whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation and curriculum vitae.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90

- Cambridge Certificate of Advanced English (CAE), minimum grade C  
This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

## Programme

The programme is 120 EC in extent and consists of the following components:

<i>Compulsory courses</i>	<b>Level</b>	<b>EC</b>
Visit to Ars Electronica Festival	400	1
Introduction to Programming	400	4
HCI & Information Visualization	400	6
New Media & New Technologies	500	5
Creative Research	500	6
Scientific Narration & Visualization	500	4
Capita Selecta I	400	3
Sound, Space & Interaction	500	4
Capita Selecta II	400	4
Research Seminar Artificial Intelligence	500	6
Research Seminar Social Technologies	500	4
Hardware & Physical Computing	400	3
Meta Media	500	2
Sciences & Humanities	500	3
Essentials in Art & Music	500	2
Electives	400+	13
Semester Project	500	20
Graduation Project	600	30
		<b>120</b>

## Substitution for Compulsory Courses

Students can qualify for substitution of certain compulsory courses within their curriculum, when they can prove already having current knowledge of the topics dealt with. Substitution should be requested via the programme's Executive Committee, and requires agreement by the lecturer of the course at hand. To receive agreement from the lecturer, the student must participate in the first lecture and present some form of proof that the knowledge was already obtained through other ways. The lecturer may decide to honour or turn down requests for substitution, based on the material provided by the student and the evaluation of such.

In case the request for substitution is honoured, the student is not relieved from obtaining the required number of ECs through other ways. For every granted substitution, students must follow another (elective) replacement course with the same number of credits or more. The contents of this replacement course must be a logical extension to the course for which substitution was granted, and must be of at least the same level.

Substitution can never be granted for a compulsory course if the student in question has failed any exam or assignment for that same course. If substitution is granted, but the student decides to follow the course nonetheless, than the substitution is retracted (becomes non-valid) when he/she fails any graded part of the course in question.

## Acceptance of Elective Courses

Elective courses can be done throughout Leiden University's various faculties, and from any accredited institute of higher education. For curricular acceptance of elective courses, prior permission must be obtained from the Media Technology programme's Executive Committee and the LIACS Board of Examiners. The decision to accept an elective course is based on course level, course load, course content and the student's personal statement of motivation. Practical guidelines for students and procedures to apply for curricular acceptance of elective courses are communicated via the programme's website.

## MSc Astronomy

**CROHO-number 60200**

The aim of the Leiden Observatory MSc programme Astronomy is to provide students with the proficiency, experience and skills to pursue a successful career in science, or in companies, industry or society in general with a strong background in scientific thinking and understanding. The programme offers seven specialisations, each comprising two years (120 EC): four research-oriented specialisations, and three combined specialisations.

The four research-oriented specializations focus on major research themes including evolution of the universe, formation and evolution of galaxies, birth and death of stars, formation and occurrence of planets near other stars, astronomical instrumentation, and the analysis of very large and complex data sets. They allow the student to choose from either a broad research profile ("Astronomy Research" specialisation), or a profile that is more focused in a particular direction. The specialisations offered (and described in detail below) are:

1. "Astronomy Research";
2. "Astronomy and Cosmology";
3. "Astronomy and Data Science";
4. "Astronomy and Instrumentation".

In addition to the research-oriented specialisations, three other specialisations are offered, which combine the main elements of the research curriculum with topics in Science Based Business (SBB), Science Communication and Society (SCS), and Education (EDU), and which are described separately.

Upon successful completion of the programme, students receive the degree Master of Science in Astronomy, with specification of the chosen specialisation.

All specialisations have the same Director, the same Education Committee, the same Board of Examiners, and the same Board of Admissions. Exceptions to this are formed by the specialisations SBB, SCS, and EDU, which for the specialisation-specific part each have their own specialisation coordinator and a central Board of Examiners appointed by the Faculty of Science. Students with an MSc in any of the seven specialisations can be admitted to a PhD programme in Astronomy.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Students can start their programme in September or February.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students with a BSc degree in Astronomy or the equivalent from Dutch universities participating in the NOVA top research school will be admitted to the MSc Astronomy programme.

Students with a bachelor degree in Astronomy, or in a field related to Astronomy, at an international University are also eligible for admission. Students with Bachelor degrees in sciences such as Mathematics, Physics, Chemistry, or Aerospace Engineering can apply for enrolment. Candidates may be required to take introductory courses covering subjects in which they are deemed to be deficient.

The Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Astronomy, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

The Board of Admissions may impose a Pre-Master programme, tailored to the background of the prospective student, before admission into the MSc programme. For students with a BSc degree in Aerospace Engineering from Delft Technical University, the Pre-Master programme will consist of the following elements from the BSc programme Astronomy (Sterrenkunde):

	<b>Level</b>	<b>EC</b>
Stars	300	5
Galaxies and Cosmology	300	5
Astronomy Lab and Observing Project	200	5
Astronomical Observing Techniques	300	5
Quantum Mechanics 1	200	7

The course Quantum Mechanics 1 may be replaced by the two courses Kwantummechanica 1 (TN 2304; 3 EC) and Kwantummechanica 2 (TN 2314; 3 EC) offered at Delft Technical University.

### **Selection of courses and Master Study Plan**

For all specialisations, the selection of course work and research projects requires prior approval by the MSc Study Adviser. In individual cases a course from a different programme or field of study may be elected, but only after prior written approval from the Board of Examiners. In this case, the student should first discuss the course of choice with the MSc Study Adviser, and obtain agreement to proceed. Subsequently the chairman of the Board of Examiners may be contacted to seek the required official approval. At the start of the Master's Programme, the student and the MSc Study Adviser together draw up a complete list of planned courses and projects (the Master Study Plan). Changes in the Master Study Plan in

the course of the programme are possible at any time, but always require prior approval by the Study Adviser.

## Types of courses

A variety of courses is given each year. Specifics for all courses can be found in the e-prospectus and at the Astronomy Education website. Courses are given at different intervals: once per year, once per 18 months, once per two years, or at irregular intervals. Students must therefore always consult the long-term teaching schedule (which is published on the Astronomy Education website and specifies the course schedule for the current and next year) when making their Master Study Plan. Courses are classified as follows:

**Astronomy Core Courses** (6 EC each): these are offered at regular intervals.

1. Origin and Evolution of the Universe;
2. Galaxies: Structure, Dynamics and Evolution;
3. Stellar Structure and Evolution;
4. Interstellar Medium.

**General Astronomy Courses** (6 EC each): these vary with time, and are offered at regular or sometimes irregular intervals. Examples include:

1. Large Scale Structure and Galaxy Formation;
2. Star and Planet Formation;
3. Computational Astrophysics;
4. The InterUniversity Courses (Interacademiaal College – IAC), organised by the NOVA research school for astronomy.

**Instrumentation-related Astronomy Courses** (6 or 3 EC each): these vary with time, and are offered at regular or sometimes irregular intervals. Examples include:

1. Astronomical Telescopes and Instruments;
2. Detection of Light a (3 EC) or a+b (6 EC);
3. Radio Astronomy;
4. Astronomy from Space;
5. High Contrast Imaging;
6. Project Management for Scientists;
7. Observational High-Energy Astrophysics.

**Specialist Astronomy Courses** (3 EC each): these vary with time and are offered at irregular intervals; these courses provide in-depth introductions to specialized topics. Examples include:

1. Observational Cosmology;
2. Astrochemistry;
3. Databases and Data Mining in Astronomy;
4. High-energy Astrophysics;
5. Gravitational Lensing;
6. Compact Objects and Accretion.

**Non-Astronomy Courses**; these must be selected from the courses offered by the Leiden MSc programmes in Physics, Mathematics, or Computer Science.

**Astronomy Research Projects.** Students in the specialisations “Astronomy Research”, “Astronomy and Cosmology”, “Astronomy and Data Science”, and “Astronomy and Instrumentation” carry out two astronomy research projects: the First Research Project and the Master’s Research Project. Students in the SBB, SCS or EDU specialisations carry out only the Master’s Research Project. All research projects have a total credit of 30 EC. For the Master’s Research Project, the total credit includes a 4 EC Master's Thesis as well as a 1 EC public presentation (the Student Colloquium).

All research projects are carried out under the supervision of a member of the scientific staff. The First and Master's Research Projects must be on different topics. The Master's Research Project can be started only after completion of the First Research Project (if that forms part of the programme). The maximum duration in calendar time of any Research Project is 9 months. However, if the First Research Project is started before November 1 of the first year, the deadline is extended to August 1 for students who started the programme in September. For students who started the programme in February this deadline is extended to January 1 if the First Research Project is started before April 1 of the first year. For all Research Projects, it is not possible to obtain a grade higher than 6 if the deadline is exceeded, unless the Study Advisor deems the delay to be caused by circumstances outside the control of the student. In the specialisations Astronomy Research, Astronomy and Cosmology, Astronomy and Data Science, and Astronomy and Instrumentation, it may be possible to carry out the Master's Research project at a university abroad. This requires explicit permission from the Study Adviser, and a Master Study Plan that allows for an extended stay abroad without causing delays to the study program. Furthermore, it requires 2 supervisors: 1 in Leiden and 1 at the institute abroad. This option is only open to students who have no delays in their program and with a grade-point average of at least 8.

## Specialisation

### Astronomy Research

#### Description

This 2-year programme consists of advanced Astronomy courses, two research projects in Astronomy, and courses on science topics related to the field of Astronomy. It allows the broadest programme, including a significant component from adjacent fields (Physics, Mathematics, and Computer Science). As such it prepares the student as much for a career in research as for a career outside academia.

#### Programme

The requirements for the programme (120 EC) are as follows:

	Level	EC
<i>Choice of</i> Astronomy core courses, at least:	500	18
<i>Choice of</i> Instrument-related courses, at least:	400-500	6
<i>Choice of</i> Astronomy courses of any type	400-500	12
<i>Choice of</i> Non-Astronomy courses	400-500	24
First Astronomy research project	500	30
Master's Astronomy research project	600	30

The following remarks apply:

1. The First Research Project has to be done in the 1<sup>st</sup> year of the programme, while the Master's Research Project has to be done in the 2<sup>nd</sup> year.
2. One of the two courses "Science and the Public: Contemporary and Historical Perspectives" and "Science Methodology" may also be chosen as a non-Astronomy course. The course "Entrepreneurship" may also be chosen as a non-Astronomy course.
3. The programme may be adapted for Master's students who have not followed the Leiden Astronomy Bachelor programme. Upon recommendation by the MSc study adviser and written approval by the Board of Examiners, the First Research Project can be reduced to a weight not smaller than 21 EC with a simultaneous increase in the



number of courses in Astronomy. These additional courses can be selected from the normal courses in the Master's curriculum, and the BSc course Radiative Processes. These students may also add Astronomy courses at the cost of the non-Astronomy courses, in consultation with the MSc Study adviser and approval by the Board of Examiners.

4. Students who have not followed the BSc course "Radiative Processes" or an equivalent course, may take this course in the MSc programme, as a general or specialised astronomy course.

The following remarks apply only for students who enrolled in the programme in February 2016 or earlier:

1. These students do a First Research Project of 24 EC and a Master's Research Project of 36 EC.
2. These students may include the 3 EC course "On Being a Scientist", which is part of the Leiden Astronomy Bachelor's programme, as either an astronomy or a non-astronomy course in the programme; however there is no obligation to follow this course.
3. For these students, the course "Stellar structure and evolution" is no longer compulsory.

## Specialisation

### Astronomy and Data Science

#### Description

The 2-year programme Astronomy and Data Science offers the student the option to follow a Research Master in Astronomy with a particular focus on the big data aspects of both astronomy (as a data-rich science) and computer science. It prepares as much for a career in astronomy as in computer science, and for careers in research as well as outside research, in academia or elsewhere in society. It consists of advanced Astronomy courses, two research projects in Astronomy, and selected courses from the Computer Science MSc programme. This specialisation is offered by Leiden Observatory in collaboration with the Leiden Institute of Advanced Computer Science (LIACS) of Leiden University.

#### Additional qualifications for admission

Students wanting to follow this specialisation must be proficient in programming, in particular in the Python language.

#### Programme

The requirements for the programme (120 EC) are as follows:

	Level	EC
<i>Choice of</i> Astronomy core courses, at least:	500	18
<i>Choice of</i> Instrument-related courses, at least:	400-500	6
<i>Choice of</i> Astronomy courses of any type	400-500	12
Compulsory computer science course (24 EC total)		
Databases and Data Mining	500	6
Advances in Data Mining	500	6
Neural networks	500	6
Bayesian networks	500	6

First Astronomy research project	500	30
Master's Astronomy research project	600	30

The following remarks apply:

1. The First Research Project has to be done in the 1<sup>st</sup> year of the programme, while the Master's Research Project has to be done in the 2<sup>nd</sup> year. The Master's Research Project must involve data manipulation (which may be simulated data) and/or computational problems.
2. One of the three courses "Science and the Public: Contemporary and Historical Perspectives", "Science Methodology" and "Entrepreneurship" may also be chosen as a general/specialist/instrumentation Astronomy course.
3. The programme may be adapted for Master's students who have not followed the Leiden Astronomy Bachelor programme. Upon recommendation by the MSc study adviser and written approval by the Board of Examiners, the First Research Project can be reduced to a weight not smaller than 21 EC with a simultaneous increase in the number of courses in Astronomy. These additional courses can be selected from the normal courses in the Master's curriculum, and the BSc course Radiative Processes.
4. Students who have not followed the BSc course "Radiative Processes" or an equivalent course, may take this course in the MSc programme, as a general or specialised astronomy course.

## Specialisation

### Astronomy and Instrumentation

#### Description

The specialisation "Astronomy and Instrumentation" offers the student the option to conduct a Research Master in Astronomy with a particular focus on advanced astronomical instrumentation, techniques, and instrument development. It prepares the student as much for a career in research as for a career outside academia.

#### Additional qualifications for admission

It is recommended that students have completed the BSc course "Introduction to solid state physics", or its equivalent. The Board of Admissions will consider the contents of the candidate's BSc curriculum when deciding on admission, and may recommend particular choices for elective courses in order to help compensate any deficiencies. The choice in elective courses in the MSc programme may be limited by the need to adapt the programme to the present knowledge of the candidate.

#### Programme

The requirements for the programme (120 EC) are as follows:

	Level	EC
<i>Mandatory Courses:</i>		
Astronomical Telescopes and Instruments	500	6
Detection of Light a+b	500	6
<i>Choice of Astronomy core courses, at least:</i>	500	6
<i>Choice of core/general/specialist Astronomy courses</i>	400-500	24-30
<i>Choice of instrumentation-related Astronomy courses</i>	400-500	12-18
First Research Project in Instrumental or General Astronomy	500	30

Second Research Project in Instrumental Astronomy

600

30

The following remarks apply:

1. Students who have not followed the BSc course Radiative Processes or an equivalent course, may take this course in the MSc programme, as a general or specialised astronomy course.
2. The specialist astronomy course “Databases and Data Mining in Astronomy” may be included as an instrumentation-related course in the above programme.
3. The following courses offered by Delft Technical University may be included as instrumentation-related courses in the above programme:
  - a. Space Instrumentation (AE4880, 4vEC)
  - b. Space Systems Engineering (AE4S12; 3 EC)
  - c. Geometrical Optics (AP3391; 6 EC)
  - d. Advanced photonics (AP3382; 6 EC)
  - e. Imaging systems (AP3221 D; 6 EC)
4. Up to 12 EC of the general/specialist Astronomy courses may be replaced by non-astronomy courses, to be taken from the MSc programs in Mathematics, Physics, or Computer Science; among these 12 EC the student may choose one of the three courses “Science and the Public: contemporary and historical perspectives”, “Science Methodology”, and “Entrepreneurship”. The Master’s Research Project may involve designing, building or testing of an instrument or instrument system, or any combination of these activities. It may be carried out in any of the Leiden Astronomy or Delft Technical Physics labs, or at external organisations directly involved in astronomical instrumentation.

The following remarks apply only for students who enrolled in the programme in February 2016 or earlier:

1. These students do a First Research Project of 24 EC and a Master’s Research Project of 36 EC.
2. These students may include the 3 EC course “On Being a Scientist”, which is part of the Leiden Astronomy Bachelor’s programme, as either an astronomy or a non-astronomy course in the programme; however there is no obligation to follow this course.
3. For these students, the course “Stellar structure and evolution” is no longer compulsory.

## **Specialisation Astronomy and Cosmology**

### **Description**

The specialisation “Astronomy and Cosmology” offers the student the possibility to conduct a Research Master in Astronomy with a particular focus on modern observational and theoretical cosmology. This specialisation is offered by Leiden Observatory in collaboration with the Institute Lorentz for Theoretical Physics in the Department of Physics at Leiden University (LION).

### **Additional qualifications for admission**

Students should have successfully completed the BSc course “Physics of elementary particles”, or its equivalent, and should have in-depth knowledge of undergraduate courses with theoretical and mathematical emphasis, including quantum physics, electrodynamics,

statistical physics, and complex calculus. The choice in elective courses in the MSc programme may be limited by the need to adapt the programme to the knowledge of the candidate. The Board of Admissions will consider the contents of the candidate's BSc curriculum when deciding on admission.

## Programme

The requirements for the programme (120 EC) are as follows:

	<b>Level</b>	<b>EC</b>
<i>Mandatory Astronomy Courses:</i>		
Origin and Evolution of the Universe	500	6
Large Scale Structure and Galaxy Formation	500	6
<i>Choice of:</i>		
Astronomy core courses	500	6
Astronomy courses of any type	400-500	18
<i>Mandatory Physics Courses:</i>		
Particle Physics and Early Universe	500	3
Origin and Structure of the Standard Model	400	3
Theory of General Relativity	400	6
<i>Choice of:</i>		
Related Physics courses	400-500	12
First Research Project in Cosmology <i>or</i> General Astronomy	500	30
Second Research Project in Cosmology	600	30

The following remarks apply:

1. Students who have not followed the BSc course Radiative Processes or an equivalent course, may take this course in the MSc programme, as a general or specialised astronomy course.
2. For students who successfully completed the 6 EC version of the course Particle Physics and the Early Universe (which was offered in previous years), this is considered to be equivalent to the 3 EC version plus the course Origin and Structure of the Standard Model.

The following remarks apply only for students who enrolled in the programme in February 2016 or earlier:

1. These students do a First Research Project of 24 EC and a Master's Research Project of 36 EC.
2. These students may include the 3 EC course "On Being a Scientist", which is part of the Leiden Astronomy Bachelor's programme, as either an astronomy or a non-astronomy course in the programme; however there is no obligation to follow this course. For these students, the course "Stellar structure and evolution" is no longer compulsory.

## Specialisation Science Based Business

### Description

The specialisation Astronomy and Science Based Business (SBB) offers students the possibility to combine astronomy with knowledge, insights and skills in the area of Management, Business, New Technology Ventures, and Entrepreneurship. Students are encouraged to broaden their horizon, to form an opinion on and prepare for a career in industry and to enhance competences for pursuing entrepreneurial business opportunities created in science and research.

Students who complete the specialisation Astronomy and Science Based Business are admissible to a PhD programme in Astronomy.

### Programme

The Astronomy and Science Based Business (SBB) programme consists of:

- a Master's Research Project (30 EC) supervised by a member of the Leiden Observatory scientific staff;
- 30 EC of courses to be selected in correspondence with the research topic; these should at least include:
  - two Astronomy core courses; and
  - 6-12 EC of non-Astronomy courses, to be taken from the programmes of Physics, Mathematics or Computer Science.
- a maximum of 20 EC of electives within either Astronomy or the SBB component;
- the SBB Management or SBB New Technology Ventures track<sup>6</sup> as described on page 81.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation Science Communication and Society

### Description

The specialisation Astronomy and Science Communication and Society (SCS) offers students the possibility to combine astronomy and science communication. Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set.

Students who complete the specialisation Astronomy and Science Communication and Society are admissible to a PhD programme in astronomy or in science communication.

### Programme

The Astronomy and Science Communication and Society (SCS) programme consists of:

- a Master's Research Project (30 EC) supervised by a member of the Leiden Observatory scientific staff;

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<sup>6</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

- 30 EC of courses to be selected in correspondence with the research topic; these should at least include:
  - two Astronomy core courses; and
  - 6-12 EC of non-Astronomy courses, to be taken from the programmes of Physics, Mathematics or Computer Science.
- a maximum of 20 EC of electives within either Astronomy or the SCS component;
- the Science Communication and Society component<sup>7</sup> as described on page 84.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

## Specialisation Education

### Description

The specialisation Astronomy and Education (EDU) prepares students for a career as physics (natuurkunde) teacher qualified to teach in Dutch secondary education.

Students who complete the specialisation Astronomy and Education are admissible to a PhD programme in Astronomy.

### Additional qualifications for admission

In addition to the general admission requirements of the MSc programme in Astronomy, students must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden – gevorderd, met spreekvaardigheid minimaal een 7 ½).

### Programme

The Astronomy and Education (EDU) programme consists of:

- a Master's Research Project (30 EC) supervised by a member of the Leiden Observatory scientific staff;
- 30 EC of courses to be selected in correspondence with the research topic; these should at least include:
  - two Astronomy core courses; and
  - 6-12 EC of non-Astronomy courses, to be taken from the programmes of Physics, Mathematics or Computer Science.
- the Education component as described on page 85.

The Astronomy component of the programme will be followed during the first year of study, the Education component will be followed during the second year.

When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced by 30 EC. The remaining 30 EC can be used for either the Astronomy or the Education component of the MSc programme.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.

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<sup>7</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

# MSc Physics

**CROHO-number 60202**

Leiden University offers a MSc programme in Physics with eight specialisations. Five of these correspond to research specialisations in the Leiden Institute of Physics (LION), including one in collaboration with the Leiden Observatory and one in collaboration with Delft University of Technology. The remaining three specialisations combine research in physics with Science-Based Business (SBB), with Science Communication & Society (SCS), or with Education (EDU). The specialisation 'Research in Physics, Casimir pre-PhD' can be followed through selection only; students admitted to the Physics Programme can apply after the first semester of their studies and are selected on the basis of their course results.

## Description

The duration of the programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Physics, with specification of the specialisation. All specialisations have the same Director, the same Board of Examiners, and the same Departmental Teaching Committee. For the specialisation specific part the specialisations SBB, SCS, and EDU, each have their own specialisation coordinator and a Board of Examiners appointed by the Faculty of Science.

The research specialisations are distinguished by a programme and a curriculum that emphasize the intended perspective and goal of the specialisation. In all cases, the programme consists of two components, a set of courses and one or more research projects. The selection of courses differs per specialisation and always comprises a mandatory part and an elective part. For the elective part, a minimum number of ECs has to be selected from the list of relevant courses; the choice of the rest remains flexible. Students may select courses from any of the other MSc Physics specialisations in Leiden, including the selected Casimir pre-PhD courses, courses offered by Delft University, and courses from the programmes of other universities. The selected programme should have a sufficient level and cohesion, and the optional part requires prior approval of the Board of Examiners, to be obtained through the Study adviser. Deviations from the standard options requires the explicit approval of the Board of Examiners.

Each programme offers the student a solid background and a thorough experience at the forefront of physics research in that specialisation, including a practical training in communication and computer skills. The goal is to train the student as an independent researcher, and to provide students with the necessary skills and proficiency to advance their career. Upon completion of the degree, the MSc graduate will be well equipped to start a PhD, work in research and development, or work in other branches of the public and private sector that require strong analytical, computational, and problem-solving skills. The 'Casimir pre-PhD' specialisation puts special emphasis on the preparation for PhD research within the Casimir Research School.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. The nominal start of the program is in September, but admission may be possible during the year for some specialisations. The specialisations 'Cosmology' and 'Casimir pre-PhD' always start in September.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation. The choice of the elective courses in the MSc

programme may be limited by the need to adapt the programme to the present knowledge of the candidate. This will be recorded in the student's study plan.

Students with a BSc degree in Physics or Astronomy from Leiden University will be admitted to the MSc Physics programme. Holders of a BSc degree in Physics or Astronomy from any other university in The Netherlands will also be admitted, provided that they fulfil the following requirements:

- BSc degree was obtained no longer than two years before
- BSc has been completed within five years
- Average grade for all BSc courses  $\geq 7.0$
- Grade for BSc research project  $\geq 7.0$

For all other candidates, the Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Physics or Astronomy, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

Candidates without a Physics or Astronomy degree will be considered upon completion of a tailored pre Master program. This consists of maximally 60 EC and is agreed with the Study adviser. It will cover and strengthen any missing topics from the following list of required BSc Physics courses and may include a selection of Physics elective courses:

- Mathematics: Linear Algebra 1NA + 2NA and Analysis 3NA (requires background of Analysis 1NA + 2NA)
- Quantum Mechanics 1 + 2
- Statistical Physics 1
- Classical Electrodynamics (requires background of Electromagnetic Fields)
- Classical Mechanics B (requires background of Classical Mechanics A)
- Introduction to Solid State Physics
- Signal Processing and Noise
- Programming Methods NA, i.e. computer programming in Python

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)



## Specialisation Research in Physics, Theoretical Physics

### Description

This specialisation prepares the student for research towards a PhD in a broad range of topics in theory, such as high energy physics and particle cosmology, life processes, and condensed matter. Upon completion of the degree, the MSc holder will be equally well prepared for a career in research and development or in other branches of the public and private sector that require strong analytical, computational, and problem-solving skills.

### Additional qualifications for admission

Students are required to have in-depth knowledge of undergraduate courses with a theoretical and mathematical emphasis, including quantum physics, electrodynamics, statistical physics, and complex analysis.

### Programme

	Level	EC
Academic and Professional Skills	400	3
Effective Field Theory	500	3
Quantum Information ( <i>formerly Quantum Theory b</i> )	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a + b	400	9
Topics in Theoretical Physics ( <i>mandatory for the specialisation Theoretical Physics</i> )	400	6
Elective courses from MSc Physics programme, with $\geq 12$ EC from Theoretical Physics, and other MSc programmes ( $\leq 6$ EC)	400-500	42
Physics research project in Theoretical Physics (division: research=36 EC, thesis=8 EC, and presentation=4 EC)	600	48

Course List: Theoretical Physics	Level	EC
Advanced Topics in Theoretical Physics I	600	6
Advanced Topics in Theoretical Physics II	600	6
Black Holes and Gravitational Waves	500	3
Complex Networks	400	6
Computational Physics	400	6
Computational Physics	400	3
Effective Field Theory ( <i>mandatory for the specialisation Theoretical Physics</i> )	500	3
Origin and Structure of the Standard Model	500	3
Particle Physics and the Early Universe	500	3
Quantum Field Theory	500	6
Quantum Information ( <i>mandatory for the specialisation Theoretical Physics</i> )	400	3
Soft and Biomatter Theory	500	6
Statistical Physics b ( <i>mandatory for the specialisation Theoretical Physics</i> )	400	3
Theoretical Biophysics	500	6
Theoretical Cosmology	500	3
Theory of Condensed Matter	500	6
Theory of General Relativity	400	6
Topics in Theoretical Physics	400	6

Most courses (including those mandatory) are offered every year. The rest are offered in alternate years. The course offering is subject to change.

## Specialisation

### Research in Physics, Biological and Soft Matter Physics

#### Description

This specialisation prepares the student for scientific research towards a PhD in experimental research in Biological Physics and Soft Matter Physics. Biological Physics aims to understand biological processes in their natural context, being cells and tissue, and is typically performed at the interface of the medical, biological and physical sciences. Soft Matter Physics focuses on the physics of soft materials, spanning from the microscopic interactions and assembly of colloids and polymers to the macroscopic behaviour of granular media, and the physics of folding and metamaterials. The programme offers the student a solid background and a thorough experience at the forefront of modern experimental physics. Upon completion of the degree, the MSc holder will be equally well prepared for a career in research and development or in other branches of the public and private sector that require strong analytical, computational, and problem-solving skills.

#### Programme

Academic and Professional Skills	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a	400	6
Elective courses from MSc Physics programme, with $\geq 12$ EC from BSM specialisation, and other MSc programmes ( $\leq 6$ EC)	400-500	45
Research project in Physics 1 (division: research=20 EC, thesis=3 EC, and presentation=1 EC)	600	24
Research project in Physics 2 (division: research=30 EC, thesis=4 EC, and presentation=2 EC)	600	36

All research projects are performed under responsibility of a LION staff member. Up to one project can be carried out outside LION.

Course List: Biological and Soft Matter Physics	Level	EC
Advanced Biophysics	500	6
Advanced Optics	500	6
Computational Physics	400	6
Computational Physics	400	3
<i>Evolution and Engineering of Living Systems (TU Delft)</i>	400	6
Frontiers of Measurement Techniques	400	3
<i>Imaging Systems (TU Delft)</i>	400	6
Magnetic Resonance Physics ( <i>specialised</i> )	500	3
Mechanical Metamaterials ( <i>specialised</i> )	400	6
Molecular Electronics	500	6
Single Molecule Optics ( <i>specialised</i> )	500	6
Soft and Biomatter Theory	400	6
Soft Matter Physics	500	6
Theoretical Biophysics	500	6
<i>The origin of Life (TU Delft)</i>	400	6

Most courses (including those mandatory) are offered every year. The rest are offered in alternate years. The course offering is subject to change.

## Specialisation

### Research in Physics, Quantum Matter and Optics

#### Description

This specialisation prepares the student for scientific research towards a PhD in experimental research in Condensed Matter Physics and Optics. Research themes comprise: scanning probe techniques, quantum optics, photon-matter interactions, molecular electronics, oxide electronics, and superconductivity. The programme offers the student a solid background and a thorough experience at the forefront of modern experimental physics. Upon completion of the degree, the MSc holder will be equally well prepared for a career in research and development or in other branches of the public and private sector that require strong analytical, computational, and problem-solving skills.

#### Programme

	Level	EC
Academic and Professional Skills	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a	400	6
Elective courses from MSc Physics programme, with $\geq 12$ EC from QMO specialisation, and other MSc programmes ( $\leq 6$ EC)	400-500	45
Research project in Physics 1 (division: research=20 EC, thesis=3 EC, and presentation=1 EC)	600	24
Research project in Physics 2 (division: research=30 EC, thesis=4 EC, and presentation=2 EC)	600	36

All research projects are performed under responsibility of a LION staff member. Up to one project can be carried out outside LION.

Course List: Quantum Matter and Optics	Level	EC
Advanced Optics	500	6
Computational Physics	400	6
Computational Physics	400	3
Condensed Matter Physics	500	6
Frontiers of Measurement Techniques	400	3
Magnetic Resonance Physics ( <i>specialised</i> )	500	3
Magnetism ( <i>specialised</i> )	500	3
Molecular Electronics ( <i>together with Delft</i> )	500	6
Quantum Information	400	3
Quantum Optics	400	6
Single Molecule Optics ( <i>specialised</i> )	500	6
Superconductivity ( <i>specialised</i> )	500	3
Surface Science ( <i>Chemistry</i> )	500	6
Theory of Condensed Matter	500	6

Most courses (including those mandatory) are offered every year. The rest are offered in alternate years. The course offering is subject to change.

## Specialisation Research in Physics, Cosmology

### Description

The Cosmology specialisation is positioned at the interface between Theoretical Physics and Observational Astronomy, and is offered jointly with the department of Astronomy. Characteristic elements of the specialisation are theory, data handling, and numerical simulations. It prepares the student for scientific research towards a PhD in a range of topics. Upon completion of the degree, the MSc holder will be equally well prepared for a career in research and development or in other branches of the public and private sector that require strong analytical, computational, and problem-solving skills.

### Additional qualifications for admission

Students are required to have in-depth knowledge of undergraduate courses with a theoretical and mathematical emphasis, including quantum physics, electrodynamics, statistical physics, and complex analysis. The specialisation 'Cosmology' also requires knowledge of 'Physics of Elementary Particles' at undergraduate level.

### Programme

	Level	EC
Academic and Professional Skills	400	3
Large Scale Structure and Galaxy Formation	500	6
Origin and Evolution of the Universe	500	6
Origin and Structure of the Standard Model	400	3
Particle Physics and the Early Universe	500	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Theory of General Relativity	400	6
Elective courses from the MSc Physics or MSc Astronomy programme, of which $\geq 12$ EC must be Cosmology courses	400-500	24
Research project in Cosmology 1	500	30
Research project in Cosmology 2 (Master's project)	600	30

Course List: Cosmology	Level	EC
Black Holes and Gravitational Waves	500	3
Computational Astrophysics ( <i>Astronomy</i> )	400	6
Databases and Data Mining ( <i>Astronomy</i> )	500	3
Gravitational Lensing ( <i>Astronomy</i> )	500	3
Observational Cosmology ( <i>Astronomy</i> )	400	3
Theoretical Cosmology	500	3
Effective Field Theory	500	3

Most courses (including those mandatory) are offered every year. The rest are offered in alternate years. The course offering is subject to change.

Transitional arrangement: Students who following the old 6 EC course on 'Particle Physics of the Early Universe' have covered the same study material as currently offered in the combination of the two 3 EC courses 'Origin and Structure of the Standard Model' and 'Particle Physics of the Early Universe'.

## Specialisation Research in Physics, pre-PhD ('Casimir')

### Description

The 'Casimir pre-PhD' specialisation is offered under the auspices of the Casimir Research School, a joint effort of the Leiden Institute of Physics (LION), and various departments at the Delft University of Technology. It prepares the student for scientific research in a PhD position within the Casimir Research School, or elsewhere, and therefore puts extra emphasis on working in a research environment. Research within Casimir has a strong focus in nanoscience with the following themes: Molecular Biophysics, Physics of Nanostructures, Quantum Matter and Functional Materials, Quantum Information and Quantum Optics, Universe Physics: Theory and Instrumentation, and Dynamic Complex Systems.

The programme follows a strict schedule, with the first year devoted to laying a theoretical basis, and the second year a combination of short intensive research projects and a long MSc thesis project, culminating in the writing of a research proposal. The short projects and the proposal writing are special characteristics of the programme, aimed to broaden the research perspective of the student.

### Additional qualifications for admission

The Casimir pre-PhD specialisation is to be followed by selection only. Students admitted to the Physics Programme can apply during the first semester of their studies through the Casimir specialisation coordinator, and are selected on the basis of (i) their academic track record (including time to diploma) during the BSc studies and (ii) the results in the first semester of the MSc programme. A grade point average of 7.5 is required, although exceptional circumstances can be taken in consideration. Formal admission takes place at the start of the second semester. Admission to the second year is on the condition that all courses of the first year (60 EC) have been successfully completed. Students who are not admitted to the second year can continue in one of the other specialisations of the Physics Master. Students who are declined either after the first semester or after the first year can continue with the regular programme without incurring delays.

### Programme

	Level	EC
Academic and Professional Skills	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a	400	6
Elective courses from the MSc Physics programme in Leiden or from the list of Casimir pre-PhD courses in Delft presented below	400-500	45
Research project in Physics (division: research=30 EC, thesis=4 EC, and presentation=2 EC)	600	36
Study projects (2x), two 8 EC projects can be combined into one 16 EC project, subject to justification	500	2 x 8
Writing Research Proposal	500	8

In the second year of the programme, students will be given the opportunity to attend a Summer School at the start of the academic year. The study projects and MSc research project, scheduled for the second year, are to be carried out in different groups. Writing a research proposal is the last item in the programme. For a limited number of students within this specialisation, a PhD position within one of the participating groups is guaranteed. Details can be found on the website of the Casimir Research School.

<b>Course List; Casimir pre-PhD courses in Delft</b>	<b>Level</b>	<b>EC</b>
<b><i>Foundational courses</i></b>		
Advanced Electrodynamics	400	6
Advanced Solid State Physics	400	6
Continuum Physics	400	6
<b><i>Topical Courses</i></b>		
Evolution and Engineering of living systems	500	6
Fundamentals of Quantum Information	400	6
Mesoscopic Physics	400	6
Molecular Electronics ( <i>Leiden/Delft</i> )	500	6
Physics of Semiconductor Nanodevices	400	3
Quantum Communication and Cryptography	400	5
Quantum Hardware	400	6
Quantum Optics and Lasers	500	6
The Origins of Life	500	6
Topology in Condensed Matter	500	6
<b><i>Methods</i></b>		
Computational Physics	400	6
Computational Physics	400	3
Electronics for Quantum Computing	400	5
Molecular Electronics ( <i>Leiden/Delft</i> )	500	6
Nanotechnology	400	6

Most courses (including those mandatory) are offered every year. The rest are offered in alternate years. The course offering is subject to change.

It is unavoidable that the study material of certain courses in Delft and Leiden show significant overlap. To avoid redundancy in the study program, the combinations of courses given below are mutually exclusive:

- Advanced Solid State Physics (Delft) ⇔ Condensed Matter Physics (Leiden)
- Fundamentals of Quantum Information (Delft) ⇔ Quantum Information (Leiden)
- Physics of Semiconductor Nanodevices (Delft) ⇔ Condensed Matter Physics (Leiden)
- Quantum Optics and Lasers (Delft) ⇔ Quantum Optics (Leiden)
- Computational Physics (Delft) ⇔ Computational Physics (Leiden)

## **Specialisation Science Based Business**

### **Description**

The specialisation Physics and Science Based Business (SBB) offers students the possibility to combine physics with knowledge, insights, and skills in the area of Management, Business and Entrepreneurship.

Students are encouraged to broaden their horizon, to form opinions, to prepare for a career in industry, and to enhance competences in pursuing entrepreneurial business opportunities stemming from research disciplines.

Students who complete the specialisation Physics and Science Based Business are also admissible to a PhD programme.

## Programme

	Level	EC
Academic and Professional Skills	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a	400	6
<i>Elective courses in correspondence with the research project</i>	400-500	9
Research project in Physics	600	36
Division: research=30 EC, thesis=4 EC, and presentation=2 EC		
Science Based Business or Research Based Business component, as described on page 81.		40-60
Elective from either MSc Physics or SBB, SRB offerings	400-500	20-0

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation

### Science Communication and Society

#### Description

The specialisation Physics and Science Communication and Society (SCS) offers students the possibility to combine physics and science communication.

Students are prepared for a career in popularisation of science or for a career as a scientist with a communication focus.

Students who complete the specialisation Physics and Science Communication and Society are also admissible to a PhD programme in physics or in science communication.

#### Programme

Academic and Professional Skills	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a	400	6
<i>Elective courses in correspondence with the research project</i>	400-500	9
Research project in Physics	600	36
Division: research=30 EC, thesis=4 EC, and presentation=2 EC		
Science Communication and Society component, as described on page 84.		40-60
Elective from either MSc Physics or SCS offerings	400-500	20-0

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

## Specialisation

### Education

#### Description

The specialisation Physics and Education (EDU) prepares students for a career as physics (natuurkunde) teacher qualified to teach in Dutch secondary education.

Students who complete the specialisation Physics and Education are also admissible to a PhD programme.

### **Additional qualifications for admission**

Apart from the general qualifications that apply for a MSc Physics, applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden – gevorderd, met spreekvaardigheid minimaal een 7 ½).

### **Programme**

	<b>Level</b>	<b>EC</b>
Academic and Professional Skills	400	3
Quantum Theory ( <i>formerly Quantum Theory a</i> )	400	6
Statistical Physics a	400	6
<i>Elective courses in correspondence with the research project</i>	400-500	9
Research project in Physics	600	36
Division: research=30 EC, thesis=4 EC, and presentation=2 EC		
Education component, as described on page 85.		60

The Physics component of the programme will be followed during the first year of study, the Education component will be followed during the second year.

When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced by 30 EC. The freed up 30 EC can be filled by either the Physics or Education course offerings.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.



# MSc Chemistry

CROHO-number 66857

The Leiden Institute of Chemistry (LIC) forms the basis for research and collaborations of the Leiden chemistry and life sciences groups. The LIC offers two MSc programmes, namely the MSc Chemistry and the MSc Life Science and Technology. Chemistry research in the LIC is centred on the two research areas *Chemical Biology* and *Energy & Sustainability*, which are leading for the courses and training projects offered in the MSc programme Chemistry.

The MSc programme Chemistry offers four specialisations, each with a focus on one of these two major research areas. The four specialisations are: Research in Chemistry (CHEM), Chemistry and Science Based Business (SBB), Chemistry and Science Communication and Society (SCS) and Chemistry and Education (EDU). The duration of each specialisation is two years (120 EC); a general overview of the content of the four specialisations is given in Table 1. Students who complete the programme receive the degree Master of Science in Chemistry, with specification of the specialisation and research area. Students with an MSc degree in Chemistry are admissible to a PhD programme.

After completion of the MSc Chemistry programme you will have developed:

- Knowledge and understanding of theoretical concepts from textbooks and primary literature pertaining to the research area
- The ability to plan research and perform experiments within an appropriate time frame
- The (experimental/computer) skills to apply standard research procedures with limited supervision
- An appropriate critical scientific attitude, i.e. the ability to analyse results and critically evaluate their validity and accuracy
- The skill to communicate research progress and results to colleagues, supervisors and experts
- The ability to write independently a structured and accurate report on performed research

Table 1: Overview of the programmes of the four MSc Chemistry specialisations

Specialisation	CHEM	EDU	SCS	SBB
Research Training Project	60	30	30	30
Academic Skills	6	6	6	6
Compulsory courses in research area	24	24 <sup>8</sup>	24	24
Essay & Colloquium	6	-	-	-
Free electives <sup>9</sup>	24	30 / 0 <sup>10</sup>	20	20
EDU/SCS/SBB components	-	30 / 60	40	40
<b>Total</b>	<b>120</b>	<b>120</b>	<b>120</b>	<b>120</b>

## Description of the research areas

**Chemical Biology** research at the Leiden Institute of Chemistry is aimed at understanding biological processes at the molecular level to strengthen the knowledge base of human health and disease. The approach to achieve this goal is a fundamental chemical one; biological

<sup>8</sup> Students in the EDU specialisation are advised to choose from both research areas, to obtain a broader knowledge of chemistry.

<sup>9</sup> The choice in the free electives is restricted to the boundaries specified here. A maximum of 20 EC can be used for extension of the research internships. A maximum of 20 EC may be used as an extension of the SCS or SBB components.

<sup>10</sup> If the student has taken a minor in Education ("tweedegraadsbevoegdheid") of 30 EC in the BSc programme, only 30 EC are necessary in the MSc programme to obtain the "eerstegraadsbevoegdheid"; then 30 EC free electives are added to the programme of the MSc Chemistry.

systems are interrogated with the aid of chemical probes. Our chemical biology research is conducted in the context of health and disease, and aims to acquire knowledge, tools and techniques for human medicine. Examples of current research:

Enzyme inhibitors or receptor ligands may become lead compounds in drug development whereas activity-based probes may evolve to become diagnostic tools to detect disease states and monitor the efficacy of therapeutic interventions. Next to this fundamental studies on the interaction of biomolecules may deliver new insights into the molecular background of disease states. The aim of this research is to design, synthesize and apply new chemical tools to answer important biological and medical questions. Activity-based protein profiling, assay development, chemical proteomics and advanced molecular biology techniques are used to determine the activity and selectivity of small molecules in physiological and disease processes.

Carbohydrates are a broad and highly diverse class of biomolecules involved in a range of biological processes in health and disease. To date there are no general synthesis methodologies to produce defined carbohydrate structures and the development of such procedures represents one of the major organic synthesis activities at Leiden University.

The interactions of proteins with small compounds, DNA and other proteins are investigated, related to the functions of histones, chromatin organization and mechanisms of antibiotic resistance. For this purpose a range of biophysical techniques is employed, such as NMR, crystallography en fluorescence spectroscopy. Dedicated paramagnetic tags are developed that open a whole new area of NMR, enabling us to study large protein complexes as well as inhibitor-enzyme interactions.

The ultimate goal is to contribute to human health through conceptually new chemical methods for diagnosis, drug development and new therapies for diseases.

The **Energy & Sustainability** research is focused on a fundamental level on chemical reactions that are of importance to the sustainable and efficient production and storage of energy, as well as the subsequent usage of stored energy. The researchers apply advanced spectroscopic techniques, nano-imaging, inorganic synthesis, and theoretical methods to elucidate the molecular processes that are at the basis of the conversion of solar energy to chemical energy. For example:

Electro catalysis is the basis for the generation of sustainable energy. Reactions of interest are specifically the redox reactions in the oxygen/hydrogen cycle (water oxidation, hydrogen evolution), the carbon cycle (reduction of carbon dioxide, oxidation of small organic molecules) and the nitrogen cycle (oxidation of ammonia, reduction of nitrate). A major advantage of molecular catalysts is that these can be varied to a large degree in order to radically improve the catalytic activity of the targeted multi-electron redox reaction.

Energy systems of the future will be based on efficient catalytic conversion of small molecules in closed cycles. The local ordering of atoms at the surface of a metallic particle determines its catalytic activity and selectivity. We study how structural changes of catalysts can be used to our advantage, and *in-situ* imaging techniques are used to study Fischer-Tropsch synthesis, NO reduction and oxidation, hydrodesulfurization, and chlorine production.

The ability to accurately predict the outcome of elementary reactions of molecules with metal surfaces is a prerequisite to the ability to make accurate predictions of many heterogeneously catalyzed processes, which are used in the production of the majority of chemicals. Computational methods are applied to obtain a better fundamental understanding of interfacial energy conversion dynamics.

Sustainable, atom-efficient catalytic reactions are necessary to replace current stoichiometric industrial processes to many bulk chemicals that are used in the production of consumer goods. The main objective of this type of research is to gain fundamental understanding of the

reactivity of transition metal complexes and to learn how we can direct the reactivity of the catalysts via novel types of intermediates to new products.

Furthermore, NMR spectroscopy is applied to understand the underlying molecular processes in photosynthesis. By resolving the responsible structural mechanisms, we may find new ways to expand the limit and improve photosynthetic species for production of biomass and solar biofuels.

### **Programme organisation**

All specialisations have the same Educational Director and the same Board of Admission. The Department Teaching and Learning Committee for the MSc programme Chemistry is combined with the one for the MSc programme Life Science and Technology and is responsible for both the Research and the Science Based Business specialisations. The EDU and SCS specialisations have their own Department Teaching and Learning Committee. The Board of Examiners of the MSc programme Chemistry is also combined with the one for the MSc programme Life Science and Technology. In addition the specialisations SBB, SCS, and EDU each have their own faculty-wide Board of Examiners appointed by the Faculty of Science for the specialisation-specific part of the MSc programme.

### **Admission to the programme**

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Students can start their programme in September or February (international students are strongly advised to start in September).

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students with a BSc degree Molecular Science and Technology (MST) from Leiden/Delft will be admitted to the MSc Chemistry. For students with a Dutch bachelor degree in a related field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Molecular Science and Technology (MST).

Students with a bachelor degree in Chemistry, or in a field related to Chemistry, at an international University are also eligible for admission. The Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Chemistry, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

HBO students can also apply for admission; they should have obtained their BAS degree within four years with an average final grade of at least 7.5 and a research internship grade of

at least 8.0. Additionally a letter of motivation by the student and a letter of recommendation of the 'studieloopbaanbegeleider' of the BAS programme is required.

To students with an outstanding track record and an outstanding research internship but with a prior education that differs from the bachelor MST programme by at most 30 ECTS, a premaster program may be offered consisting of BSc courses (30 EC). If the candidate student successfully passes all required premaster courses the student will be admitted to the MSc programme.

## **Programme**

Each student composes their own study programme (choice in core courses, electives and research training project) in consent with their mentor, who is a Principal Investigator of the LIC. The mentor generally is the supervisor of the major research training project in the research area chosen by the student. The mentor will coach the student from the admission throughout the MSc programme to the final examination. The choice in elective courses in the MSc programme may be limited by the need to adapt the programme to the present knowledge of the candidate. The web-based master planner is used for planning and registration of the study program, and is to be filled in by the student in consult with the mentor. The mentor and student discuss the progress of the student at least every 6 months using the results documented in the master planner. The programme may be adjusted during the course of the MSc study. The master planner is updated by the student on a regular basis. It is accessible to the student, the mentor and the study coordinator. The study coordinator administrates a copy of the individual study programme; it is used to keep track of the student's progress and forms the basis for the master portfolio. The study coordinator will mediate when the student encounters problems in the interaction with the mentor.

## **Programmes of the specialisations**

Specialisation-specific components of the specialisations Chemistry and Science Based Business, Chemistry and Science Communication and Society and Chemistry and Education are described separately in this Appendix.

### **Specialisation**

#### **Research in Chemistry (CHEM)**

The research specialisation offers the student the opportunity to spend two full years on training and specialisation not only to become an independent and creative researcher, but also someone who can use their analytical skills to solve other types of problems in their career in science or in society. The MSc students will become a member and colleague in one of the research groups in the LIC. The student will develop their individual MSc programme together with the mentor. The majority of the students with an MSc in Research in Chemistry will continue their career in a PhD position.

The Research in Chemistry programme (CHEM) consists of four parts: the research training project (60 EC), academic skills (6 EC, comprising Science Methodology and a writing course), the compulsory courses (30 EC) and the elective courses (24 EC).

#### **Research Training Project**

The (major) research training project is carried out in a LIC research group in one of the research areas (*Chemical Biology* or *Energy & Sustainability*) and includes a presentation for the research group and a written report (the master thesis). The research training project may be split into a major and a minor project. The major training project is limited to a minimum of 40 and a maximum of 60 EC; a minor research training project must comprise at least 20

EC. All research training projects are concluded with a written report that is graded by the main supervisor and an independent second examiner, who was not involved in the writing process. In addition, the major research training project includes a presentation for an independent jury of two staff members, as well as interested students and staff members of the LIC (Thesis Talk). The Thesis Talk jury will discuss their findings concerning the report and presentation with the research supervisors. The final grade will be based on the judgement of the supervisor, second examiner and the Thesis Talk jury. As part of their training all students attend at least 10 Thesis Talks during their MSc program.

The minor and major research training projects must be carried out in different research groups and be supervised and evaluated by different staff members, but may be related which may be reflected in a combined master thesis. In consent with the mentor the minor training project can be carried out in another research area, another institute (within the Netherlands or abroad), or in a company. All external research training projects need prior approval from the Board of Examiners. For all external research training projects a staff member of the LIC must act as a co-supervisor. This LIC co-supervisor has the final responsibility for the creation of the internship agreement, grading of the research project report and creation and signing of the internship evaluation form.

After completion of the practical work, the student and supervisor make an agreement on the deadline for handing in the final version of the MSc thesis or project report. The final version of the report should be handed in within 3 months after the last day of practical work. For all research training projects, it is not possible to obtain a grade higher than 6 if this deadline is exceeded. Students can only start with an optional second research training project (within or outside the LIC) when the first project has been successfully concluded with a grade (including a Thesis Talk for major research training projects). External training projects cannot be the major training project (the one concluded with the Thesis Talk) and should start after completion of the major training project.

### **Compulsory components**

The compulsory theoretical component comprises a selection of four core courses (24 EC), the course Science Methodology (4 EC) in combination with a writing course (2 EC) and a literature essay with colloquium (6 EC). All students attend at least 10 colloquia during their MSc program. The core courses are chosen within the research area. A list of the core courses offered by the two research areas is given in Table 2.

### **Elective components**

The elective component (24 EC) can comprise either additional theoretical courses, or an extension of the duration of a research project with a maximum of 20 EC. The mentor may limit the choice in elective courses by the need to adapt the programme to the present knowledge of the student. Students can choose their electives from the list of core courses within or outside their research area, from the list of approved elective courses that is available in the e-guide, the MSc courses offered in a Science Faculty of any Dutch university of level 400 or higher, or level 400 courses from the BSc Molecular Science & Technology or Life Science & Technology programmes provided that these were not part of the student's earlier studies. For courses outside the Leiden University Chemistry programme, other electives and for all external research projects prior approval of the Board of Examiners is required.

## Specialisation Chemistry and Science Based Business

### Description

The specialisation Chemistry and Science Based Business (SBB) offers students the possibility to combine chemistry with knowledge, insights and skills in the area of Management, Business and Entrepreneurship.

Students are encouraged to broaden their horizon, to form an opinion on and prepare for a career in industry and to enhance competences for pursuing entrepreneurial business opportunities created in science and research.

Students who complete the specialisation Chemistry and Science Based Business are admissible to a PhD programme.

### Programme

The Chemistry and Science Based Business (SBB) programme consists of:

- a research training project in Chemistry of 30 EC in one of the research groups of the Leiden Institute of Chemistry with an optional extension of 20 EC, finalised with a thesis talk (as described above);
- 24 EC of core courses to be selected in correspondence with the research topic;
- 6 EC academic skills, comprising Science Methodology (4 EC) and a writing course (2 EC);
- attendance of at least 10 thesis talks;
- 20 EC of free electives<sup>11</sup>; and
- the SBB Management or SBB New Technology Ventures track<sup>12</sup> as described on page 81.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation Chemistry and Science Communication and Society

### Description

The specialisation Chemistry and Science Communication and Society (SCS) offers students the possibility to combine chemistry and science communication. Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set. Students who complete the specialisation Chemistry and Science Communication and Society are admissible to a PhD programme in chemistry or in science communication.

### Programme

The Chemistry and Science Communication and Society (SCS) programme consists of:

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<sup>11</sup> An extension of the research project is restricted to 20 EC and no more than 20 EC can be used for SBB courses

<sup>12</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

- a research training project in Chemistry of 30 EC in one of the research groups of the Leiden Institute of Chemistry with an optional extension of 20 EC, finalised with a thesis talk (as described above);
- 24 EC of core courses to be selected in correspondence with the research topic;
- 6 EC academic skills, comprising Science Methodology (4 EC) and a writing course (2 EC);
- attendance of at least 10 thesis talks;
- 20 EC of free electives<sup>11</sup>; and
- the Science Communication and Society component<sup>13</sup> as described on page 84.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

## Specialisation Chemistry and Education

### Description

The specialisation Chemistry and Education (EDU) prepares students for a career as chemistry (scheikunde) teacher qualified to teach in Dutch secondary education. Students who complete the specialisation Chemistry and Education are admissible to a PhD programme.

### Additional qualifications for admission

Apart from the general qualifications that apply for a MSc Chemistry, applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden – gevorderd, met spreekvaardigheid minimaal een 7 ½).

### Programme

The Chemistry and Education (EDU) programme consists of:

- a research training project in Chemistry of 30 EC in one of the research groups of the Leiden Institute of Chemistry with an optional extension of 20 EC<sup>14</sup>, finalised with a thesis talk (as described above);
- 24 EC of core courses to be selected in correspondence with the research topic;
- 6 EC academic skills, comprising Science Methodology (4 EC) and a writing course (2 EC);
- attendance of at least 10 thesis talks;
- the Education component as described on page 85.

The Chemistry component of the programme will be followed during the first year of study, the Education component will be taken during the second year. When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced with 30 EC. The remaining 30 EC are added to the Chemistry programme.

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<sup>13</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

<sup>14</sup> If the student has taken a minor in Education (“tweedegraadsbevoegdheid”) of 30 EC in the BSc programme, only 30 EC are necessary in the MSc programme to obtain the “eerstegraadsbevoegdheid”; then 30 EC free electives are added to the programme of the MSc Chemistry. An extension of the research project is restricted to 20 EC

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.

### List of Core Courses

Table 2: Core courses organised by the LIC research areas *Chemical Biology (CB)* and *Energy & Sustainability (ES)*. All courses are at level 400 or 500 and encompass 6 EC.

	<b>Lecturer</b>	<b>Research area</b>
Advanced Medicinal Chemistry	van der Stelt	CB
Enzyme dynamics: NMR spectroscopy and kinetics	Ubbink	CB
Cell Biology*	Noteborn	CB
Chemical Biology	Overkleef	CB
Modern Organic Chemistry	van der Marel	CB
Molecular Biology*	Boot	CB
Reactivity in Organic Chemistry	Codée/Fillipov	CB
Supramolecular Chemistry	Kros/Kieltyka	CB
Dynamics of Molecule-surface Reactions**	Kroes/Juurlink	ES
Electrochemistry & Bioelectrochemistry	Koper	ES
Heterogeneous Catalysis	Groot	ES
Modern Quantum Chemistry	Buda	ES
Organometallic chemistry & homogeneous catalysis catalysis	Bouwman	ES
Photochemistry	Bonnet/Buda	ES
Photosynthesis & Bioenergy	Pandit	ES
Quantum Dynamics of Chemical Reactions**	Kroes	ES
Spectroscopy	Hetterscheid	ES

\* These courses cannot be chosen by students with a BSc degree in Life Science & Technology.

\*\* Biennial courses scheduled in alternating years.



# MSc Bio-Pharmaceutical Sciences

CROHO-number 60207

The programme Bio-Pharmaceutical Sciences is taught in Leiden by the Leiden Academic Centre for Drug Research (LACDR).

The aim of the MSc programme Bio-Pharmaceutical Sciences (BPS), organised by the Leiden Academic Centre for Drug Research (LACDR) of Leiden University, is to train students for a research career in drug research and development, not for a career as a (public) pharmacist. The general objective of MSc programme BPS is to teach the master's student sufficient knowledge, insight, and skills to work independently at an academic level as a drug researcher, to contribute in an original manner to recognizing, introducing and solving questions in a specific knowledge area related to drug research, to discuss this contribution with experts in the field, to inform non-specialists about their ideas, goals and the public impact of their research. The MSc programme BPS offers seven specialisations. Three of these are research specialisations corresponding to major research themes at the LACDR: Drug & Target Discovery, Systems Pharmacology, and BioTherapeutics. The remaining four specialisations combine Bio-Pharmaceutical research with training in Science Based Business (SBB), Science Communication and Society (SCS), Education (EDU), or Industrial Pharmacy (IP).

For the MSc programme BPS 72 places are available in the academic year 2017–2018. The research specialisations are considered to be default specialisations. Students following the research specialisations continue their research training in the second year. Students opting for a non-research specialisation are admitted to this specialisation after the successful completion of their Research Project 1. Admittance to a specialisation may be restricted by additional requirements or a limited number of available places.

The duration of each programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Bio-Pharmaceutical Sciences, with specification of the specialisation. Details are provided below. All specialisations have the same Director, the same Board of Examiners, and the same Department Teaching Committee. A Board of Admissions will advise on admissions. Exceptions to this are formed by the specialisations SBB, SCS, and EDU, which for the specialisation-specific part each have their own specialisation coordinator and a Board of Examiners appointed by the Faculty of Science.

Students who complete any of the specialisations in Bio-Pharmaceutical Sciences are admissible to a PhD programme in Bio-Pharmaceutical Sciences or other Life Sciences.

## Learning outcomes

Graduates of the MSc programme BPS have reached the following general achievement levels:

- a. Theoretical and practical skills in more than one specialist area of drug research such that (s)he can carry out research under overall supervision;
- b. The ability to make an independent analysis of scientific problems, analysis of relevant specialist literature, formulate verifiable hypotheses, and set up and carry out research and critical reflection on one's own research and that of others;
- c. The ability to interrelate and integrate various areas of drug research;
- d. The ability to present clearly, verbally as well as in writing, one's own research results, and the ability to communicate with colleagues and to present his/her research results as a contribution to a congress or as (part of) a scientific publication;
- e. Sufficient understanding of the social role of drug research to be able to reflect upon them and in part consequently to come to an ethically sound attitude and corresponding execution of one's professional duties.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Admission is possible throughout the year, but international students are strongly advised to start in September or February.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation. The preferred specialisation in the Bio-Pharmaceutical Sciences Master's programme should match the previous education of the applicant. The choice in optional courses in the MSc programme may be limited by the need to adapt the programme to the present knowledge of the candidate. This will be recorded in the student's study plan. Please note that basic research training in the field of life sciences is required to be eligible for the programme.

Students with a BSc degree in Bio-Pharmaceutical Sciences from Leiden University, including those holding a BSc degree in Bio-Pharmaceutical Sciences with the Specialisation Pharmacy will be admitted to the MSc Bio-Pharmaceutical Sciences programme.

Students with a BSc degree in Biology, Biomedical Sciences, Chemistry, Informatics with the specialisation Informatics & Biology, Life Science and Technology, and Pharmaceutical Sciences, as well as applicants with a higher professional education (HBO/HLO) degree (BSc in Applied Sciences) in Chemistry or Biomedical Sciences (or equivalent field of Science) are eligible for admission. The Board of Admissions will evaluate whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

As a guideline for applicants with an international BSc university degree, the education should contain basic research training in the field of life sciences, including a bachelor internship consisting of at least 10 weeks practical research training which is concluded with a thesis. The internship has to be assessed with a grade above 8.0 and the grade point average (GPA) should be above 7.5 (grades according to the Dutch grading scale).

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

As a guideline for applicants with a higher professional education (HBO/HLO) bachelor degree, the degree has to have been obtained within four years with a grade point average (GPA) above 7.5. In addition, the research project that was included in the higher professional education (HBO/HLO) programme should have been conducted at a university or a university medical centre and should have been assessed with a grade above 8.0 (grades according to the Dutch grading scale).

## Programmes of the specialisations

The aim of each programme is to train the student as an independent researcher in Bio-Pharmaceutical Sciences, and to develop the necessary skills and proficiency to advance their career.

### Specialisation

## Drug & Target Discovery

### Description

The MSc specialisation Drug & Target Discovery offers research-orientated education into the discovery of new drug targets and new lead molecules, particularly in the field of cancer. For identification of novel drug targets and development of novel, highly effective and safe drug leads students are trained in advanced imaging techniques ('systems microscopy'), in vitro and in vivo model systems, organic synthesis, molecular biology, pharmacology, and computational approaches (chem- and bioinformatics and computational biology). Two divisions of the Leiden Academic Centre for Drug Research, Medicinal Chemistry and Toxicology, and the Division of Bio-organic Synthesis of the Leiden Institute of Chemistry (LIC), are involved in the Master's specialisation Drug & Target Discovery. Admission to this specialisation is limited to 24 students.

### Learning outcome

In addition to the general achievements, graduates of the MSc programme BPS with the specialisation Drug & Target Discovery have obtained in-depth knowledge of a specific subject related to the discovery of novel drug targets and new lead molecules.

### Programme

The programme contains two research periods (51 and 36 EC), and compulsory and optional programme components (33 EC):

	Level	EC
Introduction Course BPS:		
Drug & Target Discovery in Cancer	500	5
Lecture series (in BPS)	500	4
Research Project 1, in Drug & Target Discovery		
• Literature research, practical implementation and performance	600	44
• Thesis	600	5
• Oral presentation	500	2
Research Project 2		
• Literature research, practical implementation and performance	600	31
• Thesis	600	5
Literature Study	500	7
Course Scientific Conduct	500	1
Attended Lectures and Symposia	500	1
Optional courses or traineeships	≥400 (max 12 EC <400 <sup>15</sup> )	15

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<sup>15</sup> Permission from the Board of Examiners is required for courses with level 100 or 200 and for courses of which the level is not explicitly given, e.g. courses offered by other universities and institutions of higher education.

### **Research Project 1**

Research Project 1 must be conducted within the Cluster Drug & Target Discovery of the LACDR, consisting of the divisions Medicinal Chemistry and Toxicology, or Bio-organic Synthesis (LIC). Permission from the Board of Examiners and the Director of Education is required when projects are conducted within external research groups led by Professors affiliated with the Cluster Drug & Target Discovery.

### **Research Project 2**

Research Project 2 may be conducted within the Faculty of Science in another discipline of BPS or in another MSc programme, or at the Center for Human Drug Research, the Leiden University Medical Center, other University Medical Centers or health research institutes, or at an R&D Department of a (Bio-)Pharmaceutical company. Students are encouraged to go abroad for Research Project 2. All projects outside the LACDR require permission from the Board of Examiners and the Director of Education *before the start* of the project.

### **Literature Study**

The Literature Study must be conducted at another division of the LACDR than Research Project 1 and Research Project 2. Otherwise, permission from the Board of Examiners is required. The Literature Study is completed with a written thesis.

## **Specialisation Systems Pharmacology**

### **Description**

The MSc specialisation Systems Pharmacology offers research-orientated education into understanding and predicting drug-induced modulation of disease networks at the systems level. Systems Pharmacology offers a unique combination of cutting-edge experimental training in the field of metabolomics and translational systems biology as well as quantitative pharmacology education in the area of computational modelling of pharmacokinetic and pharmacodynamic (PK/PD) relationships. Two divisions of the Leiden Academic Centre for Drug Research, Analytical Biosciences and Pharmacology, and the Center for Human Drug Research (CHDR), are involved in the Master's specialisation Systems Pharmacology. Admission to this specialisation is limited to 24 students.

### **Learning outcome**

In addition to general achievements, graduates of the MSc programme BPS with the specialisation Systems Pharmacology have obtained in-depth knowledge of a specific subject related to the understanding or the predicting of drug-induced modulation of disease networks at the systems level.

### **Programme**

The programme contains two research periods (51 and 36 EC), and compulsory and optional programme components (33 EC):

	<b>Level</b>	<b>EC</b>
Introduction Course BPS: Systems Pharmacology	500	5
Lecture series (in BPS) Research Project 1, in Systems Pharmacology	500	4

• Literature research, practical implementation and performance	600	44
• Thesis	600	5
• Oral presentation	500	2
Research Project 2		
• Literature research, practical implementation and performance	600	31
• Thesis	600	5
Literature Study	500	7
Course Scientific Conduct	500	1
Attended Lectures and Symposia	500	1
Optional courses or traineeships	≥400 (max 12 EC <400 <sup>16</sup> )	15

### **Research Project 1**

Research Project 1 must be conducted within the Cluster Systems Pharmacology of the LACDR, consisting of the divisions Analytical Biosciences and Pharmacology, or the CHDR. Permission from the Board of Examiners and the Director of education is required when projects are conducted within external research groups led by Professors affiliated with the Cluster Systems Pharmacology.

### **Research Project 2**

Research Project 2 may be conducted within the Faculty of Science in another discipline of BPS or in another MSc programme, or at the Center for Human Drug Research, the Leiden University Medical Center, other University Medical Centers or health research institutes, or at an R&D Department of a (Bio-)Pharmaceutical company. Students are encouraged to go abroad for Research Project 2. All projects outside the LACDR require permission from the Board of Examiners and the Director of Education *before the start* of the project.

### **Literature Study**

The Literature Study must be conducted at another division of the LACDR than Research Project 1 and Research Project 2. Otherwise, permission from the Board of Examiners is required. The Literature Study is completed with a written thesis.

## **Specialisation BioTherapeutics**

### **Description**

The MSc specialisation BioTherapeutics offers research-orientated education into the development of new therapeutic approaches to treat immune-based disorders, such as atherosclerosis, metabolic disorders and inflammatory skin diseases. Focus is on state-of-the-art therapies using novel biologicals, such as tolerogenic vaccines, therapeutic proteins and peptides, and gene therapy. The two divisions of the Leiden Academic Centre for Drug Research involved in the Master's specialisation BioTherapeutics are Drug Delivery Technology and Biopharmaceutics. Admission to this specialisation is limited to 24 students.

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<sup>16</sup> Permission from the Board of Examiners is required for courses with level 100 or 200 and for courses of which the level is not explicitly given, e.g. courses offered by other universities and institutions of higher education.

## Learning outcome

In addition to general achievements, graduates of the MSc programme BPS with the specialisation BioTherapeutics have obtained in-depth knowledge of a specific subject related to the development of new therapeutic approaches to treat immune-based disorders, such as atherosclerosis, metabolic disorders and inflammatory skin diseases.

## Programme

The programme contains two research periods (51 and 36 EC), and compulsory and optional programme components (33 EC):

	Level	EC
Introduction Course BPS: BioTherapeutics	500	5
Lecture series (in BPS)	500	4
Research Project 1, in BioTherapeutics		
• Literature research, practical implementation and performance	600	44
• Thesis	600	5
• Oral presentation	500	2
Research Project 2		
• Literature research, practical implementation and performance	600	31
• Thesis	600	5
Literature Study	500	7
Course Scientific Conduct	500	1
Attended Lectures and Symposia	500	1
Optional courses or traineeships	≥400 (max 12 EC <400 <sup>17</sup> )	15

### Research Project 1

Research Project 1 must be conducted within the Cluster BioTherapeutics of the LACDR, consisting of the divisions Drug Delivery Technology and Biopharmaceutics. Permission from the Board of Examiners and the Director of Education is required when projects are conducted within external research groups led by Professors affiliated with the Cluster BioTherapeutics.

### Research Project 2

Research Project 2 may be conducted within the Faculty of Science in another discipline of BPS or in another MSc programme, or at the Center for Human Drug Research, the Leiden University Medical Center, other University Medical Centers or health research institutes, or at an R&D Department of a (Bio-)Pharmaceutical company. Students are encouraged to go abroad for Research Project 2. All projects outside the LACDR require permission from the Board of Examiners and the Director of Education *before the start* of the project.

### Literature Study

The Literature Study must be conducted at another division of the LACDR than Research Project 1 and Research Project 2. Otherwise, permission from the Board of Examiners is required. The Literature Study is completed with a written thesis.

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<sup>17</sup> Permission from the Board of Examiners is required for courses with level 100 or 200 and for courses of which the level is not explicitly given, e.g. courses offered by other universities and institutions of higher education.

## Specialisation Industrial Pharmacy

### Description

The MSc specialisation Industrial Pharmacy trains students in safety and quality control in the production of medicinal products, and prepares students for a career in Quality Assurance and Quality Control in the biotechnological and pharmaceutical industry.

### Learning outcomes

In addition to general achievements, graduates of the MSc programme BPS with the specialisation Industrial Pharmacy have reached the following specific achievement levels:

- Industrial pharmaceutical knowledge and understanding of prerequisites for production, quality and safety management, and batch release;
- Experience with industrial pharmaceutical quality documentation systems;
- Knowledge of industrial pharmaceutical regulatory affairs and ethical issues.

### Additional qualifications for admission

Master's students in Bio-Pharmaceutical Sciences of Leiden University with a BSc degree in Bio-Pharmaceutical Sciences, Pharmaceutical Sciences or Pharmacy with an average grade of 7.5 or higher (grades according to the Dutch grading scale) will be considered for admittance to this specialisation of the programme.

The Board of Admissions will judge the candidate's personal skills (e.g. awareness of responsibility, accuracy, communication skills, methodological approach when analysing complex problems, and motivation) for qualification to the specialisation. Applicants must provide proof of proficiency in Dutch (TUL halfgevoerd (= staatsexamen NT2-II)). A conditional decision on admission to the specialisation Industrial Pharmacy will be made after completion of at least half ( $\geq 21$  EC) of the research project at one of the Divisions of the LACDR. If the student meets the requirements, the admission becomes unconditional after completion of Research Project 1

Admission to the programme is limited to two students in the academic year 2017-2018.

### Programme

The programme contains a research project of 49 EC (consisting of 42 EC for literature research, practical implementation and performance, 5 EC for writing a thesis and 2 EC for giving an oral presentation) and other compulsory components (71 EC):

	Level	EC
Introduction Course BPS in subject of Research project 1	500	5
Lecture series (in BPS)	500	4
Research Project 1, at one of the Divisions of the LACDR		
• Literature research, practical implementation and performance	600	42
• Thesis	600	5
• Oral presentation	500	2
Course Scientific Conduct	500	1
Attended Lectures and Symposia	500	1

Internship Quality Control/Quality Assurance, in a Pharmaceutical Company under supervision of a Qualified Person (QP) and an examiner of the LACDR, including Practical Work, Thesis and Oral Presentation	600	37
Essay Quality Control/Quality Assurance	600	7
Course Basic Good Manufacturing Practices (GMP)	NA	1
Course Ethics in Quality Control Practices	500	1
Course Legislation of Production of Medicinal Products	600	2
Course Sterile Manufacturing in Practice	600	4
Course Quality Management in Pharma and Biotech <sup>18</sup>		
• the Role of the Qualified Person	500	2
• Drug development: from 'Quality by Design' to Clinical Studies	600	2
• Sterile Manufacturing	600	2
• Quality and Safety for the Manufacturing of Biopharmaceuticals	600	2

The programme of the specialisation Industrial Pharmacy is under development and may be subject to change.

### **Research Project 1**

Research Project 1 must be conducted within any of the clusters of the LACDR or at the CHDR. Permission from the Board of Examiners and the Director of Education is required when projects are conducted within external research groups led by Professors affiliated with a cluster of the LACDR.

## **Specialisation Science Based Business**

### **Description**

The specialisation Bio-Pharmaceutical Sciences and Science Based Business (SBB) offers students the possibility to combine bio-pharmaceutical sciences with knowledge, insights and skills in the area of Management, Business and Entrepreneurship.

Students are encouraged to broaden their horizon, to form an opinion on and prepare for a career in industry and to enhance competences for pursuing entrepreneurial business opportunities created in science and research.

Students who complete the specialisation Bio-Pharmaceutical Sciences and Science Based Business are admissible to a PhD programme.

### **Learning outcomes**

In addition to general achievements, graduates of the MSc programme BPS with the specialisation Science-Based Business have reached the following specific achievement levels:

- a. insight in managerial issues related to knowledge-intensive businesses and basic theoretical skills in business disciplines most relevant to working in these businesses;
- b. the ability to make a plan for a new business or an innovation project;

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<sup>18</sup> PAOFarmacie: Netherlands Centre for Post-Academic Education in Pharmacy



- c. experience with performing business activities in an existing company or organisation or directed towards technology-based business creation.

## Programme

The Bio-Pharmaceutical Sciences and Science Based Business (SBB) programme consists of:

- the Introduction Course BPS (on the subject of the research project) of 5 EC;
- a research project of 49 EC, consisting of 42 EC for literature research, practical implementation and performance, 5 EC for a thesis and 2 EC for an oral presentation and conducted within any of the research clusters of the LACDR or at the CHDR; permission from the Board of Examiners and the Director of Education is required when projects are conducted within external research groups led by Professors affiliated with a cluster of the LACDR;
- a lecture series of 4 EC<sup>19</sup>;
- the course Scientific Conduct of 1 EC;
- attendance of Lectures or Symposia for a total of 1 EC;
- a maximum of 20 EC of electives within either Bio-Pharmaceutical Sciences or the SBB component of the programme; and
- the SBB Management or SBB New Technology Ventures track<sup>20</sup> as described on page 81.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation

### Science Communication and Society

#### Description

The specialisation Bio-Pharmaceutical Sciences and Science Communication and Society (SCS) offers students the possibility to combine bio-pharmaceutical sciences and science communication.

Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set.

Students who complete the specialisation Bio-Pharmaceutical Sciences and Science Communication and Society are admissible to a PhD programme in bio-pharmaceutical sciences or in science communication.

#### Learning outcomes

In addition to general achievements, graduates of the MSc programme BPS with the specialisation Science Communication and Society have reached the following specific achievement levels:

- a. Knowledge and understanding of modern information and communication technology;
- b. Experience in science communication;
- c. Knowledge of ethical, historical and social aspects in the area of the natural sciences.

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<sup>19</sup> The choice for lecture series and research project will be made in concert with the study adviser.

<sup>20</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

## Programme

The Bio-Pharmaceutical Sciences and Science Communication and Society (SCS) programme consists of:

- the Introduction Course BPS (on the subject of the research project) of 5 EC;
- a research project of 49 EC, consisting of 42 EC for literature research, practical implementation and performance, 5 EC for a thesis and 2 EC for an oral presentation and conducted within any of the research clusters of the LACDR or at the CHDR; permission from the Board of Examiners and the Director of Education is required when projects are conducted within external research groups led by Professors affiliated with a cluster of the LACDR;;
- a lecture series of 4 EC<sup>21</sup>;
- the course Scientific Conduct of 1 EC;
- attendance of Lectures or Symposia for a total of 1 EC;
- a maximum of 20 EC of electives within either Bio-Pharmaceutical Sciences or the SCS component of the programme; and
- the Science Communication and Society component<sup>22</sup> as described on page 84.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

## Specialisation Education

### Description

The specialisation Bio-Pharmaceutical Sciences and Education (EDU) prepares students for a career as biology (biologie)<sup>23</sup> or chemistry (scheikunde)<sup>24</sup> teacher qualified to teach in Dutch secondary education.

Students who complete the specialisation Bio-Pharmaceutical Sciences and Education are admissible to a PhD programme.

### Learning outcomes

In addition to general achievements, graduates of the MSc programme BPS with the specialisation Education have reached the following specific achievement levels:

- a. All qualifications necessary for teaching all years of secondary education and technical and vocational training (for 12–18 year-olds);

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<sup>21</sup> The choice for lecture series and research project will be made in concert with a study adviser.

<sup>22</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

<sup>23</sup> Master's Students in Bio-Pharmaceutical Sciences wishing to qualify for the school subject "Biology", need to remedy their deficiencies in concert with the teacher educator Biology of the ICLON. As a rule, Master's students with a BSc degree in Bio-Pharmaceutical Sciences of Leiden University need to complete the following courses in the Biology BSc programme of Leiden University for qualification: Biodiversiteit Plant en Fylogenie (level 100, 7 EC); Evolutie en Biodiversiteit Dier (level 100, 6 EC); Ecologie, Gedrag en Milieu (level 200, 4 EC).

<sup>24</sup> Master's students in Bio-Pharmaceutical Sciences wishing to qualify for the school subject "Chemistry", need to remedy the deficiencies in concert with the *teacher educator Chemistry* of the ICLON. As a rule, Master's students with a BSc degree in Bio-Pharmaceutical Sciences of Leiden University need to complete the following course in the Life Science & Technology BSc programme of Leiden University/Delft University of Technology for qualification: Natuurkunde (incl. aansluitmodule) (level 100, 4 EC).

## Qualification for admission

Master's students in Bio-Pharmaceutical Sciences of Leiden University with a BSc degree in Bio-Pharmaceutical Sciences as well as those with a BSc degree in Pharmaceutical Sciences, Pharmacy, Molecular Science & Technology, Chemistry or Life Science & Technology or an equivalent degree of a Dutch university will be considered for admittance to this specialisation of the programme. The teacher educator of Chemistry respectively Biology will assess if there are deficiencies in the prior education of the student. When deficiencies are identified, the teacher educator will propose how these can be solved.

Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½).

## Programme

The Bio-Pharmaceutical Sciences and Education (EDU) programme consists of:

- the Introduction Course BPS (on the subject of the research project) of 5 EC;
- a research project of 49 EC, consisting of 42 EC for literature research, practical implementation and performance, 5 EC for a thesis and 2 EC for an oral presentation and conducted within any of the research clusters of the LACDR or at the CHDR; permission from the Board of Examiners and the Director of Education is required when projects are conducted within external research groups led by Professors affiliated with a cluster of the LACDR;;
- a lecture series of 4 EC<sup>25</sup>;
- the course Scientific Conduct of 1 EC;
- attendance of Lectures or Symposia for a total of 1 EC;
- the Education component as described on page 85.

The Bio-Pharmaceutical Sciences component of the programme will be followed during the first year of study, the Education component will be followed during the second year.

When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced with 30 EC. The remaining 30 EC can be used for both the Bio-Pharmaceutical Sciences and Education component of the MSc programme.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.

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<sup>25</sup> The choice for lecture series and research project will be made in concert with a study adviser.

## **MSc Biology**

### **CROHO-number 66860**

The MSc Biology builds on the unique combination of biological institutes in Leiden joining forces: the Institute of Biology Leiden (IBL), the Institute of Environmental Sciences (CML), and the Naturalis Biodiversity Center (Naturalis). The choice of courses and research projects is further increased by the embedding in the Faculty of Science and the connections with the Leiden University Medical Center (LUMC), the Netherlands Institute of Ecology (NIOO, Wageningen) and with bioscience-based companies that are also located at the Leiden Bioscience Park.

Students can follow a general Biology programme or choose between four research specialisations *Molecular Genetics and Biotechnology (MGB)*, *From Cells to Organisms (FCTO)*, *Evolutionary Biology (EB)*, and *Biodiversity and Sustainability (BS)*, which reflect the major themes of biological research at Leiden University. In addition to the four research specialisations, three additional specialisations combine research programmes in biology with training in Science Based Business (SBB), Science Communication and Society (SCS) or Education (Edu).

The duration of the programme is two years (120 EC). Students who complete the programme receive the degree Master of Science in Biology (MSc in Biology) with specification of the specialisation, if applicable. The degree provides graduates with the academic training and research skills required to pursue a scientific or science-related career. All specialisations have the same Director of Education, Education Committee and Board of Examiners. A Board of Admissions advises on admissions.

### **Admission to the programme**

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Students can start their programme in September or February. However, they are strongly encouraged to start in September when a general introduction to the master programme and compulsory theoretical courses are scheduled.

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students with a BSc degree Biology from Leiden University will be admitted to the MSc Biology programme. For students with a Dutch bachelor degree in a related field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Biology.

Students from an international University with a bachelor degree in Biology, a bachelor degree in other Natural Sciences, Life Sciences, Mathematics, Biomedical Sciences or from a biology-related University of Applied Sciences (HBO), are also eligible for admission. The Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Biology, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

As a guideline for applicants with a HBO diploma, the HBO-diploma has to be obtained within four to five years and with an average final grade of at least 7.5 and a research internship grade of 8 or higher. Where this results in admission, this may be under the condition of specific additional course load. Where possible, deficiencies may be remedied by including particular optional elements of the MSc programme as part of the study programme.

## Specialisation

### Molecular Genetics and Biotechnology

#### Description

The master specialisation Molecular Genetics and Biotechnology integrates genetics, molecular biology, genomics and biotechnology into an attractive program for students, with excellent career perspectives. Through courses and research projects, students are trained by experts in the areas of molecular biology, microbiology, plant genetics, cellular imaging, animal disease models, and various –omics technologies and the corresponding bioinformatics. Attention is paid to the application of these techniques to biotechnology, i.e. how studies on model organisms can be translated to improve crops or human health. Students graduating in this master specialisation are well trained to start a research career in biological and medical sciences or lead projects in industrial or institutional research environments.

#### Programme

The programme of Biology and Animal Sciences and Health (120 EC) consists of:

- a theoretical part (30-60 EC); and
- one or more research projects (60-90 EC).

The programme includes several compulsory components, mostly at the start and the end of the programme, and can be expanded with a wide choice of elective elements. The mandatory components in the 1<sup>st</sup> semester aim to provide students with the theoretical and practical background needed for an efficient start of the Research Project at the end of this semester. The Research Projects are the actual core of the MSc programme. Students will be member of a research group of their choice and work full time on a specific project. Each project will be finished with an MSc thesis written in the form of a manuscript for an international scientific journal. At least one but preferably two Research Projects are part of the study programme.

The Specialisation Research Project has to be done within the theme of the specialisation at the IBL, at other departments of the Faculty of Science or at the LUMC or NIOO. Prior to the start of the Research Project, the Board of Examiners has to approve the individual study plan of the student and the Research Project agreement.

#### Compulsory components:

The compulsory theoretical components consist of at least 30 EC, and the minimum time to be spent on research projects is 60 EC. The specialisation Research Project should be minimally 36 EC, and a second Research Project should be at least 30 EC. A single research project cannot exceed 60 EC.

<i>Compulsory:</i>	<b>Level</b>	<b>EC</b>
Orientation on Molecular Genetics and Biotechnology	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6
Advanced Molecular Genetics and Biotechnology	500	3
<i>At least one of the following courses:</i>		
• Advanced Cell Biology	500	4
• Global Regulatory Networks in Bacteria	500	6
• Innate Immune Systems	500	6
• Mechanisms of Disease	500	6
• Research Project(s)	600	min. 60
(at least 36 EC within the specialisation)		
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

### Electives

Electives can consist of either additional courses or lectures, or an extension of the duration of a research project. A list of approved elective courses is available on the e-prospectus. For courses outside the LU Biology programme and for all research projects, prior approval of the Board of Examiners is required. Note: No more than 12 EC of optional theoretical elements of level < 400 are permitted and at most 15 EC of non-biology courses.

### **Approval of programme**

The individual study programme consisting of choices of courses and one or two research projects must have prior approval of the Board of Examiners.

### **Short description of the Courses**

The Molecular Genetics and Biotechnology study programme comprises several compulsory courses. The course *Orientation on Molecular Genetics and Biotechnology* provides an overview of the scientific research and research methods used in the departments participating in this MSc specialisation. The course “*Genomic Architecture*” aims at training students to become “genome-enabled” biologists by giving an overview of the structure, function and evolution of genomes, and an introduction into the bio-informatics required to study these genomes. Together with the Advanced Statistics course, and the specialisation courses, this will prepare the students theoretically for their training in scientific research during the Research Project(s).

A variety of additional courses from other MSc specialisations in Biology and from other MSc programmes at the Faculty of Science and LUMC can be chosen as electives. For details (description, literature, exam dates and further calendar events) about the different courses see the e-prospectus and Blackboard.

## Specialisation Evolutionary Biology

### Description

This research-oriented master specialisation provides students with in-depth knowledge about Evolutionary Sciences. Evolutionary changes over time and study the origin and maintenance of biological variation all over the tree of life. The mechanisms that drive the adaptation of organisms and their features are investigated at all biological levels. Thus, the specialisation includes genomics, functional developmental genetics, paleobiology, behavioural biology and evolutionary ecology. The important contribution of Naturalis to the programme makes this specialisation particularly attractive. With this master specialisation completed, the students are well equipped to start a career in evolutionary research or to take the responsibility for projects in an industrial or institutional research environment.

### Programme

The programme of Evolutionary Biology (120 EC) consists of:

- a theoretical part (30-60 EC); and
- one or more research projects (60-90 EC).

The programme includes several compulsory components, mostly at the start and the end of the programme, and can be expanded with a wide choice of elective elements. The mandatory components in the 1<sup>st</sup> semester aim to provide students with the theoretical and practical background needed for an efficient start of the Research Project at the end of this semester. The Research Projects are the actual core of the MSc programme. Students will be member of a research group of their choice and work full time on a specific project. Each project will be finished with a MSc thesis written in the form of a manuscript for an international scientific journal. At least one but preferably two Research Projects are part of the study programme.

The Specialisation Research Project has to be done in one of the IBL, CML, Naturalis, LUMC (for instance human population genetics, virus evolution, evolution of ageing, resistance etc.) or NIOO departments that contribute to the chosen specialisation. Research projects can range from experimental laboratory work on the molecular mechanisms of development to big data studies on evolutionary ecology. Students are encouraged to do an external project at an institute abroad. All Research Projects require prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

#### Compulsory components:

The compulsory theoretical components consist of at least 30 EC, and the minimum time to be spent on research projects is 60 EC. The specialisation Research Project should be minimally 36 EC, and a second Research Project should be at least 30 EC. A single research project cannot exceed 60 EC.

<i>Compulsory:</i>	<b>Level</b>	<b>EC</b>
Orientation on Evolutionary Biology	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6
Development & Evolution	500	6
Integrative Taxonomy	500	6

Research Project(s) (at least 36 EC within the specialisation)	600	min. 60
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

### Electives/Optional elements:

The optional part of the programme can consist of either additional courses or lectures, or an extension of the duration of a research project. A list of approved elective courses is available on the e-prospectus. For courses outside the Leiden University biology programme and for all research projects, prior approval of the Board of Examiners is required.

Note: No more than 12 EC of optional theoretical elements of level < 400 are permitted and at most 15 EC of non-biology courses.

### **Approval of programme**

The individual study programme consisting of choices of courses and one or two research projects must have prior approval of the Board of Examiners.

### **Short description of the Courses**

The Evolutionary Biology study programme comprises several compulsory courses. The course *Orientation on Evolutionary Biology* provides a state of the art overview of the scientific research and research methods used in the departments participating in this MSc specialisation. The course “*Genomic Architecture*” aims at training students to become “genome-enabled” biologists by giving an overview of the structure, function and evolution of genomes, and an introduction into the bio-informatics required to study these genomes. Together with the Advanced Statistics course, and one of the specialisation courses this will prepare the students theoretically for their training in scientific research during the Research Project(s).

A variety of additional courses from other MSc specialisations in Biology and from other MSc programmes at the Faculty of Science and LUMC can be chosen as electives. For details (description, literature, exam dates and further calendar events) about the different courses see the e-prospectus and Blackboard.

### **Specialisation**

## **From Cells to Organisms**

### **Description**

This research-oriented master specialisation offers students the unique possibility to integrate molecular, cellular and organismal levels of research, but also provides the possibility to specialize in one of these levels. It equips students with advanced knowledge ranging from the functioning of individual cells to the communication between cells, and the development, physiology and behaviour of multicellular organisms. An important aspect of this specialisation is to understand the molecular mechanisms underlying health and disease and how cells and organisms adapt to environmental factors ranging from light, stress and pathogens to ecological and social conditions. Model organisms include bacteria, fungi, plants and animals (invertebrates and vertebrates). The subject areas covered encompass functional



genomics, signal transduction, cellular differentiation, development, host-microbe interactions and animal behaviour.

This master specialisation is ideally suited as a basis for starting a research career at a university or research institute and for a position in a bioscience-based company.

## Programme

The programme of the specialisation From Cells to Organisms (120 EC) consists of:

- a theoretical part (30-60 EC); and
- one or more research projects (60-90 EC).

The programme includes several compulsory components, mostly at the start and the end of the programme, and can be expanded with a wide choice of elective elements. The mandatory components in the 1<sup>st</sup> semester aim to provide students with the theoretical and practical background needed for an efficient start of the Research Project at the end of this semester. The Research Projects are the actual core of the MSc programme. Students will be member of a research group of their choice and work full time on a specific project. Each project will be finished with a MSc thesis written in the form of a manuscript for an international scientific journal. At least one but preferably two Research Projects are part of the study programme.

The Specialisation Research Project has to be done within the theme of the specialisation at the Institute Biology Leiden, at other departments of the Faculty of Science or at the Leiden University Medical Center. All Research Projects require prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

### Compulsory components:

The compulsory theoretical components consist of at least 30 EC, and the minimum time to be spent on research projects is 60 EC. The specialisation Research Project should be minimally 36 EC, and a second Research Project should be at least 30 EC. A single research project cannot exceed 60 EC.

<i>Compulsory:</i>	<b>Level</b>	<b>EC</b>
Orientation on From Cells to Organisms	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6
<i>At least two of the following courses:</i>		
• Advanced Cell Biology	500	4
• Animal personality	500	6
• Development and Evolution	500	6
• Innate Immune Systems	500	6
• Mechanisms of Disease	500	6
Research Project(s) (at least 36 EC within the specialisation)	600	min. 60
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

### Electives/Optional elements

The optional part of the programme can consist of either additional courses or lectures, or an extension of the duration of a research project. A list of approved elective courses is available

on the e-prospectus. For courses outside the Leiden University biology programme and for all research projects, prior approval of the Board of Examiners is required.

Note: No more than 12 EC of optional theoretical elements of level < 400 are permitted and at most 15 EC of non-biology courses.

## Approval of programme

The individual study programme consisting of choices of courses and one or two research projects must have prior approval of the Board of Examiners.

## Short description of the Courses

The From Cells to Organisms study programme comprises several compulsory courses. The course *Orientation on From Cells to Organisms* provides a state of the art overview of the scientific research and research methods used in the departments participating in this MSc specialisation. The course “*Genomic Architecture*” aims at training students to become “genome-enabled” biologists by giving an overview of the structure, function and evolution of genomes, and an introduction into the bio-informatics required to study these genomes. Together with the Advanced Statistics course, and two specialisation courses this will prepare the students theoretically for their training in scientific research during the Research Project(s).

A variety of additional courses from other MSc specialisations in Biology and from other MSc programmes at the Faculty of Science and LUMC can be chosen as electives. For details (description, literature, exam dates and further calendar events) about the different courses see the e-prospectus and Blackboard.

## Specialisation

### Biodiversity and Sustainability

#### Description

The critical importance of biodiversity and the services provided by nature for our society is increasingly endorsed by national and international conventions. However, to implement the right policy measures for creating a sustainable society, a much better understanding of the biological processes involved is essential. This master specialisation aims to discuss and answer these societal relevant biological questions, such as; How much biodiversity do we need to ensure that nature functions well? What determines the stability of ecosystems? How can we quantify ecosystem services? Are invasive species always bad for the ecosystem? Will species be able to adapt sufficiently fast to global change and what are appropriate measures to facilitate this process? And, how can we optimize ecosystem functioning and biodiversity for a sustainable society? By using ‘sustainability’ as a guiding principle, the programme provides students with an academic attitude by stimulating reflective, independent and creative thinking to support, conserve and manage biodiversity and sustainable ecosystem services. This master specialisation prepares students for a PhD programme and/or for research positions at universities or research institutes and for positions at governmental organisations and consultancy agencies.

#### Programme

The programme of Biodiversity and Sustainability (120 EC) consists of:

- a theoretical part (30-60 EC); and
- one or more research projects (60-90 EC).

The programme includes several compulsory components, mostly at the start and the end of the programme, and can be expanded with a wide choice of elective elements. The mandatory components in the 1<sup>st</sup> semester aim to provide students with the theoretical and practical background needed for an efficient start of the Research Project at the end of this semester. The Research Projects are the actual core of the MSc programme. Students will be member of a research group of their choice and work full time on a specific project. Each project will be finished with a MSc thesis written in the form of a manuscript for an international scientific journal. At least one but preferably two Research Projects are part of the study programme.

The Specialisation Research Project has to be done in one of the IBL, CML or Naturalis departments that contribute to the chosen specialisation. Research projects can range from experimental studies on molecular tools for biomonitoring or sustainable use of resources and human impacts on biodiversity to field research in the Netherlands (e.g. on pollination services and nature conservation mechanisms) or elsewhere (e.g. terrestrial and marine studies in Southeast Asia) to study biological mechanisms associated with biodiversity and sustainability. Students are encouraged to do a second external project at an institute abroad. All Research Projects require prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

#### Compulsory components:

The compulsory theoretical components consist of at least 30 EC, and the minimum time to be spent on research projects is 60 EC. The specialisation Research Project should be minimally 36 EC, and a second Research Project should be at least 30 EC. A single research project cannot exceed 60 EC.

<i>Compulsory:</i>	<b>Level</b>	<b>EC</b>
Orientation on Biodiversity and Sustainability	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6
Ecosystems Services	500	6
Human Impacts on Biodiversity	500	6
Methods in Biodiversity Analysis	500	6
Research Project(s) (at least 36 EC within the specialisation)	600	min. 60
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

#### Electives/Optional elements

The optional part of the programme can consist of either additional courses, or an extension of the duration of a research project. A list of approved elective courses is available in the e-guide. For courses outside the Leiden University biology programme, prior approval of the Board of Examiners is required.

Note: No more than 12 EC of optional theoretical elements of level < 400 are permitted and at most 15 EC of non-biology courses.

### **Approval of programme**

The individual study programme consisting of choices of courses and one or two research projects must have prior approval of the Board of Examiners.

## Short description of the Courses

Courses cover a broad range of relevant subjects and provide in-depth theoretical knowledge as well as training in practical skills and advanced research tools. The course *Orientation on Biodiversity and Sustainability* provides a state of the art overview of the scientific research and research methods used in the departments participating in this MSc specialisation.

The course “*Genomic Architecture*” aims at training students to become “genome-enabled” biologists by giving an overview of the structure, function and evolution of genomes as tools for biomonitoring, and an introduction into bio-informatics. The interface between biodiversity and sustainability is taught in ‘*Ecosystem Services*’ and ‘*Human Impacts on Biodiversity*’. In addition, students are trained in ‘*Advanced Statistics*’ and ‘*Methods in Biodiversity Analysis*’, providing the methodological tools for their training in scientific research during the Research Project(s).

A variety of additional courses from other MSc specialisations in Biology and from other MSc programmes at the Faculty of Science can be chosen as electives. For details (description, literature, exam dates and further calendar events) about the different courses see the e-prospectus and Blackboard.

## General Biology Programme (no research specialisation)

### Programme

The General Biology programme (120 EC) consists of:

- a theoretical part (30-60 EC); and
- one or more research projects (60-90 EC).

The programme includes several compulsory components, mostly at the start of the programme, and can be expanded with a wide choice of elective elements. The mandatory components in the 1<sup>st</sup> semester aim to provide students with the theoretical and practical background needed for an efficient start of the specialisation Research Project at the end of this semester.

At least one Research Project has to be done within a research area at the IBL, CML, Naturalis, Faculty of Science or LUMC. All Research Projects require prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

#### Compulsory components:

The compulsory theoretical components consist of at least 30 EC, and the minimum time to be spent on research projects is 60 EC. Each Research Project should be at least 30 EC. A single research project cannot exceed 60 EC.

	Level	EC
<i>One of the courses:</i>		
• Orientation on Biodiversity and Sustainability	400	2
• Orientation on Evolutionary Biology	400	2
• Orientation on From Cells to Organisms	400	2
• Orientation on Molecular Genetics and Biotechnology	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6

*At least three of the courses:*

• Advanced Cell Biology	500	4
• Advanced Molecular Genetics and Biotechnology	500	3
• Animal Personality	500	6
• Paleobiology	500	3
• Development and Evolution	500	6
• Ecosystems Services	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	500	6
• Innate Immune Systems	500	6
• Integrative Taxonomy	500	6
• Mechanisms of Disease	500	6
• Methods in Biodiversity Analysis	500	6
• <i>Or courses from the list of approved electives</i>		
Research Project(s)	600	min. 60
Electives		max. 30

### Electives/Optional elements

The optional part of the programme can consist of either additional courses or lectures, or an extension of the duration of a research project. A list of approved elective courses is available on the e-prospectus. For courses outside the LU biology programme and for all research projects, prior approval of the Board of Examiners is required.

Note: No more than 12 EC of optional theoretical elements of level < 400 are permitted and at most 15 EC of non-biology courses.

### **Approval of programme**

The individual study programme consisting of choices of courses and one or two research projects must have prior approval of the Board of Examiners.

### **Short description of the Courses**

Courses cover a broad range of relevant subjects and provide in-depth theoretical knowledge as well as training in practical skills and advanced research tools. The Orientation courses provide a state of the art overview of the scientific research and research methods of the participating Institutes.

The course “*Genomic Architecture*” aims at training students to become “genome-enabled” biologists by giving an overview of the structure, function and evolution of genomes, and an introduction into the bio-informatics required to study these genomes. In addition, students are trained in ‘*Advanced Statistics*’ and follow at least one specialised course providing students with an integrated picture on specific topics for their training in scientific research during the Research Project(s).

A variety of additional courses from other MSc specialisations in Biology and from other MSc programmes at the Faculty of Science can be chosen as electives. For details (description, literature, exam dates and further calendar events) about the different courses see the e-prospectus and Blackboard.

## Specialisation Science Based Business

### Description

The specialisation Biology and Science Based Business (SBB) offers students the possibility to combine biology with knowledge, insights and skills in the area of Management, Business and Entrepreneurship.

Students are encouraged to broaden their horizon, to form an opinion on and prepare for a career in industry and to enhance competences for pursuing entrepreneurial business opportunities created in science and research.

Students who complete the specialisation Biology and Science Based Business are admissible to a PhD programme.

### Programme

The Biology and Science Based Business (SBB) programme consists of:

- 24 EC of advanced theory;
- a research project of 36 EC;
- a maximum of 20 EC of electives within either Biology or the SBB component; and
- the SBB Management or SBB New Technology Ventures track<sup>26</sup> as described on page 81.

The theoretical part of the Biology research component comprises:

	Level	EC
<i>One of the courses:</i>		
• Orientation on Biodiversity and Sustainability	400	2
• Orientation on Evolutionary Biology	400	2
• Orientation on From Cells to Organisms	400	2
• Orientation on Molecular Genetics and Biotechnology	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6
<i>At least three of the courses:</i>		
• Advanced Cell Biology	500	4
• Advanced Molecular Genetics and Biotechnology	500	3
• Animal Personality	500	6
• Paleobiology	500	3
• Development and Evolution	500	6
• Ecosystems Services	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	500	6
• Innate Immune Systems	500	6
• Integrative Taxonomy	500	6
• Mechanisms of Disease	500	6
• Methods in Biodiversity Analysis	500	6
• <i>Or courses from the list of approved electives</i>		

<sup>26</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

Research Project(s)	600	min. 60
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

The Biology component can be extended with an additional 20 EC (courses or extension of the research project to 80 EC in total). The research project has to take place in one of the research groups of the IBL, CML or Naturalis, other Institutes of the Faculty of Sciences or LUMC.

Theoretical components should be minimally at level 400. The individual study programme consisting of choices of courses and the research project must have prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation Science Communication and Society

### Description

The specialisation Biology and Science Communication and Society (SCS) offers students the possibility to combine physics and science communication.

Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set.

Students who complete the specialisation Biology Sciences and Science Communication and Society are admissible to a PhD programme in biology or in science communication.

### Programme

The Biology Science Communication and Society (SCS) programme consists of:

- 24 EC of advanced theory;
- a research project of 36 EC;
- a maximum of 20 EC of electives within either Biology or the SCS component; and
- the Science Communication and Society component<sup>27</sup> as described on page 84.

The theoretical part of the Biology research component comprises:

	Level	EC
<i>One of the courses:</i>		
• Orientation on Biodiversity and Sustainability	400	2
• Orientation on Evolutionary Biology	400	2
• Orientation on From Cells to Organisms	400	2
• Orientation on Molecular Genetics and Biotechnology	400	2
Advanced Statistics	500	4

<sup>27</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

Genomic Architecture	400	6
<i>At least three of the courses:</i>		
• Advanced Cell Biology	500	4
• Advanced Molecular Genetics and Biotechnology	500	3
• Animal Personality	500	6
• Paleobiology	500	3
• Development and Evolution	500	6
• Ecosystems Services	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	500	6
• Innate Immune Systems	500	6
• Integrative Taxonomy	500	6
• Mechanisms of Disease	500	6
• Methods in Biodiversity Analysis	500	6
• <i>Or courses from the list of approved electives</i>		
The Biology component can be extended with an additional 20 Research Project(s)	600	min. 60
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

Theoretical components should be minimally at level 400. The individual study programme consisting of choices of courses and the research project must have prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

## Specialisation Education

### Description

The specialisation Biology and Education (EDU) prepares students for a career as biology (biologie) teacher qualified to teach in Dutch secondary education.

Students who complete the specialisation Biology and Education are admissible to a PhD programme.

### Qualifications for admission

In addition to the general admission requirements of the MSc programme in Biology, students must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden – gevorderd, met spreekvaardigheid minimaal een 7 ½).

### Programme

The Biology and Education (EDU) programme consists of:

- 24 EC of advanced theory;
- a research project of 36 EC;
- the Education component as described on page 85.



The theoretical part of the Biology research component comprises:

	<b>Level</b>	<b>EC</b>
<i>One of the courses:</i>		
• Orientation on Biodiversity and Sustainability	400	2
• Orientation on Evolutionary Biology	400	2
• Orientation on From Cells to Organisms	400	2
• Orientation on Molecular Genetics and Biotechnology	400	2
Advanced Statistics	500	4
Genomic Architecture	400	6
<i>At least three of the courses:</i>		
• Advanced Cell Biology	500	4
• Advanced Molecular Genetics and Biotechnology	500	3
• Animal Personality	500	6
• Paleobiology	500	3
• Development and Evolution	500	6
• Ecosystems Services	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	500	6
• Innate Immune Systems	500	6
• Integrative Taxonomy	500	6
• Mechanisms of Disease	500	6
• Methods in Biodiversity Analysis	500	6
• <i>Or courses from the list of approved electives</i>		
Research Project(s)	600	min. 60
Electives		max. 30
<b>Total Programme</b>		<b>120</b>

The research project has to take place in one of the research groups of the IBL, CML or Naturalis, other Institutes of the Faculty of Sciences or LUMC.

Theoretical components should be minimally at level 400. The individual study programme consisting of choices of courses and the research project must have prior approval by the Board of Examiners through approval of the individual study plan of a student and approval of the research agreement.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.

# MSc Life Science and Technology

CROHO-number 66286

The Leiden Institute of Chemistry (LIC) forms the basis for research and collaborations of the Leiden chemistry and life sciences groups. The LIC offers two MSc programmes, namely the MSc Life Science and Technology and the MSc Chemistry. Life Science and Technology researches the processes in the living cell. The cell is the building block of life, the smallest unit with the characteristics of living systems. Increased knowledge of the mechanisms of the cell can lead to better medicines, new methods for combating diseases. The master programme Life Science and Technology (LST) participates in the Leiden University research profiling theme of “BioScience: Science base of Health”.

The MSc LST programme offers four specialisations: Life Science Research and Development (RESEARCH), Life Science Based Business (SBB), Life Science and Communication and Society (SCS) and Life Science and Education (EDU). The duration of each specialisation is two years (120 EC); a general programme overview of the four specialisations is given in Table 1. Students who complete the programme receive the degree Master of Science in LST, with specification of the specialisation. Students with an MSc degree in LST are admissible to a PhD programme.

*After completion of the MSc LST programme you will have developed:*

- *Knowledge and understanding of theoretical concepts from textbooks and primary literature pertaining to the research area*
- *The ability to plan research and perform experiments within an appropriate time frame*
- *The (experimental/computer) skills to apply standard research procedures with limited supervision*
- *An appropriate critical scientific attitude, i.e. the ability to analyse results and critically evaluate their validity and accuracy*
- *The skill to communicate research progress and results to colleagues, supervisors and experts*
- *The ability to write independently a structured and accurate report on performed research*

Table 1: Overview of the programmes of the four MSc LS&T specialisations

<b>Specialisation</b>	<b>RESEARCH</b>	<b>EDU</b>	<b>SCS</b>	<b>SBB</b>
Research Training Project	60	30	30	30
Academic Skills	6	6	6	6
Compulsory courses in research area	24	24 <sup>28</sup>	24	24
Essay & Colloquium	6	-	-	-
Free electives <sup>29</sup>	24	30 / 6 <sup>30</sup>	20	20
EDU/SCS/SBB components	-	30 / 60 <sup>30</sup>	40	40
<b>Total</b>	<b>120</b>	<b>120</b>	<b>120</b>	<b>120</b>

<sup>28</sup> Students in the EDU specialisation are advised to choose from both research areas, to obtain a broader knowledge of chemistry.

<sup>29</sup> The choice in the free electives is restricted to the boundaries specified here. A maximum of 20 EC can be used for extension of the research internships. A maximum of 20 EC may be used as an extension of the SCS or SBB components.

<sup>30</sup> If the student has taken a minor in Education (“tweedegraadsbevoegdheid”) of 30 EC in the BSc programme, only 30 EC are necessary in the MSc programme to obtain the “eerstegraadsbevoegdheid”; then 30 EC free electives are added to the programme of the MSc Chemistry.

## Description of the field of research

Topics in *Life Science & Technology* comprise molecular and cellular as well as chemical biology research creating an unprecedented progress in understanding of fundamental cellular processes and mechanisms underlying diseases. Knowledge about genomic organization, studies on protein-protein interactions, synthesis and application of molecular chemical structures and understanding of bio(medical) informatics are a core part of our modern understanding of health & disease. Our master students will learn to understand the molecular and structural chemical and biological aspects of disease-related processes as well as be able to apply chemical tools in treating diseases. For example:

Several disease-related studies can be carried out e.g. at the LIC, LACDR, IBL, LUMC, Dutch Cancer Institute (NKI) or ErasmusMC. Acquired and inborn errors in metabolism underlie many diseases occurring in man. The research carried out in the LIC focuses on glycosphingolipids and their metabolizing enzymes in lysosomal storage disorder, neurodegenerative disease and other metabolic syndromes.

Organic and medicinal chemistry are combined with molecular and chemical biology to develop assays to determine protein activity. In (inter)national collaboration activity-based probes are applied to visualize and control protein activity. Together with chemists we study selective kinase inhibitors to treat leukemia in preclinical models of disease, detect and modulate endocannabinoid activity and develop biomarkers for target engagement of GPCRs.

At the heart of the cell, in the nucleus, proteins and nucleic acids come together to maintain and express our genetic information. The interplay of proteins and nucleic acids in both genetic and epigenetic pathways forms one of the research focuses. How do structures, motions and interactions come together to elicit function? The main research line is centered on the molecular basis of chromatin function at the level of its repeating unit, the nucleosome.

The panel of possible research studies are broad and other research topics related to fundamental and disease-related studies on protein structures, biomaterials for biomedical purposes and immunological fundamentals and diseases can be chosen. Photodynamic activation of anticancer drugs and energy aspects of photosynthesis can be also chosen.

## Programme organisation

All specialisations have the same Educational Director and the same Board of Admission. The Department Teaching and Learning Committee for the MSc programme Life Science and Technology is combined with the one for the MSc programme Chemistry and is responsible for both the Research and the Science Based Business specialisations. The EDU and SCS specialisations have their own Department Teaching and Learning Committee. The Board of Examiners of the MSc programme Life Science and Technology is also combined with the one for the MSc programme Chemistry. In addition the specialisations SBB, SCS, and EDU each have their own faculty-wide Board of Examiners appointed by the Faculty of Science for the specialisation-specific part of the MSc programme.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of their previous training. The admission process may include an interview with the Board of Admissions. Students can start their programme in September or February (international students are strongly advised to start in September).

If additional admission requirements apply to a certain specialisation it will be mentioned in the paragraph describing the specialisation.

Students with a BSc degree Life Science and Technology (LST) from Leiden/Delft will be admitted to the MSc LST programme. For students with a Dutch bachelor degree in a related

field the Board of Admissions will evaluate whether the content of their bachelor programme is equivalent to the programme of the BSc Life Science and Technology (LST).

Students with a BSc degree in Life Sciences, or in a field related to Life Sciences, at an international University are also eligible for admission. The Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Life Science and Technology, and whether their academic background and obtained grades provide sufficient confidence that the candidate will be able to complete the Master's programme in two years. Applicants need to provide the Board of Admissions with a letter of motivation.

All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.

- IELTS: minimum 6.5, with a minimum of 6.0 for each of the components Listening, Reading, Writing and Speaking
- TOEFL: internet based 90
- Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if the student has completed their education in Canada, USA, UK, Ireland, New Zealand or Australia, or possesses an International Baccalaureate.

The Education specialisation requires proof of proficiency in Dutch Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½). (for specifications see specialisation Education)

HBO students can also apply for admission; they should have obtained their BAS degree within four years with an average final grade of at least 7.5 and a research internship grade of at least 8.0. Additionally a letter of motivation by the student and a letter of recommendation of the 'studieloopbaanbegeleider' of the BAS programme is required.

To students with an outstanding track record and an outstanding research internship but with a prior education that differs from the bachelor LST programme by at most 30 ECTS, a premaster programme may be offered consisting of BSc courses (30 EC). If the candidate student successfully passes all required premaster courses the student will be admitted to the MSc programme.

## **Programme**

Students compose their own study programme (choice in core courses, electives and research training project) in consent with their mentor, who is a principal investigator of the LIC. The mentor is the supervisor of the major research-training project of the specialisation in one of the major research areas as chosen by the student. The mentor will coach the student from the admission throughout the MSc programme. The choice in elective courses in the MSc programme may be limited by the need to adapt the programme to the present knowledge of the candidate. The web-based master planner is used for planning and registration of the study program, and is to be filled in by the student in consult with the mentor. The mentor and student discuss the progress of the student at least every 6 months using the results documented in the master planner. The programme may be adjusted during the course of the MSc study. The master planner is updated by the student on a regular basis. It is accessible to the student, the mentor and the study coordinator. The study coordinator administrates a copy of the individual study programme; it is used to keep track of the student's progress and forms the basis for the master portfolio. The study coordinator will mediate when the student encounters problems in the interaction with the mentor. LST research training projects can be performed at the LIC, LACDR, IBL, LUMC, NKI or ErasmusMC. This program aims to equip students with knowledge and expertise on molecular and biomedical fundamental level, preparing them for careers in both industrial and academic environments. Biotechnological, food and biopharmaceutical industries as well as healthcare and fundamental research institutions are probable employers of our graduates.

## **Programmes of the specialisations**

Specialisation-specific components of the specialisations Life Science Based Business, Life Science and Science Communication and Society and Life Science and Education are described separately in this Appendix.

### **Specialisation**

#### **Life Science research and development (RESEARCH)**

The research specialisation offers the student the opportunity to spend two full years on training and specialisation to become an independent and creative researcher. The MSc students will become a member and colleague in one of the research groups in the LIC. The student will develop her/his individual MSc programme together with the mentor. The majority of the students with an MSc in Research in Life Sciences will continue their career in a PhD position.

The life science research and development programme consists of four parts: the research training project (60 EC), academic skills (6 EC, comprising Science Methodology and a writing course), the compulsory courses (30 EC) and the elective courses (24 EC).

#### **Research Training Project**

The (major) research-training project is carried out within LIC research groups, LACDR, or IBL. Our MSc students also have the opportunity to carry out pre-clinical master projects in biomedical research institutes, including the LUMC, NKI or ErasmusMC. The research-training project may be split into two research-training projects: the major and minor training project. The major research-training project is limited to a minimum of 40 and a maximum of 60 EC; a minor research-training project must comprise at least 20 EC.

All research training projects are concluded with a written report that is graded by the main supervisor and an independent second examiner, who was not involved in the writing process. In addition, the major research-training project includes a presentation for an independent jury of two staff members, as well as interested students and staff members of the LIC (Thesis Talk). The Thesis Talk jury will discuss their findings concerning the report and presentation with the research supervisors. The final grade will be based on the judgement of the supervisor, second examiner and the Thesis Talk jury. As part of their training all students attend at least 10 Thesis Talks during their MSc program.

The minor and major research training projects must be carried out in different research groups and be supervised and evaluated by different staff members. In consent with the mentor the minor research training project can be carried out in another specialisation, another institute (within the Netherlands or abroad), or in industry, but a staff member of the LIC must act as a co-supervisor. This LIC co-supervisor has the final responsibility for the creation of the internship agreement, grading of the research project report and creation and signing of the internship evaluation form. Prior approval of the Board of Examiners is required for a research-training project outside the LIC institute, LUMC, NKI, ErasmusMC or IBL, LION, LIACS or LACDR

After completion of the practical work, the student and supervisor make an agreement on the deadline for handing in the final version of the MSc thesis or project report. The final version of the report should be handed in within 3 months after the last day of practical work. For all research training projects, it is not possible to obtain a grade higher than 6 if this deadline is exceeded. Students can only start with an optional second research training project (within or outside the LIC) when the first project has been successfully concluded with a grade (including a Thesis Talk for major research training projects). External training projects cannot be the major training project (the one concluded with the Thesis Talk) and should start after completion of the major training project.

## Compulsory components

The compulsory theoretical component comprises a selection of four core courses (24 EC), academic skills (Science Methodology and a writing course, 4 + 2 EC) and a literature essay with colloquium (6 EC). All students attend at least 10 colloquia during their MSc program. The four core courses are chosen from the list of core courses as described in Table 2.

## Elective components

The elective component consists of a free choice of theoretical courses (24 EC). Alternatively, a maximum of 20 EC can be used to extend the research training projects. The mentor may limit the choice in elective courses by the need to adapt the programme to the present knowledge of the student. Students can choose their electives from the list of core courses within or outside their research area, from the list of elective courses, the MSc courses offered in a Science Faculty of a Dutch university of level 400 or higher, or level 400 courses from the Bachelor programmes MST and LST provided that these courses were not part of the student's earlier programme. All other electives have to be approved by the Board of Examiners.

## Specialisation

### Life Science Based Business

#### Description

The specialisation Life Science Based Business (SBB) offers students the possibility to combine life science with knowledge, insights and skills in the area of Management, Business and Entrepreneurship.

Students are encouraged to broaden their horizon, to form an opinion on and prepare for a career in industry and to enhance competences for pursuing entrepreneurial business opportunities created in science and research.

Students who complete the specialisation Life Science Based Business are admissible to a PhD programme.

#### Programme

The Life Science Based Business (SBB) programme consists of:

- a research training project in Life Science and Technology of 30 EC in one of the research groups in the institutes specified above, with an optional extension of 20 EC, finalised with a thesis talk (as described above);
- 24 EC of core courses to be selected in correspondence with the research topic;
- attendance of at least 10 thesis talks;
- 6 EC academic skills, comprising Science Methodology (4 EC) and a writing course (2 EC);
- 20 EC of free electives<sup>31</sup>; and
- the SBB Management or SBB New Technology Ventures track<sup>32</sup> as described on page 81.

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<sup>31</sup> An extension of the research project is restricted to 20 EC and no more than 20 EC can be used for SBB courses

<sup>32</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 81.

## Specialisation **Life Science Communication and Society**

### **Description**

The specialisation Life Science Communication and Society (SCS) offers students the possibility to combine life science and science communication. Students are prepared for a career in popularisation of science or for a career as a scientist with a communicating mind-set. Students who complete the specialisation Life Science Communication and Society are admissible to a PhD programme in life science or in science communication.

### **Programme**

The Life Science Communication and Society (SCS) programme consists of:

- a research training project in Life Science and Technology of 30 EC in one of the research groups in the institutes specified above, with an optional extension of 20 EC, finalised with a thesis talk (as described above);
- 24 EC of core courses to be selected in correspondence with the research topic;
- 6 EC academic skills, comprising Science Methodology (4 EC) and a writing course (2 EC);
- attendance of at least 10 thesis talks;
- 20 EC of free electives<sup>11</sup>; and
- the Science Communication and Society component<sup>33</sup> as described on page 84.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 84.

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<sup>33</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

## Specialisation Life Science and Education

### Description

The specialisation Life Science and Education (EDU) prepares students for a career as chemistry (scheikunde) or biology (biologie) teacher qualified to teach in Dutch secondary education.

Students who complete the specialisation Life Science and Education are admissible to a PhD programme.

### Programme

The Life Science and Education (EDU) programme consists of:

- a research training project in Life Science and Technology of 30 EC in one of the research groups in the institutes specified above, with an optional extension of 20 EC<sup>34</sup>, finalised with a thesis talk (as described above);
- 24 EC of core courses to be selected in correspondence with the research topic;
- 6 EC academic skills, comprising Science Methodology (4 EC) and a writing course (2 EC);
- attendance of at least 10 thesis talks;
- the Education component as described on page 85.

The Chemistry component of the programme will be followed during the first year of study, the Education component will be followed during the second year.

When the student has passed the minor Education (30 EC) during the BSc programme, the compulsory Education component is reduced with 30 EC. The remaining 30 EC are added to the Life Science and Technology programme.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 85.

### List of Core Courses

The LST master students have to choose two (2) courses from the Molecular Sciences and two (2) from the Bio(medical) Sciences. A list of the core courses in Life Science and Technology is given in Table 2.

Table 2: Core courses in Life Science and Technology. All courses are at level 400 or 500 and encompass 6 EC.

	<b>Lecturer</b>	<b>Code</b>
<b>Molecular Sciences</b>		
Molecular Chemistry*	van der Marel	MC
Enzyme dynamics: NMR spectroscopy and kinetics	Ubbink	BIMS
Chemical Genetics	Brouwer <i>et al</i>	CG
Bionanotechnology	Schneider <i>et al</i>	BNT

<sup>34</sup> If the student has taken a minor in Education (“tweedegraadsbevoegdheid”) of 30 EC in the BSc programme, only 30 EC are necessary in the MSc programme to obtain the “eerstegraadsbevoegdheid”; then 30 EC free electives are added to the programme of the MSc Life Science and Technology. An extension of the research project is restricted to 20 EC



### **Bio(medical) Sciences**

Genome Organisation and Maintenance in Cancer and Aging	Brouwer	GCA
Bio(medical) Informatics	Wolstencroft	BMI
Global Regulatory Networks in bacteria	van Wezel <i>et al</i>	GRNB
In-vivo Biomolecular Interactions Underlying Diseases	Noteborn	IBIDE

\* This course cannot be chosen by students with a BSc degree in Molecular Science & Technology.

## **Specialisation Science Based Business**

### **Description**

The specialisation Science Based Business is for MSc students in the sciences and biomedicine who are interested in management or a career in industry. The objective of the specialisation is to teach students basic analytical frameworks and skills to analyse business-related problems and to contribute to managerial decision making, either within the context of established knowledge-intensive organisations or within the context of new technology ventures.

Students who opt for the SBB specialisation can choose from two tracks:

#### **1. The SBB Management track**

The SBB Management track provides an introduction to general management theory and practice. In addition, students will gain practical experience in applying their business knowledge and skills through working as an intern in a knowledge-intensive organisation.

*After completion of this track you will have developed:*

- *Familiarity with the 'managerial toolbox' – a basic understanding of foundational concepts and frameworks from different business disciplines.*
- *Practical skills and experience in applying the 'managerial toolbox' in the context of knowledge-intensive organisations.*
- *Basic skills in conducting business research.*

#### **2. The SBB New Technology Ventures (NTV) track**

The SBB New Technology Ventures (NTV) track offers an integrated programme that teaches students knowhow and skills related to the commercialisation of new technologies generated in research. In addition, students will gain practical experience in applying their knowledge and skills through an assignment focusing on new technology-based business creation.

*After completion of this track you will have developed:*

- *Knowledge and understanding of the entrepreneurial process with a focus on technology-based business creation.*
- *Basic skills in conducting business research.*
- *The ability to find, assess and develop business opportunities.*

- *The ability to formulate a strategy and make a business plan for a technology-based new business.*
- *Experience in creating new technology-based business.*

Both tracks emphasise small-scale, interactive teaching, that connects with management practice. This means opportunities for students to learn through real-life business case discussions, company visits, guest speakers, and hands-on business experience in internships.

## Qualifications for Admission

Admissible to the specialisation SBB are all students that are admitted to a Master Programme of the Faculty of Science or the Master Programme in Biomedical Sciences of the Faculty of Medicine (LUMC) provided that the rules and regulations of the subject Master Programme do allow so.

In addition, international applicants must provide proof of proficiency in English with an IELTS  $\geq$  6.5.

## Programme

The MSc programme in combination with the Science Based Business (SBB) specialisation consists of two components:

- a component within the chosen MSc programme:
  - *Mathematics, see page 4;*
  - *Computer Science, see page 13;*
  - *Astronomy, see page 29;*
  - *Physics, see page 38;*
  - *Chemistry, see page 46;*
  - *Bio-Pharmaceutical Sciences, see page 56;*
  - *Biology, see page 70; or*
  - *Life Science and Technology, see page 78.*
- a Science Based Business or Research-Based Business component<sup>35</sup>.

The Science Based Business component comprises at least 40 EC. An additional maximum of 20 EC of electives can be chosen from either SBB Management and/or SBB NTV courses and electives (as listed in the table below), or from the MSc programme of choice. The choice of courses and electives should be made in consultation with a study adviser, mentor, or specialisation coordinator.

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<sup>35</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

## Programme SBB Management track

The SBB Management track encompasses minimally the following modules:

	Level	EC
Strategy	400	5
Marketing (SBB)	400	3
Financial Management	400	3
Technology and Operations Management	400	4
Business Research Methods	500	5
SBB Business Studies Internship	600	20-40

The SBB New Technology Ventures (NTV) track encompasses minimally:

	Level	EC
NTV1: Entrepreneurial Opportunities	400	5
NTV2: The Entrepreneurial Process	400	5
NTV3: Business Planning	400	5
Business Research Methods	500	5
New Technology Ventures Assignment	600	20-30

In addition, the following course modules can be included the SBB tracks:

	Level	EC
Business Research Essay	600	10
Decision and Risk Analysis	400	3
Introduction to Entrepreneurship	400	3
Organisational Behaviour	400	4
Electives <sup>36</sup>	variable <sup>37</sup>	variable

## Exemptions

Students with prior education in management, business and entrepreneurship may – depending on the contents and extent of said education – be exempted from following (parts of) one or more of the courses. These courses need to be substituted such that their master programme contains at least 40 EC of SBB courses fitting in the context of business. Decisions on exemptions and substitutions are taken by the Board of Examiners.

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<sup>36</sup> Electives can either be courses from the SBB portfolio (e.g. NTV courses as part of the Management track) or courses that are offered as electives elsewhere, always to be approved by SBB staff and with a maximum of 10 EC for the SBB NTV track.

<sup>37</sup> For courses with a level <400 or unspecified levels the approval of the Board of Examiners is required next to the approval of SBB staff. Students are allowed to include a maximum of 12 EC in courses with a level <400 in their total MSc programme.

# ***Specialisation Science Communication and Society***

## **Description**

The specialisation Science Communication and Society concerns science communication in a broad sense. The programme prepares students for a career in popularisation of science, for example, as a science communicator, a science policymaker or a public relations or health communication officer, or for a career as a scientist with a communicating mind-set.

Students with an MSc specialisation Science Communication and Society are admissible to a PhD programme in their MSc research field or in Science Communication.

## **Qualifications for admission**

Admissible to the specialisation SCS are all students that are admitted to a Master Programme of the Faculty of Science or the Master Programme in Biomedical Sciences of the Faculty of Medicine (LUMC) provided that the rules and regulations of the subject Master Programme do allow so. Preferably, the BSc programme has included some coursework in (science) communication.

In addition, international applicants must provide proof of proficiency in English with an IELTS  $\geq 6.5$ .

## **Programme**

The MSc programme in combination with the Science Communication and Society (SCS) specialisation consists of two components:

- a component within the chosen MSc programme:
  - *Mathematics, see page 4;*
  - *Computer Science, see page 14;*
  - *Astronomy, see page 29;*
  - *Physics, see page 39;*
  - *Chemistry, see page 46;*
  - *Bio-Pharmaceutical Sciences, see page 57;*
  - *Biology, see page 71;*
  - *Life Science and Technology, see page 79; or*
  - *Biomedical Sciences (LUMC).*
- a Science Communication and Society component<sup>38</sup>.

Preferably, the component within the chosen MSc programme should be followed during the first year of study, the Science Communication and Society component should be followed during the second year.

The SCS specialisation programme comprises at least 40 EC. A maximum of 20 EC of electives can be filled in with either SCS courses, or with components within the MSc programme of choice. The choice of electives should be made in consultation with a study adviser, mentor, or specialisation coordinator.

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<sup>38</sup> Completion of the specialisation Science Communication and Society requires a minimum of 40 EC and a maximum of 60 EC within the SCS component.

The Science Communication and Society component consists of the following:

	<b>Level</b>	<b>EC</b>
Science Communication and Society Fundamentals	400	19
Scientific Narration and Visualization	500	4
SCS Project Proposal		
SCS Internship(s)	600	14-34
<b><u>Electives</u></b>		
SCS Elective	500	1-10
Science Journalism	400	3

The internship will be in the field of science communication (e.g. science journalism, museology, new media, health communication). The total internship period may consist of one internship, or can be divided into 2 smaller internships. Each internship includes a written report and an oral presentation. The total internship period includes a minimum of 10 EC of research in science communication.

The choice of internships should be approved beforehand by the coordinator of the specialisation and if applicable the MSc programme coordinator. A plan for the optional SCS Elective (e.g. book exam, product development) should be approved beforehand by the SCS coordinator. Science Journalism is an elective course available for students outside the specialisation (for SCS specialisation students, this course is part of SCS Fundamentals).

## ***Specialisation Education***

The specialisation Education is taught in Leiden by the Leiden University Graduate School of Teaching (ICLON)

### **Description**

The MSc specialisation Education prepares students for a career in teaching in their subject matter specialisation. This programme leads up to the so-called “eerstegraadslesbevoegdheid”, qualifying the student to teach in Dutch upper secondary education in the school subject associated with the MSc programme as indicated in the table below.

<b>Master programme</b>	<b>Qualifies for school subject</b>
Mathematics	Wiskunde (Mathematics)
Physics	Natuurkunde (Physics)
Astronomy	Natuurkunde (Physics)
Chemistry	Scheikunde (Chemistry)
Bio-Pharmaceutical Sciences	Scheikunde (Chemistry) <sup>39</sup> or Biologie <sup>40</sup> (Biology)
Life Science and Technology	Scheikunde (Chemistry) or Biologie <sup>40</sup> (Biology)
Biology	Biologie (Biology)

Students with an MSc specialisation in Education are also admissible to a PhD programme in their MSc programme.

<sup>39</sup> Students Bio-Pharmaceutical Sciences wishing to qualify for the school subject “Chemistry”, need to solve their deficiencies in concert with the *teacher educator Chemistry* of the ICLON.

<sup>40</sup> Students Bio-Pharmaceutical Sciences and Life Science and Technology wishing to qualify for the school subject “Biology”, need to solve their deficiencies in concert with the *teacher educator Biology* of the ICLON.

## Qualifications for admission

Students should be admitted to an MSc programme within the Faculty of Science. The teacher educator of the subject matter will assess if there are deficiencies in the prior education of the student. When deficiencies are identified, the teacher educator will propose how these can be solved.

For all other (international) candidates, the Board of Admissions will judge the equivalence to this BSc degree of their previous training.

Applicants must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevoerd, met spreekvaardigheid minimaal een 7 ½).

## Programme

The MSc programme in combination with the Education (EDU) specialisation consists of two components:

- a component within the chosen MSc programme (60 EC):
  - *Mathematics, see page 5;*
  - *Astronomy, see page 30;*
  - *Physics, see page 39;*
  - *Chemistry, see page 47;*
  - *Bio-Pharmaceutical Sciences, see page 58;*
  - *Biology, see page 72; or*
  - *Life Science and Technology, see page 80.*
- An Education component (60 EC).

The component within the chosen MSc programme should be followed during the first year of study, the Education component should be followed during the second year.

The Education specialisation is offered as a joint programme of the faculty and the Leiden University Graduate School of Teaching (ICLON) and consists of the following components:

	<b>Level</b>	<b>EC</b>
Educational Theory	400	5
Learning and Instruction 1	300	5
Learning and Instruction 2	400	3
Teaching Methodology 1	400	5
Teaching Methodology 2	500	5
Design Research	600	7
Teaching Practice 1		15
Teaching Practice 2		15

For students who passed the minor Education (30 EC) during the BSc programme, the programme consists of the following:

	<b>Level</b>	<b>EC</b>
Learning and Instruction 2	400	3
Teaching Methodology 2	500	5
Design Research	600	7
Teaching Practice 2		15

The remaining 30 EC can be used for both the education specialisation and the research component of the MSc programme. For LST and Chemistry the remaining 30 EC are restricted to the MSc programme.