



Universiteit Leiden

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

valid from September 01, 2016

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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

Candidates with a BSc degree or equivalent can apply for admission. The admission guidelines are given below for each 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 admission process may include an interview with the Board of Admissions. Foreign applicants must provide proof of proficiency in English (IELTS level  $\geq 6.0$ ).

Admission is possible throughout the year, but we advise foreign students to start in September or February.

## 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.

#### Qualifications for admission

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 programme.

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

## **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.

## **Qualifications for admission**

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 programme.

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

## **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**

From September 2016 the new MSc programme Statistical Science of the Life and Behavioural Science will start. 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 7.

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.

### Qualifications for admission

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 programme.

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

Foreign applicants must provide proof of proficiency in English (IELTS level  $\geq 6.5$ ).

### 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 Science Based Business or Research Based Business component<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.

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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.

## **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.

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

### **Qualifications for admission**

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 programme.

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

Foreign applicants must provide proof of proficiency in English (IELTS level  $\geq 6.5$ ).

### **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 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

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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.

## **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.

### **Qualifications for admission**

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 programme.

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

Applicants 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.

# 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**

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 programme without further requirements.

Students with a wide range of other 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 judge the candidate's academic background and motivation, and will admit a candidate to the programme if these are judged to be sufficient to succeed in the programme. The admission process may include an interview with the Board of Admissions.

A proof of proficiency in English is required (IELTS level  $\geq 6.5$ ), except for students with a bachelor's degree from a university in the Netherlands, students who have completed their education in Canada (except Québec), USA, UK, Ireland, New Zealand, or Australia, and students who completed an English-taught International Baccalaureate.

We advise students to start in September. For starting other than in September, the Board of Admissions will judge whether the candidate's academic background provides sufficient confidence that the candidate will be able to complete the Master's programme in two years.

## 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 (50 EC), track courses (12 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 Consultancy" 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	3	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>50</b>	
<b>Specialisation Courses</b>		
Study Designs in the Life and Behavioural Sciences	6	400
Introduction to the Life and Behavioural Sciences	6	400
	<b>12</b>	

### Elective Courses

<i>Choose 4 out of the following 7 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
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 for 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 (50 EC), track courses (36 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 86 EC.

Students must have completed at least 45 EC of the program of compulsory courses to enrol in the "Statistical Consultancy" 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 Computi with R	3	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>50</b>	
<b>Specialisation Courses</b>		
Databases	6	200
Introduction to Data Science	6	400
Statistical Learning Theory	6	500
Bayesian Networks	6	500
	<b>24</b>	
<b>Elective courses</b>		
<i>Choose 2 out of 3 courses</i>	12	
Advances in Data Mining	<b>6</b>	500
Neural Networks	6	500
High-Dimensional Data Analysis	6	500
<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 programme is taught in Leiden by the Leiden Institute of Advanced Computer Science (LIACS).

The specialisation Bioinformatics is taught in Leiden en 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 Leiden Institute of Advanced Computer Science (LIACS) is the computer science department of Leiden University. The LIACS offers four 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 remaining two specialisations combine research in computer science with *Science Based Business* (SBB), and *Science Communication and Society* (SCS). 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 Educational 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

Candidates with a BSc degree in Computer Science or equivalent can apply for admission. The admission guidelines are given below for each specialisation. The admission process may include an interview with the Board of Admissions. Admission is possible throughout the year, but students will start their first year either in September or February.

Foreign applicants must provide proof of proficiency in English (either a IELTS level  $\geq 6.5$ , or TOEFL score of at least 570 on paper or 230 on computer, or 90 iBT (TOEFL Internet), or a Cambridge Certificate of Advanced English (CAE), minimum grade C)

## Specialisation

### Computer Science and Advanced Data Analytics

#### Description

This master program 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. The motto of the master is "Smart Computing for Science and Society", pointing to the manifold collaborations with other disciplines (= for Science), with companies and with organizations (= for Society), and to the strong emphasis on connecting research with applications within the programme.

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.

### **Qualification for admission**

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 programme.

For all other (international) candidates, the Board of Admissions will determine the equivalence of their previous training to the before mentioned BSc degrees. 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.

### **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).

<b>Components</b>	<b>Level</b>	<b>EC</b>
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 main focus of the Bioinformatics specialisation is on *Data Analysis and Modeling*, 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 reductionistic approach.

## Qualification for admission

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 programme.

For all other (international) candidates, the Board of Admissions will determine the equivalence of their previous training to the before mentioned BSc degrees. 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.

## 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.

### Qualification for admission

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 programme.

For all other (international) candidates, the Board of Admissions will determine the equivalence of their previous training to the before mentioned BSc degrees. 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.

### Programme

The programme is 120 EC in extent, and consists of a selection of five courses from a core programme (30 EC in the first year), five specialisation courses (30 EC in the first year), and two research projects in computer science (second year; 60 EC in total).

Year 1	EC	Level
<b>Core Programme (selection of five courses)</b>		
Advance in Data Mining	6	500
Bayesian Networks	6	500
Databases and Data Mining	6	500
Evolutionary algorithms	6	500
Complex Networks	6	500
Multicriteria Optimization and Decision Analysis	6	500
Multimedia Information Retrieval	6	500
Neural Networks	6	500
Seminar Distributed Data Mining	6	500
Seminar on Constraint Data Mining	6	500
Social Network Analysis for Computer Scientist	6	500
<b>Total of 5 courses</b>	<b>30</b>	
<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>Total Year 1</b>	<b>60</b>	
<b>Year 2</b>		
<b>Research project, Thesis<sup>4</sup></b>		
Computer Science introductory research project	18	600
Computer Science master's research project (incl. 7 EC for a thesis and an oral presentation)	42	600
<b>Total</b>	<b>60</b>	
<b>Total</b>	<b>120</b>	

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<sup>4</sup> Students should have completed the first year (60 EC) prior to starting their research projects.

## **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

### **Qualification for admission**

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 programme.

For all other (international) candidates, the Board of Admissions will determine the equivalence of their previous training to the before mentioned BSc degrees. 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.

### **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 or Research Based Business component<sup>5</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.

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<sup>5</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

## **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.

### **Qualification for admission**

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 programme.

For all other (international) candidates, the Board of Admissions will determine the equivalence of their previous training to the before mentioned BSc degrees. 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.

### **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>6</sup> as described on page 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

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<sup>6</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 ICT in Business**

**CROHO-number 60205**

The programme is taught in Leiden by the Leiden Institute of Advanced Computer Science (LIACS).

The Leiden Institute of Advanced Computer Science (LIACS) offers a research master on the management and application of ICT in a business context.

The duration of the programme, which is taught entirely in English, is two years (120 EC). The programme starts in September and in February. Students who complete the programme receive the degree Master of Science in ICT in Business.

### **Description**

Rapid changes in information and communication technology (ICT) and its applications over the last years have caused major changes for 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 programme 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 socio-technical context. The programme builds on a foundation of Computer Science that students bring from their bachelor's education.

### **Qualifications for admission**

To be admitted to the MSc programme in ICT in Business, a bachelor's degree in Computer Science or a closely related subject is required. Each application is considered individually. The Board of Admissions assesses whether the candidate's academic background and work experience can be considered to be equivalent to a bachelor's degree in Computer Science. Foreign applicants must provide proof of proficiency in English (IELTS  $\geq$  6.5). Students who have a BSc in Computer Science from Leiden University are directly admissible.

### **Programme**

The master ICT in Business consists of 15 months of course-work, and a 38 EC thesis project, often based on an in-company project. The courses cover business 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.

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

### 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 (see below). All the other students follow the main curriculum.

The main curriculum consists of the following components:

<b>Components</b>	<b>Level</b>	<b>EC</b>
Global Business game	400	1
Marketing & Corporate Communications	500	3 *
System's Development and Project Management	500	6
Strategy: Process, Content, Context	500	6
ICT-enabled Process Innovation	500	3
Behavioural and Analytical Decision Making	500	6
Software Engineering	500	3
Change Management	500	3
Accounting	500	3 *
Process Modelling	500	3 *
Research Methods	500	6
Finance	500	3 *
Leading and Managing People	500	5
Managing the Digital Business	500	3
ICT Architectures	500	6
Business Intelligence	500	3 *
Managing Innovation	500	3
Research Colloquia	500	4
Capstone Cases	500	3
Electives	500	9 *
Master Thesis Research Project	600	38
		<b>120</b>

The alternative curriculum for students with a bachelor in Computer Science, specialisation "Informatica & Economie", consists of 24 EC of electives, replacing the courses marked with an \*.

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>Components</b>	<b>Level</b>	<b>EC</b>
ICT Architectures	500	6
Strategy: Process, Content, Context	500	6
Behavioural Decision Making, Managing People & Organising	500	9
Finance and Accounting	500	6
Methodology and Research Approach	500	6
Specialisation courses	500	30
Research Participation & Scientific Reporting	500	19
Master Thesis Research Project	600	38
		<b>120</b>

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.

Candidates holding a BSc, BA or equivalent degree can apply for admission, regardless of prior field of study and nationality. (See “Qualifications for Admission”). The programme is scientifically oriented and draws from various academic fields. The programme language is English.

## 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.

## Qualifications for admission

Candidates holding a BSc, BA or equivalent degree can apply for admission, regardless of prior field of study and nationality. All applicants must supply proof of prior degrees, transcripts of prior grades, curriculum vitae, a personal statement of motivation, and possibly other documentation such as letters of reference. The admission process may include an interview with the Board of Admissions. Non-Dutch applicants must provide proof of proficiency in English (IELTS level  $\geq 6.5$  or equivalent).

Applicants holding a BSc degree in Computer Science from Leiden University or a BSc major in Computer Science from Leiden University will directly be admitted to the programme. For all other applicants individually, the Board of Admissions will judge the admissibility to the programme, with observance of personal motivation, prior educational results, and specific educational, scientific and work experiences.

## 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
Human Computer Interaction	400	6
New Media & New Technologies	500	5
Creative Research	500	6
Scientific Narration & Visualization	500	4
Perceptualization	400	3
Sound, Space & Interaction	500	4
Web Technology	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 EC's 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 programme Astronomy is taught in Leiden by the Leiden Observatory.

The specialisation Astronomy and Cosmology is taught in Leiden by the Leiden Observatory and the Leiden Institute of Physics (LION).

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

The three 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, and astronomical instrumentation. They allow the student to choose from either a broad research profile (“Research in Astronomy” 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 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 six specialisations can be admitted to a PhD programme in Astronomy.

## Qualifications for admission

Students with a BSc in Astronomy or the equivalent from Dutch universities participating in the NOVA top research school are directly admitted to the programme, but additional admission requirements may apply for particular specialisations, as described below.

For all other national and international candidates, the Board of Admissions will evaluate whether their degree may be considered equivalent to a BSc in Astronomy, and whether their academic background provides sufficient confidence that the candidate will be able to complete the Master’s programme in 2 years.

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 admission process may include an interview with the Board of Admissions.

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.

Admission to the MSc programme is possible in September or February. Foreign applicants must provide proof of proficiency in English (IELTS  $\geq$  6.5).

### **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 (for courses that are compulsory in a particular specialisation), 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 specialised 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”, 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 have 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 more than 9 months 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.

## 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.

## Qualifications for admission

No additional requirements.

## Programme

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

	<b>Level</b>	<b>EC</b>
<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.
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.

## “Stream”

# Astronomy and Data Science

## Description

Within the Astronomy Research specialisation a special option is provided in the form of the “stream” Astronomy and Data Science. This 2-year programme focuses 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, 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.

## Qualifications for admission

Students wanting to follow this “stream” 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 Astronomy core courses, at least:</i>	500	18
<i>Choice of Instrument-related courses, at least:</i>	400-500	6
<i>Choice of Astronomy courses of any type</i>	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.

### Qualifications for admission

In addition to the general admission requirements of the MSc programme in Astronomy, 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 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”.

5. 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 stream is offered in collaboration with the Institute Lorentz for Theoretical Physics in the Department of Physics at Leiden University (LION).

### Qualifications for admission

In addition to the general admission requirements of the MSc programme in Astronomy, 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 present 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:

	Level	EC
<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	6
Theory of General Relativity	400	6

*Choice of:*

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.

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 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 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.

### **Qualifications for admission**

No additional requirements.

### **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 Science Based Business or Research Based Business component<sup>7</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.

### **Qualifications for admission**

No additional requirements.

### **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;
- 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>8</sup> as described on page 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

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<sup>7</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>8</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 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.

### **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.

## MSc Physics

### CROHO-number 60202

The programme Physics, including the specialisations Research in Physics, theoretical, Research in Physics, Biological and Soft Matter Physics, Research in Physics, Quantum Matter and Optics, and Research in Physics, Cosmology, is taught in Leiden by the Leiden Institute of Physics (LION) and the Leiden Observatory.

The specialisation Research in Physics, Casimir pre-PhD is taught in Leiden en Delft by the Leiden Institute of Physics (LION) and Delft University of Technology.

### Description

Leiden University offers an MSc programme in Physics with eight specialisations. Five are research specialisations. These closely follow the research at the Leiden Institute of Physics (LION) directly or in conjunction with the department of Astronomy in Leiden or the department of Applied Physics at the Delft University of Technology. The three other specialisations are combinations of physics with Science-Based Business (SBB), with Science Communication & Society (SCS) or with Education (EDU). These double specialisations are described separately in this Appendix.

The five research specialisations are:

1. Research in Physics, Theoretical Physics
2. Research in Physics, Biological & Soft Matter Physics,
3. Research in Physics, Quantum Matter & Optics,
4. Research in Physics, Cosmology (in collaboration with department of Astronomy),
5. Research in Physics, Casimir pre-PhD (in the framework of the Casimir Research School, a joint undertaking between Leiden University and Delft University of Technology). The Casimir pre-PhD specialisation 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 results.

The research specialisations distinguish themselves by a programme and a curriculum that emphasizes the intended perspective and goal of that specialisation. In all cases, the programme consists of two components, a set of courses and one or more research projects. All specialisations offer research training in preparation for the pursuance of a PhD degree as a next step, although other career options remain fully open. The 'Casimir pre-PhD' specialisation puts emphasis on preparing for PhD research within the Casimir Research School, and requires a strong academic record for admission.

The duration of the programme is two years (120 EC). Upon successful completion, students receive the degree Master of Science in Physics (with specification of the specialisation). For an academic career an MSc is required for the pursuance of a PhD degree. Details are provided below. All specialisations have the same Director of Education, the same Board of Examiners, and the same Departmental Teaching Committee.

The goal of each programme is to train the student as an independent researcher, and to develop the necessary skills and proficiency to advance his/her career. In all specialisations therefore, it is possible for the optional part to choose courses offered by other universities or graduate schools. The programme should have a sufficient level and cohesion, though, and the optional part in all cases requires prior approval of the Board of Examiners, to be obtained through the Study adviser.

## Admission to the programme

A Board of Admissions advises on admissions to the Programme. Candidates with a BSc degree in physics or equivalent can apply for admission. The additional admission guidelines are given below for each specialisation. The admission process may include an interview with the Board of Admissions.

Foreign applicants must provide proof of proficiency in English (IELTS level  $\geq 6.5$ ).

Admission is possible throughout the year, but we strongly advise international students to start in September. For the Cosmology and 'Casimir pre-PhD' specialisations the start should be in September.

## Specialisation

### Research in Physics, theoretical

#### Description

The Research in Theoretical Physics specialisation prepares the student for scientific research towards the PhD in a broad range of topics, such as High Energy Physics and Particle Cosmology; Theoretical Physics of Life Processes; and Condensed Matter Theory. Upon successful completion of the degree, the MSc graduate will also be well equipped to pursue industrial research or other problem-solving tasks that demand strong analytical and computational skills.

#### Qualifications for admission

Admission to the specialisation is subject to the following prerequisites:

- a BSc degree in Physics or Astronomy;
- in-depth knowledge of undergraduate courses with a theoretical and mathematical emphasis: quantum physics, electrodynamics, statistical physics, and complex analysis.

For all candidates, the Board of Admissions will judge the course content of the BSc degrees in view of these requirements. 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

	Level	EC
Quantum Theory a + b	400	9
Statistical Physics a + b	400	9
Topics in Theoretical Physics	400	6
<i>Elective courses from the MSc Physics programme (of which 12 EC must be Theoretical Physics courses)<sup>9</sup></i>	400-500	45
Academic and Professional Skills	400	3
Physics research project in Theoretical Physics (division: research=36 EC, thesis=8 EC, and presentation=4 EC)	600	48

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<sup>9</sup> A maximum of one master course of 6 EC can be taken anywhere at Leiden University.

<b>Course List; Theoretical Physics</b>	<b>Level</b>	<b>EC</b>
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
Effective Field Theory	500	3
Particle Physics and the Early Universe	500	6
Quantum Field Theory	500	6
Soft and Biomechanics	500	6
Theoretical Biophysics	500	6
Theoretical Cosmology	500	3
Theory of Condensed Matter	500	9
Theory of General Relativity	400	6

Note that not each of the Master Courses in Theoretical Physics is given every academic year and that also the offer of courses may change.

## Specialisation

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

#### Description

Research on Biological Physics aims to understand biological processes in their natural context, being cells and tissue. This research 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. This programme offers the student a solid background and a through experience on the frontline of physics research with a practical training of communicative and computer skills. Graduates from this Master programme will be well placed to function in positions in industry, research or society.

#### Qualifications for admission

Students from any university in the Netherlands with a BSc degree in Physics or Astronomy will be admitted to the programme. For all other (international) candidates, the Board of Admissions will judge the equivalence of their previous training to these BSc degrees. 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

	<b>Level</b>	<b>EC</b>
Quantum Theory a <sup>10</sup>	400	6
Statistical Physics a <sup>10</sup>	400	6
<i>Elective courses from the MSc Physics programme (of which 6 EC must be Theoretical Physics courses)<sup>11</sup></i>	400-500	45
Academic and Professional Skills	400	3

<sup>10</sup>The courses Quantum Theory and Statistical Physics are given in a 6 EC variant (QT a, SP a), and a 9 EC variant (QT a+b, SP a+b). In both cases the additional 3 EC can be taken as partial fulfilment for the elective courses in Theoretical Physics.

<sup>11</sup> A maximum of one master course of 6 EC can be taken anywhere at Leiden University.

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=5 EC, and presentation=1 EC)	600	36

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

## Specialisation

### Research in Physics, Quantum Matter and Optics

#### Description

This specialisation offers comprehensive coverage of major current research themes in condensed matter physics and optics. Among the research themes are scanning probe techniques, quantum optics, photon-matter interactions, molecular electronics, oxide electronics, and superconductivity. This programme offers the student a solid background and a through experience on the frontline of physics research with a practical training of communicative and computer skills. Graduates from this Master programme will be well placed to function in positions in industry, research or society.

#### Qualifications for admission

Students from any university in the Netherlands with a BSc degree in Physics or Astronomy will be admitted to the programme. For all other (international) candidates, the Board of Admissions will judge the equivalence of their previous training to these BSc degrees. 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

	Level	EC
Quantum Theory a <sup>12</sup>	400	6
Statistical Physics a	400	6
<i>Elective courses from the MSc Physics programme (of which 6 EC must be Theoretical Physics courses)<sup>13</sup></i>	400-500	45
Academic and Professional Skills	400	3
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=5 EC, and presentation=1 EC)	600	36

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

<sup>12</sup> The courses Quantum Theory and Statistical Physics are given in a 6 EC variant (QT a, SP a), and a 9 EC variant (QT a+b, SP a+b). In both cases the additional 3 EC can be taken as partial fulfilment for the elective courses in Theoretical Physics.

<sup>13</sup> A maximum of one master course of 6 EC can be taken anywhere at Leiden University.

<b>Course List; Biological and Soft Matter Physics / Quantum Matter and Optics</b>	<b>Level</b>	<b>EC</b>
Advanced Biophysics	500	6
Advanced Optics	500	6
Basics of Electron Paramagnetic Resonance	500	3
Computational Physics	400	6
Magnetism	500	3
Mechanics of Metamaterials	400	6
Molecular Electronics	500	6
Quantum Optics	400	6
Signal Processing and Noise	300	6
Single Molecule Optics	500	6
Superconductivity	500	3
<i>Surface Science (Chemistry)</i>	500	6

Note that not each of the Master Courses in Physics is given every academic year and that also the offer of courses may 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 the PhD in a range of topics. The MSc graduate will also be well-equipped for industrial research or other problem-solving tasks that demand strong analytical and computational skills.

### **Qualifications for admission**

Admission to the specialisation is subject to the following prerequisites:

- a BSc degree in Physics or Astronomy;
- in-depth knowledge of undergraduate courses with a theoretical and mathematical emphasis: quantum physics, electrodynamics, statistical physics, and complex analysis; and;
- successful completion of the undergraduate course Physics of Elementary Particles.

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

	<b>Level</b>	<b>EC</b>
Large Scale Structure and Galaxy Formation	500	6
Origin and Evolution of the Universe	500	6
Particle Physics and the Early Universe	500	6
Quantum Theory a <sup>14</sup>	400	6
Theory of General Relativity	400	6

<sup>14</sup> The course Quantum Theory is given in a 6 EC variant (QT a), and a 9 EC variant (QT a+b).

<i>Elective courses from the MSc Physics programme (of which 9 EC must be Cosmology courses)<sup>15</sup></i>	400-500	27
Academic and Professional Skills	400	3
Research project in Cosmology 1 (with written report)	500	24
Research project in Cosmology 2 (Master's project) (division: research=30 EC, thesis=5 EC, and presentation=1 EC)	600	36

<b>Course List; Cosmology</b>	<b>Level</b>	<b>EC</b>
Black Holes and Gravitational Waves	500	3
Computational Astrophysics	400	6
Databases and Data Mining	500	3
Effective Field Theory	500	3
Observational Cosmology	400	3
Theoretical Cosmology	500	3

For the elective Master courses, a choice can also be made from courses in the MSc programme Astronomy. Note that not each of the Master Courses in Cosmology is given each academic year and that also the offer of courses may change.

## 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 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 strong emphasis on working in a research environment. The research within Casimir has a strong focus in the nanosciences and is grouped in 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, in which the first year is devoted to laying a theoretical basis, and the second year to research and study projects, including the writing of a research proposal. The study projects are a special characteristic of the programme, specifically aiming at broadening the research perspective of the student.

### Qualifications for admission

The Casimir pre-PhD specialisation can be followed through 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. A grade point average of 7.5 is required, although exceptional circumstances can be taken in consideration. Formal admission then 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.

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<sup>15</sup> A maximum of one master course of 6 EC can be taken anywhere at Leiden University.

## Programme

	Level	EC
Quantum Theory a <sup>16</sup>	400	6
Statistical Physics a	400	6
<i>Elective courses from the MSc Physics programme (of which 12 EC must be from list 'Foundational', 12 EC must be from list 'Topical', and 6 EC must be from list 'Methods')</i>	400-500	45
Academic and Professional Skills	400	3
Research project in Physics (division: research=30 EC, thesis=5 EC, and presentation=1 EC)	600	36
Study projects (2x)	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 year. Research project and study projects are also guided by a strict timeline. The Research project starts in September and finishes in February. The two study projects (8 EC each) are scheduled between March and the end of May and are to be carried out in different groups, and in a different group than where the Research project took place. Writing a research proposal is the last item in the programme. For a limited number of students within this specialisation, a PhD position will be guaranteed. Details can be found on the website of the Casimir Research School.

### Course List; Casimir pre-PhD

#### **Foundational courses**

	Level	EC	
Advanced Biophysics	500	6	(L)
Advanced Electrodynamics	400	6	(D)
Advance Optics	500	6	(L)
Advanced Solid State Physics	400	6	(D)
Continuum Physics	400	6	(D)
Effective Field Theory	500	3	(L)
Fairy Tales of Theoretical Physics	400	6	(D)
Quantum Field Theory	500	6	(L)
Theory of Condensed Matter	500	9	(L)
Theory of General Relativity	400	6	(L)
Topics in Theoretical Physics	400	6	(L)

#### **Topical Courses**

Complex Networks	400	6	(L)
Evolution and Engineering of living systems	500	6	(D)
Fundamentals of Quantum Information	400	4	(D)
Magnetism	400	3	(L)
Mechanics of Metamaterials	400	3	(L)
Mesosopic Physics	400	6	(D)
Molecular Electronics	500	6	(L/D)
Physics of Semiconductor Nanodevices	400	3	(D)
Quantum Communication and Cryptography	400	5	(D)
Quantum Hardware	400	6	(D)
Quantum Optics	400	6	(L)

<sup>16</sup> The courses Quantum Theory and Statistical Physics are given in a 6 EC variant (QT a, SP a), and a 9 EC variant (QT a+b, SP a+b). In both cases the additional 3 EC can be taken as partial fulfilment for the elective courses in the category 'Foundational'.

Quantum Optics and Electronics	500	6	(D)
Single Molecule Optics	500	6	(L)
Soft and Biomechanics	400	6	(L)
Surface Science (Chemistry)	500	6	(L)
Superconductivity	400	3	(L)
The Origins of Life	500	6	(D)
Theoretical Biophysics	500	6	(L)
Topology in Condensed Matter	500	6	(D)
<b>Methods</b>	<b>Level</b>	<b>EC</b>	
Basics of Electron Paramagnetic Resonance	500	3	(L)
Computational Physics (L)/Computational Physics (D)	400	6	(L/D)
Electronics for Quantum Computing	400	5	(D)
Molecular Electronics	500	6	(L/D)
Nanotechnology	400	6	(D)
Surface Science (Chemistry)	500	6	(L)

Courses given in Leiden are denoted (L), courses given in Delft are denoted (D). Electives can be chosen from the full list, irrespective of the location. Note that not each of the Master Courses is given each academic year and that also the offer of courses may change.

## 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 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 Physics and Science Based Business are admissible to a PhD programme.

### Qualifications for admission

Students from any university in the Netherlands with a BSc degree in Physics or Astronomy will be admitted to the programme. For all other (international) candidates, the Board of Admissions will judge the equivalence of their previous training to these BSc degrees. 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 Physics and Science Based Business (SBB) programme consists of:

- Quantum Theory a (level 400; 6 EC);
- Statistical Physics a (level 400; 6 EC);
- Academic and Professional Skills (level 400; 3 EC);
- 9 EC of courses to be selected in correspondence with the research topic;
- 6 EC of free electives;

- a research project of 30 EC in one of the research groups of the Leiden Institute of Physics (LION) and a master's thesis and an oral presentation (5+1=6 EC);
- a maximum of 20 EC of electives within either Physics or the SBB component; and
- the Science Based Business or Research Based Business component<sup>17</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 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 communicating mind-set.

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

### **Qualifications for admission**

Students from any university in the Netherlands with a BSc degree in Physics or Astronomy will be admitted to the programme. For all other (international) candidates, the Board of Admissions will judge the equivalence of their previous training to these BSc degrees. 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 Physics and Science Communication and Society (SCS) programme consists of:

- Quantum Theory a (level 400; 6 EC);
- Statistical Physics a (level 400; 6 EC);
- Academic and Professional Skills (level 400; 3 EC);
- 9 EC of courses to be selected in correspondence with the research topic;
- 6 EC of free electives;
- a research project of 30 EC in one of the research groups of the Leiden Institute of Physics (LION) and a master's thesis and an oral presentation (5+1=6 EC);
- a maximum of 20 EC of electives within either Physics or the SCS component; and
- the Science Communication and Society component<sup>18</sup> as described on page 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

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<sup>17</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>18</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 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 admissible to a PhD programme.

### Qualifications for admission

Students from any university in the Netherlands with a BSc degree in Physics or Astronomy will be admitted to the programme. For all other (international) candidates, the Board of Admissions will judge the equivalence of their previous training to these BSc degrees. 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.

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

### Programme

The Physics and Education (EDU) programme consists of:

- Quantum Theory a (level 400; 6 EC);
- Statistical Physics a (level 400; 6 EC);
- Academic and Professional Skills (level 400; 3 EC);
- 9 EC of courses to be selected in correspondence with the research topic;
- 6 EC of free electives;
- a research project of 30 EC in one of the research groups of the Leiden Institute of Physics (LION) and a master's thesis and an oral presentation (5+1=6 EC);
- the Education component as described on page 85.

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 with 30 EC. The remaining 30 EC can be used for both the Physics 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.

## MSc Chemistry

### CROHO-number 66857

The programme Chemistry is taught in Leiden by the Leiden Institute of Chemistry (LIC).

The Leiden Institute of Chemistry (LIC) forms the basis for research and collaborations of the Leiden chemistry and life sciences groups. The two research areas in the LIC are *Chemical Biology* and *Energy & Sustainability*. The MSc programme Chemistry offers four specialisations, each with a focus on one of these 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).

Aim of each programme is to train the student as an independent researcher, and to develop the necessary skills and proficiency to pursue a successful career in science or in society, based on a solid background in an analytical approach of problems and thinking in solutions.. Students with an MSc degree in Chemistry are admissible to a PhD programme.

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.

All specialisations have the same Director, the same Board of Examiners and the same Board of Admission. The Department Teaching Committee for the MSc programme Chemistry is combined with the one for the MSc programme Life Science and Technology and is responsible for both Research and SBB specialisations, but not for the EDU and SCS specialisations. The specialisations SBB, SCS, and EDU each have their own specialisation coordinator and a Board of Examiners appointed by the Faculty of Science for the specialisation-specific part.

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

Specialisation	CHEM	EDU	SCS	SBB
Research Training Project	60	30	30	30
Compulsory courses in research area	24	24 <sup>19</sup>	24	24
Essay & Colloquium	6	-	-	-
Free electives <sup>20</sup>	30	36 / 6 <sup>21</sup>	26	26
EDU/SCS/SBB components	-	30 / 60 <sup>21</sup>	40	40
<b>Total</b>	<b>120</b>	<b>120</b>	<b>120</b>	<b>120</b>

### Admission to the programme

Students with a BSc degree Molecular Science and Technology (MST) from Leiden/Delft will be admitted to the programme.

All other students with a BSc degree in Chemistry, or in a field related to Chemistry, from another (international) University or HBO Hogeschool, can apply for admission. The Board of Admissions judges each application on the basis of the content of the BSc curriculum and

<sup>19</sup> Students in the EDU specialisation are advised to choose from both research areas, to obtain a broader knowledge of chemistry.

<sup>20</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>21</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.

on the grades obtained previously. In general, only students with an outstanding track record and an outstanding research internship will be admitted.

As a guideline, HBO students should have obtained their BSc degree within four years with an average final grade of at least 7.5 and a research internship grade of at least 8.0.

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

IELTS: minimum 6.5

TOEFL: internet based 90

Cambridge Certificate of Advanced English (CAE), minimum grade C

This requirement does not apply if you have completed your education in Canada, USA, UK, Ireland, New Zealand or Australia, or possess an International Baccalaureate.

The qualifications of admission are identical for all specialisations, with an exception for the specialisation Education. Additionally, applicants for the EDU specialisation must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½).

## Programme

Each student composes their own study programme in consent with the mentor, who is a Principal Investigator of the LIC. The mentor generally is the supervisor of the major research training project in one of the research areas as 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 intended programme may be adjusted during the course of the MSc programme. 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 master planner is updated by the student on a regular basis. It is accessible to the student, the mentor and the study coordinator. The mentor and student discuss the progress of the student at least every 6 months using the results documented in the planner. The study coordinator will mediate when the student encounters problems in the interaction with the mentor.

## Description of the research areas

*Chemical Biology* research at the LIC is characterised by studying and influencing physiological processes at the molecular level. Fundamental biological problems are addressed using intrinsic chemical approaches and concepts. The driving force behind the Leiden *Chemical Biology* research is the ability to design functional molecules that can be used to investigate and influence biomolecular interactions and structures. The research is inspired by physiological processes that underlie human diseases. The ultimate goal is to contribute to human health through conceptually new methods for diagnosis, drug development and new therapies for diseases.

The *Energy & Sustainability* research at the LIC is focused on chemical reactions of importance to the sustainable and efficient production and storage of energy, as well as the subsequent usage of stored energy, on a fundamental level. The Leiden research on energy and sustainability employs 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. In addition, new catalysts, materials, and molecular and supramolecular systems are being developed and investigated, especially for cyclic redox chemistry of the hydrogen-oxygen cycle, with attention for the reversible storage of hydrogen, and for the carbon cycle, in which the sustainable and reversible conversion of carbon dioxide into a liquid carbon-rich fuel is a central challenge.

## 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 her/his 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 three parts: the research training project (60 EC), the compulsory courses (30 EC) and the elective courses (30 EC). A general overview of the programme is given in Table 1.

#### Research Training Project

The (major) research training project is carried out in a LIC research group in one of the research areas (*Chemical Biology, Energy & Sustainability*) and includes a presentation for the research group and a written report (the master thesis). The major research training project is concluded with a presentation for an independent jury of two staff members, as well as interested students and staff members of the LIC (Thesis Talk). All students attend at least 10 Thesis Talks during their MSc program. 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. 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, 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 all research training projects outside the institute.

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 Projects, it is not possible to obtain a grade higher than 6 if this deadline is exceeded.

#### Compulsory components

The compulsory theoretical component comprises a selection of four core courses (24 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 (30 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 theme, 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 and 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 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;
- attendance of at least 10 thesis talks;
- 26 EC of free electives<sup>22</sup>; and
- the Science Based Business or Research Based Business component<sup>23</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.

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<sup>22</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>23</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

## Specialisation 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:

- 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;
- attendance of at least 10 thesis talks;
- 26 EC of free electives; and
- the Science Communication and Society component<sup>24</sup> as described on page 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

## Specialisation 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.

### 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 6 or 20 EC<sup>25</sup>, 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;
- the Education component as described on page 85.

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<sup>24</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>25</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

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 Chemistry 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

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>Yearly</b>	<b>Research area</b>
Modern Organic Chemistry	yes	CB
Biomolecular Structures	yes	CB
Molecular Biology	yes	CB
Supramolecular Chemistry	yes	CB
Advanced Medicinal Chemistry	yes	CB
Reactivity in Organic Chemistry	yes	CB
Cell Biology	yes	CB
Chemical Biology	yes	CB
Modern Quantum Chemistry	yes	ES
Spectroscopy	yes	ES
Organometallic chemistry & homogeneous catalysis	yes	ES
Electrochemistry & Bioelectrochemistry	yes	ES
Photochemistry	yes	ES
Quantum Dynamics of Chemical Reactions	biennial	ES
Dynamics of Molecule-surface Reactions	biennial	ES
Heterogeneous Catalysis	yes	ES
Surface Science	yes	ES
Photosynthesis & Photoenergy	yes	ES

# 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 2016–2017. 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 of other Life Sciences.

## Learning outcomes

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

- a. Theoretical and/or 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

Students holding the BSc degree in Bio-Pharmaceutical Sciences from Leiden University, including those holding a BSc degree in Bio-Pharmaceutical Sciences with the Specialisation Pharmacy, are directly admissible. For all other (international) candidates, the Board of Admissions will evaluate the equivalence of their previous training to the BSc degree of Bio-Pharmaceutical Sciences. The admission process may include an interview with the Board of Admissions to assess the competence to function at MSc level, motivation, and English language proficiency.

Applicants with a BSc (or equivalent) 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) may be considered. 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. Please note that basic research training in the field of life sciences is required to be eligible for the programme.

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).

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).

International applicants must provide proof of proficiency in English by submission of a certificate of an appropriate language test

- IELTS level: final score  $\geq 6.5$ , 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, minimum grade C

The English proficiency requirement does not apply if you have:

completed your education in Canada, USA, UK, Ireland, New Zealand or Australia, or an (English-taught) International Baccalaureate.

Admission is possible throughout the year, but we advise foreign students to start in September or February.

Additional qualifications may apply to the non-research components of the EDU and IP specialisations, which will be indicated in the corresponding sections.

## 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 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>26</sup> )	15

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<sup>26</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):

	Level	EC
Introduction Course BPS:		
Systems Pharmacology	500	5
Lecture series (in BPS)	500	4
Research Project 1, in Systems Pharmacology		
• 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>27</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.

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<sup>27</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 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.

### 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>28</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.

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<sup>28</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 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**

### **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:

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

#### **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 of ( $\geq 21$  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 2 students in the academic year 2016-2017.

## 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>29</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.

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<sup>29</sup> PAOFarmacie: Netherlands Centre for Post-Academic Education in Pharmacy

## 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. Knowledge and understanding of science- and research-driven business and initiation in business disciplines most relevant to working in this business;
- b. The ability to make a plan for a new business or an innovation project;
- c. Experience with performing business activities in an existing or directed towards setting up a new company or organisation.

### 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>30</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 Science Based Business or Research Based Business component<sup>31</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.

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<sup>30</sup> The choice for lecture series and research project will be made in concert with a study adviser.

<sup>31</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

## 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.

### 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>32</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>33</sup> as described on page 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

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<sup>32</sup> The choice for lecture series and research project will be made in concert with a study adviser.

<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 Education

### Description

The specialisation Bio-Pharmaceutical Sciences and Education (EDU) prepares students for a career as biology (biologie)<sup>34</sup> or chemistry (scheikunde)<sup>35</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);

### 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).

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<sup>34</sup> Master's Students in Bio-Pharmaceutical Sciences wishing to qualify for the school subject "Biology", need to solve remedy their deficiencies in concert with the teacher educator Biologyteacher education 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>35</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).

## 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>36</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>36</sup> The choice for lecture series and research project will be made in concert with a study adviser.

## **MSc Biology**

### **CROHO-number 66860**

The programme Biology is taught in Leiden by the Institute Biology Leiden (IBL), Institute of Environmental Sciences (CML), the Hortus Botanicus, and the Naturalis Biodiversity Center.

The Institute Biology Leiden (IBL) of Leiden University offers an attractive and varied MSc programme. Students can follow a general Biology programme or choose between four research specialisations ‘*Animal Sciences and Health (AS)*, ‘*Microbial Biotechnology and Health (MB)*, ‘*Plant Sciences and Natural Products (PS)*, and ‘*Evolution, Biodiversity and Conservation (EBC)*’, which reflect the major themes of biological research at Leiden University. A special feature of the ‘*Evolution, Biodiversity and Conservation (EBC)*’ programme is its close link with the unique biodiversity research cluster in Leiden consisting of the Institute of Environmental Sciences (CML), the Hortus Botanicus, and the Naturalis Biodiversity Center (the latter hosts both the national zoological and botanical collections). 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.

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, Department Teaching Committee and Board of Examiners. A Board of Admissions advises 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.

### **Admission to the programme**

Students with a BSc degree Biology from Leiden University will be admitted to the programme. Students with a BSc degree in Biology from another university need to apply for admission. Students with a BSc degree in other Natural Sciences, Life Sciences, Mathematics, Biomedical Sciences, as well as students with a BSc degree from a biology-related University of Applied Sciences (HBO), can also apply for admission.

For HBO bachelors, and for candidates with degrees from universities abroad and candidates with a BSc degree in any of the other Natural Sciences, Life Sciences, or Biomedical Sciences, the Board of Admissions will evaluate how the previous training matches that of the Dutch bachelors in Biology. As a guideline, 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 a specific additional course load. Where possible, deficiencies may be remedied by including some optional elements of the MSc programme as part of the study programme.

The admission process may include an interview with the Board of Admissions. Additional admission requirements may apply for a specific specialisation, if applicable they are described below. Foreign applicants must provide proof of proficiency in English (IELST  $\geq$  6.5). The score on each subtest (reading, writing, speaking) has to be at least 6.0.

### **Start of the programme**

Students may enter the 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.

## Specialisation Animal Sciences and Health

### Description

The Master specialisation Animal Sciences and Health offers a research-oriented education in animal biology with a strong focus on the generation of fundamental scientific knowledge that can lead to the improvement of human health. Important aspects of animal development and the interaction of animals with the environment can be studied at different often integrated levels ranging from the molecular, genetic and cellular levels to the organismal and population levels.

A major part of the master training is actively taking part in a running research project within the theme of the specialisation at the Institute Biology Leiden or at other research groups of the Faculty of Science or the at the Leiden University Medical Center (LUMC). There are also many possibilities for external projects at other universities or research institutes in the Netherlands or abroad.

### 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 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.

	<b>Level</b>	<b>EC</b>
Orientation on Animal Sciences and Health <sup>37</sup>	400	3
Introduction to Animal Experimentation	400	1
Genomic Architecture	400	6
Advanced Statistics	500	3
Book exam	500	3
Courses of choice	500/600	8

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<sup>37</sup> The orientation course can be replaced by an Orientation Course from a different specialisation

At least 1 of the following courses:

• Mechanisms of Disease	500	6
• Development and Evolution	500	6
Research Project(s) (at least 36 EC within the specialisation)	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-guide. For courses outside the Leiden University biology programme and for all research projects, prior approval of the Board of Examiners is required.

Note: a maximum of 12 EC of optional theoretical elements of level < 400 are permitted and max 15 EC 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 Animal Sciences and Health study programme comprises several compulsory courses. The course *Orientation on Animal Sciences and Health* 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. Together with the Advanced Statistics course, and one of the two specialisation courses Mechanisms of Disease or Development and Evolution, this will prepare the students theoretically for their training in scientific research during the Research Project(s). The mandatory courses should preferably be successfully completed before starting with the rest of the programme.

At the beginning of the second semester (in year 1 or 2) students prepare individually from an advanced text book for a specialised examination. Available book titles are provided in the electronic study guide (e-prospectus). 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**

## **Evolution, Biodiversity and Conservation**

### **Description**

Evolution, Biodiversity and Conservation is a research-oriented master specialisation in biological sciences at Leiden University that provides state of the art knowledge on subjects as ecology, evolutionary biology, biodiversity, environmental sciences and conservation.

It builds on the unique combination of biological institutes in Leiden joining forces: the Institute Biology Leiden (IBL), the Institute of Environmental Sciences (CML), and the Naturalis Biodiversity Center.

## Programme

The programme of Biology and Evolution, Biodiversity and Conservation (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 in one of the IBL, CML or Naturalis departments that contribute to the chosen specialisation. Research projects can range from experimental studies on the molecular mechanisms of development or human impacts on biodiversity to collection-based research on biodiversity or field projects in the Netherlands or elsewhere (e.g. terrestrial and marine studies in Southeast Asia). 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.

	<b>Level</b>	<b>EC</b>
Orientation on Evolution, Biodiversity and Conservation <sup>38</sup>	400	3
Genomic Architecture	400	6
Advanced Statistics	500	3
<i>At least 1 of the following courses:</i>		
• Human impacts on biodiversity	500	6
• Methods in biodiversity analysis	500	6
• Development & Evolution	500	6
Book exam	500	3
Courses of choice	500/600	9
Research Project(s) (at least 36 EC within the specialisation)	600	min. 60
Electives		max. 30

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<sup>38</sup> The orientation course can be replaced by an Orientation Course from a different specialisation

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

Note: a maximum of 12 EC of optional theoretical elements of level < 400 are permitted and max 15 EC 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 Evolution Biodiversity and Conservation* 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. 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).

At the beginning of the second semester (in year 1 or 2) students prepare individually from an advanced text book for a “*book exam*”. Available book titles are provided in the electronic study guide (e-prospectus). 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**

### **Microbial Biotechnology and Health**

#### **Description**

The Master specialisation Microbial Biotechnology and Health offers a research-oriented education in microbiology with a strong focus on the generation of fundamental scientific knowledge that can lead to the improvement of micro-organisms as production platforms for valuable compounds such as food additives and antibiotics. Important aspects of the development and physiology of micro-organisms and their interaction with the environment can be studied at the molecular, genetic, physiological and cellular levels, often in an integrated manner. Training is provided in functional genomics, cellular imaging, transcriptomics, proteomics and metabolomics and insight is given in the potential and power of these techniques in microbiological research. Particular attention is paid to the implications of these techniques for biotechnology.

A major part of the master training is actively taking part in a running research project within the theme of the specialisation at the Institute Biology Leiden, other departments of the Faculty of Science, or the Leiden University Medical Center (LUMC). There are also possibilities for an external project at an institute abroad.

## Qualifications of admission

Specific admission requirements in addition to the previously formulated general admission qualifications: Theoretical and practical knowledge of molecular biology and microbiology at BSc level is required.

## Programme

The programme of Biology and Microbial Biotechnology 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 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.

	<b>Level</b>	<b>EC</b>
Orientation on Microbial Biotechnology and Health <sup>39</sup>	400	3
Advanced Statistics	500	3
Genomic Architecture	400	6
Global Regulatory Networks in Bacteria	500	6
Book exam	500	3
Courses of choice	500/600	9
Research Project(s) (at least 36 EC within the specialisation)	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-guide. For courses outside the LU biology programme and for all research projects, prior approval of the Board of Examiners is required.

Note: maximally 12 EC of optional theoretical elements of level < 400 are permitted and max 15 EC non-biology courses.

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<sup>39</sup> The orientation course can be replaced by an Orientation Course from a different specialisation

## 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 Microbial Biotechnology study programme comprises several compulsory courses. The course *Orientation on Microbial Biotechnology* provides a state of the art overview of the scientific research and research methods used in the departments participating in this MSc specialisation taken from presentations by group leaders and PhD students. 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. Together with the Advanced Statistics course, and the specialisation course Global Regulatory Networks in Bacteria, this will prepare the students theoretically for their training in scientific research during the Research Project(s).

At the beginning of the second semester (in year 1 or 2) students prepare individually from an advanced text book for a specialised examination. Available book titles are provided in the electronic study guide (e-prospectus). 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

### Plant Sciences and Natural Products

#### Description

The Master specialisation Plant Sciences and Natural Products offers a research-oriented education in plant sciences with a strong focus on the generation of fundamental scientific knowledge that can lead to the improvement of crop quality and yield. Important aspects of plant development and the interaction of plants with the environment can be studied at different often integrated levels ranging from the molecular, genetic and cellular levels to organismal and population levels. It is also possible to study the production of plant natural products that are important for the food or pharmaceutical industries.

A major part of the master training is actively taking part in a running research project within the Plant Sciences and Natural Products research area at the Institute of Biology, the Faculty of Science, Naturalis Biodiversity Center or Institute of Environmental Sciences There are also possibilities for external projects at other plant institutes in the Netherlands or abroad.

#### Programme

The programme of Biology and Evolution, Biodiversity and Conservation (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. 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 Plant Sciences and Natural Products research area at the Institute Biology Leiden, the Faculty of Science, Naturalis Biodiversity Center or Institute of Environmental Sciences. 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.

	<b>Level</b>	<b>EC</b>
Orientation on Plant Sciences and Natural Products <sup>40</sup>	400	3
Advanced Statistics	500	3
Genomic Architecture	400	6
Book exam	500	3
Courses of choice	500/600	9
<i>At least 1 of the following courses:</i>		
• Immune system of plants	500	6
• Metabolomics	500	6
• Development & Evolution	500	6
Research Project(s) (at least 36 EC within the specialisation)	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-guide. For courses outside the LU biology programme and for all research projects, prior approval of the Board of Examiners is required. Note: maximally 12 EC of optional theoretical elements of level < 400 are permitted and max 15 EC 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 Plant Sciences and Natural Products study programme comprises several compulsory courses. The course *Orientation on Plant Sciences and Natural Products* provides a state of the art overview of the scientific research and research methods used in the departments participating in this MSc specialisation taken from presentations by group leaders and PhD students. 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. Together with the Advanced Statistics course, and one of the specialisation courses Immune

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<sup>40</sup> The orientation course can be replaced by an Orientation Course from a different specialisation

Systems of Plants or Metabolomics, this will prepare the students theoretically for their training in scientific research during the Research Project(s).

At the beginning of the second semester (in year 1 or 2) students prepare individually from an advanced text book for a specialised examination. 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. Available book titles are provided in the electronic study guide (e-prospectus). 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. 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.

At least one Research Project has to be done within a research area at the Institute Biology Leiden, the Faculty of Science, Naturalis Biodiversity Center, or 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. Each Research Project should be at least 30 EC. A single research project cannot exceed 60 EC.

	<b>Level</b>	<b>EC</b>
<i>One of the courses:</i>		
• Orientation on Animal Sciences and Health	400	3
• Orientation on Evolution Biodiversity and Conservation	400	3
• Orientation on Microbial Biotechnology and Health	400	3
• Orientation on Plant Sciences and Natural Products	400	3
Genomic Architecture	400	6
Advanced Statistics	500	3
Book exam	500	3
<i>At least 15 EC out of the courses:</i>		
• Mechanisms of Disease	500	6
• Development and Evolution	500	6
• Immune Systems of Plants	500	6

• Metabolomics	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	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-guide. For courses outside the LU biology programme and for all research projects, prior approval of the Board of Examiners is required.

Note: maximally 12 EC of optional theoretical elements of level < 400 are permitted and max 15 EC 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.

## **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 Science Based Business or Research Based Business component<sup>41</sup> as described on page 81.

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<sup>41</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

The theoretical part of the Biology research components comprises:

	<b>Level</b>	<b>EC</b>
<i>One of the courses:</i>		
• Orientation on Animal Sciences and Health	400	3
• Orientation on Evolution Biodiversity and Conservation	400	3
• Orientation on Microbial Biotechnology and Health	400	3
• Orientation on Plant Sciences and Natural Products	400	3
Genomic Architecture	400	6
Advanced Statistics	500	3
Book exam	500	3
<i>At least 9 EC out of the courses:</i>		
• Mechanisms of Disease	500	6
• Development and Evolution	500	6
• Immune Systems of Plants	500	6
• Metabolomics	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	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 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 Institute Biology Leiden (IBL), Institute of Environmental Sciences (CML) or Naturalis Biodiversity Center.

A research project within one of the 'Life Science' research groups of the Leiden Institute of Chemistry (LIC), at the Leiden Academic Centre for Drug Research (LACDR) or at the Leiden University Medical Center (LUMC) may substitute for a research project within the IBL pending prior approval by the Board of Examiners. 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>42</sup> as described on page 82.

The theoretical part of the Biology research components comprises:

	Level	EC
<i>One of the courses:</i>		
• Orientation on Animal Sciences and Health	400	3
• Orientation on Evolution Biodiversity and Conservation	400	3
• Orientation on Microbial Biotechnology and Health	400	3
• Orientation on Plant Sciences and Natural Products	400	3
Genomic Architecture	400	6
Advanced Statistics	500	3
Book exam	500	3
<i>At least 9 EC out of the courses:</i>		
• Mechanisms of Disease	500	6
• Development and Evolution	500	6
• Immune Systems of Plants	500	6
• Metabolomics	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	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 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 Institute Biology Leiden (IBL), Institute of Environmental Sciences (CML) or Naturalis Biodiversity Center.

A research project within one of the 'Life Science' research groups of the Leiden Institute of Chemistry (LIC), at the Leiden Academic Centre for Drug Research (LACDR) or at the Leiden University Medical Center (LUMC) may substitute for a research project within the IBL pending prior approval by the Board of Examiners. 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 82.

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<sup>42</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 Education

### Description

The specialisation Biology Sciences 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 Sciences 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 components comprises:

	Level	EC
<i>One of the courses:</i>		
• Orientation on Animal Sciences and Health	400	3
• Orientation on Evolution Biodiversity and Conservation	400	3
• Orientation on Microbial Biotechnology and Health	400	3
• Orientation on Plant Sciences and Natural Products	400	3
Genomic Architecture	400	6
Advanced Statistics	500	3
Book exam	500	3
<i>At least 9 EC out of the courses:</i>		
• Mechanisms of Disease	500	6
• Development and Evolution	500	6
• Immune Systems of Plants	500	6
• Metabolomics	500	6
• Global Regulatory Networks in Bacteria	500	6
• Human impacts on biodiversity	500	6
• Methods in Biodiversity Analysis	500	6
• <i>Or courses from the list of approved electives</i>		

A research project within one of the 'Life Science' research groups of the Leiden Institute of Chemistry (LIC), at the Leiden Academic Centre for Drug Research (LACDR) or at the Leiden University Medical Center (LUMC) may substitute for a research project within the IBL pending prior approval by the Board of Examiners. 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.

The Biology 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 Biology 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.

# MSc Life Science and Technology

CROHO-number 66286

The programme Life Science and Technology is taught in Leiden by the Leiden Institute of Chemistry (LIC).

The Leiden Institute of Chemistry (LIC) forms the basis for research and collaborations of the Leiden chemistry and life sciences groups. The two research areas in the LIC are *Chemical Biology* and *Energy and Sustainability*. The LIC offers four specialisations in the MSc LST programme; 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 aim of each programme is to train the student as an independent researcher, and to develop the necessary skills and proficiency to advance their career.

The duration of each specialisation is two years (120 EC); a general 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.

All specialisations have the same Director, the same Board of Examiners and the same Board of Admission. The Department Teaching Committee for the MSc programme Life Science and Technology is combined with the one for the MSc programme Chemistry and is responsible for both Research and SBB specializations, but not for the EDU and SCS specialisations. The specialisations SBB, SCS, and EDU each have their own specialisation coordinator and a central Board of Examiners appointed by the Faculty of Science for the specialisation-specific part.

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
Compulsory courses in research area	24	24 <sup>43</sup>	24	24
Essay & Colloquium	6	-	-	-
Free electives <sup>44</sup>	30	36 / 6 <sup>45</sup>	26	26
EDU/SCS/SBB components	-	30 / 60 <sup>45</sup>	40	40
<b>Total</b>	<b>120</b>	<b>120</b>	<b>120</b>	<b>120</b>

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<sup>43</sup> Students in the EDU specialisation are advised to choose from both research areas, to obtain a broader knowledge of chemistry.

<sup>44</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>45</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.

## Admission to the programme

The Board of Admissions will judge the qualifications of the applicants on the basis of the curriculum and grades of their previous training.

- Students with a BSc degree Life Science and Technology (LST) from Leiden/Delft will be admitted to the programme.
- All other students with a BSc degree in Life Sciences, or in a field related to Life Sciences, at a different (international) University or HBO Hogeschool, can apply for admission. The Board of Admissions judges each application on the basis of the content of the BSc curriculum and on the grades obtained previously. In general, only students with an outstanding track record and an outstanding research internship will be admitted.
- As a guideline, HBO students should have obtained their BSc degree within four years with an average final grade of at least 7.5 and a research internship grade of at least 8.0.
- All foreign students must provide a copy of an English proficiency certificate evidenced by an appropriate language test.
  - IELTS: minimum 6.5
  - TOEFL: internet based 90
  - Cambridge Certificate of Advanced English (CAE), minimum grade CThis requirement does not apply if you have completed your education in Canada, USA, UK, Ireland, New Zealand or Australia, or possess an International Baccalaureate.

The qualifications of admission are identical for all specialisation, with an exception for the specialisation Education. Additionally, applicants for the EDU specialisation must provide proof of proficiency in Dutch (Toelatingsexamen Universiteit Leiden –gevorderd, met spreekvaardigheid minimaal een 7 ½).

## Programme

Students compose their own study programme in consent with the 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 intended programme may be adjusted during the course of the MSc programme. 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 of the master portfolio. The student updates the master planner regularly. It is accessible to the student, the mentor and the study coordinator. The mentor and student discuss, the progress of the student at least every 6 months using the results documented in the planner. The study coordinator will mediate when the student encounters problems in the interaction with the mentor.

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 course Life Science and Technology (LST) is based on the Leiden University research profiling theme of "BioScience: Science base of Health". The study aims that students can understand the outcomes of molecular and structural chemistry and gain insight in basic targets underlying various diseases. As important students can get knowledge in the fields of bio(medical) informatics and chemical tools for health-related applications. LST master students with an interest in the molecular chemical basis of Life Sciences can perform internships at the LIC, e.g. chemical biology or IBL and LACDR. Students with a medical

preclinical biomedical interest can attend their internships at the 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 Chemistry and Science Based Business, Chemistry and Science Communication and Society and Chemistry 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 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 three parts: the research training project (60 EC), the compulsory courses (30 EC) and the elective courses (30 EC). A general overview of the programme is given in Table 1.

The (major) research-training project is carried out within the Cell Observatory or related LIC research groups or IBL and LACDR. Our MSc students also have the opportunity to carry out pre-clinical master projects in biomedical research institutes, including the LUMC, ErasmusMC and NKI.

The research-training project includes a presentation and a written report (the master thesis). The major research-training project is concluded with a presentation for an independent jury of two staff members, as well as interested students and staff members of the LIC (Thesis Talk). All students attend at least 10 Thesis Talks during their MSc program. 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. 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 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 institute.

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 Projects, it is not possible to obtain a grade higher than 6 if this deadline is exceeded.

The compulsory theoretical component comprises a selection of four core courses (24 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 below.

The elective component consists of a free choice of theoretical courses (30 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;
- 26 EC of free electives<sup>46</sup>; and
- the Science Based Business or Research Based Business component<sup>47</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.

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<sup>46</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>47</sup> Completion of the specialisation Science Based Business requires a minimum of 40 EC and a maximum of 60 EC within the SBB component.

## **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;
- attendance of at least 10 thesis talks;
- 26 EC of free electives; and
- the Science Communication and Society component<sup>48</sup> as described on page 82.

A more comprehensive description, qualifications for admission, exemptions and more information on the complete programme can be found on page 82.

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<sup>48</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 6 or 20 EC<sup>49</sup>, 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;
- the Education component as described on page 85.

The Life Science and Technology 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
Biomolecular Structures	Ubbink	SC
Chemical Genetics	Brouwer <i>et al</i>	CG
Bionanotechnology	Schneider <i>et al</i>	BNT
<b>Bio(medical) Sciences</b>		
Genome Organisation and Maintenance in Cancer and Aging	Brouwer	GCA
Bio(medical) Informatics	Gulyaev	BMI
Global Regulatory Networks in bacteria	van Wezel <i>et al</i>	GRNB
In-vivo Biomolecular Interactions Underlying Diseases	Noteborn	IBID

<sup>49</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

## ***Specialisation Science Based Business***

### **Description**

The specialisation Science Based Business (SBB) provides knowledge, insights and skills in the area of Management, Business and Entrepreneurship. Its focus is on their application in science- and research-driven organisations. Purpose is to broaden the 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 (Research-Based Business; RBB).

### **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 15;*
  - *Astronomy, see page 30;*
  - *Physics, see page 40;*
  - *Chemistry, see page 46;*
  - *Bio-Pharmaceutical Sciences, see page 57;*
  - *Biology, see page 70; or*
  - *Life Science and Technology, see page 78.*
- a Science Based Business or Research-Based Business component<sup>50</sup>.

The SBB specialisation programme comprises at least 40 EC. A maximum of 20 EC of electives can be filled in with either SBB or RBB courses (as listed in the table below), 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>50</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 registered for the Business specialisation can follow one of the following two tracks:

The General Management track which encompasses minimally the following modules:

	Level	EC
Management Fundamentals	400	15
Management Internship	600	25-36

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

	Level	EC
New Technology Ventures (NTV) courses:		
NTV1: Entrepreneurial Opportunities	400	5
NTV2: The Entrepreneurial Process	400	5
NTV3: Business Planning	400	5
New Technology Ventures Assignment	600	25-36

In addition, the following courses modules can be included in both tracks:

	Level	EC
Business Elective	400-600	3-15
Business Essay	500	3-7

## 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 management, business or entrepreneurship courses fitting in the context of business. Decisions on exemptions and substitutions are taken by the Board of Examiners.

## ***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. Also for future science teachers the specialisation is a valuable preparation.

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 5;*
  - *Computer Science, see page 16;*
  - *Astronomy, see page 31;*
  - *Physics, see page 41;*
  - *Chemistry, see page 47;*
  - *Bio-Pharmaceutical Sciences, see page 58;*
  - *Biology, see page 71;*
  - *Life Science and Technology, see page 79; or*
  - *Biomedical Sciences (LUMC).*
- a Science Communication and Society component<sup>51</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>51</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>
Fundamentals of Science Communication and Society	400	17
Project Proposal SCS	600	3
SCS Internship(s)	600	20-40
SCS Elective	500	1-10

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 the MSc programme coordinator. A plan for the optional SCS Elective (e.g. book exam, product development) should also be approved beforehand by the SCS coordinator.

## 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.

Master programme	Qualifies for school subject
Mathematics	Wiskunde (Mathematics)
Physics	Natuurkunde (Physics)
Astronomy	Natuurkunde (Physics)
Chemistry	Scheikunde (Chemistry)
Bio-Pharmaceutical Sciences	Scheikunde (Chemistry) <sup>52</sup> or Biologie <sup>53</sup> (Biology)
Life Science and Technology	Scheikunde (Chemistry) or Biologie <sup>53</sup> (Biology)
Biology	Biologie (Biology)

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

### 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 –gevorderd, met spreekvaardigheid minimaal een 7 ½).

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<sup>52</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>53</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.

## 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 6;*
  - *Astronomy, see page 32;*
  - *Physics, see page 42;*
  - *Chemistry, see page 47;*
  - *Bio-Pharmaceutical Sciences, see page 59;*
  - *Biology, see page 73; 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.