

MSc Systems Biology

(wo-master)

Maastricht University

15 June 2015

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1 Executive Summary

Maastricht University seeks accreditation for a new MSc programme in Systems Biology. The programme is offered jointly by the Faculty of Health, Medicine & Life Sciences, the Faculty of Psychology and Neurosciences and the Faculty of Humanities & Sciences of Maastricht University on the premises of the Health Campus in Maastricht, the Netherlands.

Standard 1. Intended learning outcomes

The MSc programme in Systems Biology aims to deliver graduates who are equipped with the analytical tools and innovative research methods from different disciplines (especially biology and mathematics) integrated in a single concept (systems biology), generating novel insights and testable concepts in biology, medicine, epidemiology, biotechnology, ecology and translational research. They will be able to develop new tools and novel approaches from either discipline, taking systems biology a step further. The objectives and rationale for this new MSc programme at Maastricht University are fully in tune with the systems approaches that are becoming increasingly important in the efforts to understand biology and medicine at all levels.

In the application file the intended learning outcomes have been explicitly linked to the Dublin descriptors for a master programme. In addition, the academic orientation of the programme is explained by references to the research-based learning approach, the academic skills training and the links with staff and research groups based at Maastricht University and the University of Liège. The International perspective is strong. The panel recommends establishment of an external advisory board, including representatives from industry.

The panel assesses standard 1 'Intended learning outcomes' as satisfactory.

Standard 2. Teaching-learning environment

The contents of the programme are well-considered: the staff have developed an innovative set of courses that will enable the students from life sciences and mathematics to communicate effectively and to work together in a systems approach. The role of the elective courses has been clarified during the visit and is appropriate. The list of potential internships is extensive. The examination board will closely review the internal project proposals for an adequate balance in terms of computational and biological aspects. The interaction with the University of Liège satisfies the broadening of the course as proposed by CDHO (Commissie Doelmatigheid Hoger Onderwijs, Committee on Macro-efficiency in Higher Education).

The learning environment is strong, through the integration of Problem-Based Learning (PBL), lectures, practical training and through the (international) research context of the universities of Maastricht, Liège and the wider Euregion (Aachen, Hasselt). Internationalisation comes naturally to a programme at Maastricht University. Study guidance is available, but should be extended by adding an independent mentor or a second supervisor during the thesis work. The co-supervision of thesis projects is a strong point and will contribute to the multidisciplinary nature of the programme. The admission policies are robust and appropriate for the students the programme wishes to attract. The panel advises conducting a mid-term review after the first two batches of students have graduated.

The staff is a coherent group, the programme management and teachers are capable, energetic and enthusiastic. Staff from the University of Liège contribute in a significant way and are represented on the programme committee, which is an adequate response to the CDHO advice. Involvement of Liège staff will be further extended in the near future via a memorandum of understanding specific to this programme.

The facilities are excellent. The classrooms, computer facilities and labs in the Maastricht Center of Systems Biology (MaCSBio) are all close together and ensure that the teaching is well integrated with the staff's research activities.

The panel concludes that the curriculum, staff and programme-specific facilities constitute a coherent, attractive and innovative teaching-learning environment for the students. This enables the students to achieve the intended learning outcomes.

The panel assesses standard 2 'Teaching-learning environment' as satisfactory.

Standard 3. Assessment

Having studied the submitted materials and further documentation provided in the meetings during the visit, the panel is very satisfied with the assessments provided. They apply a good combination of methods, show an outstanding balance and are appropriate for the level and contents of the programme.

The examination board were enthusiastic in reflecting about the programme and advising the programme committee. The members bring strong expertise and experience that the new programme will benefit from. The panel suggests reconsidering the position of the current external member after the start of the programme. His expertise and contribution are very valuable, but it is difficult to be a truly external member since all teaching at Maastricht University is so closely integrated.

The panel assesses standard 3 'Assessment' as satisfactory.

Standard 4. Graduation guarantee and financial provisions

The panel has ascertained from the application file and the interviews during the site visit that Maastricht University and the province of Limburg have significantly invested in the Systems Biology master programme and that Maastricht University will guarantee sufficient financial provisions in the case of start-up losses. The panel is, therefore, convinced of the viability of the programme.

The panel assesses standard 4 'Graduation guarantee and financial provisions' as satisfactory.

Given these considerations, the panel advises NVAO to take a positive decision regarding the quality of the new master programme Systems Biology offered by Maastricht University.

Maastricht University proposes that the master programme Systems Biology has a duration of two years (120 EC). The programme management's arguments regard the international requirements of the programme, based on a comparison of similar programmes internationally, and the level of complexity of the programme. The multidisciplinary domain requires knowledge and hands-on expertise in the very divergent disciplines of mathematics and the life-sciences. The panel is convinced that the qualifications the graduates should have in order for them to be competitive in the international academic job market, cannot be achieved in a

programme of less than two years. The panel, therefore, advises to grant the programme the right to offer a two-year master's programme (120 EC).

The panel confirms the allocation of sector as suggested by the applicant: Nature.

The Hague, 15 June 2015¹

Prof. dr. Han de Winde
(chair)

Dr. Marianne van der Weiden
(secretary)

¹ De instelling heeft geen feitelijke onjuistheden vastgesteld in het ontwerpadvies van 8 juni 2015, zoals bevestigd per e-mail van 15 juni 2015.

2 Procedure

2.1 Process

Macro-efficiency	12 December 2014
Application	26 January 2015
Composition panel	9 March 2015
Site visit	18 & 19 May 2015 (Maastricht)
Panel report	15 June 2015

2.2 Panel

Composition of the panel:

1. Prof. dr. Han de Winde, Professor of Industrial Biotechnology and Vice-Dean at the Faculty of Science, Leiden University (*chair*);
2. Prof. dr. Isabel Sá-Correia, Professor of Biological Sciences, Department of Bioengineering, Instituto Superior Técnico (IST), Universidade de Lisboa, Lisbon, Portugal;
3. Prof. dr. Steven Russell, Professor in Genome Biology, Department of Genetics & Cambridge Systems Biology Centre, University of Cambridge, UK;
4. Drs. Renée Verhoeven, PhD student Department of Surgery, Erasmus MC – University Medical Center Rotterdam (*student member*).

Assisting staff:

- Dr. Marianne van der Weiden, secretary to the panel;
- Michèle Wera MA, policy advisor NVAO and process coordinator.

2.3 Assessment framework

The framework for limited assessments of new programmes (2014, Nr. 36791) is used for institutions that have obtained a positive judgement following an institutional audit.² The assessment is based on a discussion with peers regarding the content and quality of the programme. It focuses on five questions:

1. What is the programme aiming for?
2. How does the programme intend to achieve its objectives?
3. How does the programme intend to assess its performance?
4. If applicable, are the objectives achieved?³
5. Does the programme have sufficient financial resources?

These five questions have been translated into five standards. Regarding each of these standards, an assessment panel gives a substantiated judgement on a three-point scale: meets, does not meet or partially meets the standard. The panel subsequently gives a substantiated final conclusion regarding the quality of the programme, also on a three-point scale: positive, negative or conditionally positive.

To assess the two-year duration (120 EC) of the programme, the panel used the NVAO Protocol *cursusduur masters* (8 October 2003).

² Institutions with a positive institutional audit may also opt for the framework relating to extensive initial accreditations.

³ If the programme has already produced graduates, the panel assesses the achieved learning outcomes.

3 Programme

3.1 Administrative data

Country	The Netherlands
Institution	Maastricht University (positive NVAO decision institutional quality assurance assessment: 15 May 2013 until 15 May 2019)
Programme	Systems Biology
Level	master
Orientation	academic (wo ⁴)
Credits	120 EC
Location	Maastricht
Mode of study	full-time
Field of study	Nature (as suggested by the applicant and confirmed by the panel)

3.2 University

Maastricht University (UM) was founded in 1976 and stands out for its innovative approach to learning (Problem-Based Learning) and international outlook (47 per cent international students). With almost 16,000 students and 4,000 staff, UM offers seventeen academic bachelor and fifty academic master programmes. The university is organised in six faculties: Arts and Social Sciences, Business and Economics, Health, Medicine and Life Sciences, Humanities and Sciences, Law and Psychology and Neurosciences.

3.3 Programme

The master programme Systems Biology is an interdisciplinary programme, offered by three faculties (Faculty of Health, Medicine & Life Sciences, Faculty of Psychology and Neurosciences, Faculty of Humanities & Sciences) and includes contributions from the University of Liège. The programme aims to help students acquire the knowledge and practical skills necessary for unravelling the complexity of biological systems, to bridge biology and mathematics from molecule to ecosystem, and to translate and integrate huge and heterogeneous data sets into biologically relevant information and experiments. Within the Netherlands, this is the first programme to provide a shared basis in mathematics and biology. The programme is a two-year (120 EC) fulltime programme, to be conducted in English, and intends to start in September 2015 with a first intake of fifteen students. The programme will be offered on the Health Campus, Maastricht. This location suits the programme's focus on human biology and health.

⁴ wo = wetenschappelijk onderwijs

4 Assessment

4.1 Standard 1 – Intended learning outcomes

The intended learning outcomes of the programme have been concretised with regard to content, level and orientation; they meet international requirements.

Findings

The master programme Systems Biology aims to deliver graduates who are equipped with the analytical tools and innovative research methods from different disciplines (especially biology and mathematics) integrated in a single concept (systems biology), generating completely novel insights and testable concepts in biology, medicine, epidemiology, biotechnology, ecology and translational research, and able to develop new tools and novel approaches from either discipline, taking systems biology a step further.

The application file lists the following domain-specific learning goals:

Upon graduation the students

1. have gathered extensive and detailed knowledge and understanding of biological and mathematical foundations of normal and pathological biological systems from molecule to population;
2. have gathered detailed knowledge and understanding of mathematical methods for the analysis of data from biological experiments and for modelling complex biological systems;
3. can apply gathered scientific knowledge, competences and skills, including programming to solve complex and relevant problems in the field of systems biology;
4. are able to comprehend new emerging concepts, theories and techniques and use these to initiate creative research for solving relevant problems in the field of systems biology;
5. can work in a multidisciplinary research group and give a significant and/or leading contribution to the scientific work within such a group;
6. have the capability to perform self- and peer-evaluation in order to continually improve themselves and their peers;
7. are able to independently propose and/or execute research projects in systems biology, analyse and interpret the results, and report to different groups of interest ranging from fellow scientists, to industrial management, policy makers and the general public;
8. are capable to communicate and create links with and between scientists and experts involved in the development, application and commercialisation of systems biology;
9. demonstrate a creative and innovative attitude in their work that is driven by scientific curiosity and life-long learning;
10. have developed into responsible and ethical scientists, who show social responsibility in the transition towards a sustainable society and industry through responsible valorisation and ownership.

In the application file these intended learning outcomes have been explicitly linked to the Dublin descriptors for a master programme. In addition, the academic orientation of the programme is explained by references to the research-based learning approach, the academic skills training and the links with staff and research groups based at the Maastricht University and the University of Liège.

The application file describes that graduates will be suited for positions in research, policy making and entrepreneurship. Currently, however, connections with industrial companies are minimal. During the site visit the panel had an interesting and constructive meeting with representatives from the professional field, but all of them represented academic institutions.

Considerations

Systems Biology is a rapidly emerging field that brings together expertise in many different disciplines from biology through engineering and the physical sciences to mathematics. There is no doubt that systems approaches are becoming increasingly important in the efforts to understand biology at all levels, from the regulatory circuitry and basic metabolism of cells, organismal development and homeostasis to the behaviour of populations. Most undergraduates are still educated at the level of individual disciplines, and while maths courses may include a small amount of biology and vice versa, there is an increasing need to train young scientists at the interface between these subjects to provide relevant expertise to address the new challenges in biological research offered by the genomics revolution. This is not to say that Systems Biology training aims to turn bioscientists into experts in mathematics or mathematicians into expert biologists, rather the aim is to educate the next generation of researchers sufficiently so they can understand each other's scientific language and develop productive interdisciplinary research programmes. The overall objectives and rationale for establishing this new masters programme at Maastricht University are fully in tune with this need and the application file sets out a roadmap for developing a relevant and well-planned course.

The panel concludes that a well-balanced mix of biology and computational subjects are suitably integrated to provide a solid foundation in systems biology. The detailed description of the course content indicates the course will deliver the intended learning outcomes. These clearly fit with the national and international qualification frameworks. The international perspective is strong.

The panel advises the programme management to set up an external advisory board and to include representatives from industry, such as pharmaceutical and biotechnology companies, in order to monitor and, if necessary, strengthen the relevance of the programme.

Conclusion

The panel assesses standard 1 'Intended learning outcomes' as satisfactory.

4.2 Standard 2 – Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable incoming students to achieve the intended learning outcomes.

Findings

Structure and contents of the curriculum

The curriculum consists of 120 EC, spread over two years of 60 EC each. See Annex 2 for a schematic overview of the programme. The cornerstones of the master are both the life sciences (biology and medicine) and mathematics (modelling, data handling and informatics). These distant disciplines are brought together within the programme. The focus of the first year is to invest in training students from diverse backgrounds to develop appropriate knowledge in the common theme of systems biology. A common basis is created through the admission strategy, introduction course, problem-based learning and multidisciplinary projects.

The introductory course, Connecting Biology and Mathematics, aims to provide basic knowledge and understanding of biological systems for non-biologists and basic knowledge and understanding of mathematical approaches for non-mathematicians. The starting point in each of these domains will be determined for each student via self-assessment. This will be used to calibrate the rest of the course in order to reach the required level of knowledge and skills. The second course, Evolution, is similarly used to familiarise both groups with each other's discipline. During the site visit the panel discussed the possible issues related to bringing together students from these diverse backgrounds. Getting non-biologists up to speed with the most basic concepts in biology, using maths students to train biologists and vice versa, cohort cohesion and interactions were addressed in several meetings during the visit. The applicants were able to provide good evidence of a coherent strategy and relevant assessments to ensure this would be achieved over the course of the first two modules.

The panel has looked into the course descriptions that were provided in the application file, and concludes that the contents are appropriate. The programme has a heavy emphasis on human systems and populations, and based on the written materials the panel had some concern that the use of classical systems models (yeast, worm, fly, ES cell) would not be covered. The applicants, however, were able to demonstrate a relevant balance between the use of model systems and the more medically oriented aspects of the programme. Regarding the two multidisciplinary projects of the first year, the applicants provided convincing arguments, based on their extensive experience in problem-based learning (PBL), that these projects were well founded and would be appropriately designed to further build cohort cohesion. The suggested exemplars provided by the programme committee were appropriate.

The structure of the second year of the programme is built on experiences from other master programmes and is robust. For the internships and master thesis research an extensive list of project titles from research groups across the three faculties and the University of Liège were provided and appeared to be both broad and appropriate. The programme management provided assurances regarding the selection of projects with an appropriate balance of experimental and computational work. Thesis projects will be co-supervised by staff with different disciplinary backgrounds. The research environment is very well-suited for thesis projects at academic master level. If specific additional expertise or knowledge is needed for

an internship the student can select an elective course from the Maastricht course catalogue, including PhD courses. These courses are then considered to be part of the internship. This was initially not clear to the panel, but was clarified during the visit.

The CDHO (Commissie Doelmatigheid Hoger Onderwijs, Committee on Macro-efficiency in Higher Education) formulated in its advice to the Minister of Education, Culture and Science, that the MSc in Systems Biology should be executed in cooperation with another university, in order to create the necessary learning environment. Following this advice, Maastricht University has decided to expand its existing cooperation with the University of Liège. The relevant research areas and infrastructure are complementary, with Liège focusing on model organisms and imaging, while Maastricht emphasises the complex human systems. In addition, this partnership strengthens the international outlook of the programme and builds on the positive experiences with cross-border cooperation in teaching of both universities. To formalise the collaboration, a programme-specific Memorandum of Understanding is currently drafted.

Didactical approach

The format of problem-based learning (PBL) is used as the main educational method, combined with formal lectures, journal clubs, practical work in labs and clinics and individual and group work on projects. PBL is characteristic of the teaching at Maastricht University and particularly suitable for the master programme Systems Biology, combining students with very different backgrounds. They will be able to share their complementary knowledge and bring it to a high joint level. PBL also helps to educate students on how to approach novel problems. In particular, the two project periods during the first year will require independent working in multidisciplinary groups to tackle a scientific problem. The panel is convinced that PBL is suitable for this academic master programme.

Maastricht University has an excellent track record in recruiting international students. In addition, the faculties and research groups involved in the programme have a wide network. This will provide opportunities for students to expand their international experience. The active participation of the University of Liège will provide easy access to a large and broad international university nearby. The proximity of the universities of Hasselt and Aachen also contributes to international opportunities at a short distance.

Study guidance is provided by the tutors (first year) and supervisors (second year). The PBL format will allow close monitoring of each student's progress. Study guidance in the second year is provided by the thesis project supervisor.

Staff

The application file provides a list of staff members who will be teaching in the programme. During the site visit, the panel met the programme management and staff members who will be involved in the programme. In each committee and course, staff members from the three faculties team up to ensure an appropriate balance between the various disciplines. The curriculum committee and the programme committee are actively involved and are clearly keen to contribute to the quality of the programme. The relationship between these two committees was, however, not completely clear.

The spread of expertise across the faculty is very good and the panel found the engagement and considerable experience of the faculty involved in teaching and assessment impressive.

New staff members are introduced to PBL from the start of their employment. The balance between research, teaching and administrative tasks is good.

Following the condition set by CDHO, the programme has established both a relationship with another university and a joint programme committee. The draft of the above mentioned programme-specific Memorandum of Understanding demonstrates good engagement by the University of Liège. At present one professor is actively involved in designing and preparing the programme and is a member of the programme committee. More faculty members from Liège will be involved after the start of the programme.

Admission procedure

The admission criteria and procedures are clearly described in the application file. Applicants will have to provide documentation concerning their academic career, English language proficiency and motivation. In an interview, the admission officer will try to determine if there is a match between the student's expectations and motivation and the programme's ambition and interdisciplinary approach. In view of the interdisciplinary aim of the programme, a balance of students with a background in the life sciences and mathematics is crucial. The programme management provided convincing evidence that they would be able to recruit a well-balanced cohort of students and that they had given consideration to the possible need for any pre-course work. Some examples of reading material in the application file were appropriate for this.

Services and facilities

During the site visit the panel was shown around the facilities (classrooms, laboratories, computers) of the interfaculty Maastricht Center of Systems Biology (MaCSBio) that will be available to the programme. The panel saw ample computing support and dedicated computer teaching suites. MaCSBio is certainly a suitable research environment to host projects.

Students will have access to the general facilities of Maastricht University, such as the library with its online services and the electronic learning environment EleUM-Blackboard. Students can access the administration system SLM (Student Life-Cycle Management) to view their study results, access schedules and timetables, and register for courses.

Considerations

On the basis of the written documentation and the visit the panel is enthusiastic about the teaching and learning environment of the MSc in Systems Biology.

The programme staff has developed an innovative set of courses that will enable students from life sciences and mathematics to communicate effectively and to work together in a systems approach. The role of the elective courses was found to be appropriate after explanation but was at first not clear to the panel. It is advisable to clarify this procedure. The list of potential internships is extensive. The panel was reassured that the examination board will closely review the internal project proposals for an adequate balance in terms of computational and biological aspects. The co-supervision of thesis projects is a strong point and will contribute to the multidisciplinary of the programme.

The learning environment is stimulating through the didactical approach and the (international) research environment. The integration of PBL, lectures and practical training is a strong point. The programme is extremely well integrated with the research activities at the universities of

Maastricht, Liège and the wider Euregion (Aachen, Hasselt). Internationalisation comes naturally to a programme at Maastricht University.

Study guidance is available, but the panel suggests that in addition to the supervisor during the master project, a student should have access to an independent mentor or a second supervisor to turn to if something goes wrong. The programme could e.g. introduce a mentor, as is done in their research master.

The admission policies are robust and appropriate for the students the programme wishes to attract. The panel advises monitoring the students' progress closely to see if it may be necessary to offer a pre-master programme or other additional preparatory courses in the future. In more general terms, a mid-term review of the programme as soon as the first two batches of students have graduated is recommended.

The staff is a coherent group, the engagement and enthusiasm of the teaching group were particularly nice to see. Staff from the University of Liège contribute in a significant way and are represented in the programme committee, which is an adequate response to the CDHO advice. The panel is convinced that the cooperation with the University of Liège is a good choice and was pleased to discover that the involvement of Liège staff will be further extended in the near future. The different roles of the curriculum committee and programme committee are not sufficiently distinct and should be clarified.

The facilities are excellent. The classrooms, computer facilities and labs in MaCSBio are all close together and ensure that the teaching is well integrated with the staff's research activities.

The panel concludes that the curriculum, staff and programme-specific facilities constitute a coherent, attractive and innovative teaching-learning environment for the students. This enables the students to achieve the intended learning outcomes.

Conclusion

The panel assesses standard 2 'Teaching-learning environment' as satisfactory.

4.3 Standard 3 – Assessment

The programme has an adequate assessment system in place.

Findings

System of assessment

The application file and the OER/EER (Onderwijs- en Examenreglement, Education and Examination Regulations) describe the programme's assessment system. Students' progress in each module will be evaluated by multiple types of assessment and at different time-points. The panel finds the mixture of module-specific examinations and graded course work very solid. The programme management provided exemplar examination papers that demonstrated rigorous and appropriate examination of the computational aspects of the courses. The documentation provided gives confidence in the quality of assessment. The assessment

procedures of projects are excellent and well controlled to normalise against different assessors and to thus strengthen reliability.

The panel was also provided with information on the assessment of the master thesis. The thesis procedure is described in detail and includes an independent second examiner.

Examination Board

During the site visit, the panel had an interview with the examination board. The chair and members represent the three faculties and bring strong expertise and experience to the board. The external member was explicitly invited because of his experience in other MSc programmes. The organisation structure of Maastricht University makes it difficult not to be involved in each other's projects, which raised questions from the panel about the independence of the external member. At present this is not an issue, but after the start of the programme this member's involvement may intensify. In that case a new external member may have to be found.

The board has taken an active role in helping to design the programme, e.g. by advising the programme committee. The regulation structure has been adopted from other programmes. For the panel, it was clear from the discussion that the examination board is well aware of its own role and responsibilities. The examination board's approval will be required for internship and thesis proposals. The board plans to provide feedback and stimulate creativity in assessment. It will collect all the exams, take an advisory role and challenge coordinators to design assignments to help longitudinal learning for students.

Considerations

Having studied the materials and based on the meetings during the visit, the panel is very satisfied with the assessments as provided. They apply a good combination of methods, show a superb balance and are appropriate for the level and contents of the programme.

The examination board showed enthusiasm in reflecting about the programme and advising the programme committee. The members bring strong expertise and experience, which the new programme will undoubtedly benefit from. The panel suggests reconsidering the position of the current external member after the start of the programme. His expertise and contribution are very valuable, but it is difficult to be a truly external member since all teaching at Maastricht University is so closely integrated.

Conclusion

The panel assesses standard 3 'Assessment' as satisfactory.

4.4 Standard 4 – Graduation guarantee and financial provisions

The institution guarantees students that they can complete the entire curriculum and makes sufficient financial provisions available.

Findings

The application file describes the graduation guarantee and financial provisions for the programme. In 2012, Maastricht University received a 15 million Euros subsidy from the

Province of Limburg to develop a bachelor programme Liberal Arts and Sciences, a master programme Biobased Materials including research within the Aachen-Maastricht Institute for Biobased Materials, and a master programme Systems Biology including research within the Brightlands Health Campus. A further 10 million Euros will be granted if the start of the education and research is evaluated to be successful by the province. In 2013, these plans were integrated in a long-term investment plan for strengthening the regional economy and campus developments of the province of Limburg: the Kennis-as, with investments up to 600 million Euros. The Executive Board of Maastricht University guarantees that the financial provisions of the sciences within the Faculty of Humanities and Sciences are sufficient to cover start-up losses, even if the expected extra subsidy of 10 million Euro for the period 2016-2022 should not be available.

The proposed budget looks feasible to the panel. The panel expects that the programme will be attractive to a sufficient number of qualified students to make the programme viable. The panel agrees that it is a sensible decision to start with a small number of fifteen students and gradually let it grow to a yearly intake of twenty-five students. In the first year an even smaller batch could be a good starting-point to work out all details in a controlled manner.

Considerations

The panel has ascertained that Maastricht University and the Province of Limburg have invested strongly in the master programme Systems Biology, and is convinced that Maastricht University will guarantee sufficient financial provisions in the case of start-up losses. The panel is, therefore, convinced of the viability of the programme.

Conclusion

The panel assesses standard 4 'Graduation guarantee and financial provisions' as satisfactory.

4.5 Final conclusion

On the basis of the application file and the discussions during the site visit, the panel concludes that the academic master programme Systems Biology is an ambitious programme in a relevant domain. It meets the increasing need to train young scientists at the interface between the life sciences and mathematics, providing relevant expertise to address the new challenges in biological research offered by the genomics revolution. The intended learning outcomes reflect the contents and approach of the programme and clearly fit with the national and international qualification frameworks. An external advisory board would be useful.

The structure and contents of the curriculum are well considered. The set of introductory courses aims to familiarise students from different disciplinary backgrounds with each other's vocabulary and methods. The coursework and projects show a good balance between the use of model systems and the more medically oriented aspects of the course. The cooperation with the University of Liège provides the complementary expertise for this balance. At the same time, this cooperation strengthens the international outlook of the programme. The research environment of MaCSBio is excellent for an academic master programme.

The didactic approach of PBL helps the students to develop into creative and responsible researchers. The admission criteria are clear and appropriate. The applicants provided convincing evidence that they would be able to recruit a well-balanced cohort of students. The quality of the academic staff and the services and facilities constitute a coherent and attractive

teaching-learning environment for the students. The programme management and staff members are enthusiastic and capable. The panel advises expanding the student guidance in year two to include a project mentor.

The examination board has been established and is developing procedures to actively monitor and stimulate the quality of assessments. The Education and Examinations Rules are in order and exemplars of the assignments give the panel full confidence in the quality of the assessment system.

Maastricht University guarantees that students who have been admitted to the programme, can complete the entire curriculum. The financial provisions are sufficient. The commitment of the province of Limburg is strong.

The panel's final conclusion therefore is satisfactory.

4.6 Recommendations

The panel advises:

- establishing an external advisory board, including members from industry;
- extending student guidance during the thesis project by assigning a mentor or an independent second supervisor to every student.

4.7 Advice on two-year duration of programme

Findings

Maastricht University proposes that the master programme Systems Biology has a duration of two years (120 EC). The programme management's arguments regard the international requirements of the programme and the level of complexity of the programme, reflecting the requirements of the broad multi-disciplinary domain, requiring knowledge and hands-on expertise in mathematics and the life-sciences.

The learning outcomes to be attained by the students must be consistent with the international requirements for the domain. To check the domain-specific standards in the field of systems biology, the programme management has investigated similar master programmes internationally:

- Master Integrated Systems Biology, Université de Luxembourg (120 EC);
- Erasmus Mundus Master's Programme in Systems Biology, KTH Royal Institute of Technology, Sweden; Instituto Superior Técnico, Portugal; Aalto University, Finland (120 EC);
- Master of Systems Biology, Ulster University, UK (180 EC).

From the comparison of these programmes it is clear that all strive for a strong knowledge base in both the life sciences and the methodological and computational science. All stress the importance of integrating research in the educational programme and include a longer period of master thesis research and internships, ranging from 30 to 60 EC. All programmes span a period of two calendar years (Ulster University offering three semesters per calendar year).

The programme management argues that the learning objectives of the master in Systems Biology can only be reached in a 2-year programme, because systems biology is a broad multi-disciplinary domain, requiring knowledge and hands-on expertise in mathematics and the life-sciences. Training interdisciplinary master students to be able to perform cutting-edge

interdisciplinary scientific research is based on a first year of courses, assignments, practical exercise (programming and lab), projects. This creates the basis to be able to design, write and carry out a competitive scientific research project in the second year, in which the knowledge of the first year on mathematics and biology is combined. It takes time to bring a diverse group of students, coming from biology, biomedical sciences, molecular life sciences, life sciences and technology, medical natural sciences, mathematics, informatics, physics or chemistry at the same interdisciplinary level.

In addition, the programme management refers to the importance of practical research training and the need for a strong integration of practical competence and skills training in academic programmes in the sciences. Without this practical education, the graduates have less chance of a proper scientific career, because their education will be seen as flawed: missing a critical part of the competences and skills beta-scientists in general should acquire during study. Especially doing actual research is seen as one of the core competences of the graduates, which is expressed in the intended learning outcomes of the MSc Systems Biology and the size of the research project (48 EC).

Considerations

The panel has assessed the arguments, using the criteria put forward in the Protocol cursusduur masters of NVAO, published on 8 October 2003.

The first criterion refers to the international requirements for a master programme in the relevant domain. Generally speaking, master programmes in the sciences have a duration of two years since the introduction of the bachelors and masters in the Netherlands. Academic programmes in the sciences in the Netherlands were set at a duration of five years (300 EC; three years bachelor; two years master), in order to allow the students to attain an international comparable level. The international standard for the programmes was five years and offering an education of four years, implying a one-year master's programme, would have put graduates of Dutch programmes in an unfavourable position compared to their peers abroad, regarding the knowledge and skills they would have acquired. More specifically for the MSc Systems Biology, the panel regards the comparison made by the programme management to be relevant and thorough, and concludes that similar programmes abroad take two years (120-180 EC). In the opinion of the panel, graduates of the proposed programme should take a two-year master's programme to achieve the learning outcomes, set at an international level.

According to the second criterion, it should be convincingly shown that the learning outcomes that enable the students to compete on an equal basis with their peers from other countries, cannot be attained in a one-year programme. The panel is convinced that the multi-disciplinary domain, requiring knowledge and hands-on expertise in mathematics and the life-sciences, the competences and skills to work effectively in multi-disciplinary project teams and the practical lab and research skills are essential to the programme. Since the programme is a research-oriented programme, the thesis should be the result of a substantive research project. The panel strongly feels that the qualifications the graduates should have in order for them to be competitive in the international academic job market, cannot be achieved in a programme of less than two years.

Conclusion

Given strong arguments in favour of a duration of two years, the panel advises to grant the programme the right to offer a two-year master's programme (120 EC).

4.8 Advice on sector(s) in the Central Register of Higher Education

Findings

Maastricht University proposes that the master programme Systems Biology be registered in the sector Nature.

Considerations

The panel confirms that the master programme Systems Biology, building on the disciplines of life sciences and mathematics, fits best in the sector Nature.

Conclusion

The panel confirms the allocation of sector as suggested by the applicant: Nature.

5 Overview Assessment

STANDARD		ASSESSMENT
1 Intended learning outcomes	The intended learning outcomes of the programme have been concretised with regard to content, level and orientation; they meet international requirements.	satisfactory
2 Teaching-learning environment	The curriculum, staff and programme-specific services and facilities enable incoming students to achieve the intended learning outcomes.	satisfactory
3 Assessment	The programme has an adequate assessment system in place.	satisfactory
4 Graduation guarantee and financial provisions	The institution guarantees students that they can complete the entire curriculum and makes sufficient financial provisions available.	satisfactory
FINAL CONCLUSION		SATISFACTORY

Annex 1 – Panel

Prof. dr. J.H. (Han) de Winde (chair)

Han de Winde (1962) obtained an MSc in organic chemistry and biochemistry at the Vrije Universiteit Amsterdam, and a PhD in molecular biology, University of Amsterdam. He was postdoc and assistant professor at University of Leuven; principal scientist Microbial Genetics and Physiology, DSM Life Sciences RD&T while part-time chair of Industrial Genomics at Delft University of Technology. Since 2006 he was director, Department of Biotechnology, Delft University of Technology, chair of Genetics and Genomics of Industrial Microorganisms and business director of the Kluyver Center for Genomics of Industrial Fermentation. Since 2010 he is vice chairman of the Chemistry Board of the Dutch National Science Foundation. Since 2013 he is vice dean, Faculty of Sciences, Leiden University and chair of Industrial Biotechnology. Han de Winde is an expert in microbial molecular genetics and metabolic engineering, in the field of signal transduction and control of physiology, growth and development of bacteria, yeast and fungi. His expertise extends to implementation and development of Systems and Synthetic Biology in microbial strain and process improvement. He is author of over eighty scientific publications and of ten filed patents families.

Prof. dr. Isabel Sá-Correia

Isabel Sá-Correia (1952) obtained her diploma in Chemical Engineering, PhD (Yeast Biology) and “Habilitation” (Biological Sciences) from Instituto Superior Técnico (IST), Technical University of Lisbon. As Fulbright Visiting Assistant Professor she did postdoctoral studies (Molecular Biology of Pseudomonas) at the Medical Center, University of Illinois at Chicago (1985/86). Full Professor of IST since 1995, she was Associate and Assistant Professor at IST where she initiated and coordinates the area of Biological Sciences. She is in the Directive Board of the Institute for Bioengineering and Biosciences and member of IST Scientific Council and University of Lisbon General Council. At IST, she is the Director of the PhD in Biotechnology and Biosciences, the Masters in Biotechnology and in Microbiology and the Erasmus Mundus Masters in Systems Biology (IST + KTH in Sweden + Aalto University in Finland). Her research interests are in the areas of Molecular and Cellular Microbiology, Functional and Comparative Genomics and Microbial Biotechnology. She has co-authored over 200 scientific articles, 40 book chapters and the public database YEASTRACT (<http://www.yeasttract.com/>) and currently has an h-index=36 (Web of Science) or 43 (Google Scholar). She supervised 15 post-doctoral programmes, 28 PhD and 35 Master theses. She is currently the President of the Portuguese Society of Microbiology. She chairs the External Evaluation Committee “Biochemistry and Biotechnology” of the Portuguese Agency for Assessment and Accreditation of Higher Education.

Prof. dr. Steven Russell

Steven Russell (1963) obtained a BSc in molecular biology, where he graduated with the top 1st class degree in the year, and PhD in Genetics from the University of Glasgow. He was a postdoctoral research associate and then senior research associate with Prof Michael Ashburner in the Department of Genetics, University of Cambridge. In 2000 he became Director of Genomics in the Department of Genetics, University of Cambridge, was appointed a University Lecture in 2003 and became the founding Director of the Cambridge Systems Biology Centre in 2005, where he has served as Director or Deputy Director ever since. In 2008 he was appointed to a University Readership and in 2013 as Professor of Genome Biology in the University of Cambridge. His research interests include the genomics of

Drosophila developmental biology, the analysis of genome-wide gene expression data and in transcription factor biology. He has published over 80 peer-reviewed papers, a well regarded text book on microarray data analysis and has extensive experience in teaching and training in the field of genomics and systems biology.

Drs. C.J. (Renée) Verhoeven (*student member*)

Renée Verhoeven (1987) started her academic career in 2005 as a Dutch Law student at Tilburg University. In 2007 she started studying Medicine at the Erasmus University Medical Center in Rotterdam. Belonging to the top 10% of best performing students of her year, Renée was selected to combine a Research Master in Clinical Research at the Netherlands Institute for Health Sciences (NIHES) with her medical training. Her Master Thesis on biomarkers in liver transplantation was awarded as the best NIHES Master Thesis in Clinical Research in 2012 with an 'outstanding' thesis defence. From 2012-2014 she continued her research on biomarkers as a PhD student, for which she received multiple awards on both national and international conferences, as well as a travel scholarship to obtain research experience at the University hospital of Zürich, Switzerland. Since 2014, Renée is a member of the basic science committee of the International Liver Transplantation Society (ILTS) for which she organises state of the art symposia on basic science in liver transplantation at international conferences. Next to her study, Renée volunteers in teaching surgical abdominal anatomy classes for medical students. After finishing her medical study and PhD research at the end of 2016, Renée intends to pursue a career in a surgical related field.

Assisting staff:

- Dr. Marianne van der Weiden, secretary to the panel;
- Michèle Wera MA, policy advisor NVAO and process coordinator.

All panel members and the secretary signed a declaration of independence and confidentiality prior to the assessment process.

Annex 2 – Overview of the programme

Title	Type	Level	Credits	Year/Period
Connecting biology and mathematics	Intro-course	Basic	6 EC	Year 1 Period 1 (4 weeks)
Evolution	Block-course	Basic	6 EC	Year 1 Period 2 (4 weeks)
Comparative biology	Block-course	Intermediate	12 EC	Year 1 Period 3 (8 weeks)
Project 1: What makes us human?	Project	Intermediate	6 EC	Year 1 Period 4 (4 weeks)
Heart-Brain connection	Block-course	Advanced	12 EC	Year 1 Period 5 (8 weeks)
Cancer, metabolic syndrome and chronic disease	Block-course	Advanced	12 EC	Year 1 Period 6 (8 weeks)
Project 2: Modelling life	Project	Advanced	6 EC	Year 1 Period 7 (4 weeks)
Designing and writing a basic and applied research project in systems biology	Block-course	Advanced	12 EC	Year 2 Period 1 (8 weeks)
Senior practical training Elective courses Thesis Poster presentation	Internship Courses Thesis	Advanced	48 EC	Year 2 Period 2 (32 weeks)

Annex 3 – Programme site visit

**MACSBIO Institute, Universiteitssingel 60, Maastricht, Room M1.11
Monday 18 May 2015**

12.00 – 15.00 Preparatory meeting panel during lunch (closed meeting)

15.00 – 15.30 Short presentation new programme and concept of problem-based learning

- Prof. dr. Bert Smeets, Programme Director
- Bakir Bulic MSc, Project Manager
- Drs. Fred Offerein, Managing director Sciences

15.30 – 16.15 Tour through the buildings and facilities

- Bakir Bulic MSc, Project Manager
- Emma den Brok, 2nd year student Maastricht Science Programme
- Heidi Cohen, 2nd year student Maastricht Science Programme

16.15 – 17.00 Preparatory meeting panel (continued)

17.00 – 17.30 Meeting with Deans / Vice-deans

- Prof. dr. Bernadette Jansma, Dean Faculty of Psychology and Neuroscience
- Prof. dr. Franz Palm, Dean Faculty of Humanities & Sciences
- Prof. dr. Nanne de Vries, Vice-dean Faculty of Health, Medicine and Life Sciences

17.30 – 18.00 Meeting with representatives of the Examination Board

- Prof. Ralf Peeters, Department of Knowledge Engineering, Faculty of Humanities & Sciences. chair
- Dr. Willem Voncken, Department of Genetics and Cell Biology, external member
- Dr. Arjan Blokland, Faculty of Psychology and Neuroscience

18.15-18.45 Skype meeting with Prof. dr. Kristel van Steen, Université de Liège

Tuesday 19 May 2015

09.00 – 09.45 Meeting with the programme management and designers of the curriculum

- Dr. Ronald Westra, Department of Knowledge Engineering
- Prof. dr. Ella Formisano, Faculty of Psychology and Neuroscience
- Prof. dr. Bert Smeets, Faculty of Health, Medicine and Life Sciences, Programme Director
- Bakir Bulic MSc, Project Manager

10.00 – 11.00 Meeting with staff responsible for courses (mandatory and electives), projects, internship and thesis

- Dr. Giancarlo Valente, Faculty of Psychology and Neuroscience
- Dr. Kâmil Uludağ, Faculty of Psychology and Neuroscience
- Dr. Roy Erkens, Maastricht Science Programme
- Dr. Steven Kelk, Department of Knowledge Engineering
- Dr. ir. Zita Soons, Department of Knowledge Engineering

11.15 – 11.45 Meeting with representatives of the Programme Committee

- Dr, Pieter Collins, Department of Knowledge Engineering
- Prof. dr. Peter de Weerd, Faculty of Psychology and Neuroscience
- Prof. dr, Bert Smeets, Faculty of Health, Medicine and Life Sciences

12.00 – 12.30 Meeting with representatives of the professional field

- Prof. dr. Roel Braekers, Interuniversity Institute for Biostatistics and statistical Bioinformatics, Centrum voor Statistiek, Universiteit Hasselt
- Prof. em. dr. Roel van Driel, Director Netherlands Consortium for Systems Biology
- Prof. dr. Wim Vanduffel, Research Group Neurophysiology, Laboratory for Neuro- and Psychophysiology, Faculty of Medicine, KU Leuven

12.30 – 13.30 Lunch and meeting panel (closed meeting)

13.30 – 14.15 Final panel meeting (continued)

14.15 - 14.30 Feedback session

- All interested UM staff involved in the master

Annex 4 – Documents reviewed

- Accreditation file (information dossier)
- Application for the assessment of an extended master programme Systems Biology
- Programme-specific Memorandum of Understanding University Maastricht – Université de Liège (draft)
- Education and Examination Regulations 2015-2016
- Examples of assessments (Take-home exams and computational assignments including assessment criteria)
- Assessment and supervision criteria for the master thesis

Annex 5 – Abbreviations

ba	bachelor
EC	European Credit
ma	master
MaCSBio	Maastricht Center of Systems Biology
NVAO	Nederlands-Vlaamse Accreditatieorganisatie (Accreditation Organisation of the Netherlands and Flanders)
PBL	Problem Based Learning
RBL	Research Based Learning
UM	University of Maastricht
wo	wetenschappelijk onderwijs

This panel report was commissioned by NVAO for the initial accreditation of the wo-master's programme Systems Biology of Maastricht University.

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