LIFE SCIENCES AND

NATURAL RESOURCES

BIOTECHNOLOGY AND BIOINFORMATICS

WAGENINGEN UNIVERSITY

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REPORT ON THE BACHELOR'S PROGRAMME BIOTECHNOLOGIE AND THE MASTER'S PROGRAMMES BIOTECHNOLOGY AND BIOINFORMATICS OF WAGENINGEN UNIVERSITY

This report takes the NVAO's Assessment Framework for Limited Programme Assessments as a starting point (September 2016).

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES

Bachelor's programme Biotechnology

Name of the programme:	Biotechnologie (Biotechnology)
CROHO number:	56841
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specializations or tracks:	-
Location:	Wageningen
Mode(s) of study:	full time
Language of instruction:	Dutch, English
Expiration of accreditation:	31-12-2019

Master's programme Biotechnology

Name of the programme:	Biotechnology
CROHO number:	66841
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	5
Location:	Wageningen
Mode(s) of study:	full time
Language of instruction:	English
Expiration of accreditation:	31-12-2019

Master's programme Bioinformatics

Name of the programme:	Bioinformatics
CROHO number:	60106
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specializations or tracks:	2
Location:	Wageningen
Mode(s) of study:	full time
Language of instruction:	English
Expiration of accreditation:	31-12-2019

The visit of the assessment panel Biotechnology and Bioinformatics to Wageningen University took place on the 8th, 9th and 10th of October 2018.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Wageningen University
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on March 7th, 2018. The panel that assessed the bachelor's programme Biotechnology and the master's programmes Biotechnology and Bioinformatics consisted of:

- Prof. dr. S. (Stanley) Brul (Chair), professor Molecular Biology and Microbial Food Safety at the Universiteit of Amsterdam (UvA) and chair of the Dutch institute for Biology (NIBI).
- Dr. A. A. J. (Annik) van Keer, educational advisor at the Faculty of Science at Utrecht University.
- Prof. dr. S. (Sue) Harrison, professor in Chemical Engineering and director of the Centre for Bioprocess Engineering Research (CeBER) at the University of Cape Town (South-Afrika) and of the Future Water Research Institute at the University of Cape Town.
- Prof. dr. S. (Sven) Panke, professor in Bioprocess Engineering at the Department of Biosystems Science and Engineering at the Eidgenössische Technische Hochschule (ETH) in Zürich (Switzerland).
- B. (Boas) van der Putten, graduated in 2017 in Biomedical Sciences at the University of Amsterdam. He is currently working on two PhD tracks at the AIGHD/AMC.

The panel was supported by dr. M.J.V. (Meg) Van Bogaert, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

Preparation
In preparation of the site visit, the panel studied several documents amongst others: the NVAO assessment framework (2016), the institutional audit of WU and the previous programme assessments (of 2012). The accreditation system has entered its third phase (concurrently with a second round of institutional audits). Wageningen University (WU) has recently successfully passed its second institutional audit. The new NVAO assessment framework is "geared to a quality assurance system that is based on trust in the existing, high quality of Dutch higher education".

In 2012 the bachelor's and master's programmes in Biotechnology were assessed with an overall good, the master's programme in Bioinformatics was assessed with an overall satisfactory. The previous panel considered the Biotechnology programmes to focus on actual integration of biology with engineering, giving them a strong and unique position in Europe. The panel considered that the Bioinformatics programme was relevant, up to date and promising for the future. The panel was very impressed with various aspects of the teaching and learning environment, choices in teaching methods clearly supported the achievement of the intended learning outcomes. Well-structured curricula added to the good assessment of this standard. The strengthening of the position of the Examining Boards was considered a positive aspect of all programmes and all programmes had a well-balanced mixture of assessment methods. The quality of theses was impressive, although the Bioinformatics programme showed less consistency in the high quality.

With the new philosophy of the framework and the last assessment of these specific programmes in mind, in this report the panel (of peers) does not want to elaborate too long on the different criteria of the four standards of the limited framework. The overall evaluation of the programmes by this panel is, as it was in 2012, good. Therefore, the panel wants to concentrate on how the

programmes developed since 2012 and where the programmes can become even better than they already are.
QANU received the self-assessment report of the Biotechnology and Bioinformatic programmes on 23 August 2018 and made it available to the panel. The panel members read the self-assessment and prepared questions, comments and remarks prior to the site visit. The secretary collected these questions in a document and arranged them according to panel conversation and subject.

In addition, panel members read recent theses from each programme. In consultation with the chair, fifteen theses per programme were selected from the academic years 2015-2016 and 2016-2017, covering the full range of marks given and all specialisations. The panel members also received the grades and the assessment forms filled out by the examiners and supervisors. An overview of all documents and theses reviewed by the panel is included in Appendix 4.

The programme management drafted a programme for the site visit. This was discussed with the secretary and chair of the panel. As requested by QANU, the programme management carefully selected discussion partners. A schedule of the programme for the site visit is included in Appendix 3.

Site visit
The site visit took place on 8, 9 and 10 October 2018 at WU. In a preparatory meeting on the first day of the site visit, the panel members discussed their findings based on the self-evaluation and on the theses and formulated the questions and issues to be raised in the interviews with representatives of the programme and other stakeholders.

During the site visit, the panel studied a selection of documents provided by the programme management. They included course descriptions, course materials, written exams, assignments and other assessments.

The panel interviewed the programme management, students, alumni, staff members, members of the Programme Committee and members of the Examining Board.

After the final meeting with the management, the panel members extensively discussed their assessment of the programmes and prepared a preliminary presentation of the findings. The site visit was concluded with a presentation of these preliminary findings by the chair.

Report
After the visit, the secretary produced a draft version of the report. She submitted the report to the panel members for comments. The secretary processed corrections, remarks and suggestions for improvement provided by the panel members to produce the revised draft report. This was then sent to WU to check for factual errors. The comments and suggestions provided by the programme management were discussed with the chair of the assessment panel and, where necessary, with the other panel members. After incorporating the panel's comments, the secretary compiled the final version of the report.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of both the standards and the programme as a whole.

Generic quality
The quality that, in an international perspective, may reasonably be expected from a higher education Associate Degree, bachelor's or master's programme.

Unsatisfactory
The programme does not meet the generic quality standard and shows shortcomings with respect to multiple aspects of the standard.

Satisfactory
The programme meets the generic quality standard across its entire spectrum.

Good
The programme systematically surpasses the generic quality standard.

Excellent
The programme systematically well surpasses the generic quality standard and is regarded as an international example.

SUMMARY JUDGEMENT

Standard 1

The bachelor's programme Biotechnology focuses on the application-oriented integration of biological disciplines and process engineering and offers a broad foundation. The master's programmes Biotechnology focuses on in-depth knowledge and skills, enabling graduates to function as academic experts in inter- and multidisciplinary teams where they will work on the design and development of biotechnological products and processes. Both programmes tie in the Wageningen University profile and convincingly integrate engineering with bio-sciences. The intended learning outcomes (ILOs) are well defined, linked to the Dublin descriptors, appropriate and according to the panel well positioned for academic bachelor's and master's programmes in Biotechnology the abovementioned profile. Both programmes fit the requirements of the professional field, also providing flexibility to students to develop towards their ambitioned expertise. The panel considers that the biotechnology sector requires graduates who can function on the interface of engineering and bio-sciences.

The master's programme in Bioinformatics focuses on the application of computer sciences in broad field of biological systems engineering. Both systems biology and bioinformatics are explicitly incorporated in the programme. According to the panel the strength of the programme is that it attracts computer scientists to enrol in the same programme that attracts students with a biology background. This leads to a truly interdisciplinary programme. The ILOs are linked to the Dublin descriptors, of academic master's level and broadly defined to allow students with different background to enrol and choose their own path within one of the tracks offered. The panel recommends including ethical and integrity issues specifically in the ILOS. The professional field for graduates requires flexible expert who are able to apply knowledge and skills in bioinformatics and systems biology to the different fields of life sciences and according to the panel the graduates fulfil this requirement.

Standard 2

The bachelor's and master's programme Biotechnology consists of well-designed curricula offering a combination of biosciences and engineering, with a high level and content of the courses. The bachelor's programme is well structured, includes all essential disciplines and allows sufficient flexibility for students to design their own learning path. The master's programme in Biotechnology consists of six specialisations to allow for more focus, with one course that provides the unifying biotechnology identity. The curriculum of the master's programme Bioinformatics includes both the systems biology and informatics perspective. The structure of the curriculum is clear, and students have ample opportunity to design their own learning path. The panel recommends to the programme to enable and supports students from one cohort to regularly meet and include bioinformatics examples in courses that also serve students from other programmes. The teaching staff and study advisers of all programmes are skilled and engaged. For all three programmes there is also a clear relationship between the ILOs and the objective of the courses although attention is requested to making ethical and integrity issues explicitly visible as a learning line. The Biotechnology programmes are dealing well with the increasing student numbers, e.g. by introducing a *numerus fixus* and making use of Lab-buddy in the bachelor's programme and by introducing additional courses in the master's programme. The panel emphasizes the importance of sustainability with respect to these measures. For example, the increasing student numbers lead to more difficulties for students to find thesis topics.

Standard 3

Both programmes have developed a solid system of assessment, which is based on the Wageningen University wide assessment policy. Sufficient attention is paid to the validity, reliability and transparency of examinations. The design of sample tests studied by the panel is adequate: the examinations sufficiently match the course specific learning goals and teaching methods. The level and content of the examinations is appropriate. According to the panel the overall thesis assessment and procedure was thorough and with strict regulations and there is variety in its

interpretation. The panel has two notes concerning the assessment forms: for each programme the weighing of the different components on the assessment form should be agreed upon and deviation from this standard should be limited and motivated. The second note is that qualitative feedback should be part of all thesis assessment forms, supervisors should be obligated to provide useful written feedback in addition to oral feedback. Finally, the panel established that the EB safeguards the overall level of assessment in the programmes to the best of its abilities. The panel is positive about the frequency the EB visits the Chair Groups and by the recommendations that are given to the programme management.

Standard 4
For all three programmes the panel verified the achieved level by reading fifteen theses, all were considered to be within the range of satisfactory to excellent and reflect the content and profile of the programmes. Both master's programmes have a clear view on the prospective positions of students in the professional field, or in academia. The professional field is regularly invited to give guest lectures. Alumni confirmed this view and consider their programme to be valuable for their current position. In addition to (application of) knowledge, they learned to work in an interdisciplinary team. The panel was impressed by the level achieved by both the bachelor's and the master's students. The bachelor graduates are well prepared for the master's programme and thereafter a PhD trajectory or a job in industry.

The panel assesses the standards from the *Assessment framework for limited programme assessments* in the following way:

Bachelor's programme Biotechnology	
Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	good
Standard 3: Student assessment	satisfactory
Standard 4: Achieved learning outcomes	good
General conclusion	good

Master's programme Biotechnology	
Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	good
Standard 3: Student assessment	satisfactory
Standard 4: Achieved learning outcomes	good
General conclusion	good

Master's programme Bioinformatics	
Standard 1: Intended learning outcomes	good
Standard 2: Teaching-learning environment	good
Standard 3: Student assessment	satisfactory
Standard 4: Achieved learning outcomes	good
General conclusion	good

The chair prof. dr. Stanley Brul and the secretary of the panel dr. Meg Van Bogaert hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 11 March 2019

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED FRAMEWORK ASSESSMENTS

Governance structure of Wageningen University (WU)
In contrast to many other Dutch Universities, WU has only one faculty: The Faculty of Agricultural and Environmental Sciences. Therefore, the governance structure of WU also differs from most other universities. The Rector Magnificus of the university is also the Dean of the Faculty. The Dean of the Faculty appoints the Programme Board, which consists of four professors and four students. The Programme Board is the legal governing body of the university's 18 BSc and 28 MSc degree programmes. The Programme Board is responsible for the design, content, quality and financing of the programmes.

Each programme has its own Programme Committee. A Programme Committee consists of an equal number of students and staff members who are appointed by the Programme Board. Programme Committees advise the Programme Board on the design and content of their degree programmes.

The Programme Board does not employ the lecturers (of the programme's courses); these are employed by one of the 94 Chair Groups. These generally include a Chair Holder (full professor), academic and support staff, postdocs and PhD students. The Programme Board, its Programme Committees, and the Chair Groups together form the WU education matrix organization.

The Executive Board of WU has appointed four Examining Boards (EB), each responsible for a group of related degree programmes (domains) and Chair Groups. Examining Boards are independent from the Programme Board and include staff members from the domain. The Examining Boards assess the individual study programmes of students and award student degrees. The Examining Boards also appoint the course examiners and monitor changes to the assessment strategy of interim examinations in the annual education modification cycle. The Examining Boards assure the quality of the interim examinations, and for that reason periodically visit Chair Groups to discuss the validity and reliability of the assessments.

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings

Bachelor's and master's programme Biotechnology
Profile and objective
As stated in the self-evaluation report the main characteristic of the bachelor's programme in Biotechnology is the focus on the application-oriented integration of biological disciplines and process engineering. The metaphor of an hourglass is used to illustrate this characteristic. Wageningen University (WU) offers education in all disciplines contributing to biotechnological developments. The bachelor's programme offers a broad foundation in all disciplines and introduces students to a large variety of applications.

The main focus of the master's programme Biotechnology is on increasing student's depth of knowledge and additional skills acquisition to enable graduates to function as academic experts in inter- and multidisciplinary teams. In these teams they will work on the design and development of biotechnological products and processes. Biotechnology is crucial to the rapid developments being made in a large number of scientific applications, many of which will have impact on politics and society. Graduates of this programme will have expert skills needed for these technical and scientific developments. Wageningen University is one of few Dutch universities offering academic

courses in all directions of biotechnology and the only one offering a Biotechnology master's programme.
According to the panel the Biotechnology programmes clearly tie in with the Wageningen University profile and convincingly integrate the engineering and bio-sciences. The panel concludes that the bachelor's programme successfully aims at training students to integrate engineering and bio-sciences aspects. This integrative aspect sets the Wageningen Biotechnology programme apart from other Dutch bachelor programmes in the field, despite the fact that some overlap is observed by the panel with, for example, the Delft "Biotechnology" bachelor's programme, more specifically Life Science & Technology of Delft and Leiden University. The objective of the bachelor's programme is to deliver academics who are able to function under supervision in multidisciplinary teams solving problems in the design or handling of biotechnological products and processes, now and in the future. Within the broad programme, students get plenty of freedom to design their own path throughout the programme in choosing courses that are matching their interests and skills. This is appreciated both by students and the panel. In contrast to this broad approach in the bachelor's programme, the master's programme allows for more in-depth knowledge and skills. With six specialisations the programme as a whole covers a broad field and students are able to look for the path that best fits their own interests and strengths. Notwithstanding the many specialisations, the master's programme focuses on interaction between students in a common course. According to the panel this results in cross-disciplinary and interdisciplinary integration in the programme and leads to a clear biotechnology identity of the programme.

Intended learning outcomes, level and orientation
For both the bachelor's and master's programme in Biotechnology the intended learning outcomes (ILOs) are provided in Appendix 1. The bachelor's programme has translated its objective into 11 ILOs, which are also linked to the Dublin descriptors for bachelor's programmes. Being a multidisciplinary science and linking biology to engineering, Biotechnology bachelor graduates must have an overview of the aspects necessary to develop or improve a biotechnological product or production process. From the self-evaluation report it becomes clear that graduates are required to have a multidisciplinary approach and require knowledge and basic understanding in basic disciplines, for example mathematics, molecular biology and engineering. Both are covered in the programme (ILOs 1-4). Furthermore, the ILOs focus on graduates being able to contribute to research and development projects by application of knowledge and skills (ILOs 5-6). In addition, biotechnologists must be able to translate requests from interested parties into ideas and be able to communicate about these requests. This includes social, ethical, economic and legal constraints (ILOs 7-10). The bachelor's programme has an academic orientation, focussing on research and design. At bachelor's level, students acquire basic knowledge and skills in all the disciplines involved in biotechnology, specialisation in one discipline is not compulsory. The programme provides fundamental competencies for further study directed at research and design in the complementary master's programmes.

As biotechnology merges the power of biology and engineering, the ILOs of the master's programme are partly based on the European Network for Accreditation of Engineering Education and partly on the Dutch domain specific framework for Biology programmes. The ILOs describe an overview of biotechnological core disciplines and in-depth knowledge and skills in one of these disciplines (ILO 1+2). Graduates are able to apply specialised knowledge and skills in biotechnological research and design projects and take responsibility for their own sub-project (ILOs 2-5). Furthermore, graduates' function as experts in multi- or interdisciplinary teams working on a biotechnology product design or development. They can translate requests from an interested party into development and design and are aware of non-technical restraints (ILOs 6-10). Finally, the graduate has developed an academic attitude for lifelong learning (ILO 11). The panel concludes that the ILOs fit both the engineering aspects and bio-sciences aspects of the programme and are of academic master's level. This is specifically evident in ILO 3, where the distinction is made between product design and process design.

The panel reviewed the ILOs and considers them appropriate and well positioned for academic bachelor's and master's programmes in Biotechnology that focus on the integration of engineering and bio-sciences. The bachelor ILOs describe the broadness of the programme in a way that allows students to define their own path while achieving the ILOs. The master ILOs allow for specialisation, while still combining both bio-science and engineering.

Requirements of the professional field and discipline
Biotechnology is a rapidly developing science with applications in a large and growing number of fields. In the self-evaluation report it is stated that in this dynamic field of science, professionals should be flexible and need to constantly update themselves with new developments. The External Industrial Advisory Committee represents the professional field and provides regular feedback to the programmes. This committee stated that in addition to the broad bachelor's programme, the master's programme should focus on specialisation.

The panel considers that both the bachelor's and master's programme fit with the requirements of the professional field. The broadness of the programmes allows for flexibility and students are most likely trained to work in bioprocessing, white and grey biotechnology (industrial and environmental biotechnology), vaccines and biopharmaceuticals. Students are explicitly not trained to replace the "classical" engineer, or bio-scientist. The programmes aim at a third set of graduates that will function in between bio-science and engineering. The biotechnology sector in the Netherlands is large and, according to the panel, it makes sense to train for these intermediate positions.

The External Industrial Advisory Committee regards the bachelor's programme mainly as an entrance to master's programmes in Life Sciences. This is why this Advisory Committee recommended to limit specialisation possibilities at the bachelor's level in order to cover a broad overview of all biotechnological disciplines. Nevertheless, there are opportunities in smaller companies for bachelor's graduates, although there is competition with Universities of Applied Science in this respect. It is clear to the panel that although bachelor graduates can enter the labour market, nearly all graduates choose to continue their studies in a master's programme, either at Wageningen University or elsewhere. The panel is of the opinion that there is room for master graduates in industry and companies. Many continue with a PhD thesis. Also, for the latter group, there is ample room in industry and companies.

Master's programme Bioinformatics
Profile and objective
The main characteristic of the master's programme in Bioinformatics is the application of computer science in the analysis and interpretation of large heterogeneous biological data sets and the engineering of biological systems. It is an interdisciplinary field, which facilitates the transition from traditional reductionist approaches into data-driven discovery. Bioinformatics aims to increase understanding of biological processes and the programme teaches students to develop and apply computer science processes and tools for biological systems. With biology as a central theme, technological advances have led to the development of a number of high throughput methods that have led to an increase in new data-type centric specialisations and new, often interdisciplinary fields.

Both the analysis of topology of the system (systems biology) and the description of the components (bioinformatics) play an indispensable role in understanding the biosystem as a whole. The programme has two tracks, one specialising in bioinformatics and the second in systems biology. The first track focuses on application-oriented integrations of biological disciplines with computer sciences solutions. The second track focuses on integrative approaches and pathway analysis of biosystems.

The panel discussed the profile of the Bioinformatics programme and concludes that it fits within the Wageningen University profile. In addition to two tracks (split by content) the programme focuses on two flavours (split by approach/methodology); on the one hand there is attention to the

interpretation of biological data and the development of bioinformatic tools, and on the other hand to developing the dynamic and mechanistic relationships between the parts of the biological system. The panel is of the opinion that the decision to make this an independent programme rather than a specialisation within another programme is justified. The strength of it being an independent programme is that it attracts computer scientists to enrol into the same programme that attracts students with a biology background. The variety of backgrounds of enrolling students clearly is an opportunity for the programme to be interdisciplinary. The panel recommends the programme to pay attention to an overarching bioinformatics identity of the programme in addition to the identity of the two tracks.

Intended learning outcomes, level and orientation
Bioinformatics is an interdisciplinary field that bridges the gap between the traditional reductionist approaches, the complexity of biological cells and organisms, and data-driven discovery. The ILOs of the master's programme in Bioinformatics are provided in Appendix 1. As computational analysis starts with recognition of the biological problem and formulation of the biological question, sufficient knowledge and understanding of the domains of (molecular) biology, mathematics, control engineering, informatics and statistics are required (ILOs 1-4). In addition, data driven discovery requires an interdisciplinary approach as a bioinformatician needs to communicate with others in the field, which often have a different background, and be able to translate requests from external parties into ideas (ILOs 5-7). Students must be able to function in multi- and interdisciplinary research environments and have to contribute to research and development projects by applying their knowledge and skills (ILOs 2+7). Bioinformatics graduates have to be capable of lifelong learning and must be able to design their own learning path (ILO 8). The ILOs correspond to the Dublin descriptors for master's programmes.

The panel established that the ILOs are broad and of academic master's level. The broad definition of the ILOs is required to allow students with different backgrounds to enrol and choose their own path within one of the two tracks offered. The panel noticed that ethical aspects are not explicitly part of the ILOs of the master's programme Bioinformatics, while big data handling, in particular in the context of personalized medicine, requires students to also deal with ethical and integrity issues. The panel therefore recommends to explicitly mention these aspects in the ILOs.

Requirements of the professional field and discipline
Bioinformatics facilitates the process of data-driven approaches, which has increased in life sciences research in the past decade. The professional field for graduates includes bioinformatics facilities, biological research laboratories, pharmaceutical, food, bio-based, plant breeding and seed companies. The professional field requires flexible experts who are able to apply knowledge and skills in bioinformatics and systems biology to the different fields of life sciences. In addition, the experts have to stay in touch with new developments in the field. The External Industrial Advisory Committee stresses that both experts in life sciences and computer sciences are required in the professional field. The panel confirms that although approximately 80% of the graduates continue their studies with a PhD, graduates are well equipped to take positions in industry and other companies.

Considerations
The panel thinks that the current profiles and objectives of all three programmes are well chosen. With all aspects of biotechnology being represented in the Chair Groups, these programmes fit the WU profile. The programmes are truly interdisciplinary, the panel identified courses in each programme that not only combine two disciplines, but also integrate them. For the master's programmes this is the situation in most courses. In the first year of the bachelor's programme the basics of the various disciplines are taught in a monodisciplinary way. This provides students with a firm basis to continue multi- and interdisciplinary in the second and third year.

The ILOs are well defined. The specificity of the ILOs shows that students are trained in biotechnology or bioinformatics. At the same time the ILOs are defined broad enough to not only

educate students from heterogeneous backgrounds. The ILOs of the master's programme in Biotechnology also allow for the many specialisations, the ILOs of the master's programme in Bioinformatics clearly distinguish the two specialisations. The ILOs fit the profile and objectives of the programmes and are geared towards the demands of the professional field. The External Advisory Board provides input from the professional field for all three programmes. Specifically, in the master's programmes the connection to the professional field is established via the internship. The panel concludes that the programmes are aware of the expectations of the professional field.

Conclusion
Bachelor's programme Biotechnologie: the panel assesses Standard 1 as `good'.
Master's programme Biotechnology: the panel assesses Standard 1 as 'good'.
Master's programme Bioinformatics: the panel assesses Standard 1 as 'good'.

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings for the bachelor's and master's programme in Biotechnology
Curriculum, content and design of the bachelor's programme in Biotechnology
In order to achieve the ILOs as described in Standard 1, the bachelor's curriculum contains five compulsory study tracks followed by an individual track. The tracks are cross-linked to interact with and support each other. An overview of the curriculum is provided in Appendix 2. The five compulsory tracks are:
1. Mathematical track
2. Chemical track
3. Engineering track
4. Biological track
5. Integrative track

The Mathematical and Chemical tracks are included to support the other tracks. They are therefore scheduled in the first year of the programme and are a prerequisite for the other tracks. The tracks lead to the five core courses of the programme: *Microbial Physiology, Enzymology, Gene Technology, Bioreactor Design and Biotechnology*. These five core courses examine all but one ILO in the programme. ILO 11 is not covered in the core courses and is achieved via the restricted optional courses. Courses prior to these five core courses endow students with the necessary competences to successfully complete the core courses. In the self-evaluation report the relation between the curriculum and the ILOs is provided.

Students can make individual choices within the programme, this is referred to as the individual track. This individual track consists of restricted optional courses in year 2, free choice courses and/or a minor and the compulsory but individual bachelor's thesis. In this individual track students can choose to specialise or to broaden their scope. The mathematical track is offered in small units; depending on the background of the students, the first unit is either algebra, or statistics. This way students can catch up and start at the same level in the second unit of the mathematical track. The panel was pleased to learn that the entry requirements for mathematics will be formally increased. In the future only mathematics B at VWO level will be accepted. This will decrease the efforts required to bring all students to the same level and will allow for more time for other courses and topics, or for more advanced mathematics topic.

In response to the previous assessment and the remarks by that panel, a number of changes were made. To more strongly emphasise the programmes foundations in engineering, the Engineering track was lengthened, and an extra *Process Engineering* course was added. In addition, a fundamental course (*Analytical Methods in Organic Chemistry*) was moved to the first year. Now all courses of the supporting fundamental study tracks are concentrated in the first year. With the

mandatory study advice (BSA), by the end of the first year, students have to show adequate performance in these fundamental courses to be allowed to continue their studies. Furthermore, the names of some courses were changed to better match the basic discipline taught in the course. According to the self-evaluation report, many improvements of the curriculum were made by adapting existing courses. Some innovations, however, can only be introduced with new courses. Novel courses are always first introduced as restricted optionals and, if successful, potentially converted to required courses.

The panel considers the level and content of the courses in the bachelor's curriculum to be very high.
The panel was impressed by the teaching materials, variety of teaching methods and concludes that the students in this programme are taught very well. In year 1, *Cell biology* is an excellent course to set the scene and get students actively involved. The on-line material is state of the art interactive and student centred. Another very good example is the new second year iBiosystems course, for now still optional. The course uses a mix of didactical methods including is both wet and dry lab-based assignments. After the students have completed the course, they are able to analyse genomics predictions, analyse and design in an iterative manner wet-dry lab experiments, as well as store the data in a FAIR manner. Other representative examples are the courses in "Bioprocess Engineering Basics", "Basic Cell Factory Design" and "Bioreactor Design".

The freedom students have to develop their own path throughout the curriculum is strongly appreciated by the panel. In collaboration with the study advisers students manage to really create their own coherent programme and achieve the ILOs. The study advisers support and guide students in making choices throughout the programme, based on their personal skills and interests.

The panel agrees with the programme that the scientific fundamentals of Biotechnology are changing rapidly and appreciates the fact that new courses get time to mature as a restricted optional course before being implemented as a compulsory course. Nevertheless, it is also of the opinion that there are a number of developments in the field that should be included in courses for all students. Two examples were discussed during the site visit. Firstly, the fast developments in the field of -omics are included throughout the curriculum, but there should be clear learning lines that link these parts logically and visibly. The second issue was programming skills/coding, currently not necessarily covered in the mandatory part of the curriculum. The panel considers that programming is increasingly important in the field of biotechnology and all students should have the ability to programme/code at the end of the bachelor in addition to being able to use modelling programmes. The panel is of the opinion that the use of programming tools can be incorporated in other courses, but students should be explicitly taught about the thinking behind the programming. That way, students will be able to use it as more than a tool. The panel understands that introducing a compulsory course on programming/coding is more easily said than done and it appreciates the response by the programme management during the site visit that this will be considered.

A more general recommendation to the bachelor's programme is to make the learning lines more explicit. A number of topics are taught in several courses, both related to content and skills. The most obvious example is ethical aspects and scientific integrity. These topics are part of several (compulsory) courses throughout the curriculum as the teaching staff and management clearly informed the panel, for example the GMO debate. However, the panel noticed that students seem to be unaware of this learning line.

Relation ILOs and bachelor's programme Biotechnology
In the self-evaluation report the programme includes an overview of the relation between ILOs and the programme (courses). Each course addresses a number of ILOs and all courses combined (not including electives) cover each of the ILOs on more than one occasion. Another overview in the self-evaluation report shows in which courses the ILOs are assessed. The programme director

informed the panel that although not provided in the self-evaluation report, there is also an overview of the assessment methods that are used.

Curriculum, content and design of the master's programme in Biotechnology
The master's programme Biotechnology offers five specialisations:
1. Cellular Molecular Biotechnology
2. Food Biotechnology
3. Medical Biotechnology
4. Process Biotechnology
5. Environment and Bio-based Technology

The specialisations have a common structure with 24 EC of specialisation courses and 24 EC of free optionals at the start of the first year. Of the specialisation courses, half is compulsory while the other half is restricted optionals. The first year ends with students from all specialisations following the common course in *Bioprocess design* in mixed teams. The second year consists of the master's thesis (36 EC) and an academic internship or a second thesis. A schematic overview of the curriculum is provided in Appendix 2.

The panel appreciates the fact that students start the second year with a thesis at Wageningen University where they learn to do research in a familiar, rather safe environment. Subsequently they take the internship outside Wageningen and can use the experience from the thesis. Although students can opt for a second thesis, the panel thinks it is very important for students to be able to do both a thesis and an internship, which broadens their horizon and helps them make up their mind on their future opportunities. Although according to the programme internships take four months (24 EC), many students opt for a six-month internship since many companies require at least 6 months. The students stated to the panel that it is possible to graduate within two years when the summer break is used for the internship and when 6 EC can be taken from elective courses to increase the value of the internship to 30 EC. However, the panel observes that less than 50% of the students actually graduate within two years. The panel therefore emphasizes to the programme management and study advisers that the possibilities should be made clear from the very start of the programme, so that students can plan this part of the programme with enough time in advance.

The specialisation courses, both compulsory and optional, provide students with the necessary knowledge and skills to complete the course *Bioprocess design*, the thesis and the internship/second thesis successfully. In addition, the specialisation courses guarantee that students have advanced knowledge and skills in their particular area of specialisation. In the self-evaluation report it is stated that students get freedom to choose courses, thesis and internship to reflect the student's personal competencies. The individual tracks within the specialisations ensure that students with different bachelor's degrees and from different countries all have reached the required level when they start the *Bioprocess Design* course. In the self-evaluation report an overview of all courses and the learning outcomes is provided.

Being the common course for all students, *Bioprocess Design* offers multidisciplinary teams of 7-9 students in which students perform a feasibility study and then design a biotechnological product and process. Students learn to communicate and cooperate within teams and combine different expertise to meet the requirements of an external stakeholder. The course contains both project-oriented work and technical design. The panel is enthusiastic about this *Bioprocess Design* course from strain construction to product. It stimulates teamwork, integrates a variety of competences in the team and clearly contributes to the integrative identity of the Biotechnology graduate from Wageningen.

The dynamic developments in the sciences of biotechnology require continuous adaptations in the master's programme. Offering state-of-the-art research and design topics are a prerequisite to educate future-proof experts. At the same time, students have to develop expertise in standard

approaches that continue to be important in the industry. New courses are first introduced as optional courses and, in a later stage, might replace outdated programme elements. Examples are the emergence of CRISPR-Cas technology, the increasing importance of synthetic and systems biology and in general an increased interest in bio-based technology.

Similar to the bachelor's programme, the panel considers the level and content of the courses to be very high. It was impressed by the teaching materials, variety of teaching methods and concludes that the students in this programme are taught very well. The freedom students have to develop their own specialisation is appreciated, while at the same time all students have the same, clear biotechnology identity. The input and advice of the study advisers play a crucial role in the design of a coherent, individual path for each student. Student feedback is taken seriously and leads to improvements in the courses and programme. In this, the panel observes that the programme committee plays a proactive and important role. A minor point of administrative attention is the fact that bachelor's students can already select master's courses, which can prematurely preclude them from specific master's specialisations if these courses are compulsory in this specialisation and they cannot follow a course twice.

Relation ILOs and master's programme Biotechnology
In the self-evaluation report the programme includes an overview of the relation between ILOs and the programme. Each course addresses a number of ILOs and all courses combined (not including electives) cover each of the ILOs on more than one occasion. Another overview in the self-evaluation report shows in which courses the ILOs are assessed. The programme director informed the panel that although not provided in the self-evaluation report, there is also an overview of the assessment forms that are used. The panel noticed that despite the fact that ethical issues and scientific integrity are explicitly mentioned in the intended learning outcomes, these topics are included only in one course and rather implicitly. Biotechnology is dealing with a number of controversial ethical issues in society and therefore a learning line about ethics and scientific integrity should be made much more explicit within the programme.

Student numbers in the bachelor's and master's programme Biotechnology
In the self-evaluation report attention is given to the effects of the rapidly changing and developing dynamics of biotechnology and the implications on the bachelor's and master's programme. In addition, the growth of student numbers forced the programmes to adapt scheduling over the years to accommodate the increasing student numbers. This rescheduling was done gradually and smoothly and was accompanied by other small improvements of the curricula.

In addition to student numbers, the heterogeneity of enrolling students in the master's programme Biotechnology is a challenge that is dealt with in a number of ways. Students with deficiencies are stimulated to use online modules provided to them, study advisers guide students in making the right choices to deal with any deficiencies and many lecturers start a course with a short recap of previous courses. The panel agrees with these measures but warns that the latter remedy should be balanced to also accommodate students who already have the knowledge. An earlier complaint by students, lack of depth in certain courses, was dealt with by the programme management. For students who lack laboratory skills, there is an intensive lab course at the end of the first year. This way, all students are well prepared when starting their thesis project.

Despite increasing the frequency of courses, the bachelor's programme had to introduce a *numerus fixus* to continue guaranteeing a high-quality practical component. Student numbers increased from approximately 25 in 2006 up to over 130 in 2016. With the introduction of the *numerus fixus* in 2017, just under 100 students enrolled that year. The panel in depth discussed the increasing student numbers, the effect on the programme and the measures taken. It concludes that the programme management is dealing very well with the challenges it encounters. The introduction of the *numerus fixus* provides a high level of certainty that the quality of the programme will not be affected by even more student applications. A number of measures taken by the programme specifically impressed the panel. Firstly, the use of "Lab buddy", an electronic learning environment

that stimulates students to start with the design of experiments and helps students solve problems during practical work. Lab buddy not only supports students in preparing their practicals, it allows the lecturers to deal with more cognitive complex topics during the practicals, as Lab buddy helps students with the basic issues. Another nice example the panel came across was "Team 1". This mobile unit of four teachers can be hired by Chair Groups to support large practicals. This way not all Chair Groups have to hire individual staff members themselves and the programme as a whole can deal with peaks in workload. An additional benefit is that these teachers are involved in multiple courses and in a positive way add to the coherence and avoidance of overlap between courses. Finally, the study advisers play an important role in guiding and advising students. The panel concluded during the site visit, that students are happy with the support of study advisers.

Student intake in the master's programme has strongly increased over the past decade, with over 150 students enrolling in 2016. By offering five specializations, the working load is distributed. An upside to the high student numbers is the fact that more staff could be hired and more (elective) courses could be introduced in the past years. The downside is that a limit had to be enforced on the maximum number of students that are allowed to take a course in a certain term. Dealing with increasing student numbers specifically is a challenge for the thesis part of the programme, for which each student has to be provided with a topic and supervisor.

According to the students the panel talked to, this was indeed one of the few downsides of the high student numbers: the fact that not all students are able to write their thesis on the topic of their first choice. This is indeed a challenge for the programme management that is working hard to accommodate as many students as possible with their first choice. In fact, all of the students the panel talked to were able to get the thesis topic they wanted. The master's thesis-ring in which students that do their thesis in the same Chair Group meet regularly, discuss their progress and give peer feedback seems to support the supervision of large student numbers. Overall, the panel is of the opinion that until now the programmes are dealing with the increasing student numbers while maintaining quality, but further growth will provide challenges that might not easily be overcome.

Teaching-learning environment bachelor's and master's programme Biotechnology
A mix of teaching methods is used throughout the compulsory courses in the curricula, both to accommodate different student preferences and different ILOs. The bachelor's programme has an average of 22 contact hours. According to the self-evaluation report, practical hours represent a large part of this (42% of the contact hours), and this), reflects the application-oriented character of Biotechnology and is a strength of this programme. A typical course presents theoretical knowledge in lectures, provides insight and skills development during tutorials or group work and teaches practical skills during lab experiments. Some Chair Groups have computer-based learning material. Innovation within courses often includes methods that stimulate students to become more active in designing and creating awareness of their own learning path. The programme has introduced a course that includes peer feedback from fellow students. Within the bachelor's thesis there is increasing focus on reflection on the students' own position.

Student feedback is taken seriously and leads to improvements in the courses and programme. In this, the panel observes that the programme committee plays a proactive and important role.

In the first year of the master's programme a mix of teaching methods is used, including group work, lectures, (lab)practicals, tutorials and excursions. In two compulsory courses of the Cellular Molecular and the Process Technology specialisations, intensive teaching methods are applied in order to reach more ILOs. Project and group work occur more frequent compared to the bachelor's programme. Projects are often used to teach research and design skills, while group work is crucial to learn how to function in multi- and interdisciplinary teams.

Master students are stimulated to define their own learning path, including choosing a specialisation and courses best fitting their personal goals. Study advisers support students in this

process and give advice during a discussion with the student before the start of the programme. At the end of the first year, before enrolling in the *Bioprocess Design* course, students have to ask for approval of their individual study programme for further study. In the second year students get individual supervision while they work on their thesis and internship. In this year the amount of contact depends on the type of work and individual support needed. In order to deal with increasing student numbers, many Chair Groups have set up thesis rings. In the thesis rings, students give feedback on each other's writing of individual thesis chapters. One staff member guides the thesis rings. Approximately half of the students are from the Netherlands, over a quarter are European and about a quarter are non-European international students. In addition to on-campus teaching online study materials have been developed, among which MOOCs.

The panel concludes that the curriculum in combination with the teaching-learning environment clearly enables students to achieve the ILOs.

Teaching staff bachelor's and master's programme Biotechnology
Despite recruitment of new teaching staff, the strong increase in student numbers between 2006 and 2016 could not be matched. The student-staff ratio in 2016 was 12:1 for the bachelor's programme and 21:1 for the master's programme. In the bachelor's programme specifically the quality of practicals was under pressure due to the high number of students and limited lab-equipment. Therefore, it was decided to introduce a *numerus fixus* in 2017. This allows the programme to offer the intensive supervision that is necessary to keep the quality of the teaching at the ambitioned level. The increasing student numbers did allow additional staff to be hired, which enabled the programme to develop new courses, like *Biorefinery* and *iBiosystems*. In the master's programme the advantages of increasing student numbers are the opportunity to hire new staff and to develop new specialized courses. On the downside, there is a limit to the number of students allowed to take a course in a certain term.

Staff members are often active in both the bachelor's and master's programme, although full professors are often more involved in the master's phase. Many advanced courses are managed and taught by tenure trackers developing a research group in the field of the course. The quality of the teaching staff is considered a strength by the programmes. Students mention the quality of teachers and study advisers as a strength as well. Full professors and tenure trackers all teach a number of compulsory courses, other lecturers are of PhD level and in some cases, technicians are involved. The Chair Groups offering most bachelor's thesis topics enable their lecturers to join the Programme Committee. In addition, lecturers can and do act as advisers of this Programme Committee.

Didactic skills of staff are considered to be important, as well as good research reputation. Most staff has the university teaching qualification (UTQ) and most Chair Group Leaders have a prominent research profile. In the self-evaluation report it is stated that the major threat in the past period was work pressure. To deal with this, new staff was hired, and retired staff was convinced to stay on teaching. Chairs also started to share staff for practical lab class assistance in the first year in order to deal with peak demand due to large student numbers in a single course. In addition to increased staff numbers, focus lied on efficiency. As an example, Lab-buddy was mentioned.

The panel noticed that 30% of the master's programme teaching staff and 25% of the bachelor's programme teaching staff has no UTQ. During the site visit, the panel gathered more information about the quality of the teaching and learnt that students are very satisfied with it. New teaching staff is obliged to obtain a UTQ. The panel furthermore learned that the low UTQ percentages are partly the result of the abandoned policy that a UTQ can only be obtained by completing a full programme. For senior teaching staff with a lot of experience only recently a tailor made UTQ programme is available. The panel is confident that this tailor-made programme will increase the percentages to the level that reflects the quality of the teaching staff.

Considerations for the bachelor's and master's programme Biotechnology
The biotechnology programmes consist of a well-designed curriculum offering a combination of biosciences and engineering, with high level and content of the courses. There is a clear relationship between the ILOs and the objectives of the courses, although the ILO with respect to integrity and ethical issues could be more explicitly visible as a learning line. The bachelor's curriculum is structured and includes all essential disciplines and allows for flexibility for students to design their own learning path. The master's programme consists of six specialisations to allow for more focus, with the impressive *Bioprocess Design* course as a unifying element that provides the group of students with a biotechnology identity. Both programmes deal well with the increasing student numbers, although further growth is limited with respect to thesis topics. In addition to introducing a *numerus fixus* in the bachelor's programme the panel was impressed by the lab-buddy and Team 1. The master's programme took the growth as an opportunity to introduce more courses. There is a good connection to the professional field. The staff and study adviser are skilled and engaged. Overall the conclusions on the teaching-learning environment is very positive.

Findings for the master's programme Bioinformatics
Curriculum, content and design of the master's programme Bioinformatics
The master's programme Bioinformatics has four compulsory elements in the first year followed by an individual part, including thesis (36 EC) and internship (24 EC) in the second year. An overview of the curriculum is provided in Appendix 2.

The first of the four compulsory elements are basic courses: each student follows a 6 EC course, the exact type of which depends on the student's previous education students, *Programming in Python, Personal Genetics* and *Cell Physiology and Genetics*.

The second element consists of a total of 18 EC of courses on bioinformatics, systems biology and statistics, which are compulsory for all students. For the third element students have to choose at least 6 EC of an (additional) life sciences course and 12 EC of course work from one of the two tracks: Informatics or systems biology. The fourth element is an *Academic Master Cluster* of 12 EC. Students choose the basic and restricted optional courses in consultation with the study adviser, as well as the type of academic master cluster, and the chair group that shall be responsible for thesis and internship. The two tracks are reflecting the two major current instances of the use of computational methods in biology, and they require slightly different computational methods and tools.

Similar to the master's programme in Biotechnology, the panel appreciates the fact that students start their second year with a thesis at Wageningen University, where they learn to do research in a familiar environment. Subsequently students can do their internship in an external environment and can use their experience from the thesis. For students who want to focus on an academic career, there is the opportunity to do a second thesis instead of the internship. According to the students the panel interviewed, a significant number of students opt for this second thesis. The panel thinks it is important for students to be able to choose and design their own path throughout the programme and therefore it is positive about the possibility of a second thesis.

Although, according to the self-evaluation report, internships are expected to take four months (24 EC), many students opt for a six-month internship, since many companies require at least six months. The students stated to the panel that it is possible to graduate within two years when the summer break is used for the internship and when 6 EC can be taken from elective courses to increase the value of the internship to 30 EC. However, the panel observes that less than 50% of the students actually graduate within two years. The panel therefore emphasizes to the programme management and study advisers that the possibilities should be made clear from the very start of the programme, so that students can plan this part of the programme with enough time in advance.

Bioinformatics applies the tools and approaches that students need to be able to analyse large data sets generated in various fields of life sciences. Both the fields of informatics and life sciences are dynamic and have developed rapidly, which leads to continuous development of the programme. Existing courses are given by Chair Groups that are responsible for both research and education, assuring the translation of research into education. Furthermore, new courses are developed and introduced, first as optional courses and subsequently – if needed – as compulsory courses. A recent example is the course *Algorithms in* bioinformatics. Finally, some Chair Groups offer experimental education in non-curricular optional courses. Examples are the course *Big Data* and *Advanced modelling in systems biology*.

After the previous reaccreditation a number of improvements were made to the curriculum; new courses were introduced, other courses shifted in the curriculum or were made compulsory. In particular, the Programme Committee focussed on improvements in the systems biology track. It paid attention to the logical setup of the tracks and proposed a number of changes. The panel considers the changes to the programme to be an improvement and the level and content of the courses is good. Teaching materials and variety of teaching methods clearly fulfil the requirements set by the learning goals in the courses. For example, in the course *Programming in Python* some students start as novices, but in the end are able to write quite complex Python scripts. Furthermore, courses have incorporated state of the art genomics data and data analysis. Genomics data generation is given appropriate attention. The new *iBiosystems* course is a very good example of a state-of-the-art course in the genomics and systems biology field with state-of-the-art didactical approaches.

The background of enrolling students varies and to best serve all students the programme starts with basic courses that provide students with knowledge and skills in the domains they might have missed in their pre-education. The two tracks furthermore facilitate it for the students to choose restricted optionals to further specialise in the same direction as their pre-education. In the academic master cluster students develop abilities to function as expert in research and design projects in multi- and interdisciplinary teams. Research competences are developed in the thesis and internship. According to the panel the programme has found a nice way to adopt students from very different disciplinary backgrounds in one programme. Each student chooses one of three basic courses, after which the cohort is at a more similar level in the basic disciplines. It is complex to verify the competences of the vast variety of enrolling students in relation to entry requirements. The panel was pleased to notice that the Programme Committee is taking action if problems occur. However, to prevent a number of issues, it might help the programme to further formalize the requirements on the required core biology and on core computational science. This way students are aware of the requirements and are able to work on repairing their deficiencies before starting the programme.

The importance of computational concepts in modern biology implies that a number of courses of the bioinformatics master are shared with (many) students from other programmes. Nevertheless, the panel considers the level and content of the courses adequate for a Bioinformatics programme. The one point of attention might be that in more general courses examples that are provided are often not on biological topics. On the longer term, with increasing student numbers in the Bioinformatics master programme, joining courses of other programmes might no longer be feasible. This might offer new opportunities to focus the course content.

The panel also registered that the "programme identity" among the Bioinformatics master programme was less developed than among the students from the Biotechnology master programme. It concluded that this was due to the broad audience in central courses and the fact that enrolling students can come from very different backgrounds. In fact, the panel understood that in the beginning students are sometimes not even aware which other students in the same course are from the same programme. The panel recommends that the programme committee should find a solution and support community building early on. from the start of their programme. One example is to include a specific bioinformatics course, or to put the bioinformatics students

together in working groups in those courses that which have a large number of out-of-programme students.

Relation ILOs and master's programme Bioinformatics
In the self-evaluation report the programme includes an overview of the relation between ILOs and the programme. Each course addresses a number of ILOs and all courses combined (including restricted electives) each of the ILOs on more than one occasion. Another overview in the self-evaluation report shows in which courses the ILOs are assessed. The programme director informed the panel that although not provided in the self-evaluation report, there is also an overview of the assessment forms that are used.

Finally, although ethical and integrity issues are not explicitly part of the ILOs, the panel is of the opinion that it is important that bioinformatics graduates are aware on how to deal with ethical and integrity issues and that students can be made much more explicitly aware of these issues in the programme.
Teaching-learning environment of the bioinformatics programme
The abstract nature of the computational and information tool sets, that are key to this programme, requires often hand-on exercises rather than classical lectures. Thus, a major part of the teaching methods in the first year involves practicals and tutorials. To develop academic skills, specifically related to communication and teamwork, part of the teaching methods involves group work. According to the panel the programme is doing well in providing classes, practicals and tutorials that deal with the abstract nature. Students learn what they are supposed to, and the various teaching methods ensure that they achieve both, to learn and to implement their knowledge.

Compared to other Wageningen programmes the number of contact hours in the first year is relatively high with 22 per week. This is due to the large percentage of practicals. The study adviser is involved in designing the individual study plan for each student prior to the start of the programme.
Within the track chosen, students are encouraged to define their own learning path best fitting their personal goals. The panel considers this to be very good and student-oriented. It does require support and guidance by the study adviser in defining the individual programmes of students and help them making choices. In the recent past there were issues with a study adviser in the Bioinformatics programme and the programme is still dealing with the consequences. Even though improvements were made, the role of the study adviser is interpreted differently by students and study adviser. Attention to the connection between study adviser and students is therefore still required.

Bioinformaticians require access to advanced high-performance computing facilities. A number of Chair Groups have invested in hardware specifically for bioinformatics research and education. Wageningen hosts its own high-performance cluster which is used for teaching and is available for master's thesis projects. Wageningen University has also recently initiated the building of a data competence centre that will support student in bioinformatics by offering an integrated portal to courses, expertise and resources.

The panel concludes that the curriculum in combination with the teaching-learning environment clearly enables students to achieve the ILOs. This is specifically impressive considering the diverse backgrounds of enrolling students.

Teaching staff of the Bioinformatics master's programme
Student enrolment numbers have more than doubled since the previous accreditation and are around 25 students per year. Additional staff was hired to deal with the increased student numbers, but the student-staff ratio increased to 15:1. According to the self-evaluation report the present inflow of students is high enough to enable the continuation of the programme. Many courses are coordinated and given by tenure trackers who link their research field to the education.

Didactic skills of staff are considered important, as well as a good research reputation. Most staff has the university teaching qualification (UTQ) and most Chair Group Leaders have a prominent research profile. In the self-evaluation report it is stated that the engagement of staff in the programmes results in high work pressure. The panel also noticed that 30% of the master's programme teaching staff has no UTQ. During the site visit, the panel gathered more information about the quality of the teaching and learnt that students are satisfied with it. Students mentioned in particular that the engagement of staff in education is high and strongly appreciated. New teaching staff is obliged to obtain a UTQ. The panel furthermore learned that the low UTQ percentages are partly the result of the policy, now abandoned, that a UTQ can only be obtained by completing a full programme. For senior teaching staff with a lot of experience only recently a tailor made UTQ programme has become available. The panel is confident that this tailor-made programme will increase the percentages to the level that reflects the true quality of the teaching staff.

Considerations for the master's programme Bioinformatics
The curriculum of the master's programme Bioinformatics clearly offers a bioinformatics profile from two perspectives, systems biology and informatics. The structure of the curriculum is clear, and students have ample opportunity to design their own path within the programme. The relationship between curriculum and ILOs is clear. The panel recommends the programme to pay attention to the bioinformatics identity of the students, by enabling and supporting all students from the same cohort to regularly meet and by including bioinformatics examples in courses that also serve student from other programmes. The staff is skilled and engaged, the issues around the study advisor are being solved. The overall conclusion on the teaching learning environment is positive.

Conclusion
Bachelor's programme Biotechnologie: the panel assesses Standard 2 as 'good'.
Master's programme Biotechnology: the panel assesses Standard 2 as 'good'.
Master's programme Bioinformatics: the panel assesses Standard 2 as 'good'.

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings
General assessment policy
In 2017, Wageningen University renewed its vision on education alongside its education assessment policy. This assessment policy defines why and how the university assesses and how the roles and responsibilities are distributed. Its goal is to generalise assessment rules and policies and to make them transparent to both lecturers and students. In this policy, the ILOs of the degree programmes are the starting point. These are described for every programme and are in line with the Dublin descriptors. Furthermore, in every programme the university tries to create a clear relation between the ILOs and the learning outcomes of the courses, the teaching and learning activities and the assessment.

The panel finds that Wageningen University has a good general assessment policy and the programme has a clear assessment plan. The Biotechnology and Bioinformatics programmes follow this general assessment policy and apply different assessment methods (assignments, project reports, oral presentations and performance evaluations) that are aligned to the different learning outcomes and the panel verified that all learning outcomes are assessed. The panel concludes that the courses are adequately assessed, and it witnessed some nice examples of assessment strategies and rubrics.

The panel did notice for all three programmes differences in weighing of the different criteria on the thesis assessment form between Chair Groups. On the one hand the panel understands that using one assessment form for all programmes at Wageningen University must allow for differences between disciplines and therefore different weighing of – for example – the practical work. However, it is also of the opinion that within one programme, Chair Groups should agree on a certain standard weighing. However, this weighing should not only be based on Chair Group decisions. The panel also is of the opinion that students from the same programme doing their thesis at different Chair Groups need to be assessed using similar weighing. Thesis supervisors who want to deviate from this standard should then motivate why. This could be the case when qualitative instead of quantitative research is done, or when the thesis is in the social sciences area.

There is a clear connection between the assessment methods that are being used and the complexity of the learning objectives. There is a course dependent assessment strategy that is written down in a clear and transparent (digital) course guide. During the site visit, the panel learned from the Examining Board (EB) that it is satisfied with the quality of the assessment. The students told the panel that they experienced a transparent and objective assessment system.

Examining Board
At Wageningen University there are four Examining Boards (EB), each responsible for the assurance of the quality of examination of a group of related degree programmes. The members are appointed by the Executive Board and at least one member is independent (not related to the degree programmes). For each course a member of the lecturing staff is appointed as examiner by the responsible EB. The examiner is responsible for the assessment strategy of the course(s).

The EB, accompanied by an assessment expert, tries to visit each Chair Group once every four years. It checks a sample of theses and internship assessments and during the visit it discusses the validity, reliability and transparency of the assessments (of the courses). When necessary, it proposes improvements. From the interview during the site visit, the panel concludes that the EB is well aware of its legal duties and responsibilities. The EB that is responsible for the Biotechnology and Bioinformatics programmes is the largest of the four EB's. Although the panel understands that visiting all Chair Groups is time consuming and not possible in the provided time frame, it recommends to the EB to more frequently meet with each Chair Group. This will shorten the PDCA cycle. The panel was very pleased to learn that the EB's will be given more funding by the university to do their important work.

Bachelor's and master's programme Biotechnology
ILOs are achieved in a series of steps in the form of study tracks. The ILOs are assessed according to the Wageningen University assessment policy and guidelines in the course where they are achieved. The assessment strategy is determined by the complexity of the ILO, most include multiple assessments.

In the bachelor's programme all courses test ILOs at lower cognitive level by written exams (MC, closed and open questions). Higher cognitive level ILOs are examined in open question exams, oral presentation and/or written reports. Practicals are usually assessed by general performance in the lab, written reports and/or oral presentations. Recently assessment of a digital lab journal and digital lab report was added. In the study handbook the type of examination is published. The course guide contains more details on examination strategy, including on how final grades are determined. Each exam is offered three times per year. According to the self-evaluation report, assessments are not only evaluating the achievement of ILOs, but are also intended for providing feedback to an individual student. This enables the student to reflect on his/her own performance.

The ILOs in the master's programme are achieved in a number of stages and are assessed in the course where they are taught. The complexity of an ILO determines the type of assessment strategies applied. Most courses include multiple assessments to cover the ILOs in the course.

Advanced knowledge is assessed in specialisation courses by way of written exams. ILOs for a higher cognitive level, like application of knowledge, judgements and design are mainly assessed in open question written exams or by oral presentations. Publication of the assessment strategy and feedback is organised similarly to the bachelor's programme and comply with the Wageningen University regulations.

The panel reviewed a number of assessments during the site visit and concludes that courses are adequately assessed and with a nice variety in assessments. It saw some nice examples of assessment strategies, rubrics etc.

Bachelor thesis
Although all ILOs are already covered in the courses, the bachelor's thesis is considered the element that demonstrates the level of education of the graduate. The thesis includes individual research or technical design. Students join an on-going research project at one of the Chair Groups. The final assessment includes a written report, an oral presentation and a final evaluation. The weighing and criteria are available to students prior to the start of the project and given on the assessment form. Both supervisor and a senior staff member of the Chair Group assess the thesis. Furthermore, the Programme Committee monitors grading differences and thesis evaluations to ensure fair and comparable grading among different Chair Groups. The panel is pleased that during the thesis process a go/no-go is implemented. This Go/No-go, however, needs more attention as the panel found that not all Chair Groups are using it and some Chair Groups use their own decision criteria. The assessment of the quality and progress will help students to graduate sooner. Sometimes students need some stimulation to increase their effort, others might be better of changing their project.

Master thesis and internship Biotechnology
During the thesis, students join an on-going research or design project at the Chair Group offering the thesis. Students set up and perform their own part of research or design, and present results both orally and in a written report. Thesis work is assessed on research and design competence, the thesis report, an oral presentation and a final discussion.

The participating Chair Groups adjust the shares of the main criteria to fit them to the type of research and design for the specific topic. The weighing is known by the student prior to the start of the project. Two assessors assess the thesis work and half way through the thesis there is an interim-assessment. Students with insufficient progress receive a warning through their thesis and if results do not improve, students are advised to stop and start a new thesis. If no warning is given half way and a student fails, he/she is allowed to improve the work, do an additional assignment or start a new thesis. The Programme Committee monitors grading differences and thesis evaluations to ensure fair and comparable grading across Chair Groups. Whether a student passes or fails the thesis, financial compensation is given to the Chair Group involved to assure that financial incentives are not a reason for passing a thesis. The panel is pleased that during the thesis process a go/no-go is implemented. This will certainly help students in graduating on time.

For both the bachelor's and master's thesis the panel considers the assessment to be as can and should be expected. The one comment the panel has is the fact that many of the assessment forms contained a limited amount of written feedback. Despite the fact that students receive oral feedback on multiple occasions throughout the thesis, the panel emphasizes the importance of also providing them with written feedback. Not only does it make the assessment transparent, it also allows the EB and others to assure and verify the quality of the assessment. For students the re-reading the feedback will help them on the long term.

The programme finishes with an internship of four months. The internship is supervised by both a Wageningen University examiner and a supervisor from the internship organisation. The internship is assessed by a written report, a self-reflection on the internship and an oral presentation by the student. The panel finds the procedures of the internship to be solid and transparent. However,

although it applauds the attention that is paid to self-reflection, it doubts that –even with a rubric- a self-reflection report can be objectively graded. Students can opt to replace the internship by a second thesis. According to the panel this is valid for students who want to continue with a PhD (on average, 60% of the students of a cohort do so). The panel does observe that by this replacement the ILO that includes reflection is assessed in only one course (Bioprocess Design). This is adequate but limited and requires attention.

Master's programme Bioinformatics
By offering different programme elements the ILOs' are achieved in a series of steps. The programme follows the university wide requirements, ILOs are assessed in the course where they are achieved. As most courses include more than one ILO, multiple types of assessments are used in each course. An example of the assessment blend that is used is the course *Bioinformation Technology*: There is a written examination assessing knowledge and understanding of computational tools and an assignment assesses the ability to apply the methods and evaluate ~omics derived information. Other courses involve for example a written assessment, oral presentation or participation during a discussion. Students can choose between three variants of the Academic Master Cluster. The panel considers that the programme has a good variety of assessment forms. During the site visit the panel looked at a number of assessments into more detail and observed solid course rubrics and assessment plans.

Master thesis and internship Bioinformatics
In the self-evaluation report it is stated that the quality of the programme is best represented by the final thesis. Thesis projects are in general performed individually and finalized with a written report, an oral presentation and a final discussion. The thesis is assessed by the supervisor and a senior staff member of the Chair Group involved. When a thesis is supervised by two Chair Groups, the two examiners come from these two chairs. The procedure of assessment is similar to the master thesis Biotechnology. Similar to the Biotechnology programmes, the panel points out the limited written feedback on a number of assessment forms. The assessment of the Bioinformatics internship is similar to that of the thesis, although a different assessment form was used to reflect the different nature of the internship.

For both the master's thesis the panel considers the assessment to be as can and should be expected. The one comment the panel has is the fact that the assessment forms in general contained a limited amount of written feedback. Despite the fact that students receive oral feedback on multiple occasions throughout the thesis, the panel emphasizes the importance of also providing them with written feedback, because re-reading the feedback will help students on the long term.

Considerations
The panel finds that Wageningen University has a good general assessment policy and the Biotechnology and Bioinformatic programmes follow this policy and has a clear assessment plan. Different assessment methods are applied that are aligned to the different learning outcomes. All ILOs are assessed and a clear distinction between the assessment methods that are being used and the complexity of the learning objectives is observed. For each course the (digital) course guide contains an assessment strategy. The panel concludes that the assessments are clear and transparent and sufficient attention is paid to validity, reliability and transparency of assessments.

The panel found that the EB knows its legal duties and responsibilities. However, the panel thinks the Board should visit the Chair Group(s) more frequently to execute its PDCA cycle and should be more in the lead to force management to fine tune its theses grading policy. The panel is pleased that more funding will be made available to the EB

According to the panel the overall thesis assessment and procedure was thorough and with strict regulations and there is variety in its interpretation. The panel has two notes concerning the assessment forms: for each programme the weighing of the different components on the

assessment form should be agreed upon and deviation from this standard should be limited and motivated. The second note is that qualitative feedback should be part of all thesis assessment forms, supervisors should be obligated to provide useful written feedback in addition to oral feedback.

Conclusion
Bachelor's programme Biotechnologie: the panel assesses Standard 3 as 'satisfactory'.
Master's programme Biotechnology: the panel assesses Standard 3 as 'satisfactory'.
Master's programme Bioinformatics: the panel assesses Standard 3 as 'satisfactory'.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings
To review the achieved ILOs the panel studied documents like course manuals, fifteen theses for each programme and spoke to alumni of the programmes.

Bachelor's programme Biotechnology
The panel agreed with the grading by the thesis supervisors and on no occasion deviated in its grading by more than 1 grade. No theses that were read by the panel were considered insufficient, in fact most theses were of high quality and contained interesting work on topical research. Also, the level of English was up to level.

In addition to the studied theses and other materials the panel spoke with staff, students and alumni about the perspective of graduates of the bachelor's programme. As mentioned in Standard 1, most graduates continue with a master's programme and according to the self-evaluation report only a limited number of industrial companies consider a bachelor's degree adequate to start a professional career. The panel considers that bachelor's graduates are adequately prepared to start a professional career at the end of the programme, although the programme focuses more strongly on continuing studies in a master's programme.

More than 95% of the graduates of the Biotechnology bachelor programme enrol in a master's programme at one of the Dutch universities, 80% chooses the master's programme Biotechnology at Wageningen University. A vast majority of the bachelor's graduates manages to successfully complete the master's programme Biotechnology within three years. This implies that they are well prepared to continue their studies.

Master's programme Biotechnology
As students from different backgrounds enrol in the programme, many courses start with a summary of the expected knowledge and skills. At the end of a course the assessment is the same for all students. The panel is positive about the fact that students have to choose the first course of the programme based on their previous educational and select the discipline they are not (yet) familiar with. This is a major step in levelling the baseline knowledge and skills of students from different disciplinary backgrounds.

The panel read 15 theses and agreed with the grading by the thesis supervisors. No theses that were read by the panel were of insufficient quality. The panel was overall very positive about the high quality of the theses they read and considers them to clearly represent graduates who combine bio-sciences and engineering in one programme. The topics of the theses were well chosen, showed the variety of specialisations and the state-of-the-art research that is being conducted in the Chair Groups.

The success rates of students are high, within less than 3 years over 80% of one cohort has graduated. Members of the External Industrial Advisory Committee confirmed that graduates have

a valuable combination of expertise and interdisciplinary skills. Most graduates easily find a job at academic level around their graduation. Over 60% start a PhD project, others start in biopharma, food, bio-based, seed or consulting engineers companies.

The panel met with a confident group of alumni, who were very satisfied about the courses, content and structure of the programme. The alumni stated that they felt well prepared for jobs both within and outside academia. An important aspect in being prepared is the result of the internships. The panel was impressed by the clear position alumni have on the labour market, not focussing on either biosciences or engineering, but on the interface of both. Many graduates continue with a PhD before finding a job in industry.

Master's programme Bioinformatics
Similar to the master's programme Biotechnology, a diverse group of students enrols in the master's programme Bioinformatics. In order to allow all students to achieve the ILOs the first part of the programme is focussed on getting students on the required basic level in all disciplines. Depending on their background, all students choose courses that fit their personal disciplinary background. The panel is convinced that by using this construction, all students are able to achieve the ILOs at the required level.
The panel read 15 theses and agreed with the grading by the thesis supervisors. No theses that were read by the panel were of insufficient quality. With the exception of two theses, the panel considers the quality of the theses to be high and the topics well fitting in this programme. Two theses were adequate, but justly received a grading of only 6.5. The high quality of research within the Chair Groups is reflected in the level of the theses. Some theses were written in the form of a research paper.

The success rates of students are adequate, within less than 3 years over 80% has graduated. In the self-evaluation report it is stated that the performance of graduates after graduation reflects the quality of the programme. At the moment of graduation all students already have a job offer, this has been the situation for a number of years. Most graduates start a PhD project, other graduates have started as entrepreneurs. A number of students get offered a position by the company where they do their internship.

The panel met with a confident group of alumni, who were very satisfied about the courses, content and structure of the programme. The alumni stated to feel well prepared for jobs both within and outside academia. An important aspect in being prepared for a job in industry or a company is the internships. The panel was impressed by the positions alumni have on the labour market, not focussing on either biosciences or engineering, but on the interface of both. Many graduates continue with a PhD before finding a job in industry.

Considerations
For all three programmes the panel verified the achieved level by reading 15 theses. All theses were considered to be within the range of satisfactory to excellent and reflect the content and profile of the programmes. Both master's programmes have a clear view on the prospective positions of students in the professional field, or in academia. There are many (often personal) connections between teaching staff and professional field. The latter is regularly invited to give guest lectures. Alumni confirmed this view and consider their programme to be valuable for their current position. In addition to (application of) knowledge, they learned to work in an interdisciplinary team.

The panel concludes that graduates of the bachelor's and the master's programmes Biotechnology and the master's programme Bioinformatics have achieved the ILOs. It was impressed by the level achieved by both the bachelor's and the master's students. The bachelor graduates are well prepared for the master's programme and thereafter a PhD trajectory or a job in industry.

Conclusion
Bachelor's programme Biotechnologie: the panel assesses Standard 4 as 'good'.
Master's programme Biotechnology: the panel assesses Standard 4 as 'good'.
Master's programme Bioinformatics: the panel assesses Standard 4 as 'good'.

GENERAL CONCLUSION

The panel concludes that all three programmes managed to retain the high quality of the programme in the evaluation period, despite the increase of student numbers.

Conclusion
The panel assesses the *bachelor's programme Biotechnologie* as 'good'.
The panel assesses the *master's programme Biotechnology* as 'good'.
The panel assesses the *master's programme Bioinformatics* as 'good'.

APPENDICES

APPENDIX 1: INTENDED LEARNING OUTCOMES

ILOs of the bachelor's programme in Biotechnology

	After successful completion of the programme graduates are expect to be able to:	Dublin descriptors: Have knowledge and understanding	Apply knowledge and understanding	Making judgement's	Communication	Learning Skills
1	apply and integrate basic theoretical knowledge of biotechnological key disciplines physical chemistry, organic chemistry, biochemistry, microbiology, process technology, molecular and cellular biology and genetics	X	X			
2	explain an entire biotechnological product or production process including the consequences of changes in biological, chemical or technological parameters on the biotechnological product or production process	X				
3	apply laboratory techniques, analytical measurements, mathematical, computational and statistical methods in biotechnological-oriented cases	X	X			
4	resolve (under supervision) a pre-defined biotechnological research question, development or design problem into verifiable research or design questions		X	X		
5	develop (under supervision) a research plan in which research question, hypothesis, experimental set-up and data analysis are described in relation to relevant literature		X	X		
6	execute (under supervision) simple scientific experiments, test the hypothesis and analyse and interpret own experimental data and data presented in literature and on internet, in order to develop new (biotechnological) knowledge, product or process		X			
7	demonstrate an academic attitude by generating and recognizing creative ideas and recognizing limits of scientific knowledge		X	X		
8	communicate verbally and in writing about results of learning or experiments				X	
9	co-operate in a multi-disciplinary team on a pre-defined biotechnological-oriented research question, design or development problem				X	
10	judge (under supervision) technological, ethical, societal and economic consequences of biological, chemical and technological changes in the design of a biotechnological product or production process			X		
11	reflect (under supervision) upon personal knowledge, skills, attitudes and functioning, both individually and in discussions with others and design and plan their own learning path					X

ILOs of the master's programme in Biotechnology

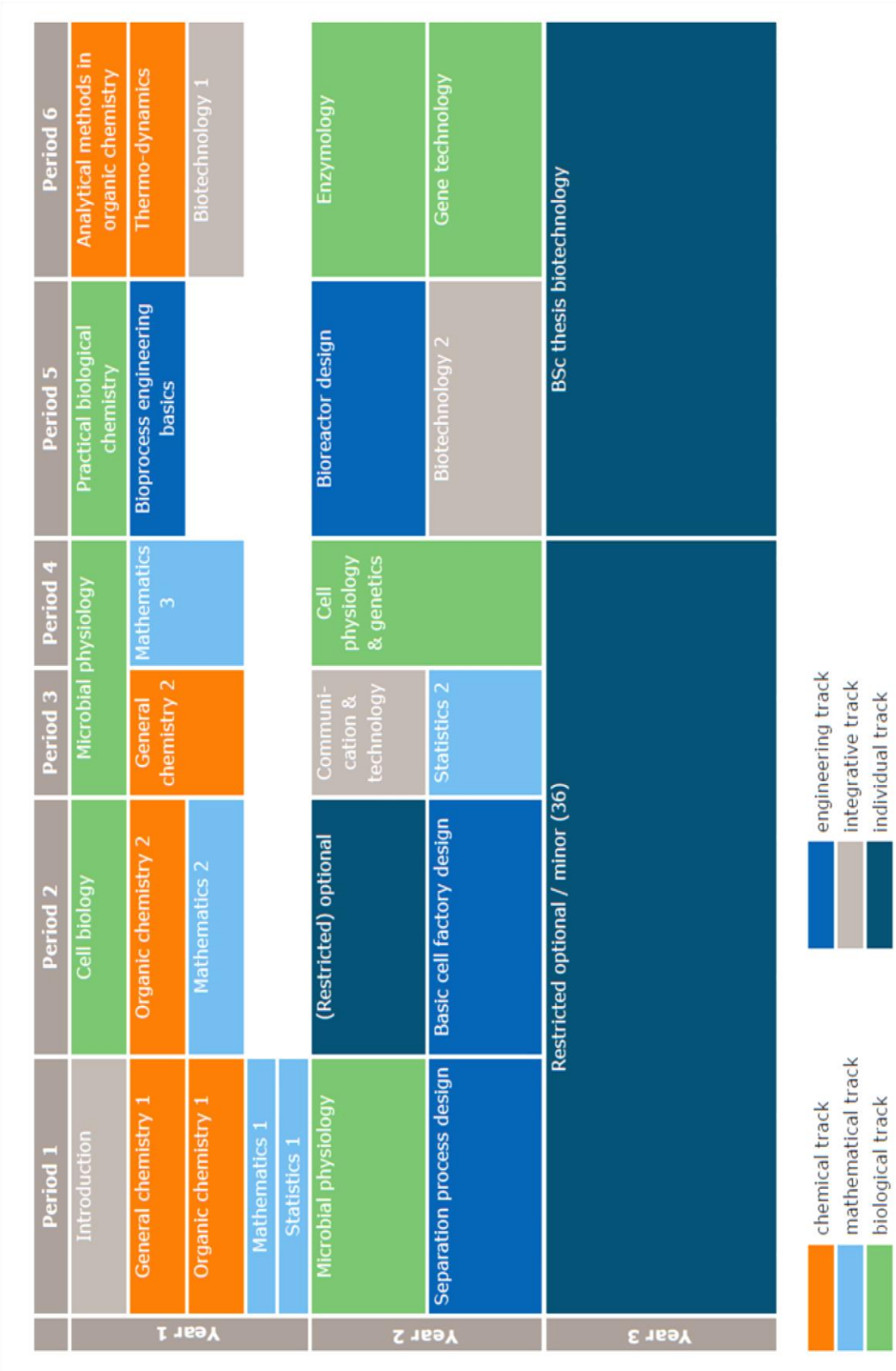
	After successful completion of the programme graduates are expect to be able to:	Dublin descriptors				
		Have knowledge and understanding	Apply knowledge and understanding	Making judgement's	Communication	Learning Skills
1	select, understand and integrate skills in basic and applied disciplines of biotechnology					
2	apply advanced knowledge of own specialization					
3	design a new biotechnological product or process by applying knowledge of the biotechnological key disciplines in an integrated approach					
4	develop a research plan in which research question, hypothesis, experimental set-up and data analysis are described in relation to relevant literature					
5	execute experiments, test hypothesis and analyse and interpret own experimental data and/or data presented in literature and on internet, in order to meet the objectives of the biotechnological research and development project					
6	design a new biotechnological product or process that meets the objectives and demands of an interested party					
7	demonstrate an academic attitude by: a. generating creative ideas; b. recognizing the limits of scientific knowledge; c. reason logically and abstractly in discussions with both experts and laymen					
8	communicate verbally and in writing about the results of learning, experiments and project work with colleagues and non-colleagues					
9	co-operate in an international multi-disciplinary team (including planning activities, taking responsibilities and motivating co-workers) on a biotechnological-oriented research question, design or development problem					
10	judge technological, ethical, societal and economic consequences of biological, chemical and technological changes in the design of a biotechnological product or production process					
11	reflect upon personal knowledge, skills, attitudes and functioning, both individually and in discussions with others (including the interested party and experts) and design and plan their own learning path					

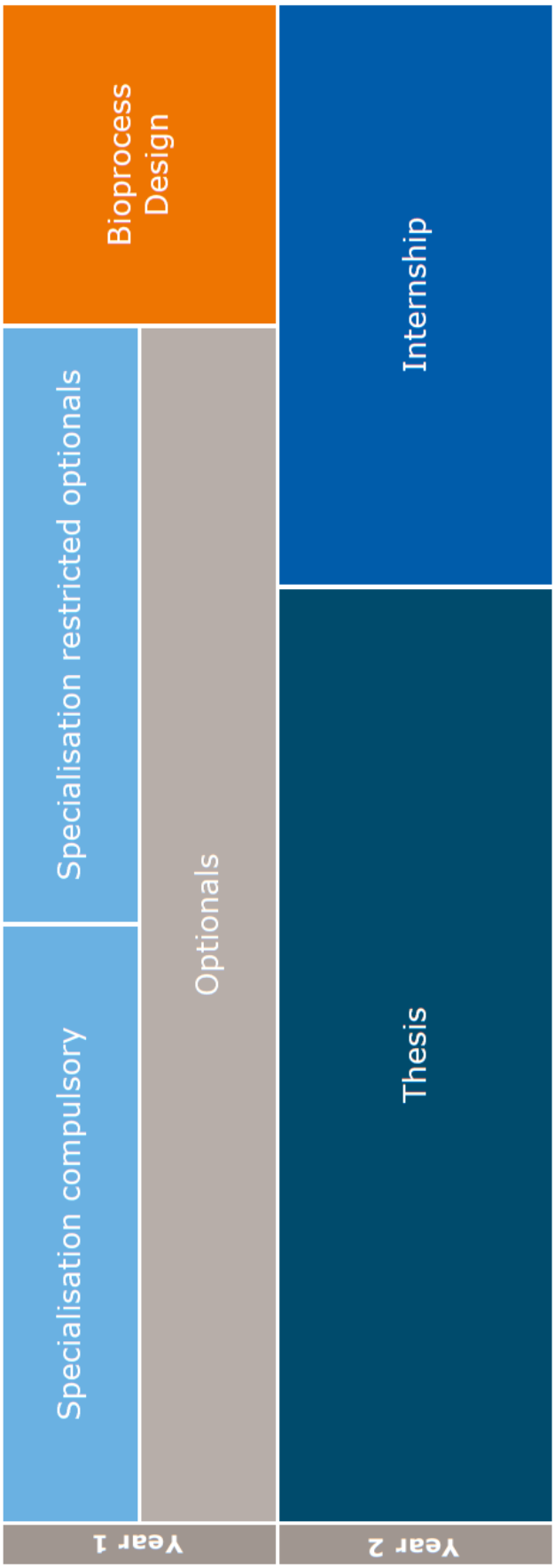
ILOs of the master's programme Bioinformatics

After successful completion of the programme graduates are expect to be able to:	Dublin descriptors: Have knowledge and understanding	Apply knowledge and understanding	Making judgement's	Communication	Learning Skills
1 select, understand, apply and integrate skills and knowledge in basic and applied disciplines of bioinformatics	X	X			
2 develop a research plan in which research question, hypothesis, data collection and analysis are described in relation to relevant literature		X	X		
3 handle and apply large scale biological information, particularly genetic information	X	X			
4 execute techniques and systematic methods to use large scale biological information to solve biological questions		X	X		
5 co-operate in an international multi-disciplinary team (including planning activities, taking responsibilities and motivating co-workers) on a bioinformatic or systems biology -oriented research question, design or development problem		X	X	X	
6 determine and solve complex biological problems in teams in an integrated approach	X	X	X	X	
7 communicate verbally and in writing about the results of learning, experiments and project work with colleagues and non-colleagues				X	
8 reflect upon personal knowledge, skills, attitudes and functioning, both individually and in discussions with others (including the interested party and experts) and design and plan their own learning path				X	X

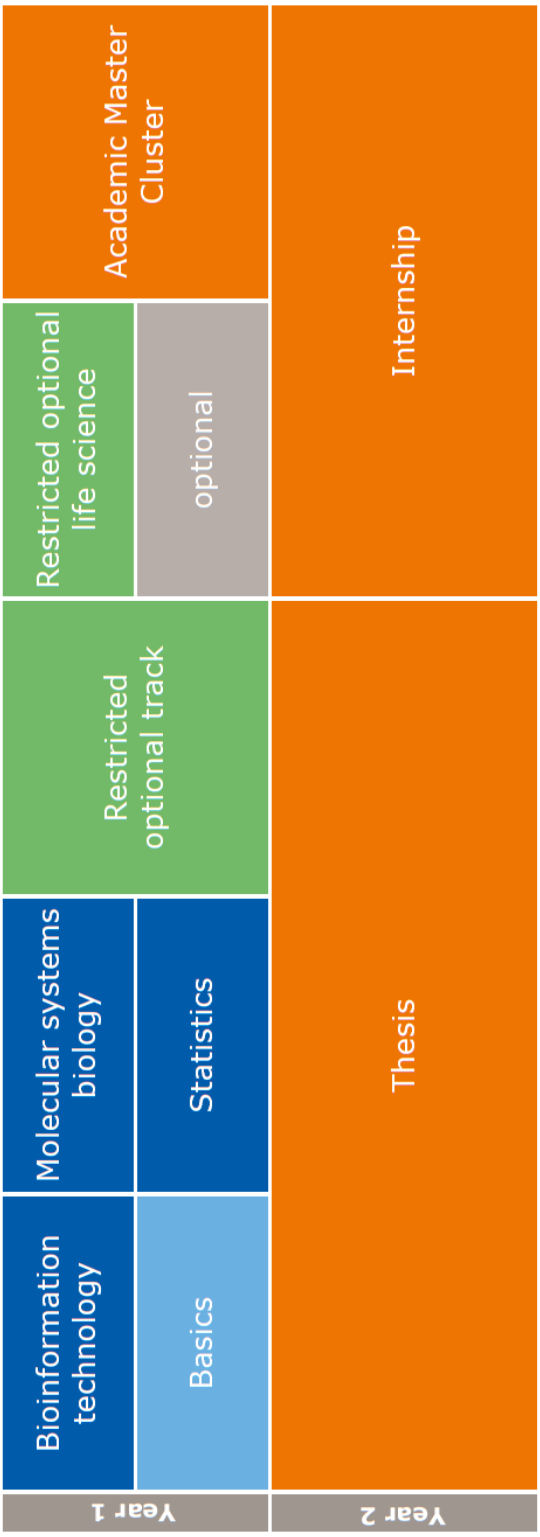
APPENDIX 2: OVERVIEW OF THE CURRICULA

Curriculum of the bachelor's programme Biotechnology





Curriculum of the master's programme Biotechnology



Curriculum of the master's programme Bioinformatics

APPENDIX 3: PROGRAMME OF THE SITE VISIT

8 October 2018		
16.00	18.00	Arrival of panel, Preparation BSc and MSc, internal meeting

9 October 2018		
8.45	9.30	Arrival of panel, documentation review
9.30	10.15	Interview with management (including Programme Committee)
10.15	11.00	Students BSc
11.00	11.15	Break
11.15	12.00	Students MSc BT
12.00	12.45	Teaching staff BSc, MSc BT
12.45	13.30	Lunch Break
13.30	14.15	Students MSc BI
14.15	15.00	Teaching staff MSc BI
15.00	15.15	Break
15.15	15.45	Examining Board and Study Adviser(s)
15.45	17.30	documentation review, deliberations panel and preparation final interview
17.30	18.15	Alumni

10 October 2018		
09.00	09:30	documentation review
09.30	10.15	Final interview with management
10.15	12.30	Deliberations panel, formulating preliminary findings and conclusions + lunch
12.30	13.00	Feedback of preliminary findings and conclusions

APPENDIX 4: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied fifteen theses of the bachelor's programme Biotechnology and the master's programmes Biotechnology and Bioinformatics. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

- Annual reports by the Examining Board
- Annual reports and minutes by the Programme Committee
- Extensive information and documentation on the following courses:

Microbial Physiology	MIB20306
Enzymology	BIC20806
Bioreactor Design	BPE21306
Applied Molecular Microbiology	MIB30306
Advanced Bioreactor Design	BPE36306
Metabolic Engineering of Industrial Microorganisms	BPE34306
Bioinformation Technology	SSB20306
Molecular Systems Biology	SSB30306
Advanced Bioinformatics	BIF30806