

Research Assessment 2016-2021

Science for Life Utrecht University

Bijvoet Centre for Biomolecular Research

Institute of Biodynamics and Biocomplexity

Institute of Environmental Biology

Utrecht Institute for Pharmaceutical Sciences

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1. Introduction

1.1 Background

This report presents the assessment of the research conducted at four collaborating research institutes at the Faculty of Science of Utrecht University (UU) in the Netherlands in the period 2016-2021:

- Bijvoet Centre for Biomolecular Research (Bijvoet Centre),
- Institute of Biodynamics and Biocomplexity (IBB),
- Institute of Environmental Biology (IEB),
- Utrecht Institute for Pharmaceutical Sciences (UIPS).

These institutes collaborate under the umbrella name 'Science for Life' (S4L). They are responsible for all research at the Departments of Biology and Pharmaceutical Sciences, and roughly half that at the Department of Chemistry within Utrecht University's Faculty of Science. The assessment was performed by an external review committee using the Strategy Evaluation Protocol 2021-2027 (SEP).¹ The primary aim of SEP assessments is to evaluate the research quality, societal relevance, and viability of a research unit considering its own aims and strategy, and to suggest improvements where necessary.

Target groups that are served by this assessment include:

- S4L researchers and management of the institutes, who need to know how the quality of the research, its societal relevance, and its strategy are perceived by independent experts and how these elements can be improved, with explicit attention to the aspects of Open Science, PhD Policy and Training, Academic Culture, and Human Resources Policy,
- the Boards of UU and the Faculty of Science who wish to track the impact of their research policy,
- the Dutch government that evaluates the outcomes of assessments in connection with the institution's accountability for expenditure and its own efforts to support an outstanding research system,
- society and the private sector that seek to solve a variety of problems using the knowledge that the research of the institutes delivers.

1.2 Members of the assessment committee

The Board of UU has appointed as members of the assessment committee:

- Professor Ad IJzerman, *chair* (professor emeritus Leiden University, the Netherlands),
- Professor Michel Labouesse (Sorbonne, Paris, France)
- Professor Christine Queitsch (University of Washington, Seattle, USA)

¹ The SEP was drawn up and adopted by the Association of Universities in the Netherlands (VSNU), Royal Netherlands Academy of Arts and Sciences (KNAW), and the Netherlands Organisation for Scientific Research (NWO). All research conducted at the various Dutch universities, university medical centres (UMCs), and NWO or KNAW institutes is assessed once every six years in accordance with the SEP.

- Professor Joel Sussman (Weizmann Institute of Science, Rehovot, Israel)
- Professor Franca Fraternali (University College London, United Kingdom)
- Dr Victor Carrion Bravo (Leiden University, the Netherlands)
- MSc Iris Bally (Hubrecht Institute, Utrecht, the Netherlands).

Professor Maria Jose Alonso (University of Santiago de Compostella, Spain) was originally also appointed as a committee member but had to withdraw due to personal circumstances. Dr Linda van den Berg (Washoe Life Science Communications, the Netherlands) served as the secretary to the assessment committee. The committee members had previously declared to have no conflicts of interest. The evaluation and recommendations in this report constitute the committee's consensus. 'Currently' refers to the time of the site visit; 'we' refers to the committee members.

1.3 Procedure

The committee evaluated the research conducted at the S4L institutes based on

- the institutes' self-evaluation report, which described the mission and strategy of the institutes during the evaluation period; reflected on the quality and relevance of the research, the PhD policy and training, the working environment, and personnel policies; and presented SWOT analyses and strategies for 2022-2027,
- a series of interviews during a site visit in November 2022 with the dean, department heads, institute directors, director of the graduate school, and representatives of principal investigators (PIs), early career staff, PhD candidates, and technicians, as well as tours of the facilities. The discussions were transparent and constructive. The site visit programme is listed in Appendix 1.

The committee met online twice prior to the site visit to ensure that there was sufficient time to prepare for the interviews. In addition, six committee members joined a part of the annual S4L conference the day before the site visit.

Assessment criteria

The assessment committee evaluated the S4L research based on three assessment criteria, all considering the institutes' own aims and strategy:

- **Research quality**, i.e., the quality and scientific relevance of the S4L research in an international and national context, including contributions to the body of scientific knowledge and the academic reputation and leadership within the field,
- **Relevance to society**, i.e., impact, public engagement, and uptake of the S4L research in economic, social, cultural, educational, or other terms, including the teaching- research nexus,
- **Viability**, i.e., the extent to which the S4L goals for the coming six-year period remain scientifically and societally relevant; whether its aims, strategy, the foresight of its leadership, and its overall management are optimal to attain these goals; and whether the plans and resources are adequate to implement this strategy; including a reflection on the viability of S4L in relation to the expected developments in the field and society as well as on the wider institutional context of the S4L institutes.

In addition, the committee was asked to reflect on the following additional aspects:

- How could the S4L institutes further intensify their interactions and collaborations with other researchers within UU's Strategic Theme Life Sciences?
- How could knowledge transfer and innovation be further optimized?
- How can the S4L technology platforms be more optimally used, and their function and maintenance safeguarded for the future?

Aspects

In line with the SEP and in relation to the aims and strategy of the institutes, the assessment committee incorporated four specific aspects in the assessment at the institute level, because these help to shape the quality of the research unit:

- **Open science**
 - involving stakeholders in the preparation and execution of the S4L aims and strategy; presenting and bringing the S4L research to other researchers and societal stakeholders,
 - way of handling research data, methods, and materials, including reusing data and applying the FAIR principles; making publications available through open access.
- **PhD policy and training**
 - institutional context of the PhD programme including position of the PhD training in the S4L research; programme content and structure; selection and admission procedures for PhD candidates,
 - supervision of PhD candidates and functioning of the quality assurance system, effectiveness of the training and supervision plans; duration, success rate, exit numbers; guidance of PhD candidates to the job market and career prospects.
- **Academic culture**
 - **openness, (social) safety and inclusivity** of the research environment, reflecting on the culture in terms of appreciating the multiplicity of perspectives and identities in the workplace; measures that are taken to ensure openness, safety, and inclusivity; how responsibility is taken by leaders to contribute to such an academic culture,
 - the S4L policy on **research integrity** and the way the institute facilitates the relevant actions and requirements, reflecting on data integrity; the extent to which an independent and critical pursuit of science is made possible; the degree of attention given to integrity and ethics; the prevailing research culture and mode of interaction; relevant dilemmas (e.g., authorship, ethical considerations regarding privacy or collaborations with stakeholders) that have arisen and how the S4L has dealt with them.
- **Human resources (HR) policy**
 - extent to which **diversity** (gender, age, ethnic & cultural background, disciplines) is a concern at present, reflecting on how the S4L institutes guarantee diversity-promoting HR practices such as inclusive selection and appraisal procedures and its actions and plans,
 - S4L policies on **talent** selection and development, i.e., the S4L recruitment policies; opportunities for training and development; coaching and mentoring; career perspectives for researchers and research support staff; selection, training, promotion, and retention policy; the way that the S4L institutes offer opportunities for diverse career paths and ensures that researchers are properly evaluated, rewarded, and incentivised.

These aspects are mainly discussed in Chapter 2. We have not written separate paragraphs about the aspects in the chapters about the individual institutes because most of the committee's comments on the aspects pertained to all four institutes.

1.4 Research unit under assessment: Science for Life

Science for Life is a cluster of four collaborating institutes that conduct fundamental and technology-oriented life sciences research expressed by their mission of 'studying the building blocks of life', at the Faculty of Science of UU:

- The **Bijvoet Centre for Biomolecular Research** studies life at the molecular scale, focusing on the biomolecules that make up living organisms. It is mainly embedded in the Department of Chemistry, with some parts in the Department of Pharmaceutical sciences,
- The **Institute of Biodynamics and Biocomplexity** focuses on molecular mechanisms and fundamental principles that underlie dynamic biological processes. It is embedded in the Department of Biology,
- The **Institute of Environmental Biology** studies molecular and ecological life processes of plants, microbes, and animals. It is embedded in the Department of Biology.
- The **Utrecht Institute for Pharmaceutical Sciences** contributes to developing effective and safe medications for society by studying processes around discovery, development, and use of drugs and medical nutrition. It is embedded in the Department of Pharmaceutical sciences.

The institutes joined forces in 2015 to facilitate coordination, collaboration, and joint policy making. Each of the institutes is led by a scientific director who is responsible for the research quality assurance and the academic strategy of the institute. The heads of the relevant departments are responsible for personnel, finances, and the coherence between research and education. Taken together, the institutes receive ~52M€ of annual funding and host approximately one hundred principal investigators (details about personnel and funding can be found in Appendix 2). At UU, typical percentages of time spent on research are 40% for professors, associate professors, and assistant professors; 90% for postdocs; and 75% for PhD candidates. The Faculty of Science has an undergraduate School for BSc education and two graduate schools for MSc and PhD education (one in the natural sciences and one in the life sciences), as well as a School of Pharmacy.

The S4L institutes are embedded in a larger cluster of institutions that perform life science-related research at Utrecht Science Park. This '**UU Strategic Theme Life Sciences**' (STLS)² brings together scientists, clinicians, veterinarians, and students from the Faculties of Science, Medicine, and Veterinary Medicine, the University Medical Centre Utrecht (UMC Utrecht), the Princess Máxima Centre for Paediatric Oncology, and the Hubrecht Institute. Using their expertise and the on-campus facilities, they team up with private partners, patient organizations, investors, and the public to find and implement solutions for grand societal challenges. The S4L institutes also have connections with the other strategic themes of the university, in particular with 'Pathways to Sustainability'. In addition, the S4L institutes closely collaborate with relevant UU focus areas, such as Artificial Intelligence and the Utrecht Bioinformatics Centre (UBC). S4L is also actively involved in a strategic alliance between UU, UMCU, Wageningen University and Research, and Technical University Eindhoven, addressing urgent societal challenges related to health, food, energy, and sustainability.

² UU has organized its research into four strategic themes, one of which is 'Life Sciences'.

2. Evaluation of Science for Life as a whole

2.1 Summary of S4L strategy and aims

According to the self-assessment report, S4L aims to bring novel insight and detail to mankind's understanding of how life and its components work ('studying the building blocks of life'). S4L focuses on fundamental questions and technology development within the chemical, biological, and pharmaceutical sciences, aiming for international excellence in fundamental life sciences. S4L research is largely curiosity-driven. The research outcomes are thought to provide a firm knowledge base for future solutions for urgent health and environmental challenges. The S4L institutes pursue an intellectual and collaborative research environment that provides great freedom and inspiration for their scientists, enabling them to pursue fundamental bioscience questions of the highest scientific and societal relevance. As will be discussed in this report, this strategy has proved to be fruitful. Standing for basic research and being very good at it, and organizing excellent high-end technology platforms while also providing high-quality teaching to students, is admirable.

During the site visit, the overarching future ambitions of S4L were presented as follows:

- being inspiring advocates for fundamental research,
- organizing and developing high-end technology platforms,
- playing a central role in the UU life sciences,
- training and mentoring the next generation of life scientists,
- providing an inspiring, safe, and inclusive research environment,
- pushing the principles of Open Science,
- implementing the new recognition and reward system (TRIPLE, see section 2.8).

2.2 S4L research quality

In line with their strategic aims, the S4L institutes have contributed substantially to the body of fundamental scientific knowledge about the building blocks of life in the past six years, as evidenced by the examples given in Chapters 3-6. The S4L scientists have outstanding international reputations as evidenced by the multitude of high-impact publications and the impressive number of highly competitive research grants that they have managed to acquire. For instance, Albert Heck (2017) and Anna Akhmanova (2018) were awarded the Spinoza Prize, which is the highest distinction in Dutch science, during the review period. Corné Pieterse received the Spinoza Prize in 2022.

Moreover, the S4L scientists have made crucial contributions to the development of the high-end research facilities that are available at Utrecht Science Park. Examples of state-of-the-art technologies include advanced light and electron microscopy, X-ray crystallography, and Nuclear Magnetic Resonance (NMR); analytical and synthetic technologies for (bio)molecules such as mass spectrometry-based proteomics and metabolomics, next-generation sequencing, and single-cell technologies; and high-throughput phenotyping technologies. Many of these facilities are embedded in larger collaborative research infrastructure initiatives at the local, national, or international level. This research infrastructure supports Utrecht-based life sciences research and attracts academic and industrial collaborators from across the country and beyond. It thus contributes to the collaborative

research environment that the institutes aim for. Taken together, the committee is impressed by the exceptional quality of the research and the facilities at S4L.

2.3 S4L societal relevance

During the evaluation period, the S4L strategy promoted curiosity-driven research. In the long term, the fundamental insights produced by this research will be invaluable to address the health and environmental challenges that society is currently facing. S4L research has also resulted in shorter-term societal benefits. Collaborations with university medical centres, societal organizations, and companies have resulted in applicable know-how, thus spurring economic activity and knowledge development in the Netherlands and abroad. An inspiring example is the large public-private research programme on lettuce in which the IBB and IEB participate (LettuceKnow). This programme uses lettuce as a model crop for fundamental scientific research into the optimal genetic composition of leafy vegetables and other so-called composites. At the same time, it aims at improving the crop industry.

By educating BSc, MSc, and PhD students, the institutes are training the next generation of experts in subdisciplines of biology, biochemistry, and pharmaceutical sciences, as well as bioinformaticians and computational biologists. The PhD graduates of S4L obtain positions in academic institutions, companies, governmental organizations, and non-governmental organizations, disseminating the knowledge and expertise that they acquired during their PhD training in Utrecht. The institutes also actively participate in outreach activities, such as visiting high schools and elementary schools; creating videos, presentations, and publications targeted at the general public; and participating in interviews in newspapers, national radio and television. Additional appealing examples of the uptake of S4L research results by various stakeholder groups are provided in Chapters 3-6.

PhD candidates at UU can receive entrepreneurial training, which is a sign that the university acknowledges the importance of knowledge transfer and innovation. In addition, Utrecht Science Park hosts a substantial number of companies, building an ecosystem for translational activities. For instance, Danone Nutricia Research at Utrecht Science Park closely collaborates with UIPS. As will be discussed in section 2.4, the committee recommends intensifying the community building efforts of S4L; this may help the institutes to become more visible to private partners. At the same time, the infrastructure and regulations at UU do not favour the foundation of spin-off activities by PIs. This may be a general shortcoming in the Dutch academic climate. For instance, the committee understood that UU scientists with full-time employment are not allowed to perform more than 0.1 FTE of extra work on top of their working hours (or generate more than 10% of extra income) on side activities such as a spin-off company. Scientists would need to change their appointment into a part-time position to be able to spend more time on developing a start-up. Perhaps the university could consider adjusting these requirements, for instance by allowing scientists to spend e.g., a higher percentage of their time on a start-up company for e.g., a period of one year.

2.4 S4L viability

The committee is highly positive about the viability of S4L. The topics that the institutes are studying will be of high and growing societal relevance in the years to come. The institutes have an adequate

scientific and societal strategy for the future. They have managed to create a lively scientific community, which has expanded during the review period and is firmly embedded in the larger research community at Utrecht Science Park. They currently harbour many established scientists that are considered international leaders in their fields, as well as talented young researchers. These scientists have convincingly shown their ability to attract an impressive amount of external funding. In addition, UU's Faculty of Science is relatively financially healthy because of recent developments in the Dutch science funding landscape (e.g., the implementation of the so-called Sector Plans³). Taken together, the institutes' human and financial resources appear to be sufficient to implement their strategy for the future. To ensure that the institutes will continue to thrive, we recommend (i) continuing the investments in community building, (ii) ensuring a stable and advantageous housing situation, (iii) enhancing the visibility and accessibility of the facilities, (iv) providing good career perspectives for high-end technical support staff as well as specialists at the intersection of bioinformatics, computational biology, and classical biology, and (v) improving the scalability of the computational infrastructure. We will elaborate on these topics below.

Community building

S4L constitutes a loose network of four institutes that play a leading and connecting role within the life sciences community at Utrecht Science Park. Joining forces has enabled the institutes to strengthen their interactions, speak with one voice, and provide a platform for scientific exchange and technology sharing. The S4L community has expanded during the review period and now gathers most fundamental life sciences research groups at Utrecht Science Park, i.e., groups from the Faculty of Science, Faculty of Veterinary Medicine, UMCU, Hubrecht Institute, and Princess Máxima Centre.⁴ S4L organizes an annual conference that attracts more than 400 participants and a bi-monthly S4L Café. The annual conference is lively and well-visited, but the S4L Cafés do not appear to be well-known. There is a Young Investigators Forum (YIF), representing S4L group leaders at the stage of assistant and associate professor. The YIF organizes social networking events to exchange experiences and discuss ideas on relevant topics.

The committee recommends intensifying the community building efforts of S4L. This may strengthen the role of the S4L institutes as leaders and connectors of the local fundamental life sciences community and may help them to present themselves to private partners. Newly hired researchers (at all levels) should receive a more structured introduction to S4L facilities and activities, for instance by offering lab tours like the tours that the committee received during the site visit, or by organizing a 'S4L introduction day'. In addition, a community for S4L postdocs should be launched following the successful example of the YIF. Postdocs from other institutions may be welcomed in this new postdoc community. Postdocs tend to be a 'forgotten' group of scientists, while dozens of

³ Sector Plan 2.0 was initiated in 2018 by the Ministry of Education, Culture and Science, and intended to strengthen fundamental research and education in the natural and technical sciences by expanding research capacity; attracting and retaining new research talent; and improving gender balance. The Chemistry Department (Bijvoet Centre) received funding from this Sector Plan 2.0. A third generation of Sector Plans within the Science domain was recently initiated (June 2022). This new Sector Plan will boost fundamental research and science education, which will specifically benefit the Departments of Pharmaceutical Sciences (UIPS) and Biology (IEB and IBB). (*Text adapted from self-assessment report.*)

⁴ Note that this assessment report focuses exclusively on the research of the four institutes at the Faculty of Science.

them are employed at S4L. There is an undesired distinction between PhD candidates and postdoctoral co-workers at the level of training and support.

The structural budget for the S4L umbrella is very small, essentially sufficient for the organization of the annual conference. We recommend increasing this budget to facilitate community building at every level of the career ladder. To this end, the top (i.e., faculty management) may wish to encourage bottom-up initiatives. The institutes could also consider dedicating a percentage of their institute budget to S4L activities, for instance by using a percentage of the overheads on grants. If the S4L budget would be increased, the institutes could also consider offering seed money for new projects involving two groups from distinct institutes (enhancing interactions across institutes) or creating a track for PhD projects supervised by two PIs from different disciplines to foster interactions as well as 'train brains' in a different way.

Housing situation

At UU, housing scenarios are mainly developed at the level of the university. At present, the S4L research groups are distributed over three buildings (Kruyt, Bloembergen, and David de Wied). The Kruyt building is scheduled for intensive renovations, so the research groups that are currently located in this building will have to move – at least temporarily. The previous (2017) assessment committee of S4L stated that collaboration between the institutes could be enhanced if the Bijvoet Centre, IBB, and IEB could move into a new building in the vicinity of the David de Wied building, which is the current location of UIPS. This vision was shared by the institutes and the faculty management. Recently, dedicated housing of the new electron microscopy facilities has been realized near the UIPS location, but the future housing of the other S4L institutes is still unclear. We noticed that the current housing plans create stress among the personnel of the institutes. Moving experimental equipment such as mass spectrometers, NMR equipment, and advanced microscopes is a complex undertaking that is expected to severely impact scientific output in the months surrounding the move. The committee strongly recommends limiting the number of moves. In addition, it is important that the scientists have a seat at the table in the negotiations and deliberations about their future housing situation. Ideally, the four institutes should be housed in one building, or at least in close proximity, to optimally facilitate collaborations and support their excellent research.

Technology platforms and technical support staff

The technology platforms play a central role in the strategy and aims of S4L. Different access systems are in place for different facilities. For instance, access to the imaging facilities at the IBB is free, whereas access to the new NPEC facility will require fees because it is a national facility. The mass spectrometry facility asks no fee for service for small projects and does not require co-authorship on papers that result from the use of the facility. Larger projects are considered collaborations and may lead to co-authorships. This no-fee model will be in place as long as the mass spectrometry infrastructure is funded as a national facility. Other access models may benefit from a subscription fee or joint investments to ensure that the platforms remain viable, so that innovations and replacements are part of the cost system used. Joint S4L applications for funding may impress grant providers even more.

Overall, the access systems appear to work well at the level of institutes but are not optimal yet when scientists from other institutes wish to use a facility. The visibility of the facilities may be enhanced. The S4L website is most likely to be the primary entry point for external visitors. Although the technology platforms are well-represented at this website, the information is not always complete and up to date (e.g., the contact links on some pages refer to links that do not exist anymore). We recommend ensuring that (contact) information is continuously updated. We also recommend organizing lab tours to familiarize new scientific employees with the facilities (especially onboarding tenure trackers). The S4L technology platforms are exemplary and deserve to be better known among all staff members.

High-quality scientifically trained technical support staff is a crucial prerequisite to ensure preservation of know-how and to maintain the attractiveness of the institutes. We recommend creating permanent positions for talented scientifically trained technical support staff that can operate the state-of-the-art equipment of the institutes, along with appropriate opportunities for career progression. We recognize that this may currently not be in the 'culture' of Dutch science, but it is crucial for making state-of-the-art instruments work in the highest possible way. There are surprisingly many skilled scientists who do not aspire to be PIs but would be very happy to have a long-term position as a 'staff scientist'. These staff scientists should be supported to spend time on improving the function of their instrumentation in terms of hardware and/or software (i.e., new algorithms). In parallel, the institutes and the university should find a way to recognize the value of these staff scientists, in terms of pay, tenure, and special awards for them. This topic should be on the agenda at the level of the university and the Faculty of Science, and it should also be approached proactively by the institutes themselves. One possibility might be to spend a percentage of research grants on positions for talented support staff. UIPS and IBB appear to be able to create this type of permanent position, so the other institutes may wish to follow their example.

Computational infrastructure

Modern life sciences research is computationally intensive and is expected to become vastly more intensive in the six years to come. This is true for both experimental and computational branches of the life sciences. The S4L institutes are currently using a mix of centralized and decentralized computational infrastructure and associated technical support. This appears to work well at present but seems to be fragmented and to lack scalability. With the ever-increasing data load, scalability is crucial. We recommend continuously monitoring the future scalability and integration of the current and future systems, such as the UU-wide system 'Yoda'. S4L should create opportunities for computational scientists and support staff from the different institutes to learn from each other, and to advise the S4L/faculty/university board depending on the level of complexity and costs.

2.5 S4L Open Science

The committee learned that the Executive Board of UU has launched an Open Science Programme, to stimulate and enable UU scientists to implement Open Science into their daily practice. The Open Science Community Utrecht has an active branch in the Faculty of Science and organizes activities such as an annual Open Science symposium and courses for reproducible data practices. In addition, the Faculty of Science has installed an Open Science Team that helps to develop a UU-wide Open Science platform and promotes applying for the UU Open Science grants. The Faculty of Science

intends to employ a dedicated support officer to address submission and administration of open access publications. In 2021, around 90% of all publications of the four institutes were open access. This high percentage of open access publications facilitates the uptake of the S4L research results by scientists and other stakeholders. However, the costs for open access publications are high. These costs are currently largely covered by nation-wide agreements between the Dutch universities and publishers. S4L should consider how to safeguard open access should such agreements disappear.

For research data management, a UU-wide system called 'Yoda' enables researchers from UU and their partners to securely deposit, share, publish, and preserve large amounts of research data during all stages of a research project. S4L researchers combine this Yoda system with other local and national solutions for data storage and sharing. We recommend continuously monitoring the future scalability of the current system of data storage and management, as was discussed in 2.4.

2.6 S4L PhD policy and training

Institutional context

The S4L institutes currently harbour around 350 postdocs and PhD candidates. This large number of starting scientists adds to the lively atmosphere at the institutes. The committee met many enthusiastic and talented PhD candidates during the site visit. The PhD candidates at S4L are typically enrolled in UU's Graduate School of Life Sciences (GSLs), which is a collaboration between the Faculties of Science, Veterinary Medicine, and Medicine. The GSLs offers 15 disciplinary PhD programmes. S4L PhD candidates are predominantly enrolled in the programmes Computational Life Sciences; Biomembranes; Molecular Life Sciences; Cancer, Stem Cells & Developmental Biology; Drug Innovation; and Environmental Biology. A PhD Council gives solicited and unsolicited advice to the management of the GSLs. Annual activities of the PhD Council include a PhD Survey, a PhD Day, and the election of the (Co-) supervisor of the Year.

Supervision and training

The GSLs guidelines prescribe that PhD candidates have at least two supervisors, one of which acts as the daily supervisor and the other as independent advisor. A GSLs training & supervision agreement is created at the beginning of each PhD track, describing the frequency of meetings and the training plan. PhD candidates are offered courses in academic or transferrable skills through the GSLs PhD Course Centre. PhD candidates may apply for a GSLs training certificate at the end of their PhD tracks, which is done by around 25% of the candidates. A 20 European Credit education programme is required to obtain the GSLs certificate. During the site visit, we noticed that in some cases, personal development of a PhD candidate relies on whether a supervisor allows the candidate to spend (sufficient) time on this education programme. We recommend monitoring adherence to the programme more closely, if not done so already, so that the vast majority of PhD candidates will obtain the GSLs training certificate.

Duration

The duration of PhD tracks is rather long in some of the S4L institutes, with a significant proportion of the PhD candidates taking five years or longer to graduate. We acknowledge that an extension to the regular four years may be advantageous for some PhD candidates. For instance, some PhD

candidates require a substantial amount of time to learn how to operate the complex equipment that is used in their studies. In addition, some research funding opportunities in the Netherlands (e.g., the ‘Veni’ grants of the Dutch Science Council) can only be applied for within three years after PhD graduation, creating a delicate balance between graduating within four years and realizing high-impact scientific papers that would increase the likelihood of obtaining such grants. Having said that, we urge that long PhD terms should not be the result of poor monitoring and guidance by the supervisors. In addition, finishing a PhD thesis while being unemployed should be avoided at all costs and is legally not an option. Therefore, we applaud the new initiative to create a ‘completion plan’ after three years into the PhD track.

To the GSLS staff, we recommend obtaining detailed insight in the relatively long duration of the PhD tracks and the reasons for that. With those data, the institutes will be better equipped to design appropriate policies. A concrete method to collect these data could be to organize exit meetings with an external or confidential advisor for all PhD candidates. This person may then actively recommend changes based on the results of these exit meetings.

Quality assurance

The GSLS strives to provide PhD candidates a safe, inspiring, and innovative academic environment, with ample opportunities for training and personal development. To this end, several concrete actions were undertaken during the evaluation period:

- developing a new quality assurance plan for doctoral education (improvements include a new PhD Guide with clear guidelines and definition of the PhD thesis requirements and a ‘completion plan’ that is co-created by PhD candidates and their supervisors after three years),
- developing a toolkit for supervisors, including a training course on supervision of PhD students that has recently become mandatory,
- developing a new training in personal effectiveness for PhD candidates,
- launching initiatives to enhance social security and mental well-being of PhD candidates,
- organizing activities to compensate for the negative effects of the COVID-19 pandemic on the research progress and well-being.

In general, the committee is impressed by the new PhD guide and the other measures that were recently installed to safeguard high-quality training of PhD candidates at the GSLS. The right procedures appear to be in place. Now, it is time to actively ensure that these procedures will always be followed up in the future. For instance, there should be consequences for the institution or the supervisors if the Training and Supervision Agreement is not filled out, if there are no yearly meetings with the supervision team, if the student does not follow enough courses, etcetera. Ensuring the actual implementation of the guidelines described in the new PhD guide in daily practice will be highly beneficial for the research quality, societal impact, and viability of the S4L institutes in many ways. It will make the institutes highly attractive to talented PhD candidates from across the globe. We also recommend implementing monitoring by an independent **external** advisor, by organizing at least one annual meeting with an advisor that is not affiliated with the same institute as the PhD candidate.

Career prospects

It is important to realize that most PhD candidates and postdocs will eventually not pursue an academic career. Therefore, a clear view on job opportunities and career paths should be stimulated, in which former students may play an active role. To this end, a solid 'alumni/ambassador programme' would be beneficial. The active links with industrial partners may also create new perspectives for the future careers of PhD candidates.

2.7 S4L academic culture

The S4L institutes strategically strive to create an intellectual and collaborative research environment that provides freedom and inspiration to the scientists. The institutes have set up a buddy system in which new staff members are coupled to more experienced staff members. In general, the committee observed a pleasant and lively work environment during the site visit.

In 2019, the Dutch universities have drawn up a statement on social safety, committed to providing a safe environment of collegiality, integrity, equality, respect, openness, and attention to each other. Specific regulations have been established in various codes of conduct. UU has developed guidelines how to act upon encountering inappropriate behaviour. Three types of confidential advisors are available to S4L employees and students:

- a 'UU confidential advisor for inappropriate behaviour' available for all students, PhD candidates, and employees,
- a 'UU confidential advisor research integrity' who can be contacted by students, PhD candidates, and employees with questions or complaints about research integrity, including suspicion or observation of an injustice (violation of integrity) and scientific misconduct,
- a dedicated 'PhD confidential advisor', who can be contacted by PhD candidates at the Faculty of Science in case they encounter issues with their development or supervisor (since 2021).

The committee learnt that the faculty has started trials in which the PhD confidential advisor schedules yearly meetings with all PhD candidates, to proactively enable them to share any concerns about their work environment. We are very positive about the preliminary results that have been shared with us, and strongly encourage further implementation of this system.

During the evaluation period, the S4L institutes engaged in several activities to raise awareness about social safety, e.g., dilemma games organized by UIPS, an active bystander training organized the faculty, and the 'Mindlab play' theatre performance hosted by UU. As a result, scientists are becoming more and more aware of these issues. Regarding research integrity, the committee learned that the GSLS started offering compulsory annual modules of integrity training for PhD candidates in 2020. In addition, integrity workshops are organized during the first week of the GSLS research master programmes.

Taken together, the committee is impressed by the awareness of the institute leaders and their interest in what can be done to ensure social safety and research integrity. We encourage the institutes to continue along this line because there is room for improvement (as is the case in any institution).

2.8 S4L human resources policy

Diversity

The Faculty of Science has tried to improve the gender diversity of its scientific staff during the review period. For instance, at least half of the positions created by the recent Sector Plan 2.0 had to be filled by female scientists. In addition, the faculty has installed an Equality, Diversity, and Inclusion Committee, which has implemented programmes such as the tenure track Westerdijk fellowship for talented female researchers. Members of recruitment committees follow a training on unconscious (gender) bias and at least one of the members of these committees is female. Nevertheless, there is clear room for improvement within the S4L institutes – the number of female scientists is not that high, and there is a fundamental imbalance in female representation between divisions of the institutes. We encourage the faculty to invigorate its ambitions. As an example, we suggest planning for dual hires as young researchers often face the ‘two-body problem’. Having a faculty position (or any position) available for a partner will make it more likely to attract female talent. Consideration should also be given to advise incoming faculty and postdoctoral researchers on school and day care options.

Diversity also pertains to age; LGBTQ+; disability; and cultural, ethnic, or religious backgrounds. The committee acknowledges that the faculty is aware of the importance of these aspects of diversity. We encourage both the faculty and the individual institutes to continue striving for a more balanced representation of minorities among their staff. Perhaps a percentage of the overhead on grants may be used for start-up packages to attract talented new staff members from minority groups. Another possible (more long-term) recruitment strategy could involve organizing and funding summer research internship programmes for high school and BSc students belonging to minority groups. These students are often not aware of the career possibilities available in scientific research and could witness academic environments first-hand during such internships. It requires considerable effort to set up such internships, but experience elsewhere shows that they are highly effective in recruiting motivated minority students for doctoral studies. In turn, their presence generates the welcoming and inclusive atmosphere that lends itself to attracting qualified minority staff and faculty.

Talent management

UU and the Faculty of Science offer a variety of trainings to staff members, including for instance a two-day training in management for future leaders. Staff members and their supervisors engage in annual assessment and development interviews to monitor progress. In September 2022, UU implemented the TRIPLE model (Team Spirit, Research, Impact, Professional practice, Leadership, and Education) to evaluate the performance of staff members and to allow for a more balanced appreciation of the different talents among scientists. This model is the local implementation of the Dutch Recognition and rewards programme.⁵ The committee noticed that for young investigators,

⁵ The Recognition and rewards programme (R&R) advocates a modernisation of the system of recognition and rewards at Dutch universities. This should improve the quality of the key areas education, research, impact, leadership, and (for UMCs) patient care. The programme has been developed in cooperation with all universities, UMCs, reputable research institutes, and research funders. TRIPLE (Team Spirit, Research, Impact, Professional practice, Leadership, and Education) is the local implementation of R&R. Rather than expecting excellence in all domains, the TRIPLE model stimulates diversity in profiles and career paths. The implementation of TRIPLE for assistant and associate professors started in September 2022.

the criteria for the promotion from assistant to associate professor were not always clear, i.e., when can they apply for this promotion and what are the exact criteria for the evaluation. We recommend communicating this clearly.

Due to the strongly competitive job market, the S4L institutes are increasingly aware that attracting and retaining talent is not trivial. In addition, once talent is hired, it needs to 'fly'. More than before, funding is made available by the institutes to enable junior PIs to be joined by a PhD candidate or a technician, or other 'perks' are provided to attract talents. For instance, the policy regarding start-up packages for tenure trackers at the Department of Biology has changed during the review period. The department has started supplementing tenure track positions with a PhD research position and some start-up funding, to make IBB and IEB more attractive to talented young researchers. The committee heard a similar line of reasoning and implementing at the other S4L institutes. As a result, the current population of tenure trackers has received variable start-up packages, which appears to have created some feelings of discomfort and inequality among the pool of young investigators. We recommend that all incoming tenure trackers receive standard start-up packages because it will jumpstart their career.

In addition, it is important to develop a strategy to support the careers of young specialists at the intersection of bioinformatics, computational biology, and classical biology. This expertise should not be viewed as a service, but as a scientific discipline on its own, and it is important to ensure that talents in this field can develop professionally, i.e., the discipline should be valued and protected. This is in line with the concept of 'room for everyone's talent', i.e., creating opportunities for diverse career paths. The committee appreciates the 'AI Technology for Life' initiative of UU's Faculty of Science, which promotes interactions between S4L and the Institute of Information and Computing Sciences at UU.

Several suggestions to ensure that the talent management policies at the S4L institutes will optimally equip them for the future were already mentioned in previous sections:

- We recommend devoting more attention to training, supervision, and career perspectives of postdocs at the S4L institutes (discussed in 2.4).
- We observed that many new positions were created during the review period, but these were primarily PI positions. Scientifically trained support staff is also highly important to achieve the aims of the institutes, so we advise to create permanent positions for scientifically trained support staff (discussed in 2.4).
- Often, new hires are accompanied by a partner or family. It would be worthwhile to explore the opportunities for 'dual hires' to be an attractive employer (discussed above in 2.8).

3. Assessment Bijvoet Centre for Biomolecular Research

Bijvoet Centre for Biomolecular Research

Scientific director: Professor Baldus (2016-2019), Professor Alexandre Bonvin (2019-present)

Mission: to discover the molecular basis of life with a focus on the biomolecules that make up all living organisms, including humans; to train the next generation of scientists; foster an open and collaborative research culture; and disseminate the research results.

Department: Chemistry, Pharmaceutical Sciences

Research groups:

1. Biomolecular Mass Spectrometry and Proteomics (also embedded in UIPS),
2. Chemical Biology and Drug Discovery (also embedded in UIPS),
3. Membrane Biochemistry & Biophysics,
4. NMR Spectroscopy,
5. Cellular Protein Chemistry,
6. Structural Biochemistry.

Research staff in 2021: 25 scientific staff; 68 postdocs & PhD candidates (Table 1 in Appendix 2)

Total funding in 2021: 17.6 M € (Table 2 in Appendix 2)

PhD programme coordinated by Bijvoet Centre: Molecular Life Sciences

3.1 Summary of Bijvoet strategy & aims

Strategy in 2016-2021

During the review period, the strategic aims of the Bijvoet Centre were (*text from self-assessment report*):

- attracting and fostering research talent for carrying out research at the highest level in life sciences,
- maintaining and strengthening a world-class research infrastructure,
- providing a stimulating environment that fosters a collaborative culture and Open Science.

Future strategy

For the next six years, the institute has defined the following aims (*text from self-assessment report*):

- fostering a culture of Open Science, inclusion, and diversity,
- training the next generation of scientists,
- maintaining and strengthening the infrastructure and its leading position at both national and international level,
- continuing developing experimental and computational technologies to push forward scientific boundaries in studying the molecules of life,
- performing world-leading and cutting-edge biomolecular research with societal impact,

- disseminating the research to the public, policy makers, scientific peers, learners, and other stakeholders to show the value of the scientific research, its methodology and its results, as well as the excitement of the researchers for scientific discovery.

The Bijvoet Centre intends to focus on technological advances; membrane processes; and protein biogenesis, folding and interactions as main research areas in the years to come. We suggest that the Bijvoet Centre might consider an additional focus on ‘molecules in the context of the cell’ or ‘structural biology *in vivo*’.

3.2 Bijvoet research quality

The Bijvoet Centre is a mature research institute, and the committee rates the Bijvoet research and the technological facilities as outstanding. The research groups have their roots and expertise in advanced experimental techniques in structural biology, chemical biology, biochemistry, biophysics, and structural bioinformatics. They use their expertise and high-end equipment to produce fundamental insights into protein biogenesis, folding, and interactions as well as membrane processes. The recent recruitment of new staff and investments into instrumentation have expanded the scope of the Bijvoet research to encompass higher-order molecular organization, the supra-structure of biomolecular systems, and the structure and function of biomolecular systems in cellular and organism settings.

The Bijvoet scientists have published 950 research articles during the review period. Their papers had a mean field-weighted citation index of 2.1, meaning that they were cited more than twice the world average for this field. In addition, the Bijvoet Centre has contributed to the scientific literature with 74 reviews, 20 book chapters, 61 PhD theses (2 *cum laude*), and 25 other types of publications such as editorials and news articles. An example of a highlight is the work on determining the mechanisms of action of antibiotics. Another highlight is the *in situ* cryo-electron tomography imaging of mammalian sperm. Initial results have generated important insights into sperm physiology and evolution, which are also relevant for other polarized cell types, such as muscle cells, neurons, photoreceptors, and hair cells. The structural biology expertise at the Bijvoet Centre is excellent and this research benefits from a strong interdisciplinary component, integrating mass-spectrometry and cryo-electron microscopy (both single-particle and tomography). This creates the possibility to understand the function of very large assemblies in the cell at an unprecedented level. Some remarkable successes have been achieved in revealing functional mechanisms of very large antibody assemblies of immune complement activation.

During the review period, the Bijvoet Centre has strategically invested in its technological facilities. A new Electron Microscopy Centre and a new Protein Research Facility were established recently. The research infrastructure of the Bijvoet Centre is world-class, including facilities such as an NMR large scale facility, Biomolecular mass spectrometry and proteomics facility, National single crystal X-ray facility, in addition to the new Electron Microscopy Centre and Protein Research Centre. These facilities are at the forefront of current technologies and the Bijvoet success in a variety of application areas is impressive. Many of these facilities are part of national or European research infrastructure initiatives such as Instruct-ERIC. The facilities support more than 200 national and international users per year. The researchers of the Bijvoet Centre actively engage in instrument development and they contribute to e-infrastructure and impactful software such as HADDOCK.

Through these activities, the institute contributes substantially to biomolecular research in the Netherlands and beyond.

3.3 Bijvoet societal relevance

Bijvoet research produces knowledge with a broad spectrum of potential applications in human health and disease (e.g., cancer, neurodegenerative diseases, infectious & immune diseases, COVID-19). The institute has close ties to the private sector; around 11% of its research funding comes from contract research with companies. In addition, the Bijvoet Centre contributes to society by educating the next generation of scientists and through media exposure, visits to high schools and primary schools, and a YouTube channel.

Training the next generation of scientists is a crucial aspect of the Bijvoet strategy to ensure societal impact in addition to high-quality science. Most PhD candidates at the Bijvoet Centre are enrolled in the PhD programme 'Molecular Life Sciences' of the GSLS, which is organised by the Bijvoet Centre. Some PhD candidates participate in other programmes, in particular the 'Biomembranes and Drug Discovery' programme. The Bijvoet PhD Committee helps to create an inclusive environment by organizing social events and lecture series for PhD candidates and postdocs. The PhD graduates of the Bijvoet Centre obtain positions in companies, academic institutions, governmental organizations, and national laboratories. The institute's relationships with industry may facilitate career tracks in that direction. Speaking with PhD candidates, we found that they were at a very high-level, i.e., competitive with or better than students at other top universities in Europe and the USA.

3.4 Bijvoet viability

With its state-of-the-art research infrastructure, its excellent staff that appears to interact well, and a sustainable level of funding, the Bijvoet Centre appears well-equipped to attain its goals for the future. In addition, their plan for the evolution of the facilities seems to be in place. There are plans to change the management structure of the institute to increase the representation of early career scientists and PIs from all career stages. The new Protein Research Centre and Electron Microscopy Centre will strengthen the research of the Bijvoet Centre, and it will promote interactions with the other S4L institutes at the Faculty of Science, UMCU, and the Faculty of Veterinary Medicine. The institute can be particularly proud of these new facilities.

The Bijvoet Centre recently hired many new PIs, which is a positive development. In addition, the institute strategically promoted staff members to associate professor positions and attracted professors by special appointment. In view of recent machine-learning developments in the field of structural biology, we recommend strengthening the expertise in artificial intelligence because that would complement and reinforce the already very strong expertise at the Bijvoet Centre. We also recommend actively recruiting more female structural biologists in addition to the one that was recently hired to optimally equip the institute for the future.

An important concern is the future housing situation of the Bijvoet Centre. The research groups of the institute are currently spread over three buildings. One of these (the Kruyt building) is scheduled for intensive renovations, so the research groups located in this building will have to move, at least

for a certain amount of time. The future housing situation is still unclear, which appears to create stress among the scientists. Moving the Bijvoet Centre's advanced equipment will be a complex undertaking, so we strongly recommend limiting the number of moves (also discussed in 2.4). In addition, the distribution of the Bijvoet research groups over multiple buildings does not optimally facilitate collaborations, so we argue for housing the scientists under one roof if possible.

4. Assessment Institute of Biodynamics and Biocomplexity

Institute of Biodynamics and Biocomplexity (IBB)

Scientific director: Professor Sander van den Heuvel (2015-present)

Mission: to gain fundamental understanding of living systems at the molecular and cellular level through quantitative interdisciplinary approaches ('fundamental biology for future innovation').

Department: Biology

Research units:

The IBB consists of more than twenty PI groups that work in seven thematic research divisions ('Chair groups'), which operate as four complementary research units:

1. Cell Biology, Neurobiology and Biophysics,
2. Developmental Biology,
3. Genome Biology and Epigenetics,
4. Theoretical Biology and Bioinformatics.

Research staff in 2021: 29 scientific staff; 82 postdocs & PhD candidates (Table 3 in Appendix 2)

Total funding in 2021: 7.3 M € (Table 4 in Appendix 2)

PhD programmes: the IBB coordinates Computational Life Sciences, co-organizes Molecular Life Sciences, and is actively involved in Biomembranes and Cancer, Stem Cells & Developmental Biology.

4.1 Summary of IBB strategy & aims

Strategy in 2016-2021

According to the self-assessment report, the strategic aims of the IBB in the period 2016-2021 were:

- Increasing its staff to reach a critical mass and form a well-connected diverse group of internationally leading scientists, who participate in multidisciplinary research programs, develop advanced technologies and data analysis tools, obtain ample funding, and publish articles of the highest quality and impact,
- maintaining and further strengthening the expertise centres and research facilities,
- contributing to interdisciplinary BSc, MSc, and PhD programmes and providing an inspiring and safe research environment in which students and postdocs obtain hands-on expertise and training in research,
- expanding connections with other S4L institutes, Utrecht life sciences communities, other national and international institutes, industry, and society.

Future strategy

For the next six years, the institute has defined the following aims:

- promoting additional growth of the staff in a way that improves the coherence and synergy within the IBB,

- maintaining and expanding state-of-the-art research facilities,
- improving junior recruitments by including start-up funding for a PhD position and equipment support,
- increasing the visibility of the IBB societal relevance by contributing to disease topics and connecting to industry,
- continuing to promote Open Science.

For its future scientific strategy, the IBB envisions a focus on the (self-) organization, proliferation, differentiation and functioning of cells and tissues in their native environment, in healthy and pathological conditions, and combined with testing and uncovering the effects of drugs. To facilitate this approach, the IBB intends to invest in bioinformatic data integration and quantitative image analysis, with emphasis on machine learning and other artificial intelligence technologies. In addition, the institute wants to strengthen its expertise in synthetic biology and cell-virus interactions. The committee was not fully convinced by the arguments to strengthen the expertise in these two fields. The IBB is involved in a large project on synthetic biology with Wageningen University & Research, but the committee is not sure if this will result in sufficient critical mass for this topic at the IBB. The same holds for the new focus on virus-cell interactions. We will further discuss the issue of critical mass in section 4.4.

4.2 IBB research quality

The committee is impressed by the excellent science and equipment at the IBB. During the review period, the IBB has tried to create a collaborative and inspiring research environment, in which experimental and theoretical scientists perform multidisciplinary research at an internationally high-ranking level. Indeed, the committee observed an extremely collaborative atmosphere during the site visit. This approach appears to be fruitful because the IBB scientists have contributed substantially to advancements in the understanding of molecular mechanisms and general principles that underlie the formation and functioning of living cells and higher order cellular systems.

The IBB scientists published 567 research articles during the review period. Their papers had a mean field-weighted citation index of 2.4, meaning that they were cited 2.4 times the world-average for this field. In addition, the IBB contributed to the scientific literature with 72 reviews, 14 book chapters, 68 PhD theses (5 *cum laude*), and 27 other types of publications such as opinions. IBB scientists have acquired many highly competitive national (Veni, Vidi, Vici) and international (ERC Starting, ERC Consolidator, ERC Synergy, Marie Curie ITN, Human Frontier Science Programme) grants, as well as major collaborative grants. The IBB's role in the prestigious Gravitation programme IMAGINE! is another sign of research excellence.

An example of a highlight is the research on cells in their native environment using novel technological approaches such as 3D super-resolution microscopy and expansion microscopy. IBB scientists have pioneered the use of optogenetics to re-engineer cellular processes using automated optogenetic control. They have also developed nanobodies, which are increasingly used in various approaches for protein purification, imaging, and therapeutic applications. Scientists from the IBB are world leaders in studying microtubule dynamics within different cellular contexts, the mechanisms defining cell polarity, the population dynamics of immune cell types, and genome evolution. A key

aspect of the IBB is their investment in bioinformatics, computational biology & theory, which is becoming increasingly important in modern biology.

Developing and maintaining state-of-the-art research facilities has been and will be a crucial aspect of the IBB strategy. The institute has invested in the microscopes and support staff of the Biology Imaging Centre (BIC) and other facilities during the review period. The institute harbours outstanding facilities, such as the BIC that enables advanced microscopy, the Utrecht Bioinformatics Cluster that facilitates data science and high-performance computing, the zebrafish facility, a flow cytometry facility, and the UU nanobody facility. By providing access to its research facilities and developing technologies and data analysis tools, the IBB adds to the advancement of the field of biology beyond its own walls. During the tour of the IBB facilities, we were particularly impressed by the BIC and the research presentations given by several IBB PhD candidates. Their research projects were universally exciting and of high quality, and the PhD candidates were clearly highly enthusiastic and in command of their research. These young researchers and their equally young mentors were the best advocates imaginable for the impressive research quality at the IBB, and its societal relevance and viability.

4.3 IBB societal relevance

Results obtained by IBB scientists contribute to a better understanding of human health issues such as cancer and neurological disorders, and of sustainable food production. Their work also provides new therapeutic opportunities, and more generally helps improving mankind's understanding of living systems. During the review period, the institute has increased its focus on mechanisms of health and disease and engaged with patient organizations and foundations (in particular in the field of Alzheimer's disease), thus enhancing the visibility of the societal impact of the IBB research. IBB scientists also perform applied projects through major collaborative research programmes with industrial partners. They engage in collaborations with university medical centres and companies in the areas of cancer treatment and of food production to ensure that their research results are beneficial for society. By engaging with the public and high school students, the institute ensures that its research results are taken up by a broader group of stakeholders. To further enhance the visibility of the IBB and promote a cohesive appearance, we suggest improving the website of the institute. We recommend organizing structural support for this.

One of the strategic aims of the IBB is educating and training high-quality scientists and critical minds. The institute started a new international BSc programme 'Molecular and Biophysical Life Sciences' and a new MSc programme 'Bioinformatics and Biocomplexity' during the review period. It also organizes the interdisciplinary 'Quantitative Biology' honours programme. In general, the institute provides its researchers with a strong training in quantitative biology, thus contributing to the dissemination of such quantitative expertise to society. The PhD candidates at the IBB are typically enrolled in one of four different programmes: Molecular Life Sciences, Computational Life Sciences, Biomembranes, or Cancer, Stem Cells & Developmental Biology. The committee met many excited and happy PhD candidates that stressed the highly collaborative environment at the IBB, as well as their enthusiasm for the great technological facilities, in particular the imaging facilities.

4.4 IBB viability

The IBB harbours many top researchers that are leaders in their fields, who have gathered an exceptional level of funding despite their high teaching load. The institute has an impressive range of facilities and appears well-equipped to attain its goals for the future. In addition, these scientists are addressing research topics that will remain highly relevant to science and society in the years to come. In the past six years, the IBB has strived to reach a critical mass and form a well-connected diverse group of scientists. The institute has strengthened the chair groups through strategic hirings, installed a chair in genome biology & epigenetics, and hired staff with predominantly teaching responsibilities. In addition, the interaction with other partners in the S4L community was intensified.

During the site visit, the IBB presented the common denominator of its PI groups as ‘shared research interests and strategies, such as cell biology, developmental biology, neurobiology, biophysics, genome biology & epigenetics, bioinformatics, and theoretical biology’. However, it is unclear to the committee how the IBB uses its hiring choices to consolidate and reach critical mass and work on cohesiveness. We recommend safeguarding the cohesiveness of the institute and preventing new PIs from being isolated. For instance, the committee felt that to remain competitive, the new chair in genome biology should not remain alone in his field. In addition, we were concerned that hiring a new professor in virology would also lead to an isolated scientist. Moreover, the IBB comes across as composed of two distinct parts, with one group doing mostly cell biology in a broad sense but not gene expression/chromosome studies, and another group doing computational studies focusing on theory/immunology or evolution. Before expanding in two new directions, perhaps the IBB should consider strengthening the connections among the existing groups (see also below). As mentioned in 4.2, we suggest improving the website of the institute to promote a cohesive appearance. We also suggest highlighting joint publications to demonstrate integration within the IBB and beyond.

In the self-assessment report, the IBB listed the modest level of active collaboration between the experimental and theoretical groups as a weakness. We have several suggestions on how to stimulate this collaboration in the future:

- Earmark specific seed money for fellowships for PhD students that work with two supervisors: one in experimental biology and the other in theoretical physics or theoretical biology or another S4L institute. This would encourage bridges and it trains students to think interdisciplinarily.
- Create a track for PhD students that are interested in getting trained at the intersection of experimental biology and theoretical physics/biology.
- Facilitate recruitments that bridge experimental and theoretical groups.

The IBB is housed in the Kruyt Building on Utrecht Science Park. This building is scheduled for intensive renovations, so the IBB research groups located in this building will have to relocate, at least for a certain amount of time. The exact relocation plans are still unclear. Moving the advanced equipment of the institute will be a complex undertaking, so we strongly recommend limiting the number of moves and we argue for housing all S4L scientists in close proximity if possible (also discussed in 2.4).

5. Assessment Institute of Environmental Biology

Institute of Environmental Biology (IEB)

Scientific director: Professor Corné Pieterse (2009-present)

Mission: to perform cutting-edge, curiosity-driven research at the international forefront of our science fields to discover conceptually novel molecular, genetic, physiological, and ecological principles of how plants, microbes and animals interact and adapt to their often hostile biotic and abiotic environment to maximize growth, fitness, and survival ('understanding nature for future innovations').

Department: Biology

Chair groups:

1. Molecular Microbiology,
2. Plant-Microbe Interactions,
3. Plant Stress Resilience,
4. Translational Plant Biology
5. Plant-Environment Signalling,
6. Ecology & Biodiversity,
7. Animal Behaviour & Cognition.

Research staff in 2021: 31 scientific staff; 91 postdocs & PhD candidates (Table 5 in Appendix 2)

Total funding in 2021: 10.2 M € (Table 6 in Appendix 2)

PhD programme coordinated by IEB: Environmental Biology

5.1 Summary of IEB strategy & aims

Strategy in 2016-2021

IEB has organized its research in three strategic research themes:

1. Inspired-by-nature-based discovery of how plants adapt to environmental stress, aiming to gain a deep conceptual understanding of molecular, genetic and (eco)physiological mechanisms in wild and cultivated plant species that enable plants to cope with diverse environmental stresses,
2. Microbes and microbiomes for sustainability of life, aiming to gain fundamental understanding of how microbes grow, develop, survive, and reproduce to foster the development of novel strategies to utilize microbes for our own benefit and harness their potential for sustainable microbiome-based improvements of our future crop systems that are less dependent on chemical fertilizers and pesticides,
3. Ecology for the future: from theory to impact, aiming to uncover the underlying mechanisms and processes that drive ecosystem dynamics, but also to utilize this knowledge to impact future policy and environmental practices.

During the review period, the IEB strategy has focused on

- striving to perform ground-breaking fundamental research towards conceptually novel discoveries with impact in the science field,
- stimulating team-effort science combining different disciplines and expertise,
- creating an open, friendly, inclusive, and lively research community in which a shared enthusiasm for science forms the basis for coaching and training of our next generation scientists,
- translating new discoveries to fuel true innovations in agriculture, industry, nature conservation and animal welfare by engaging in collaborations with the Dutch green life sciences industry and other societal stakeholders.

Future strategy

In the years ahead, IEB intends to continue pursuing the three research aims mentioned above, spearheading fundamental research at the international forefront to understand nature for future innovations. IEB aims to

- strategically attract new staff with promise for the future,
- capitalize on its research facilities,
- maintain a good balance between fundamental and translational research,
- continue to promote Open Science, as well as an inclusive and diverse academic community.

IEB aims to invest in quantitative biological data integration (artificial intelligence, multi-omics, phenomics) and attract new talent in the relevant scientific fields. In addition, the institute will exploit the possibilities offered by the new Netherlands Plant Eco-phenotyping Centre (NPEC) facility and the existing infrastructures BioCliVE and Phytotron. IEB expects to be able to expand its opportunities to translate its fundamental discoveries into solutions for more sustainable and climate resilient crop systems through several large public-private partnership initiatives that it engaged in (the TTW programmes CROP-XR, PLANT-XR, and the Gravitation programme MiCRop).

5.2 IEB research quality

The committee is impressed by the stellar research quality of IEB and the investments that the institute has made in its research facilities. IEB scientists are leaders in their fields. They study the (molecular) biology, physiology, and ecology of plants, microbes, and animals in the context of their environment. Using excellent research facilities such as the Phytotron for high-precision plant growth, a research greenhouse, and the BioCliVE long-term experimental platform, they have produced important novel insights into the mechanisms through which plants, microbes, and animals interact and adapt to their environment to maximize growth, fitness, and survival. Overall, the committee was truly impressed by the global vision of IEB, the continuum in the research interests developed by IEB, the choice of new recruitments, and their communication skills with both scientists and the general public as evidenced for instance by the quality of their website.

The IEB scientists published 619 research articles during the review period. Their papers had a mean field-weighted citation index of 3.4, meaning that they were cited more than 3-fold above the world-average for this field. In addition, IEB contributed to the scientific literature with 91 reviews, 19 book chapters, 79 PhD theses (1 *cum laude*), and 57 other types of publications. Examples of research highlights include a ground-breaking study showing that plant roots sense soil compaction through

restricted gas diffusion, several recent manuscripts revealing novel aspects of plant-microorganism interactions that are relevant for developing a sustainable agriculture, studies connecting plant light responses to defence responses against pathogens, studies on the evolution of dynamic barrier cell types, and animal behavioural studies in primates and birds. The committee visited the future NPEC facility and was highly impressed by its potential. The NPEC is a collaboration with Wageningen University & Research, made possible by a national Roadmap infrastructure grant. It will enable IEB researchers to study the influence of temperature, hygrometry, light duration, and the microbiome on both roots and leaves/flowers in isolation and in combination. Furthermore, they will be able to simultaneously gather omics and cellular imaging data, enabling an integrated organismal view of plants.

5.3 IEB societal relevance

IEB research delivers fundamental insights that relate to multiple grand societal challenges: food security, climate change, biodiversity decline, and sustainable systems. The societal relevance of these topics is increasing dramatically, and we would like to point out that ‘not working on human disease’ is not a weakness. IEB scientists took the lead in initiating the UU-wide ‘Future Food Utrecht’ research community, which is part of the UU strategic theme ‘Pathways to Sustainability’ and aims to translate conceptually novel discoveries into sustainable innovations in agriculture, industry, nature conservation, and animal welfare.

To support its outstanding research and its societal impact, IEB aims to create a research community in which a shared enthusiasm for science forms the basis for coaching and training the next generation of scientists. Indeed, the committee observed that the PhD candidates at IEB appear to be very happy. The institute coordinates the PhD programme ‘Environmental Biology’ within the GSLS. The leader of this PhD programme is very active and committed to the PhD regulations. PhD candidates at IEB are enrolled in either the Environmental Biology or Biomembranes PhD programmes of the GSLS. In addition, they are enrolled in national graduate schools (Experimental Plant Sciences and Production Ecology & Resource Conservation), at which they have an independent advisor. Of the 2013-2015 cohort of PhD candidates, the majority graduated within five years. Of the 2016 cohort, a substantially smaller percentage graduated within five years. According to IEB, this was due to climate chamber failure extensions and corona extensions. Our general suggestions to limit the duration of PhD tracks and safeguard the quality of PhD training are discussed in section 2.6.

During the review period, the institute has actively engaged with industry (e.g., plant breeding and biotechnology companies) and societal stakeholders (e.g., nature organizations, non-governmental organizations, and governmental organizations) to ensure that its discoveries can fuel innovations. IEB is in close contact with Utrecht Holdings (the knowledge transfer office of UU and UMCU) to encourage entrepreneurship. Three successful start-ups emerged from IEB research during the review period. In addition, IEB scientists have mingled in public debates and engaged in outreach activities, such as a debate on gene editing technologies, television interviews, and collaborations with artists. IEB’s public outreach activities are well thought-through; the committee appreciates that a tab on the website is dedicated to outreach.

5.4 IEB viability

IEB appears well-equipped to attain its goals for the future. IEB scientists have demonstrated to be able to conduct excellent research and attract a substantial amount of funding, including many prestigious personal and team-effort grants. The institute has organized training and coaching for its scientists to apply for specific types of funding. In addition, they have engaged in many productive partnerships with industry and societal stakeholders. The new NPEC is a world-class research infrastructure that will facilitate world-leading research in the years to come. IEB has a valid vision for the future, which is forward-looking and supported by funding mechanisms (e.g., CROP-XR/Plant-XR, NPEC, Sector Plan, and Faculty of Science funding for AI Technology for Life) and well-aligned with societal needs. The Future Food Utrecht initiative offers great opportunities to achieve societal impact. IEB has encouraged internal interactions to facilitate conceptual advances. As a result, the overlapping research topics display an impressive cohesiveness. During the review period, the institute has made new hirings to strategically strengthen its profile. The institute acknowledges that it is important to further increase the diversity of its senior staff. In addition, they are committed to talent management.

We have several suggestions to further improve the excellent viability of IEB:

- Like the IBB and some of the Bijvoet research groups, IEB is housed in the Kruyt Building, which is scheduled for intensive renovations. The relocation plans are still unclear. We strongly recommend limiting the number of moves of the research groups and the equipment and we argue for housing all S4L scientists in close proximity if possible (also discussed in 2.4).
- IEB could consider offering seed money for new projects involving two groups from distinct S4L institutes (enhancing interactions across institutes) or creating a track for PhD projects supervised by two PIs from different disciplines to foster interactions as well as ‘train brains’ in a different way (also discussed in 2.4).
- The number of support staff members with a permanent position appears to be very limited at IEB. We encourage the faculty to consider developing a strategic plan to ensure the viability of NPEC beyond its currently guaranteed support to reap the largest possible return on the investment and the greatest impact on Dutch and European science and society. This facility has no equal elsewhere in the world and it will attract the best and the brightest scientists in plant science, microbiology, and ecology to Utrecht, as well as future funding.
- It is also important to consider if the available bioinformatics infrastructure (i.e., facilities for data integration and data storage, including data scientists) will be sufficient to handle the amount of data that will be generated with the NPEC facility.

6. Utrecht Institute for Pharmaceutical Sciences

Utrecht Institute for Pharmaceutical Sciences (UIPS)

Scientific director: Professor Heck (2015-2018), Professor Roos Masereeuw (2018 – present)

Mission: to explore advanced and affordable biomolecular and cellular therapies (Future Medicines).

Research divisions:

1. Pharmacology,
2. Chemical Biology and Drug Discovery (also embedded in the Bijvoet Centre),
3. Pharmacoepidemiology and Clinical Pharmacology,
4. Pharmaceutics,
5. Biomolecular Mass Spectrometry and Proteomics (also embedded in the Bijvoet Centre).

Department: Pharmaceutical Sciences

Research staff in 2021: 104 scientific staff; 108 postdocs & PhD candidates (Table 7 in Appendix 2)

Total funding in 2021: 16.7 M € (Table 8 in Appendix 2)

PhD programme coordinated by UIPS: Drug Innovation

6.1 Summary of UIPS strategy & aims

Strategy in 2016-2021

UIPS researchers focus on drug development, drug action, and drug therapy of biomolecules, as well as the societal aspects of these therapies. UIPS has traditionally focused on biomolecules rather than small synthetic molecules and on precompetitive research rather than mimicking biotech or pharma companies. The institute focuses on precision medicine, which it defines as ‘an innovative approach to tailoring disease prevention and treatment that takes into account differences in people’s genes, environment and lifestyles, and requires omics approaches’.

Future strategy

In 2020, the Department of Pharmaceutical Sciences produced a ‘Vision 2025’ document, describing its aims for education, research, and societal outreach. According to this document, UIPS aims to contribute to

- the fundamental and translational aspects of making new drugs and diagnostics,
- the fundamental and translational aspects of measuring for precision medicine purposes,
- modelling using data science.

The institute aims to focus on biomolecular and cellular therapies and to make better predictive and translational models in the years to come. The committee thinks that it is crucial that UIPS will

incorporate 'Big Data and artificial intelligence' into its future scientific strategy in addition to modelling using data science.

6.2 UIPS research quality

Leveraging its expertise in immunology, glycobiology, pharmacoepidemiology, biomolecular delivery, and proteomics, UIPS has made an outstanding contribution to the field of pharmaceutical sciences during the review period. UIPS research is strongly interdisciplinary, and the research facilities of the institute are very impressive. In our opinion, the self-assessment report did not fully do justice to the strengths of UIPS. We applaud the interdisciplinarity, the richness of equipment, and the multiscale approaches at this institute. We noticed that UIPS manages to offer permanent positions to scientifically trained technical support staff. This example may be adopted by the other institutes. To support its high-quality research, UIPS is using the UU-wide Yoda system for FAIR and secure data storage.

Overall, UIPS research is aimed at 'future medicines' including modalities such as advanced therapy medicinal products. This is a very crucial direction for the development of new therapies and distinguishes UIPS from many other pharmaceutical research centres who devote much less attention to this direction of research. In addition to disciplines such as pharmacology and pharmaceuticals, the domains of pharmacoepidemiology and pharmaco-economics are also among UIPS' strengths. Regulations and (future) restrictions related to personal data and privacy may hamper progress in the latter area.

The UIPS scientists published 2129 research articles during the review period. Their papers had a mean field-weighted citation index of 2.1, meaning that they were cited more than twice the world-average for the field of pharmaceutical science. In addition, UIPS contributed to the scientific literature with 313 reviews, 20 book chapters, 182 PhD theses (3 *cum laude*), and 98 other types of publications. Examples of research highlights include the work on the human plasma IgG repertoire, and the technologically advanced orbitrap-based single molecule charge detection mass spectrometry applied to enable single ion detection of adeno-associated viruses. In addition, the research of the institute is taking a very timely and modern twist that should be encouraged and strengthened: integrating single-cell mass-spectrometry (MS) with pharmacology and epidemiology to dissect immune responses to viruses and other infections. Novel translational routes are developing successfully in coupling *de novo* antibody sequencing with MS-based techniques to tackle complex clinical samples from endogenous sources such as serum and other liquid biopsies.

6.3 UIPS societal relevance

One example of a key research result and its societal implication is the discovery that antibodies from COVID-19 patients bind to the coronavirus SARS-CoV-2 in their own unique way. UIPS researchers discovered these distinctive binding properties using single-molecule analyses. Being able to select the best-binding antibodies from a pool of antibodies obtained from the blood of COVID-19 patients may lead to new medicines to treat COVID-19.

UIPS considers the training of professionals and researchers as its most important contribution to society. The institute is responsible for the BSc programme in Pharmacy, including the international honours programme 'College of Pharmaceutical Sciences'. In addition, it is responsible for the MSc of Pharmacy programme and the research MSc programme Drug Innovation. The PhD programme Drug Innovation is coordinated by UIPS as well. The majority of PhD candidates at UIPS are enrolled in the Drug Innovation PhD programme, which currently has more than 150 PhD candidates. This active PhD community was challenged by the COVID lockdowns and building renovations during the review period, as one of their buildings received an extensive makeover to accommodate the cryo-EM facility.

In addition to training professionals, UIPS has contributed to society through strategic alliances with clinically oriented research institutions, companies, and health organizations, and by occupying important positions in the Dutch health landscape. One of the UIPS representatives that were interviewed during the site visit suggested that a general risk-adverse climate in the Netherlands hampers translation of academic research results into practical applications. This may be a general shortcoming in the Dutch academic climate. Suggestions to partially tackle this difficult issue were discussed in section 2.3.

6.4 UIPS viability

UIPS celebrated its 30 years anniversary in 2022. The institute has strategically positioned itself as a bridge between the Department of Chemistry, Department of Biology, and UMCU, which makes sense. The permanent staff was able to acquire both personal grants as well as funding for large consortia. UU has invested substantially in the computational infrastructure (HPC and support staff) at the university level, which is beneficial for UIPS. Taken together, the committee has the impression that the institute is properly equipped to reach its strategic goals. We agree with the institute that the connection between teaching pharmaceutical sciences and research focus at the divisions, and between lab and non-lab research can be improved.

During the evaluation period, UIPS has used human resources measures to strengthen its viability. The institute hired assistant professors on tenure track to increase the focus of its research programmes. A significant part of the senior staff at UIPS will retire within the next five years and the group to follow up the career ladder is rather small. They have a good strategy to address the resulting gap between staff at full professor level and assistant/associate level. The institute is aware of the importance of diversity and is also actively working on social safety, for instance by organizing dilemma games. We have several recommendations that may help to ensure that UIPS will continue to thrive in the future:

- UIPS could use more data scientists, so we recommend recruiting these.
- Ensure that UIPS obtains sufficient critical mass to support the input of artificial intelligence methodologies.

7. Summary and recommendations

7.1 Summary of observations and conclusions

In line with their strategic aims, the S4L institutes have performed excellent technology-driven fundamental science in the period 2016-2021. Their research covers a broad spectrum of fundamental and more applied research questions, offering perspectives for improved healthcare and a more sustainable society. The institutes harbour state-of-the-art equipment and superb technology platforms. This research infrastructure supports Utrecht-based researchers and attracts academic and industrial collaborators from across the country and beyond. The institutes are pushing the principles of Open Science to promote the uptake of their research results by peers and stakeholders. Their collaborations with university medical centres, societal organizations, and companies result in applicable know-how, thus spurring economic activity and knowledge development in the Netherlands and abroad. The institutes also engage in a variety of outreach activities.

The PhD candidates at S4L are enrolled in Utrecht University's Graduate School of Life Sciences, which organizes training and support. The large number of enthusiastic PhD candidates adds to the lively atmosphere at the institutes. The average duration of PhD tracks is rather long in some of the S4L institutes, but it is difficult to interpret this without further details. We recommend organizing exit meetings with PhD candidates after their track has ended to get more insight in this. The graduate school has developed a new quality assurance plan for doctoral education. In general, the committee is impressed by the new PhD guide and the other measures that were recently installed to safeguard high-quality training of PhD candidates at the graduate school. The right procedures appear to be in place. Now, it is time to actively ensure that these procedures will be followed up in the future. In addition, we recommend implementing active monitoring of the professional and personal development of PhD candidates by an independent external advisor and providing a clear view on job opportunities and career paths.

The topics that the S4L institutes are studying will be of high and growing societal relevance in the years to come. The human and financial resources of the institutes appear to be sufficient to implement their strategy for the future. They have managed to create a lively scientific community, which has expanded during the review period and is firmly embedded in the larger research community at Utrecht Science Park. The institutes have an adequate scientific and societal strategy for the future. The institute leaders are aware of the importance of diversity, social safety, and research integrity, and are interested to learn how to overcome the associated challenges.

To ensure that the institutes will continue to thrive, our main recommendations are to (i) continue the investments in community building, for instance by launching a community for S4L postdocs, (ii) ensure a stable and advantageous housing situation for the institutes with minimal moves of research groups and their equipment, (iii) ensure that the new PhD guidelines are universally followed, (iv) provide good career perspectives for high-end technical support staff, (v) enhance the visibility and accessibility of the facilities, and (vi) improve the scalability of the computational infrastructure. A complete list of recommendations and suggestions is provided in section 7.3.

7.2 Additional questions posed in the Terms of Reference

How could the S4L institutes further intensify their interactions and collaborations with other researchers within the STLS?

The S4L institutes play a connecting role in the broader life sciences community at Utrecht Science Park. S4L is exemplary, so we recommend enhancing its visibility for the other Utrecht-based research groups in this field. As discussed in section 2.4, possible approaches include launching a community for S4L postdocs, and increasing the structural budget for the S4L umbrella. This may strengthen the role of the S4L institutes as leaders and connectors of the local fundamental life sciences community and may help them to present themselves to private partners.

How could knowledge transfer and innovation be further optimized?

As discussed in section 2.3, S4L research creates a wealth of fundamental knowledge about the building blocks of life that has great potential to contribute to solutions to the urgent challenges that society currently faces. PhD candidates at UU can receive entrepreneurial training, which is a sign that the university acknowledges the importance of knowledge transfer and innovation. In addition, Utrecht Science Park hosts a substantial number of companies, building an ecosystem for translational activities. Intensifying the community building efforts of S4L may help the institutes to become more visible for private partners. At the same time, the infrastructure and regulations at UU do not favour the foundation of spin-off activities by PIs. This may be a general shortcoming in the Dutch academic climate. The committee wonders whether UU could grant sufficient room (e.g., for one year) and ownership to scientists that want to spend more time on developing a spin-off company.

How could the S4L technology platforms be more optimally used, and their function and maintenance safeguarded for the future?

As discussed in section 2.4, different access systems are currently in place for different facilities. Some of these access models may benefit from introducing a subscription fee or joint investments to ensure that the platforms remain viable, so that innovations and replacements are part of the cost system used. Joint S4L applications for funding may impress grant providers. Overall, the access systems appear to work well at the level of institutes but are not optimal yet when scientists from other institutes wish to use a facility. The visibility of the facilities may be enhanced. Although the technology platforms are well-represented at the S4L website, the (contact) information needs continuous updating and is sometimes missing at present. We also recommend organizing lab tours to familiarize new scientific employees with the facilities (especially onboarding tenure trackers). The S4L technology platforms are exemplary and deserve to be better known among all staff members. In addition, we recommend creating permanent positions for talented scientifically trained technical support staff that can operate the state-of-the-art equipment of the institutes.

7.3 Complete list of recommendations and suggestions mentioned in the report

(Note that the recommendations and suggestions are addressed at the institutes, unless indicated otherwise.)

Recommendations and suggestions for S4L as a whole

- Explore opportunities to grant sufficient room to scientists that want to spend time on developing a spin-off company (recommendation for the university, p. 9 & 34).
- Intensify the community building efforts of S4L, for instance by offering a more structured introduction to S4L facilities and activities to newly hired researchers, launching a community for S4L postdocs, increasing the structural budget of the S4L umbrella, and offering seed money for projects involving multiple S4L institutes (p. 10 & 25 & 29).
- Ensure a stable and advantageous housing situation for the institutes, by limiting the number of moves of the research groups and their equipment, giving the scientists a seat at the table in the negotiations and deliberations about their future housing situation, and striving for the optimal situation where the four institutes would be housed in close proximity (recommendation for the university, p. 11 & 21 & 25 & 29).
- Enhance the visibility and accessibility of the research facilities, for instance by continuously updating the (contact) information on the S4L website and by offering lab tours to new personnel (especially tenure trackers) (p. 12).
- Develop a strategy to support the careers of scientifically trained technical support staff, for instance by spending a percentage of research grants or the overhead on grants on permanent positions for talented support staff (recommendation for the university, faculty, and institutes, p. 12 & 17).
- Continuously monitor the scalability and integration of the current and future computational infrastructure, including the current system of data storage and management (p. 12 & 13).
- Consider how to safeguard open access to publications should nation-wide agreements between the Dutch universities and publishers disappear (recommendation for the university, p. 13).
- Actively ensure that the procedures to safeguard high-quality training and supervision of PhD candidates described in the new PhD guide will be followed up in the future. There should be consequences for the institution or the supervisors if the procedures are not followed up (p. 13).
 - Monitor adherence to the PhD programme more closely, so that the vast majority of PhD candidates will obtain the GSLS training certificate (p. 13).
 - Collect more detailed data about the (often long) duration of the PhD tracks and the reasons for that. Finishing a PhD thesis while being unemployed should be avoided at all costs and is legally not an option (recommendation for the GSLS, p. 14).
 - Appoint an independent external advisor for every PhD student who annually surveys progress and organizes exit meetings at the end of the PhD trajectory (p. 14).
 - Facilitate a clear view on job opportunities and career paths for PhD candidates, for instance by launching an alumni programme (p. 15).
- Continue the endeavour to safeguard social safety and research integrity because there is room for improvement, as is the case in any institution. We applaud the trial in which the PhD confidential advisor schedules yearly meetings with all PhD candidates and strongly support the implementation of this system (p. 15).

- Invigorate the ambitions for a more balanced representation of females and minorities among the scientific staff, for instance by using a percentage of the overhead on grants for start-up packages to attract talented new staff members from minority groups, by considering dual hires to attract female talents, or by organizing and funding summer research internship programmes for high school and BSc students belonging to minority groups (p. 16).
- Ensure that promotion criteria for the transition from assistant to associate professor are clear for young investigators (p. 17).
- Evaluate the success and potential pitfalls of the various approaches to offering start-up packages to tenure trackers and try to offer start-up packages to all incoming tenure trackers (p. 17).
- Develop a strategy to support the careers of young specialists at the intersection of bioinformatics computational biology and classical biology. This discipline should be valued and protected (p. 17).
- Devote more attention to training, supervision, and career perspectives of postdocs at the S4L institutes (p. 10 & 17).

Recommendations and suggestions specific for the Bijvoet Centre

- Consider ‘molecules in the context of the cell’ or ‘structural biology in vivo’ as an additional research focus in the years to come (p. 19).
- Strengthen the expertise in artificial intelligence because that would complement and reinforce the already very strong expertise at the Bijvoet Centre (p. 20).
- Recruit more female structural biologists in addition to the one that was recently hired (p. 20).
- Strive to house the Bijvoet scientists under one roof (p. 21).

Recommendations and suggestions specific for the IBB

- Organize structural support to improve the IBB website and ensure that the website presents the IBB research in a cohesive way (p. 24).
- Ensure that the hiring strategy promotes cohesiveness and prevents new PIs from being isolated (p. 25).
- Earmark seed money for fellowships for PhD students that work with two supervisors: one in experimental biology and the other in theoretical physics or theoretical biology or another S4L institute. This would encourage bridges and train PhD students to think interdisciplinarily (p. 25).
- Create a track for PhD students that are interested in getting trained at the intersection of experimental biology and theoretical/biology (p. 25).
- Facilitate recruitments that bridge experimental and theoretical groups (p. 25).

Recommendations and suggestions specific for IEB

- Consider creating seed money for new projects involving two groups from distinct S4L institutes (enhancing interactions across institutes) or creating a track for PhD projects supervised by two PIs from different disciplines to foster interactions as well as ‘train brains’ in a different way (p. 29).
- Develop a strategic plan to ensure that NPEC will have sustainable support staff in the future (p. 29).

- Consider if the available bioinformatics infrastructure (i.e., facilities for data integration and data storage, including data scientists) will be sufficient to handle the amount of data that will be generated with the NPEC facility (p. 29).

Recommendations and suggestions specific for UIPS

- Incorporate 'Big Data and artificial intelligence' into its future scientific strategy and ensure that UIPS obtains sufficient critical mass to support the input of artificial intelligence methodologies (p. 30 & 32).
- Continue the endeavour to improve the connection between teaching pharmaceutical sciences and research focus at the divisions, and between lab and non-lab research (p. 32).
- Recruit more data scientists (p. 32).

Appendix 1. Site visit programme

Monday, November 14

S4L Conference, Jaarbeurs Utrecht: <https://www.uu.nl/en/S4L2022>

17:30 – 18:00 Welcome drinks (during drinks & bites S4L Conference)

Review committee, Linda van den Berg (Secretary), Isabel Arends (Dean), Institute directors

19:00 – 21:30 Working dinner

Review committee and Linda van den Berg (Secretary)

Hotel

Tuesday, November 15				Location
8:30	8:45	Private kick-off meeting	Review committee	<i>Kruyt building O128</i>
8:45	10:00	Faculty Management and institute directors Welcome by Dean Introduction S4L: 10' presentation by Corné Pieterse General questions by committee	Dean Dept. Heads (Biol., Chem. and Pharm. Sciences) S4L institute directors Director doctor education Graduate School LS	<i>Kruyt building O128</i>
10:00	10:30	Coffee break, brief evaluation Preparation for IBB	Review committee	<i>Kruyt building O128</i>
10:30	11:30	Institute of Biodynamics and Biocomplexity (IBB) 5' presentation by Institute Director 5' research highlight by PI 50' questions/discussion	IBB representatives	<i>Kruyt building O128</i>
11:30	12:30	IBB lab tour + meet staff		<i>Kruyt building</i>
12:30	14:00	Lunch Interim evaluation IBB Preparation for IEB	Review committee	<i>Kruyt building O110</i>
14:00	15:00	Institute of Environmental Biology (IEB) 5' presentation by Institute Director 5' research highlight by PI 50' questions/discussion	IEB representatives	<i>Kruyt building O128</i>
15:00	16:00	IEB lab tour + meet staff		<i>Kruyt building</i>
16:00	16:30	Interim evaluation IEB	Review committee	<i>Kruyt building O128</i>
16:30	17:15	PhD candidates all institutes 4-5 per institute	Review committee	<i>Kruyt building O128</i>
17:15	17:45	Early career staff all institutes 4-5 per institute	Review committee	<i>Kruyt building O128</i>
17:45	18:30	Young Investigators Forum YIF board	Review Committee	<i>Kruyt building O128</i>
18:30	19:00	Taxi to restaurant		
19:00	21:30	Dinner	Review committee Dean Dept. Heads S4L directors 2 YIF Board members	<i>Goesting</i>

Wednesday, November 16				Location
8:30	8:45	Preparation for Bijvoet Center	Review committee	<i>Kruyt building O128</i>
8:45	9:45	Bijvoet Center 5' presentation by Institute Director 5' research highlight by PI 50' questions/discussion	Bijvoet representatives	<i>Kruyt building O128</i>
9:45	10:45	Bijvoet lab tour + meet staff		<i>Kruyt building</i>
10:45	11:15	Coffee break, Interim evaluation Bijvoet	Review committee	<i>Kruyt building O128</i>
11:15	12:30	Walk to DDW building 12:00 lunch @ DdW Preparation for UIPS	Review committee	<i>David de Wied building M3.04</i>
12:30	13:30	Utrecht Institute for Pharmaceutical Sciences (UIPS) 5' presentation by Institute Director 5' research highlight by PI 50' questions/discussion	UIPS representatives	<i>David de Wied building M3.05</i>
13:30	14:30	UIPS lab tour + meet staff		<i>David de Wied building</i>
14:30	15:00	Interim evaluation UIPS	Review committee	<i>David de Wied building M3.04</i>
15:00	15:30	Wrap up meeting Final interview with management/feedback session	Review committee, Dept. Heads Institute Directors	<i>David de Wied building M1.01</i>
15:30	17:15	Private final meeting	Review committee	<i>David de Wied building M1.01</i>
17:15	17:30	Presentation of provisional findings by chairman review committee	Public Faculty Dean Dept. Heads Institute directors	<i>David de Wied building M1.01</i>
17:30	18:30	Closing, drinks and bites	Public Faculty Dean Dept, heads Institute directors	<i>David de Wied building M1.01</i>

Appendix 2. Quantitative data on the S4L composition and funding

The tables in this appendix were copied from the S4L self-assessment report.

Explanation of staff tables

The number of FTE (full-time equivalents) in the staff tables refers to the total employment of the research staff. A researcher with a full-time position thus counts for 1 FTE, even though this person will typically spend a significant amount of time on non-research activities such as teaching. At UU, typical percentages of time spent on research are 40% for professors, associate professors, and assistant professors; 90% for postdocs; 75% for PhD candidates; and 100% for external fellowship holders. Each year, 31 December was used as date for the headcount and FTE counting.

Explanation of funding and expenditure tables

'Direct funding' is funding by the university ('basisfinanciering'), 'Research grants' are grants obtained in national and international scientific competition through open calls, such as grants from NWO, KNAW, and ERC. 'Contract research' is funding for specific research projects obtained from external organisations, such as industry, governmental ministries, the European Commission, and charity organizations.

Table 1: Bijvoet Centre research staff (only including staff employed by Department of Chemistry)

# / FTE	2016	2017	2018	2019	2020	2021
Full professor	8 / 7,00	7 / 6,00	9 / 6,50	9 / 6,60	9 / 7,00	9 / 7,00
Associate professor	3 / 3,00	5 / 5,00	6 / 6,00	8 / 8,00	7 / 7,00	7 / 7,00
Assistant professor	11 / 10,60	12 / 11,60	11 / 10,80	9 / 8,80	10 / 9,80	9 / 8,80
Total scientific staff	22 / 20,60	24 / 22,60	26 / 23,30	26 / 23,40	26 / 23,80	25 / 22,80
Postdocs	22 / 21,10	25 / 24,60	27 / 25,90	31 / 29,85	28 / 27,05	25 / 23,55
PhD candidates	50 / 50,00	43 / 43,00	37 / 37,00	41 / 41,00	42 / 41,30	43 / 43,00
Total PD + PhD	72 / 71,10	68 / 67,60	64 / 62,90	72 / 70,85	70 / 68,35	68 / 66,55

Table 2: Bijvoet Centre funding and expenditure

	2016	2017	2018	2019	2020	2021
Funding:						
Direct funding (1)	2.9M€ / 28%	3.5M€ / 38%	3.4M€ / 35%	3.8M€ / 32%	4.2M€ / 39%	4.0M€ / 23%
Research grants (2)	5.9M€ / 57%	5.7M€ / 62%	4.8M€ / 49%	6.0M€ / 52%	4.8M€ / 45%	12.1M€ / 69%
National grants	4.4M€	4.0M€	3.1M€	3.7M€	2.7M€	9.6M€
International grants	1.5M€	1.7M€	1.7M€	2.4M€	2.1M€	2.5M€
Contract research (3)	1.6M€ / 15%	1.3M€ / 12%	1.0M€ / 11%	1.4M€ / 12%	1.2M€ / 11%	1.1M€ / 6%
Other	-	0.3M€ / 3%	0.4M€ / 4%	0.5M€ / 4%	0.6M€ / 5%	0.5M€ / 2%
Total funding	10.4M€ / 100%	10.8M€ / 100%	9.6M€ / 100%	11.6M€ / 100%	10.8M€ / 100%	17.6M€ / 100%
Expenditure:						
Personnel costs	6.3M€ / 61%	6.1M€ / 56%	6.5M€ / 67%	7.4M€ / 63%	7.6M€ / 70%	8.1M€ / 46%
Other costs	4.1M€ / 39%	4.7M€ / 44%	3.1M€ / 33%	4.2M€ / 37%	3.2M€ / 30%	9.5M€ / 54%
Total expenditure	10.4M€ / 100%	10.8M€ / 100%	9.6M€ / 100%	11.6M€ / 100%	10.8M€ / 100%	17.6M€ / 100%

Table 3: IBB research staff

# / FTE	2016	2017	2018	2019	2020	2021
Full professor	5 / 4.9	5 / 4.9	7 / 6.9	7 / 6.9	8 / 7.9	8 / 7.9
Associate professor	7 / 6.2	8 / 7.2	5 / 5	6 / 5.5	5 / 4.5	6 / 5.5
Assistant professor	10 / 9.2	9 / 8.2	9 / 7.9	11 / 10.6	13 / 12.6	15 / 14.4
Total scientific staff	22 / 20.3	22 / 20.3	21 / 19.8	24 / 23	26 / 25	29 / 27.8
Postdocs	28 / 27.2	29 / 27.9	19 / 18.3	18 / 18	22 / 21.8	18 / 18
PhD candidates	57 / 34.6	68 / 46.3	63 / 47.5	67 / 49.5	69 / 54.7	64 / 47
Total PD + PhD	85 / 61.8	97 / 74.2	82 / 65.8	85 / 67.5	91 / 76.5	82 / 65

Table 4: IBB funding and expenditure

IBB	2016	2017	2018	2019	2020	2021
Funding						
Direct funding	€2,0m / 31%	€2,0m / 27%	€2,2m / 28%	€2,3m / 30%	€2,4m / 27%	€2,8m / 38%
Research grants	€3,7m / 57%	€4,6m / 62%	€4,8m / 63%	€4,6m / 61%	€5,0m / 64%	€3,9m / 54%
Contract research	€0,7m / 11%	€0,7m / 10%	€0,6m / 8%	€0,6m / 8%	€0,4m / 6%	€0,5m / 7%
Other	€0,1m / 1%	€0,1m / 1%	€0,1m / 1%	€0,1m / 1%	€0,0m / 0%	€0,0m / 1%
Total funding	€6,5m / 100%	€7,4m / 100%	€7,7m / 100%	€7,6m / 100%	€7,8m / 100%	€7,3m / 100%
Expenditure						
Personnel costs	€5,0m / 76%	€5,5m / 74%	€5,8m / 77%	€6,0m / 78%	€6,2m / 80%	€6,0m / 83%
Other costs	€1,6m / 24%	€1,9m / 26%	€1,7m / 23%	€1,6m / 22%	€1,6m / 20%	€1,3m / 17%
Total expenditure	€6,5m / 100%	€7,4m / 100%	€7,6m / 100%	€7,6m / 100%	€7,8m / 100%	€7,3m / 100%

Table 5: IEB research staff

# / FTE	2016	2017	2018	2019	2020	2021
Full Professor	9 / 7.8	9 / 7.8	9 / 7.7	9 / 7.7	10 / 9	10 / 9
Associate Professor	2 / 1.5	2 / 1.5	4 / 3.4	4 / 3.4	3 / 2.9	3 / 3
Assistant Professor	15 / 13.3	17 / 15.6	14 / 13.4	15 / 13.9	16 / 13.9	18 / 16.1
Total scientific staff	26 / 22.6	28 / 24.9	27 / 24.5	28 / 25	29 / 25.8	31 / 28.1
Postdocs	19 / 16.7	18 / 15.5	18 / 15.5	22 / 19.7	22 / 20.4	22 / 21.2
PhD candidates	54 / 52.6	55 / 52.7	61 / 58	59 / 55.5	61 / 48.8	69 / 68.2
Total PD + PhD	73 / 69.3	73 / 68.2	79 / 73.5	81 / 75.2	83 / 69.2	91 / 89.4

Table 6: IEB funding and expenditure

IEB	2016	2017	2018	2019	2021
Funding					
Direct Funding	€3,0m / 46%	€3,3m / 45%	€3,3m / 44%	€3,3m / 41%	€3,9m / 38%
Research Grants	€2,7m / 42%	€3,0m / 40%	€3,1m / 42%	€3,5m / 44%	€4,8m / 47%
Contract Research	€0,8m / 12%	€1,1m / 15%	€1,1m / 15%	€1,2m / 15%	€1,5m / 14%
Other	€0m / 0%	€0m / 0%	€0m / 0%	€0m / 0%	€0m / 1%
Total Funding	€6,4m / 100%	€7,3m / 100%	€7,6m / 100%	€8,0m / 100%	€10,2m / 100%
Expenditure					
Personnel costs	€5,1m / 80%	€6,0m / 81%	€6,4m / 84%	€6,6m / 83%	€8,5m / 83%
Other costs	€1,3m / 20%	€1,4m / 19%	€1,2m / 16%	€1,4m / 17%	€1,8m / 17%
Total expenditure	€6,4m / 100%	€7,3m / 100%	€7,6m / 100%	€8,0m / 100%	€10,2m / 100%

Table 7: UIPS research staff

# / FTE	2017	2018	2019	2020	2021	2021
Full professor	23/14	21/11,6	22/14,5	22/15,4	23/16,8	25/17,7
Associate professor	21/19,5	21/19,4	15/13,1	21/15,2	18/13,2	20/15,1
Assistant professor	45/31,6	45/32,8	48/35,5	42/32,3	42/33,8	45/36,8
Jr assistant professor	6/5,8	4/3,8	2/1,8	7/6,6	13/12,2	14/13,5
Total scientific staff	95/70,9	91/67,6	87/64,9	92/69,5	96/76	104/83,1
Postdocs	39/36,6	38/6,2	39/36,3	35/32,5	28/26,3	32/30,9
PhD candidates	57/56,2	62/60	57/55,1	66/64,3	76/73,5	76/74,5
Total PD + PhD	96/92,8	100/96,2	96/91,4	101/96,8	104/99,8	108/105,4
All PhD candidates	177	186	188	198	207	193

Table 8: UIPS funding and expenditure

	2016	2017	2018	2019	2020	2021
Funding						
Direct funding (1)	6,2m / 46%	6,2m / 42%	5,9m / 41%	6,1m / 40%	6,8m / 45%	7,4m / 44%
Research grants (2)	4,2m / 31%	4,3m / 29%	4,5m / 31%	5,1m / 34%	4,8m / 32%	5,4m / 32%
National	2,6m	2,8m	2,2m	3,4m	2,8m	2,1m
International	1,6m	1,5m	2,3m	1,7m	2,0m	3,3m
Contractresearch (3)	3,0m / 22%	4,1m / 28%	4,0m / 28%	4,0m / 26%	3,3m / 22%	3,7m / 22%
Other	0,1m / 1%	0,2m / 1%	0,1m / 1%	0,0m / 0%	0,1m / 1%	0,2m / 1%
Total funding	13,6m / 100 %	14,8m / 100%	14,5m / 100%	15,2m / 100%	15,0m / 100%	16,7m / 100%
Expenditure						
Personnel costs	9,7m / 71%	10,8m / 73%	10,9m / 75%	11,1m / 73%	11,9m / 79%	12,6m / 75%
Other costs	4,0m / 29%	4,0m / 27%	3,6m / 25%	4,2m / 27%	3,1m / 21%	4,2m / 25%
Total expenditure	13,6m / 100%	14,8m / 100%	14,5m / 100%	15,2m / 100%	15,0m / 100%	16,7m / 100%