Research Assessment Report 2021

Institute for Molecules and Materials
Contents

1. Introduction
1.1 Background 1
1.2 Members of the assessment committee 2
1.3 Procedure 3
1.4 Research unit under assessment: Institute for Molecules and Materials 7
1.5 Summary of IMM aims and strategy 9

2. Evaluation of the Institute for Molecules and Materials as a whole
2.1 IMM aims and strategy 13
2.2 Research quality 16
2.3 Societal relevance 21
2.4 Viability 24

3. Evaluation per theme
3.1 Structure and Dynamics of Molecules 29
3.2 Chemistry of Complex Systems 33
3.3 Spectroscopy of Quantum Matter 41

4. Summary of conclusions and recommendations 45

5. Response of the institute 48

Appendices
Site visit programme 54
Quantitative data on the IMM’s composition and funding 57
1. Introduction

1.1 Background
This report presents the assessment of the research conducted at the Institute for Molecules and Materials (IMM) of Radboud University (Nijmegen, the Netherlands) in the period 2015-2020. The assessment was performed by an external review committee using the Strategy Evaluation Protocol 2021-2027 (SEP). 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, and NWO or KNAW institutes is assessed once every six years in accordance with the SEP. The primary aim of SEP assessments is to evaluate the research quality, societal relevance, and viability of a research unit in light of its own aims and strategy, and to suggest improvements where necessary.

Target groups that are served by this IMM assessment include:

- the researchers and management of the IMM, who need to know how the quality of IMM 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 Board of Radboud University and the Faculty of Science who wish to track the impact of their research policy,
- the Dutch government that would like to know 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 IMM delivers.

1.2 Members of the assessment committee
The Board of Radboud University has appointed as members of the assessment committee:

- Professor Thom Palstra, chair (University of Twente, the Netherlands),
- Professor Jeffrey Reimer (UC Berkeley, USA),
- Professor Elena Besley (University of Nottingham, UK),
- Professor Ed Tate (Imperial College London, UK),
- Professor Rein Ulijn (City University New York, USA),
- Professor Claus M. Schneider (Forschungszentrum Jülich GmbH, Germany),
- Professor Silke Biemann (Ecole Polytechnique, France),
- Dr Eline Hutter (Utrecht University, the Netherlands),
- MSc Hannah Jonas (University of Amsterdam, the Netherlands).
Dr Linda van den Berg (Washoe Life Science Communications) served as the secretary to the assessment committee. The committee members have 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 IMM based on
● the institute’s self-evaluation report, which described the mission, objectives, structure, management, PhD training programme, career and diversity policy, and academic culture of the institute, as well as a reflection on the research quality, societal impact, facilities, a SWOT analysis, and the future strategy of the institute as a whole and the three themes,
● a series of interviews during a site visit in October 2021, with the Faculty Board, IMM Board, theme representatives, and representatives of assistant professors, associate professors, postdocs, PhD candidates, and technicians, as well as a tour of the facilities. The discussions were transparent and constructive. The site visit programme is listed in Appendix 1.

The global COVID-19 crisis prevented one committee member from physically visiting the institute, but the others
were present at the IMM during the site visit and received a guided tour of the facilities. In addition, the full committee met virtually twice prior to the site visit, ensuring that there was sufficient time to prepare for the interviews. We are confident that the hybrid nature of the site visit (i.e., partially virtual and partially in-person) did not prevent us from receiving a clear view of the research conducted at the IMM and carrying out a solid and careful review.

Assessment criteria
The assessment committee evaluated the IMM research based on three assessment criteria, all in light of the institute’s own aims and strategy:

• **Research quality**, i.e., the quality and scientific relevance of the IMM 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 IMM research in economic, social, cultural, educational or other terms, including the teaching-research nexus,

• **Viability**, i.e., the extent to which the IMM’s 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 the IMM in
relation to the expected developments in the field and society as well as on the wider institutional context of the IMM.

The committee was also asked to consider the organization in three research themes and to suggest alternatives for this organizational structure.

**Aspects**

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

- **Open science**
  - involving stakeholders in the preparation and execution of the IMM aims and strategy,
  - opening up the IMM work 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 program, including position of PhD candidates and PhD training in the IMM research,
  - selection and admission procedures for PhD candidates,
  - program content and structure,
• 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 IMM 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 IMM 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 IMM guarantees diversity-promoting HR practices such as inclusive
selection and appraisal procedures and its actions and future plans,

- IMM policies on **talent** selection and development, i.e., the IMM 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 IMM offers opportunities for diverse career paths and ensures that researchers are properly evaluated, rewarded and incentivised.

1.4 Research unit under assessment: Institute for Molecules and Materials

The Institute for Molecules and Materials (IMM) was founded in 2005 and is one of the research institutes of the Faculty of Science of Radboud University. It is an interdisciplinary research institute in chemistry and physics that aims to create, discover, and understand processes and phenomena in atomic and molecular environments. This aim is pursued by 24 IMM research groups – 18 within the IMM research institute itself and 6 within the organizational units of the High Field Magnet Laboratory (HFML) and the Free Electron Laser for Infrared eXperiments (FELIX). At present, the research of the IMM is organized in three themes:

- **Theme 1: Structure and Dynamics of Molecules**, aiming to acquire a detailed understanding of molecular
structures and interactions (theme representative: Arno Kentgens),

- **Theme 2: Chemistry of Complex Systems**, aiming to understand chemical processes in which many different compounds react in multiple steps in mixtures at high overall concentrations, inspired by the chemical processes in living cells (theme representative: Floris Rutjes),

- **Theme 3: Spectroscopy of Quantum Matter**, aiming to understand, develop, and manipulate materials based on collective or emergent quantum effects, which could lead to new types of functions (theme representative: Alex Khajetoorians).

HFML and FELIX are both running a user programme and are independent organizational units with their own management owing to the specific financial structure associated with these large facilities. During the review period, HFML-FELIX was jointly financed (50-50) by Radboud University and NWO. At present, the director of HFML is Peter Christianen; the director of FELIX is Britta Redlich.

**Management and organization**
The institute is governed by a five-member IMM Board, which consists of a director (Floris Rutjes), managing director (Ralph Jaspers), two full professors (Arno Kentgens and Alex Khajetoorians) and a PhD representative (Lian Blijlevenens). The current members of the Board were installed in September 2019 for a four-year-period. The IMM Board is
supported by the IMM Office, which consists of a secretary (Ine Verhaegh-Peeters), a communications officer (Miriam Heijmerink), and a website editor (Brigitte Loozen). The IMM Board is advised by a Scientific Advisory Board (SAB), theme trios, and the group leaders (Group Leaders Lunch). In 2020, the IMM installed the PhD Panel IMM (PPIMM), consisting of six members and chaired by IMM Board member Lian Blijlevens. The PPIMM organizes a variety of activities for PhD candidates and advises the IMM Board.

Staff and funding
In 2020, the IMM consisted of 58 research staff, 100 postdocs and junior researchers, 175 PhD candidates, 50 technicians, and 25 other support staff. Taken together, these persons represent a total of 286 FTE appointed at Radboud University and 88 FTE appointed elsewhere (e.g., PhD candidates and postdocs that were employed by NWO, PhD candidates with external fellowships, professors by special appointment, and guests). More details about the IMM staff can be found in Appendix 2. The annual turnover of the institute amounts to approximately €25 million. As can be seen in the figure in Appendix 2, the IMM obtains approximately 60% of this turnover via research grants and contract research. More details about funding can be found in Appendix 2.

1.5 Summary of IMM aims and strategy
The IMM has formulated the following official mission statement: ‘The IMM is a research institute in chemistry and
physics that fosters interdisciplinarity by crossing traditional boundaries. Our mission is to create, discover, and understand processes and phenomena in atomic and molecular environments. We focus on fundamental research and explore the opportunities for societally relevant applications, thereby educating the next generation of leaders in science and innovation.’

In line with this mission, the institute has formulated multiple objectives:

- carry out fundamental and interdisciplinary research,
- increase the impact of IMM research on society,
- continuously innovate with the high-level research infrastructure,
- educate research professionals working at the interface of chemistry and physics.
The IMM aims to distinguish itself from similar institutes by the intense collaboration between chemists and physicists and between experimentalists and theoreticians. In addition, the institute considers its excellent infrastructure as a unique selling point. The IMM has strategically organized its research into three themes to promote internal collaborations.

In the next six years, the IMM plans to continue along the road of high-quality fundamental research with a perspective for long-term applications. In light of the expected developments in science funding and society, the IMM will also aim at performing more direct application-driven research in order to address urgent societal problems. To this end, the institute has identified several topics that reflect both fundamental science and societal challenges. These include:

- **Sustainable development**
  - Intelligent matter: neuromorphic computing, dissipationless information transfer,
  - Electrochemical conversions, renewable energy,
  - Machine learning approaches in predictive chemistry, process optimization,

- **Medicinal chemistry: health diagnostics, drug discovery and delivery, physics approaches to neuroscience.**

In addition, the IMM plans to recruit three to five professors by special appointment, who should stimulate public-private collaboration. The institute aspires to further exploit the
interdisciplinarity that it can offer as a result of its broad research focus. The IMM will encourage activities that increase interaction among its research groups, e.g., idea vouchers, rotating topics, and directly-funded PhD candidates. When appointing new scientific staff, the institute clearly plans to search for candidates whose expertise complements the existing expertise, thus promoting new interactions.
2. Evaluation of the Institute for Molecules and Materials as a whole

2.1 IMM aims and strategy

The IMM strategy of conducting fundamental research at the interface of chemistry and physics in combination with developing unique research infrastructure has been very fruitful in the past six years. It has resulted in impressive contributions to the body of scientific knowledge, high international visibility of individual researchers and groups, an excellent track record in acquiring competitive grants, and appealing examples of societal applications. In the next six years, the IMM aspires to improve its overall international visibility and its alignment with the national and European funding landscape. In order to achieve this goal, the committee recommends reconsidering the IMM strategy as detailed below.

The current strategy of encouraging collaboration between experts in physics and chemistry in molecular and materials science creates a common denominator. If, in the years to come, the IMM aspires to carry its international visibility to the next level, establishing a truly unique profile going beyond a collective of collaborating groups with excellent scientists, we recommend that the institute searches for strategies to develop an overall Identity. This IMM Identity could be developed in close consultation with external organizations, while considering the following elements:
• Differentiation: what distinguishes the IMM from other institutes?
• Relevance: which societal needs may be fulfilled by IMM research results?
• Coherence: what is the ‘IMM brand’ that is coherently visible in its messages, communication activities, and interactions with others?
• Esteem: what are the emerging characteristics of scientific excellence both internally and externally?

The overall IMM Identity should exploit the existing strengths and it should clearly position the institute in the national and international scientific landscape. For instance, the proposed topics of sustainability and medical chemistry are timely and fit in larger initiatives such as the UN Sustainable Development Goals and ‘Groeifonds’, but the IMM should also evaluate whether they provide a narrative of excellence in this field for which the institute can claim leadership and recognition in the future.

We recommend that the IMM organizes structured internal discussions on the IMM Identity and discerns how it is perceived by its partners, students, and society at large. In addition, the institute should determine how it wants to be perceived, i.e., what is the core driver for its research; what does it want to contribute to science and society? A clear identity will certainly place the IMM in the position of a natural leader and partner in (inter)national programmes with academic, industrial and societal collaborators. In addition, it will help to attract a diverse pool of talented
students and scholars from across the globe. The IMM Identity should guide strategic choices regarding internal and external collaborations, new appointments, as well as the organizational structure of the institute. The committee was also asked to consider the organization in three research themes and to suggest alternatives for this organizational structure, but we think that the discussion on the organization in three research themes should be addressed after the discussion about the IMM Identity. The organizational structure should be aligned with the mentioned elements of differentiation, relevance, coherence, and esteem.

It is essential that the internal view on the IMM Identity will be complemented by in-depth discussions with external partners, in particular the Scientific Advisory Board. The committee learned that the last meeting of the SAB took place in 2017. We strongly recommend the IMM to revive the SAB or install a new one, because the SAB can help to position the institute, strategically advise on directions, and provide an external research quality assessment that is in line with the guidelines of the San Francisco Declaration on Research Assessment (DORA). In addition, other stakeholders should be involved in the discussions, such as alumni, representatives of society, and aspiring students and postdocs.
2.2 Research quality

In line with its current strategy, the IMM has contributed substantially to the body of fundamental scientific knowledge at the interface of chemistry and physics in the past six years, as evidenced by the examples that we provide in Chapter 3. The research outputs of the researchers of the IMM are invariably of high quality; these researchers have outstanding international reputations and excellent track records in acquiring competitive grants and contracts. A number of researchers are undisputed international leaders in their respective fields. Taken together, the committee is impressed by the excellent quality of the IMM research. As discussed in section 2.1, we recommend organizing structured discussions on the overall IMM Identity to improve the international visibility of the institute as a whole rather than the individual researchers.

A major objective of the IMM is to develop and maintain state-of-the-art research infrastructure. The institute has created the right conditions to attain this objective. As a result, the institute harbours a range of unique facilities and equipment that is not available elsewhere, including the High Field Magnet Laboratory / Free-Electron Lasers for Infrared eXperiments (HFML-FELIX), the Magnetic Resonance Research Center (MRRC), Scanning Probe in Nijmegen (SPiN), the Nanolab, and the Laserlab. These facilities are supported by highly skilled technical support staff. Many of the facilities are offered as user facilities with open access, thus not only supporting the IMM’s own outstanding research and
fostering internal collaborations, but also inviting many scholars from across the globe and creating an inspiring environment, as was evident during the guided tour that we received during the site visit. The institute has appointed a data steward in each research group and a data officer for the institute to integrate adequate research data management.

Another major objective of the IMM is to educate research professionals. PhD candidates and postdocs perform most of the actual research within the institute, so the education of these young scientists directly contributes to the institute’s excellent research quality and reputation. The IMM runs its own graduate school, in which 175 PhD candidates are enrolled at present. The training programme includes mandatory courses about didactic skills, taking charge of your PhD, scientific integrity, and scientific writing. To ensure adequate supervision, the PhD candidates have a direct supervisor and an external supervisor. In addition, they are assigned a tutor who is not involved in the research. The institute monitors the progress of its PhD candidates with a Training and Supervision Plan, a Graduation Plan, and standardized annual discussions with the PhD candidate and the supervision team. The PhD candidates appear to be aware of the Training and Supervision Plan and they adhere to the associated guidelines. The candidates also know how to find the courses and training. It is apparent that the quality of the PhD training is very high, because IMM PhD graduates are sought after and many of them secure
excellent jobs in industry and academia. In addition, some of the PhD candidates start their own companies. The IMM offers excellent support to postdocs as well, including training for grant applications and entrepreneurship.

Despite the excellent support and training that the IMM offers to its young staff, the institute indicated that it experiences difficulties in attracting high-quality external MSc students and PhD candidates. Developing a clear identity may help to solve this problem (section 2.1). Three additional measures may also help to create an optimal atmosphere to attract and retain talented young scientists.

First, based on our discussions, the committee recommends ensuring that the daily practice at the IMM motivates PhD students and postdocs to engage in bottom-up collaborations, especially since interdisciplinarity is at the core of the IMM strategy. PhD students and postdocs should feel empowered to collaborate with other IMM research groups and to engage with the network of external collaborators of the IMM. At present, young scientists’ opportunities for collaboration depend on – and appear to be restricted by the limitations of – the network of their supervisors, and in some cases also depend on the supervisor’s attitude towards collaborative research. The committee recommends giving young scientists more autonomy in this area. This should be organized at the level of the institute. In addition, the younger researchers do not appear to have a complete view of the ongoing research at
the IMM and collaborations may rely on accidental encounters. We suggest making the IMM science more known and accessible to young scientists through the effective use of lectures, as well as screens and posters in the building that present recent breakthroughs and discoveries. This has the potential to boost interactions between young members of the institute leading to new, unexpected, and potentially invaluable collaborations.

Second, and in line with the above, combining different disciplines into one institute is a good strategy to promote interdisciplinary research, but it may also complicate the communication between the staff, and especially PhD candidates and postdocs. For instance, the committee learned that some IMM colloquia are not well attended by younger scientists (or those outside the discipline of the colloquium topic) because they lack the basic knowledge to understand the lectures. It should be ensured that the colloquium speakers are made aware that the subject matter should be understandable to researchers at all levels and from all disciplines within the institute. We suggest diversifying the IMM colloquium committee and add a PhD candidate or postdoc. In addition, we recommend regularly organizing an IMM retreat to promote internal collaboration and to jointly work on the identity of the IMM. Postdocs may wish to organize themselves and meet on a regular basis.

Third, the committee noticed that the institute is research-focused rather than education-focused. Publishing in high
impact factor journals seems a goal in itself at the IMM, as is evidenced by the content of the self-evaluation report and the tenure track criteria (requiring three high-impact papers). Committee engagement with young IMM scientists suggests that they consider *Nature* or *Science* papers to be necessary to acquire individual grants from NWO and the European Commission. They were not aware of ‘Recognition and rewards’, nor of the fact that some universities now hire tenure trackers with a teaching-focused profile. In light of the developments at NWO and the DORA, there could be more emphasis on out-of-the-box ideas and interdisciplinary research projects rather than high impact factor publications as a measure of quality. The IMM would benefit from broadening its view on ‘excellence’, for instance by broadening the tenure track criteria that are now still largely metric-based, and better valuing staff who play an important role in the education program, as a potential strategy to attract more students.

The committee therefore invites the IMM to develop a way to assess quality beyond using metrics (i.e., quartile scores of journals and lists of acquired grants). For instance, the SAB can provide an external quality assessment that is in line with the DORA. Leading universities are currently developing non-metric (narrative) systems to evaluate research quality and we encourage the institute to convey these ongoing changes to its young researchers. It is important that senior staff sets an example to young researchers in the sense that *Nature* and *Science* publications...
are not the sole definition of research quality. It is the committee's opinion that these adjustments will help the institute to attain its strategic aims in the future, including attracting talented students and scholars.

2.3 Societal relevance
During the past six years, the IMM strategy fostered fundamental research, with a focus on long-term applications. Nevertheless, IMM research has resulted in societal benefits through patents, spin-off companies, and collaborations with companies in externally funded projects. Appealing examples of the uptake of IMM research results by various stakeholder groups are provided in Chapter 3. One of the main objectives of the IMM is to increase the impact of its research on society. The institute also aspires to perform more direct application-driven research to address urgent societal problems.

To increase the societal impact of the IMM research in the future, we recommend strategic engagement with stakeholders, who should be involved in the preparation and execution of the IMM aims and strategy. They can help develop a clear identity, including the specific societal issues the IMM wants to contribute to (section 2.1). These interactions with stakeholders should have a bidirectional character. Societal relevance is not only achieved by delivering research results that benefit society, but also by truly engaging with societal groups and understanding their needs. Although the committee heard several good
examples of *ad hoc* initiatives, the IMM seems to lack an institute-wide strategic approach to engage in discussions with relevant stakeholders such as alumni, the SAB, partners in industry, and others. For instance, the committee learned that alumni that currently work in industry recently participated in a virtual meeting with PhD candidates. We applaud this initiative and suggest that such initiatives should be supported and rolled out at the level of the institute in the future.

In line with the above, we recommend deeper engagement with the general public; the IMM should articulate the high societal relevance of its research more clearly to society at large. The committee learned that the IMM frequently organizes guided tours of its facilities, but we heard few examples of citizen science projects, science events, or social media presence. We also learned about the IMM’s impression that undergraduate students frequently seek out different research topics in physics (e.g., astrophysics, particle physics) and have little knowledge about the ongoing research at the IMM. Further engagement with the public may help the IMM to align its research with the national science (funding) landscape and to improve the visibility of its research locally and globally, in order to attract talented MSc students, PhD candidates, and other researchers.

Educating research professionals with expertise at the interface of chemistry and physics is a crucial component of
the institute’s societal impact strategy. The IMM engages in a variety of activities to achieve this objective, ranging from outreach activities to primary and secondary school students, to education of BSc and MSc students, and training of PhD candidates. The training of PhD candidates contributes substantially to the institute’s societal impact because these young professionals take their knowledge and skills beyond the walls of the IMM when they continue their careers in academia or industry. As discussed in section 2.2, the IMM has developed an excellent PhD training programme. Approximately 50% of the PhD graduates of the IMM end up pursuing a career in industry, so we encourage the institute to ensure that PhD candidates with an interest in industry are offered the opportunity to already engage with industry during their PhD track, for example through internships. We also recommend to consider developing more articulate paths towards an academic versus an industrial career to adequately prepare PhD candidates for these two career paths. We acknowledge that this will probably happen *ad hoc* now, but we recommend adopting a more structural institute-wide approach. Clear career paths with the associated guidance may also make the institute more attractive to talented MSc students that are looking for a PhD position.

The majority of PhD candidates at the IMM graduate between four and five years after they started their PhD tracks. Nevertheless, a significant numbers of PhD candidates at the IMM do not finish their degree or take
more than five years to do so. According to the IMM, the majority of these latter candidates find a new job and then lose the motivation to finish their theses. We recognize that the IMM has taken various measures to ensure that PhD candidates will complete their PhD theses within the allocated timeframe, including the introduction of a Graduation Plan. The committee supports the institute in these efforts. The Graduation Plan appears to be an adequate measure; we recommend ensuring that those involved are aware of the consequences if major deviations from the plan occur.

Organizing adequate research data management and making scientific publications openly available can promote the uptake of research results by stakeholders. The IMM currently stores the research data associated with its publications on the manuscript server. The institute plans to store its research data with the associated metadata at the Radboud Data Repository in the near future to further open up its work. The committee learned that around 70% of the IMM’s publications are open access at present. We urge the IMM Board to actively take control over the implementation of its open access policy and strive for a higher percentage of open access publications to maximize the uptake of the IMM research by scientists and other stakeholders.

2.4 Viability
Molecular and materials science is expected to receive increasing attention in science and society in the years to
come and the research foci of the IMM are expected to remain highly relevant. The IMM has several valuable assets that contribute to the institute’s very high viability: a group of scientists that have an excellent track record in acquiring competitive grants (including several excellent junior scientists with a promising future), a unique research infrastructure, and a strong PhD programme (criticisms above notwithstanding). Another asset of the IMM is the atmosphere at the institute. The IMM fosters an open culture that facilitates critical scientific discussions. The atmosphere is welcoming, which was emphasized many times by employees from abroad. Another testimony of the pleasant atmosphere is the fact that many of the PhD candidates at the IMM first performed their MSc internship at the institute and then stayed there to embark on a PhD project. Initiatives from PhD candidates, postdocs, and tenure trackers to organize events are stimulated and facilitated by the IMM Board. Ambition is appreciated and stimulated at the IMM. There appears to be a good balance between ‘home-trained’ employees (i.e., those that have been working at the IMM since their PhD or postdoc period) and employees that were trained outside the institute. In Chapter 3, we will comment on the question whether the goals of each of the themes will remain scientifically and societally relevant in the years to come.

Although the IMM has an excellent track record in acquiring competitive grants, it is a constant challenge to maintain this level of funding. To keep the research infrastructure at the
current level, a substantial amount of funding is required, and the institute considers its funding situation as a threat. The IMM therefore aims to participate more in larger consortia and set up broader research programmes. The committee recognizes the rationale of this ambition but would like to caution that it may be very challenging to substantially increase or even maintain the present amount of external funding without adapting the IMM strategy (section 2.1).

In the past six years, the IMM Board has primarily adopted a facilitating role. Looking to the future, we advise the IMM Board to adopt a more active leadership role in consultation with the Faculty Board and the University Board. We recognise that the excellent science of the IMM is largely facilitated by a culture in which scientists have the intellectual freedom to influence the direction of their research. However, a limitation of this bottom-up approach is that the IMM experiences difficulties to achieve international visibility and alignment with the funding landscape (section 2.1). It is the committee's opinion that the IMM Board is responsible for structuring the strategic discussions about the identity of the institute, inspiring the staff, and involving external experts and stakeholders.

Similarly, the IMM Board has primarily adopted a facilitating role regarding the training of PhD candidates and the implementation of the policies on Open Science, diversity & inclusivity, and research integrity. These aspects are mostly
left to the interpretation of the individual research group leaders at present. We already mentioned the example of the guidance of the PhD candidates to the job market, which currently is the responsibility of their supervisors, rendering the candidates dependent on the networks of their supervisors and their attitude. Another example pertains to inclusivity and social safety: the structure and procedures to ensure these aspects are in place at the IMM, but people on the work floor are not always completely aware of the procedures. A website with contact details of confidential advisors is advertised at strategic locations throughout the IMM building, but this may not be the most effective way to form an inclusive and safe community. The IMM Board should ensure that the right information reaches all employees and that the Board makes itself accountable to that end. Similarly, a system is in place to tackle issues with scientific integrity, e.g., there is a confidential counsellor. Some groups indicated that they discuss this topic on a regular basis, for instance by jointly analyzing papers in journal clubs. However, the topic may not be equally ‘top of mind’ in all groups. Research integrity is ‘how to do things correctly’ and it should be in the DNA of the institute. It should be discussed in each group on a regular basis and the director should publicly take leadership to promote the importance of integrity and inclusivity.

Gender diversity and inclusivity have substantially improved at the IMM since 2016, largely under the auspices of a gender diversity committee at the level of the Faculty of
Science. Other aspects of diversity could still be improved and supported at the Faculty level. The committee feels that the institute has a rather narrow view on diversity and inclusivity. For instance, we noticed that many IMM representatives defined diversity in terms of male/female and Dutch/non-Dutch. Other aspects of diversity such as cultural background, sexual orientation, age, and socio-economic heritage do not appear to be prominently present in the institute’s discussions about diversity and inclusivity. This limited view on diversity may decrease the institute’s attractiveness to talented scientists and students. We suggest looking at the ‘Diversity by Design hiring protocol’, which was implemented in some Universities in the United Kingdom to ensure a fair and inclusive selection process. We also note that the ‘Principles of Community’ and associated accountability, such as given at https://chemistry.berkeley.edu/cbe/diversity-equity-and-inclusion can be effective in strengthening human resources and diversity and inclusion.

Diversity, inclusivity, social safety, and research integrity require daily attention in any research institute. The committee observed that the IMM takes these topics seriously and that the structure to ensure them is in place. Now it is time rethink how to communicate within the institute to maximally foster a vibrant, diverse, inclusive, safe, and integer atmosphere that will constitute the optimal conditions for the institute to attain its objectives.
3. Evaluation per theme

3.1 Structure and Dynamics of Molecules (Theme 1)

Introduction
Theme 1 seeks to obtain a bottom-up understanding of molecules and their interactions, with ever larger complexity. The scientists explore the boundaries of fundamental physics and chemistry to yield insights into complex macroscopic systems.

Research quality
The research quality of Theme 1 is largely underpinned by impressive research facilities and infrastructure that serve as a fertile ground for the development of new experimental and theoretical methodologies at the interface between physics and chemistry. This combination of unique instrumentation and advanced theoretical methods, coupled with excellent technical support, enables advances in both fundamental and application-driven science in the field of complex molecules and macroscopic systems. Using advanced imaging methods and fully quantum theoretical approaches to study molecule-molecule collisions and scattering, coupling solid-state Nuclear Magnetic Resonance (NMR) and ab initio methods to tackle the improvement in the photovoltaic performance of materials are examples of internationally leading research efforts. The publication record associated with this theme is excellent. The theme provides a caring, inclusive, and supportive environment to
BSc/MSc and PhD students; promoting and advertising this environment will help to retain the best students from diverse backgrounds.

**Societal relevance**
Theme 1 has presented a number of strong case studies with tangible societal impact, including the development of a line shape theory for collision-induced absorption in molecular oxygen, now used by the National Institute of Standards and Technology (NIST) and others to improve the calibration of remote sensors, the development of the infrared ion spectroscopy method used to identify new biomarkers for metabolic diseases, and the communication to researchers worldwide about experimental tools such as the Stark decelerator. The committee notes the emphasis on relevance to other scientific communities and the lack of reported attention to engaging the general public.

**Viability**
The Theme 1 vision for the next six years of ‘transforming this field from probing nature with the highest level of detail into manipulating nature with the highest degree of control’ provides an excellent focus and context for future research efforts. This vision is anticipated to remain at the cutting edge both scientifically and societally. Theme 1 has the capacity, a clear plan, and ample resources to achieve its goals. Closer collaborations with stakeholders and industry will accelerate these efforts in funding environments that emphasize commercialisation. It is worth noting that solid-
state NMR is also encompassed at a number of institutes around Europe, including ETH, EPFL, Lyon, and Grenoble. Many of these institutes have strategically chosen methodologies for strategic vision (e.g., DNP at Lyon). For NMR to remain viable at the IMM, a clear strategic vision needs to be furthered. The committee welcomes the focus on for instance new micro-instrumentation, but Karlsruhe is emerging in this arena as well.

**Recommendations for Theme 1**

Several simple measures may help to further increase the academic reputation and leadership of Theme 1 within the field and its societal relevance:

- Advance the international visibility and the influence of the theme within the relatively young institute by leading (as principal investigators, PIs) large international and European funding initiatives and by engaging in collaborative research with leading authorities in the field (worldwide). HFML-FELIX and MRRC enjoy considerable international visibility; it may be useful to leverage this visibility by expressing ‘strands’ from Theme 1 in lectures given by the facility staff outside the IMM.

- Accelerate the impact of Theme 1 research in industry by providing viable applications and seeking opportunities to deploy them in industry. Current activities in knowledge transfer and the evaluation of relevant markets where these techniques could be deployed are not fully exploited. For example:
- Develop bespoke, proof-of-principle computational modelling tailored to specific markets. This will exemplify the value Theme 1 can add to each industry.

- Deploy dossier(s) of technical information, relevant to each market identified, that can be used to leverage external company interest. Translation of the developed techniques into the broader markets will lead to significant impact.

- Strengthen your connections to Radboud Innovation Science and Radboud Innovation (the University technology transfer office) for knowledge and technology transfer activities. These connections appear to be nominal at the moment.

- Engage the broader public by highlighting the use of the extraordinary experimental facilities to address local and community problems, as well as substantive ‘museum’ quality tours with the acronym facilities. Such public engagement might be best delivered by younger staff, including MSc or PhD students.
3.2 Chemistry of Complex Systems (Theme 2)

Introduction

Inspired by chemistry in nature, Theme 2 aims to understand, design, and control complex chemical systems at different length and time scales. The theme is the largest of the three IMM themes, and it is extremely broad in scope, covering the research areas of complex molecular systems and chemical biology.

Research quality

The complex molecular systems research area is comprised of scientifically excellent research groups. Collectively, they cover a broad range of disciplines (synthetic organic, analytical, and polymer chemistry; synthetic biology; biomolecular engineering; biophysics), giving rise to an interesting mix of research activities and capabilities in this emerging area of molecular science. The PIs are a group of established and early career researchers, who have unique and internationally recognized individual research foci. Collectively, they provide a rich and exciting research team.

The research area of chemical biology includes a focus area on chemical biology and medicinal chemistry directly addressing biological systems, as well as fundamental physical chemistry addressing synthetic complex systems with emergent biomimetic behaviour. Multiple examples of excellent research with high relevance to the field internationally were showcased. For example, the research on physical origins of processes controlling transcription or
translation is truly integrative, addressing the full range of scales from chemical to biochemical and cellular. Research on reactive intermediates is also at the cutting edge, with very exciting developments in combining mass spectrometry and laser science for analytical chemistry, which are quite unique. There is also outstanding work on soft matter systems for drug delivery. Overall, the chemical biology activities have both breadth and depth of quality, and many groups take good advantage of the unique strengths of the institute. This chemical biology area is somewhat less established in its direct interactions with biology and medicine, but there is evidence that this is rapidly developing with new tenure track hires and recently tenured professors clearly positioned at the chemistry/biology interface, thereby strengthening links to the medical school.

The research area of complex molecular systems clearly generates many creative concepts that could become big ideas / grand challenges that the group leaders can collectively focus on. Many of these areas are still in their infancy in terms of presenting a clear and unique vision and strategy. For example, the use of artificial intelligence and machine learning was mentioned in the context of predicting polymorphs and predicting reactivity and functionality in complex chemical systems, with an identified need to provide training sets (referred to as ‘big chemistry’). Another area was the use of chemical systems in information processing, which ties with areas such as intelligent matter, brain-like computing, which in turn has loose connections
with the neuromorphic computing and green IT research areas within the IMM. To gain further international recognition and attract large funding, more structure and clarity is needed around these emerging exciting and unique topical areas. The committee observed that these cross-disciplinary (and cross-theme) research focus areas mostly emerge in a bottom-up fashion and are driven by strengths in these areas. The current approach appears to be that stakeholders are only engaged once there is critical mass behind a certain idea; we recommend that these stakeholders are involved much earlier, so that they can help shape the vision.

The PhD candidates we encountered in this theme were enthusiastic and engaged, with more evidence of academic freedom from the bottom up than was observed in other themes. Nevertheless, more could be done to actively encourage them to seek new collaborations and gain better awareness of research activities and infrastructure within the IMM. We complement the team with the satisfaction expressed by PhD candidates and postdocs about their research and training experiences.

The committee understood that Theme 2 researchers are now seeking more opportunities to align their excellent research activities with larger funding opportunities within the Netherlands or Europe. With such a diverse theme, it can be difficult to achieve a clear coherent mission that all researchers can support. Without a clearly formulated
mission, it is harder to achieve the external visibility and recognition that the theme is currently aspiring to. In their self-assessment, the collective uniqueness was not clearly formulated. Instead, the description of the theme was broad, and this lack of clear identity continued in the presentation during the site visit. In addition, the links to national and international research centres were not so clear, with limited evidence that this theme has compared its international profile with its peers, or attempted to identify best practises and innovations outside the local environment.

Cross-cutting activities between themes appear to be only at an early stage of discussion. For example, the committee noticed that Theme 3 is interested in complexity research from the physics perspective, and they expressed an interest to work on chemical complexity, but they viewed chemistry problems still too complex for them to tackle. It is proposed that these discussions continue in order to learn where common ground exists that these exciting opportunities can be explored.

**Societal relevance**
Evidence was provided that this theme engages with industry partners, but the ratio of patents to papers is low in a theme which has natural alignments to applications in healthcare. More could be done to ensure that every PhD candidate gets the opportunity to engage with industry, or for those interested to be enabled to undertake a placement
or industry experience during their PhD before they are required to decide on their post-PhD career path. Strengthening links to industry by engaging them in co-designing projects and co-supervision of research projects at multiple levels (MSc, PhD) would be valuable, particularly in view of the upcoming Masters in medicinal chemistry.

**Viability**

Theme 2 as a whole appears to be adequately equipped to implement its strategy in the next four to five years thanks to the presence of multiple outstanding research groups with the capacity to secure large personal grants from NWO and ERC. The theme's research plans are centred around multiple subject specific programmes led by a single PI, and, for chemical biology, appear to be primarily aimed at consolidating and developing existing research streams. The theme lacks a clear strategy to establish a leadership position in one or two areas which could result in leading bids for larger scale EU funding.

The appointment of the new chair in medicinal/neurochemistry is an interesting opportunity to properly embed connections with biomedicine, an area in which Radboud University is strong. However, this may be a challenging hire since drug discovery or medicinal chemistry is not an area for which the institute or university currently has an international reputation, and it is very clearly an applied science where the highest impact will arise from collaborations outside the IMM. It also lacks a clear
connection to the physics strengths of the IMM. The logic of hiring in this field makes sense from an educational perspective, with the initiation of a new Masters course in medicinal chemistry. However, the IMM may struggle to establish what is a relatively resource-intensive activity in competition with other very well-established centres in the Netherlands – for example in Groningen, Utrecht, or Leiden, where there are already many groups working in collaboration. The committee is concerned that such a group would not be able to establish a world-leading drug discovery activity because there is limited existing culture of collaboration in this specific area, and where the post holder would need to build up cutting edge equipment and infrastructure. Whilst the match between small molecule chemistry and neurochemistry is appropriate given the importance of signalling chemistry and the need to pass the blood-brain barrier, the broader landscape is shifting. Traditional small molecule medicinal chemistry is becoming replaced at the cutting edge of therapeutics discovery by biotherapeutics, nucleic acid drugs, cell and gene therapies, and new modalities such as protein degradation.

This theme has built an outstanding and excellent foundation to build upon. There already exist some very strong collaborations between the research groups within the theme, but they are still limited in size and scope. We learned from the self-assessment and site visit discussions that the theme members have realized that they would benefit from being more collaborative within IMM (across
the themes) to successfully apply for larger grants. Some research groups work between the IMM and the hospital; these seem more remote from IMM’s core activity. If these will remain part of the institute, they should be better integrated; the upcoming hire of a medicinal chemistry chair could be an excellent opportunity to secure this activity.

**Recommendations for Theme 2**

- Carefully consider the long-term viability of a medicinal chemistry activity at the IMM, including the potential changes in multidisciplinary culture and resources required to establish a chair and group in this area. Fact-finding visits to peer institutes in the Netherlands and internationally (e.g., in Oxford, Dundee, Institute of Cancer Research, Dortmund, Dana Farber, Leiden, Groningen) could be useful for the leadership to refine solutions to the challenges of bringing together chemistry and biomedicine, and the environment required to support internationally excellent research in this field. It will be important that this hire also works beyond the old paradigms of one small molecule drug-one target, perhaps encompassing some of the emerging areas (e.g., heterobifunctional compounds/non-traditional pharmacology, nucleic acid therapies). Due consideration could be given to hiring this leadership position directly from industry, an approach which has been successful in Dundee, Newcastle, and Leiden, alongside several institutes in the
USA which have specifically targeted hires of multiple ex-pharma PIs.

- Explore new mechanisms to translate excellent science into applications to support societal relevance and training. For example, in the medicinal chemistry/chemical biology area, we recommend prioritising collaborations with drug discovery companies, involving local SMEs or international biopharma industry in the SAB, involving industry in co-supervision and co-creation of Masters level projects, and delivering on the excellent plan to instigate visiting professorships from these companies. Industry showcases can be an excellent way to support this objective, by bringing in decision makers at local and national/international SMEs and larger companies for a ‘show and tell’ event with relevant research groups and students.
3.3 Spectroscopy of Quantum Matter (Theme 3)

*Introduction*

Theme 3 focuses on the design, characterisation, and manipulation of physical phenomena stemming from solid-state materials.

*Research quality*

The theme has produced an impressive number of high-quality contributions to fundamental science down to the smallest length and time scales. The majority of these contributions have a very high scientific relevance in general, and some of them are truly ground-breaking and pushing the boundaries of present scientific knowledge in the field. Examples include studies of complex systems, such as the identification of a spin-glass phase in elemental Neodymium, the measurement of quantum oscillations (and corresponding derivation of the Fermi surface) of the recently explored ZrSiS material, the demonstration of photo-magnetic recording in an iron garnet, or a very successful line of theoretical developments proposing and exploring new (‘dual’) approaches to the quantum many-body problem. Based on their results (publications, grants), we can judge that the individual topic leaders in Theme 3 have a very high academic reputation and a demonstrated leadership in their individual fields of expertise. The scientists of Theme 3 have an impressive track record in joint experimental-theoretical works, some of them driven by the theory side and others by the experimental side. The group benefits from its outstanding experimental
equipment and facilities, in particular the HFLM-FELIX, allowing THz spectroscopy in world-record intensity magnetic fields among other things.

**Societal relevance**
The research results of Theme 3 are highly relevant to society. The interplay between complexity and disorder is important to understand magnetism and magnetic phenomena, which was demonstrated on the self-induced spin-glass in Nd metal. Another example of ground-breaking societal impact is the demonstration of optomagnetic switching without external magnetic field. The latter can have a strong influence on the development of dissipationless information transfer. The development of improved solar cells for solar energy harvesting is another example of a subject of high societal impact. Finally, the understanding and control of quantum states may be a crucial element to mastering quantum technologies up to the field of quantum information.

Theme 3 has various projects and collaborations with companies and external partners, for instance in low-dissipation ultrafast data storage – a topic that also is at the heart of the ‘Green IT’ activity of the IMM. To further disseminate the various approaches and their role in the Green IT framework to the general public, more emphasis may be put on outreach activities (e.g., an IMM Green IT evening).
Viability

Theme 3 has developed a well-thought-out roadmap of its research ambitions for the coming years, embracing topics ranging from the setup of an atomic scale self-learning neuromorphic device, new insights into transport properties of correlated electron materials in their strange metal or unconventional superconducting phases, to the development of 2D materials for energy efficient computing or of nearly non-dissipative materials for energy efficient data processing. These goals build on their track record and expertise, and they cleverly place the theme into a wider context of research with direct societal impact. Given the otherwise assumed fundamental nature of the research carried out by the scientists of Theme 3, this appears a particularly suitable approach. The overall setting of goals of Theme 3 therefore appears appropriate given the theme’s mission and strategy and addresses important fundamental scientific questions, the answer to which could also stimulate application-oriented research and technological advances.

Theme 3 anticipates the retirement of several established PIs in the coming years, including the leaders of the Theory of Condensed Matter research group and the Correlated Electron Systems research group at HFML-FELIX. Furthermore, they plan to hire a new chair to link to their clean room facility, combining quantum materials themes and device physics. Finally, they wish to extend their expertise in mid-IR, XUV, and X-ray spectroscopies at the
assistant professor level. On the one hand, these upcoming vacancies constitute an ambitious human resources challenge, the solution of which requires identifying and attracting first-class scientists ready to engage in the further development of the research landscape in condensed matter at the IMM and HFLM-FELIX. On the other hand, it constitutes an excellent opportunity to carry the presently existing dynamics over to the next generation of PIs, while integrating new timely topics and methods into the institute. The declared research ambitions of the team give strongest hopes that these opportunities will be wisely used, if the necessary support will be provided (e.g., in the form of appropriate search committees).

**Recommendations for Theme 3**

- Use the ‘human resources challenge’ as an opportunity to strategically consider if the current profiles fit the desired identity of the institute. Would a choice for e.g., Green-IT as a major research focus of the institute lead to different choices? Staff renewal is a challenge but even more an opportunity, also to go in new directions.
- Consider investing more in outreach to disseminate the theme’s approaches and their role in the Green IT framework to the general public (e.g., an IMM Green IT evening).
4. Summary of conclusions and recommendations

Overall, the committee was highly impressed by the quality and relevance of the research conducted at the IMM in the period 2015-2020. In line with its strategy, the institute has contributed substantially to the body of fundamental scientific knowledge at the interface of chemistry and physics. The international visibility of many IMM researchers is high and they have an excellent track record in acquiring competitive grants. The IMM has also established a research infrastructure that is unique in the world, supporting the IMM’s own outstanding research and fostering internal collaborations, and creating an inspiring environment that attracts scholars from across the globe. The institute has provided appealing examples of the uptake of its research results by various stakeholder groups. The strong PhD programme contributes to the excellent science as well as the societal relevance of the IMM.

To increase its international visibility, recognized leadership, engagement in large initiatives, and opportunities for funding, the institute should develop an overall IMM Identity in consultation with external stakeholders. The overall identity of the IMM should exploit the existing strengths and it should clearly position the institute in the national and international scientific landscape. A clear identity will place the IMM in the position of a natural leader.
and partner in (inter)national programmes with academic, industrial, and societal collaborators. In addition, it will help to attract a diverse pool of talented students and scholars from across the globe. The identity should guide strategic choices regarding internal and external collaborations, new appointments, and the theme structure of the IMM. We therefore recommend that the institute organizes structured discussions about its identity and that stakeholders are actively engaged in these discussions. These stakeholders first and foremost include the SAB, but also alumni, companies, other collaborators, and agencies.

In addition, the IMM would benefit from broadening its view on ‘excellence’, for instance by broadening the metric-based tenure track criteria to include a narrative and evidenced-based assessment system. Such a system may reward staff that play an important role in the education programme, hence promoting student engagement and recruitment. At many competitive institutions, bibliometric and citation-based assessments are considered to overemphasize numeracy and further disadvantage underrepresented groups. The committee invites the IMM to develop a way to measure its quality beyond using metrics.

**The committee’s main recommendations are:**

- We recommend the IMM Board to organize structured discussions about the IMM Identity and to strategically engage with the SAB and other stakeholders in these discussions (page 9, 12).
• We advise the IMM Board to adopt a more active leadership role in consultation with the Faculty Board and University Board to ensure the implementation of the policies on Open Science, research integrity, inclusivity, and social safety into the daily practice of all research groups (p14).

• We recommend measuring the IMM research quality beyond using metrics and broadening the definition of excellence (p12).

• We recommend ensuring that the atmosphere at the IMM breathes diversity and inclusivity and broadening the view on diversity and inclusivity (p14).

• We advise to engage more with the general public and articulate the societal relevance of the research more clearly to society at large (p12).
5. Response of the institute
Reaction of the Institute for Molecules and Materials on the Research Assessment Report 2021

The IMM board would like to thank the assessment committee for the Research Assessment report 2021. In hindsight, we have been fortunate that the assessment was planned in a time window where a physical site visit was possible. We feel that this has significantly contributed to the quality of the discussions and resulted in a more complete picture of our institute.

We are pleased with the report as it is generally very positive about the IMM’s past performance in terms of research and impact, and the creation of a unique infrastructure. It also provides a number of concrete suggestions for improvement that we will implement in the years to come. In this reaction these suggestions have been clustered in order to address the important topics.

First of all, the committee recommends that the institute searches for strategies to develop an overall Identity. In the report are suggestions for the lines along which this identity could be formed, and the stakeholders that should be involved. One of these stakeholders is the Scientific Advisory Board, of which the committee suggests reviving it or installing a new one. The IMM recognizes the point of the identity, when it comes to the external visibility that could be improved. We plan to install a new Scientific Advisory Board in 2022, with whom annual discussions will be planned about strategic aspects. Meanwhile, internal strategy meetings have started about some of the topics that will
shape the future strategy and visibility of the IMM. The latter will be based on the reputation of the groups and of the facilities that are crucial for the IMM research. In the second half of 2022 we plan to consolidate this new strategy, which will also form a basis to strengthen our reputation over the next five years.

Secondly, the committee suggested three additional measures to help to create an optimal atmosphere to attract and retain talented young scientists:
1. Ensuring that the daily practice motivates PhD students and postdocs to engage in bottom-up collaborations.
2. Making sure the broad range of topics in the IMM does not hinder accessibility of the colloquia and presentations, by ensuring that the colloquium speakers are made aware of this and by diversifying the IMM colloquium committee through adding a PhD candidate or postdoc.
3. Developing a way to assess quality beyond using metrics (i.e., quartile scores of journals and lists of acquired grants).

With regard to the first point, several steps have been made in the past year to facilitate bottom-up contact between PhD students. This includes setting-up the PhD Panel IMM (PPIMM) and organizing a PhD day that has unfortunately been thwarted by COVID. The IMM board will also explore the possibilities to organize similar activities geared towards postdocs. Via direct funding the IMM does stimulate bottom-up collaboration, by allocating most of this money to collaborations between multiple departments. Concerning colloquia, the speakers are always informed about the width of research in the institute and instructed to give a general introduction to their topic. We are currently renewing the colloquium committee and will implement the suggestion to add a PhD student or postdoc. Concerning the aspect of
developing new ways to assess quality, we support this recommendation, but also feel that a faculty- and university-wide strategy is required. Recently, several steps have been taken at the university level to develop new “Erkennen en waarderen” policy. Within the IMM we will continue to look critically at the composition of our hiring and evaluation committees and as IMM board we will carefully assess the reports of these committees.

Thirdly, the committee advises: To increase the societal impact of the IMM research in the future, we recommend strategic engagement with stakeholders, who should be involved in the preparation and execution of the IMM aims and strategy. The IMM fully agrees with this point, and intends to include one or two members from industry in the Scientific Advisory Board. In the next years, we also aim to attract a number of professors by special appointment from industry with a track record in areas where the institute plans to create impact. The IMM initiatives go hand in hand with the impact strategy of Radboud University, that includes activities for the whole spectrum from outreach to co-creation with external stakeholders. Additionally, the committee encourages the institute to ensure that PhD candidates with an interest in industry are offered the opportunity to already engage with industry during their PhD track...... to consider developing more articulate paths towards an academic versus an industrial career. The institute will look into the possibilities to do this more extensively. In the new graduate school training programme a career guidance course is already obligatory in the third/fourth year.

About the future of the IMM, the committee says: Molecular and materials science is expected to receive increasing attention
in science and society in the years to come and the research foci of the IMM are expected to remain highly relevant. The IMM has several valuable assets that contribute to the institute’s very high viability: a group of scientists that have an excellent track record in acquiring competitive grants (including several excellent junior scientists with a promising future), a unique research infrastructure, and a strong PhD programme (criticisms above notwithstanding). Another asset of the IMM is the atmosphere at the institute.

The committee suggests the IMM Board to adopt a more active leadership role in consultation with the Faculty Board and the University Board. We recognise that the excellent science of the IMM is largely facilitated by a culture in which scientists have the intellectual freedom to influence the direction of their research. However, a limitation of this bottom-up approach is that the IMM experiences difficulties to achieve international visibility and alignment with the funding landscape ...

Specifically on this point, the IMM has taken new initiatives in the past few months. Mission10-x is a mostly centrally steered initiative in which the IMM plays an important role, and which could lead to more international interactions and exposure. With regard to Groeifondsaanvragen and Zwaartekrachtprojecten the IMM board signals opportunities and coordinates joint efforts. We plan to do this also for topics that will be key in the IMM strategy for the coming years.

The committee also states: Similarly, the IMM Board has primarily adopted a facilitating role regarding the training of PhD candidates and the implementation of the policies on Open Science, diversity & inclusivity, and research integrity. And
further in the report: *Gender diversity and inclusivity have substantially improved at the IMM since 2016, largely under the auspices of a gender diversity committee at the level of the Faculty of Science. Other aspects of diversity could still be improved and supported at the Faculty level. The committee feels that the institute has a rather narrow view on diversity and inclusivity..... We suggest looking at the ‘Diversity by Design hiring protocol’, which was implemented in some Universities in the United Kingdom to ensure a fair and inclusive selection process.* The IMM board fully underlines the importance of open science, research integrity and diversity and inclusivity. These topics will be put on the agenda of the IMM board and the IMM group leader lunch more often. Our Scientific Integrity course will remain in the PhD programme, and at colloquia and our annual sIMMposium we will seek opportunities to draw attention to these topics. Regarding the larger scope of diversity than only male/female, the IMM is involved in faculty- and university-wide policy development on diversity and inclusivity, for example through membership of and chairing the GenDi committee. We feel that developing and implementing policy in this field requires a university-wide approach.

With regard to Theme 2, the committee states: *The appointment of the new chair in medicinal/neuro chemistry is an interesting opportunity to properly embed connections with biomedicine, an area in which Radboud University is strong. However, this may be a challenging hire since drug discovery or medicinal chemistry is not an area for which the institute or university currently has an international reputation, and it is very clearly an applied science where the highest impact will arise from collaborations outside the IMM.....However, the IMM*
may struggle to establish what is a relatively resource-intensive activity in competition with other very well-established centers in the Netherlands – for example in Groningen, Utrecht, or Leiden, where there are already many groups working in collaboration. The committee is concerned that such a group would not be able to establish a world-leading drug discovery activity because there is limited existing culture of collaboration in this specific area, and where the post holder would need to build up cutting edge equipment and infrastructure.

We are happy that the committee also sees the medicinal chemistry chair as an opportunity to embed connections with biomedicine. On the other remarks, the IMM board disagrees with the committee, and is confident about the strength, scientific connections and national and international status of this area. This is also supported by the fact that our chemical biology programme, which has medicinal chemistry embedded, has been designated a national zwaartepunt by the national sector plan committee in 2019. Furthermore, the IMM has currently over 10 PI's working in the field of chemical biology, and over 10 ongoing externally funded projects with commercial partners on related topics. Additionally, in past research in this area gave rise to multiple spin-off companies in this field of which Synthon, Byondis, Symeres and Synaffix are the most prominent ones.

The board of the IMM would like to thank the committee once again for their valuable time and input. We are confident that with the help of the actions following from this report, we can further strengthen our institute and optimally prepare for the opportunities that lie ahead.

Floris Rutjes, Director Ralph Jaspers, Managing Director
Appendix 1. Site visit programme

DAY 1: Tuesday 12 October (Hotel)

16.30 Welcome reception and introduction (Rector Magnificus, Dean, IMM Board)
17.30 Dinner and preparations

DAY 2: Wednesday 13 October (Huygens Building)

08:30 Taxi to university campus
09.00 Interview IMM Board and Faculty Board (Dean: Professor Lutgarde Buydens, Vice Dean: Professor Richard van Wezel, IMM Board: Professor Floris Rutjes (director), Professor Arno Kentgens, Professor Alex Khajetoorians, Ralph Jaspers (managing director), Lian Blijlevens (PhD representative))
09.45 Recording findings
10.00 Interview with Theme 2 representatives (Professor Wilhelm Huck, Professor Jana Roithová, Professor Floris Rutjes, Professor Elias Vlieg, Dr Kim Bonger)
10.45 Recording findings
11.00 Break
11.30 Interview with Theme 3 representatives (Professor Peter Christianen, Professor Misha Katsnelson, Professor Alex Khajetoorians, Professor Alexey Kimel, Dr Nadine Hauptmann)
12.15 Recording findings
12.30  Lunch
13.30  Interview with PhD candidates (Lian Blijlevens (PhD Panel IMM), Fabio Formisano (PhD Panel IMM), Lotte Gerrits, Sandra Kleuskens, Jasper Linnartz, Jaya Mehara, Kshiti Mishra, Taha Selim, Anne Swartjes, Werner van Weerdenburg, Jeroen van der Wiel (PhD Panel IMM), Angel Wong)
14.15  Recording findings
14.30  Break
14.45  Tour facilities (HFML-FELIX, MRRC, Mass spec labs, New Organic Chemistry Labs, STILL lab, Laser Labs)
17.15  Recording findings
18.15  Walk to restaurant
18.30  Dinner with IMM delegation (IMM Board + Professor Herma Cuppen, Professor Alexey Kimel, Professor Britta Redlich, Professor Jana Roithová, Professor Elias Vlieg, Dr Steffen Wiedmann)
DAY 3: Thursday 14 October (Huygens Building)

08:30 Taxi to university campus
09.00 Interview with Theme 1 representatives (Professor Gerrit Groenenboom, Professor Arno Kentgens, Professor Bas van de Meerakker, Professor Britta Redlich, Dr Joost Bakker)
09.45 Recording findings
10.00 Interview with assistant and associate professors (Dr Daria Galimberti (tt assistant professor), Dr Maike Hansen (tt assistant professor), Dr Jeroen Jansen (associate professor), Dr Paul Kouwer (associate professor), Dr Dennis Lowik (assistant professor), Dr Malte Rösner (tt assistant professor), Dr Jolijn Onvlee (tt assistant professor), Dr Steffen Wiedmann (assistant professor)
10.30 Recording findings
10.45 Break
11.15 Interview with postdocs (Dr Jessie van Buggenum, Dr Hidde Elferink, Dr Qiao Li, Dr Monica Rodriguez, Dr Shaohua Zhang)
11.45 Recording findings
12.00 Lunch
13.00 Interview with the IMM Board
13.30 Recording findings
15.30 Presentation preliminary findings
16.00 Informal Drinks
Appendix 2. Quantitative data on the IMM’s composition and funding

(Note that The Dutch system for academic funding consists of three categories: 1st stream or direct funding, i.e., money from the government, 2nd stream funding, i.e., money from the government distributed via NWO by means of grant applications, 3rd stream funding, i.e., all other sources of money, including but not limited to EU grants and contracts with companies.

<table>
<thead>
<tr>
<th>Table IMM.3: Numbers of research staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>----------------</td>
</tr>
<tr>
<td><strong>Tenured</strong></td>
</tr>
<tr>
<td>Full professors</td>
</tr>
<tr>
<td>Professors by special appointment</td>
</tr>
<tr>
<td>Associate professors</td>
</tr>
<tr>
<td>Assistant professors</td>
</tr>
<tr>
<td>Researchers</td>
</tr>
<tr>
<td><strong>Non-tenured</strong></td>
</tr>
<tr>
<td>Researchers</td>
</tr>
<tr>
<td>PhD students</td>
</tr>
<tr>
<td><strong>Total research staff</strong></td>
</tr>
</tbody>
</table>

**Figure IMM.4: FTEs in the IMM**

**Figure IMM.5: Turnover of the IMM**