Leibniz Gemeinschaft

Der Senat

24. November 2020

Stellungnahme zum Leibniz-Institut für Interaktive Materialien e.V., Aachen (DWI)

Inhaltsverzeichnis

Vorbemerkung

Die Einrichtungen der Forschung und der wissenschaftlichen Infrastruktur, die sich in der Leibniz-Gemeinschaft zusammengeschlossen haben, werden von Bund und Ländern wegen ihrer überregionalen Bedeutung und eines gesamtstaatlichen wissenschaftspolitischen Interesses gemeinsam gefördert. Turnusmäßig, spätestens alle sieben Jahre, überprüfen Bund und Länder, ob die Voraussetzungen für die gemeinsame Förderung einer Leibniz-Einrichtung noch erfüllt sind.[1]

Die wesentliche Grundlage für die Überprüfung in der Gemeinsamen Wissenschaftskonferenz ist regelmäßig eine unabhängige Evaluierung durch den Senat der Leibniz-Gemeinschaft. Die Stellungnahmen des Senats bereitet der Senatsausschuss Evaluierung vor. Für die Bewertung einer Einrichtung setzt der Ausschuss Bewertungsgruppen mit unabhängigen, fachlich einschlägigen Sachverständigen ein.

Vor diesem Hintergrund besuchte eine Bewertungsgruppe am 20. und 21. Januar 2020 das DWI in Aachen. Ihr stand eine vom DWI erstellte Evaluierungsunterlage zur Verfügung. Die wesentlichen Aussagen dieser Unterlage sind in der Darstellung (Anlage A dieser Stellungnahme) zusammengefasst. Die Bewertungsgruppe erstellte im Anschluss an den Besuch den Bewertungsbericht (Anlage B). Das DWI nahm dazu Stellung (Anlage C). Der Senat der Leibniz-Gemeinschaft verabschiedete am 24. November 2020 auf dieser Grundlage die vorliegende Stellungnahme. Der Senat dankt den Mitgliedern der Bewertungsgruppe und des Senatsausschusses Evaluierung für ihre Arbeit.

1. Beurteilung und Empfehlungen

Der Senat schließt sich den Beurteilungen und Empfehlungen der Bewertungsgruppe an.

Das DWI – Leibniz-Institut für Interaktive Materialien e.V. in Aachen erarbeitet sehr erfolgreich Methoden und Konzepte zur Entwicklung von Materialfunktionen, die Eigenschaften lebender Materie wiedergeben. Dazu nutzt das Institut maßgeblich Ansätze aus der Chemie, den Ingenieurwissenschaften und der Biotechnologie. Das Institut ist im Transfer seiner Erkenntnisse in die industrielle, zunehmend auch in die medizinische Anwendung aktiv.

Das DWI wurde 1952 als „Deutsches Wollforschungsinstitut“ mit einem Schwerpunkt im Bereich der Protein- und Biomaterialforschung gegründet. Ab 2003 wurden die Arbeiten sehr erfolgreich auf technische Materialien und Nanotechnologie für Weiche Materie (soft matter) ausgeweitet. Der große Erfolg dieser **Entwicklung** wurde in der Evaluierung des Wissenschaftsrates bestätigt, die 2014 zur Aufnahme des DWI in die gemeinsame Bund-Länder-Förderung führte. Gleichzeitig erfolgte die Umbenennung in DWI – Leibniz-Institut für Interaktive Materialien. Im Sommer 2019 trat der Direktor in den Ruhestand ein. Gemeinsam mit der RWTH Aachen ist es gelungen, erneut einen international ausgewiesenen Wissenschaftler für diese Position zu gewinnen.

[1] Ausführungsvereinbarung zum GWK-Abkommen über die gemeinsame Förderung der Mitgliedseinrichtungen der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V.

Seit der Evaluierung durch den Wissenschaftsrat hat sich das DWI sehr positiv entwickelt. Mit hervorragenden Rekrutierungen, auch auf der Leitungsebene, wurde die Grundlagenforschung, wie seinerzeit empfohlen, deutlich gestärkt. Gleichzeitig ist das Institut stark gewachsen. Dieses **Wachstum** geht in erster Linie auf eine äußerst erfolgreiche Drittmitteleinwerbung zurück, wobei das Institut den Anteil an kompetitiven Mitteln deutlich gesteigert hat. Hervorzuheben sind die sieben ERC Grants (drei *Advanced*, zwei *Starting* und zwei *Consolidator Grants*), die DWI-Wissenschaftlerinnen und -Wissenschaftler seit der letzten Evaluierung einwarben.

Die **Organisationsform** des DWI war in den vergangenen Jahren gut geeignet, die verschiedenen Arbeitsgruppen über fünf Forschungsprogramme interdisziplinär aufeinander zu beziehen. Sie muss nun aber an die Vergrößerung des Instituts und die wissenschaftlich-strategischen Planungen für die nächsten Jahre angepasst werden, wie es das DWI in seiner Institutsstellungnahme bereits vorsieht. Die **Leistungen** der Forschungsprogramme werden drei Mal als „sehr gut" und zwei Mal als „sehr gut bis exzellent" bewertet. Forschungsergebnisse erscheinen regelmäßig in hochrangigen Zeitschriften, der Wissenstransfer erfolgt über sinnvoll ausgewählte Projekte mit Industriepartnern bzw. über Patente.

Das DWI **plant**, die Forschung an bioaktiven und bioinstruktiven Materialien in Richtung medizinischer Anwendungen voranzutreiben. Dazu wird derzeit gemeinsam mit dem Universitätsklinikum Aachen die wissenschaftliche Infrastruktur *first in Translation* (*fi*T) aufgebaut. Durch die enge Verknüpfung von Forschung, Praxis und Genehmigungsexpertise soll die Translation der interaktiven Materialien vorangebracht werden. Für das Vorhaben wird derzeit in unmittelbarer Nähe zum DWI ein neues Gebäude errichtet; die Inbetriebnahme ist für 2022 vorgesehen.

In diesem Zusammenhang wurde das überzeugende Konzept *Programming and Translating Soft Materials for Interaction with Alive Matter* entwickelt. Es zielt darauf ab, Eigenschaften und Funktionen von Materialien mit Hilfe von großen Datenmengen zu bestimmen. Das DWI sieht dafür dauerhaft insgesamt rund 3 Mio. € p.a. vor, finanziert über einen Eigenanteil (0,3 Mio. €) und zusätzliche Mittel der institutionellen Förderung (2,7 Mio. €). Der Senat befürwortet nachdrücklich, zum nächstmöglichen Zeitpunkt einen Antrag für einen „kleinen strategischen Sondertatbestand" in dem dafür vorgesehenen Verfahren vorzulegen.

Die **Kooperation** des DWI mit der RWTH Aachen und dem Universitätsklinikum Aachen ist hervorragend. Mit der Klinik wurde sie durch die Gründung von *fi*T noch weiter gestärkt. Darüber hinaus ist das DWI an zahlreichen Verbundvorhaben und Projekten mit Unternehmen beteiligt. Wie bei der Evaluierung durch den Wissenschaftsrat empfohlen, hat das Institut seine Kooperationen mit Partnereinrichtungen im Ausland ausgebaut, zum Beispiel über zwei EU-geförderte Allianzen. Die Assoziierung von international führenden Wissenschaftlerinnen und Wissenschaftlern mit komplementärer Expertise ist ein geeignetes und strategisch noch weiter zu schärfendes Instrument der internationalen Zusammenarbeit.

Der **wissenschaftliche Nachwuchs** wird am DWI sehr gut gefördert. Die Zahl der Promovierenden und der abgeschlossenen Dissertationen ist hoch. Die Promotionsbetreuung

erfolgt im Rahmen eines verpflichtenden Mentoring Programms. Der **Anteil von Wissenschaftlerinnen** am DWI lag Ende 2018 bei 35 %. Von den sechs Professuren ist jedoch nur eine und von den derzeit drei Nachwuchsgruppenleitungen keine mit einer Frau besetzt. Auf Leitungsebene muss das DWI daher deutliche Verbesserungen in der Gleichstellung der Geschlechter erreichen. Das sehr erfolgreiche Modell der unabhängigen Nachwuchsgruppen bietet dafür gute Möglichkeiten. Auch in Beirat und Aufsichtsgremium müssen zukünftig mehr Frauen beteiligt werden.

Das DWI ist international sichtbar und anerkannt. Die langfristig und interdisziplinär angelegte grundlagen- und anwendungsorientierte Forschung zu Weicher Materie ist in dieser Form an einer Hochschule nicht möglich. Eine Eingliederung des DWI in eine Hochschule wird daher nicht empfohlen. Das DWI erfüllt die Anforderungen, die an eine Einrichtung von überregionaler Bedeutung und gesamtstaatlichem wissenschaftspolitischem Interesse zu stellen sind.

2. Zur Stellungnahme des DWI

Der Senat begrüßt, dass das DWI beabsichtigt, die Empfehlungen und Hinweise aus dem Bewertungsbericht bei seiner weiteren Arbeit zu berücksichtigen.

3. Förderempfehlung

Der Senat der Leibniz-Gemeinschaft empfiehlt Bund und Ländern, das DWI als Einrichtung der Forschung und der wissenschaftlichen Infrastruktur auf der Grundlage der Ausführungsvereinbarung WGL weiter zu fördern.

2 January 2020

Annex A: Status report

Leibniz Institute for Interactive Materials (DWI), Aachen

Contents

1. Key data, structure and tasks

Key data

Year established:	1952 as "Deutsches Wollforschungsinstitut e.V."
Admission to joint funding by Federal and *Länder* Governments:	2014
Admission to the Leibniz Association:	2014
Last statement by the German Council of Science and Humanities:	2013
Legal form:	Registered association
Responsible department at *Länder* level:	Ministry of Culture and Science North Rhine-Westphalia
Responsible department at Federal level:	Federal Ministry of Education and Research

Total budget (2018)

5.4 M€ institutional funding

6.7 M€ revenue from project grants

0.4 M€ revenue from services

Number of staff (2018)

102 individuals in research and scientific services

31 individuals in service sector

19 individuals in administration

Mission and Research Structure

The mission of DWI – Leibniz Institute for Interactive Materials is to conduct scientific research on the development, processing, and functionality of materials, film and fiber structures and their products, as well as the development and research of components for new technologies (see Statutes §2, 2).

Research at DWI is organized into five Research Programs (RPs, see Chapter 7) each of which is coordinated by two members of the Scientific Board (see Chapter 5) together with Junior Group or Project Leaders. DWI's matrix organization aims at the convergence of expertise, methods, and skills from different disciplines. Thus, in the five RPs the competences of several Working Groups (WGs) in the fields of synthetic macromolecular chemistry, functional and active polymers, polymeric biomaterials, biotechnology and chemical process engineering are integrated (see Appendix 1).

Research Activities are supported by the shared analytical facilities (Center for Chemical Polymer Technology (CPT), see Chapter 2).

2. Overall concept, activities and results

The DWI research mission targets the transition from homogeneous molecular assemblies to complex molecular systems. It involves overarching length scales, bridging chemical synthesis of molecules and colloids and their assembly into larger functional constructs. Another objective of DWI's research is the incorporation of dynamic properties to render passive materials active and interactive with their environment.

The five RPs cover different aspects for the development of molecular materials that follow the hierarchical design principles of nature with the objective to realize active properties. While RP 1 and RP 2 are dedicated to bottom-up synthesis and assembly as well as top-down fabrication of materials and their building blocks, RP 3 – RP 5 investigate functions and interactive material systems in different environments and settings. The RPs are described in detail in Chapter 7.

To bestow artificial (hybrid) materials with the level of complex functions of natural systems, DWI follows a long-term research strategy reflected in a three-stage road map:

- Understanding and controlling self-assembly and hierarchical structure formation from single molecules, molecular building blocks, and colloids to functional systems and compartmentalized structures in thermodynamic equilibrium (static self-assembly).
- Realizing switchability and multi-stability in combination with feedback loops, co-existence of multiple different states driven and controlled by external fields, and dissipative processes required for switching and memory-effects under non-equilibrium conditions.
- Integration of energy sources or motors into materials for autonomous interaction with the environment to achieve specific functions, such as self-repair, active transport or motility and to allow dynamic self-organization.

DWI activities combine fundamental research with the aim to transfer findings from (macro)molecular sciences towards application concepts. The institute points out that most application-oriented activities are pre-competitive yet still in close collaboration with partners from industry, in particular with small and medium enterprises. At an early stage, basic research questions are analyzed regarding their relevance for practical use and subsequently such developments are integrated into translational strategies. Moreover, DWI supports spin-offs and grants licensing rights for the translation into commercial developments (see below).

Results

In recent years DWI scientists facilitated the realization of several material platforms and systems, which represent the basis for future developments towards the long-term goal of developing programmable and interactive materials. In the following, some highlights regarding research, transfer and the operation of research infrastructure are presented.

Research

Between 2016 and 2018, research at DWI resulted in 408 publications, including 391 articles in peer-review journals (see Appendix 2).

Functional and switchable microgel systems: One important material platform of DWI is microgels. These are functional macromolecular structures, which combine properties of macromolecules and polymer colloids due to their open network-like structure and ability to swell in water. At DWI, contributions were made regarding the modelling and synthesis approaches to tailor the size, chemical structure, and architecture of microgels. These efforts resulted in novel microgel systems with various payloads including organocatalysts, plasmonic nanoparticles, antibacterial agents, and anchor peptides. Especially, the combination of microgels with anchor peptides that specifically bind to the surfaces of leaves led to the creation of novel nutrient and fungicide release systems for plant protection. To further increase the functionality of this class of soft materials, switchable microgels were pioneered at DWI. This regards the ability of microgels to respond to external stimuli by abrupt change of swelling degree, size, and mechanical properties. Therefore, molecular switches were incorporated into the microgel structure to control noncovalent interactions on the molecular scale using external stimuli such as pH, temperature or light. This resulted in microgel systems with double-temperature-responsive properties exhibiting both tunable upper and lower critical solution temperatures, with tailored release kinetics of proteins and with photo-controllable assembly characteristics. Another trigger of migrogels exploited at DWI is magnetic fields leading to the Anisogel technology. For the regeneration of soft, sensitive tissues, such as the spinal cord, low invasive, injectable materials are required to avoid additional damage. Researchers at DWI provided the first solution of a hybrid material, which can be injected and provides defined oriented guiding elements for nerve cells. This was achieved by magneto-responsive rod-shaped microgels that align in a magnetic field after injection and maintain their orientation due to crosslinking of a surrounding hydrogel precursor solution. After successful establishment of guiding cells by magnetic fields in vitro, the next step is application of such microgel systems in vivo.

Light-actuated soft matter: One aim of DWI is mimicking natural materials and their active properties. Examples are the emulation of the pulsation of living matter and motility of microorganisms. Scientists at DWI approached this challenge by hydrogel-based material systems that transform thermal energy generated by absorption of laser light into periodic mechanical motion. Therefore, the thermomechanical actuation capabilities of microgels were combined with the photothermal properties of gold nanorods incorporated into these microgels as optical absorbers. This concept allowed developing a microscopic hydrogel actuator that can pump, rotate, and move forward by its body deformation. Moreover, this photothermal actuating hydrogel was exploited to investigate the effect of mechanical beating on cells. Therefore, patterned hydrogel films were synthesized with a chemical composition that ensures cell adhesion and growth and at the same time, the hydrogel undergoes a volume change near body temperature. Through light irradiation, the hydrogel can be mechanically actuated leading to reduced cell migration

and enhanced binding strength of the cells to the substrate. In the future, this active platform will play an important role at DWI to study life-like mechanical stresses on other relevant cell types including stem cells.

Bioinspired out-of-equilibrium systems: To approach adaptive, self-regulating or self-propelling materials, it will become necessary to master dissipative structures that form at out-of-equilibrium conditions. Such dissipative assemblies, which represent a novel class of materials, were successfully realized at DWI, relying on different energy inputs. In the area of self-propelling micro-objects, a micro-swimmer driven by light was fabricated. This micro-swimmer undergoes complex motion in response to continuous light irradiation that causes a thermal response, i.e., repetitive swelling and unswelling, of a helical hydrogel body. This out-of-equilibrium response can yield precise and fast shape deformations as needed for mobile microscale robots. In another example, catalytic control of the time domain of pH-responsive peptide hydrogelators was achieved by combining a fast, acidic activator with the slow, enzymatic, feedback-driven generation of a base in a closed system. These transient hydrogel states can be programmed over orders of magnitude in time and result in dynamic gels with predetermined lifetimes, which can be used for fluidic guidance, burst release, and self-erasing rapid prototyping. In addition to light and protons, biochemical fuels were utilized to design dissipative self-assembly systems. In a collaborative research project, the dissipative self-assembly of FtsZ (a bacterial protein fiber homologue of tubulin), which relies on guanosine-5'-triphosphate (GTP) as energy source for polymerization, was studied within coacervate droplets. The coacervates consisted of cationic supercharged polypeptides and anionic ribonucleic acid (RNA) that undergo liquid-liquid phase separation. Upon consumption of GTP, FtsZ forms fibers within the coacervates and elongates the coacervate droplets into extended structures that finally divide. This highly dynamic fibril system, in which open compartments are used to modulate the rates of dissipative self-assembly by restricting the energy uptake from the environment, may provide a general route to chemical systems exhibiting life-like behavior.

Operation of Research Infrastructure

At DWI, synthetic and analytical facilities are centralized within the Center for Chemical Polymer Technology (CPT), which provides various characterization methods and samples of special building blocks used in the different RPs or required by industry. In addition to analysis and characterization, CPT ensures the implementation of synthetic protocols.

CPT uses well-equipped laboratories for the synthesis and fabrication of different materials (e.g. chemical synthesis, biosynthesis and biotechnology laboratories), including clean room facilities. It provides a variety of methods for assessing the composition and structure of polymer systems, for the structural characterization of polymer samples and particles and general physical-chemical characterization of colloid and polymer samples. Furthermore, it operates a surface characterization facility dedicated to functional surfaces, fibers, and films.

CPT solely provides services to support DWI activities whereas original research is exclusively performed in the RPs. CPT is operated based on a separate accounting, i.e., DWI users are charged for their use of CPT instrumentation and personnel by additional costs (without investment and overhead). Services of CPT include analytics, also for samples from outside customers, on a full cost-plus profit base. The generated revenues are used to reduce costs of internal services and for investments in new equipment.

Transfer

Intellectual property generated at DWI with economic potential has been protected by patenting and some patents have successfully been licensed by companies. Between 2016 and 2018 DWI applied for a total of 7 patents and was granted 5. DWI for example contributed to the fabrication of 5-Euro and 10-Euro coins, which can be potentially used in coins worldwide increasing the security standards. DWI also developed a production process for different kinds of model fibrous microscopic particles of well-defined sizes and shapes now available for internal and external customers via DWI's CPT.

Transfer from the institute starts to materialize in first spin-off companies. One successful company from the DWI is dealing with research data management and currently the institute is working on a startup company for plant protection.

To promote scientific exchange and knowledge transfer, DWI regularly organizes a number of conferences. For example, reflecting the institute's roots in textile and fiber research, on a triennial basis and together with partners in Dresden and Denkendorf/Stuttgart, the Aachen-Dresden-Denkendorf International Textile Conference with about 600 participants is organized.

3. Changes and planning

Development since the previous evaluation

In 2014, when DWI was incorporated into the Leibniz Association, it had established a matrix organization being composed of five RPs on the one hand and the individual WGs with their complementary expertise on the other, common use of infrastructure and an open laboratory structure with experimentation and office space shared between the different WGs.

Motivated by its scientific roadmap to develop truly interactive materials and as recommended by the Council of Science and Humanities in 2013, DWI strengthened basic research and increased the expertise in physics, physical chemistry and simulation. The new Scientific Board Members and the majority of employees hired after the 2013 evaluation, focus on fundamental research. This resulted in increased DFG and ERC funding. DWI scientists currently hold three ERC Advanced Grants. In December 2019, one DWI Junior Group Leader has received an ERC Consolidator Grant, whereas the recipient of another earlier ERC Consolidator Grant left the institute in 2015. In addition, two other DWI Junior Group Leaders, of whom one meanwhile left the DWI, each received an ERC Starting Grant.

Based on its history as the German Wool Research Institute, one of DWI's areas of expertise concerns functional fibers and textiles. While DWI maintained these competences, it

strengthened and expanded its expertise in biomedical research over the past six years. Today, several of DWI's projects aim at developing new materials to be translated into the clinic for biomedical applications. To achieve this, the institute collaborates with multiple groups at the Medical Faculty of RWTH Aachen University. For example, within an ERC Starting Grant, biohybrid and bioinspired materials for the regeneration of damaged spinal cord tissue are being developed. Within another project, a general nucleic acid drug carrier system is developed for treatment of eye diseases and various vaccination purposes. One ERC Advanced Grant deals with the late stage modification of natural product-derived aminoglycoside antibiotics for overcoming antibacterial resistance, ultrasound-activatable and targeted antibiotics as well as in vivo infection imaging systems. Furthermore, at DWI blood treatment devices, such as new hemo-compatible functionalized dialysis membranes and full blood absorbers are developed in cooperation with a company.

Since 2014, two Scientific Board Members have left DWI for leading positions at a Fraunhofer Institute and TU Braunschweig and two Junior Group Leaders have accepted calls to W3 professorships at Freiburg and Ulm Universities.

Consequently, three new joint appointments were initiated by DWI and RWTH Aachen University. They resulted in hiring two new W3 Professors, one of which became the new Scientific Director of DWI in 2019. Furthermore, one former Junior Group Leader received a W2 tenure track professorship and two new Junior Groups started in 2016 and 2018.

Strategic work planning for the coming years

Within the next decade, DWI plans to further grow as a materials research institute aiming at leadership in the development of active and interactive material platforms for future applications. Therefore, innovations in the area of bioactive and bioinstructive materials will be pushed towards biomedical applications, for which a dedicated infrastructure (*fi*T) will be established.

DWI successfully acquired funds of 15.4 M€ to construct a 3500 m^2 (brutto) building comprised of laboratories, clean rooms, and training facilities. This **joint lab "*first in* Translation" (*fi*T)** will be operated in close collaboration with the Medical Faculty of RWTH Aachen University. The construction will start in spring 2020 and the opening of the building is scheduled for the second half of 2022.

The tasks of *fi*T will be: i) to validate preclinical therapeutic modalities according to Good Laboratory Practice regulations, ii) to develop a fabrication process of new therapeutic modalities according to Good Manufacturing Practice, and iii) to obtain permission from the approval authorities for conducting clinical trials and thus also for the examination by the ethics committee.

Besides establishing this scientific infrastructure, DWI is acquiring funds of 3.5 M€ from the BMBF through the project *New Ways to Accelerated Translation of Biologized Medical Products* (ATBMP) to set up the necessary organizational framework.

In addition, DWI's expertise in the area of optically active and charge flow-controlling materials shall be directed towards the development of materials for information storage

and processing to enable new device concepts. Moreover, DWI plans to pursue sustainable material systems by actively developing and implementing new approaches for bio-based polymers and recycling, contributing to circular economy. DWI has defined a materials development roadmap, a strategy to translate the material innovations into the clinic and market, and to stay competitive in the field of interactive materials research in the future.

To further strengthen its network with German partners, DWI joined the Max Planck School "Matter to Life", which is organized by the Universities of Heidelberg, Göttingen, and Munich, as well as DWI and various Max Planck Institutes. The program involving the first group of students started in fall 2019.

DWI has developed a strategic action of interlinked measures to address and overcome critical shortcomings. These are namely the need for a dedicated infrastructure as well as in-house expertise in theoretical understanding of (bio)material systems and their behavior in contact with living matter. Furthermore, DWI sees the need for a strong network in its field of research.

Planning for additional funds deriving from institutional funding

DWI points out that setting up the institute on a broader scientific footing can only be realized through an increase in the core budget. Therefore, the institute plans to apply for a *minor extraordinary item of expenditure of a scientific-strategic nature* (kleiner strategischer Sondertatbestand). The overall costs amount to a permanent extension of DWI's core budget by 2.718 M€ starting in 2022. The scientific content of the measure is supported by DWI's Scientific Advisory Board (SAB) and Board of Trustees.

The title of the measure is *"Programming and Translating Soft Materials for Interaction with Alive Matter"*. The goal is to obtain and exploit big data in order to predict and select materials with specific properties and functions, specifically in the context of their interactions with living systems. Therefore, by operating the experimental infrastructure for fabrication of bioactive and bioinstructive materials to interact with alive systems and by implementing data-driven simulation approaches, DWI plans to facilitate the design of active and interactive materials and accelerate their translation into biomedical products and devices.

Sketch of the factual and personnel planning:

- Implementing the Joint Lab "*first in Translation*" with the Medical Faculty of RWTH Aachen University. The DWI explains that it needs additional financial resources to sustainably operate *fi*T and permanent staff to guarantee maintenance of equipment, processes and knowledge in regulatory affairs. The personnel requirements amount to 12 individuals (1 head (E15), 2 senior scientists (E14), 1 data specialist (E14), 5 technicians (3 E12 with clean room expertise and 2 E8), 1 IT support (E10) and 2 individuals for building maintenance).
- Establishing a physics theory group exploiting big data. To sustainably strengthen the theory competence at DWI (see above), the institute plans to establish a new (bio)physics group thereby extending the Scientific Board with an additional member

dedicated to “Data-driven Interactive Materials Simulation”. The new position will be a W2 joint appointment with RWTH’s Department of Physics. The personnel requirements amount to 7 individuals (1 W2 professorship, 1 senior scientist (E14), 4 doctoral students (E13) and 1 IT support (E10)).

- Installation of two new experimental Junior Groups. One will be devoted to “Experimental BioMaterials Science”, recording, processing and analyzing big data from the evaluation of interactive and biomedical materials to verify simulations and predictions of the new senior theory group. The other one will target “Living Materials Systems” by devising approaches to combine synthetic macromolecules fabricated at DWI with genetically modified organisms for the design and construction of genetically engineered living materials. The installation of these two temporary Junior Groups is planned as a lasting measure to continuously revitalize the research at DWI in the future. The personnel requirements amount to 8 individuals (2 Junior Group Leaders (E15), 4 doctoral students (E13) and 2 technicians (E8)).
- Participation in the Max Planck School “Matter to Life”. It is planned to allocate funding for three doctoral students and the involvement of DWI scientific staff in the School’s master program by taking over lectures and seminars at the campus of the University of Heidelberg and by offering courses, internships, and master projects in Aachen.

In summary the measure includes funding for 27 positions for individuals at DWI and 3 doctoral students at the Max Planck School, as well as funds for operating *fi*T.

„Extraordinary item of expenditure“: summary of funds planning

	2022	Permanently (starting 2023)
Own funds + additional funds = „extraordinary item of expenditure“	1.988 M€	3.018 M€
Own funds from existing funding by institution (at least 3 % of core budget)	300 k€	300 k€
Additional funds of institutional funding	1.688 M€	2.718 M€

4. Controlling and quality management

Facilities, equipment and funding

Funding

DWI joined the Leibniz Association in 2014. That related to a steady increase of institutional funding from 4.34 M€ in 2012 to 5.4 M€ in 2018. At the same time the revenue from project grants increased from 3.0 M€ (37 percent of the overall budget) in 2012 to 6.7 M€ in 2018 (55 percent of the overall budget). In 2018, DWI’s total revenues amounted to 12.5 M€, being composed of institutional funding by the Federal and State *(Länder)* Governments, of funding from project grants, and of income from services (0.4 M€). See Appendix 3.

In 2018 the revenues from project grants split into 2 M€ from the EU, 1.7 M€ from the German Federation of Industrial Research Association (AiF), 1.3 M€ from Federal and State *(Länder)* Governments and 1.1 M€ from the German Science Foundation (DFG). DWI

scientists currently (December 2019) hold three ERC Advanced Grants, one ERC Consolidator Grant, and one ERC Starting Grant, a DFG Leibniz-Prize and a Heisenberg Fellowship, as well as a Volkswagen Freigeist Fellowship. In 2018, DWI acquired funding from the Leibniz Program for Women Professors.

Facilities

DWI building is located on Campus Melaten of RWTH Aachen University. It currently consists of two interconnected parts. They were put in operation in 2004 and 2012, respectively, resulting in an overall floor area of 10,500 m^2, with more than 60 percent laboratory space. The basement houses a biosafety level 1 (S1) laboratory equipped for protein engineering, a facility for larger machines and devices (Technikum) as well as a small clean room and a library. The new building of *fi*T (Chapter 3) will be directly connected to the current DWI buildings. A part of the scientific infrastructure is maintained within the analytical facilities and transfer services (Center for Chemical Polymer Technology (CPT)), described in Chapter 2.

DWI is surrounded by RWTH Aachen buildings housing thematically-related research entities. The institute benefits from RWTH infrastructure including the university's IT services. In addition, DWI employs one in-house IT system administrator and one scientist in charge of data management.

As a large part of the current research at DWI is now directed to the interaction of synthetic materials with biological systems, the space for cell culture facilities has grown since 2013 from 23 m^2 to a total of 160 m^2 with the main Cell Lab (93 m^2) registered as an S1 Facility in 2018. With regard to prokaryotic systems, a S2 microbiology laboratory equipped with a drip flow biofilm reactor with low shear and continuous flow is in service and allows the evaluation of antimicrobial and antiadhesive substances and surfaces following industrial standards.

Organisational and operational structure

The institute is headed by the Managing Board consisting of the Scientific Director, the Administrative Director, and the Vice Scientific Director. The Managing Board takes responsibility for the daily management as well as the definition of long-term research goals.

Subjects that are of overall importance for the institute and strategic measures are discussed in the monthly meetings of the Scientific Board ("Professorium"). It consists of the six professors including the Scientific Director and Vice Scientific Director, all of them jointly appointed with RWTH Aachen University and heading a Working Group at DWI. They develop the annual research plan in detail, oversee and coordinate the work in the RPs together with Junior Group and Project Leaders. Depending on the subjects to be discussed, Junior Group Leaders, Associated Scientists or other co-workers may join the meetings of the Scientific Board.

Together with the Scientific Board, the Project Development Conference (Projektentwicklungskonferenz, PEK) is DWI's major tool to organize the project-based research at the institute. It comprises the extended Scientific Board (Scientific Board Members + Junior

and Independent Group Leaders + Associated Scientists), Project Leaders, and experienced postdocs. In its monthly meeting, new projects and their fit into one of the five RPs are being discussed.

The research and future planning for each of the five RPs is jointly coordinated by two Scientific Board Members with complementary expertise. They are supported by two Junior Group Leaders or Project Leaders for each RP. In order to implement the measures decided by the Managing and Scientific Boards and to monitor the institute's performance, these Boards are supported by a science management team, consisting of staff members from different working areas within DWI including scientific as well as administrative personnel.

Quality Management

Important components of DWI's internal quality management are an annual Strategy Seminar and the preparation of the annual program budget and research plan with its performance monitoring. Also, DWI applies a strategy- and performance-oriented allocation of funds.

The strategy-oriented allocation is set in the budget based on the joint decision of the Scientific Board and is used for realizing high priority actions to develop DWI's research program and for covering overarching requirements. As opposed to a group- or department-oriented allocation, these allocations are realigned each year and aim to target jointly responsible activities, such as new Junior Groups and infrastructure facilities.

By applying the allocation model, the core budget contains an amount of up to 1.0 M€ which is annually made available to the Scientific Board Members via performance-oriented allocations. The allocation is based on attracted funds.

DWI has implemented the rules of "Good Scientific Practice". In 2017, an ombudsperson and a deputy were elected.

DWI has committed itself to increasing access to its research results both for the scientific community and the general public, following the open access policy of the Leibniz Association.

According to the DWI, at the institute special care is taken that research data are properly archived for purposes of both verification (safe-guarding scientific integrity) and safe-keeping of valuable data sets. DWI participates in initiatives, such as the Leibniz expertise network for research data (LeibnizData) and the FAIRmat consortium to develop standards in the materials sciences for the National Research Data Infrastructure.

DWI is currently in the process of developing strategies for knowledge and technology transfer and to anchor a sustainable exploitation culture at the institute. All applications and granted patents were screened with the support of an external business developer and categorized. DWI hired a new employee in the summer of 2019 who currently establishes a continuous workflow for evaluating the transfer potential of current DWI projects. These transfer activities are being supported by the CPT (see Chapter 2) as well as the Scientific and Industrial Advisory Boards.

Quality management by advisory boards and supervisory board

The Board of Trustees (Kuratorium) is the supervisory body of the institute, consisting of seven members including representatives of the state, the federal government, and RWTH Aachen University. The Board of Trustees approves the annual program budget and research plan, appoints members of the Managing Board, the Scientific Board, and the SAB, approves the annual financial statements, and supervises all scientific, programmatic, as well as financial matters at DWI. As DWI is a registered association (e.V.), the Board of Trustees proposes its final approvals to the General Assembly of DWI Members.

The Scientific Advisory Board (SAB) currently consists of twelve members from science and industry, representing the different disciplines within DWI. All major decisions at DWI involve recommendations and the approval of the SAB. The SAB convenes annually for a one- or 1.5-day meeting to assess the performance and future objectives of DWI, including the program budget and research plan. The SAB audits the institute once between two external evaluations. All statements and recommendations of the SAB are forwarded to the Board of Trustees. The chairman of the SAB takes part in the meetings of the Board of Trustees as a guest.

DWI has two industrial advisory boards, which mainly consist of experts from companies. In the meetings of the industrial advisory boards, DWI presents project results and new research concepts for application-oriented projects in order to discuss their translational research for a future application as well as economic perspectives. The Industrial Advisory Board Textiles/Materials has about 50 members and convenes twice a year. The board helps DWI to select application-oriented projects in the area of fibers, films, and textiles. The Industrial Advisory Board Hair Cosmetics, which has about 20 members from cosmetics and chemical industry, meets once or twice a year. It supports the hair cosmetics research at DWI and helps to organize the program of the biannual international “HairS” symposium with an average number of around 150 participants.

5. Human Resources

As of December 31, 2018, a total of 152 people worked at DWI. Of these employees, 102 were scientists or worked in scientific services and 31 in service positions. 19 people worked in the administration team. In addition, there were 52 student assistants, five scholarship recipients, and two external Associated Scientists (see Appendix 4).

Since the evaluation by the Council of Science and Humanities in 2013, the total number of people working at DWI has increased by 25 percent (counted by contracts and compared to December 31, 2012: 122 people). According to DWI, the majority of employees hired since then strengthens basic research at DWI (see Chapter 3).

Management

Members of DWI’s Managing Board are the Scientific Director, the Administrative Director, and the Vice Scientific Director. They are appointed by the Board of Trustees for a period of five years and individually have the right and power of sole representation.

The Managing Board is responsible for the management of DWI, closely connected and supported by the Scientific Board. Senior members of the Scientific Board hold joint professorships and are appointed according to the legislation and rules of the State North Rhine-Westphalia and RWTH Aachen University. For appointing members of the Managing Board the guidelines of the Leibniz Association for appointing Scientific Directors as well as for Administrative Directors are followed.

Since the last evaluation, both Scientific Directors have been newly appointed. In 2018, the then Vice Scientific Director of DWI accepted the position of Vice Rector for Research and Structure at RWTH Aachen University and the vacancy at DWI was filled in August 2018. One year later the Scientific Director of DWI was newly appointed.

The Scientific Board is further strengthened by Associated Scientists. These are professors who committed themselves to long-term cooperation within the RPs. Their strategic appointment is decided by the Managing Board in close consultation with the Scientific Board and the SAB. Their appointment is not limited to a certain number of years but is regularly evaluated during meetings of the aforementioned boards. They have access to DWI's laboratories and infrastructure and have their own budget to hire a limited number of doctoral students or postdocs. While contributing to acquiring third-party funding for the institute, they can also be supported by strategy-oriented allocations from the institute's core budget. Currently, six professors are Associated Scientists at DWI, three from the RWTH Aachen University, one from the University of Ulm and two from the Moscow State University.

Postdoctoral staff

Postdocs are members of DWI's WGs and work on one or more projects within the RPs, without having project responsibility. They receive full-time contracts, usually for a duration of two years. Postdocs are mentored by the Scientific Board Members. With growing experience, postdocs have the chance to accept more responsibility and become Project Leaders at DWI.

Project Leaders take responsibility for managing projects and they support the Scientific Board Members in coordinating the RPs. They are not allocated to a specific WG. Instead, they are supervised by the Scientific Board Members who are responsible for the project which is currently being managed by the Project Leader.

The Junior Group leaders are selected and recruited by the Scientific Board Members. DWI provides the Junior Group Leaders financial support to build a small WG to enable initial experimental research. The Junior Group Leaders are mentored and are provided time to write proposals so they can finance their own WG and become more financially independent. For Junior Group Leaders DWI aims at Sofia Kovalevskaja awards (AvH), ERC Starting Grants or Emmy Noether junior groups. DWI currently has two Junior Group Leaders.

DWI has the possibility to nominate Independent Group Leaders. They have a Doctoral degree and postdoctoral experience, have attracted at least one major third-party grant, and their competences complement the expertise already available at the institute. They are, however, only mentored to a certain extent and only involved in selected matters by the Scientific Board. Currently, one Independent Group Leader is nominated by the DWI.

Doctoral Candidates

In December 2018, 67 doctoral candidates worked at the institute. Between 2016 and 2018 a total of 70 doctoral degrees were completed under primary supervision of DWI Scientific Board Members. The average PhD duration at DWI is four years.

Doctoral students are associated with one WG and typically work on one, possibly more specific projects in one RP. They are employed on the basis of regular working contracts, typically amounting to 50 percent of the full working time in the first year and 67 percent in the following years. Engineers are employed on full time (100 percent) working contracts.

DWI doctoral students participate in the institute's Mentoring Program, which includes the assignment of two mentors for each doctoral candidate. Within the four-year PhD project, three obligatory mentoring meetings are scheduled to discuss and evaluate the scientific results of the Doctoral candidate, his/her overall performance as well as the quality of the supervision by the mentors. The participation in the Mentoring Program is obligatory for all doctoral candidates working at DWI, independent of the scientific focus of the research and the educational background. Currently, more than 80 doctoral students are participating in the Mentoring Program. The doctoral students present their research in the weekly Institute Seminar. Once a year a Doctoral Student Retreat is organized. Together with partners from industry, DWI organizes seminars and events for doctoral students, such as summer/winter schools, talent awards or discussion forums.

DWI maintains contact to its Alumni. They are being invited to participate in DWI events and conferences or to give lectures. Starting in summer 2020, DWI will organize biannual alumni meetings.

Non-scientific staff

The group of non-scientific staff members consists of dedicated employees in laboratory and technical service positions as well as in administration positions, many of which have a long-term or permanent contract at DWI.

In 2016, DWI introduced a rotation program for the group of laboratory assistants and technicians. Technical Staff members support work in the different RPs. They are not assigned to the WGs on a permanent basis but according to their competences and their contribution to running as well as planned projects. Vocational training takes place both at the workplace itself and through participation in internal and external training events.

DWI is involved in the training of laboratory technicians in a program coordinated by RWTH Aachen University. Every summer, DWI welcomes three new RWTH apprentices in the institute. In addition, from 2016 till 2018, one apprentice received the training as a management assistant in office administration. In total, twelve apprentices completed their training between 2016 and 2019.

Equal opportunities and work-life balance

On December 31, 2018, women accounted for 35 percent of staff in research and scientific services. One of the six positions in the Scientific Board was and is held by a woman. None

of the Junior Group Leaders, one of the Associated Scientists, and 23 out of 67 doctoral candidates (34 percent) were female. The Administrative Director of the DWI is female.

DWI has implemented the cascade model for the academic sector and determined specific target quotas for each staff and management group. The implementation of equal opportunities is a task of the Managing Board, supported by the Equal Opportunities Officer who has a budget at her disposal (since 2017: basic budget of 35 K€ per year). Further funds are provided according to need and via strategic budget allocation.

To promote female scientists and to qualify women for top scientific positions, DWI supports participation in scholarship and mentoring programs. In 2018, a tenure-track professorship was established at DWI together with the RWTH Aachen University (W2/W3 tenure-track) and a female candidate was appointed to the position.

In addition to individual measures such as flexible working hours, part-time work, temporary exemption from compulsory attendance, mobile working, family-friendly meeting times, assistance in finding suitable childcare and a parent-child office, in 2019 DWI has also advocated the title "Total E-Quality".

In January 2019, DWI founded the "Equal Opportunities and Diversity" working group with the aim of further develop the concept of diversity and equal opportunities in all areas and offers of DWI.

6. Cooperation and environment

Cooperation with Universities

RWTH Aachen University is DWI's prime cooperation partner. All six Scientific Board Members of DWI have been jointly appointed and hold chairs or research areas at the university. The jointly appointed person has responsibilities in both organizations to a different degree. There exist 80/20 (four members of the Scientific Board) appointments as well as 50/50 appointments (two Members of the Scientific Board).

All members of DWI's Scientific Board fulfil teaching obligations at RWTH Aachen University (depending on the above mentioned proportions; on average five weekly hours) and more than 100 PhD, MSc, and BSc theses are supervised every year.

DWI has dedicated user contracts for getting access to RWTH infrastructure, such as the Magnetic Resonance Center, the joint Aachen-Jülich Facility for Electron Microscopy as well as the Clean Room Facility of the Department of Materials in Electrical Engineering. Currently, DWI is significantly strengthening its ties to the Medical Faculty of RWTH Aachen University by setting up the joint lab *fi*T (Chapter 3).

DWI also cooperates with groups and institutes at other German universities, either in bilateral or larger coordinated research networks. These networks are often DFG-funded (see below). Furthermore, DWI is pursuing bilateral collaborations with German universities in projects funded by the Volkswagen Foundation, BMBF, AiF, and the Leibniz Competition.

Participation in research networks

DWI scientists are currently engaged in one Collaborative Research Centre (SFB which is coordinated by an Associated Scientist of DWI, while a DWI Scientific Board Member is the Vice Speaker, and overall ten projects are run by DWI scientists), three Priority Programs (SPP), two Research Training Groups (GRK) and one Research Group all funded by the DFG.

Cooperation with Leibniz institutes and extramural research institutes

DWI is part of the Leibniz Research Alliance "Leibniz Health Technologies", where it mainly contributes to the competence area "Bioactive Interfaces". Within the Leibniz Association, the strongest links exist between DWI and the Leibniz Institute of Polymer Research Dresden (IPF) as well as the Leibniz Institute of Photonic Technology (IPHT) in Jena. DWI is also collaborating with the Leibniz Institute for New Materials (INM) in Saarbrücken and the Leibniz-Institut für Analytische Wissenschaften - ISAS in Dortmund.

Through the Collaborative Research Centre, and through the Jülich Aachen Research Alliance JARA in the field of soft materials research, the DWI cooperates with the Forschungzentrum Jülich, a member of the Helmholtz Association. The Section JARA-SOFT consists of scientists at Forschungszentrum Jülich, RWTH, and DWI, and is dedicated to the multidisciplinary research dealing with synthetic and biological soft matter.

With its involvement in the Max Planck School "Matter to Life", DWI has the opportunity to participate in a Max Planck research and training network. Moreover, DWI collaborates with the Fraunhofer Institute for Laser Technology (ILT) in Aachen and the Fraunhofer Institute for Applied Polymer Research (IAP) in Golm within the framework of AiF and BMBF projects.

International Cooperation

DWI maintains contacts with several Dutch and Belgian Universities, for example in Eindhoven, Twente, Groningen or Gent. The institute is also involved in the Aachen Maastricht Institute for Biobased Materials (AMIBM). Since September 2017, DWI has been a member in the project "EUSMI", which is funded by the EU for a period of four years.

DWI collaborates with many international universities, non-university and industrial partners. Within the ITN BIOGEL, funded by the Marie-Skłodowska-Curie action of the European Commission from 2015 to 2018, DWI initiated or strengthened collaborations with the École Polytechnique Fédérale de Lausanne, Radboud University Nijmegen and the University of Valladolid; overseas with the University of Pennsylvania (USA) and the University of Osaka (Japan). The EU-funded training network ALERT, which deals with development of new biocides and antimicrobial surfaces, is coordinated by a DWI scientist.

DWI is one of eleven consortium members of the project EVPRO (Extracellular Vesicles Promoted Regenerative Osseointegration) which aims to counteract the shortened lifetime of implants and to reduce the risk of inflammation of hip revision prostheses. This Horizon 2020 EU project started in January 2019 and runs until the end of 2022.

Within the UMBRELLA framework coordinated by RWTH Aachen University and Forschungszentrum Jülich, DWI collaborates with Technion in Israel in the domain of new desalination material systems. DWI also collaborates with Lomonosov Moscow State University, as reflected by a large number of cooperative publications as well as by association of scientists.

DWI sustains exchange of students and scientists with the École Nationale Supérieure des Arts et Industries Textiles ENSAIT in Roubaix France and the Centre for Polymer Science and Engineering of the Indian Institute of Technology in New Delhi, India.

Collaboration with industry

To interact with companies and acquire specific expertise for planned projects, DWI is a member of several umbrella organizations, such as Forschungskuratorium Textil e.V., Berlin, and DECHEMA e.V., Frankfurt. DWI works with registered societies, such as LifeTec to strengthen life science activities in the Aachen-Jülich region, to support the polymer trade sector with different public engagement and - relation actions and TEXTRANET an association of European textile research institutes to coordinate research efforts and venues.

DWI's Association of Friends allows DWI to interact personally and directly through its members to generate new projects with a focus on applied research.

In the frame of a long-lasting collaboration with Covestro Deutschland AG, DWI researchers develop new sustainable and non-toxic flame retardants for polycarbonates. Together with Altana AG, DWI has established a program where students conduct their practical work for their doctoral or MSc thesis at the Byk laboratories, generating knowledge transfer on a practical level.

Institution's status in the specialist environment

Within the Leibniz Association, three Leibniz institutes share a materials-oriented, complementary research focus: The Leibniz Institute of Polymer Research Dresden (IPF) focuses on polymeric functional materials, the Leibniz Institute for New Materials (INM) in Saarbrücken works on functional inorganic materials, and DWI explores and develops (bio)hybrid and interactive material systems.

Worldwide, a growing number of renowned institutes and research clusters are active in this field of research. Prominent examples include:

- Wyss Institute for Biologically Inspired Engineering, Harvard University;
- Pritzker School of Molecular Engineering, Chicago;
- Radboud Institute for Molecules and Materials, Radboud University Nijmegen;
- Institut de Science et d'Ingénierie Supramoléculaires in Strasbourg;
- Freiburg Centre for Interactive Materials and Bioinspired Technologies.

DWI established a scientific profile that, according to the institute, compares well with internationally renowned research organizations. While the number of participating research team members in the above institutes often is larger compared to the DWI team of PIs, the degree of integration of the disciplines in DWI appears to be higher.

7. Subdivisions of DWI

Research Program 1 (RP 1): Aqua Materials – Materials Formed from or for Aqueous Systems; Chemistry in Water

(Average 2016-2018: 20.7 FTE, thereof 5.6 FTE Research and scientific services[1], 9.2 FTE Doctoral candidates, and 5.9 FTE Service staff)

RP 1 focuses on the development of water-based synthetic methods to generate molecular building blocks that enable the complex and hierarchical interactions of materials. With this RP, DWI strives to address the challenges of how properties of matter emerge from the complex correlations of their constituents and how to characterize and control complex material systems.

Over the past years, these challenges were tackled by focusing research efforts on the improvement of chemical and enzymatic ligation, conjugation, precipitation, and polymerization reactions using conventional and flow chemistries with emphasis on fast kinetics, quantitative turnover, and bio-orthogonality. Since the last evaluation, in RP 1 the development of synthetic methods was gradually intensified to provide tailored molecular building blocks and enable applications as well as functional systems in RPs 2-5. In RP 1 scientists designed and synthesized (bio)macromolecules and colloids with precise control over their chemical structure, topology, and architecture to steer their self-assembly into hierarchically organized materials and fabricate complex structured materials using spinning, printing, and casting techniques. Specific attention was devoted to the manipulation of matter exploiting responsivity to temperature, pH, light, and mechanical force as well as to the formation of dynamic bonds for reversibility and degradability. Alongside, simulations played an increasingly important role in the efforts allowing to better understand and predict the complex interactions of materials in water.

RP 1's future developments will focus on synthetic key technologies, such as:

- Sustainability aspects of polymeric materials;
- Reactions in confined spaces (bio-inspired catalyst systems) and under spatio-temporal control;
- Chemistry in flow towards continuous and far-from-equilibrium processes;
- Fast, quantitative, and remote-controlled (NIR light, force, magnetic fields) bio-orthogonal ligation and conjugation reactions for creating bioconjugates with potential in biomedical applications;

[1] This number does not include Scientific Board Members, who contribute to the research of several RPs.

- Switchable and stimuli-responsive multi-component systems enabling the development of truly interactive materials by user-material and material-material interfacing.

Between 2016 and 2018, scientists in RP 1 published 140 articles in peer-reviewed journals. In the same time period the institutional funding was 2.7 M€. The revenue from project grants totaled 3.1 M€, with 1.1 M€ spent from Federal or State *(Länder)* governments, 1.1 M€ from EU grants and 667 K€ from the German Science Foundation (DFG). 29 doctoral degrees were completed.

Research Program 2 (RP 2): Synthiofluidics – Assembly and Fabrication of Well-Defined Micro- and Nano-Objects

(Average 2016-2018: 11.6 FTE, thereof 3.0 FTE Research and scientific services[1], 5.8 FTE Doctoral candidates, and 2.7 FTE Service staff)

RP 2 "Synthiofluidics" deals with microphase and microfluidic controlled synthesis and processes. Research in RP 2 builds on reactions in water as well as water-soluble components produced in RP 1 and versatile methods for reproducible and reliable synthesis of nano- to micro-sized objects are being developed. Toward this goal, flow-assisted molecular transport, reaction-compartments in specific architectures and stimulus-induced reaction mechanisms, such as photopolymerizations, are utilized to achieve well-defined material properties and functions. Challenges lie in the synthesis of either very small (< 20 nm) or very large colloidal structures (> 10 µm) with a defined geometry and chemical composition, and potentially under physiological, biocompatible conditions. Therefore, precise spatio-temporal control over the reagents and chemical reactions plays a key role to form unique structures under dissipative non-equilibrium conditions, for example to realize anisometric hydrogel particles. In particular, hydrodynamic focusing, incubation, fluid addition, and droplet operations, such as dispensing, merging, mixing, and splitting are exploited for confined reaction containers. Photocleavage initiated reaction cascade is an important approach that facilitates an externally controlled rapid gelation process for the production of containers with encapsulated particles or molecules.

The concepts at DWI of the last years, towards programmable molecular and colloidal systems, will in the future focus on the real-time manipulation and monitoring of the synthesized structures through integrated triggers and spectroscopy sensor systems. The methods developed in RP 2 are being used for specific tasks in other RPs, particularly for biomedical-oriented applications in RP 5.

The future planning of RP 2 revolves around the following three objectives:

- Construction of nanometer-sized particles and compartments through batch-based self-assembly techniques to achieve unique physical properties and chemical reactivity;
- Synthesis of novel nano- and micro-scale building blocks with microfluidics for precisely controlled material properties that include size, morphology, and softness;
- Manipulation of nano- and micrometer sized containers in microfluidics – new methods for reagent injection and curing.

Between 2016 and 2018, scientists in RP 2 published 60 articles in peer-reviewed journals. In the same time period the institutional funding was 1.9 M€. The revenue from project grants totaled 1.8 M€, with 922 K€ spent from Federal or State *(Länder)* governments, 399 K€ from the German Science Foundation (DFG), 291 K€ from the industry and 137 K€ from EU grants. One patent was applied for and one granted. Nine doctoral degrees and two habilitations were completed.

Research Program 3 (RP 3): Macromolecular Films and Fibers – Functional Surfaces and Interfaces

(Average 2016-2018: 12.9 FTE, thereof 4.4 FTE Research and scientific services[1], 4.4 FTE Doctoral candidates, and 4.1 FTE Service staff)

RP 3 focuses on steering and exploiting structure formation at surfaces and interfaces that are responsive to external changes in their environment. The long-term goal is to develop systems that autonomously and selectively react towards external stimuli while neglecting others. In this RP particular attention is paid to films and fibers, methods to create them, and to control their response. A broad number of approaches is employed to generate surfaces and interfaces spanning from chemical and physical coatings to the introduction of functions by frustration and confinement. The latter relies on the fact that molecules – three-dimensional in nature – have to adapt their conformation and shape to the two-dimensional interface. This results in the generation of new structures and functions that only exist at and because of the interface and this represents a unique aspect within RP 3. Scientists working in RP 3 are devoted to developing switchable and adaptive systems through the controlled exploitation of metastable states. Various stimuli (temperature, light, electric or magnetic fields, mechanical stress, solvent uptake, pH, adsorption/binding of ions, interaction with macromolecules and cells) induce molecular changes, which can be amplified by the hierarchically organized material structures to alter their microscopic and macroscopic properties.

A number of synthetic and biological building blocks used in this program are provided by RPs 1 and 2. Since the functionality and interaction of a material is essentially determined by its interfacial properties, the results of the projects in RP 3 provide a fundamental basis for further studies in the other RPs.

The future challenges in RP 3 lie in developing systems that autonomously and selectively react towards external stimuli. Scientists in RP 3 will also actively work on coatings for medical devices, including implants and indwelling catheters, with antimicrobial, non-cell adhesive, lubritious, and other properties. The main challenges of the future work in RP 3 are:

- Mimicking the key features of the cell membrane (thickness, flexibility, stability);
- Ability to co-assemble synthetic building blocks with natural bioreceptors;
- Generation of a stealth environment within biological systems;
- Programmed 2D display of binding elements.

Between 2016 and 2018, scientists in RP 3 published 63 articles in peer-reviewed journals. In the same time period the institutional funding was 2.55 M€. The revenue from

project grants totaled 2.3 M€, with 1.4 M€ spent from Federal or State *(Länder)* governments, 416 K€ from the German Science Foundation (DFG), 376 K€ from the industry and 80 K€ from EU grants. One patent was applied for and four doctoral degrees were completed.

Research Program 4 (RP 4): Transport, Reaction and Exchange Systems – Material Systems for Controlled Transport, Reaction, and Exchange: Separation and Reaction Controlling Systems

(Average 2016-2018: 22.4 FTE, thereof 2.3 FTE Research and scientific services[1], 13.9 FTE Doctoral candidates, and 6.2 FTE Service staff)

Interactive material systems serve as essential functionality for applications, such as molecular separation, energy storage, and chemical conversion. These systems are envisioned as highly integrated multi-component and multi-scale materials based on the three functions:

- Selective molecular transport at and through interfaces;
- Chemical transformations;
- Energy storage and conversion.

The vision of RP 4 is to integrate these three basic principles into new complex and interactive material systems functional in a non-equilibrium state. Biological organisms serve as inspiration and generally integrate these functions at the sub-cellular, cellular, and tissue level. The systems addressed in RP 4 are (i) microscopic compartment systems, such as droplets, capsules, vesicles or microgels, acting as a reservoir for controlled release, uptake, and conversion; and (ii) macroscopic devices for conversion, polymerization reaction, desalination, protein separation, or electrochemical energy storage.

Current and future interests for microscopic material systems strive for understanding transmembrane transport facilitated by selective adhesion, curvature-mediated transport, or transport mediated by biological transmembrane channel proteins as well as artificial microgels to enhance selectivity. These principles guide the development of macroscopic material systems, which include microfabricated objects such as droplets with reaction und molecular transport properties as well as photochemically-prepared soft responsive micro-objects. These material systems are being studied on different length and time scales to gain insight into how bulk properties emerge from the spatio-temporal interplay of single micro-entities.

Between 2016 and 2018, scientists in RP 4 published 68 articles in peer-reviewed journals. In the same time period the institutional funding was 4.6 M€. The revenue from project grants totaled 4.7 M€, with 2.8 M€ spent from Federal or State *(Länder)* governments, 1.12 M€ from EU grants and 337 K€ from the German Science Foundation (DFG). Three patents were applied for and two granted. 12 doctoral degrees were completed.

Research Program 5 (RP 5): Bioactive and Bioinstructive Materials – Materials Designed for Active Interaction and Integration with the Biological Environment

(Average 2016-2018: 23.7 FTE, thereof 8.6 FTE Research and scientific services[1], 9.9 FTE Doctoral candidates, and 5.3 FTE Service staff)

RP 5 focuses on establishing bioactive and bioinstructive materials that can direct and respond to their environment. The synthesized nano- and micro-scale building blocks of RP 1 and 2 and fabrication methods from RP 2-4 are employed to assemble material systems that interact with triggers, such as light, pH, and external fields, biomolecules, biological fluids, bacteria and mammalian cells as well as tissues. The design parameters of these systems offer spatiotemporal control in their biochemical, mechanical and structural function. Over the past six years, many new material systems were established in multiple fields, with the focus on advanced biomedical systems. RP 5 is now subdivided in interactive materials for carrier-based therapeutics, bioinspired functional surfaces, organs on a chip, regenerative hydrogels, and screening systems, with a final goal to reach clinical translation. To facilitate bridging the gap between the laboratory and the clinic, the new building of our joint lab *fi*T will allow to produce selected biomedical materials in a GLP/GMP compliant manner. Together with new expertise brought into the institute, future research in RP 5 will continue to focus on the design and production of innovative interactive biomaterial systems that fulfil environmental and medical needs for a better life.

The future developments of RP 5 will focus on the following key technologies:

- Drug delivery systems that release active molecules on demand by external triggers;
- Hemocompatible and cell-selective coatings for medical devices and implants;
- Injectable regenerative hydrogel therapies for soft oriented tissues;
- Magnetic-field assisted bioprinting to control the architecture of ex vivo tissue models;
- Actuating hydrogels to study mechanobiology;
- Protocells as simulators to mimic and study the response of cells;
- Molecular sensors to study the behavior of mammalian cells and protocells;
- Transfer to the clinic via successful establishment and operation of the *fi*T.

Between 2016 and 2018, scientists in RP 5 published 58 articles in peer-reviewed journals. In the same time period the institutional funding was 5 M€. The revenue from project grants totaled 4.65 M€, with 1.92 M€ spent from EU grants, 1.34 M€ from Federal or State *(Länder)* governments, 904 K€ from the German Science Foundation (DFG) and 331 K€ from the competitive procedure of the Leibniz Association. Two patents were applied for and two granted. Nine doctoral degrees and one habilitation were completed.

8. Handling of recommendations from the previous evaluation

DWI responded as follows to the recommendations of the last external evaluation (highlighted in italics, see also statement of the Council of Science and Humanities issued on 17 July 2013):

1) *An expansion of DWI should [...] concentrate above all on **expanding basic research**, both thematically as well as spatially/apparatively and personnel-wise. In order to establish DWI as a research institute with a strong basic research base in the interactive materials research field, DWI should endeavour to significantly **increase the share of DFG and EU third-party funding** and at the same time **maintain industry-related funding**, especially in the area of fiber and textile research but not expand it further*.

The institute elaborates that DWI has significantly strengthened its fundamental research. Strategic efforts focused on i) gathering the expertise and research interests of actively recruited new co-workers and Scientific Board members, ii) implementing new methodology, techniques, and instrumentation, iii) acquiring new research projects, and iv) publishing in high-calibre scientific journals in the field. Third-party funding was increased, especially the share of DFG (from 231 K€ in 2011 to 1.1 M€ in 2019) and EU funding. See Chapter 3 and 4 and Appendix 3 for details.

2) *The strong financial commitment of the state of North Rhine-Westphalia to the establishment of a first-class Service Center (CPT) at DWI is explicitly welcomed. With the CPT, the DWI provides services for its own research programs and also provides an important infrastructure for materials research for other research institutions and companies. In order to ensure CPT's long-term success, it is essential to have **adequate equipment** and, above all, the opportunity **to employ technical and scientific personnel at the DWI on a continuous basis**. In the medium term, the **CPT should be self-financing according to full cost accounting**.*

The structure of the CPT has been reorganized in recent years according to the DWI and the areas of competence have been sharpened. The available range of methods has continuously been expanded throughout the years to strengthen the methodological expertise available in the CPT. On the one hand, this has been realized by purchasing complementary equipment from special funds of the state of North Rhine-Westfalia and on the other hand by integrating existing analytical instruments into the CPT.

The DWI explains that hiring of highly qualified personnel for the CPT, however, remains challenging. The majority of the technical and scientific personnel working for CPT, including its coordinator, is employed on a permanent basis. The CPT is not yet self-sustaining and further profiling of the CPT is currently being pursued. See Chapter 2.

3) *In the future, DWI should put **more emphasis on the interdisciplinary training of doctoral students** in order to enable them to successfully participate in interdisciplinary research projects. In addition, DWI should introduce a **mentoring program for doctoral students** as planned.*

DWI points out that, since 2013, the institute has strengthened its structures and processes to train doctoral students considerably. In 2014, a mentoring program was established (see Chapter 5). For example, DWI introduced the weekly institute seminar, in which every doctoral student is presenting on a regular basis. In addition, DWI doctoral students organize their annual retreat, which promotes the interdisciplinary exchange of knowledge, fosters cooperation, and facilitates socialization across WGs. DWI participates in structured programs such as the GRK 2375 "Tumor-Targeted Drug Delivery", the GRK 2415 "Mechanobiology in Epithelial 3D Tissue Constructs (MEƎT)", the EU ITN BIOGEL and the EU Cofund training network ALERT thus connecting young scientists to interdisciplinary research endeavours on campus. Moreover, DWI is proud to participate in the Max Planck School "Matter to Life" (see Chapter 6).

4) *The DWI at the RWTH Aachen e.V. and the state of North Rhine-Westphalia are striving to locate the institute in Section D (Mathematics, Natural and Engineering Sciences) of the Leibniz Association within the framework of joint funding by the federal and state governments. In particular, DWI would complement the research activities of the Institute for Polymer Research in Dresden (IPF) and the Institute for New Materials (INM) in Saarbrücken. (…) It is expected that DWI, IPF, and INM will form a new research network within the Leibniz Association, oriented towards innovative ways of materials research. The potential for* ***synergies between the three institutes should be consistently exploited****.*

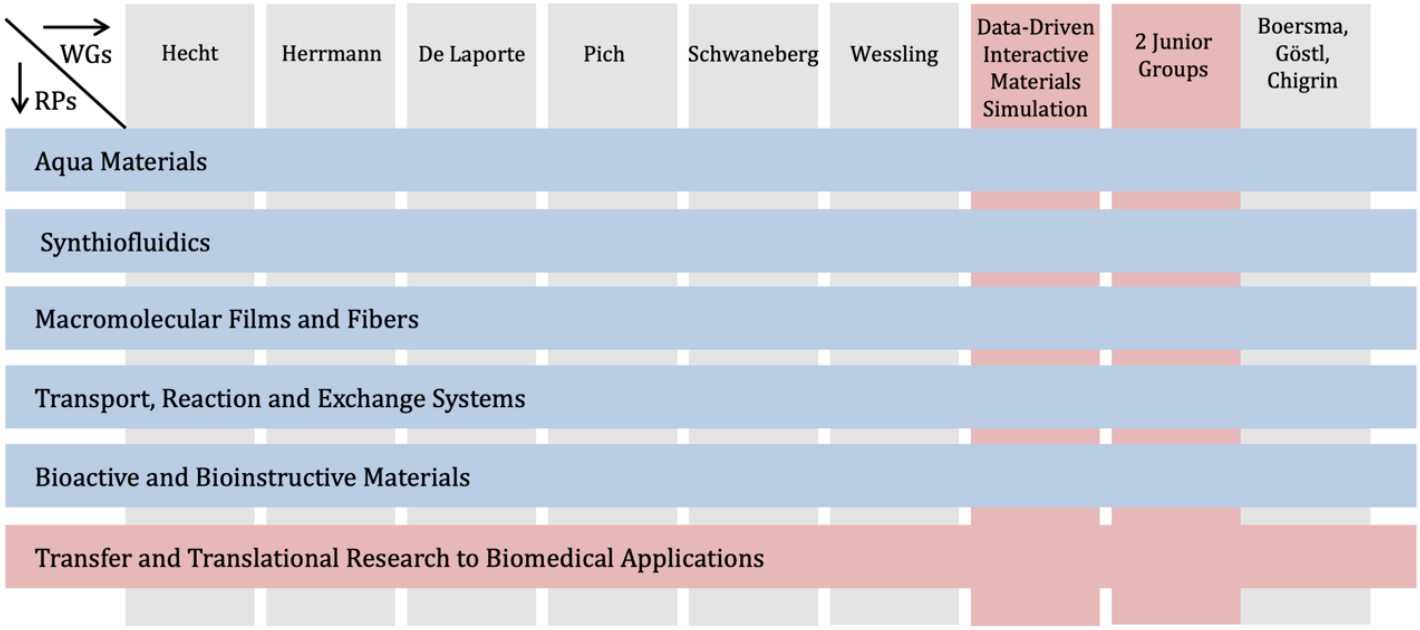
Since its admission to the Leibniz Association, DWI has intensified its cooperation with other Leibniz institutions (see Chapter 6). On the one hand, this concerns individual projects, for example projects in the Leibniz competition. Instead of establishing a new Leibniz research network, DWI decided to join and strengthen the existing network "Leibniz Health Technologies", connecting 14 Leibniz institutes, including both IPF in Dresden and INM in Saarbrücken. Together with the IPF, DWI was successful to acquire a collaborative research fund to develop an organ-on-a-chip system for a biomimetic artificial lung.

5) *In order to further* ***increase the international visibility*** *of DWI, especially in the field of interactive materials, the DWI should strive for even* ***more*** *committed* ***cooperation*** *with research institutions, especially* ***in English-speaking countries****.*

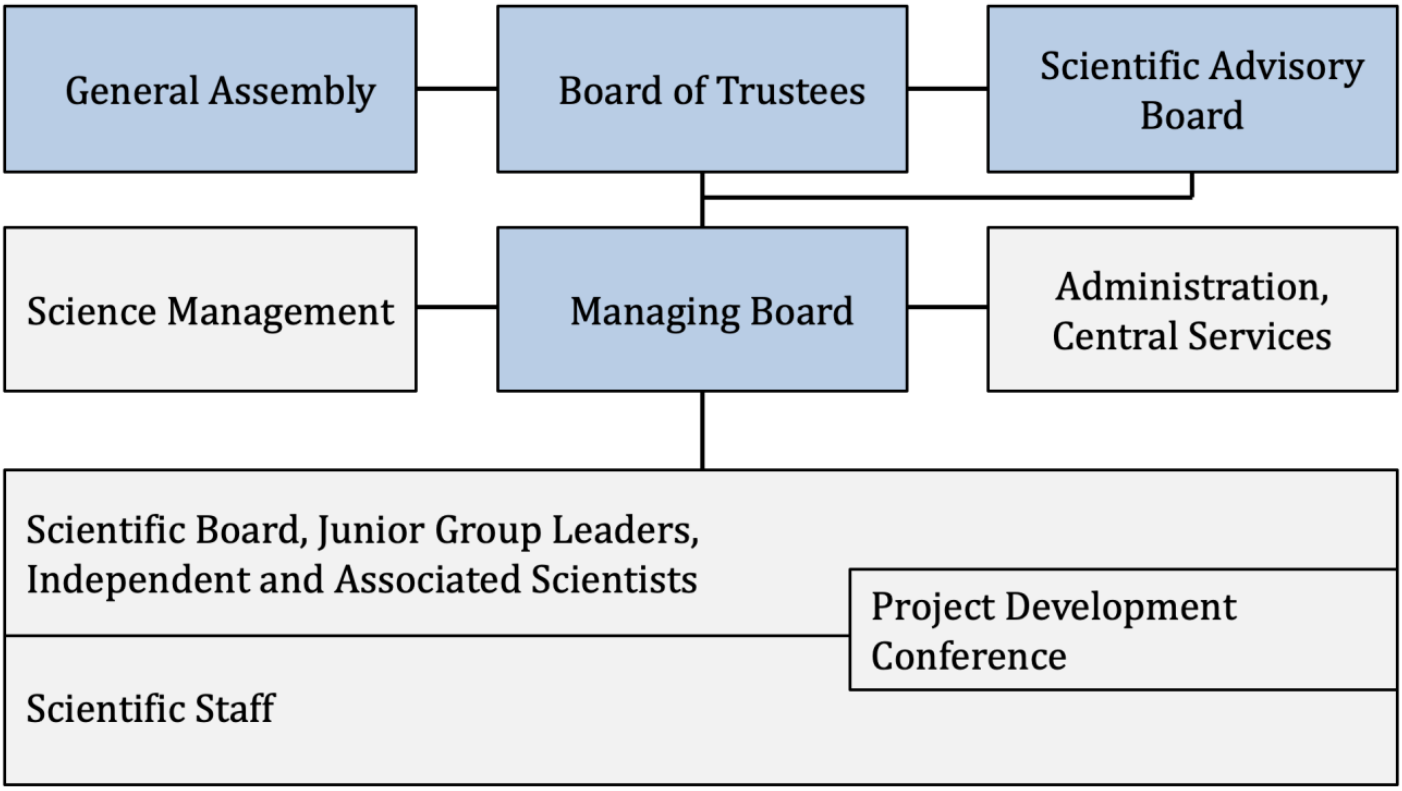
In recent years, DWI has expanded its international cooperation network, for example by coordinating the EU-funded doctoral training network "BIOGEL" (2015–2018). Connections have been built by each Scientific Board Member to internationally renowned groups in top research institutions around the globe and in particular in the US as manifested in established collaborations (for example at Harvard and Stanford Universities as well as the Universities of California and Cambridge) and documented by joint publications. Due to the dynamic developments in Asia and in particular in China, DWI has established research collaborations, for example with the Institute of Chemistry of the Chinese Academy of Sciences (CAS) in Beijing and the Institute of Applied Chemistry CAS in Changchun.

Appendix 1

Organisational Chart



Matrix organization of DWI. Complementary and interconnected Research Programs (RPs, rows) are pursued by Working Groups (WGs, columns, associated WGs not shown). New activities to be established by means of a budget extension (Sondertatbestand) are highlighted in red.



Organizational chart of DWI. Blue boxes indicate bodies of the registered association “DWI – Leibniz-Institute für Interaktive Materialien e.V.” whereas grey boxes concern the organizational units within the research institute

Appendix 2

Publications and patents

	Period		
	2016	**2017**	**2018**
Total number of publications	**137**	**132**	**139**
Monographs	2	-	-
Individual contributions to edited volumes	4	-	3
Articles in peer-reviewed journals	130	128	133
Articles in other journals	-	3	1
Working and discussion papers	-	-	1
Editorship of edited volumes	1	1	1

Industrial property rights [2)]	**2016**	**2017**	**2018**
Patents (granted/applied)	1 / 3	3 / 1	1 / 3
Other industrial property rights (granted/applied)	-	-	-
Exploitation rights / licenses (number)	-	-	-

[2] Concerning financial expenditures for revenues from patents, other industrial property rights and licences see Appendix 3.

Appendix 3 Revenue and Expenditure

Revenue		2016			2017			2018		
		k€	%	%	k€	%	%	k€	%	%
Total revenue (sum of I., II. and III.; excluding DFG fees)		**10,380.3**			**12,215.2**			**14,097.2**		
I.	**Revenue (sum of I.1., I.2. and I.3)**	**9,553.6**	**100 %**		**11,358.3**	**100 %**		**12,506.3**	**100 %**	
1.	INSTITUTIONAL FUNDING (EXCLUDING CONSTRUCTION PROJECTS AND ACQUISITION OF PROPERTY)	5,230.0	55 %		5,319.0	47 %		5,396.0	43 %	
1.1	Institutional funding (excluding construction projects and acquisition of property) by Federal and *Länder* governments according to AV-WGL	5,230.0			5,319.0			5,396.0		
1.2	Institutional funding (excluding construction projects and acquisition of property) not received in accordance with AV-WGL	0.0			0.0			0.0		
2.	REVENUE FROM PROJECT GRANTS	4,041.3	44 %	100 %	5,791.0	55 %	100 %	6,708.7	55 %	100 %
2.1	DFG	971.8		24 %	653.4		11 %	1,098.2		16 %
2.2	Leibniz Association (competitive procedure)	138.1		3 %	132.4		2 %	60.1		1 %
2.3	Federal, *Länder* governments	1,044.4		26 %	1,556.8		27 %	1,324.0		20 %
2.3.1	*including BMBF*	*998.4*			*1,398.1*			*1,139.8*		
2.3.2	*including State North Rhine-Westfalia (NRW)*	*46.0*			*158.7*			*184.2*		
2.4	German Federation of Industrial Research Association (AiF) [1]	803.8		20 %	1,228.5		21 %	1,678.8		25 %
2.5	EU	638.4		16 %	1,714.8		30 %	1,972.2		29 %
2.6	Industry	333.0		8 %	359.8		6 %	269.3		4 %
2.7	Foundations	39.3		1 %	107.5		2 %	216.4		3 %
2.8	Association of Friends of Deutsche Wollforschungsinstitut [2]	72.4		2 %	37.7		1 %	89.7		1 %
3.	REVENUE FROM SERVICES	282.3	3 %		248.3	2 %		401.6	3 %	
3.1	Revenue from commissioned work	282.3			248.3			401.6		
3.2	Revenue from publications	0.0			0.0			0.0		
3.3	Revenue from exploitation of intellectual property for which the institution holds industrial property rights (patents, utility models etc.)	0.0			0.0			0.0		
3.4	Revenue from exploitation of intellectual property without industrial property rights	0.0			0.0			0.0		
II.	**Miscellaneous revenue** (e.g. membership fees, donations, rental income, funds drawn from reserves)	**826.7**			**856.9**			**1,590.9**		
II. 1	thereof: cash resources third party funding	770.7			366.9			575.9		
II. 2	thereof: cash resources core funding	56.0			490.0			1,015.0		
III.	**Revenue for construction projects** (institutional funding by Federal and *Länder* governments, EU structural funds, etc.)	0.0			0.0			0.0		

Expenditures		k€	k€	k€
Expenditures (excluding DFG fees)		**10,380.3**	**12,215.2**	**14,097.2**
1.	Personnel	6,461.9	6,460.2	7,683.0
2.	Material expenses	2,666.4	2,907.8	4,111.9
2.1	*thereof expenditures used for registering industrial property rights (patents)*	*64.36*	*42.20*	*52.67*
3.	Equipment investments	762.1	1,029.4	1,909.3
4.	Construction projects, acquisition of property	0.0	0.0	0.0
5.	Other operating expenses	490.0	1,817.8	393.0
DFG fees (if paid for the institution – 2.5% of revenue from institutional funding)		126.7	128.4	130.9

[1] Arbeitsgemeinschaft industrieller Forschungsvereinigungen – AiF in short – is the leading national organization promoting applied research

[2] Association of Friends of Deutsche Wollforschungsinstitutis committed to maintaining and intensifying ties between academia of DWI and industry by establishing contacts between managers, companies and DWI scientists and sponsoring application driven projects.

Appendix 4

Staff

(Basic financing and third-party funding / proportion of women (as of: 31.12.2018)

	Full time equivalents		Employees		Female employees		foreigners
	Total	on third-party funding	Total	on temporary contracts	Total	on temporary contracts	Total
	Number	Percent	Number	Percent	Number	Percent	Number
Research and scientific services	**79.8**	72 %	**102**	84 %	36	83 %	**46**
Professors/Scientific Directors (C4, W3 or equivalent)	1.6	0 %	2	0 %	-	0 %	-
Professors/Working Group Leaders (W3, W2 or equivalent)	2.8	0 %	4	25 %	1	100 %	3
Independent and Junior Group Leaders (E15, E14 or equivalent)	2.0	100 %	2	100 %	-	0 %	-
Academic Staff, Senior Scientist (E15, E14 or equivalent)	3.0	32 %	3	33 %	1	0 %	1
Academic Staff in non-executive positions (E14, E13 or equivalent)	20.3	66 %	22	59 %	10	50 %	10
Doctoral candidates (E13 or equivalent)	49.1	84 %	67	100 %	23	100 %	30
Associated Scientists (with work contract)[1]	1.0	0 %	2	100 %	1	100 %	2
External Associated Scientists[1]			2				
Service positions	**24.4**	39 %	**31**				
Laboratory and Technical (E9 - E12)	6.3	17 %	9				
Laboratory and Technical (E5 - E8)	16.1	52 %	20				
Workshops (E5 - E8)	1.0	0 %	1				
Information Technology - IT (E9 - E12)	1.0	0 %	1				
Administration	**17.8**	2%	**19**				
Administrative Director	1.0	0%	1				
Staff position (from E13)	2.0	0%	2				
Internal administration (E13, E14)	0.5	0%	-				
Internal administration (financial administration, personnel, etc.) (E9 - E12, upper mid-level service)	4.4	5%	5				
Internal administration (financial administration, personnel, etc.) (E5 - E8, upper mid-level service)	7.2	3%	8				
Building Service and Others (E1-E10)	2.8	0%	3				
Student assistants	**11.9**	6 %	**52**				
Trainees[2]	**10**	-	-				
Scholarship recipients at the institution[3]	**5.0**	100%	**-**		3		8
Doctoral candidates	3.0	100%	-		2		3
Post-doctoral researchers	2.0	100%	2		1		2

[1] On December 31, 2018, DWI had four Associated Scientists. Two of them have a work contract at DWI, two of them have a collaboration agreement with DWI (External Associated Scientists).

[2] In cooperation with RWTH Aachen University, DWI provides training for 10 trainees per year. They are employed by RWTH Aachen University.

[3] All scholarship recipients exclusively receive external funding.

27 July 2020

Annex B: Evaluation Report

Leibniz Institute for Interactive Materials (DWI), Aachen

Contents

Summary and main recommendations

DWI – Leibniz Institute for Interactive Materials in Aachen – very successfully conducts research into methods and concepts for developing material functions that reproduce the properties of living matter. It utilises, first and foremost, approaches deriving from chemistry, engineering, and biotechnology but has expanded its expertise in recent years to embrace physics, physical chemistry and simulation. One important focus is set on translating the materials developed into applications, particularly in medicine and pharmacy.

DWI was founded as the "German Wool Research Institute" in Aachen in 1952; from 2003 onwards, under the then new director, it was developed very successfully to address technical materials and soft matter nanotechnology. In 2014, the institute was incorporated in the Leibniz Association, and renamed DWI – Leibniz-Institute for Interactive Materials, with joint funding by the Federal and *Länder* Governments. Due to retirement, the position of Scientific Director was refilled in 2019. The institute and the involved committees succeeded in recruiting an internationally recognised researcher for the position.

Since the evaluation by the German Council of Science and Humanities in 2013, DWI has developed very positively, reinforced its basic research in line with recommendations and very successfully recruited scientific staff. Particularly on the strength of increased third-party funds, the institute has grown significantly. Special mention should be made of the seven ERC grants acquired by DWI-researchers since the last evaluation. The institute's very good, in some cases even excellent, research results regularly appear in high-ranking journals. Research is organised in a matrix of discipline-based Working Groups and five Research Programmes that coherently build upon one another. The latter are rated as "very good" in three cases and "very good to excellent" in two.

A core element of DWI's future planning is the joint lab "first in Translation" (*fi*T) that is due to start operating in 2022 as a joint scientific infrastructure together with the Medical Faculty at RWTH Aachen University. Construction of a dedicated new building is scheduled to begin in 2020. *fi*T will create the foundations for furthering progress in medicine by translating interactive materials into innovative medical products for application in the clinic.

DWI is internationally visible and recognised. As recommended, the institute has expanded its collaborations with partners abroad. Also, the institute is involved in projects with more than 60 companies. Cooperation between DWI and RWTH Aachen University is excellent. Six leading researchers hold joint professorships at the university. DWI is part of many collaborative research projects (SFB, SPP, GRK, FOR) and has contributed to the success of RWTH in the Excellence strategy. Special mention should be made of the existing very productive cooperation with Aachen University Hospital which will be further reinforced by the creation of the joint lab *fi*T.

Special consideration should be given to the following main recommendations in the evaluation report (highlighted in **bold face** in the text):

<u>Overall concept, activities and results</u> (Chapter 2)

1. In past years, DWI's current matrix structure has proven to be a good instrument for achieving interdisciplinary connectivity between the different Working Groups via the five Research Programmes. It is, however, becoming increasingly difficult to integrate what are in some cases very extensive externally funded projects (e.g. ERC grants) in the existing framework. In order to ensure that projects do not have to be artificially divided up amongst various Research Programmes and that achievements can be clearly attributed, the management and committees should continue to develop the organisational structure.

Changes and planning (Chapter 3)

2. In order to be able to realise its convincing plans for the future in their entirety, DWI intends to apply for additional funding from the Federal and *Länder* Governments (minor extraordinary item of expenditure). A concept entitled "Programming and Translating Soft Materials for Interaction with Alive Matter" is set to be implemented which will use big data to determine the properties and functions of matter. According to DWI's calculations, the ongoing costs of this measure amount to 3.018 M€, of which DWI would cover 0.3 M€ from its budget (own contribution). The remaining 2.7 M€ should be covered by a permanent increase in joint funding from the Federal and *Länder* Governments commencing in 2022. Application to the Federal and *Länder* Governments for this measure via an extraordinary item of expenditure funding process is expressly endorsed.

Human resources (Chapter 5)

3. The share of female researchers in non-executive positions at DWI is at 35 percent, which is equal to the usual level in this subject area. However, none of the three independent (junior) group leader positions and only one of the six positions on the Scientific Board is held by a woman. DWI is strongly encouraged to significantly improve the gender equality situation at executive level and set itself more ambitious goals. Its highly successful junior research group program offers good opportunities for recruiting young female researchers to work at DWI. This program should be used to a greater extent in the future.

Cooperation and environment (Chapter 6)

4. DWI has created a very good collaborative instrument through the appointment of Associated Scientists. Currently, six researchers are associated with DWI in this way. In the future, this instrument should, however, be used more strategically in order to distinguish highly renowned international researchers, whose expertise meaningfully complements DWI, through a temporary association.

1. Overall concept, activities and results

DWI – Leibniz Institute for Interactive Materials in Aachen – very successfully conducts research into methods and concepts for developing material functions that reproduce the properties of living matter. It utilises, first and foremost, approaches deriving from chem-

istry, engineering and biotechnology but has expanded its expertise in recent years to embrace physics, physical chemistry and simulation. One important focus is set on translating the materials developed into applications, particularly in medicine and pharmacy.

Research at DWI is organised in a matrix structure. Six of the discipline-based working groups are headed by researchers who hold joint professorships at RWTH Aachen University (see Chapter 6). Also, there are three independent (junior) groups and several Associated Scientists. Staff are allocated to the senior researchers according to the current projects so that cooperation changes on a flexible basis. The projects themselves are organised in five coherent Research Programmes (RPs) that focus on developing new active material properties: two RPs (RP1 and RP2) work on molecular and microscopic building blocks, the others address functional surfaces and interfaces (RP3), material systems that function in a non-equilibrium state (RP4) and materials designed for active interaction with and in the biological environment (RP5). Three of the Research Programmes are rated as "very good", two as "very good to excellent" (see Chapter 7).

In past years, DWI's current matrix structure has proven to be a good instrument for achieving interdisciplinary connectivity between the different Working Groups via the five Research Programmes. It is, however, becoming increasingly difficult to integrate what are in some cases very extensive externally funded projects (e.g. ERC grants) in the existing framework. In order to ensure that projects do not have to be artificially divided up amongst various Research Programmes and that achievements can be clearly attributed, the management and committees should continue to develop the organisational structure.

Results

Research

DWI's very good, in some cases even excellent, research results are reflected in corresponding publications which regularly appear in high-ranking journals.

The excellent quality of research has been recognised by numerous highly competitive individual and project grants (see Chapter 4). Special mention should be made of the seven ERC grants that DWI researchers acquired between the last evaluation and December 2019: three ERC Advanced Grants, two ERC Consolidator Grants and two ERC Starting Grants (whereby two of the grantees, one with a starting grant and one with a consolidator grant, have in the meantime taken up new positions, e.g. as W3-Professor at the University of Freiburg).

Operation of Research Infrastructure

DWI's excellent research infrastructure is concentrated within the Center for Chemical Polymer Technology (CPT). CPT carries out excellent, indispensable services for DWI researchers; upon payment, external scientists can also use these services (see Chapter 4).

Transfer

The significance of the transfer and translation of materials developed at DWI continues to grow, especially in relation to applications in medicine and pharmacy. It is welcomed

that the strategy is being further developed and that the institute has created a staff position for this purpose.

Transfer from the institute usually takes place in the context of joint projects with industry and/or patents. Between 2016 and 2018, DWI applied for a total of seven patents and was granted five. In collaboration with the Federal Bank of Germany and the Federal Mints, for example, a new method of introducing security features onto three-component five- and ten-euro coins was developed. Furthermore, a spin-off company working in the field of research data management with a focus on documentation and data mining of material synthesis protocols has been founded by the institute. Another spin-off in the field of plant protection is planned which will use the rain-proof feature of DWI's patented *green*Release technology to reduce the use of pesticides.

In the field of translation, DWI cooperates very closely and successfully with partners at Aachen University Hospital (see Chapter 6). A joint scientific infrastructure, the "first in Translation" (*fi*T) lab, which is currently under construction, is extremely promising (see Chapter 3).

2. Changes and planning

Development since the previous evaluation

DWI was founded as the "German Wool Research Institute" in Aachen in 1952. In the context of wool and textile research, it originally focussed on protein research, macromolecular chemistry and biomaterials research. From 2003 onwards, under the then new director, DWI was developed very successfully to address technical materials and soft matter nanotechnology. The institute was evaluated by the German Council of Science and Humanities in 2013 and granted joint funding from Federal and *Länder* Governments in 2014; it was renamed DWI – Leibniz-Institute for Interactive Materials – at the same time. Since then, the institute has developed very positively. Institutional funding increased by one million euro (25%) from 2012/13 to 2018; third-party funding almost doubled (see Chapter 4) and the number of positions (FTEs) grew by 50 percent. At present, work is still organised in Working Groups and five Research Programmes which have, however, continued to develop significantly and now employ more staff.

One crucial mainstay for this positive development was excellent recruitment, including at the executive level. In this constellation, DWI reinforced its basic research, as recommended, which has had the very positive effect of significantly increasing the proportion of third-party funding acquired through competitive procedures, especially from the DFG and EU.

DWI made an important step with regard to its international position by joining the newly-founded Max Planck School "Matter to Life" (see Chapter 6). Furthermore, the joint lab "first in Translation" (*fi*T) has been launched (see below). The director at the time was of decisive importance for these and other developments. He retired from this position in 2019 and is now continuing to contribute successfully to DWI's activities as a senior professor, as impressively demonstrated by his acquisition of an ERC Advanced Grant.

The new director took up his position in August 2019. The institute and the involved committees succeeded in recruiting an internationally recognised researcher for the position. His expertise in light-driven materials and devices excellently complements and extends the spectrum of the institute's performance and competencies.

Strategic work planning for the coming years

DWI's plans for further development follow on convincingly from the plans of recent years. The overarching goal is to hone the institute's profile as a materials research institute focussing on soft matter. In order to implement its strategy, DWI is planning to drive research on bioactive and bioinstructive materials in the direction of biomedical applications. It is a convincing strategy to utilise DWI's strengths in soft and mostly water-based materials for developments in this area.

The core element of its planning is the lab "first in Translation" (*fi*T), a joint scientific infrastructure with the Medical Faculty at RWTH Aachen University that is scheduled to go into operation in 2022. The *fi*T Board of Directors will comprise one hospital representative and one DWI representative. Both partners are strongly financially involved. Moreover, 3.5 M€ are currently being acquired from the BMBF to create the necessary organisational framework for this infrastructure. Construction of the proposed new building is scheduled to begin in 2020.

The very well thought-out planning for operating *fi*T envisages close cooperation between the partners in exploring new materials for biomedical applications. A further important building block will be the development of an organisational structure to produce high-quality test specimens and conduct standardised safety tests as well as safe clinical studies. *fi*T will create the foundations for advancing progress in medicine by transforming interactive materials into innovative medical products for application in the clinic.

Planning for additional funds deriving from institutional funding

In order to be able to realise its convincing plans for the future in their entirety, DWI intends to apply for additional funding from the Federal and *Länder* Governments (minor extraordinary item of expenditure). A concept entitled "Programming and Translating Soft Materials for Interaction with Alive Matter" is set to be implemented which will use big data to determine the properties and functions of matter. The concept comprises the sustainable operation of *fi*T (permanent staff and maintenance of equipment); the appointment of a new professor for Digital BioMaterial Simulation; the establishment of two new Junior Groups in "Experimental BioMaterials Science" and "Living Materials Systems" as well as the participation of three doctoral candidates in the Max Planck School "Matter to Life." In summary, the plan is to apply for financing for 27 positions at DWI and three doctoral positions at the Max Planck School as well as funding for operating *fi*T. The individual measures have been very well coordinated and constitute a coherent overall concept.

According to DWI's calculations, the ongoing costs of this measure amount to 3.018 M€, of which DWI would cover 0.3 M€ from its budget (own contribution). The remaining 2.7 M€ should be covered by a permanent increase in joint funding from

the Federal and *Länder* Governments commencing in 2022. Application to the Federal and *Länder* Governments for this measure via an extraordinary item of expenditure funding process is expressly endorsed.

3. Controlling and quality management

Facilities, equipment and funding

Funding

The provision of institutional funding is sufficient to cover DWI's current portfolio of activities. In 2018, the institute had a core budget of approx. 5.4 M€ at its disposal. This represented an increase of 24 percent since the last evaluation and subsequent incorporation into funding from the Federal and *Länder* governments. Third-party research funding totalled approx. 6.7 M€ in 2018, an increase in the proportion of the overall budget from 46 percent in 2012 to a remarkable 55 percent in 2018. As recommended by the German Council of Science and Humanities, DWI thus managed to increase the proportion of funding both from the DFG (from 12% to 17%) and the EU (from 14% to 25%). In addition to the ERC grants already mentioned, this was partly a result of five projects within an RWTH collaborative research centre (SFB 985 Functional Microgels and Microgel Systems) in which DWI researchers are involved. At the same time, DWI still benefits significantly from industry-related funding; it does, however, pursue the sound strategy of only taking on projects that fall within the institute's research portfolio.

DWI's income from services amounted to approx. 402 K€ (3% of the overall budget) in 2018 and was almost exclusively derived from income for services in the context of CPT (see below).

Facilities and equipment

DWI has its own excellent facilities with laboratories and equipment pooled in the Center for Chemical Polymer Technology (CPT). They include BSL1 and BSL2 laboratories. In order to maintain the high quality of services, it is important to employ the technical and scientific personnel working for CPT on a permanent basis. This had been recommended by the German Council of Science and Humanities and has now largely been implemented. It is welcomed that the institute is seeking to enhance CPT's profile so that in the medium term, CPT will be able to finance itself completely.

Organisational and operational structure

DWI's current matrix organisation should be developed further (see recommendation, Chapter 2)

Particular mention is to be made of the excellent collaboration across groups. A team-focussed leadership concept is also being practised extremely successfully. The core element

is the project development conference. In continuing to develop DWI's organisational structure, attention should be paid to retaining both these elements.

Quality Management

DWI has instituted rules to ensure good scientific practice and enlisted an ombudsperson since 2017. Quality management is also applied to Research Data Management and Transfer.

Every year, DWI earmarks 1 M€ (2019) for performance-oriented funding allocation (LOM) in order to honour the competitive acquisition of research funding. It is a constructive step to clearly recognise successful grants from the DFG, ERC and other scientific foundations within DWI. LOM is not granted for contract research third-party funding.

Quality management by the Scientific Advisory Board and Board of Trustees

The Scientific Advisory Board fulfils its mission as an external advisory body appropriately. It conducted an interim audit in 2016 usually held at Leibniz institutes. In the future, apart from considering overarching topics, more attention should be paid to the performance of individual units within DWI.

The Board of Trustees convincingly fulfils its statutory role as a supervisory body. It is to be particularly acknowledged that great dedication was shown in conducting the process of appointing a new Scientific Director.

The share of women on the DWI-Boards should be increased. Of the 12 members of the Scientific Advisory Board, only two are female. There is no woman on the Board of Trustees.

DWI has two Industrial Advisory Boards focussing on hair cosmetics and textiles/materials which are mainly composed of experts from companies. DWI has benefitted from this distinctive network for many years. It is strongly welcomed that the institute is currently examining whether the size and composition of the two boards corresponds to the institute's present requirements.

4. Human Resources

Management

DWI is very well managed by the Scientific Director, the Vice Scientific Director and the Administrative Director. Both scientific leadership positions were filled very advantageously in 2017 and 2019 with internationally recognised researchers who are already shaping the institute's strategic direction. The engagement of the Administrative Director who has been in charge since 2013, has made a significant contribution to DWI's success.

DWI's six senior researchers, including the Scientific Director and Vice Scientific Director, form DWI's Scientific Board. They hold joint appointments as W2 or W3 professors at RWTH Aachen University. The Scientific Board's expertise is complemented by six Associated Scientists, a system which has proven to be very productive (see Chapter 6). DWI has a flat hierarchy which facilitates speedy communication amongst all those involved.

Postdoctoral staff

With regard to their own personal profiles and visibility within the community, postdocs are promoted very well at DWI. The institute's excellent scientific infrastructure provides ample opportunities for development. Experienced researchers act as project leaders and are thus involved in developing the Research Programmes.

DWI regularly recruits well-reputed young scientists to work at the institute. The junior research groups are also very well supervised and contribute to the institute's success. They are currently referred to as "Junior Groups" or "Independent Groups". It is welcomed that DWI intends to decide on a uniform nomenclature.

It does DWI great credit that two of its former junior research group leaders have been appointed to W3 professorships in Germany since the last evaluation. An additional junior research group leader was retained at DWI thanks to a joint appointment to a W2 tenure-track professorship at RWTH Aachen University. The three newly-established junior research groups (two Junior Groups and one Independent Group) are pursuing promising projects. It is very advantageous for postdoctoral development that RWTH Aachen University is prepared to recognise their role as official doctoral supervisors. This should be implemented as soon as possible.

Doctoral candidates

The number of doctoral candidates and completed dissertations is high. On the reporting date, 31 December 2018, 67 doctoral candidates were employed at the institute (plus three scholarship recipients). In the period 2016 to 2018, 70 doctorates were completed under primary supervision of DWI Scientific Board members. Doctoral candidates are assigned to a specific Working Group but often work on more than one project. The average duration of doctorates is four years, which is long but appropriate in the specific context of the subject area.

Supervision of doctoral candidates conforms with current practice. It is conducted in the context of a mandatory mentoring programme and every candidate is assigned two mentors. As recommended seven years ago, doctoral candidates are offered broad, cross-disciplinary training in the various scientific techniques that are used in the different RPs. In addition to in-house events, doctoral candidates have the opportunity to participate in the extensive range of courses offered by the RWTH Center for Doctoral Studies.

It is welcomed that DWI maintains active contact with its alumni and plans to hold biannual alumni meetings. Doctoral candidates benefit from DWI's extensive network and have many diverse career opportunities. A transfer to industry, in particular, is an attractive alternative to continuing in an academic career.

Non-scientific staff

DWI provides appropriate continuing education opportunities for its non-scientific staff. It is welcomed that the institute is very involved in a programme coordinated by RWTH Aachen University to train laboratory technicians. Moreover, the institute itself trains administrative staff. Between 2016 and 2018, twelve apprentices completed their training.

Equal opportunities and work-life balance

Equal opportunities

Of the 102 people employed in research and scientific services on 31 December 2018, 36 were women (35%). At 34 percent, the share of female doctoral candidates is also on a par with the community in general.

As such, the share of female doctoral candidates and researchers in non-executive positions at DWI is at the usual level in this subject area. However, none of the independent (junior) group leader positions and only one of the six positions on the Scientific Board is held by a woman. DWI is strongly encouraged to significantly improve the gender equality situation at the executive level and set itself more ambitious goals. Its highly successful junior research group program offers good opportunities for recruiting young female researchers to work at DWI. This program should be used to a greater extent in the future.

It is welcomed that DWI's Equal Opportunities Officer has been provided with a dedicated budget. In 2019, the institute was awarded the Total-E-Quality certificate.

Compatibility of family and career

DWI offers appropriate measures to promote the reconciliation of work and family life. The institute has a parent-child workspace and helps its staff to find daycare facilities. DWI has flexible working hours and allows staff to be absent from the workplace for certain periods and to work from home.

5. Cooperation and environment

National collaborations

DWI's collaboration with RWTH Aachen University and Aachen University Hospital is excellent. It is crucially influenced by the fact that six of the institute's jointly appointed senior researchers spend 20 percent of their time (four senior researchers) or 50 percent (two senior researchers) working at the university. It is good to observe that they are seriously involved in research and teaching as well as in RWTH committees. It should also be noted that one of the DWI researchers became Vice Rector for Research and Structure at RWTH Aachen University in 2018.

DWI is part of many collaborative research projects (SFB, SPP, GRK, FOR) and has contributed to the success of RWTH in the Excellence Strategy. Moreover, DWI strengthens the research location Aachen, e.g. via JARA-SOFT, one of the five sections in the Jülich Aachen Research Alliance (JARA). Special mention should be made of the existing very productive cooperation with Aachen University Hospital which will be further reinforced by the creation of the joint lab *fi*T. DWI researchers have access to RWTH infrastructure like the Magnetic Resonance Centre, the joint Aachen-Jülich electron microscopy facility and a clean room facility.

Within the Leibniz Association, DWI cooperates with a number of institutes involved in the Leibniz Research Alliance "Leibniz Health Technologies". Close cooperation has also

been developed with the Leibniz Institute of Polymer Research Dresden (IPF) which is, inter alia, funded through the Leibniz Competition.

International networking

DWI is internationally visible and recognised. As recommended, the institute has expanded its collaborations with partners abroad.

At the European level, DWI is involved in various H2020-funded alliances, such as the European Soft Matter Infrastructure EUSMI and the EVPRO consortium that aims to counteract the shortened lifetime and to reduce the risk of inflammation of hip replacement prostheses. The Marie Skłodowska-Curie Innovative Training Network BIOGEL (2015-2018), which included US and Japanese partners, was coordinated by DWI.

DWI's involvement in the Max Planck School "Matter to Life", which is operated by the universities of Heidelberg, Göttingen and Munich together with various Max Planck Institutes, constitutes an important step on the path to greater internationalisation. It offers a combined Master-PhD fast track for particularly gifted international students. The plan to finance three doctoral candidates at the school in the framework of an extraordinary item of expenditure (Chapter 3) is, therefore, expressly supported.

DWI has created a very good collaborative instrument through the appointment of Associated Scientists. Currently, six researchers are associated with DWI in this way. In the future, this instrument should, however, be used more strategically in order to distinguish highly renowned international researchers, whose expertise meaningfully complements DWI, through a temporary association.

Collaborations with industry

At both the national and international level, DWI has an excellent network of industrial partners that is also supported by the Industrial Advisory Boards (see Chapter 4). Especially in the context of research projects funded by the AiF[1] and BMBF, the institute is involved in projects with more than 60 companies producing functional materials.

6. DWI Research Programmes

Research Programme 1 (RP 1): Aqua Materials – Materials Formed from or for Aqueous Systems; Chemistry in Water

(Average 2016-2018: 20.7 FTE, thereof 5.6 FTE Research and scientific services[2], 9.2 FTE Doctoral candidates, and 5.9 FTE Service staff)

RP 1 focusses on the development of water-based synthetic methods to generate molecular building blocks, one of the key elements of DWI's research strategy. This RP also investigates the structure formation of these building blocks, which is key for realising functions in the other RPs. The RP's research portfolio has been successfully developed in the last few years. Particularly the topics addressed by DWI's new Scientific Director in the

[1] Arbeitsgemeinschaft industrieller Forschungsvereinigungen – AiF in short – is the leading national organization promoting applied research

[2] This figure does not include Scientific Board Members, who contribute to research in several RPs.

area of optically active materials are a very promising addition. His work on the development of (photo)responsive macromolecular and supramolecular systems to (optically) control and drive chemical, physical, and biological processes have already been integrated very effectively.

Special mention should be made of the excellent work on fibrin hydrogels with tailored mechanical properties and good adhesion to various surfaces. These activities have great translational potential, such as for applications in the production of coatings for implants. Excellent results have also been achieved in research on linear functional polymers, especially near-IR responsive materials. Research on encapsulated enzymes for drug delivery is another highlight.

The RP's research results are regularly published in high-ranking journals. It also benefits from significant third-party funding.

Overall, RP 1 is rated as "very good to excellent".

Research Programme 2 (RP 2): Synthiofluidics – Assembly and Fabrication of Well-Defined Micro- and Nano-Objects

(Average 2016-2018: 11.6 FTE, thereof 3.0 FTE Research and scientific services[1], 5.8 FTE Doctoral candidates, and 2.7 FTE Service staff)

RP 2's activities are strongly method-related and focus on structure formation by phase segregation, nucleation and growth, syneresis as well as flow processes in microfluidics, and small-scale free-form fabrication. Whilst RP 1 studies molecular responses, RP 2 focusses on the development of processing conditions, small reaction volumes and synthesis environments for RPs 2-5.

Special mention should be made of the work on novel techniques of hollow fibre synthesis for the production of truly three-dimensional microtubes. RP 2 has also very successfully explored supercharged polypeptides which were utilised to assemble membrane-like structures.

Research results are published very well. The RP also benefits from significant third-party funding. In September 2018, a very successful Junior Group Leader in RP 2 accepted a professorship at the University of Ulm. Recent achievements show that the RP has mastered this period of upheaval very well.

RP 2 is rated as "very good".

Research Programme 3 (RP 3): Macromolecular Films and Fibers – Functional Surfaces and Interfaces

(Average 2016-2018: 12.9 FTE, thereof 4.4 FTE Research and scientific services[1], 4.4 FTE Doctoral candidates, and 4.1 FTE Service staff)

RP 3's activities concentrate on steering and utilising the structure formation of macromolecular films and surfaces for controlled interaction with fluids, polymers, biological building blocks and cells. The RP has a broad spectrum of materials and expertise with a focus on solid surfaces as well as liquid-liquid and liquid-gas interfaces. To realise functions at such interfaces, synthetic and biological molecules developed in RPs 1 and 2 are

utilised. At the same time, the activities form an important basis for developments in RPs 4 and 5.

One of the highlights of the work conducted by RP 3 is its research on modifying surfaces with molecules that catch particles of a specific diameter. This work could potentially be used to catch bacteria and has great potential for translation. The research on anchor peptides also has great potential, both in basic research and applications. It will prove challenging to select the most promising possibilities for potential applications from the numerous developments emerging from RP 3.

Research results are regularly published very well. The RP also benefits from significant third-party funding.

RP 3 is rated as "very good".

Research Programme 4 (RP 4): Transport, Reaction, and Exchange: Separation and Reaction Controlling Systems

(Average 2016-2018: 22.4 FTE, thereof 2.3 FTE Research and scientific services[1], 13.9 FTE Doctoral candidates, and 6.2 FTE Service staff)

RP 4 studies material systems that function in a non-equilibrium state. Work focusses on integrating various functional materials to create novel material systems. Applications are to be found in selective transport of matter at and through interfaces, chemical transformations as well as energy storage and conversion. In its work, RP 4 draws on the synthesis techniques and surface functionalities developed in RPs 1-3. It is remarkable that, despite the theoretical emphasis of RP 4, consideration is given to potential applications of its research.

In order to reinforce its theoretical work, RP 4 very successfully cooperates with strong partner institutes, which has led to excellent results. Special mention should be made of the research on reaction-diffusion polymerisation in membraneless coacervates together with the Margarita Salas Center for Biological Research (Spain) and Radboud University (Netherlands). Moreover, important contributions are evolving in connection with a microscopic hydrogel actuator which can pump, rotate and move forwards by means of body deformation.

RP 4's results are regularly published at a high level. The RP also benefits from significant third-party funding.

RP 4 is rated as "very good".

Research Programme 5 (RP 5): Bioactive and Bioinstructive Materials – Materials Designed for Active Interaction and Integration with the Biological Environment

(Average 2016-2018: 23.7 FTE, thereof 8.6 FTE Research and scientific services[1], 9.9 FTE Doctoral candidates, and 5.3 FTE Service staff)

RP 5 develops novel interactive biohybrid materials with new material functions by combining material sciences with tissue engineering, biotechnology, biochemistry and synthetic biology. The nano- and microscale building blocks of RPs 1 and 2 together with the fabrication methods of RPs 2-4 are used to assemble material systems that interact with

triggers, such as light, pH and external fields, biomolecules, biological fluids and tissue. Clinical translation is the objective of these activities.

The work on injectable anisotropic hydrogels and the project on the generation of artificial cells with physiologically relevant crowding are particularly successful. In order to continue the innovative boost RP 5 has achieved in recent years and close the gap between laboratory research and the hospital setting, selected GLP/GMP compliant biomedical materials must be produced. For this purpose, RP 5 is dependent on the further development of *f*iT. If this succeeds, the materials developed by RP 5 have enormous potential to trigger actual medical applications.

The excellent research results are published appropriately. The RP also benefits from significant third-party funding.

Overall, RP 5 is rated as “very good to excellent”.

7. Handling of recommendations from the last external evaluation

DWI successfully addressed the recommendations made by the German Council of Science and Humanities (*Wissenschaftsrat*) in 2013 (see Status Report, p. A-23f).

Appendix

1. Review Board

Chair (Member of the Leibniz Senate Evaluation Committee)

Cynthia **Volkert**	Institute of Materials Physics, University of Göttingen

Deputy Chair (Member of the Leibniz Senate Evaluation Committee)

Evamarie **Hey-Hawkins**	Institute of Inorganic Chemistry, Leipzig University

Reviewers

Seema **Agarwal**	Chair for Macromolecular Chemistry II, University of Bayreuth
Andreas **Bausch**	Chair for Cellular Biophysics, Technical University of Munich
Michael R. **Buchmeiser**	German Institutes of Textile and Fiber Research (DITF) Denkendorf and Chair of Macromolecu-lar Compounds and Fiber Chemistry, University of Stuttgart
Sandrine **Gerber**	Institute of Chemical Sciences and Engineering, Ecole Polytechnique Fédérale de Lausanne
Jörg **Kutter**	Department of Pharmacy, University of Copenhagen
Joerg **Lahann**	Biointerfaces Institute, University of Michigan
Heike **Walles**	Research Center Dynamic Systems, University of Magdeburg
Wilfried **Weber**	Centre for Biological Signalling Studies and Chair of Synthetic Biology, University of Freiburg

Representative of the Federal Government (Member of the Leibniz Senate Evaluation Committee)

absent with apologies	Federal Ministry of Education and Research, Bonn

Representative of the Länder *Governments (Member of the Leibniz Senate Evaluation Committee)*

Marc **Brüser**	Ministry of Science, Further Education and Culture of Rhineland-Palatinate, Mainz

28 August 2020

Annex C: Statement of the Institution on the Evaluation Report

Leibniz Institute for Interactive Materials (DWI), Aachen

First and foremost, the DWI – Leibniz Institute for Interactive Materials is grateful to the Leibniz Association as well as all members of the review board for their efforts in organizing and conducting a fruitful and fair evaluation. We are proud of the resulting favorable report, which is confirming the remarkable development of our institute during the first Leibniz funding period. We thank the reviewers for their appreciation of our past achievements and their strong and absolute support of our future plans.

In this context, DWI particularly appreciates the thoughtful recommendations provided by the review board. We would like to briefly comment on the key comments:

• *Organizational structure:* We highly appreciate the considerate remark concerning the further development of our organizational structure. With our additional focus on translation in the field of medicine, we will consider the extension of the number of research programs. At the same time, DWI plans to improve its matrix structure to strengthen our integrated interdisciplinary approach while clarifying allocation of resources and responsibilities to ease monitoring of individual research activities and performance.

• *Gender balance:* We will continue to act according to our equal opportunity strategy to broaden the diversity of our team at all levels. In particular, DWI will commit great effort to increase the number of female junior group leaders and members of the scientific board in the coming years. Encouraged by a recent successful example, DWI plans to identify suitable female researchers at an early career stage and develop their academic and leadership skills in-house.

• *Associated scientists:* We acknowledge the need to further develop and differentiate our models to integrate external expertise. In the future, DWI plans to use this tool in a more strategic fashion to connect to scientific leaders in a particular field and to support promising emerging investigators. Association is already temporary and will be revisited annually.

• *Strategic plans for additional institutional funding:* We feel honored by the strong endorsement of our future plans to be realized via an extraordinary item of expenditure. Realization of our concept “Programming and translating Soft Materials for Interaction with Alive Matter” with its interlinked measures to integrate essential new data-driven approaches, to establish a unique infrastructure for translation (*fi*T), and to enhance our scientific network via the Max Planck School “Matter to Life” will be key for the successful future development of DWI and inevitably requires the additional resources.

Finally, we want to seize this opportunity to express our sincere gratitude to everyone who has been contributing and supporting our institute in the past, in particular during the transformative first years in the Leibniz Association. Specifically, we are indebted to the members of our Board of Trustees as well as our Scientific and Industrial Advisory Boards. The present evaluation report encourages us to continue our successful journey to become a world leading soft materials research institution – a unique place where a team from different disciplines and diverse backgrounds develops and applies fundamentally new interactive materials.