2023
Annual report

Department of Biomaterials and Biomedical Technology (BBT)

UMCG

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FOREWORD 1

Hélder Santos
Head of the department

Hereby, it is my great pleasure to present our very first Annual Report of the Department of Biomaterials and Biomedical Technology (BBT), former Department of Biomedical Engineering (BME). With this report, we aim to provide our community with a quantitative overview of all our activities and achievements in the year 2023, including our scientific research, educational programs, business development, and outreach initiatives. At BBT, we value all these domains equally and are extremely proud to share all that has been accomplished in 2023.

Since the 1st of September 2021, I proudly took the Chair as the new Head of the Department and together with the management team, we have been very actively working on the renovation of the Department on all fronts, from the content to personnel and beyond. Our mission and ambition are therefore more viable and relevant than ever before. As a recent highlight of our top-research ambition, we have initiated in our department for the first time ever, a new research line fully focused on 3D-(bio)printing technology, and to lead this fast-growing research field we are very delighted to have hired a new and highly motivated talent Group Leader, Dr. Monize Caiado Decarli, a former researcher at Maastricht University (MERLN Institute) and University of Campinas (School of Chemical Engineering).

This report highlights the achievements of 2023, but our work since my start here has been supported by exceptional top Principal Investigators working in 9 top-notch research areas with a very oriented clinical translation, closely managed by the management team. BBT would not be complete without the fantastic secretarial support team and the innumerable and valuable current and past PhD students, postdocs, and technicians. Thus, altogether, I am very optimistic that BBT in 2024 will continue the same road of success we all wish for. BBT provides a great research and teaching environment, welcoming everyone around the world.

BBT strives to be well-known in the national and international fields of biomaterials, biomedical technology, biomedical engineering, and all its subtopics. In the past years, we have recruited excellent group leaders, PhD students, and postdocs, who, when graduate from BBT, easily find new positions in prestigious academic and industrial environments. We have also increased our collaborations with a rapidly increasing number of biotech and pharma companies, and with our colleagues within UMCG, Innovation Center, and FSE, via HTRIC and beyond. Moreover, we have proudly launched a spin-off company, QT Sense, a deep-tech startup that emerged from the research group of Prof. Dr. Romana Schirhagl, who invented a technique that has the potential to detect sepsis within seconds, increasing the chances of patient survival.

On behalf of all our department members, I would also like to express my appreciation to our collaborators and funding agencies, and everyone else I might have unintentionally forgotten here; without your support, all of this would not have been possible.

It has been truly a pleasure to be part of the ''new' BBT team in the past 2.5 years, and I am proud of and indebted to our research and technical staff, and the many students for their unwavering commitment, creativity, and cooperation in the year 2023. I am very proud of helping bring together the current team of BBT scientists and help establish a climate of open communication that fosters excellence in research. Together with their team members, BBT researchers represent a creative and dynamic force that will help us to translate some of the technologies we are developing closer to being applied in the clinic.

In the upcoming year, 2024, I foresee we will continue our path toward excellence in innovation, research, and teaching, and we will continue the valorization of our research work toward relevant societal impact.

Hélder Santos
Head of the department
May 2024

RESEARCH AT BBT 2

BBT is an internationally recognized research and teaching academic department, aiming to apply the principles and problem-solving techniques of engineering to biology and medicine.

Our mission is to conduct research and to provide training on the application of engineering and biomaterials in the human body. Our focus is on pre-clinical research, but also clinically oriented research and education are conducted in collaboration with clinical departments. We aim to restore function in patients with irreversible loss of function, which cannot be achieved by natural bodily processes using biomaterials or innovative technologies like 3D-bioprinting, or to prevent potential loss of function by developing improved diagnostic methods, imaging techniques and robotic surgery.

BBT is focused on the devolvement of biomaterials and biomedical technology solutions to answer medical problems. Specifically, we work in multidisciplinary teams, and we focus on 9 major top-level research areas: Bioimaging and analysis, biomaterials-associated infections, biotribology and regeneration, cell-biomaterial interactions, materiobiology and nanobiomaterials, surgical robotics, targeted drug delivery and nanomedicines, regenerative medicine, and biofabrication and 3D-bioprinting, in which we are internationally leading. We strive to address and help solving medical problems using collaborative, multi-disciplinary, technology-oriented approaches, which include next generation nanotechnology, microfluidics, 3D-bioprinting, robotics, and cell- and animal-based models and beyond. We aim to work closely with the staff at UMCG and FSE, and together find solutions to support our collaborators from the clinical departments in the hospital (UMCG). Our activities are part of the newly established 'Personalized Medicine Research Institute Groningen (PRECISION)', which we are very proudly actively involved, and we aim to have an important role in education and research within the framework of The Health Technology Research and Innovation Cluster (HTRIC).

BBT aims to continue growing towards a world-class research and education department on Biomaterials and Biomedical Technology, internationally renowned for its cutting-edge biomedical science for clinical translation, its teaching excellence, innovations and its top-class facilities. The development of novel tools and technology, innovations and new education strategies are required to become an excellent unit for education and research, which is our strategic focus. Our goals are to obtain relevant external financed grants which naturally will lead to impactful publications, and to deliver excellent education related to the biomaterials biomedical engineering aspects, always with a clinical translation mindset. We also aim to attract top-level scientists of all levels of seniority. Our priority and strategy focus also strives to partner with industry for co-creation and co-innovation development, helping to generate medical-based products, for example, by developing novel tools and technology required to answer medical questions.

We believe that collaboration in science, where multiple teams work towards a common goal, is required to reach our purpose, and thus, we remain very committed to contributing to talent development in the field of biomaterials and biomedical engineering and technologies.

RESEARCH GROUPS AT BBT 3

3.1 Translational Bionanomicro Theragenerative Medicine

GROUP LEADER: Mohammad-Ali Shahbazi

In our research, we focus on several lines of investigation:

- Tissue-mimicking hydrogels and scaffolds for regenerative purposes
- Development of biomimetic nanomedicines for controlled drug release
- Near-infrared responsive nanomaterials
- Microneedles to improve the therapeutic performance of medicines

Our research team makes the unique bridge between immunology, pharmaceutical nanotechnology and material science to build innovative drug delivery formulations.

3.2 Bacterial Adaptivity

GROUP LEADER: Brandon W. Peterson

The Peterson group focuses on interactions between bacteria and their surroundings. In relation to biomaterials, it encompasses bacterial adhesion, surface properties, stress adaptation, antimicrobial resistance, and effectiveness of drug delivery targeting systems. Most Bacterial Associated Infections (BAI) are linked to the virulence factor of biofilm growth. Our group also studies interactions between biofilms and their environments, including detachment and re-adhesion phenomenon. Understanding how bacteria interact with their environment is critical to developing new successful techniques to combat the severe threat of antimicrobial resistance.

3.3 Translational Bionanomicro Theragenerative Medicine

GROUP LEADER: Hélder Santos

We shape the future of multifunctional medicines through the combination of material science, biology, medicine, chemistry, 3D-printing, and nanotechnology by developing novel drug delivery platforms, including nanomedicines, to a broad range of clinical targets.

In our research we focus on several lines of investigation:

- Synthesis and fabrication of tissue-mimicking hydrogels and scaffolds for regenerative purposes.

- Development of bio-inspired and responsive nanomedicines for controlled drug release.
- Microfluidic-assisted preparation of drug formulations.
- Microneedles to improve the therapeutic performance of medicines.
- 3D-prining of biomaterials for regenerative engineering and tissue engineering.

3.4 Biomaterials-associated Infections

GROUP LEADER: Henny van der Mei

The mechanism of microbial adhesion either through aggregation with each other, adhesion to tissue or to a medical implant and in addition the adaptive response, are investigated. The adaptive response includes the production of an extracellular polymeric matrix that protects biofilm bacteria against environmental attacks, including antibiotics and the immune system. Also, the interaction between tissue cells, immune cells and bacteria is a topic we investigate on modified biomaterials.

Main fields of research interest:

- Prevention of microbial adhesion on biomaterials by anti-adhesive coatings, antimicrobial coatings, surface topographies.
- Stimulate the immune system to attack microbial adhesion.
- Non-antibiotic strategies based on nanotechnology for infection-control.

3.5 Targeted Drug Delivery with Nanomedicine

GROUP LEADER: Inge Zuhorn

Many drugs are unstable in the human body causing quick loss of activity and the need for high dosing and repeated administration. Moreover, drugs can produce side effects, such as liver toxicity as commonly observed with a.o. chemotherapy. The encapsulation of drugs in nanoparticles (i.e., nanomedicine) may help to improve drug stability, and reduce side effects. The targeting of nanomedicine to diseased tissue without harming healthy tissue is considered the Holy Grail of drug delivery. We develop nanomedicine to treat brain diseases in order to enhance drug efficacy, reduce side effects and achieve optimal treatment outcome.

3.6 Biomaterial associated infections and Biocompatibility

GROUP LEADER: Jelmer Sjollema

Jelmer Sjollema concentrates on the effects of a foreign body (e.g. an implant) on the local cellular host environment and the impact of a bacterial infection in the context of Biocompatibility. The group tries to develop both sophisticated animal and in vitro models to study the local cellular environment around foreign bodies. On one hand, we focus on intravital imaging in mice to quantify cellular influx around the implant. On the other hand, we develop a 3D-printed tissue mimic to study the spatial and temporal behavior of a co-culture of macrophages, fibroblasts, and bacteria around implanted particles.

3.7 Materiobiology and Nanobiomaterials

GROUP LEADER: Patrick van Rijn

We aim to direct cellular behavior by means of material properties. In order to achieve this, a fundamental understanding needs to be created how cells respond to materials, in particular towards several parameters simultaneously. Parameters like stiffness, chemical composition (charge, polarity, non-covalent interactions, hydrophobicity, etc.), and topography are parameters known to drastically influence cellular behaviors. When the single parameters influence the behavior of cells then combined parameters do this as well and not necessarily in a predictive fashion. We study this using complex multiparameter interfaces and nanomaterials.

3.8 Biotribology and Regeneration

GROUP LEADER: Prashant Kumar Sharma

Our main research interests are:

- Salivary Lubrication: Hydration and lubrication enhancement in the oral cavity to help dry mouth patients.
- Ocular Lubrication: Hydration and lubrication enhancement at the eyelid-cornea or eyelid-contact lens interface to help patients of dry eye disease.
- Articular Lubrication: Enhancement of cartilage lubrication, stopping the progression of cartilage damage and its restoration to help early articular pain relief and postponement of arthroplasty.
- Coatings: Devising lubricant coatings e.g. for meniscus implants or cardiovascular and urinary catheters.

3.9 Bioimaging and Bioanalysis

GROUP LEADER: Romana Schirhagl

My group uses diamond-based quantum sensing for biomedical applications. This technique allows nanoscale MRI measurements by optical means. More specifically, we use small diamond particles which allow us to translate magnetic signals into optical signals. In a biological environment, we are sensitive to free radicals. Thus, this method can be used to measure stress responses in cell for instance for fundamental research, diagnosis or drug testing.

3.10 Surgical Robotics

GROUP LEADER: Sarthak Misra

We develop novel techniques to reach challenging locations within the body. We design a range of flexible minimally invasive surgical instruments and microrobotic systems, and robotically control them using various clinical imaging modalities such as ultrasound, computed tomography and magnetic resonance images.

The Surgical Robotics Lab (SRL) is composed of an interdisciplinary team of engineers from diverse backgrounds (Mechanical, Electrical, Biomedical, Applied Physics, and Technical Medicine). We closely collaborate with our clinical partners at Radboud University Nijmegen Medical Center, and Medisch Spectrum Twente.

SRL is equipped with rapid prototyping facilities such as 3D printer and laser cutter, and also access to the department workshop. Further, we also have 3D ultrasound (research) systems and several navigation instruments.

3.11 Cell-biomaterial Interactions

GROUP LEADER: Theo van Kooten

Expertise on cell-material interactions in general. Current topics are macrophage-mediated polymer degradation, study of the foreign body response and interactions with infection, such as in the window-on-a-mouse implant model. This extends into fibrosis model studies, of which the lens epithelial cell response is an interesting example. For cell-material interaction studies the cell culture lab, confocal microscopy, histology, and a plate reader are the basic tools. Research is embedded in the research institutes MoHaD and PRECISION.

RESEARCH PROJECTS 4

At BBT, biomedical engineering research focuses on the advances that improve human health and health care in different fields. Each year our researchers apply for and receive funding from various research funding agencies across the world. Below we list out the projects that received funding and started with a starting date in 2023. The starting date is when both the UMCG and the funding agency agree that the Grant Agreement enters into force.

4.1 Projects/grants awarded to PIs with a starting date in 2023

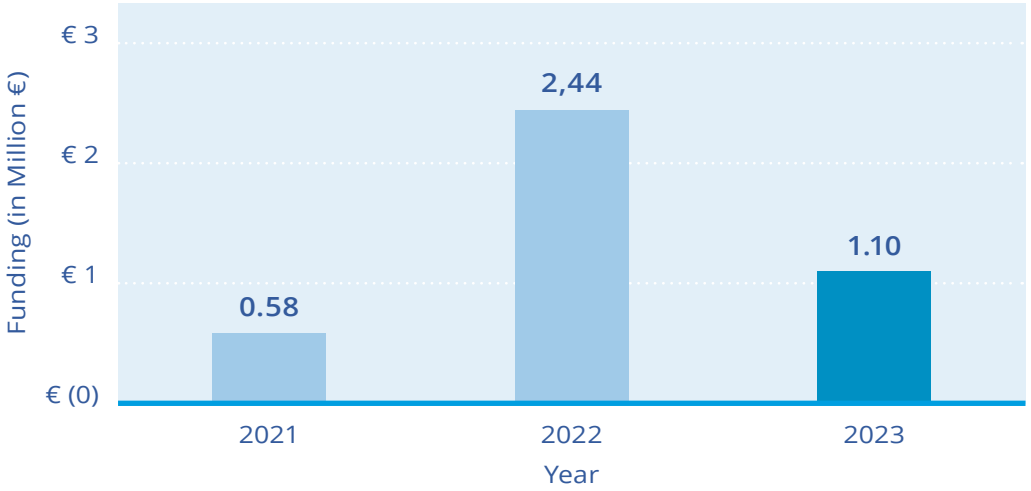
#	Group Leader	Funding Body	Project Title	Funding Awarded
1	Rijn, van P.	Internal call UMCG - Kisuma Chemicals B.V.	Responsive hydrotalcites delivery vehicle as smart filler for degradable biomedical implants	€ 200.000
2	Rijn, van P.	Internal call UMCG - PPP	Responsive hydrotalcites delivery vehicle as smart filler for degradable biomedical implants	€ 132.000
3	Rijn, van P.	SNN	iMPaCT-implants: intelligent Manufacturing from PAtient Centred Technology focused on implants.	€ 287.380

4.2 Projects/grants awarded to PhDs/ Postdocs with a starting date in 2023

#	PhD/ Postdoc	Group Leader	Funding Body	Project Title	Funding Awarded
1	Luigia Serpico	Almeida Santos, H.A.	HORIZON-MSCA-2022-PF-01	SUNSET: Targeting cancer with multi-engineered selenium nanoparticles (SeNPs): Development of a biocompatible nanocomposite for targeted gene therapy in BRAF-mutated resistant melanoma	€ 187.624
2	María Idaira Pacheco Fernández	Almeida Santos, H.A.	HORIZON-MSCA-2021-PF-01	M4LIVER: Application of Metal-organic frameworks synthesized by Microfluidics in Microextraction for Metabolomics: development of a non-invasive bioanalytical method for early diagnosis of fatty Liver diseases	€ 187.624
3	Jie Gao	I.S. Zuhorn	De Cock-Hadders Stichting 2023	Design of brain-targeted extracellular vesicles	€ 4.500
4	Siyu Fan	R.S. Schirhagl	De Cock-Hadders Stichting 2023	Fan Free radicals are built in skin cells in response to radiation, pollution, or toxic chemicals.	€ 4.500
5	Arturo Elias Llumbet	R.S. Schirhagl	De Cock-Hadders Stichting 2023	Progressive characterization of the D-Galactose murine model of accelerated aging	€ 4.500
6	Lisa Tromp	Rijn, van P.	De Cock-Hadders Stichting 2023	High-Throughput Screening to Elucidate Biomaterial-Associated Fibrosis	€ 4.500
7	Adéla Melcrová	Schirhagl, R.	The Foundation to Prevent Antibiotic Resistance	Reversing antimicrobial resistance	€ 86.461

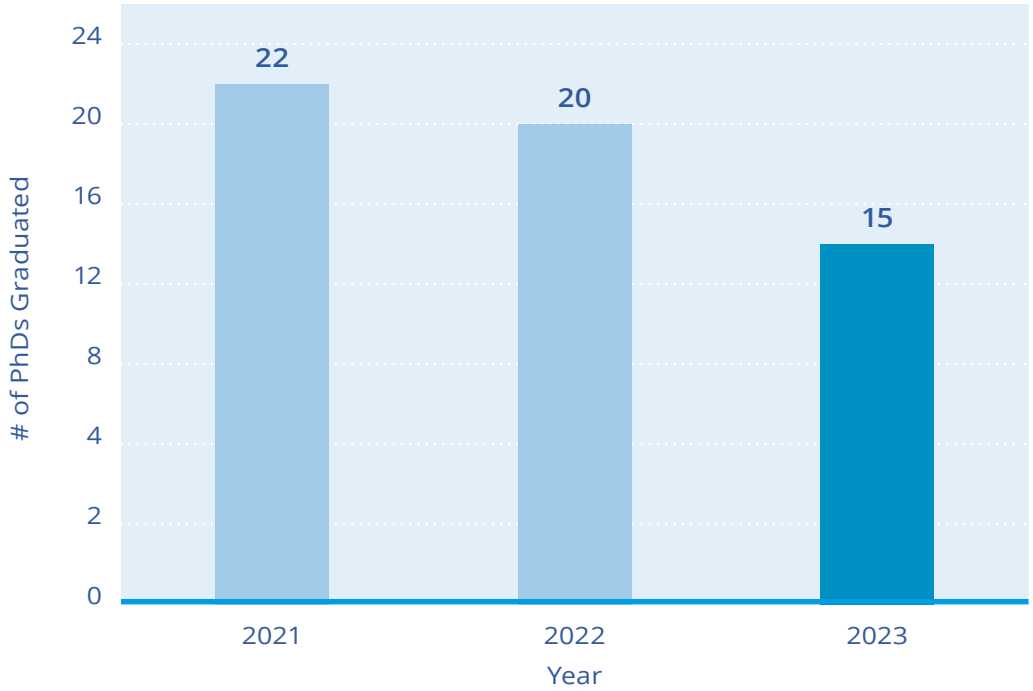
FACTS AND FIGURES 5

5.1 Funding of projects/grants started per year



* See Section 4 for a list of projects started in 2023.

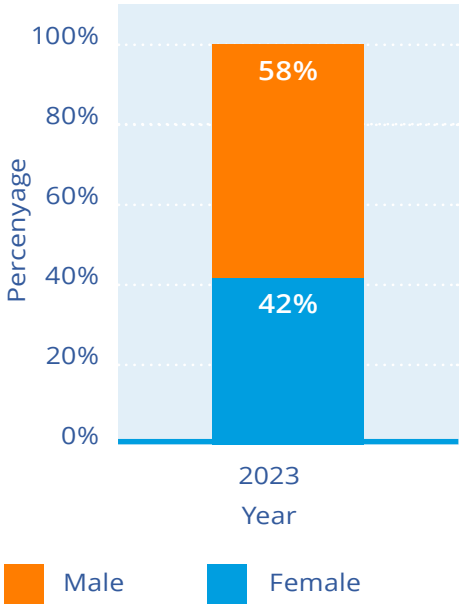
5.2 PhD Graduations



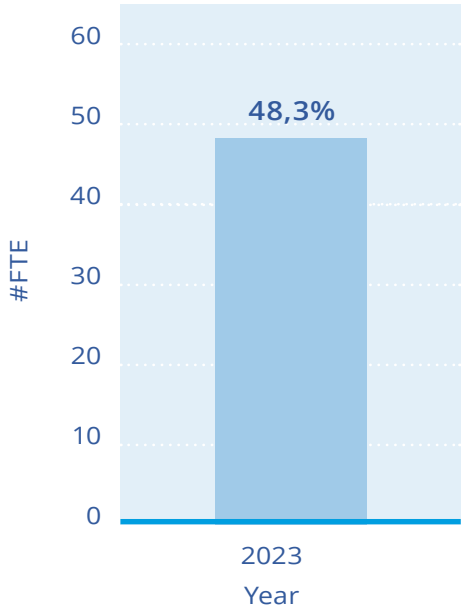
* See Appendix 1 for a list of all PhD theses defended in 2023.

5.3 Personnel

Gender



FTE



** FTE calculation excludes Bursary PhD students and guests.*

Staff	Percentage
Scientific staff	10
Teaching staff	1
Researcher	12
PhD	16
PhD Bursary	46
Support staff	15

Staff age	Percentage
1-24	3.3
25-34	64.8
35-44	16.5
45-54	4.4
55-59	3.3
60-65	6.6
66-99	1.1

Staff nationalities
Belgium
Brazil
Chili
China
Colombia
Cyprus
Germany
Great Britain
India
Iran
Italy
Mexico
the Netherlands
Poland
Portugal
Russia
Spain
Tsjech
Türkiye
United States

Management team BBT	
Hélder Santos	Head of the Department
Wytse Hogewerf	Managing Director
Henk Heidekamp	Cluster Director
Kevin Huizinga	Financial Controller (Resigned on 01-05-2024)
Jesse Medema	Financial Controller
Ria Ubels	Quality Assurance Manager and Staff Advisor
Mallikarjuna Gurram	Project Manager
Sonja van Deemter	Secretary (Retired on 13-04-2023)
Willy Koebrugge	Secretary

EDUCATION 6

BBT is involved in the teaching of BSc and MSc students in multiple curricula, including Biology, Biomedical Sciences, Biomedical Engineering, and Molecular Medicine and Innovative Treatment (MMIT).

BBT members have roles as programme directors, course coordinators and lecturers. Dr. Jelmer Sjollema is the programme director of the Biomedical Engineering MSc (FSE). Prof. Inge Zuhorn is the programme director MMIT, a two-year selective MSc programme (FMS). In addition, BBT is involved in the HTRIC with prof. Santos as one of the scientific directors (2022–2024).

Number of teaching hours by the staff members of BBT			
Faculty	**Departments**	**BSc (in hrs)**	**MSc (in hrs)**
Faculty of Medical Sciences (FMS)	Medicine	308.5	14.3
	Dentistry	14	0
	Human Movement Sciences	0	0
	MMIT	0	585
	GSMS	92	68
	Junior Scientific Masterclass	0	0
	Total	**414.5**	**667.3**
Faculty of Science and Engineering (FSE)	Biomedical Engineering	3553.2	1851.95
	Biomedical Sciences	0	196
	Biology	4	0
	Chemical Engineering	6	6
	Chemistry	0	0
	Pharmacy	0	2
	Life Science and Technology	0	0
	Behavioural and Cognitive Neurosciences	7	27
	Biomolecular Sciences	0	0
	Nanoscience	0	0
	Medical Pharmaceutical Sciences	0	0
	Total	**3570.2**	**2082.95**
Total number of hours:		**3984.7**	**2750.25**

SCIENTIFIC DISSEMINATION & BUSINESS DEVELOPMENT 7

At BBT, we encourage and support researchers to share our know-how, drive discoveries toward applications, and (in doing so) collaborate with industries. We welcome collaborations to generate access to our scientific ideas and state-of-the-art facilities. Below we list out results from our recent efforts to connect science with business.

QT Sense: Delivering nanodiamonds into tissues

In 2023, the foundation was laid for QTsense (https://www.qtsense.com/), a startup company (founded Feb 24) that emerged from Romana Schirhagl's group. The company commercializes equipment for performing quantum sensing equipment in living cells. Compared to the equipment in the research group, the commercial equipment is smaller, user-friendly and portable.

While diamond-based quantum sensing has been demonstrated in living cells earlier, measurements in tissues are still challenging. We have resolved several of the main hurdles towards measurements in living tissues. First, we have established how to deliver nanodiamond particles into tissues. Second, we have developed methods to perform quantum sensing measurements despite the large background fluorescence in tissues. Third, we have improved the loss of viability during the sample preparation and measuring process.

As a result, a patent has been submitted to protect the IP which is now licensed to QTsense: *S. Fan, A. Elias Llumbet, A. Sigaeva, Y. Zhang, M. Lobita, M.-A. Shahbazi, H. Santos, R. Schirhagl, Pending (2023)*

OUTREACH & DISSEMINATION 8

Besides research and education, all scientific staff members from BBT, including PhD students, postdocs, and group leaders, have been actively involved in the scientific outreach and dissemination activities. Below we list out the notable activities by BBT during the last year. A fully documented list of achievements can be found on our Twitter account and our BBT news website:

> https://x.com/BBT_UMCG_RUG
> https://umcgresearch.org/w/news-overview-biomaterials-and-biomedical-technology

Examples of the outreach activities by the PIs, PhDs, Postdocs, and Technicians:

1 Kiyan Musaie, a PhD student from the group of Dr. Shahbazi received the BeNeLux 2024 Young Scientist Travel Grants of the Controlled Release Society. https://www.controlledreleasesociety.org/community/chapters/2024-young-scientist-travel-grants

2 Dr. Shahbazi was recognized as an Emerging Investigator by the Nanoscale Journal from Royal Society of Chemistry: https://pubs.rsc.org/en/content/articlepdf/2024/nr/d4nr90119c?page=search

3 Both Shantou University Medical College and Shantou Daily have written (in Chinese) about our research on quantum sensing in human granulosa cells (in collaboration with the Center of reproductive Medicine, UMCG) (source: https://strb.dahuawang.com/content/202310/11/c146260.htm) as well as Nuan Lin's award for this work at the E-MRS meeting earlier this year. If you do not speak Chinese you can read the original article (published in ACS Central Science) here: https://pubs.acs.org/doi/full/10.1021/acscentsci.3c00747

4 Nuan Lin has received a SHARE award for the best paper for her work with our group Quantum Sensing of Free Radicals in Primary Human Granulosa Cells with Nanoscale Resolution. (Source: https://pubs.acs.org/doi/full/10.1021/acscentsci.3c00747)

5 The de Cock-Hadders foundation has awarded Nuan Lin and Elkin Escobar for their respective Chaves's proposal and the collaborative (Annemieke Hoeks group) project.

6 Adéla Melcróvá has created a video about her research in fighting antimicrobial resistance : (source: https://twitter.com/AdelaMelcrova/status/1724726513155658180)

7 Nuan Lin (our collaborator from the Center of Reproductive medicine) has been awarded with the Young Researcher Award at the E-MRS conference at the 2023 Fall meeting for our shared work on quantum sensing in granulosa cells.

8 Yue Zhang has won a prestigious grant from the Humboldt foundation to continue her career as a postdoc in Mainz.

9 Alina Sigaeva has won the Young Investigator Award from the Society for Free Radical Research-Europe.

10 Britt Coenen has won the second prize for her poster at the annual symposium of the GBB (Groningen Biomolecular Sciences and Biotechnology Institute).

11 David Hernan Aguirre Padilla has won an ATTP scholarship and will join us as a double degree student both RUG and the University of Chile.

12 Britt Coenen has been accepted in the Young NCOH board (source: https://ncoh.nl/about/young/)

13 Arturo Llumbet has received funding from the de Cock-Hadders Stichting already for the second time, supporting his project on relaxometry for studying ageing in mice.

14 Siyu Fan has won a de Cock-Hadders Stichting grant

15 Alina Sigaeva has received a Rubicon prestigious grant which will allow Alina to continue her excellent work as a postdoc in Sweden (KTH, SciLifeLab, with Prof. Emma Lundberg, head of Human Protein Atlas project).

16 Adéla Melcrova's project (a new way to reverse antibiotic resistance and new ways to study antibiotic resistance) has been awarded by the PAR foundation (2 out of 171 category science!)

17 Brandon Peterson, Mohammad-Ali Shahbazi, Patrick van Rijn and Hélder Santos: presentations at the HOVO ('Hoger Onderwijs Voor Ouderen')-Noord-Nederland

18 Sarthak Misra's research has been widely broadcast in public media (e.g., print, radio, TV), and has put UT in the limelight. Some examples are: BBC News, Los Angeles Times, De Volkstrant, BNR Nieuws, NPO1 (EenVandaag), NPO1 (De Wereld van Morgen), VPRO (De Volmaakte Mens)

19 Inge Zuhorn was interviewed by EVCNA (Extracellular Vesicles and Circulating Nucleic Acids), a journal that publishes studies on academic and translational level in the field of EVs and nucleic acids to be used in clinical settings. The interview is part of the EVCNA expert interview series. (https://www.youtube.com/watch?v=jrN0miNAoeM)

20 Jie Gao, Ginevra Mariani, Karina Köpke, Mariana Leal Estrada and Meng Qiao all obtained a de Cock-Hadders grant.

21 Jelmer Sjollema participated in Dartbac (several Consortium meetings) and Surfsafe final conference (Porto, September 2023).

APPENDIX 1
PHD GRADUATIONS

More details about the PhD graduations can be found on the university research portal.

1	PhD Student:	**Ruoyu Cheng**
	Promotor(s):	Hélder Almeida Santos
	Co-promoter(s):	Ali Shahbazi, Tapio, H.J. (ext)
	Thesis title:	Smart nanoparticle-based platforms for regulating tumor microenvironment and cancer immunotherapy
	URL:	https://research.rug.nl/en/publications/smart-nanoparticle-based-platforms-for-regulating-tumor-microenvi-2
2	PhD Student:	**Shuang Tian**
	Promotor(s):	Henk Busscher, Henny van der Mei, Yijin Ren
	Co-promoter(s):	-
	Thesis title:	Polymeric micelles for the dispersal of infectious biofilms
	URL:	https://research.rug.nl/en/publications/polymeric-micelles-for-the-dispersal-of-infectious-biofilms
3	PhD Student:	**Sidi Liu**
	Promotor(s):	Henk Busscher, Henny van der Mei, Yijin Ren
	Co-promoter(s):	-
	Thesis title:	Macrophage-membrane coated nanowired surfaces for diagnosing and cleansing of infected blood
	URL:	https://research.rug.nl/en/publications/macrophage-membrane-coated-nanowired-surfaces-for-diagnosing-and-

4 **PhD Student:** **Olga Sójka**
Promotor(s): Henny van der Mei, Patrick van Rijn
Co-promoter(s): Gagliano, M. Christina (ext)
Thesis title: Influence of physicochemical surface properties on biofilm formation in drinking water distribution systems: role of pipe materials and a nanogel coating
URL: https://research.rug.nl/en/publications/influence-of-physicochemical-surface-properties-on-biofilm-format

5 **PhD Student:** **Rui Shi**
Promotor(s): Henk Busscher, Henny van der Mei, Yijin Ren
Co-promoter(s): -
Thesis title: High yield harvesting of bacterial outer membrane vesicles for the treatment of meningitis
URL: https://research.rug.nl/en/publications/high-yield-harvesting-of-bacterial-outer-membrane-vesicles-for-th

6 **PhD Student:** **Da-Yuan Wang**
Promotor(s): Henk Busscher, Henny van der Mei, Yijin Ren
Co-promoter(s): -
Thesis title: A self-targeting liposomal drug carrier with water as a pH-responsive functionality
URL: https://research.rug.nl/en/publications/a-self-targeting-liposomal-drug-carrier-with-water-as-a-ph-respon

7 **PhD Student:** **Claudia Reyes San Martin**
Promotor(s): Romana Schirhagl
Co-promoter(s): Aldona Mzyk
Thesis title: Nanodiamond relaxometry in sperm cells and collective cancer cell migration
URL: https://research.rug.nl/en/publications/nanodiamond-relaxometry-in-sperm-cells-and-collective-cancer-cell

8	PhD Student:	**Yue Zhang**
	Promotor(s):	Romana Schirhagl
	Co-promoter(s):	Aldona Mzyk
	Thesis title:	Fluorescent nanodiamonds in cells: uptake, biocompatibility and quantum sensing
	URL:	https://research.rug.nl/en/publications/fluorescent-nanodiamonds-in-cells-uptake-biocompatibility-and-qua
9	PhD Student:	**Runrun Li**
	Promotor(s):	Romana Schirhagl
	Co-promoter(s):	Gosia Wlodarczyk-Biegun
	Thesis title:	Diamond-based Sensors and Biolabels for Biomedical Applications
	URL:	https://research.rug.nl/en/publications/diamond-based-sensors-and-biolabels-for-biomedical-applications
10	PhD Student:	**Thea Vedelaar**
	Promotor(s):	Romana Schirhagl
	Co-promoter(s):	Viraj Damle
	Thesis title:	Data processing and applications of fluorescent nanodiamonds for bio-technology
	URL:	https://research.rug.nl/en/publications/data-processing-and-applications-of-fluorescent-nanodiamonds-for-
11	PhD Student:	**Ari Ortiz Moreno**
	Promotor(s):	Romana Schirhagl
	Co-promoter(s):	Aldona Mzyk
	Thesis title:	Biomedical engineering basics for diamond quantum relaxometry
	URL:	https://research.rug.nl/en/publications/biomedical-engineering-basics-for-diamond-quantum-relaxometry
12	PhD Student:	**Valentina Vignali**
	Promotor(s):	Patrick van Rijn
	Co-promoter(s):	Brandon Peterson
	Thesis title:	Overcoming health challenges: a journey through horizon scanning, disinfection, and biocatalytic functionalization strategies
	URL:	https://research.rug.nl/en/publications/overcoming-health-challenges-a-journey-through-horizon-scanning-d

13

PhD Student:	**Lei Li**
Promotor(s):	Patrick van Rijn
Co-promoter(s):	Inge Zuhorn
Thesis title:	Biomedical relevant layered double hydroxides as versatile drug carriers and nanofillers
URL:	https://research.rug.nl/en/publications/biomedical-relevant-layered-double-hydroxides-as-versatile-drug-c

APPENDIX 2 PUBLICATIONS

More details about these publications can be found on the university research portal.

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COLOPHON

Coordination:
Hélder Santos
Wytse Hogewerf
Henk Heidekamp
Mallikarjuna Gurram
Willy Koebrugge

Design:
Dorel Xtra Bold

CONTACT

Visiting Address
Department of Biomaterials and Biomedical Technology (BBT)
University Medical Center Groningen (UMCG)
Postbus 30.001
9700 RB Groningen
The Netherlands

Postal Address
Department of Biomaterials and Biomedical Technology (BBT)
University Medical Center Groningen (UMCG)
A. Deusinglaan 1, building 3215 13th floor, FB40
9713 AV Groningen

Secretariat:
Willy Koebrugge
w.a.koebrugge@umcg.nl
+31 50 361 60 94

Website
https://umcgresearch.org/w/biomaterials-and-biomedical-technology


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