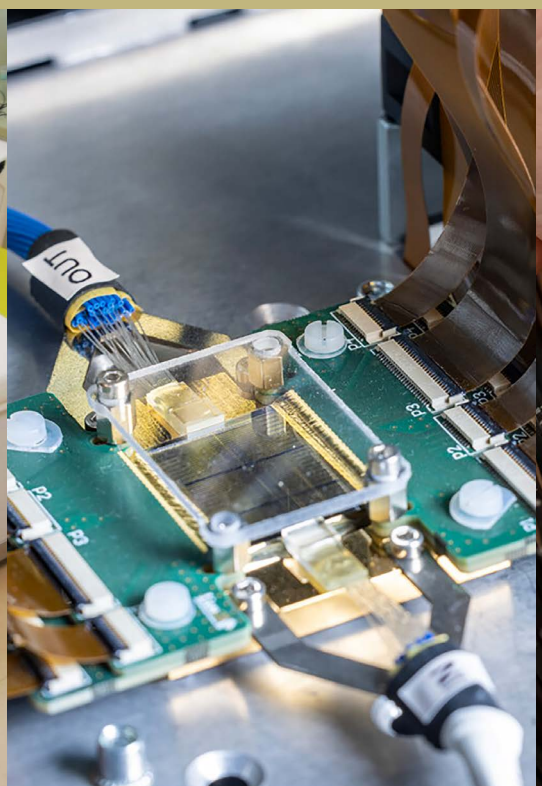
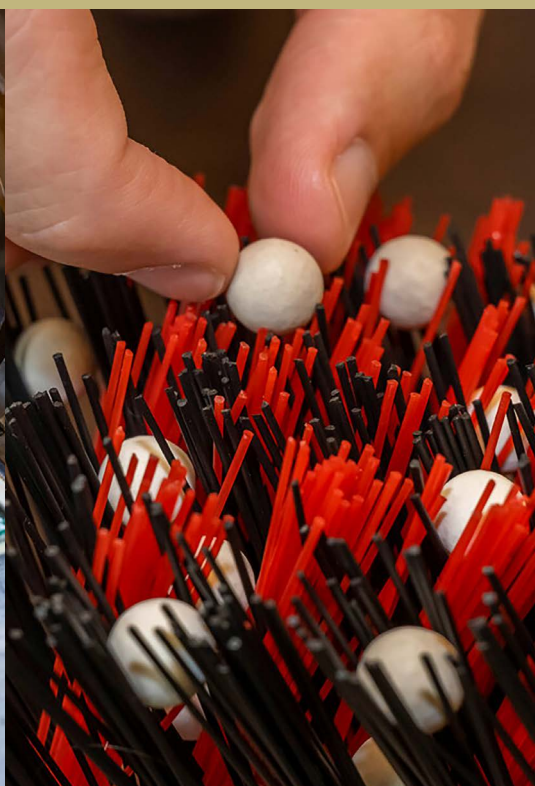
FACULTY OF SCIENCE AND TECHNOLOGY (S&T)
UNIVERSITY OF TWENTE

SELF-EVALUATION REPORT

RESEARCH EVALUATION 2015-2022

UNIVERSITY OF TWENTE.





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RESEARCH EVALUATION 2015-2022

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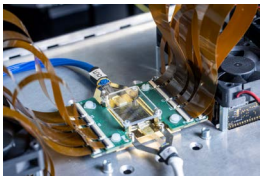
Website www.utwente.nl/en/tnw/

The Twente Photoacoustic-Ultrasound Mammoscope 3 (PAM3) images blood vessels deep in the breast in the context of breast cancer.
PI (research group): Srirang Manohar (Multi-Modality Medical Imaging, M3I).



Spin-off QuiX Quantum.
PI (research group): Jelmer Renema (Adaptive Quantum Optics, AQO).
Photographer: Rikkert Harink.

Artificial nose concept.
PI (research group): Sissi de Beer (Biomolecular Nanotechnology, BNT).
PhD candidate: Leon Smook.
Photographer: C. R. Menningh.

CONTENTS

GLOSSARY

This section describes some of the terms and acronyms used in this document as they are intended to be understood in the document.

Academic staff: Refers in this document to staff appointed by the faculty and includes full professors, associate professors, assistant professors, lecturers, researchers/Post-docs, and PhD candidates.

Appointments: Refers to the number of contracts, including both part-time and full-time employees. It is slightly different than the number of employees (also called headcount) because an employee can have one or more contracts in different units.

Cluster: At the Faculty of Science and Technology (S&T), an organisational unit that brings together several complementary research groups around a scientific subject to focus on content and quality in both education and research. Clusters have no formalised rights or mandate.

Department: Group of several research groups sharing facilities, responsibility for teaching and research expertise, with an elected board and formalised rights and responsibilities (including budget and HR responsibility), i.e., a mandate to make decisions.

Domain: Specific areas of knowledge or expertise within the S&T faculty, in this case Applied Physics, Chemical Science and Engineering, and Health.

FAIR (data) principles: Research data, at the latest when they are static, should be Findable, Accessible, Interoperable and Reusable.

First, second, and third money stream: The revenue of the Dutch universities can be roughly divided into three streams of funding. The first money stream refers to direct government funding. The second money stream is indirect government funding for specific research projects, for example from the Dutch Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW). The third money stream relates to contract research (e.g., companies, private investors) and EU funded research.

Field Weighted Citation Impact (FWCI): The ratio of the total citations actually received by the denominator output and the total citations expected based on the average of the subject field. Exactly 1 means that the output performs just as expected for the global average. More than 1 means that the output is more cited than expected according to the global average. For example, 1.48 means 48% more cited than expected. Less than 1 means that the output is cited less than expected according to the global average.

FTE: Full-Time Equivalent. This indicates the number of hours an employee works. An FTE of 1.0 is equivalent to a full-time employee (in our university: 38 hours/week). The concept is used to count hours worked rather than the number of employees or the number of appointments.

Gravitation (Zwaartekracht): Is one of the NWO programmes for scientific consortia (Gravitation | NWO).

Knowledge and Innovation Agendas (KIAs): NWO is responding to major societal transitions by investing more than 100 million euros a year in research in which public and private parties work together (Knowledge and Innovation Agendas (KIAs) | NWO).

National Growth Fund (NGF): Initiative of the Ministry of Economic Affairs and the Ministry of Finance for project investments in the fields of knowledge development and in research, development and innovation (National Growth Fund | NWO).

Netherlands Enterprise Agency (NEA): Organisation that supports entrepreneurs and organisations to invest, develop and expand their businesses and projects in the Netherlands and abroad (Netherlands Enterprise Agency (rvo.nl).

NWA (Nationale Wetenschapsagenda): Research programme funded by NWO, addressing scientific topics that have been defined on the basis of a consultation of Dutch citizens (Dutch Research Agenda (NWA) | NWO).

NWA-ORC (Research along Routes by Consortia): Funding programme in the NWA that enables interdisciplinary research and innovation (Research along Routes by Consortia (NWA-ORC) | NWO).

NWO: NWO is the Dutch Research Council, one of the most important science funding agencies in the Netherlands (Homepage | NWO).

Principal Investigator (PI): Assistant, associate and full professors who lead research projects.

RIS Utwente (also known as PURE): The Research Information System (RIS) is the back-end system where researchers can manage their profiles, research units, projects, research output, datasets, activities, prizes and press/media. University of Twente Research Information is the public portal where profiles, research units, projects, research output, datasets, activities, prizes and press/media are published.

SDGs (Sustainable Development Goals): Also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.

Sector Plan / STEM Sector Plan: The sector plans for scientific research and university education describe the specific topics and focus areas on which financial investments are done by the government. We will refer to the 'Sectorplan Bèta en Techniek' by STEM Sector Plan. Of the STEM Sector Plan, the Science and Technology areas apply to the S&T faculty.

SEP (Strategy Evaluation Protocol): The Strategy Evaluation Protocol (SEP) for 2021-2027 has been approved by Universities of the Netherlands, NWO and KNAW. The SEP is used every six years to evaluate the quality, relevance and viability of research at public institutions in the Netherlands (Strategy Evaluation Protocol 2021–2027 (knaw.nl)).

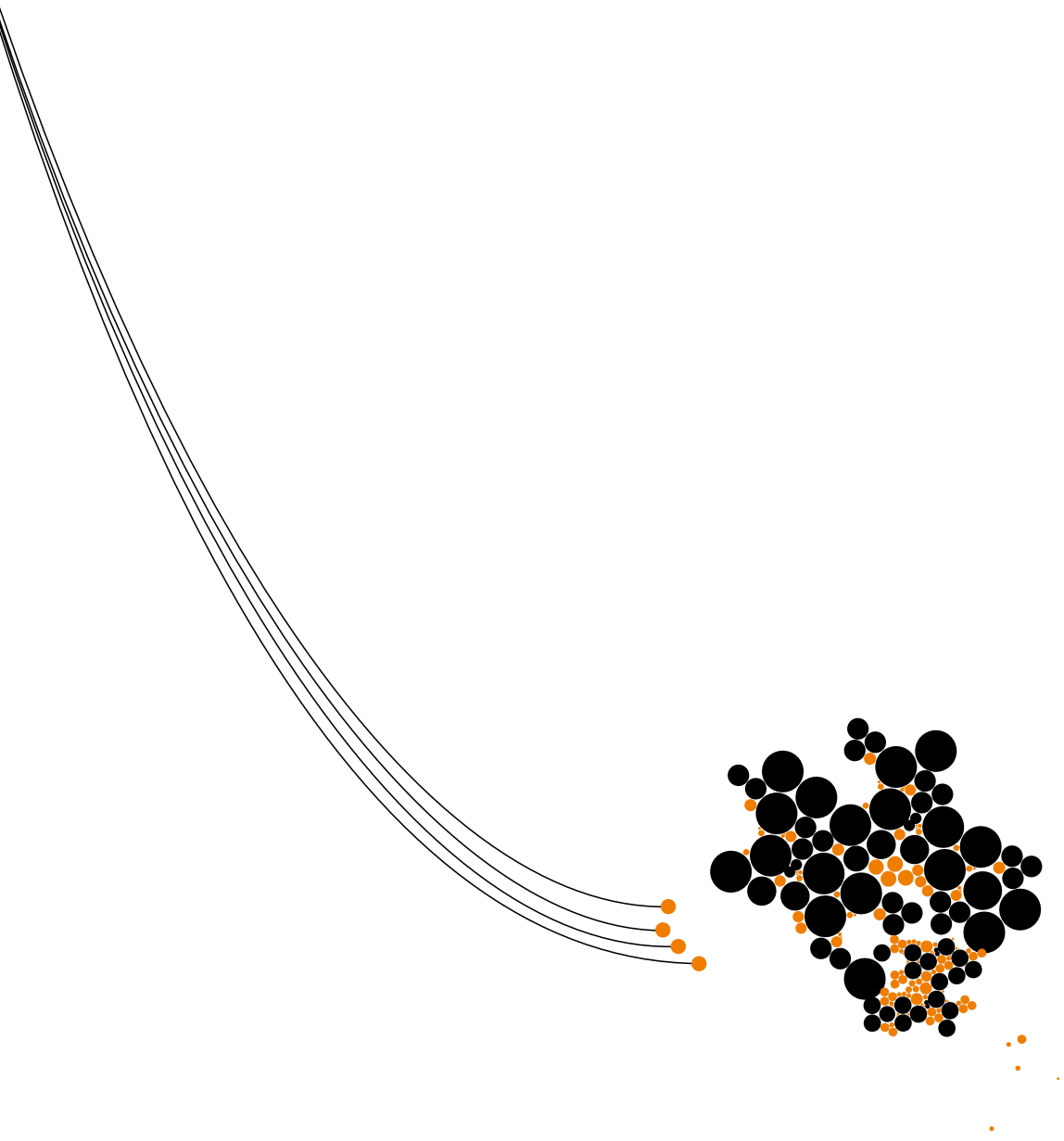
Support staff: All people who work for the university who are not appointed in a scientific position (see for scientific positions: Academic staff)

Tenure Track (TT): The TT is a career development track intended for development towards a full professorship (Notitie HR (utwente.nl)).

TGS (Twente Graduate School): Unit at UT that coordinates the doctoral programmes at UT. (Doctoral programmes at the University of Twente (utwente.nl))

Top Sectors: National initiative for collaboration of industry, science and government (Home | Topsectoren).

Visiting Fellow: researcher from other academic institutions, or persons from business, industry, or government, affiliated with a research group. Visiting fellows are not considered UT employees and do not receive salary from UT, however, to grant access to university facilities and services, formal appointments must be made.



1. PREFACE

An understated pride and collective commitment characterise the Faculty of Science and Technology (S&T) of the University of Twente. The faculty is regarded and respected as central to the mission of the UT, combining strong fundamentals with real-world relevance, contributing to solve complex sociotechnical challenges.

Our aim is continuous improvement of the faculty, and we view this Strategic Evaluation as an opportunity to reflect further and deeper, together. We are delighted to present this self-evaluation report of the faculty, and look forward to sharing insights and ideas, both critical and constructive, during the upcoming review.

We have organised the report according to the main evaluation criteria of the Strategy Evaluation Protocol (Strategy Evaluation Protocol 2021–2027 (knaw.nl)): Research Quality, Societal Relevance, and Viability, with special attention to four specific aspects: 1) Open Science, 2) PhD Policy and Training, 3) Academic Culture and 4) Human Resources Policy.

In addition, we ask the committee to consider our organisational model and leadership structure. Are they fit for purpose? In brief, does the committee recognise our ambition to achieve

- a less complex organisational structure,
- better visibility and recognition of the S&T community,
- more attention for talent management, and
- a stronger focus on research lines that create (scientific and/or societal) impact.

We are currently in the midst of a transition from a faculty consisting of more than 40 independent research groups to a structure involving more shared responsibility. Introducing 8 departments defined by common expertise and infrastructure, we will mandate responsibility for research, education and valorisation, as well as decisions regarding personnel, finances and facilities. For us, this is a terra incognita, and we welcome the advice and suggestions of the committee to improve our organisation, leadership, and our research portfolio.

This document results from the collective efforts of many, both within the faculty and in the central organisation of the University of Twente. Here we specifically express our gratitude to the writing and reading committees. The report has been approved by the Faculty Board and the Executive Board of the University of Twente.

On behalf of the Faculty Board,

Jennifer Herek and Wiendelt Steenbergen
Dean and Vice Dean Research
Faculty of Science and Technology

2. SUMMARY

Here we present a critical self-evaluation of the research activities in the Faculty of Science & Technology (S&T), University of Twente (UT), the Netherlands. The self-evaluation report is prepared according to SEP 2021 – 2027 protocol and concerns the period 2015 – 2022. The Executive Board of the UT prescribed that this report should contain considerations on the level of (1) the overall faculty and (2) the three constituting domains: Applied Physics, Chemical Science and Engineering, and Health. Previous research evaluations have been conducted separately for Applied Physics (2018) and Chemical Science and Engineering (2015). The Health domain had not been previously evaluated as a stand-alone domain within the faculty, though some research was considered in the other two domains.

The S&T faculty is in the midst of an impactful transition. The governance (structure) is changing by transforming the research clusters into formal departments based on common expertise. Unlike the clusters, the departments will be led by collegial boards with formalized rights and responsibilities, i.e. a mandate to take decisions. The faculty has also identified six research themes that connect our expertise with practical/down-to-earth scientific problems with everyday consequences: 1) Climate 2) Energy 3) Health, 4) Safety & Security, 5) Sustainable Materials & Processes, and 6) Water. This means that, more than ever before, the S&T faculty is strongly focusing on the societal relevance of its research. Additionally, the S&T faculty explicitly wishes to contribute to long-term viability by improving the assistant- and associate professors' position and will push forward to strengthen its position with regard to national and international visibility & recognition, successful applications for personal and consortia grants, prizes & awards, and attracting & retaining top academics for all ranks and from all over the world.

However, as many institutions in the Netherlands, the S&T faculty is currently facing challenges that have been perceived by many as threats: national political discussions on internationalization in higher education, societal trends, and geopolitical developments. These developments can hamper the talent pool and finances as well as restricting the free choice of research activities and partners. Given the limited influence of the faculty on such external factors, it is important to concentrate on what is within the faculty's (internal) locus of control. In so doing, it is vital that the S&T faculty remains steadfast in its path. This means that the S&T faculty continues its efforts to make sustainability-oriented scientific and societal impact through research, education, and valorisation in the intertwined domains of Applied Physics, Chemical Science and Engineering, and Health. This report shows that the faculty creates such impact by research products, use of research products, and marks of recognition respectively for, by and from peers and societal target groups. These favourable outcomes underscore some of the inherent strengths of the S&T faculty:

- state-of-the-art facilities and infrastructure;
- cross-domain collaborations with good collegial atmosphere;
- balance between fundamental and applied research with a strong focus on societal problems and collaborations with stakeholders;
- valorisation through demonstrable technology readiness level and strong focus on entrepreneurship (spin-off companies); and
- a flat hierarchy with easily approachable faculty management and support units.

The S&T faculty has to hold on to these strengths, needs to turn opportunities into effective actions, and must overcome current weaknesses such as malfunctioning systems and a suboptimal alignment between support services and the true needs of research(ers). We are committed to creating a thriving and sustainable environment for research with impact, and hope that this report will provide insights and inspiration that lead the way.

3. AN INTRODUCTION OF THE FACULTY OF SCIENCE AND TECHNOLOGY

3.1 THE SCIENCE AND TECHNOLOGY (S&T) FACULTY AT A GLANCE

S&T's vision is to empower society to build a sustainability-oriented future. S&T's mission is to make a sustainability-oriented scientific and societal impact through our research, education, and valorisation in the intertwined domains of Applied Physics, Chemical Science and Engineering, and Health (S&T Faculty Strategy 2023 – 2027).

The current research in the S&T faculty spans three main research domains: Applied Physics, Chemical Science and Engineering, and Health. This self-evaluation report will consider the research in all three domains.

Until more than 20 years ago, the domains Applied Physics and Chemical Science and Engineering were organised in two separate faculties. Around the year 2002, these faculties were merged into a single faculty S&T. In early 2000, Health was introduced via the educational programme of Biomedical Engineering, and later via Technical Medicine, and Health Sciences, which subsequently was incorporated to the faculty as a domain in 2010. While S&T and its predecessors had a long tradition in biomedically oriented research, the status of Health as a third domain was formalised in 2015. Previous research evaluations have been conducted separately for Applied Physics (2018) and Chemical Science and Engineering (2015). Health had not been evaluated before as a stand-alone domain within the faculty. This domain has developed strongly into an important third pillar of the faculty, as will be described in this research evaluation (see also Chapter 5 Evidence and accomplishments). Regarding education, the S&T faculty is currently responsible for 6 Bachelor programmes, 7 Master programmes, and 2 Multidisciplinary Master programmes. In addition, the faculty hosts several services and support units such as the Education Support Office, Human Resources, and Finance and Control.

In the evaluated time frame the faculty has strongly grown. In 2015, the faculty employed in total 797 employees (including 432 PhD candidates, excluding 97 visiting fellows) (see also Appendix A, Table E2). In 2023, the S&T faculty has approximately 1150 employees in total, of which 607 employees is academic staff (53%) including 281 PhD candidates and excluding 174 visiting fellows. The distribution over the three domains is as follows: 48 percent in Applied Physics, 30 percent in Chemical Science and Engineering, and 21 percent in Health. However, there is overlap between the domains. Currently, the faculty is governed by a collegial faculty board, consisting of the dean, vice deans of education and research, and a managing director, supported by an advisory team consisting of a student assessor, the heads of the Finance and HR departments, and policy advisers.

In 2013, the faculty board was composed only of the dean. The dean was the formal supervisor of all full professors, but also of the head of all support services (e.g., heads of finance and HR). There was no director of operations or managing director. So, the dean was responsible for scientific management and business management. The dean was supported by a management team that included the heads of finances and HR. In 2014, a managing director was appointed who became the head of finances

and other support staff who used to work under the formal supervision of the dean. Also, a vice dean Health was appointed in 2015 (also called pro-dean, without formal mandate). In the period 2015 – 2018, initiated by the S&T faculty, the notion evolved at the UT that collegial faculty boards would be more suitable for the faculties. To get a similar organisation structure for all the faculties, and to synchronise with developments nationally, in 2017 it was decided that next to the dean and the managing director, faculty boards should introduce the positions of a vice dean education and a vice dean research. The position of vice dean Health disappeared with the introduction of the new board structure.

Over the past ten years, the S&T faculty has implemented an ambitious plan for attracting new talented staff (including implementation of tenure track system) and, as a result, has grown significantly, from 31 to more than 40 research groups. This growth is partly resulting from the Tenure Track policy and from investments via the Dutch STEM Sector plans. The Sector plan positions (altogether 12) are distributed over clusters/departments as follows: 1 Applied Nanophotonics (ANP), 2 Bioengineering Technologies (BET), 1 Chemical Engineering (CE), 3 Molecules and Materials (MolMat), 1 Membrane Science and Technology (MST), 3 Nanoelectronic Materials (NEM), and 1 Physics of Fluids (PoF).

Also, some very large groups were split into smaller units. The groups are formally chaired by a full professor (group leader) who is responsible for the group's research programme, educational activities, finances, and HR matters, and who is the formal supervisor of all academic and support staff in the group. The full professors represent the research groups in the faculty and the research institutes (see Appendix B). In addition to the group leader, research groups may consist of other Principal Investigators (PIs), including full professors, part-time professors, associate professors, and assistant professors, who provide input for scientific development and act as (daily) supervisors of the PhD candidates. A research group can comprise of several teams, typically consisting of one or more supervisors, one or more PhD candidates and/or post-docs and several bachelor and master students. Moreover, management assistants and technicians support the research groups. Technicians are co-responsible for maintaining the infrastructure of the groups and provide support to education activities.

At a higher organisational level, research is organised into clusters, which include several chairs with complementary scientific topics. The cluster formation started informally in 2016 and took its final shape in 2018. Guiding considerations behind the cluster formation were the external profiling of the research areas in our faculty, optimal use of existing strengths and available infrastructure to meet the scientific, educational, and societal challenges as well as increasing the possibilities for future financing. Most established clusters are led by a diverse board (without mandate) consisting of principal investigators from the participating research groups. Until the end of 2023, the S&T research groups were combined into 11 clusters, shown in Table 1. In January 2024, the governance of the faculty will change. Eight departments will be formed, building on the previously formed clusters as depicted in Table 1. Unlike the clusters, these departments will have governance boards and have more formalised rights and responsibilities, i.e., a mandate to take decisions. For more information about these changes, see Chapter 6 'Strategy for 2023 - 2027'.

Table 1: Overview of the 11 clusters that will evolve into 8 departments from 2024. The table shows how some clusters have been brought together. The Soft Matter cluster is split up and spread over different departments

11 CLUSTERS (2018-2023)	8 DEPARTMENTS (FROM 2024)
Medical Imaging and Diagnostics (MID)	Biomedical Imaging & Sensing (BIS)
Translational Physiology (TP)	
Energy, Materials & Systems	Nano Electronic Materials and thin films (NEM)
Nano Electronic Materials	
Applied Nanophotonics (ANP)	Applied Nanophotonics (ANP)
Membrane Science and Technology (MST)	Membrane Science and Technology (MST)
Physics of Fluids (PoF)	Physics of Fluids (PoF)
Soft Matter (SM)	--
Bioengineering Technologies (BET)	Bioengineering Technologies (BET)
Molecules and Materials (MOLMAT)	Molecules and Materials (MOLMAT)
Process and Catalysis Engineering (PCE)	Chemical Engineering (CE)

Finally, to get a complete picture of the faculty, it is important to mention the following other relevant changes in recent and coming years that (will) have an impact on the faculty:

1) Strengthening of focus areas and investments in future growth (particularly via the Sector Plans).
2) Adjustments to the financial allocation model,
3) Redefining the Tenure Track programme,
4) The introduction of a new faculty strategy (2023 - 2027) including changing governance and empowering the new generations of scientists (see Chapter 6 'Strategy for 2023 - 2027'), and
5) The formulation of a new research strategy, to be completed in 2024.

These changes will be further described in Chapter 4 (points 1 to 3) 'Mission, strategic aims, and strategy 2015 – 2022' and in Chapter 6 (point 4) 'Strategy for 2023 - 2027'.

3.2 THE NEARBY ENVIRONMENT: THE S&T FACULTY WITHIN THE UNIVERSITY OF TWENTE

To provide organisational context in which S&T research is conducted, we describe below the governance structure of the UT (see Figure 1). The governance of UT is based on a matrix organisation of five faculties (such as S&T) and three interfaculty research institutes, MESA+, TechMed and Digital Society Institute (DSI) . For more information about MESA+ and TechMed, in which many S&T researchers participate, see Appendix D (c). The institutes are responsible for initiating interdisciplinary research across faculties, in collaboration with the faculties. They also initiate and coordinate strategic programmes and consortia, connect researchers in multidisciplinary projects and partly manage the associated research infrastructure. Researchers from all faculties participate in these institutes. The institutes receive a strategic budget for their main mission of initiating multidisciplinary research co-operations.

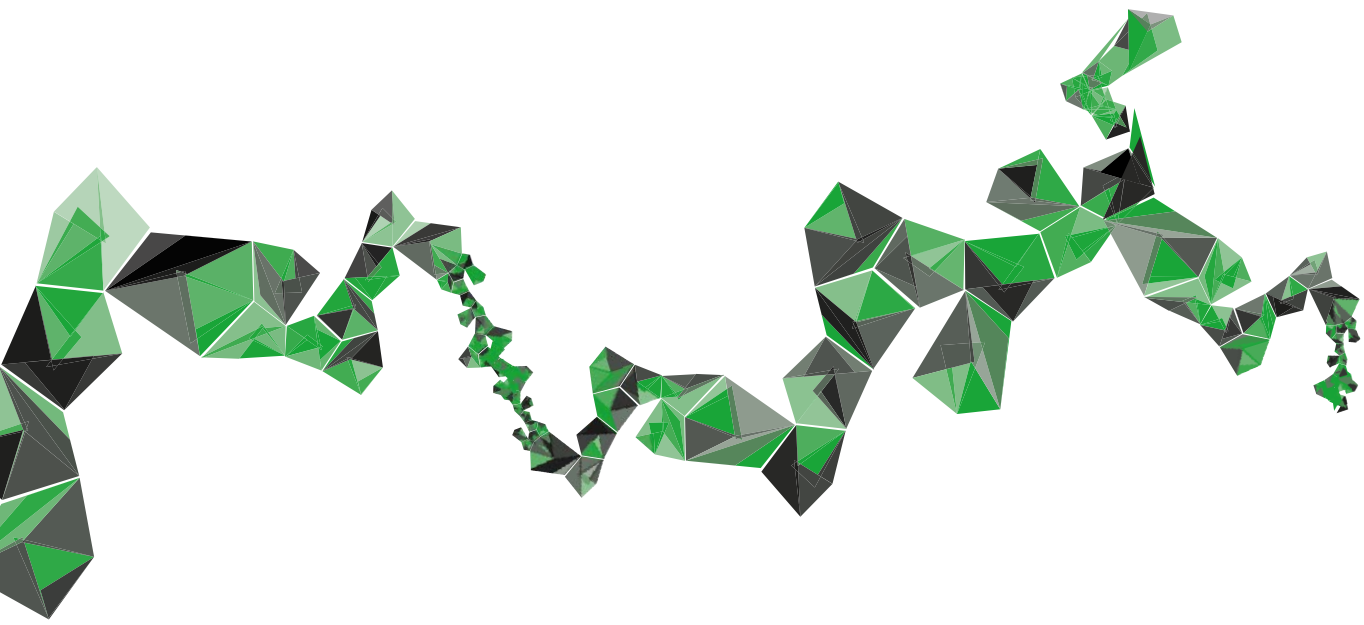
Figure 1: Internal structure of the University of Twente with the faculties and institutes (the S&T faculty is highlighted in yellow)

Based on the disciplinary strengths that the research groups and clusters/departments represent, they play important roles in the more interdisciplinary research collaborations that are initiated through the institutes (Figure 2). Within the institutes interdisciplinary collaborations are stimulated through Centres of Expertise. These centres offer external businesses a single contact point that can help answer highly specialised research questions. S&T researchers collaborate in TechMed's BioImaging Centre (BioImaging Centrum | Technisch Medisch Centrum | Universiteit Twente (utwente.nl) and various MESA+ centres such as the Molecules Centre, the Twente Centre for Advanced Battery Technology, and Organ-on-Chip Centre Twente (Centres of expertise | MESA+ Institute for Nanotechnology (utwente.nl)). MESA+ also manages the NanoLab, a large scale interdisciplinary cleanroom infrastructure, in close collaboration with the Faculty of Electrotechnical Engineering, Mathematics and Computer Science (EEMCS) and S&T. Together with the UT Executive Board, the deans of the faculties and the scientific directors of the institutes form the university's strategic consultation body, in which the strategy and policy of the university are discussed at large.

↓ Table 2: The three S&T domains Health, Applied Physics and Chemical Science and Engineering, with their associated departments and research groups from January 2024, and their connections with the institutes and MESA+ thematic centres.

	FACULTY SCIENCE & TECHNOLOGY				INSTITUTES (INTERDISCIPLINARY COLLABORATIONS)										
							MESA+								
DISCIPLINARY STRENGHTS	DOMAIN	DEPARTMENTS		RESEARCH GROUPS	TECHHMED	DSI	General	Battery Centre	Molecules Centre	Solar Centre	BRAINS Centre	Organs-on-Chip Center	Piezo MEMS Center	Quant Centre	Integrated Photonics Centre
								1	2	3	4	5	6	7	8
	HEALTH	Biomedical Imaging & Sensing (BIS)	6	Clinical Neurophysiology (CNPH)	X										
				Biomedical Photonic Imaging (BMPI)	X							X			
				Magnetic Detection & Imaging (MD&I)	X										
				Cardiovascular and Respiratory Physiology (CRPH)	X										
				Multi-Modality Medical Imaging (M3I)	X										
				Healthcare Technology Implementation (HTI)	X										
		Bioengineering Technologies (BET)	4	Developmental Bioengineering (DBE)	X		X		X			X			
				Applied Stem Cell Technologies (AST)	X							X			
				Nanobiophysics (NBP)	X		X		X						
				Advanced Organ bioengineering and Therapeutics (AOT)	X							X			
	CHEMICAL SCIENCE AND ENGINEERING	Membrane Science and Technology (MST)	3	Membrane Science and Technology (MST)			X		X						
				Soft Matter, Fluidics and Interfaces (SFI)											
				Films in Fluids (FIF)			X		X						
		Molecules & Materials (MolMat)	6	Biomolecular Nanotechnology (BNT)	X		X		X						
				Molecular Nanofabrication (MNF)	X		X	X	X		X	X			
				Hybrid Materials for Opto-Electronics (HMOE)			X		X		X				
				Bioelectric signaling and engineering (BioEE)	X				X						
				Bioelectronics (BE)	X		X		X						
				Sustainable Polymer Chemistry (SPC)			X	X	X						
		Chemical Engineering (CE)	5	Catalytic Processes and Materials (CPM)			X	X							
				Sustainable Process Technology (SPT)			X	X	X						
				Mesoscale Chemical Systems (MCS)	X		X	X	X	X			X	X	
				Physics of Complex Fluids (PCF)											
				PhotoCatalytic Synthesis (PCS)			X	X	X	X					
	APPLIED PHYSICS	Physics Of Fluids (PoF)	1	Physics of Fluids (PoF)	X		X								
		Nanoelectronic Materials and Thin Films (NEM)	6	Inorganic Materials Science (IMS)			X	X		X	X		X		X
				Interfaces and Correlated Electron Systems (ICE)		X	X				X			X	
				Physics of Interfaces and Nanostructures (PIN)			X							X	
				Energy, Materials & Systems (EMS)											
				Computational Chemical Physics (CCP)			X		X	X				X	
				XUV Optics (XUV)			X						X		
		Applied Nanophotonics (ANP)	5	Optical Sciences (OS)			X								
				Integrated Optical Systems (IOS)	X		X							X	X
				Complex Photonics Systems (COPS)			X							X	
				Adaptive Quantum Optics (AQO)			X							X	X
				Nonlinear Nanophotonics (NLNP)			X							X	X

The university has five faculties. S&T faculty is the largest in terms of personnel and financial turnover. In 2022, S&T received a total of M€ 98,9 1st/2nd/3rd money stream funding, of which M€ 64,1 million was allocated to the research groups, and the remaining amount to the research institutes, the educational programmes, general faculty and the Twente Graduate School (which coordinates all doctoral programmes at the UT, see paragraph 5.8).



4. MISSION, STRATEGIC AIMS AND STRATEGY 2015-2022

4.1 MISSION STATEMENT FOR THE FACULTY OF SCIENCE AND TECHNOLOGY

In 2018, the mission of the S&T faculty was defined as: *to provide excellent education in a selected number of academic programmes, encompassing disciplines in Science and Technology, as well as from the area of Health and Biomedical Technologies. To perform cutting-edge and societally relevant research in selected fields connected with these educational programmes* (S&T Faculty Strategy 2018–2023).

For the evaluation period, important considerations connected to this mission were that the faculty should (I) select focus areas that would produce a good research portfolio for the forthcoming years and make them more visible, (II) be able to act more effectively on the (inter)national stage in terms of research funding, especially in the form of large consortia, and (III) be attractive for talent. The latter aspect also entailed a revision of the current evaluation criteria and procedures. Furthermore, (IV) the infrastructure had to be kept at a high level, including several new facilities. In addition to all these goals, given the size and complexity of the faculty, manageability had to be improved. In general, the opinion was that the faculty should be able to act more strategically rather than opportunistically.

4.2 STRATEGIC GOALS AND STRATEGY

(I) SELECTION OF RESEARCH FOCUS AREAS, AND ENHANCING THEIR VISIBILITY

In the years 2015–2016, the S&T faculty board, in consultation with the faculty at large, the faculty council and the UT research institutes selected the following 11 research focus areas:
(1) Applied Nanophotonics (ANP); (2) Bioengineering Technologies (BET); (3) Energy Materials and Systems (EMS); (4) Medical Imaging and Diagnostics (MI&D); (5) Membrane Science and Technology (MST); (6) Nano-electronic Materials (NEM); (7) Molecules and Materials (MolMat) ; (8) Physics of Fluids (PoF); (9) Process and Catalysis Engineering (PCE, now Chemical Engineering, CE); (10) Soft Matter (SM); and (11) Translational Physiology (TP). This selection was based on existing strengths and available infrastructure, on the relevance to scientific and societal challenges as well as to our educational programmes and considering the opportunities for future funding. The research areas formed the basis for the formation of the research clusters (see Appendix B and Research | Clusters | Science and Technology Faculty (TNW) (utwente.nl)) and became the guiding themes in the attraction of talent, for example through the STEM Sector plan.

The clusters were intended 1) to strengthen the research by enhanced collaboration and sharing of networks, 2) to provide an fertile setting to blend fundamental and application-oriented research, 3) to create higher external visibility of main research strengths and educational specialisations, 4) to provide an attractive and fruitful embedding for tenure trackers and other young staff, 5) to make optimal use of infrastructure, and 6) to facilitate a strategic discussion on the further development of the respective research fields, e.g. in relation to succession planning. It was recognised that some research groups and individuals clearly fitted in more than one cluster. Therefore, it was agreed with selected individual PIs to become associated with two clusters, and three clusters also included

a group from another faculty (i.e., ANP, MI&D, and NEM). The approach for cluster formation and their organisation was organic or bottom-up and showed high degrees of autonomy in cluster evolution and management. This also explains why clusters are in different stages of organisation currently. What follows are a number of observations about clusters in the past period:

- Cluster formation has led to more collaborations between research groups, and to use of each other's infrastructure.
- In order to enhance the visibility of our research, centres have been founded within or between clusters, while clusters appeared to be more beneficial for the internal cohesion.
- Clusters have made it more easy for young academic staff, in particular those who had no specific preference for or affinity with one specific research group.
- Clusters have proven to be beneficial for initiating discussions about the research strategy and the need of new staff positions.
- However, the informal character of clusters made these discussions sometimes non-obligative. This will be different in departments with a mandate. See chapter 6 for more information on the new governance structure as of 1 January 2024.

(II) ATTRACTING FUNDING AND STRENGTHENING OUR ROLE IN LARGE CONSORTIA

It was recognised in 2014–2015 that while the faculty did well in attracting individual and smaller scale research grants, the attraction of large consortium grants and taking on leadership roles in the associated consortia could be strengthened. This was one of the strategic aims in the interplay between the research institutes (esp. MESA+ and TechMed) and the S&T faculty. This was especially in the positioning for the, National Growth Fund (coming up in 2020) that the institutes played a pivotal role. For other major consortium grants, like the NWO Gravitation and NWA-ORC calls, individual researchers that showed the ambition to take up a leading role were supported with practical and financial support, in part through the UT's Strategic Business Development department.
For certain research fields, like e.g., Integrated Photonics, Solar Cell Materials, Energy-Efficient Computing, Quantum Technologies, and Organ-on-Chip Technologies, it was anticipated that large scale funding would become available in the forthcoming years. The faculty decided to invest extra in such fields, e.g., by the attraction of additional young and senior researchers, to be well positioned for this.

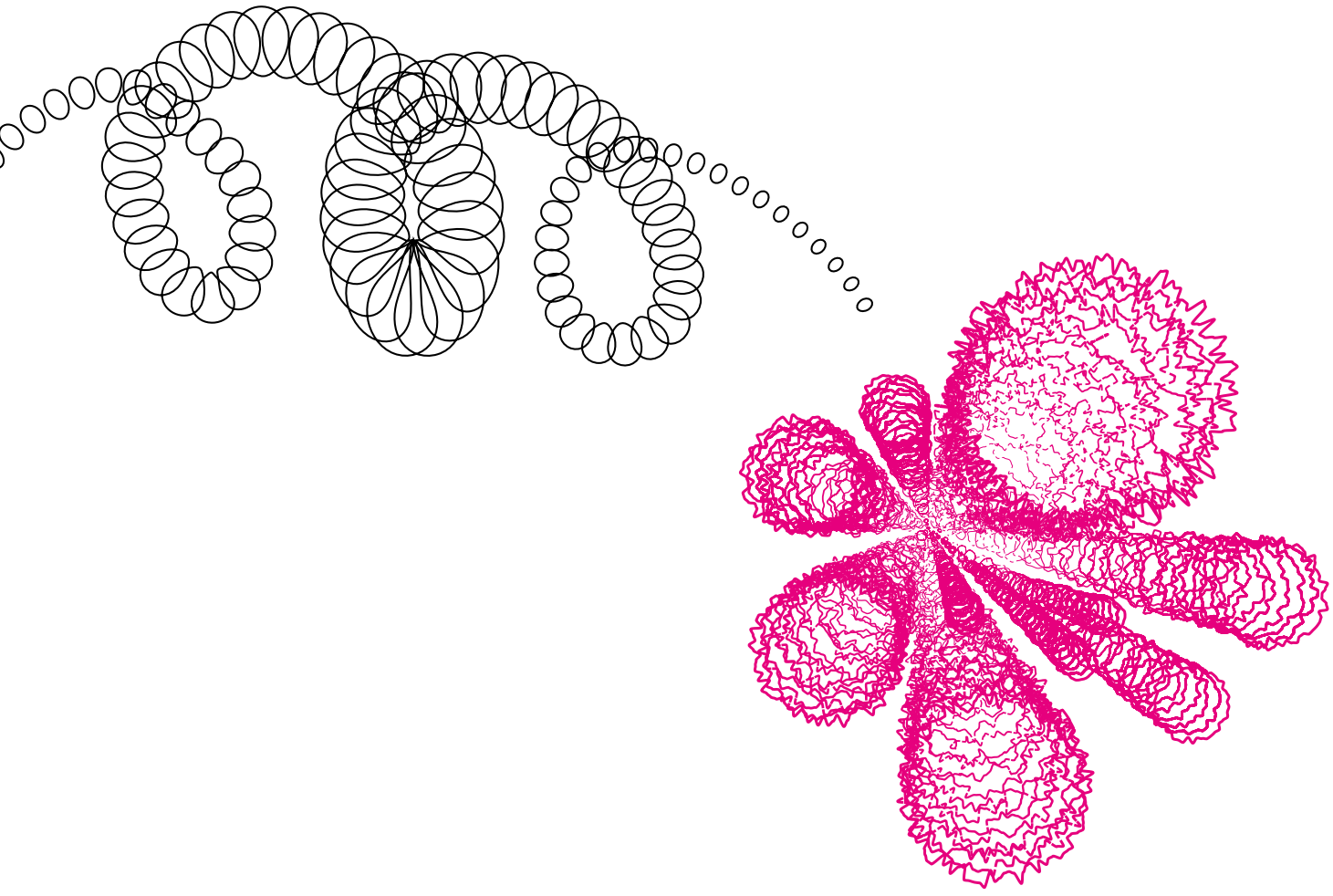
(III) ATTRACTING TALENT; TOWARDS MORE STRATEGIC HIRING AND ENCOMPASSING EVALUATION POLICIES

A prominent topic during the evaluation period was the Tenure Track (TT) system for talented new hires introduced in 2012. The TT is a career development track intended for development towards a full professorship and its conditions are described here: Notitie HR (utwente.nl). Because many incumbents and all new assistant and associate professors within S&T were initially placed in a TT scheme, the faculty hosted 45 TTs in 2014 and it became clear that this number was far too high for sustainable future capacity planning. Therefore, the TT hiring strategy was redefined so that the number of TTers was more realistic, and with a much better chance of creating optimal conditions for the PIs entering as TTer.
The large number of TTers was not the only issue that needed revision. In 2014, performance indicators were very quantitative and foremost associated with research metrics: a checklist with figures referring to numbers of publications, etc. More encompassing qualitative indicators, such as societal and economic impact and / or quality of education, service to the faculty or support to colleagues were not or hardly taken into account. The goal of the S&T faculty was then to adopt a more holistic performance evaluation for TTers, away from a purely quantitative approach and more in line with what is currently known as the recognition and rewards movement (Recognition & Rewards programme - Recognition & Rewards (recognitionrewards.nl)). An additional goal was offering a TT startup package to give the starting PIs a more realistic chance of successfully completing the tenure track. These startup packages were missing at

the beginning of the TT-system but have since been introduced UT wide. Besides, new researchers no longer automatically entered the TT-system, but the possibility was also created to appoint assistant or associate professors as staff within the existing research groups.
As a result of the measures taken, the number of TTers in S&T gradually decreased over the years. Various TTers made it to full professorship or left the TT programme for a regular assistant or associate professor position in the faculty. The TTers that left the faculty S&T, mostly because of external opportunities, typically ended up in good positions elsewhere, as is elucidated in Appendix C. .

(IV) OPTIMISING HOUSING AND INFRASTRUCTURE FOR THE THREE DOMAINS

To further strengthen our positioning on the selected research focus areas, the faculty, together with the UT Executive Board and the leadership of the research institutes, decided to invest in infrastructure. New facilities were needed for the health-related research and teaching activities, and it was decided to convert the former "Technohal' into the TechMed Center. Additionally, it was decided to upgrade the High Pressure Lab.



5. EVIDENCE AND ACCOMPLISHMENTS

This chapter provides evidence of the S&T faculty's research quality, societal relevance, and viability. We demonstrate this along the lines of the six assessment dimensions provided by SEP (see Appendix D (a), Table 1 / SEP Table E1), where possible S&T's different research domains are taken into account: Applied Physics, Chemical Science and Engineering, and Health. In this chapter, arguments will be established for the viability of all three S&T domains and their contribution to research quality and societal relevance by presenting results on several indicators. Furthermore, several case studies are presented. These cases show the intertwinement of (1) fundamental and applied sciences as well as (2) the connectivity between research quality and societal relevance. Both axes are crucial for achieving the S&T faculty's mission (see Chapter 4). The evidence was collected by using different sources:

- University of Twente (UT) research information system PURE (University of Twente Research Information (utwente.nl)),
- SciVal (SciVal | Research performance assessment solution | Elsevier) and Scopus (Scopus | Abstract and citation database | Elsevier),
- the websites of all S&T research groups and in particular the groups 'news' category (Research | Research groups | Science and Technology Faculty (TNW) (utwente.nl)),
- the S&T Contract Office and the S&T HR and Finance departments,
- the Business Intelligence (BI) studio of the University of Twente,
- the Twente Graduate School (TGS),
- UT's People Pages (People Pages: Find employees | Contact & phonebook | University of Twente (utwente.nl)),
- the UT's website and search engine (University of Twente (UT) | Research University in Enschede | The Netherlands (utwente.nl)),
- the curricula vitae of several S&T researchers, and
- NovelT, the regional knowledge transfer organisation in which the University of Twente participates (Home (novelt.com)).

5.1 RESEARCH QUALITY

This section presents the status quo of S&T in terms of research quality. Separate paragraphs describe the research quality alongside the three assessment dimensions as presented in SEP, Table E1 (see Appendix D (a), Table 1 / SEP Table E1):

- Research products for peers,
- Use of research products by peers, and
- Marks of recognition from peers.

5.1.1. RESEARCH PRODUCTS FOR PEERS

The S&T faculty decided to rely on the following indicators of demonstratable research products or output for peers: *Refereed articles, Reviews, Book Chapters, Conference Proceedings, PhD theses*, and *Invited Lectures* (Appendix D (a), Table 1 / SEP Table E1). Appendix D (a) Table 2 shows a selection of conferences where S&T community members held invited lectures for peers. The PURE information about invited lectures is not complete. Table 3 shows the aggregated results of five main types of publications: refereed articles, reviews, book chapters, conference proceedings, and PhD theses. For all publication types, the output of each domain is indicated. For instance, the total number of refereed journal articles in 2022 is 624. As can be seen from Table 3, the three domains contribute equally with 194, 229, and 201 refereed journal articles per year for Health, Applied Physics, and Chemical Science and Engineering, respectively. The average number of refereed journal articles per staff member amounts to 2.3 articles per scientific staff per year (corrected for joint publications). Notably, the scientific staff in the Health domain shows a significantly higher average annual output per staff (3.35) than the Applied Physics domain (1.65),

with Chemical Science and Engineering taking an in-between position (2.76) The average number of published review articles is notably lower in the Applied Physics domain than in the Chemical Science and Engineering and especially the Health domain.

While the number of book chapters and conference proceedings fluctuates across the evaluated period, their averages are a good indicator for the overall performance of the S&T faculty regarding research quality output. The number of refereed articles, however, declined in 2021 and 2022. Perhaps, the implemented restrictions and measures in 2020, as a response to the Covid-19 pandemic, had a negative effect on the productivity of the staff members and their teams, resulting in a decline in the two years thereafter. This effect, surprisingly, did not influence the PhD theses, which remained stable throughout the evaluated period.

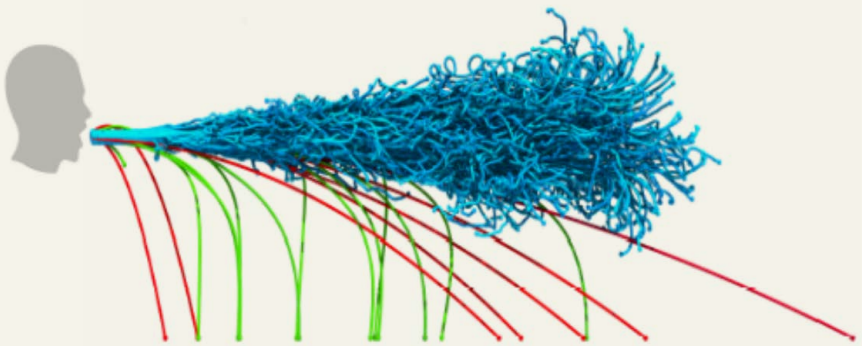
Table 3: Overview of publications provided by S&T scientists (download RIS Utwente, April 2023a)

	2015	2016	2017	2018	2019	2020	2021	2022	AVERAGE/ YEAR	AVERAGE/ YEAR/ STAFF* FTE
Refereed articles	**747**	**814**	**730**	**789**	**778**	**790**	**744**	**624**	**752**	**2,32**
Health	246	257	230	246	228	232	187	194	228	3,35
Applied Physics	217	261	241	264	279	259	303	229	257	1,65
Chemical Science and Engineering	284	296	259	279	271	299	254	201	268	2,76
Reviews	**18**	**19**	**33**	**52**	**45**	**66**	**49**	**59**	**43**	**0,13**
Health	9	9	19	38	29	35	27	37	25	0,37
Applied Physics	2	3	3	3	4	11	10	6	5	0,03
Chemical Science and Engineering	7	7	11	11	12	20	12	16	12	0,12
Book chapters	**39**	**20**	**13**	**30**	**12**	**11**	**15**	**40**	**23**	**0,07**
Health	11	4	3	7	7	5	6	12	7	0,10
Applied Physics	11	7	5	10	3	4	2	8	6	0,04
Chemical Science and Engineering	17	9	5	13	2	2	7	20	9	0,09
Conference Proceedings	**59**	**54**	**72**	**41**	**97**	**56**	**80**	**68**	**66**	**0,20**
Health	9	8	13	9	19	22	12	16	14	0,21
Applied Physics	38	27	50	24	57	24	51	46	40	0,26
Chemical Science and Engineering	12	19	9	8	21	10	17	6	13	0,13
PhD Theses	**73**	**97**	**64**	**71**	**63**	**67**	**66**	**69**	**71**	**0,22**
Health	10	24	17	14	12	18	16	14	16	0,24
Applied Physics	33	31	27	25	27	27	26	24	28	0,18
Chemical Science and Engineering	30	42	20	32	24	22	24	31	28	0,29

* average/year/ staff fte is based on 324 scientific staff members

[a] The data for PhD theses are based on download RIS Utwente, August 2023

S&T staff members share an important denominator: their research shows a fine alignment of fundamental and applied research also observable in subsequent publications. The Physics of Fluids (PoF) department serves as an excellent example (for the full case study, see Appendix Case Studies, Case 1 PoF).



PHYSICS OF FLUIDS

Excellent examples of the interplay between fundamental, curiosity-driven studies and applied, problem-inspired research are found in the Physics of Fluids (PoF) department. From basic studies on, *e.g.*, turbulent multi-phase flows involving moving objects and thermal gradients, important insights are acquired related to, *e.g.*, the energy

5.1.2. USE OF RESEARCH PRODUCTS BY PEERS

For showing the use of research products by peers, the S&T faculty chose citations including citation analysis. Usually, citation analysis compares the performance of a unit of analysis (here: research domains) to the world average. However, a benchmark with Dutch universities provides additional information, and could even be regarded as a better benchmark. It also adds context-information to the benchmark with the world average. Therefore, we chose to perform citation analysis on both levels: the world/global and national. The benchmark with Dutch universities can be found in Appendix D (a),and here we focus on the comparison with the world average.

Method used:

- The citation analysis was performed using SciVal, based upon (only) the publication types *Articles* and *Review articles* as registered in the UT Research Information System PURE. The export from PURE to SciVal, using DOI, was successful for 98% of the publications.
- Publications with more than 50 authors were removed from the analysis because they disturb the analysis and a fair comparison between the domains. The removed number of publications per domain are: 0 for Chemical Science and Engineering, 9 for Applied Physics, 27 for Health, in total 36 publications.
- Self-citations are included in the analysis.

The outcomes for the indicators *FWCI* and *% of publications in the Top 10% most cited publications* are very useful to interpret the trends in time. Using the outcomes to compare the three domains asks for some caution, especially in case of the Top 10% indicator (explanation below).

Citations per publication

Older publications tend to have more citations than newer publications, simply because they have had longer time to receive them from subsequent work.

Table 4: Citations per publication

	2015	2016	2017	2018	2019	2020	2021	2022	OVERALL
# citations /publication	43	39	38	32	29	22	14	5	27
Health	48	46	53	42	36	24	16	5	34
Applied Physics	37	34	24	24	22	17	12	5	21
Chemical Science and Engineering	44	38	40	28	28	26	13	5	26

* average/year/ staff fte is based on 324 scientific staff members
[a] The data for PhD theses are based on download RIS Utwente, August 2023

Field Weighted Citation Impact (FWCI).

FWCI presents citation data in a way that inherently takes into account the lower number of citations received by relatively recent publications, thus avoiding the dip in recent years seen with Citations per Publication. A FWCI of 1.00 indicates that the entity's publications have been cited exactly as would be expected based on the global average for similar publications (those publications in the Scopus database that have the same publication year, publication type, and discipline).

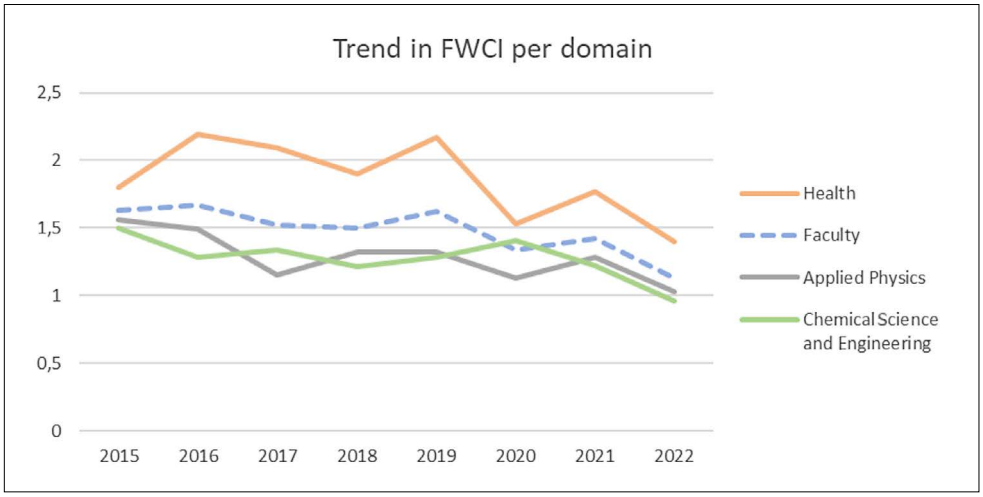


Figure 2: Trend in FWCI per domain

The averages for the domains over the whole period are: 1,86 for Health, 1,28 for Applied Physics, and 1,26 for Chemical Science and Engineering. The FWCI score of 1,47 for the faculty over the years 2015-2022 means that S&T-publications have been cited 47% more than would be expected based on the global average for similar publications. The decline in citation-impact may partially be explained by the growing competition from Asia.

Top 10% citations

Outputs in top citation percentiles indicate the extent to which an entity's publications are present in the most cited percentiles of a data universe: how many publications are

in the top 10% of the most cited publications? This metric is useful to benchmark the contributions towards the most influential, highly cited publications in the world of entities of different sizes, but in similar disciplines.

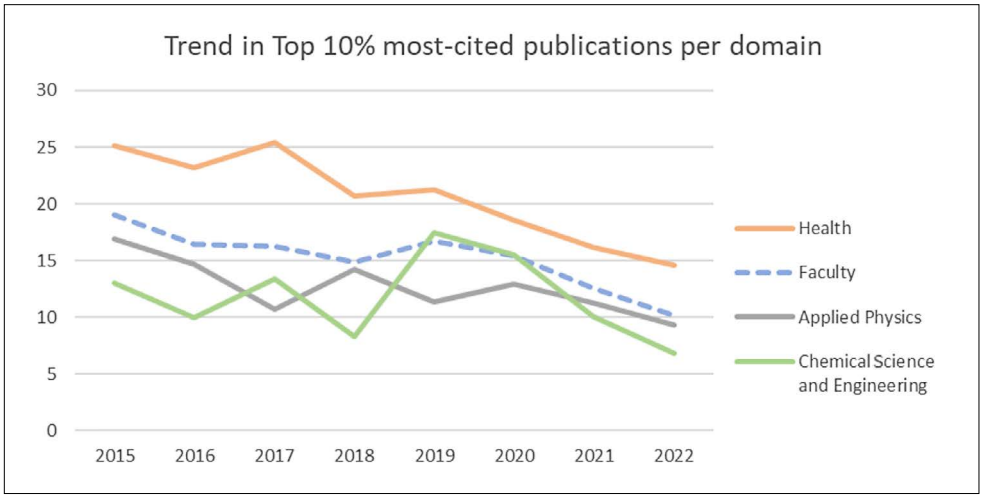


Figure 3: Trend in Top 10% most cited publications per domain

The overall-score over the period is 20.7% for Health, 12.6 % for Applied Physics, and 11.6% for Chemical Science and Engineering. This metric should be used with care when comparing entities in different disciplines. Citation counts tend to be higher in disciplines such as immunology and microbiology, whose academics tend to publish frequently and include long reference lists. The overall-score for the faculty of 15.1% means that the contributions of the faculty towards the most influential publications were higher than could be expected in relation to the world average (of 10%).

5.1.3. MARKS OF RECOGNITION FROM PEERS

The S&T faculty decided to choose for the following indicators:

1. **Research grants awarded to individuals**: pertains to grants awarded by research funding organisations to individual researchers in recognition of what peers consider outstanding achievement, such as the personal NWO and ERC grants.
2. **Grants awarded to major collaborative research projects**: pertains to funds awarded to research projects under the EU's Horizon 2020 programme, NWO's Gravitation programme and the NWO XL programme, in which researchers affiliated with the research unit act as principal applicant/investigator or as lead partner.
3. **Grants awarded to individuals or collaborative research projects**: pertains to funds awarded to research projects by research funds and institutions other than grants under (1) and (2), in which researchers affiliated with the research unit act as principal applicant/investigator or lead partner.
4. **Prizes awarded to individuals**
5. **Memberships of prestigious scientific councils or committees**
6. **Memberships of editorial boards**

It is important to remark that only the data presented for indicator 1 are complete (NWO grants and ERC-Starting, Consolidator, and Advanced grants). The data presented for indicators 2–6 and ERC Proof of Concept grants are incomplete. For the grants, the faculty lacks a single point of information in the financial systems. Referring to Prizes and Memberships, the information in UT's research information system PURE is incomplete.

The results of **Research grants awarded to individual S&T researchers** are shown in

Table 5. Appendix D (b), Table 1 shows the awarded research grants divided alongside the three research domains of the S&T faculty. A distinction has been made between national grants awarded by the Dutch Research Council (NWO) and the personal grants awarded by the European Research Council (ERC). In the Netherlands, the NWO Veni, Vidi and Vici grants are known as the NWO Talent Programme (NWO Talent Programme | NWO) and are considered the most prestigious personal grants. They share a similar reputation as prestigious personal grants awarded by the ERC (Starting, Consolidator, and Advanced grants). S&T researchers also received ERC Proof of Concept grants, but the data is incomplete. Table 5 shows continued success related to receiving prestigious NWO and ERC personal grants.

Table 5: Overview of research grants awarded to individuals, sorted by year

	2015	2016	2017	2018	2019	2020	2021	2022	OVERALL
NWO	**2**	**5**	**4**	**3**	**3**	**7**	**6**	**5**	**35**
Veni	1	1	2	2		5	2	1	14
Vidi		3	1		2	2	2	2	12
Vici	1	1	1	1	1		2	2	9
ERC	**3**	**1**	**5**	**2**	**2**	**2**	**4**	**9**	**29**
Starting grant	2	1	1	1	2	1	3	1	12
Consolidator grant			1	1		1	1	1	5
Advanced grant			2					2	5
Proof of Concept grant	1		1					5	7
Total	**5**	**6**	**9**	**5**	**5**	**9**	**10**	**14**	**63**

S&T researchers strongly collaborate with (inter)national industrial partners and other academic organisations and research institutes. This research is financed mainly by science foundations, companies, and other external partners. Consequently, we chose **Grants awarded to major collaborative research projects** as an important indicator for recognition from peers. The results regarding this indicator are shown in Table 6. Appendix D (b), Table 2 shows the awarded grants divided alongside the three research domains of the S&T faculty. Horizon 2020 was the EU's research and innovation funding programme in the period 2014-2020, which was followed up by Horizon Europe. However, other grants that belong to this indicator are specific to the Netherlands and often transcend academia by involving partners beyond (e.g., governmental bodies, business community, see also Appendix D (b), Table 10). Examples of such grants or programmes include

- Perspectief | NWO,
- Crossover Programme | NWO,
- Open Competition Domain Science -XL | NWO,
- Mission-driven calls (KIC 2020-2023) | NWO,
- Gravitation | NWO,
- Research along Routes by Consortia (NWA-ORC) | NWO,
- The National Growth Fund | English | Nationaal Groeifonds, and
- Netherlands Enterprise Agency Top Consortia for Knowledge and Innovation (KIAs, Joining a TKI (rvo.nl)).

Table 6: Overview of Grants awarded to major collaborative research projects, sorted by year

	2015	2016	2017	2018	2019	2020	2021	2022	2023	TOTAL
Horizon Europe / 2020		3	1	1	3	2	1	0	3	14
NWO Perspectief		1			1		4	2		8
NWO Crossover*					1					1
NWO XL						7		1		8
NWO KIC				1		1		2		4
NWO Gravitation			1					1		2
NWA-ORC								2		2
National Growth Fund							2	5	6	13**
KIA					1	2	+ 2b		8	13
Total	**0**	**4**	**2**	**2**	**6**	**12**	**9**	**13**	**17**	**65**

* Only applicable for Chemistry
** In several National Growth Funds multiple projects with S&T researchers
[b] Year of two KIAs unknown

Table 6 shows that substantial efforts have been made by S&T researchers to maintain a leading position within the Dutch research landscape, both in terms of fundamental science and thematic applied science. The latter is typically realised via direct collaboration with industry, and most commonly takes form in large national public-private enterprises in which S&T holds a significant presence. Notable examples of this include four large Growth Fund programmes: NXTGEN HIGHTECH (450 M€), PhotonDelta (471 M€), QuantumDeltaNL (615 M€), and GroenvermogenNL (338 M€). The NXTGEN HIGHTECH aims at developing a new generation deep-tech equipment, which will address major societal challenges including health, energy, and sustainability, while simultaneously aiming to increase the competitiveness, earning capacity and employment of the Netherlands. PhotonDelta is an international ecosystem of academics and companies that jointly aim at developing photonic tech that will tackle societal challenges such as sustainability while creating a new European industry in (amongst others) quantum computing, which synergistically interacts with the goals of QuantumDeltaNL. Finally, GroenvermogenNL aiming for greening the Dutch economy is designed to accelerate the implementation of green hydrogen applications in industries such as the chemical industry, the transport industry and heavy industry by using innovative production methods and green hydrogen.

The NEM department is just one of the faculty's outstanding examples for successfully building bridges between fundamental research and application-oriented research from industry. The department's strategy and approach is rewarded with prestigious research grants awarded to individuals (for example, 2x Veni, 3x Vidi, 3x Vici, 2x ERC-Starting Grant, 1x ERC Proof of Concept), grants awarded to major collaborative research projects (for example,2x NWA-ORC, 3x National Growth Fund [NXTGEN Hightech Equipment, Circular Batteries, SolarNL]), and NWO KIC (see Table 2) , and invited presentations at top international conferences (MRS, EMRS, ACS, ECS, IUPAC) (for the full case study, see Appendix Case Studies, Case 2 Energy Materials Research):

ENERGY MATERIALS RESEARCH

Researchers from the Nano Electronic Materials (NEM) department have developed novel battery materials and solar energy materials within the framework of the development of materials for energy. By performing excellent research at a fundamental level and by collaborating with applied and technology-driven research groups at other faculties (ET & EEMCS), twin research centres (Battery Centre Twente & Solar Centre Twente) and large national programs (BatteryNL and SolarLabNL) have been established.

In Table 7 we present **Grants awarded to individuals or collaborative research projects**. Appendix D (b), Table 3 shows the awarded grants divided alongside the three research domains of the S&T faculty. This indicator refers to grants received by research funds and institutions other than the grants presented in Table 5 and 6. For funding from Dutch soil, it is very valuable to mention large infrastructure grants such as NWO's programme 'Research Infrastructure: national consortia' (for S&T successes see here National hDMT facility Organ-on-Chip Development Centre at University of Twente (utwente.nl)) and Checking 'hidden layers' for creating greener batteries and catalysts (utwente.nl)). The EIC Pathfinder Challenge is a very prominent and prestigious EU grant example. Recently, in 2023, together with a colleague from the ET faculty, Dimitrios Stamatialis (BET department) received this renowned grant (UT to develop artificial placenta system in EU project (utwente.nl)). However, already in 2022, colleagues from the same department received a EIC Pathfinder Challenge grant for another project (for the full case study, see Appendix Case Studies, Case 3 Heart2Beat).

HEART2BEAT

Scientists at the Bioengineering Technologies (BET) department focus on advancement of the diagnosis and understanding of diseases by development and application of innovative, multidisciplinary approaches inspired by technology and biology. Recently, an ERC advanced grant Heart2Beat was awarded, where the aim is to construct a functional human mini-heart capable of pumping fluid, thus simulating the primary function of the human heart.

Our researchers achieved success at a large number of funding agencies outside and inside the EU (for example, European Co-operation in Science and Technology, European Fund for Regional Development, ACTPHAST, German Research Foundation, and VolkswagenStiftung). Moreover, they are successful within UTs internal grants for cooperating with hospitals in the region (Pioneers in Health Care grant and TURBO grant) or private enterprises (Connecting Industries grant) and collaboration grants with the University of Münster (WWU) or Waterloo. However, for reasons of overview and representation, we decided to restrict Table 7 to national grants with a good amount of S&T presence:

- NWO open competition Domain Science XS, ECHO, and M grants,
- Open Technology Programme | NWO),
- Demonstrator | NWO,
- Take-off | NWO,
- Open Mind | NWO

Table 7: Overview of Grants awarded to individuals or collaborative research projects, sorted by year

	2015	2016	2017	2018	2019	2020	2021	2022	2023	TOTAL
NWO XS					2	1	3	1	4	11
NWO ECHO*		2		1						3
NWO M							3	2	4	9
NWO Open Technology			1		1	1	1	3		7
NWO Demonstrator	1					1	2		1	5
NWO Take-off		1		1	2	2		3	4	13
NWO Open Mind		1	1				1		2	5
Total	**1**	**4**	**2**	**2**	**5**	**5**	**10**	**9**	**15**	**53**

* Only chemistry. The programme has been replaced by the open competition of the NWO Domain Science.

In addition to all the aforementioned grant achievements, the S&T staff members are also successful in receiving funding from foundations and public organisations without a main focus on research funding. This is particularly true for researchers within the Health domain. We consider such sponsors as 'financial and material support offered by society'. According to SEP, this indicator is a mark of recognition from societal target groups. Consequently, we will present this information in paragraph 5.2.3. In the previous years, the Dutch funding landscape has changed: not only new funding opportunities made an entrance, but well-established funding agencies lost their independent status. In 2017, the Stichting voor Fundamenteel Onderzoek der Materie (FOM) (annual budget: 90 M€) and Technologiestichting STW (annual budget: 104 M€) were incorporated by NWO. S&T researchers have been very successful in FOM and STW funding. Just to mention one example, Detlef Lohse from the PoF department, received 22 M€ in 32 grants from FOM and 11.4 M€ in 13 grants from STW, since his arrival in Twente in 1998.

To sum up and quantify the funding successes of the S&T researchers we refer to the total funding received by the S&T staff members for the period 2015 – 2022 (see Appendix D (b), Table 4 / SEP Table E3).

Another mark of recognition from peers is Prizes awarded to individuals or collaborative research projects. According to SEP, this indicator pertains to prestigious research prizes that are not connected to research grants, such as the Nobel Prize, Breakthrough Prize,

Abel Prize, Fields Medal, research prizes by learned societies, etc.. However, in her own policy document on Prizes & Awards (st-guidelines-for-prizes-and-awards.pdf (utwente.nl)), the S&T faculty has a different approach towards Prizes & Awards:

All Prizes & Awards are valuable. From poster and other visualisation prizes for doctoral candidates over lecturer recognition for innovation in learning to lifetime achievement awards for mature cracks, all Prizes & Awards should be celebrated.

S&T realises that winning or being nominated for less well-known or prestigious Prizes & Awards often yields steppingstone effects. Conquering the K2 or Mount Everest is the pinnacle of many efforts and not the beginning or the middle of a mountaineer's biography. As is true for climbers, also scientists start by overcoming smaller rocks and peaks. This means also that talent has to be supported and developed from scratch. Consequently, S&T affirms that all Prizes & Awards, their nominees and laureates deserve to be recognised and cherished. Holding on to our principles, we decided to present a selection of Prizes & Awards that our PhD candidates, junior, mid-career, and senior scientist have received, sorted by research domain (see Appendix D (b), Table 5)
The fifth indicator of recognition from peers is Memberships of *prestigious scientific councils or committees*. Many S&T scientists of all research domains are (appointed / elected) members, presidents, (executive) board members, chairs and so on of prestigious scientific councils or committees. Appendix D (b), Table 6 provides a selection of such associateships.
Finally, the last chosen indicator for recognition from peers is *Memberships of editorial boards.* A significant number of S&T scientists from all research domains provide this important academic service for peers and often the most acknowledged journals in their respective fields. Appendix D (b), Table 7 shows a selection sorted by research domain.

5.2 SOCIETAL RELEVANCE

Reaching out to society is ingrained in the faculty's way of working and a clear component of S&T's vision (see paragraph 4.1). Consequently, we use this paragraph to provide evidence for this claim. The societal relevance of research is determined by the implications that the results have, for example, for industry, sustainability, public debates, and choices by citizens and policy makers. Societal relevance can occur on three levels: global (themes with an international scope), national (the Netherlands), and local (Twente or the region of Overijssel). Separate paragraphs describe the societal relevance alongside the three assessment dimensions as presented in SEP, Table E1 (see Appendix D (a), Table 1 / SEP Table E1):

- Research products for societal target groups,
- Use of research products by societal target groups, and
- Marks of recognition from societal target groups.

Before presenting the evidence for these three dimensions separately, we would like to equip the reader with some general information. Appendix D (b), Table 8 shows a selection of media attention aimed at a professional and/or a general audience for S&T research products, use of products, and marks of recognition. The information shows that local, national, and international media (e.g., newspapers, magazines, websites, radio, and tv) cover the achievements of our researchers. Moreover, staff members from all domains present their work to a general audience (e.g., Laat je hersenen kraken in de Universitent! | Zwarte Cross) and professionals directly. Referring to the latter, a few examples from the past: the World Economic Forum, the Digital Summit Euregio (NL/Germany), BASF (Germany), the Dutch Banking Association, ABN AMRO, the Holland High Tech Event, Philips Research Laboratories Eindhoven (NL), and Alzheimer Nederland.

Pointing to the global level and referring back to publication output (paragraph 5.1.1 Table 1), Table 8 shows an indication of the associations between S&T-publications and the United Nations Sustainable Development Goals (SDGs). Linking scientific output to SDGs is a recently (2023) introduced opportunity of the University of Twente's research information system PURE. Authors can voluntarily opt for this function and choose the SDGs themselves. Therefore, we can assume that the data presented in Table 8 is incomplete. Nevertheless, we consider this information as indicative.

Table 8: Sustainable development goals (SDGs) associated with refereed publications by S&T scientists

SDG	KEYWORD	HEALTH	APPLIED PHYSICS	CHEMICAL SCIENCE AND ENGINEERING	TOTAL
1	No poverty				0
2	Zero hunger			13	13
3	Health	96	32	33	161
4	Education			1	1
5	Gender Equality				0
6	Clean water	2	1	10	13
7	Clean energy	7	40	75	122
8	Decent work & economic growth			12	12
9	Industry, innovation & infrastructure		2	7	9
10	Reduced Inequalities			3	3
11	Sustainable cities	1		5	6
12	Consumption & production	1	1	18	20
13	Climate		7	17	24
14	Life below water		8	5	13
15	Life on land		1	3	4
16	Peace & law			1	1
17	Partnership			1	1

Until now, in their publications the S&T staff members seem not to focus on SDG 1 and 5: No poverty respectively Gender Equality. The top-3 SDGs covered by publications are Health (n=161), Clean energy (n=122), and Climate (n=24). The so-called 'Malaria case' is an excellent example of how fundamental research within the Chemical Science and Engineering domain can contribute to SDG 3: Good health and well-being (for the full case study, see Appendix Case Studies, Case 4 Fighting Malaria by Curing the Mosquito).

FIGHTING MALARIA BY CURING THE MOSQUITO

Researchers from the Molecules and Materials (MolMat) department focus on curing malaria in mosquitos rather than in humans. In collaboration with researchers from across Europe, embedded within the EuroNanoMed Project 'NANOpheles', the researchers aim at the development of nanoparticles carrying parasite-killing drugs that can attach to ookinetes, malaria parasites that invade the mosquitos. This led in 2023 to the foundation of the startup company IntriS b.v.

When combining the results of SDG 6 (Clean water) and 14 (Life below water) into a category 'Water health', another conclusion can be drawn: it is viable to state that this topic also receives significant attention from S&T researchers (26 publications). Additional support for this claim is also delivered by the strong connection to WETSUS, the European centre of excellence for sustainable water technology (Home - Wetsus - European centre of excellence for sustainable water technology). Several PhD students work for WETSUS, but will graduate at UT. The case 'Hollow Fibre Nanofiltration, from nano-scale layers to full-scale processes' shows the importance of Water among S&T researchers in an excellent way (for the full case study, see Appendix Case Studies, Case 5 Hollow Fibre Nanofiltration).

HOLLOW FIBRE NANOFILTRATION

Researchers from the Membrane Science and Technology (MST) cluster have developed cost-effective hollow fiber nanofiltration (NF) membranes for the filtration of micro-pollutants from surface water in The Netherlands. Over a period of approximately 10 years, MST researchers developed such hollow fiber NF membranes from a fundamental level to commercialized applications, including the foundation of the spin-off company NX Filtration that made an Initial Public Offering in 2021.

5.2.1 RESEARCH PRODUCTS FOR SOCIETAL TARGET GROUPS

The S&T faculty decided to choose for the following indicators:
1. Patents,
2. Websites for professional visitors,
3. Lectures, masterclasses and conferences for a general audience,
4. Performance for TV, radio or in other public media, and
5. Organisation of or contribution to an event.

In fact, in Appendix D (b), Table 8, besides 'Patents' all indicators have been addressed including those that refer to the use of research products by societal target groups (i.e., Projects in co-operation with societal parties and Spin-off companies; see paragraph 5.2.2) and marks of recognition from societal target groups (i.e., Financial and material support by society, Memberships of civil-society organisations, and Public prizes; see paragraph 5.2.3). Therefore, this paragraph will be used to highlight an indicator of research products that is key for societal stakeholders: patents. Intellectual property acquisition and valorisation of S&T faculty breakthroughs and inventions are supported by NovelT, which is founded by the University Twente (Home (novelt.com)). Based on data provided by NovelT, since 2015, S&T staff members have filed 126 inventions for patent protection (see Figure 4). Many of these inventions are made at the interface of the three research domains thereby illustrating the fruitful and effective nature of the vision and organisation of the S&T faculty. A key feature of the integrated workflow is the determination of proposed value, and the associated identification of commercial partners for licensing/ purchasing of patents as well as the founding of spin-off companies (see next paragraph) to fuel the local entrepreneurial ecosphere and make financial contributions to society and the local and (inter)national level.

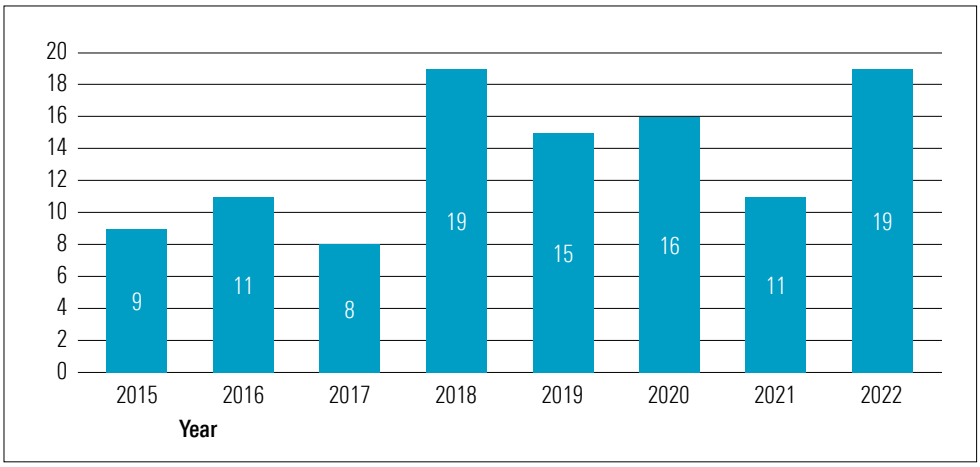


Figure 4: Inventions for patent protection, period 2015 – 2023 (NovelT, October 2023)

5.2.2 USE OF RESEARCH PRODUCTS BY SOCIETAL TARGET GROUPS

The following indicators represent the use of S&T staff members research products by society an appropriate manner:
1. Spin-off companies,
2. Projects in co-operation with societal parties (e.g., industry, hospitals, government),
3. Collaborations with and for patient groups, and
4. Use of products in policy.

1. Spin-off companies

Strongly related to patents (see former paragraph) are our researchers' efforts in

founding *spin-off companies*. Appendix D (b) Table 9 shows spin-off companies from / with involvement of S&T staff members. We would like to draw attention to four spin-off companies: H2Care, IamFluidics BV, River BioMedics, and QuixQuantum BV. H2Care's proprietary technology platform is based on the in-situ formation of the CartRevive™ hydrogel implant. Via the European Innovation Council (EIC) Accelerator programme, the European Commission has awarded the company €6 million in blended financing Hy2Care receives €6M EU funding for optimal cartilage repair (utwente.nl)).

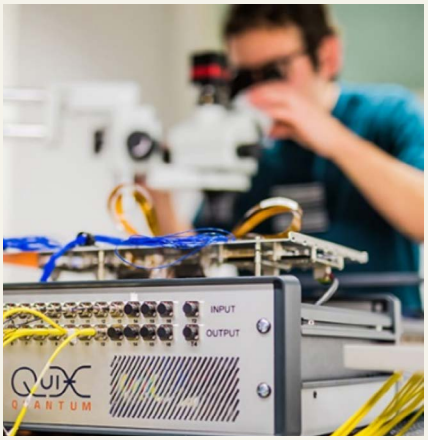
IamFluidics develops customised microencapsulation solutions for healthcare and consumer products. The company has been recognised as one of the top 10 most groundbreaking academic startups in the Netherlands by the Academic Startup Competition, is the winner in the top 5 Biotech companies to watch in 2021 according to CIO Bulletin, and has been awarded the most promising Biotech company in Europe 2020. Moreover, MIT Technology Review has awarded IamFluidics founder Tom Kamperman with the title 'Innovators under 35'. IamFluidics received substantial funding from entrepreneurs, Innovation Industries (Innovation Industries | European Impact and Deep Tech VC), and EU EFRO.

River BioMedics develops 3D cardiac in vitro models for the discovery and development of novel cardiac drugs. The company secured seed funding to progress its cardiovascular disease pipeline (New Investor Libertatis Ergo Holding, FIRST Fund, KIKK Capital and Oost NLfunding). Furthermore, River BioMedics has been granted from the EIC-Transition to bring hiPSC-3D cardiac strips into a high throughput setting and received an EIC-Pathfinder Challenge grant. This grant will fund the development of a pumping human Mini-heart and swimming human Bio-Robot by a consortium composed of two companies, River BioMedics (RBM) and NanoScale Systems (Nanoss) GmbH and two universities, the University of Twente and Universidad de Málaga (see also Appendix Case Studies, Case 3 BET: Heart2Beat).

Finally, **QuiX Quantum**, the market leader in photonic quantum computing, passes the revue (for the full case study, see Appendix Case Studies, Case 6 QuiX Quantum).

QUIX QUANTUM

Through the initial work of a PhD candidate embedded in two different research groups in the Applied NanoPhotonics (ANP) cluster, followed by a collaboration between the UT cluster and Oxford University, the foundation was laid for the successful spin-off company QuiX Quantum. Integrated photonic processors are made here that can be used for photonic quantum computing. QuiX Quantum is closely involved with several S&T groups embedded in the ANP cluster and has put Twente on the map as a world-famous hotspot for photonic quantum computing.



2. Projects in co-operation with societal parties

In paragraph 5.1.3 and in particular Table 2, grants awarded to major collaborative research projects were presented. Within these collaborations, not only do other research institutions participate, as well as societal partners such as industry, hospitals, and government. Appendix D (b), Table 10 shows a selection of *projects in co-operation with societal partners* (e.g., industry, hospitals, government). It is viable to conclude that S&T researchers participate in various projects/ programmes in collaboration with societal partners. Partnerships with medtech and deep-tech companies - be it large or small enterprises - are crucial for bringing real solutions to the international market and to grow S&T's societal and economic impact. The list of industrial partners is impressive and includes large to very large companies as well as many regional companies (e.g., Demcon, Baat, Hankamp, Panton, Holland Innovative, Movella, Unitron, UNeedle).
In addition, via the research institutes MESA+ and TechMed strategic partnerships with hospitals, companies and other stakeholders have been established. Via the TechMed Centre, S&T has established relationships with all University Medical Centres and with several large hospitals and other healthcare organisations in the Netherlands. Formal research partnerships are in place with Radboudumc, UMCG, MST, ZGT, Rijnstate and Isala and with Rehabilitation centre Roessingh. Furthermore , there are (formalised) collaborations with more specialised hospitals, like centres for rehabilitation and the Dutch Cancer Institute and mental health organisations such as Dimence Groep. To stimulate new strategic collaborations and partnerships and to attract future funding for collaborative projects, the UT initiated several internal grants (see also paragraph 5.1.3) such as Pioneers in Healthcare (with MST, ZGT, Deventer Ziekenhuis, Saxion and Reggeborgh) and the TURBO grants (with Radboudumc). Particularly the strong collaboration with partners in the region will enable S&T to have a significant impact on health.

3. Collaborations with and for patient groups

The third indicator of the use of research products by societal target groups is Collaborations with and for *patient groups*. There are long-term collaborations with patient organisations and with health care funds such as the Dutch Kidney Foundation, Cancer Foundation, Heart Foundation, and ReumaNederland. The latter recognised the bioengineering groups of S&T at the TechMed Centre as 'Research Centre of Excellence'. Furthermore, S&T researchers are involved in multiple consortia such as: TOPFIT and hDMT. TOPFIT focusses on innovations that contribute to the sustainable organisation and provision of healthcare, from the hospital to the personal living environment, to prevent diseases and disease burden. hDMT, the Institute for human organ and Disease Model Technologies, aims to develop and qualify cell culture models that mimic healthy and diseased human tissues based on Organ-on-Chip technology, and to facilitate their valorisation and implementation. The S&T staff members are proximate and visible for patients. Collaboration within the aforementioned clinical network is strongly supported by the numerous clinical internships of the Technical Medicine educational programme. All internship projects are supervised by clinicians and scientific staff from the UT. In addition to this internship network, there are more than 40 dual scientific staff positions (including 17 clinical professors) with healthcare institutions. An excellent example of care at the patients' side is the work of the Clinical Neurophysiology research group (for the full case study, see Appendix Case Studies, Case 7 Coma after cardiac arrest).

4. Use of products in policy

Finally, the research products of S&T staff members are also *used in policy*. Dutch guidelines for prognostication of comatose patients after cardiac arrest have recently been updated based on the research of the Clinical Neurophysiology (CNPH) research group. Moreover, S&T researchers participate in the Transition Programme for Innovation without the use of animals (TPI) (created in collaboration with TPI partners Nationaal Comité Advies Dierproevenbeleid (NCAD), KNAW, ZonMw,TOP sectors LSH and Chemistry,

COMA AFTER CARDIAC ARREST

Researchers from the Clinical Neurophysiology (CNPH) research group focus on improved prognostication and personalized treatment for the clinical care of comatose patients hospitalized to intensive care after a cardiac arrest. This is achieved by being involved in the clinical care of these patients and by focusing on three complementary elements, often in the framework of (inter)national collaboration: pathophysiological understanding, diagnostics and treatment.

Stichting Proefdiervrij and the Ministries of LNV, OCW, VWS, EZK and I&W). The aim is to create a well-balanced, broadly supported (by the scientific community and society) advisory document, which will highlight areas with promising animal-free innovations and areas where animal experiments cannot be replaced with the current technologies (to enable new therapeutic technologies to reach the clinic).

5.2.3 MARKS OF RECOGNITION FROM SOCIETAL TARGET GROUPS

The societal achievements of S&T's researchers reported in paragraphs 5.2.1 and 5.2.2 are rewarded by societal target groups. This last category of societal relevance will be demonstrated by relying on three indicators:

1. Financial and material support by society,
2. Memberships of civil society advisory bodies, and
3. Public prizes.

S&T researchers receive financial support from health care funds such as the Dutch Cancer Society, Dutch Kidney Foundation, ReumaNederland, Dutch Heart Foundation, and Dutch Parkinson Fund. Moreover, staff members from all domains are *members of civil society advisory bodies* (Appendix D (b), Table 11) such as the European Commission on Public Health and Schering Foundation. Finally, the S&T researchers have been awarded *Public Prizes* such as the Hind Rattan Award and the Prince Friso Engineering Prize from the Royal Institute of Engineers (KIVI) (Appendix D (b), Table 12).

5.3 VIABILITY

The relatively small size of the faculty allows for short lines of communication, and, effectively, a rapid acquisition and transfer of information relating to internal and external developments. However, the rather complex organisational structure and governance

based on the large number of research groups and clusters without mandate , has played a limiting role. Specifically, this had led to unclear responsibilities on the domain-, cluster-, and research group-level, opacity, and a suboptimal interaction between the faculty and its members. It is anticipated that the forthcoming strengthening of the faculty's focus, established through the formation of eight departments, will further contribute to the adaptability of the faculty. Noteworthy, the mandates, duties, and lines of communications there must be adequately formulated and the formation of departments must not lead to a counterproductive outcome owing to discussions regarding finances and positions of power.

Personnel, resources, and finances. The faculty is well-equipped for the future as it has hired an increasing number of very promising young scholars through the tenure track system and Sector plan funding. More specifically, investment of the STEM Sector plan (thus, funding in the first money stream) has resulted in the appointment of 12 tenure trackers: 5 in the Applied Physics domain, 5 in Chemical Science and Engineering and 2 in Health. The existing infrastructure (see 5.4) provides fertile soil for the faculty to realise its delineated plans and ambitions while newly established research centres provide ample opportunities to realise large fundings for equipment.
The aforementioned positive developments are expected to maintain the excellent research quality of S&T but the growing costs for both personnel and the maintenance of infrastructure would provide financial challenges. Table E3 (Appendix D (b), Table 4) shows that the financial position is strongly supported by funding in the second and third stream, which has gradually improved over the evaluated period (+70% in year 2023 as compared to year 2016). However, the faculty's revenue is currently negative. The faculty anticipates that the costs for material and resources will only continue to increase in the future which will hamper further investments in personnel and infrastructure.

5.4 INFRASTRUCTURE

Research infrastructure refers to the faculty's facilities, resources and services that are of fundamental significance for outstanding research and boosting valorisation.
A sophisticated and state-of-the-art infrastructure is vital for attracting ambitious staff, PhD candidates, MSc & BSc students, companies and other partners, as well as setting up collaborations with other research institutes and companies and for successful funding applications. Consequently, strengthening research infrastructure is one of the guiding principles of S&T's strategy. In this paragraph, the faculty's infrastructure is described amongst others based on the 'S & T Faculty Strategy 2023-2027' and the 'Annual Plan 2024 faculty of S&T'.

S&T bolsters excellent research infrastructures. Research groups within the faculty typically have their own laboratories, which are sometimes shared with other groups and third parties. This helps in setting up short lines for collaborations (also with other faculties). In addition, researchers within S&T make use of state-of-the art facilities such as the MESA+ NanoLab (interfaculty facility with EEMCS), the High Pressure Lab, the TechMed Centre, the BioImaging Centre and the soon to be build Organ-on-Chip Centre. A descriptive summary on what these state-of-the-art facilities encompass is given in Appendix D (c). The research equipment of NanoLab and the High Pressure lab has benefited enormously from the National Growth Fund, with substantial amounts and new impetus for quantum, integrated photonics, gravitational waves, etc. The NanoLabNL of which the S&T faculty is a leading partner, is now recognised by the Permanent Committee for Large-Scale Research Infrastructure (PC-GWI) (National Roadmap for Large-Scale Research Facilities | NWO).

Long-term viability of S&T's research infrastructure is under pressure (as earlier mentioned in 5.3). To ensure such long-term viability the base funding of the research infrastructure

needs to be optimised, at the UT level as well as at the (inter)national level. Furthermore, S&T's dependency on individual grants/incidental research funding for the financing of research infrastructure needs to be decreased. Long-term investment planning of research infrastructure and ensuring relevant investment budgets is key.

One of the elements of long-term investment planning is the creation of new incentives for shared infrastructure and the expansion of already initiated joint initiatives. An adequate governance model for shared infrastructure needs to be developed for this purpose, to ensure that research infrastructure stays aligned with developing research needs. This includes (i) developing guiding principles and incentives for increased stimulation of the sharing of infrastructure, (ii) developing a clear vision—together with the EEMCS and ET faculties—on how to share facilities/infrastructure between faculties, without barriers for researchers to work across faculty borders and (iii) stimulating and coordinating third-party usage of strategic infrastructure to connect to the larger ecosystem. Besides that, S&T prioritises the alignment of research infrastructure needs of individual research chairs with the existing large scale infrastructure available at the UT (e.g., NanoLab, High Pressure Lab, analysis labs in several faculties and institutes) to avoid redundant investments in equipment that is already available at the premises of the UT (also important from a sustainability perspective). Active co-operation with UT's institutes is of vital importance to make sure S&T's infrastructure is part of larger research infrastructure grants.

The Faculty Board expects and actively endorses participation of all relevant scientific staff including assistant and associate professors as representatives in national and international consortia for infrastructure grants and stimulates infrastructure in scientific grants (equipment, cleanroom hours, etc.). Within the University of Twente, grant support is offered.

Research support infrastructure

The Grants Office (part of the central Strategic Business Development department, SBD) offers training and events to help prepare for a research proposal. They can, for instance, give an overview of the grants landscape within Europe and the Netherlands and offer support in proposal writing. In addition, researchers can become a member of the SBD-Grants Office Support HUB, an interactive environment where the most recent information on grants is shared. For collaborative projects, a good starting point would be informing with peers or other relevant contacts.

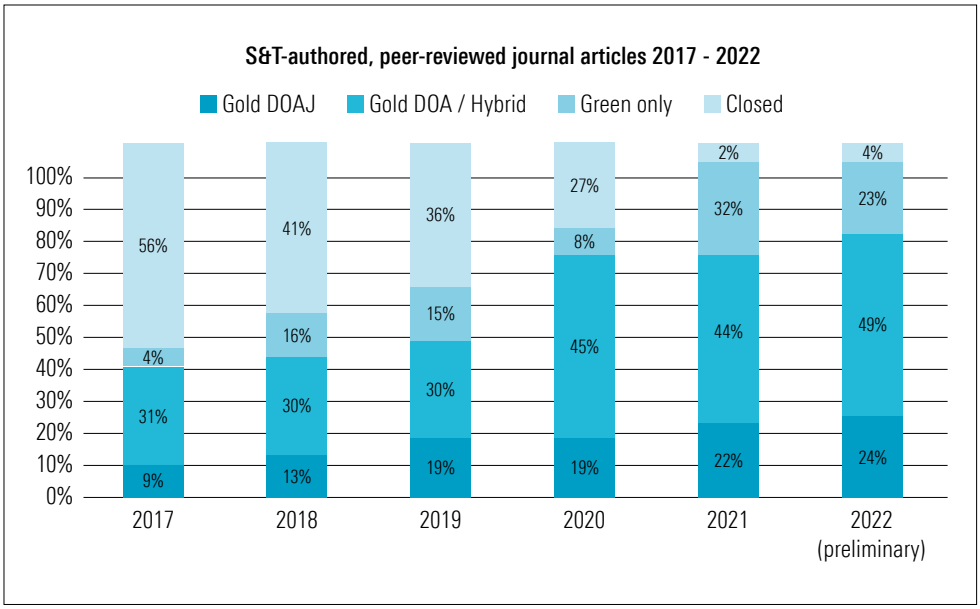
Further research support is provided (but not limited to) in the form of IT facilities and procedures and facilities on e.g. project management or scientific integrity. Aside from the public information the University of Twente provides, the S&T faculty also provides an Intranet research support website with information relevant for S&T employees. Here, all soft infrastructure relevant for S&T members is shared. For instance, additional information on, for example, grant support, Prizes & Awards, research data management, open science, the ethics committee, health & safety regulations, integrity and privacy.

5.5 OPEN SCIENCE

The S&T faculty recognises that research is undergoing an important paradigm shift towards Open Science. This means that the research unit is open to researchers from outside and involves and cooperates with societal stakeholders. In this context, open to other researchers strongly points to the availability of research outputs for the use and reuse, according to the FAIR principles. In preceding paragraphs (e.g., 5.1.3, 5.2.2, and 5.2.3), we provided evidence of the openness of S&T researchers to colleagues from beyond the faculty and UT and their embeddedness in the wider society by, for example, co-operation in (large) consortia, participation in UT's internal collaboration grants,

alliances with and for patient groups, and memberships of civil society advisory bodies. Therefore, in this paragraph we focus on Open Science related to research outputs for other researchers.
S&T developed a general Research Data Management (RDM) policy in 2020 and employs data stewards who developed a practical DMP Tool: an application that helps researchers create data management plans (DMPs). The tool, in particular, is introduced i) to PhD candidates as a mandatory course, in collaboration with the Twente Graduate School (see also section 5.8), and ii) to researchers when they need to file an RDM plan for a granted project. The software is supported by the service department LISA (Library, ICT services & archive).
The RDM policy stipulates that authors who are affiliated with the UT have to make sure that the final PDF file of all their publications is uploaded to RIS Utwente (also known as PURE). The UT-affiliated publication should have open access (OA), preferably immediately with a licence for reuse , but at the latest 6 months after the first online publication date. UT authors should preferably publish in high quality OA journals that are listed in the Directory of Open Access Journals (DOAJ), and in the almost 10 000 journals that allow submission at a 100 % discount. These journals can be found in the UT Journal Browser (UT Journal Browser | Service Portal | University of Twente (utwente.nl)).

Figure 5: S&T-authored, peer-reviewed journal articles 2017 - 2022



The Taverne opt-in and opt-out procedure came into effect at the University of Twente in 2020 and 2021, respectively.With these procedures in place, nearly all peer reviewed articles are open in some way. Analysis of the usage of the Taverne procedure indicates:
- A significant number of documents appears with a corresponding author without UT e-mail address;
- the affiliation is often given as the University of Twente, the faculty S&T or MESA+; and
- some groups use pre-print servers as a way for open access publications.

Most importantly, the analysis shows that papers could have been full Open Access under the licenses of the UT, but authors did not make use of that opportunity. In addition, it shows that the RDM policy of the S&T should receive more visibility and awareness.

PhD theses. PhD theses are nearly by definition Open Access. Sometimes embargoes are used, if a collaborating company wants to assess patents potentials, or if a publication will

be submitted to a journal that counts an open thesis as a previous publication and thus marks it as plagiarism.

Open Datasets. Datasets resulting from research can be archived in three ways: closed (either digitally or on paper) in the archives of the research groups, whether or not available upon request), in data repositories and as supplemental data in an article. The developed DMP Tool, a storage decision tree aims to promote publishing datasets in Surf drive under UT-licence. But since these tools were fully implemented in 2021, the deposition of datasets in repositories is not a well-established practice yet.

Supplemental data. Traditionally, in chemistry journals, but more and more in other disciplines, supplemental data can be shared. Roughly 10% of the S&T-publications contain supplemental data, mostly in the journals of the American Chemical Society, but also in some other journals.

Preprints. Within the physics domain, publication of preprints (in arXiv.org) is a common practice. Within the chemistry domain, publications of preprints appear in chemRxiv.

5.6 HR POLICY

Human resource (HR) management is organised centrally at UT, and the HR department at S&T implements and supports the implementation of central policies. HR policies encompass the full scope of HR practices and processes to attract, develop, motivate, and retain high-performing and satisfied employees. Employee professional development is central to the yearly appraisal and supported by a wide range of training and courses available at the UT, with a special focus on leadership development opportunities. The faculty strives to use Strategic Personnel Planning (SPP) for analysing the inflow, flow-through, and outflow of employees. The results of SPP are used to determine current and future staffing needs. However, the registration systems for personnel (AFAS and UNIT4) require improvement, as the current system has proven to be insufficiently equipped for generating insights into personnel and finances.

Diversity. The S&T faculty strives for a diverse workforce which can contribute to a greater sense of community and a stronger home base for students. In January 2020, the UT implemented English as the official working language. This also has been done for creating a more inclusive environment. The faculty follows the university's strategy and policies in the area of Diversity, Equity and Inclusion (DE&I) and uses the central recruitment policy and tools. Over the past years, the UT has invested in increasing the number of female talent in academic top positions with tools such as Hypatia chairs and UTwist programme. In 2016, the S&T faculty applied the UTwist tool for attracting one talented female tenured track scientist. Moreover, in the period 2015–2022, several female S&T scientists received NWO's Aspasia funding (Final round of Aspasia opens this summer | NWO). HR is also focusing on inclusive recruitment, paying attention to a diverse composition in appointment committees, with at least one woman present, and training in inclusive writing and becoming aware of implicit biases. Although the targets mainly focus on gender diversity, DE&I has received UT wide more attention in recent years in terms of ethnicity, age, sexual orientation, cultural or socio-economic background.

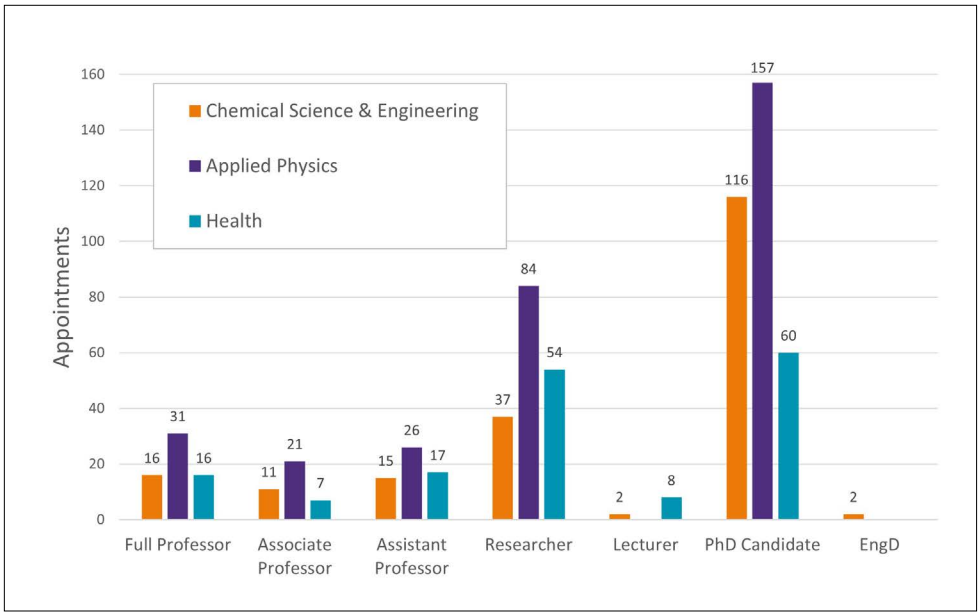
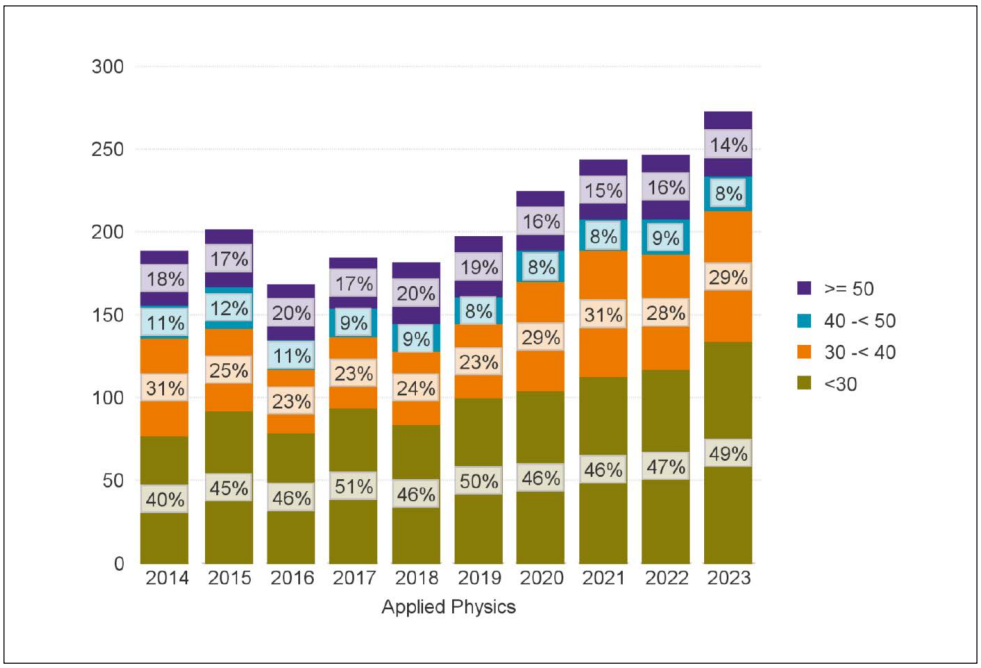
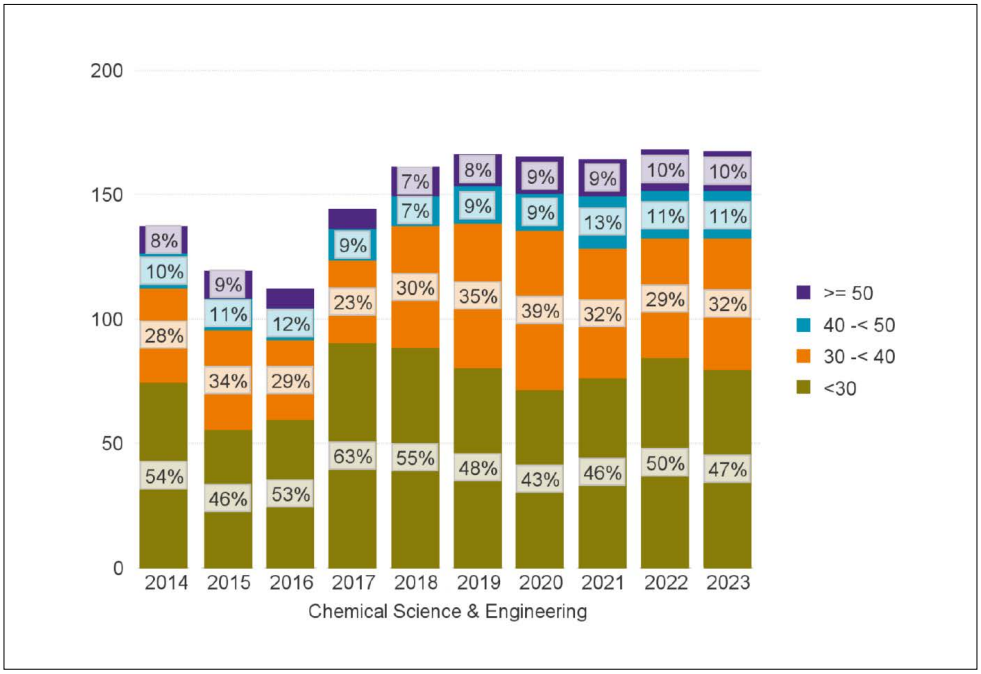


Figure 6: Number of scientific staff members per position per domain at S&T (in 2023); Source: TNW HR 01.01-HR Dashboard 30-09-2023, BI-Studio, UT





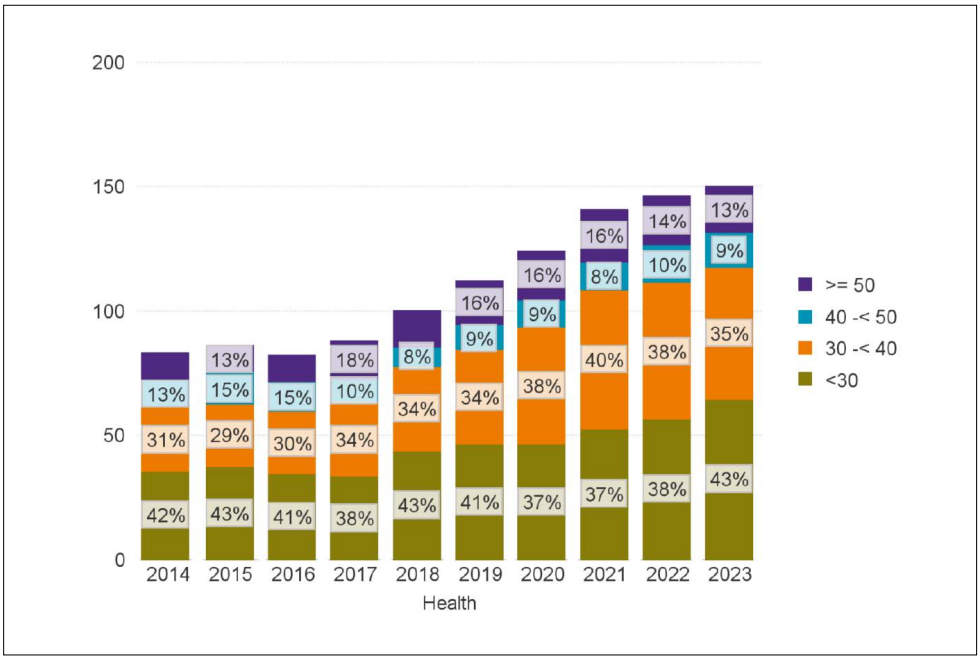
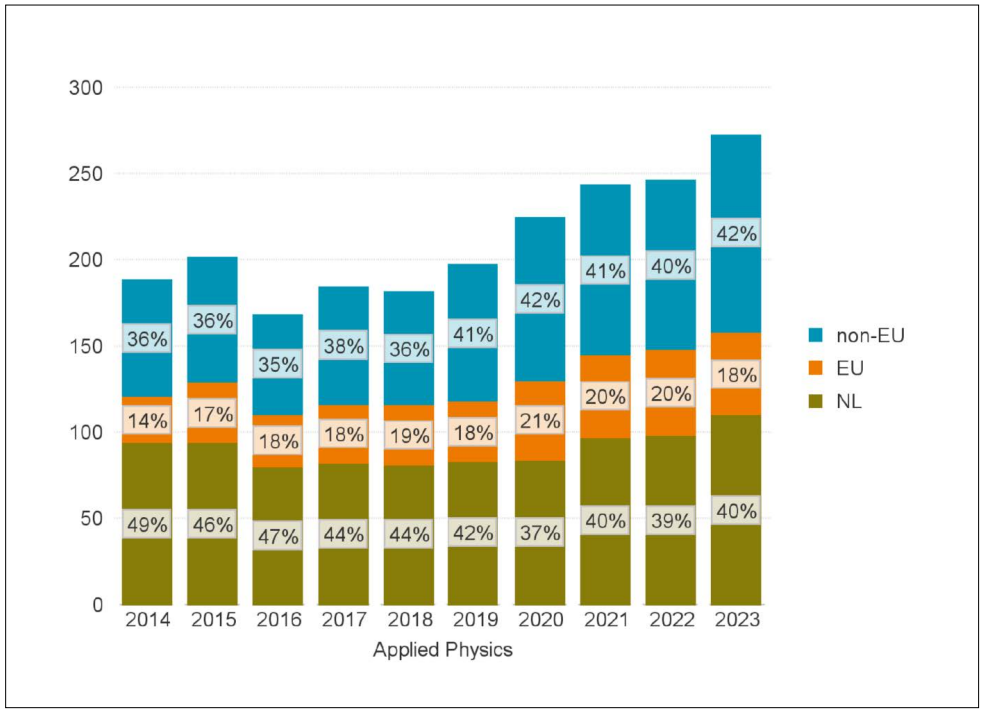


Figure 7 (a, b, and c): Age distribution in Applied Physics, Chemical Science and Engineering and Health; on the left axis the number of staff is given. Source: TNW HR 01.01- HR Dashboard 30-09-2023, BI-Studio, UT.

The S&T faculty has a fairly young workforce with small differences between domains. From 40% (Health) to 50% (Applied Physics) of scientific staff are on average between 23 and 30 years old, which can be explained because PhD candidates in the faculty represent more than half of the scientific staff as shown by the distribution of scientific staff per position per domain (Figures 6 and 7a, b, and c).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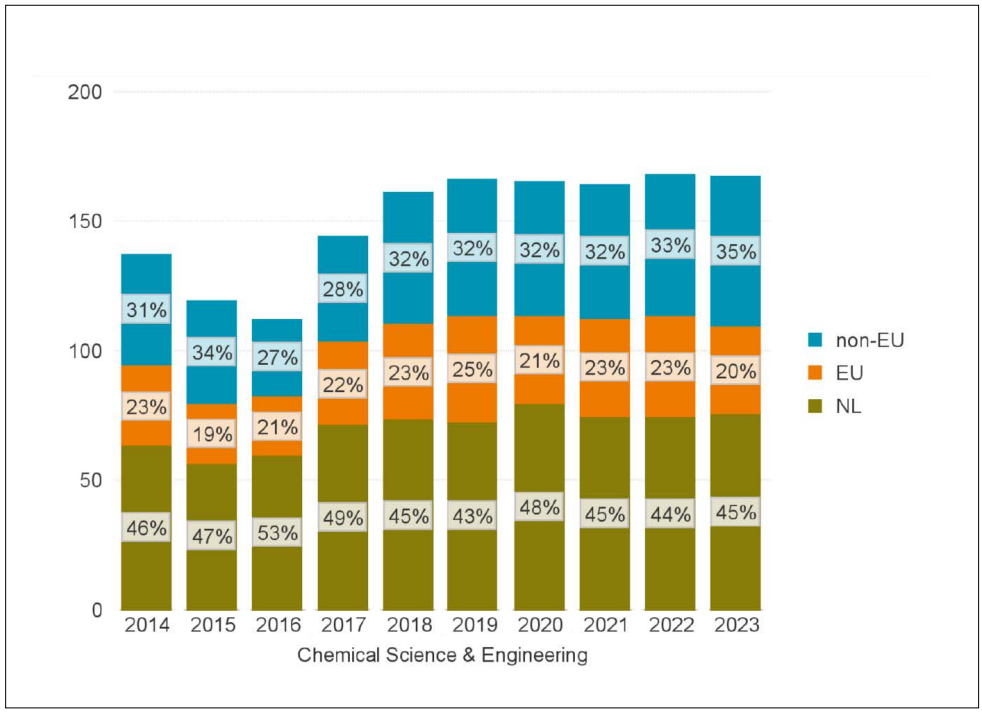
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Chemical Science & Engineering

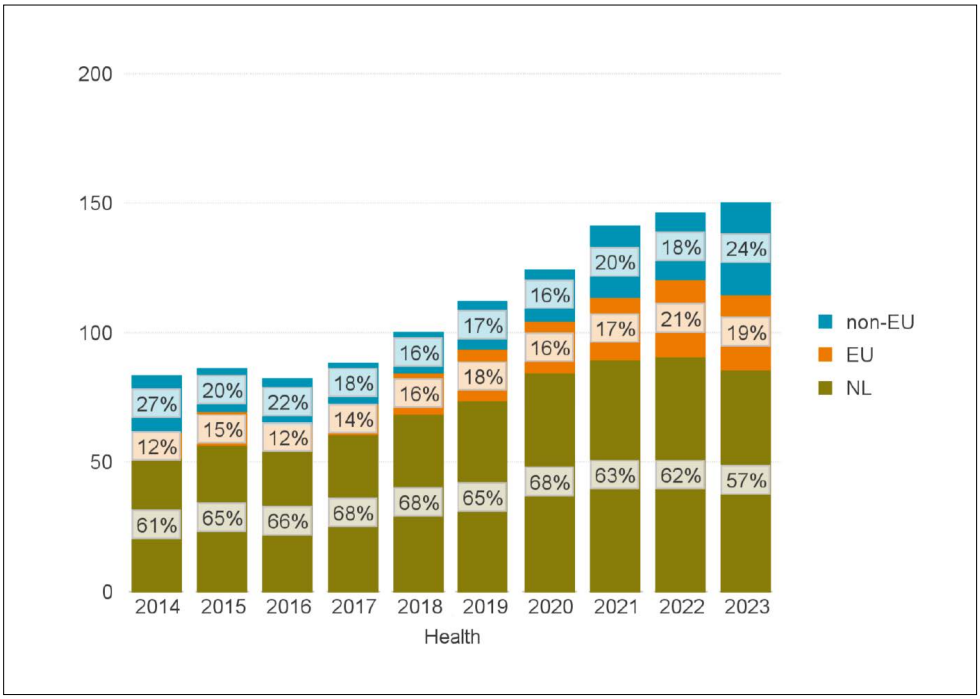
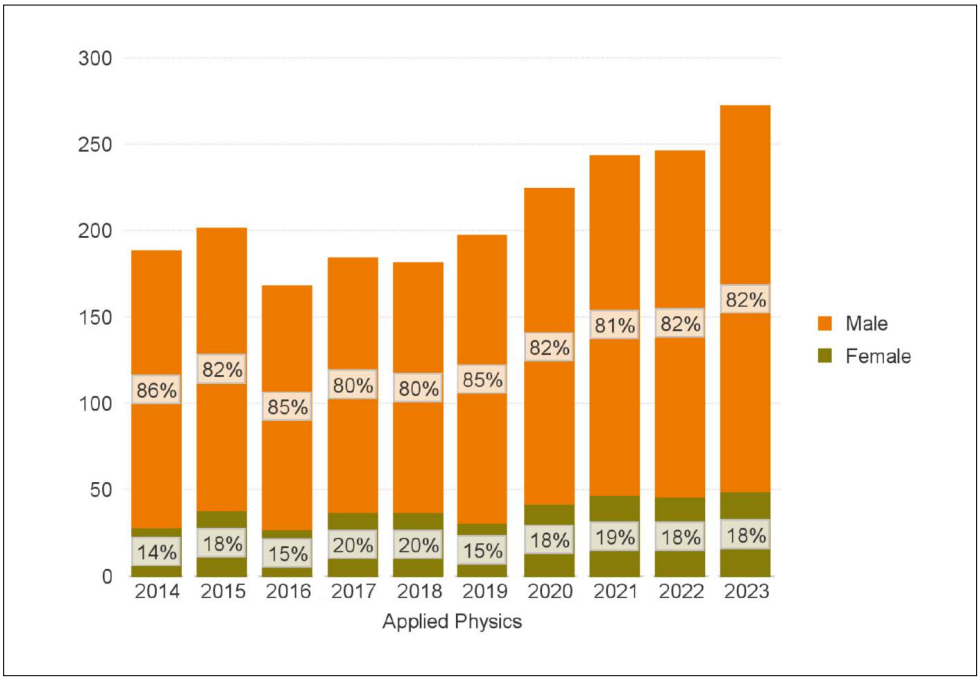
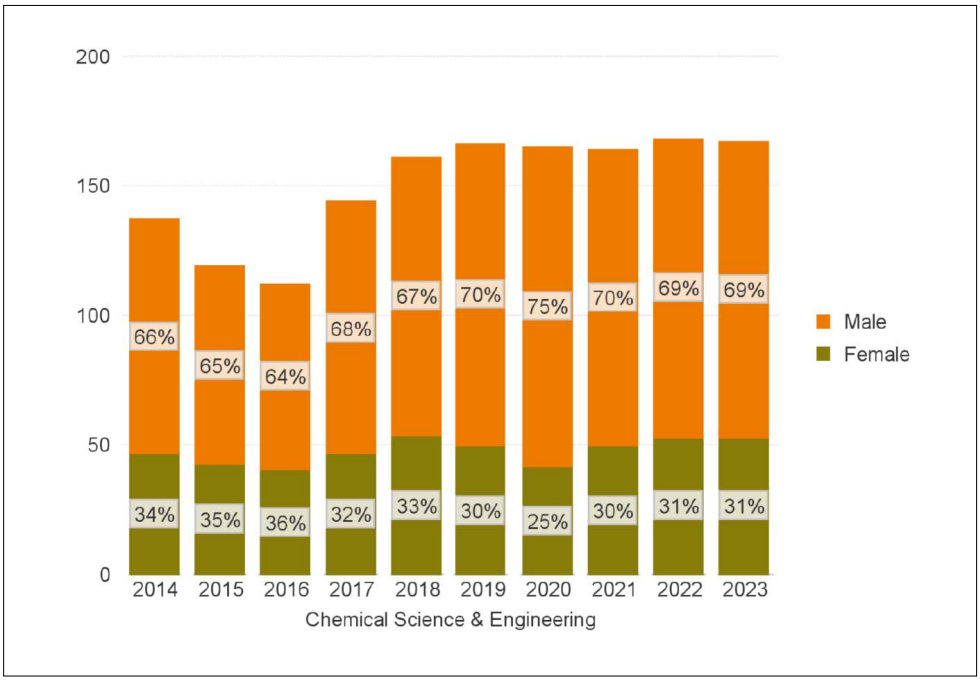


Figure 8 (a, b, and c): Nationalities in Applied Physics, Chemical Science and Engineering and Health; on the left axis the number of positions is given. Source: TNW HR 01.01- HR Dashboard 30-09-2023, BI-Studio, UT

Figure 8 shows that about half of the total S&T scientific staff is international, with more than 50 different nationalities, distributed differently across the different domains (60% Applied Physics, 55% Chemical Science and Engineering, and 44% Health). Health is less international than the other two, probably because of the project collaborations with hospitals and the required professional registration (the so-called BIG registration). PhD candidates in a hospital environment must be able to speak Dutch.





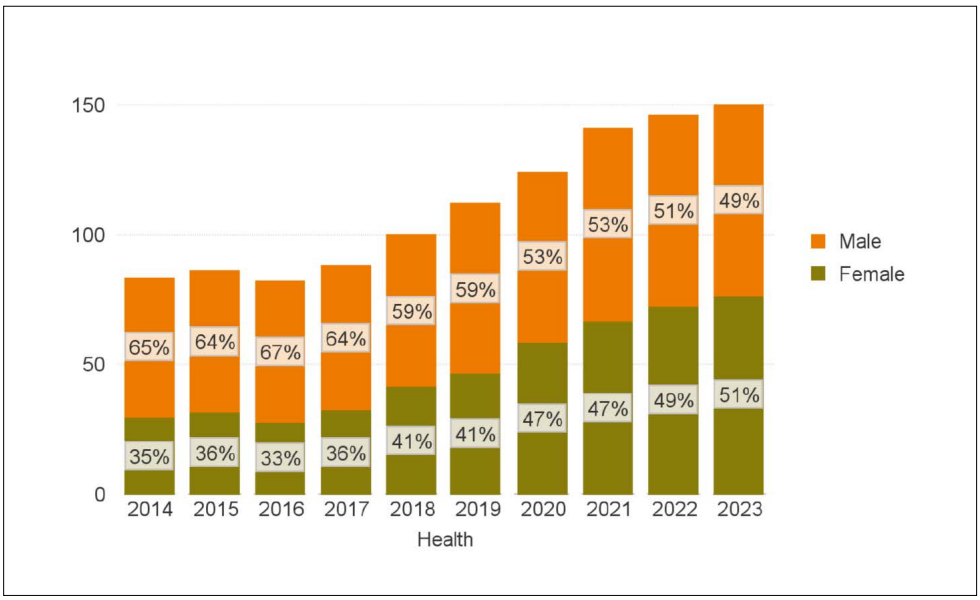


Figure 9 (a, b, and c): Gender balance in Applied Physics, Chemical Science and Engineering and Health; on the left axis the number of positions is given. Source: TNW HR 01.01- HR Dashboard 30-09-2023, BI-Studio, UT

Not only in terms of nationality, but also the gender balance among the faculty's scientific staff shows remarkable differences depending on the domain: for Applied Physics 82% are men, 70% for Chemical Science and Engineering, and 50% for Health (see Figure 9). The overall growth in the number of female academic staff remains a challenge for the faculty, especially in Applied Physics and Chemical Science and Engineering. Health is more diverse by gender.

% FEMALE POSITIONS IN FTE				
FACULTY S&T	**31-12-2020**	**21-12-2021**	**31-12-2022**	**1-10-2023**
Female full professors	8%	8%	9%	9%
Female associate professors	14%	28%	34%	37%
Female assistant professors	31%	30%	33%	29%
Female researchers	26%	29%	26%	23%
Female lecturers	53%	52%	52%	64%
Female PhD candidates	31%	33%	34%	33%
S&T total	**35%**	**36%**	**37%**	**37%**

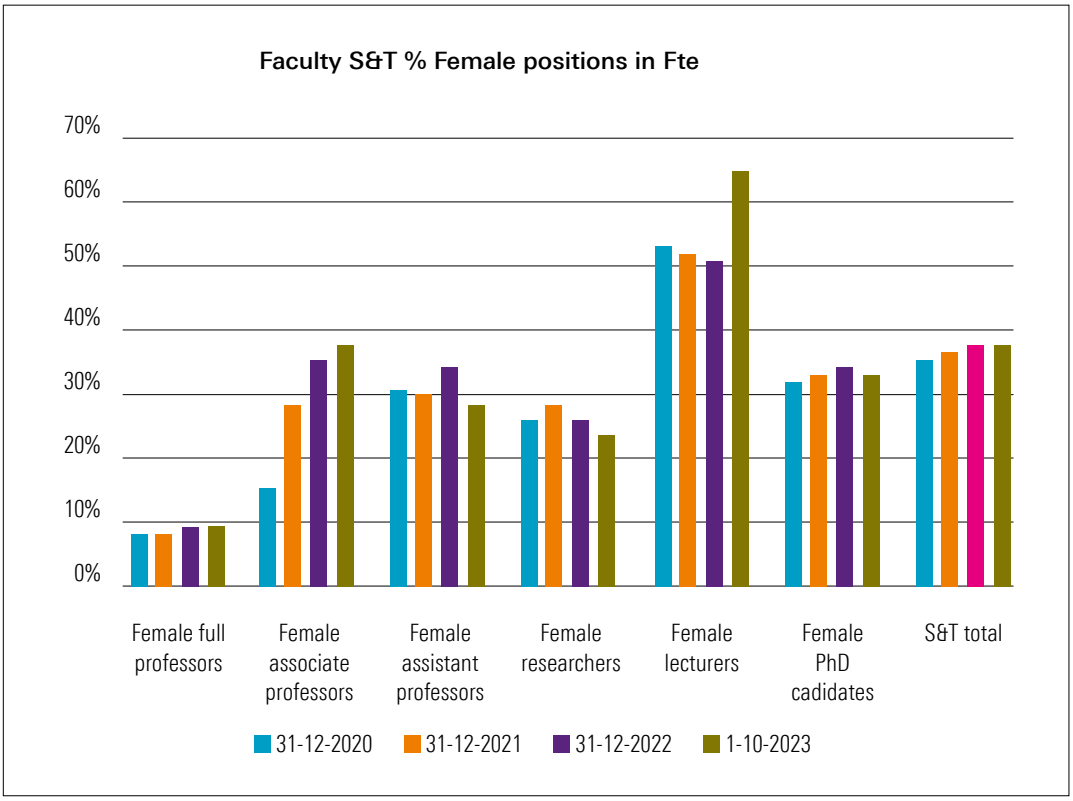


Table 9 and Figure 10 Percentage of female academic staff at the Faculty of S&T in FTEs in the various positions.
Source: Info MyHR 1-10-2023

Although the faculty as a whole has historically a low female workforce, there has been a remarkable increase in the number of female associate professors in recent years, from 14% in 2020 to 35% in 2023. The percentages of female staff in the other academic levels remain fairly stable, with 8% female full professors in 2020, to 9% in 2023 and 31% female assistant professors in 2020 and now 33%. The number of female PhD candidates is also stable: from 31% in 2020 to 34% in 2023 (see Table 9 and Figure 10). Appendix D (d), Figure 1 shows an overview of the S&T faculty demographics.

Talent management. The S&T faculty acknowledges that research excellence is just one aspect important for high-performing academic teams. Performance assessment policies therefore aim to recognise and reward excellent teaching, valorisation, team science, and impact. The faculty has made significant progress during the recent years in professionalising the performance management cycle. On an individual level, performance is discussed during annual appraisal interviews. Faculty-wide criteria for promotion are deliberately broadly phrased and cover research, teaching, societal impact, management and overall 'good academic citizenship'. Although this is reflective of the Recognition & Rewards programme, its principles have yet to be fully implemented at the UT and S&T. To enable diverse career paths, state-of-the-art talent management requires recognising and rewarding the competences of involved staff, also outside the current Dutch university job ranking system (UFO). Likewise, assessment will not only be performed at the individual, but also team level.
The university has introduced a tenure track (TT) system for young staff since 2012 (see also Chapter 4). Notably, many tenure trackers reckon that the current organisation structure undermines the role of TT's as independent scientists, because it impedes their visibility as well as their academic freedom required for the development of their own research lines. These observations confirm concerns raised by the committees of the previous Applied Physics (2018) and Chemical Science and Engineering (2015) research evaluations. The fact that ius promovendi does not extend to assistant or associate professors is seen as the greatest obstacle to limit the personal growth of particularly, but not limited to, young staff members.
At the UT there still is an ongoing discussion whether assistant professors and associate professors should get more rights concerning the supervision of PhD candidates (e.g., the right to confer doctorates) that have been recruited on their own funded research lines. In recent years, the Doctorate Board also grants associate professors (UHD-1) the right to confer doctorates, provided they fulfil relevant criteria. Within the Doctorate board, our faculty will remain an advocate for extending the ius promovendi to a larger group of academic staff.
Important components of the talent management activities in our faculty are

- an active promotion and support of nominations for prizes and awards, in particular for early- and mid-career stages, and recognition of prize-, award and grant winners in all career stages, and of grant sizes and
- efforts to consistently support researchers in grant proposals, in particular for personal grants in which their personal profile is an important assessment criterion.

5.7 ACADEMIC CULTURE

A good academic culture is a crucial precondition for sustainable scientific practice including, for example, research integrity. Such a culture requires an environment that not only stimulates individual excellence, but also advocates co-operation between researchers and social safety (Ellemers). The UT adopts this view and for the good of this introduced the House of Integrity. At the level of the S&T faculty, our culture and way of working is characterised by our core values: trust, balance, and guts.

Social safety

All people affiliated with the UT including those who do not have a labour contract,

can rely on UT support focused on reporting and complaint handling which includes confidential advisers, PhD/EngD counsellors, an ombuds officer, and an integral safety manager. To simplify the available information in a user-friendly way, the UT offers flow charts that show the different actions which can be taken to resolve or report complaints. Much is being done to combat undesirable behaviour at UT, there are codes-of-conduct, procedures and support contacts for reporting incidents. However, although the UT recognises social insecurity as a risk factor, as in all other universities, incidents still occur as can be seen from different publications (e.g., SEG Inclusion report, Annual report ombuds 2022-2023 (EN def).pdf (utwente.nl)). Despite the existing structures, there still seems to be a barrier to reporting inappropriate behaviour (SEG report, IncludeU, Well-being report).
The number of complaints to the confidential counsellors of the University of Twente originating from S&T staff has increased from 2-4 per year until 2020, to 10-15 per year in 2021-2023. The majority of these complaints concerned unacceptable behaviour.

There is a growing awareness throughout the academic world that dependency relationships can lead to undesirable effects. A point for improvement for the UT and the faculty is to actively support prevention. In June 2022 the S&T faculty held a Month of Integrity with workshops and lectures to increase awareness. Unfortunately, the events and activities were poorly attended. Although not mandatory, the faculty also encourages its employees to join centrally organised training to increase awareness and empower the staff to discuss behaviour, values, norms and group dynamics. Some exemplary training opportunities are: Bystander Training, Well-being Development Leadership Expedition, Supervising PhDs, Coaching and Effective Management, and Academic leadership.

Scientific integrity
In addition to social safety, scientific integrity is also crucial for a healthy academic culture. All employees have a responsibility to uphold standards of scientific integrity adhering to guidelines defined in the Netherlands Code of Conduct for Scientific Practice and the European Code of Conduct for Scientific Integrity. To raise employee awareness on scientific integrity, several courses and toolboxes have been provided by the UT.
In 2019, the UT adopted a central research ethics policy to make the ethical review of research common practice. For the faculties S&T and ET (Engineering Technology) a joint Ethics Committee is appointed to facilitate and monitor that all research conforms to high ethical standards. Ethical review is mandatory in situations where human/animal material or subjects, genetically-modified cells or organisms, data with a conflict of interest and research classified as 'dual use' research (e.g., can be used in military or police technology) are involved. For complaints regarding (possible) violation of scientific integrity the first point of contact is one of the two confidential advisers for research integrity. Possible follow up steps are taken care of by the Scientific Integrity Committee (CWI) who will advise the Executive Board on a decision to make. The UT recently appointed an internal and an external whistleblowing officer.

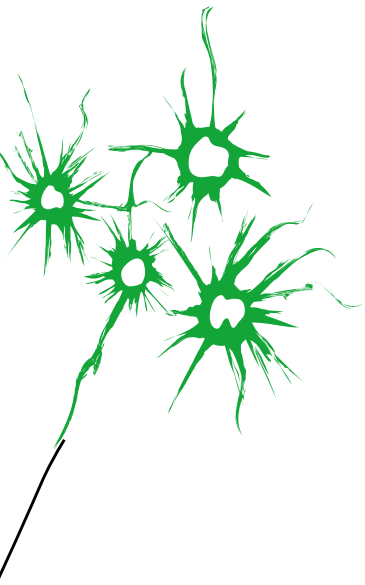
5.8 PHD POLICY AND TRAINING

PhD trajectory within the S&T faculty. Within the S&T faculty, PhD candidates are of essential importance for the performance of academic research. The doctoral training programmes in which all PhD candidates are embedded, are coordinated by the Twente Graduate School (TGS, Doctoral programmes at the University of Twente (utwente.nl)). These programmes include a science-oriented PhD programme and a design-oriented Engineering Doctorate (EngD) programme. The latter is an educational programme which is not offered by the S&T faculty (even though some employees are involved in a supervisory role) and will therefore not be discussed further in this document.
The doctoral regulations are approved by the Doctorate Board and adopted by the Executive Board. Typically, a PhD trajectory takes place over a period of 4 years during

which the PhD candidate is obliged to obtain 30 European credits (EC) of education as part of their doctoral educational programme. These credits are composed of 15±5 EC in various scientific disciplines (e.g., courses offered by disciplinary faculties, institutes or research schools) and 15±5 EC in academic skills, personal 'transferrable skills' and career development (e.g., courses offered by the UT for broadening). A personalised career development plan is made with the promotor within the first 3 months of the doctoral education programme. Aside from offering courses to PhD candidates, TGS also offers courses to supervisors for good supervision.

Recruitment of novel PhD candidates occurs typically via maintaining internal talent/ students or via competitive selection of external talent. Vacancies for external talent are being made aware simultaneously via specialised digital vacancy boards (e.g., academictransfer.com) and via the institutional website (e.g., utwentecareers.nl). Recruitment format is upon discretion of the responsible principal investigator and associated selection team. The progress of PhD candidates is monitored in the online platform Hora Finita. During the second half of the first year, a go/no-go assessment also referred to as the 'qualifier' takes place, which the doctoral candidate needs to pass to continue. In case of a negative outcome, a second qualifier needs to be planned to perform reassessment within a period of 3 months, accompanied by explicitly agreed milestones to be achieved by the candidate. If the candidate also does not pass the second qualifier, the PhD trajectory will be stopped. The vast majority of the PhD candidates pass their qualifier.

When the PhD candidate passes the qualifier, a request to the Doctorate Board for the appointment of one or two promotors and a maximum of two co-promotors will be made (with a minimum of 2 and a maximum of 4 promotors plus co-promotors). At the end of each year, an annual interview takes place with the PhD candidate to discuss the progress. During this interview, scientific and personal progression of the PhD candidate is reflected upon, interaction and needs and wants of both supervisor and PhD candidates are discussed, and new agreements made to enable maximal progress, all in a bilateral manner. Upon completion of all requirements, the promotor can digitally request the graduation of a PhD candidate. In case of exceptional performance, the promotor or a member of the graduation committee can request the candidate to be awarded with the distinction 'Cum Laude' ("with honours") After approval by the dean the decision is taken by a closed vote immediately after the PhD thesis defence.



Important organisations where PhD candidates can find information and support are:

- Twente Graduate School (TGS). The Twente Graduate School coordinates all doctoral programmes of the S&T faculty. TGS is currently well positioned for its role.
- PhD Network of the University of Twente (P-NUT). P-NUT is the official PhD association of the University of Twente. It is run by PhD candidates and helps other PhD candidates. They provide information, organise events for PhD candidates and have a sustainable platform to facilitate inclusion of international PhD candidates.

Within the time frame of 2015 to 2022, 711 PhD candidates started their thesis, of which 268 have defended their thesis successfully (see Table 10 / SEP Table E4a). 72 people have dropped out of the PhD programme, accounting for 9.4 % of all PhD candidates. The average duration for people who started in 2015 is 56 months, which will increase once the remaining 5 active people finish. This is higher than the 48 months which is typically associated with contracts of PhD candidates. However, it should be taken into account that longer durations are also the result of e.g., part-time contracts, pregnancies, long-term illnesses, etc. Furthermore, due to the Covid 19-pandemic, typically 3 months of extension were awarded to PhD candidates due for graduation in the time period 2020–2023. Based on a TGS analysis presented in October 2022, the length of the PhD trajectory of S&T is slightly lower than the UT average.

Table 10 / SEP Table E4a: Overview of study success of the 2015-2023 PhD cohorts of S&T according to Hora Finita (September 2023)

START YEAR	ACTIVE	DROPOUT	PHD GAINED (AVERAGE DURATION IN MONTHS)	TOTAL
2015	5	12	68 (56)	85
2016	2	15	59 (55)	76
2017	20	10	70 (52)	100
2018	22	9	47 (46)	78
2019	65	9	20 (41)	94
2020	83	9	3 (24)	95
2021	85	4	0	89
2022	89	4	1 (15)	94
2023	55	0	0	55
Total	426	72	268	766

Demographics on and excellence of PhD graduates. In the period of 2015 to 2022, a total number of approximately 570 people obtained their PhD degree within the S&T faculty (this includes people who started prior to 2015). The number of candidates graduated in each year is reported in Table 11. It should be noted that based on the information source, either RIS Utwente or Hora Finita, slightly different numbers per year are given. The discrepancies can be explained through the criteria used for counting in the different systems. In addition, Table 11 shows the number of people who graduated cum laude sorted by gender. Within the timeframe 2015-2022, the people who graduated cum laude is 6.2 %. For male candidates, the percentage is 7.8 %, whereas for female candidates this percentage is only 2.7 %, showing a significant inequality. The distribution of candidates over the domains and the corresponding gender numbers are given in Table 12. Two important observations can be made from the latter table. First, the number of PhD candidates graduated in the Health domain (125) is considerably lower compared to the domains of Chemical Science and Engineering (225) and Applied Physics (220). Second, 32 % of the candidates was female, with the female percentage being significantly higher in the Health domain (43 %) and significantly lower in the Physics domain (22 %).

Table 11 / SEP Table E4b: Number of graduated PhD candidates in S&T groups, according to RIS Utwente (August 2023) and Hora Finita (September 2023). The small differences in the number of graduations per year are the result of different information sources being used. Additionally, the number of PhD defences awarded cum laude are presented by gender

	2015	2016	2017	2018	2019	2020	2021	2022	TOTAL
Total graduations[a]	73	97	64	71	63	67	66	69	570
Total graduations[b]	76	97	61	72	60	64	71	66	567
Male (cum laude)[b]	57 (6)	67 (3)	43 (2)	44 (3)	37 (2)	42 (3)	50 (4)	44 (7)	384 (30)
Female (cum laude)[b]	19 (0)	30 (0)	18 (1)	28 (0)	23 (3)	22 (0)	21 (0)	22 (1)	183 (5)

[a] Data retrieved from RIS utwente (August 2023)
[b] Data retrieved from Hora Finita (September 2023)

Table 12 / SEP Table E4c: Number of graduated PhD candidates in S&T groups in the period 2015-2022, sorted by domain and gender, according to F/M numbers provided by TGS and RIS Utwente (August 2023)

DOMAIN	CHEMICAL SCIENCE AND ENGINEERING	HEALTH	APPLIED PHYSICS
Female	82	54	48
Male	142	70	170
Not given	1	1	2
Total	225	125	220

The background of the graduated PhD candidates in the period 2015–2022 is very diverse, as can be seen in Appendix D (e), Table 1. All inhabited continents are represented,. The number of Dutch citizens make up 38 %; the number of EU-citizens excluding Dutch people make up 20 %. 36 % of the Dutch people have a regional background (within a radius of 45 km from the University of Twente). Interestingly the strong regional background is less dominantly observed for German PhD candidates: 29 % of the German PhD graduates had a background within a radius of 100 km from the University of Twente.

Next, we pay attention to the relationship between PhD theses and the sustainable development goals (SDGs). The number of PhD theses which adhere to these SDGs are given in Appendix D (e), Table 2. Although the number of theses explicitly related to SDGs is in the minority, there are still some interesting trends. A large focus of the SDG's lies on good health and well-being, especially within the Health domain. Also, prominently present in the Chemical Science and Engineering domain is research on affordable and clean energy. The number of theses associated with SDGs for Applied Physics is low. This can be explained by the fact that Applied Physics is typically a more fundamental domain and corresponding research is not associated with SDGs (yet). Nevertheless, developments on such a fundamental level are critical to make advancements in other fields which do relate to SDGs.

Finally, we look at the career paths of the PhD candidates which graduated at the S&T faculty within the timeframe 2015–2022 (see Table 13) For 535 PhD candidates these numbers are presented in Table 13. By far the largest amount of people continue their career in Industry (53 %), with academia (26 %) being the second most pursued career. In industry, ASML is the most popular company to work at (49 PhD graduates) and the University of Twente the most popular academic institution (41 PhD graduates). The distribution of career paths of the PhD candidates by gender is shown in Table 14. For women, the outflow towards health care (57 %) and higher education other than academia (56 %) is relatively high. The flow towards industry (30 %) and academia (29 %) is relatively low. From the people continuing their career at the University of Twente only 20 % of the people is female. Clearly, there is significant room for improvement for maintaining female talent within the University of Twente.

Table 13: Career pathways of PhD candidates graduated in the period 2015-2022, sorted by domain, according to info provided by research groups and LinkedIn (September 2023)

FROM \ TO	ACADEMIA	GOVERNMENT	HEALTH CARE/HOSPITAL	INDUSTRY	BANK	INDUSTRY & UT	ICT CONSULTANT	OTHER EDUCATION	RESEARCH INSTITUTES
Chemical Science and Engineering	47	2	2	120				5	29
Health	18	3	19	61		2		2	13
Applied Physics	73	5	2	100	8		1	2	21

Table 14: Career pathways of PhD candidates graduated in the period 2015-2022, sorted by gender, according to info provided by research groups and LinkedIn (September 2023)

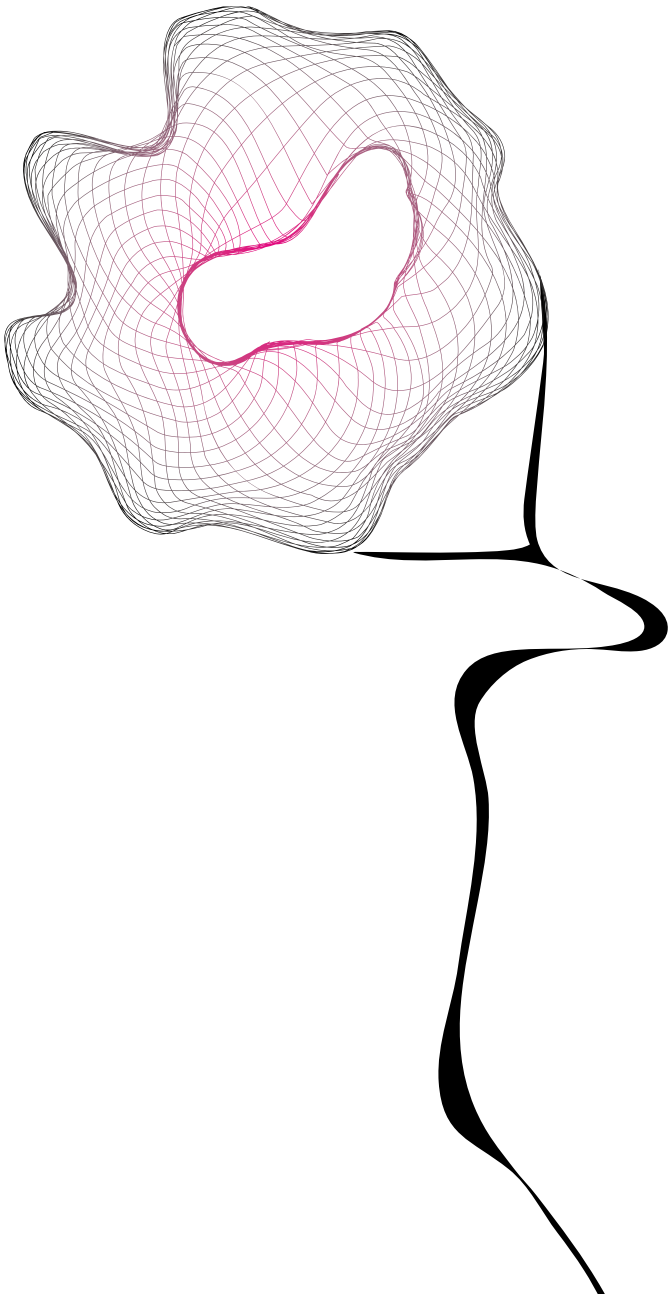
GENDER \ TO	ACADEMIA	GOVERNMENT	HEALTH CARE/HOSPITAL	INDUSTRY	PUBLISH	BANK	OTHER EDUCATION	RESEARCH INSTITUTES	RESEARCH INSTITUTES
Female	40	4	13	85	2	1	5	20	29
Male	97	6	10	192		7	4	41	13
Not given				6				2	21

Finally, in Appendix D (e), Tables 3 and 4 data are presented about the country and the domain in which PhD graduates continue their careers. Many PhD graduates, including non-Dutch ones, continue their career in The Netherlands. A significant number of Asian graduates return to their country of origin, and a significant number of graduates from the EU move toward a position within the EU, both in the Netherlands as well as outside. Appendix D (e), Table 4, as mentioned in section 5.6, shows that there is more internationalisation for PhD graduates ending up in the Chemical Science and Engineering and Applied Physics domains and less so in the Health domain.

Points for improvement regarding PhD policy. The following points for further improvements and future discussions should be considered:

- Working with Hora Finita is often considered to be a challenge: time-consuming, bureaucratic, and not user-friendly.
- With multiple (co-)promotors involved, the current procedure could benefit from a more detailed plan at the start of the track regarding the roles, responsibilities, and rights of each member of the supervision team.
- Raising awareness at the level of the supervision team regarding timely graduation is anticipated to benefit the PhD candidate trajectories within the contractually allotted time frame.

- Objective assessment of PhD qualifiers and yearly interviews could be further improved by letting the external member have a leading role. At S&T, the main leading role is still performed by the promotor, who is often involved in the research and its associated outcomes. The current formation of larger departments might play a role in providing a role for enhanced objectivity of assessment.



6. STRATEGY FOR 2023–2027

What must be done to maintain what is already good for S&T's research quality, societal relevance, and viability, what is in need of improvement, and how can we best implement improvements? This final chapter of the S&T self-evaluation report focuses on this threefold question. The writing team performed a SWOT-analysis that received feedback from several readers (see Table 15). For an appropriate response to the SWOT results, we also build on the (future) departments input for the S&T research strategy. S&T is currently in the process of developing a research strategy that reflects and supports what lies within the DNA of the faculty. For realising this aim, the departments were requested to formulate their own strategy. This chapter draws on these contributions as well as on the general S&T strategy 2023 – 2027 (Strategy document 1 September 2023.pdf (utwente.nl)). Moreover, it will be shown that the current preparedness for the future is compatible with the continuous evolution of the faculty, anchored in 20+ years of strategic decision-making.

Table 15: SWOT-analysis for the S&T faculty 2023 - 2027

STRENGTHS	WEAKNESSES
1. Research excellence as demonstrated by internationally recognised researchers, acquisition of prestigious EU and national grants (both personal and consortium grants), including by younger generation, excellent publishing rates (high impact and visibility). 2. State-of-the-art facilities available. 3. Cross domain collaborations with good collegial atmosphere. 4. Good balance between fundamental and applied research, strong focus on societal problems and collaborations with stakeholders (companies, knowledge partners such as universities of applied science etc.). 5. Valorisation through demonstrable technology readiness level and strong focus on entrepreneurship (spin-off companies) and research on societally relevant topics. 6. Flat hierarchy, easily approachable top/faculty management and support units.	1 .Vision for UT and S&T needs to be more long-term and consistent, and needs to be implemented accordingly. 2. High workload in the primary processes, based on increasing administrative and managerial tasks. 3. Unclear responsibilities and various levels of governance between the disciplines, clusters/departments, and research groups. 4. Department formation might lead to counterproductive discussions about money and positions. 5. Insufficient HR policies and practices regarding retaining and promoting scientific and supporting staff. 6. Aspects related to team science and recognition and rewards need further improvements.
OPPORTUNITIES	**THREATS**
1. Strong connection with the region (including Germany), industry, and society at large, providing a solid basis for new collaborations and initiatives. 2. Well positioned to acquire targeted investments from the government (e.g., National Growth Funds, Sector plans) addressing grand societal challenges. 3. Department formation can strengthen and focus the research programmes, strategic decision making, and help in attracting funding and in enhancing visibility. 4. S&T could further improve upon aspects that are seen throughout academia, related to e.g., social safety, work-life balance, diversity, etc.	1. Financial situation is critical. Income of the faculty does not follow increasing basic costs. 2. Suboptimal visibility may cause underrepresentation of S&T members in national and international research consortia and media. 3. Societal trends and geopolitical developments limit free choice of research activities and partners. 4. National political discussions on internationalisation in higher education hamper the talent pool and affect finances. The consequences will differ for each domain.

(I) IMPROVED STRUCTURE AND GOVERNANCE

In the years 2015–2016, the S&T faculty board selected eleven research focus areas. This selection was based on existing strengths, available infrastructure, the relevance to scientific and societal challenges as well as on educational programmes and considering the opportunities for future funding. These research areas formed the basis for the formation of the research clusters (see paragraph 3.1, Table 1). The approach for cluster formation and their organisation was organic or bottom-up and showed high degrees of autonomy in cluster evolution and management. The S&T Faculty Strategy 2023–2027 reconsiders key expertise areas, research themes, and departments with a mandate. The strategy identifies five key expertise areas ((1) Fluids & Soft Matter, (2) Materials (3) Medical Technology, (4) Photonics, and (5) Processes) that contribute to one or more of the following six research themes: 1) Climate 2) Energy 3) Health, 4) Safety & Security, 5) Sustainable Materials & Processes, and 6) Water. Taking into account the aforementioned considerations for cluster formation, but with an awareness for issues that deserve to be amended, the S&T Faculty Strategy 2023–2027 continues the process of transition anchored in shared research and societal relevance strengths and opportunities by refocusing on departments (see also paragraph 3.1, Table 1).

The SWOT-analysis shows that the formation of departments is seen as having potential opportunities and weaknesses. As for the strengths, department formation might strengthen and focus the research programmes, strategic decision making, enhance visibility and help in attracting funding and in enhancing visibility. Weaknesses refer to unclear responsibilities and various levels of governance between the disciplines, clusters/departments, and research groups, and department formation might lead to counterproductive discussions about money and positions. It will be shown that Opportunities and Weaknesses share common denominators.

In contrast to the clusters, departments will have a mandate to take decisions (including, for example, budget and HR responsibility), and have more formalised rights and responsibilities. Departments, in consultation with the faculty board, will draft their own budgets and annual plans. They will be responsible for defining new scientific staff positions, and for the internal allocation of technical and other support and of office and lab space, and for guaranteeing continuity in the educational programmes. This is a shift of responsibilities from the groups to the departments. Clusters and departments also differ concerning (formal) leadership. While clusters had a coordinator without mandate, each department will have a collegial but formally installed board that consists of a mixture of scientific and support staff, at various seniorities, including at least one scientific staff member who is not a full professor. Department boards are composed of permanent staff members or tenure trackers of the department, on the basis of nomination (including self-nomination). They are appointed by the Faculty Board for a period of two years with one possible extension of two years, and the department board membership is a part-time position (between 0.5 to 1 day a week). The department board consists of a head and at least two other members, who are responsible for education and research, respectively (i.e., deputy heads). To support the department board, the position of department board coordinator will be introduced. These coordinators will liaise with the faculty support organisation regarding operational affairs and play a vital role in reducing administrative burden.

As mentioned before, these changes might have positive and/or negative effects. The faculty board is convinced that the direction is strongly predicted by the 'preparedness for mandate' and takes co-responsibility in this. First, the faculty board provides guidelines for the nomination, installation, and responsibilities of the department boards. Second, the faculty board supports the recruitment, selection, and development of department coordinators. Third, the faculty board prepares Finances and HR for their role as a department-oriented sparring partner. Fourth, the faculty board stimulates and actively

supports (by, for example, communications, lobbying inside and outside UT, funding) the departments in their efforts as recognisable and expertise-guided entities.

(II) SELECTION OF RESEARCH FOCUS AREAS, AND ENHANCING THEIR VISIBILITY

The aforementioned reconsideration of key expertise areas and research themes is crucial for telling the narrative of the contemporary S&T faculty to the academic world and society at large. The latter points also to the faculty's open science endeavours. Currently, the faculty is home to several part-time professors from industry and hospitals. The S&T Faculty Strategy 2023–2027 aims to further strengthen its societal relevance by introducing 'Fellows'. Clinical or industrial fellows who not necessarily have the position of full professors may be appointed in a strategic collaboration between the faculty and a company or a clinic. Some of the aims will be to introduce clinical or industrial competencies into the research practice (for instance to reach a higher TRL than usual), and to lower the barriers between industry and the faculty's research and education.

The S&T faculty is also infused by the thought that spin-offs have an important role in diminishing the distance to society. After all, as shown in paragraph 5.2.2 and table 9 in Appendix D(b)., the S&T spin-offs contribute to industrial and individual solutions for issues high in demand. The period 2015–2022 shows an increase in spin-offs and the S&T faculty continues to support such entrepreneurial endeavours . Also, outside spin-offs S&T researchers devote their knowledge and skills to topics relevant for societal transitions such as those related to clean energy, clean water, improved climate, and personalised health. This is shown by their successful applications for personal and collaborative grants (see also next section) centred around such topics.

However, to push S&T's core expertise in the prime spotlights and on stages, more efforts are needed. In co-operation with the institutes, the faculty will promote figureheads or 'ambassadors' for obtaining prime positions in national programmes (see next section), in discussion bodies (ERC, EU, NWO, Dutch Heart Foundation, etc.) and negotiations with potential partners. Scientific staff will be supported at earlier career stages to act as ambassadors by stimulating more and more diverse department representatives for such initiatives. Supported by Marketing & Communication, the faculty will provide more online exposure of achievements and possibilities for collaboration, such as startups, spin-offs, and centres. The faculty and the S&T community will share contributions with high scientific and societal impact through social media (e.g., Facebook, Instagram, LinkedIn) and scientists will be supported in making optimum use of these media.

(III) ATTRACTING FUNDING AND STRENGTHENING OUR ROLE IN LARGE CONSORTIA

Although traditional funding prospects such as NWO and ERC are still very relevant, many new opportunities have arisen. For example, in the Netherlands the National Growth Fund (NGF), the Knowledge and Innovation Agendas (KIA's), and Nationale Wetenschapsagenda (NWA) are latest drivers for societal change on themes such as security, energy transition and sustainability. Within all these programmes public and private parties work together, stimulating open science and a cross-fertilisation between scientific and societal relevance. Moreover, collaboration in such consortia is a way to promote and benefit from team science. These funding opportunities also provide a true advantage for financing state-of-the-art equipment and infrastructure that can be made (more) accessible for researchers from other faculties leading to enhanced multidisciplinary projects, and for society (hospitals, industry, etc.). As such, next to the well-known personal funding routes (NWO, ERC), successful infrastructure grant applications and participation in large consortia have the potential to balance somewhat a threat identified in the SWOT-analysis: the financial situation. In paragraph 5.1.3 it was shown that S&T faculty members are successful in personal, collaborative and infrastructure funding endeavours. Several departments anticipate in particular a strong growth in consortia research activities (NGF, KIA's, NWA, etc.) pointing towards an increasing importance of team science.

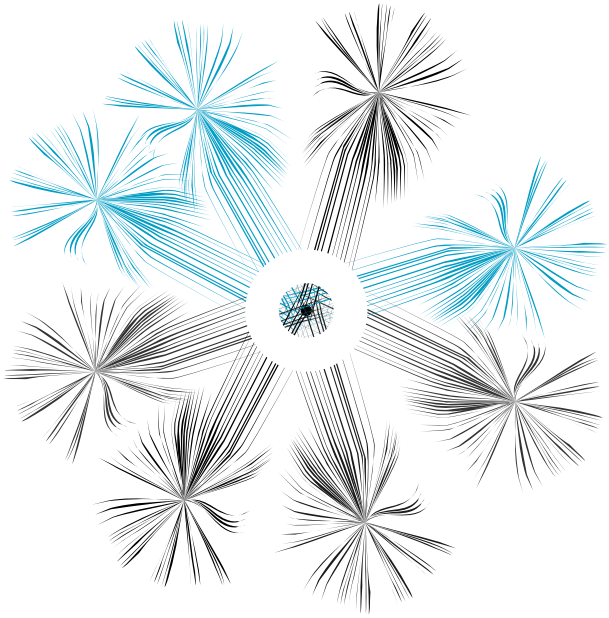
For strengthening the faculty's funding position and role in large consortia, a better visibility (see previous section) of the S&T research trademarks is a necessary precondition: to mention a few, the key expertise areas, research themes, entrepreneurial mindset, working at the interface of fundamental and applied research, strong connectedness with and embeddedness in society. Moreover, the institutes play an important role in an improved positioning of the faculty. However, this is not sufficient for funding success: preparations and execution demand severe time investments. As shown by the SWOT-analysis, the high workload in the primary processes, based on increasing administrative and managerial tasks, is a severe weakness that also has to be considered as a burden affecting funding applications and achievements. For counteracting workload unrelated to core tasks, it is important to nourish a devoted, professional and client-centred support environment. Although the S&T faculty invested in such support by, for example, hosting a contract office, providing a research support website, a monthly research newsletter, assistance on demand by the data stewards, the research policy officer, etc., and short lines of communication and co-operation with UT's Grants Office, all these interventions are not sufficient for balancing scientists workload. First of all, the work on this self-evaluation report showed once more that financial, HR, and research information systems (i.e., PURE) are currently not able to provide information in an easy and SEP compatible way. Moreover, the systems and in particular PURE are not user-friendly enough for delegating registration of the full array of research output and activities related to societal relevance. Second, centrally organised service departments and their support often seem not focused enough on the needs of the primary process, and this can cause extra pressure. Therefore, it is necessary to re-think and re-organise support services alongside the true demands and needs of education, research, and valorisation.

(IV) ATTRACTING, SCOUTING, DEVELOPING, AND RETAINING TALENT: TOWARDS MORE STRATEGIC HR

From 2012 onwards, the introduction, maintenance, and improvement of the Tenure Track (TT) system – the route to permanent full professor position - was important for attracting talent. Although the system still exists, for counteracting high pressure and labour contract instability, Dutch universities are changing the TT-system into an academic career track with opportunities for a permanent position after 18 months. The need for change has been also expressed by the S&T faculty's Tenure Track platform that has been installed by the faculty board in 2022. Assistant and associate professors, whether they are tenure trackers or not, demand an improvement of their position by enhancing their visibility, access to information (e.g., finances, HR, national and regional initiatives), responsibility, academic independence, and general professional maturation. The S&T Faculty Strategy 2023–2027 supports these demands by several interventions (see Strategy document 1 September 2023.pdf (utwente.nl), page 7-8). By catering the needs of assistant and associate professors, the S&T faculty strives for enhanced attractiveness, development, and retainment of scientific talent.

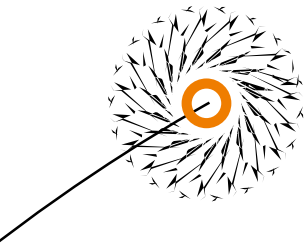
Current threats identified in the SWOT-analysis might have negative consequences for incumbent and future scientific talents for the most junior academic talents of tomorrow: the PhD students. Geopolitical developments and national political discussions on internationalisation in higher education might cause a decrease in foreign influx, while such influx is much needed for Applied Physics and Chemical Science and Engineering. For the S&T faculty it is vital to remain welcoming and attractive for those from abroad and close-by. The appeal of the S&T faculty also shown in this self-evaluation report, state-of-the-art supervision, and excellent learning, training and career guidance opportunities will positively affect the attractiveness of the S&T faculty for current and future generations of PhD students. The Twente Graduate School provides training for supervisors and (mandatory) education for PhD students. The S&T faculty board will actively discuss with TGS for all supervisors (and not only promoters) to have access to UT's PhD candidates tracking system (Hora Finita), as well as feedback opportunities for education offered by TGS, in addition to involvement in the design of the TGS educational

programme. Moreover, the S&T faculty supports all professional development activities aiming for excellent leadership.



APPENDIX

APPENDIX A TABLE E2 DEVELOPMENT OF AMOUNT OF RESEARCH STAFF



	2015		2016		2017		2018	
TOTAL S&T RESEARCH	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff								
Assistant professor	35	26	39	26	38	29	41	36
Associate professor	36	32	37	30	34	31	34	28
Full professor	46	33	50	34	44	34	43	35
Postdoc	138	85	125	60	117	85	152	100
PhD candidates	432	314	393	281	408	313	409	306
Total research staff	**687**	**491**	**644**	**432**	**641**	**491**	**679**	**505**
Support staff	110	74	103	74	104	75	105	77
Visiting fellows	97	46	118	29	94	36	88	35
Total staff	**894**	**611**	**865**	**536**	**839**	**602**	**872**	**617**

	2019		2020		2021		2022	
TOTAL S&T RESEARCH	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff								
Assistant professor	45	41	53	44	53	46	58	47
Associate professor	32	24	34	26	34	29	39	32
Full professor	50	41	57	47	59	48	63	51
Postdoc	155	101	163	105	178	118	175	110
PhD candidates	417	320	444	342	471	348	473	359
Total research staff	**699**	**527**	**751**	**564**	**795**	**590**	**808**	**600**
Support staff	115	82	120	89	137	93	133	91
Visiting fellows	82	25	66	27	130	42	174	47
Total staff	**896**	**634**	**937**	**680**	**1.062**	**725**	**1.115**	**738**

APPENDIX B LIST OF RESEARCH GROUPS EMBEDDED IN DEPARTMENTS (OCTOBER 1ST, 2023)

APPLIED NANOPHOTONICS

Research groups:	Optical Sciences (OS)	Full prof.: Offerhaus Assistant prof.: Alvarez Chaves, Ojambati
	Complex Photonics Systems (COPS)	Full prof.: Vos Part-time full prof.: Barnes
	Adaptive Quantum Optics (AQO)	Full prof.: Pinkse Associate prof.: Klärs Assistant prof.: Renema
	Integrated Optical Systems (IOS)	Full prof.: Garcia Blanco Assistant prof.: Chang Part-time full prof.: Offrein
	Nonlinear Nanophotonics (NLNP)	Full prof.: Marpaung

BIOENGINEERING TECHNOLOGIES

Research groups:	Developmental Bioengineering (DBE)	Full prof.: Karperien Associate prof.: Leijten, Paez, Post Part-time full prof.: Saris, Kruijt
	Applied Stem Cell Technologies (AST)	Full prof.: Passier Associate prof.: Broersen, van der Meer, Bansal Assistant prof.: Schwach Part-time full prof.: Mummery
	Advanced Organ bioengineering and Therapeutics (AOT)	Full prof.: Grijpma, Stamatialis, Prakash Assistant prof.: Poot, Van Bochove, Ter Beek, Moreira Teixeira Leijten Part-time full prof.: Eglin
	Nanobiophysics (NBP)	Full prof.: Claessens Assistant prof.: Blum, Vutukuri, Ojambati Part-time full prof.: Ruers

BIOMEDICAL IMAGING & SENSING

Research groups:	Biomedical Photonic Imaging (BMPI)	Full prof.: Steenbergen Associate prof.: Vellekoop, Bosschaart Assistant prof.: Kappert Part-time full prof.: Slart, de Geus-Oei
	Magnetic Detection & Imaging (MD&I)	Full prof.: Ten Haken Associate prof.: Alic Assistant prof.: Simonis, Brink
	Multi-Modality Medical Imaging (M3I)	Full prof.: Manohar Assistant prof.: Groot Jebbink, Bellos-Grob Part-time full prof.: Geelkerken, Gupta, Reijnen, Schechopoulos, Veltman
	Healthcare Technology Implementation (HTI)	Full prof.: Verdaasdonk
	Cardiovascular and Respiratory Physiology (CRPH)	Full prof.: Donker Assistant prof.: Fresiello, Mos-Oppersma
	Clinical Neurophysiology (CNPH)	Full prof.: Van Putten, Hofmeijer Assistant prof.: Le Feber, Frega, Piastra, Part-time full prof.: Norris

MEMBRANE SCIENCE AND TECHNOLOGY

Research groups:	Membrane Science and Technology (MST)	Full prof.: De Vos Part-time full prof.: Roesink, v/d Meer Assistant prof.: Haase
	Soft Matter, Fluidics and Interfaces (SFI)	Full prof.: Lammertink, Part-time full prof.: Schroen Associate prof.: Wood
	Films in Fluids (FIF)	Full prof.: Benes Part-time full prof.: Bargeman Assistant prof: Roth

NANOELECTRONIC MATERIALS AND THIN FILMS

Research groups:	Inorganic Materials Science (IMS)	Full prof.: Rijnders, Ten Elshof , Koster, Huijben Associate prof.: Moralis Masis, Saive, Kaghazchi Assistant prof.: Baeumer
	Interfaces and Correlated Electron Systems (ICE):	Full prof.: Hilgenkamp, Brinkman, Palstra Associate prof.: Golubov, Li Assistant prof.: Adagidelin
	Physics of Interfaces and Nanostructures (PIN)	Full prof.: Zandvliet Associate prof.: Wormeester, Kooij Assistant prof.: Van Houselt, Bampoulis
	Energy, Materials and Systems (EMS)	Full Prof.: Ter Brake, Van Oort Associate prof.: Vanapalli, Dhalle Assistant prof.: Kario, Van Limbeek
	Computational Chemical Physics (CCP)	Full prof.: Filippi Associate prof.: Brocks, Leppert Assistant prof.: Bokdam
	XUV Optics (XUV)	Full prof.: Ackermann Part-time full prof.: Schuurmans Assistant prof.: Yaksin, Van de Kruijs, Sturm, Makhotkin, Van den Beld, Bayraktar

MOLECULES AND MATERIALS

Research groups:	Biomolecular Nanotechnology (BNT)	Full prof.: Cornelissen Associate prof.: Paulusse, De Beer Assistant prof.: Michel-Souzy
	Molecular Nanofabrication (MNF)	Full prof.: Huskens, Jonkheijm Associate prof.: Lindhoud Assistant prof.: Wong
	Sustainable Polymer Chemistry (SPC)	Full prof.: Wurm Associate prof.: Hempenius Assistant prof.: Gojzewski, Duvigneau
	Bioelectronics (BE)	Full prof.: Lemay
	Bioelectric Signalling and Engineering (SPC)	Full prof.: Kocer
	Hybrid Matarials for Opto-Electronics (HMOE)	Full prof.: Nijhuis Assistant prof.: Lin

PHYSICS OF FLUIDS

Research groups:	Physics of Fluids (PoF)	Full prof.: Lohse, van der Meer, Snoeijer, Versluis Part-time full prof.: Van der Linden, De Korte, Sun, Prosperetti, Verzicco, Zhang Associate prof.: Marin, Maass, Krug, Stevens, Huisman Part-time associate prof.: Van der Hoef Assistant prof.: Lajoinie

CHEMICAL ENGINEERING

Research groups:	Catalytic Processes and Materials (CPM)	Full prof.: Lefferts Part-time full prof.: Meulenberg, Nijmeijer Associate prof.: Faria Albanese Assistant prof.: Banerjee, Pizzoccaro
	Sustainable Process Technology (SPT)	Full prof.: Kersten, Franke, Zondervan, Brilman, Schuur Part-time full prof.: Lange Associate prof.: Ruiz Ramiro
	Mesoscale Chemical Systems (MCS)	Full prof.: Gardeniers Associate prof.: Fernandez Rivas, Tas Assistant prof.: Susarrey Arce
	PhotoCatalytic Synthesis (PCS)	Full prof.: Mul Associate prof.: Huijser Assistant prof.: Altomare, Katsoukis, Wenderich
	Physics of Complex Fluids (PCF)	Full prof.: Mugele Associate prof.: Duits Assistant prof.: Siretanu

APPENDIX C CURRENT POSITIONS OF THE INDIVIDUALS WHO HAVE LEFT THE S&T TENURE TRACK (PERIOD 2015-2022)

GENDER	CURRENT POSITION	EMPLOYER	COUNTRY
1 .Male	Associate Professor	Lehigh University	USA
2 .Male	Scientist	Miltenyi Imaging / industry	Germany
3 .Male	Assistant Professor	S&T, Univ. of Twente	Netherlands
4. Male	Full Professor	TU/e	Netherlands
5. Male	Scientist daily operations	SPL / industry	Netherlands
6 .Male	Chief Technology Officer	Xsensio / industry	Switzerland
7. Female	Dir. Business Development	CMCiB / industry	Spain
8. Female	Full Professor	University of Maastricht	Netherlands
9 .Female	Associate Professor	S&T, Univ. of Twente	Netherlands
10. Female	Head of Laboratory	Sanofi / industry	Germany
11. Male	Associate Professor	RUG	Netherlands
12. Male	Senior Process Chemist	Syngenta / industry	United Kingdom
13. Male	Full Professor	RWTH Aachen	Germany
14. Female	Associate Professor	TU/e	Netherlands
15. Male	Scientific Director	Liposoma / industry	Netherlands
16. Female	Activities supervisor	Parnassia Group / care organisation	Netherlands
17. Male	Full Professor	Universiteit Maastricht	Netherlands
18. Male	Full Professor	S&T, Univ. of Twente	Netherlands
19. Male	Associate Professor	S&T, Univ. of Twente	Netherlands
20. Male	Sustainability Opportunity Manager	Shell / industry	Netherlands
21. Male	Sales Applications Scientist	Bruker Nano Surfaces & Metrology / industry	United Kingdom
22. Male	Research Associate	University College London	United Kingdom
23. Male	Adjunct Professor (retired)	S&T, Univ. of Twente	Netherlands
24. Male	Full Professor	Tsinghua University	China
25. Male	Full Professor	Maastricht University	Netherlands
26. Female	Associate Professor	University of Alberta	Canada

APPENDIX D (a) CHAPTER 5 – PARAGRAPH 5.1.1 AND 5.1.2

Table 1 / SEP Table E1: Categories of evidence for the quality domains of research quality and relevance to society including selected indicators

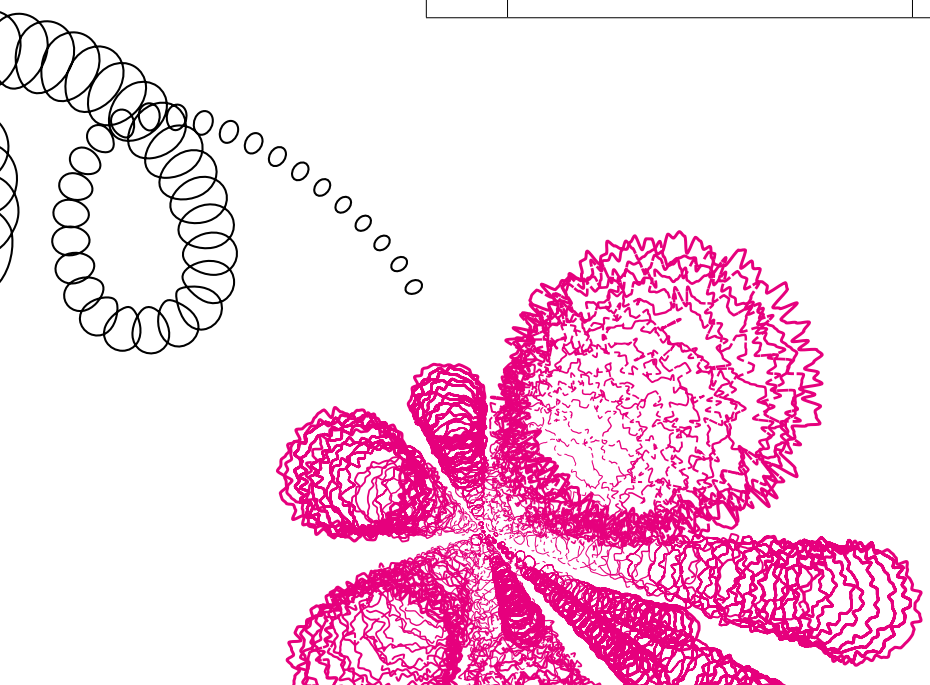
		QUALITY DOMAINS	
		RESEARCH QUALITY	RELEVANCE TO SOCIETY
Assessment dimensions	**Demonstrable research products**	**for peers** 1. Refereed articles 2. Reviews 3. Book chapters 4. Conference proceedings 5. PhD theses 6. Invited lectures	**for societal target groups** 1. Patents 2. Websites for professional visitor, 3. Lectures, masterclasses and conferences for a general audience 4. Performance for TV, radio or in other public media 5. Organisation of or contribution to an event
	Demonstrable use of research products	**by peers** 1. Citations including citation analysis	**by societal target groups** 1. Spinn-off companies 2. Projects in co-operation with societal parties (e.g., industry, hospitals, government) 3. Collaborations with and for patient groups 4. Use of products in policy
	Demonstrable marks of recognition	**from peers** 1. Research grants awarded to individuals (NWO, ERC, etc.) 2. Grants awarded to major collaborative research projects (Horizon 2020, NWO Gravitation programme, and NWO Large programme) 3. Grants awarded to individuals or collaborative research projects 4. Prizes awarded to individuals 5. Membership of prestigious scientific councils or committees 6. Membership of editorial boards	**from societal target groups** 1 .Financial and material support by society 2. Memberships of civil society advisory bodies 3. Public prizes

Table 2: Selection of invited lectures of S&T researchers at conferences

DOMAIN	CONFERENCE	DOMAIN	CONFERENCE
HEALTH	BioSelect conference Rotterdam	APPLIED PHYSICS	Inauguration Speaker of the Alps Fluid Dynamics Tour
	Annual meeting of the European League against Rheumatoid Arthritis (EULAR), Madrid		Mid-West Fluid Dynamics Tour
	Annual meeting of the International Cartilage and Joint Regeneration Society, Vancouver		Stewartson Memorial Lecture Oxford
	Annual meeting of the Osteoarthritis Research International meeting (OARSI), Toronto		Reiss Memorial Lectures Northwestern University
	Forum for Regenerative Medicine Berlin		Beeldvorming in de Urologie IV 2019
	BioSelect conference in Munich		Royal Institute of Technology, Sweden
	annual CELLS | Musculoskeletal 2016 meeting Amsterdam		Leeds Microbubble Symposium 2018: Fabrication, Characterisation and Translational Applications
	Dutch Society for Calcium and Bone Metabolism in Papendal		Universitat der Bundeswehr Munchen, Germany
	annual meeting of the European Society for Peadiatric Endocrinology Barcelona		Norwegian University of Science and Technology, Norway
	Belgian Society for Tissue Engineering and Regenerative Medicine Prometheus in Leuven		Mini Symposium Unveils Confocal Microscope combined with Brandaris 128 2019
	Brightlands Polymer Days 2021		COST workshop on Dynamics of Interfaces in Complex Fluids, Erlangen
	47th European Society of Artificial Organs Congress, ESAO 2021		Kickoff collaborative research centre on wetting phenomena, Darmstadt
	Event title59th Annual Meeting of the Japanese Society for Artificial Organs, JSAO		American Physical Society, Division of Fluid Dynamics
	20th ESOT biennial Congress		Wind Energy Science Conference in Cork
	6th world congress of the Tissue Engineering and Regenerative Medicine International Society, TERMIS		EERA JP Wind Workshop
	ESAO-IFAO Webinars "Artificial Organs & Regenerative Medicine Clinical Challenges - Emerging Technologies		Annual Meeting of the Division of Fluid Dynamics
	Hemodialyse Update 2021 : Van theorie naar praktijk		Fundamental of Nanotechnology, FON
	Jahrestagung der Deutschen Gesellschaft für Nephrologie		Optics Summerschool
	Drexel University, United States		Micro Nano Symposium
	Artificial Organs 2016: A Symposium of the International Faculty for Artificial Organs		University of Münster, Germany
	RWTH Aachen University, Germany		Physics Veldhoven
	11th European and Global Summit for Clinical Nanomedicine, Targeted Delivery and Precision Medicine		University of Edinburgh, United Kingdom

	ESPGHAN Monothematic Conference 2018: Management of Progressive Liver Diseases	APPLIED PHYSICS	6th International Conference on Nanoscience and nanotechnology
	26th Annual Scientific Meeting of Indian National Association for Study of the Liver		First International Workshop on Control of Quantum and Classical Waves in Complex Media
	All India Institute of Medical Sciences		Physics Veldhoven
	Event title15th European Symposium on Controlled Drug Delivery		IEEE Photonics Society Summer Topicals Meeting Series
	Liquid Biopsy Symposium 2019		University of Erlangen-Nuremberg, Germany
	Circulating Biomarkers, Exosomes & Liquid Biopsies Europe 2019		Yale University, United States
	International symposium Resolving Cancer Heterogeneity		44th Annual Meeting NNV AMO Lunteren
	27th European symposium on Ultrasound Contrast Imaging 2022		Eindhoven University of Technology, Netherlands
	Digestive Disease Days 2018: Clinical update of Chronic Mesenteric Ischaemia		QuSoft, Netherlands
	Stichting Vasculair Onderwijs, Netherlands		Quantum, Atomic, and Molecular Physics, QuAMP 2021
	VERVE Symposium 2018		Harvard University, United States
	45th Veith Symposium 2018		Photonics in Switching and Computing
	EVAS2 Investigators Meeting 2018		Asia Communications and Photonics Conference, ACP
CHEMICAL SCIENCE AND ENGINEERING	EMRS Spring Meeting 2019: European Materials Research Society		University of Münster, Germany
	Annual Meeting of the Belgian Ceramic Society, BCerS		University of Bristol, United Kingdom
	14th International Conference on Modern Materials and Technologies, CIMTEC		Delft University of Technology, Netherlands
	18th International Conference on Plasma Surface Engineering		University of Paderborn, Germany
	11th International Conference on Environmental Catalysis		University of Science and Technology of China, China
	256th ACS National Meeting & Exposition 2018: Nanoscience, Nanotechnology and Beyond		MIT
	IUPAC|CHAINS		University of Copenhagen, Denmark
	MRS Spring		International Workshop on Emergent Relativistic Effects in Condensed Matter
	3rd NanoBio Surfaces and Interfaces in Healthcare and Science		Physics Veldhoven
	4TU Centre for Engineering Education		2nd Alistore European Research Institute Biannual Meeting
	66th AVS International Symposium 2019		5th Workshop on Complex Oxides
	Solliance 2018 meeting		Oak Ridge National Laboratory, USA
	Nordic Femtochemistry Conference 2018		Les Diablerets, Switzerland
			CECAM 2021
			IEEE Photonics Society Summer Topicals Meeting Series

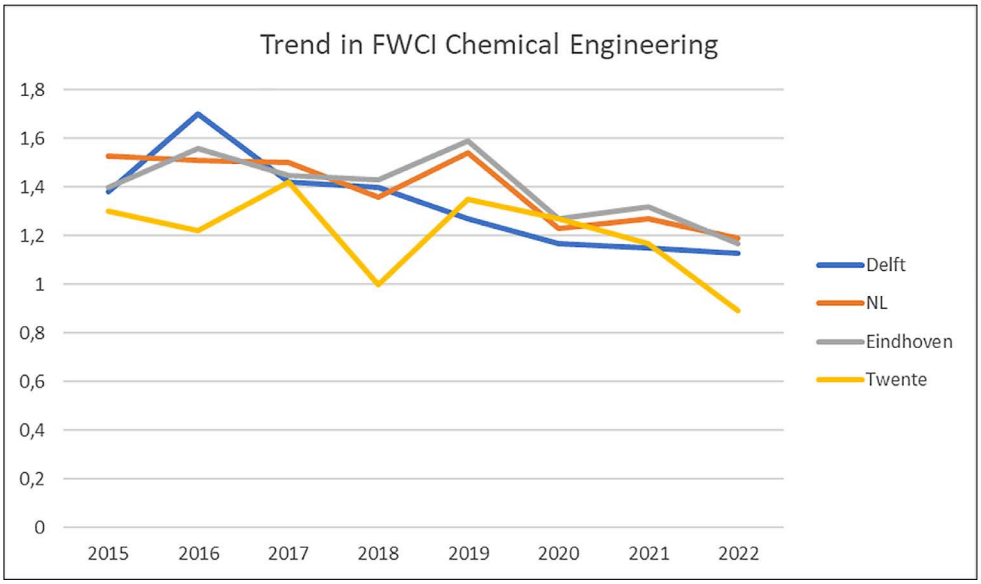
		APPLIED PHYSICS	PRACE 19th SSC Meeting
			Theoretical Chemistry Colloquium
			16th International Congress of Quantum Chemistry
			13th International Symposium on Photonic and Electromagnetic Crystal Structures
			Women in Photonics
			Physics Veldhoven
			EUV Source Workshop
			EUV Source Workshop
			EUV Source Workshop
			SPIE Optics + Optoelectronics 2017
			Conference of Applied Surface Technology
			Plasma Science & Entrepreneurship workshop
			International MicroNanoConference
			Workshop on Nano-electronic Materials
			International Symposium on Future Optics 2019
			SPIE Photonics West 2019
			OSA Advanced Photonics Congress 2018
			Leibniz Institute of Polymer Research Dresden (IPF), Germany
			Applied Industrial Optics 2021
			MPI Polymer days 2019
			Faraday Discussion on Chemical Physics of Electroactive Materials 2017
			Event title253rd ACS National Meeting
			Clarkson University, United States
			IBS Conference on Surface Atomic Wires 2019
			Advanced Research Center for Nanolithography (ARCNL)
			Helmholtz Centre Dresden-Rossendorf (HZDR), Germany
			CRC Colloquium 2019

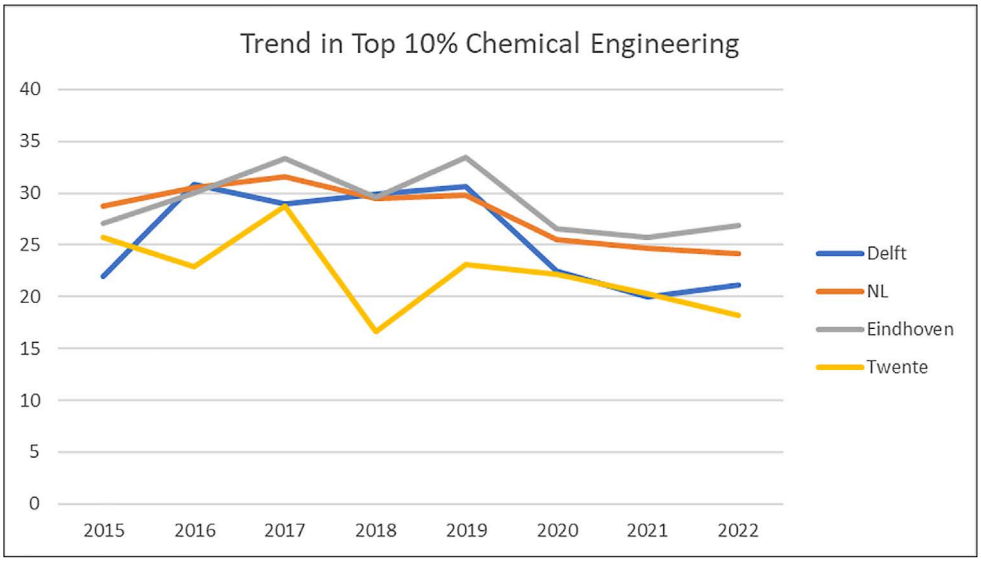


PARAGRAPH 5.1.2: CITATION ANALYSIS OF THE DOMAINS ON THE NATIONAL (DUTCH) LEVEL

Method used:
- Entities Delft University of Technology (TU Delft), Eindhoven University of Technology (TU/e), UT and ''Dutch universities'' selected in SciVal, in combination with the filter for subject areas.
- This selection of fields is ''top down'' by Scopus and does not exactly match the S&T-publications in Applied Physics, Chemical Science and Engineering, and Health. If other UT-faculties publish in these fields, their publications are included in this analysis. And part of the S&T-publications will probably be related to other fields.

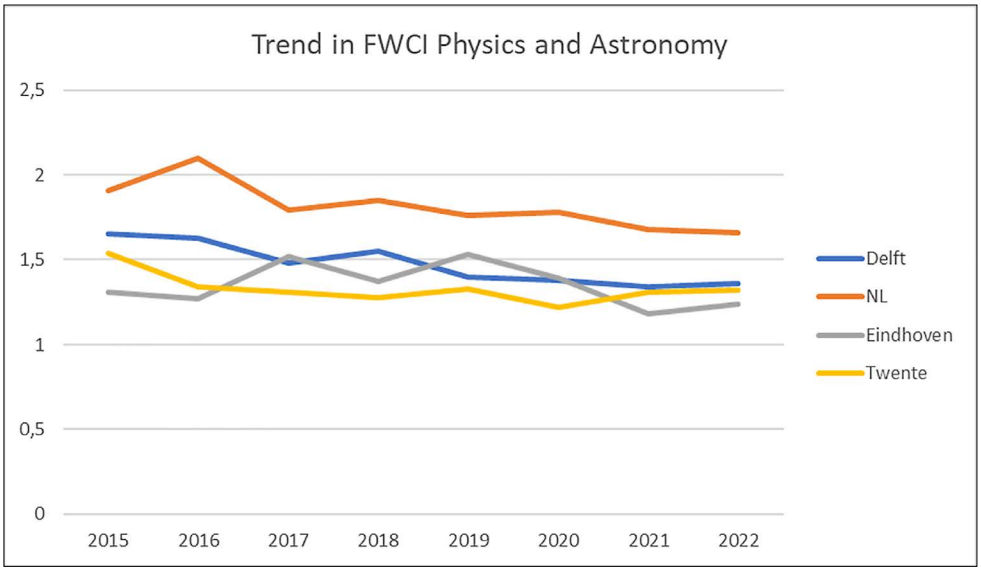
The benchmark shows that the trend for Chemical Science and Engineering declines at all universities in the analysis (see figures 1a and 1b). The common explanation, or part of it, could be a growing competition from Asia.

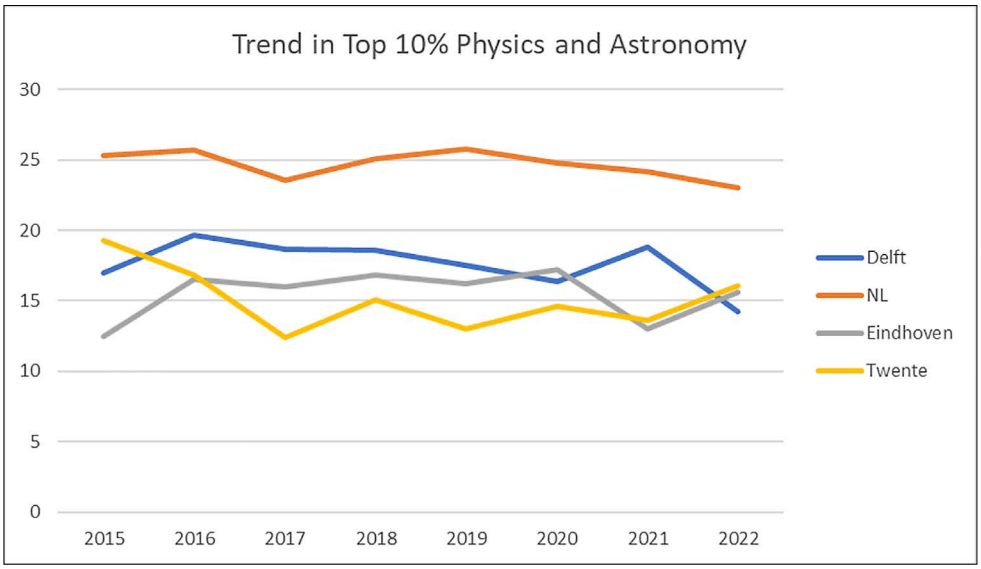




Figures 1a and 1b: Trend in FWCI and Trend in Top 10% for S&T Chemical Science and Engineering compared to other Dutch universities

The subject-area 'Applied Physics' is not available in SciVal, therefore, Physics was chosen (see figures 2a and 2b).

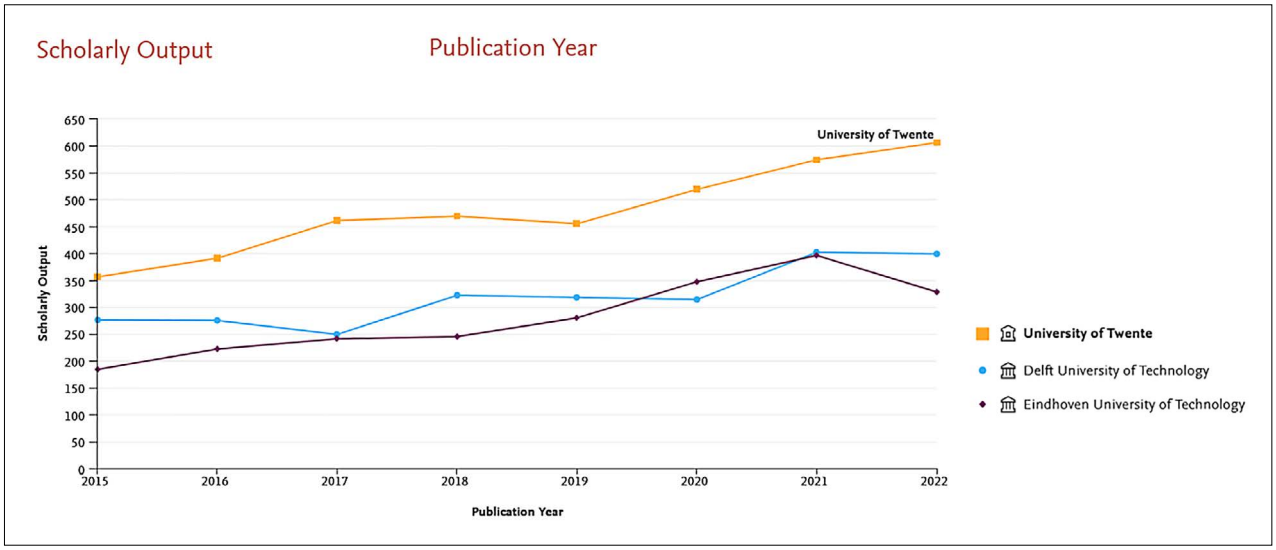


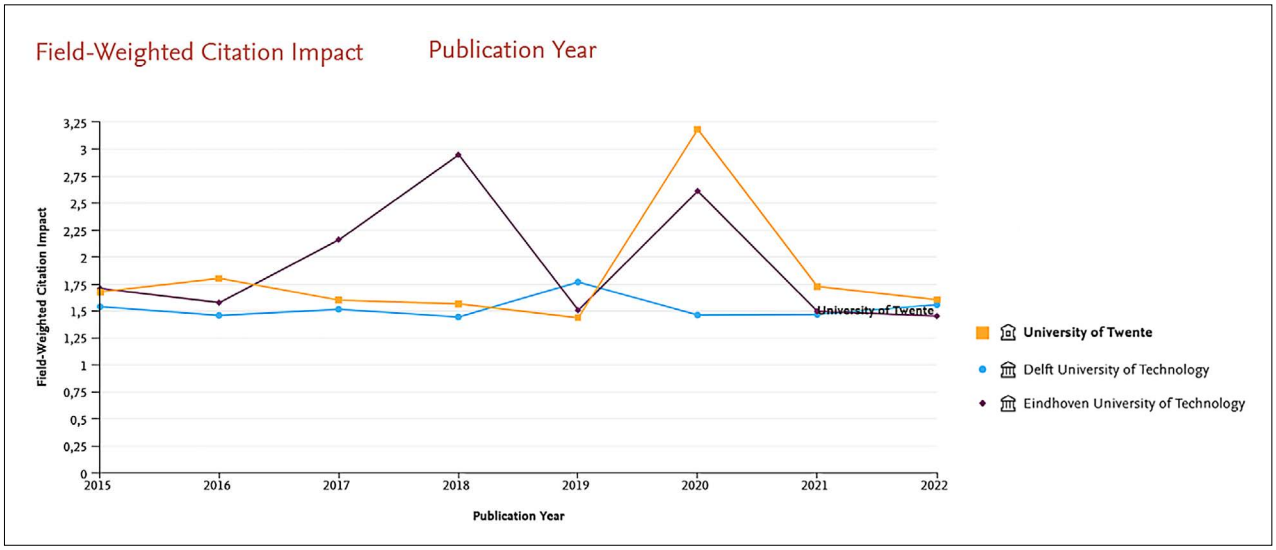


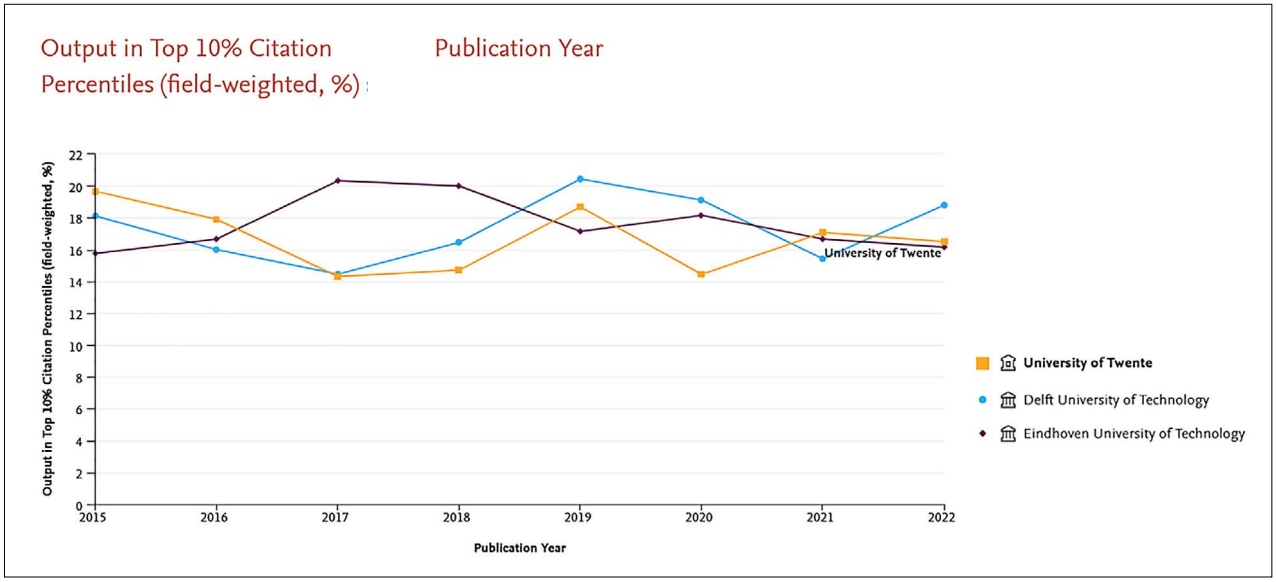
Figures 2a and 2b: Trend in FWCI and Trend in Top 10% for S&T Applied Physics compared to other Dutch universities

The Health domain has its roots in Biomedical Engineering, Technical Medicine, and Health Sciences and not in classical medicine (see paragraph 3.1). There is no filter for 'technical medicine' in SciVal. Consequently, the filter 'medicine' was used. However, the SciVal-subject field-filter for 'medicine' probably leads to the selection of a lot of publications that were written by other UT-faculties.

The results show that the UT has a good citation impact and produces significantly more output than Delft and Eindhoven in this field but performs less good in the most cited publications (see Figures 3a, 3b, and 3c). The ARWU Global ranking of Academic Subjects has a subject-rank for 'medical technology'. In this ranking, the Health domain ranks 150-200 in 2023. The indicator *Category Normalised Citation Impact* (CNCI) is comparable with FWCI. On a scale from 0-100, in 2018 the UT scored 80.2 for this indicator, in 2020 77.0, and in 2023 71.0.







Figures 3a, 3b, and 3c: Trends in Publication output, FWCI, and Top 10% for S&T Health compared to other Dutch universities

APPENDIX D (b) CHAPTER 5 – PARAGRAPH 5.1.3

Table 1: Overview of Research grants awarded to individuals, sorted by research domain

	HEALTH	APPLIED PHYSICS	CHEMICAL SCIENCE AND ENGINEERING	TOTAL
NWO	**11**	**16**	**8**	**35**
Veni	6	5	3	14
Vidi	3	6	3	12
Vici	2	5	2	9
ERC	**5**	**12**	**11**	**28**
Starting grant	3	6	3	12
Consolidator grant		2	3	5
Advanced grant	1	2	1	4
Proof of Concept grant	1	2	4	7
Total	**16**	**28**	**19**	**63**

Table 2: Overview of Grants awarded to major collaborative research projects, sorted by domain

	HEALTH	APPLIED PHYSICS	CHEMICAL SCIENCE AND ENGINEERING	TOTAL
Horizon Europe / 2020	3	8	3	14
NWO Perspectief	3	3	2	8
NWO Crossover*			1	1
NWO Open Competition – XL[a]	2,5	5	0,5	8
NWO KIC		1	3	4
NWO Gravitation	1	1		2
NWA-ORC		2		2
National Growth Fund	3	6.5	3,5	13**
KIA[b]	3	5	3	11
Total	**15,5**	**31,5**	**16**	**63**

* Only applicable for Chemistry

** In several National Growth Funds multiple projects with S&T researchers

[a] One XL grant was shared between Health and Chemical Engineering. This was counted as a 0,5 for both.

[b] From two KIA grants the domain is unknown.

Table 3: Overview of Grants awarded to individuals or collaborative research projects, sorted by domain

	HEALTH	APPLIED PHYSICS	CHEMICAL SCIENCE AND ENGINEERING	TOTAL
NWO XS	2	4	5	11
NWO ECHO*			3	3
NWO M		5	4	9
NWO Open Technology	4	2	1	7
NWO Demonstrator[a]	2	0,5	2,5	5
NWO Take-off	3	5	5	13
NWO Open Mind	3	1	1	5
Total	**14**	**17,5**	**21,5**	**53**

*Only chemistry. The programme has been replaced by the open competition of the NWO Domain Science.
[a] One NWO Demonstrator grant was shared between Applied Physics and Chemical Engineering. This was counted as a 0.5 for both.

Table 4 / SEP Table E3: Funding received by S&T scientists

	2015		2016		2017		2018	
TOTAL	IN K€	IN %	IN K€	IN %	IN K€	IN %	IN K€	IN %
Funding:								
Direct funding (1st money stream)	26,500	47%	29,332	53%	29,806	54%	31,788	54%
Research grants (2nd money stream)	12,418	22%	9,918	18%	11,226	20%	12,092	21%
Contract research (3rd money stream)	17,819	31%	16,085	29%	14,194	26%	15,020	26%
Total funding	**56,738**		**55,335**		**55,226**		**58,900**	
Expenditure:								
Personnel costs	33,394	59%	31,299	57%	31,680	58%	35,056	60%
Material costs	3,291	6%	3,243	6%	3,015	5%	3,516	6%
Other costs	19,860	35%	20,618	37%	20,327	37%	20,328	35%
Total expenditure	**56,545**		**55,161**		**55,022**		**58,900**	

Table 4 / SEP Table E3: Funding received by S&T scientists

	2019		2020		2021		2022	
TOTAL	IN K€	IN %	IN K€	IN %	IN K€	IN %	IN K€	IN %
Funding:								
Direct funding (1st money stream)	32,355	54%	35,959	57%	38,730	56%	42,878	58%
Research grants (2nd money stream)	12,582	21%	11,737	19%	12,877	19%	10,865	15%
Contract research (3rd money stream)	14,525	24%	14,957	24%	17,443	25%	20,451	28%
Total funding	**59,462**		**62,652**		**69,050**		**74,194**	
Expenditure:								
Personnel costs	37,674	63%	41,384	66%	45,180	65%	48,646	66%
Material costs	3,118	5%	2,847	5%	4,048	6%	4,221	6%
Other costs	18,670	31%	18,345	29%	19,822	29%	21,327	29%
Total expenditure	**59,462**		**62,575**		**69,050**		**74,194**	

Table 5: Prizes & Awards PhD candidates, junior, mid-career, and senior scientist, sorted by research domain

TYPE OF RESEARCHER	DOMAIN S&T RESEARCHER	NAME PRIZE/AWARD	YEAR
PhD Candidate	Health	Twente Graduate School Award	2022
		KHMW Young Talent Pfizer Prizes for Life Sciences	2022
		UT PhD Media Award	2022
		2 x 4TU.Health Poster PhD competition	2023
		2 x Best oral presentation TechMed Research Day	2023
		2 x Best poster pitch TechMed Research Day	2023
		Poster prize at the Gordon Research Conference	2023
		First Poster Prize Advanced Functional Polymers for Medicine	2021
		Second Prize FIGON Dutch Medicine Days	2020
		Golden Master Award	2016
		First Poster Prize Pancreas Spring Meeting	2017
		Third Poster Prize CLINAM	2017
		Best Poster Prize NBTE	2016
		First Poster Award at CLINAM	2016
		Best Presentation award NBTE	2020
		Overijssel PhD Award	2019
		Dutch Biophysics BIOPM Thesis Award	2019
		Amsterdam Science & Innovation Award 2016	2016
		1st Prize Poster session Dutch Biophysics	2016
		UT in the Media Award	2023
		Overijssel PhD Award	2020
		Poster award European Molecular Imaging Meeting	2020
		Poster Award Dutch Society for Simulation in Healthcare (DSSH)	2016
	Applied Physics	Best poster prize award European Semiconductor Laser Workshop (ESLW) 2022	2022
		3 x Optica Student Paper Award Optica Advanced Photonic Congress	2022
		Best Regular Oral Presentation International conference on Laser Applications in Life Sciences	2022
		Poster Award Materials Research Society spring meeting	2023
		IEEE CSC Fellowship Award	2016
		IEEE CSC Graduate Study Fellowship	2016
		IEEE CSC Fellowship Award	2015
		SPIE Seno Medical Best Paper	2016
		MUSIM Poster Prize	2023

TYPE OF RESEARCHER	DOMAIN S&T RESEARCHER	NAME PRIZE/AWARD	YEAR
PhD Candidate	Applied Physics	Poster Award EMRS2019	2019
		Best Poster Award EUV Workshop	2019
		Best Poster Award EMRS2018	2018
		Best Poster Award DSL-2018	2018
		3rd place in the Simon Stevin Fellow context	2016
		Best presentation award INASCON 2018	2018
		DUDOC PhD grant Dutch Ministry of Education Culture and Science	2016
	Chemical Science and Engineering	Unilever Research Prize 2022	2022
		KNCV Golden Master Award	2022
		Best poster award 2nd International tandemPV Workshop	2022
		Best presentation prize at the 18th edition of the Netherlands Process Technology Symposium	2023
		Poster Prize International Symposium "Supramolecular Chemistry on Proteins"	2016
		Best poster award Young European Catalysis Network	2023
		Best poster Dutch Polymer Days (DPD)	2019
		Unilever Research Prize	2018
		Marie Curie ERS/EU Respire3 grant from European Respiratory Society (ERS)	2018
		Best poster Dutch Polymer Days (DPD)	2016
		Journal of Materials Chemistry B Poster Prize	2015
		Marcel Mulder prize	2020
		Unilever Research Prize	2020
		Poster Prize International Symposium Insights into Gas Diffusion Electrodes	2019
		Poster Award International Conference on Solid State Ionics	2019
		Hogendoorn award in Fluid Mechanics	2017
		Oral presentation award Euromembrane 2015	2015
		Excellence award in Membrane Engineering Euromembrane 2015	2015
		Brightlands Polymer Days 2021	2021
		Centennial Future Leaders of Polymeric Materials Science and Engineering by the Polymeric Materials (ACS)	2023

TYPE OF RESEARCHER	DOMAIN S&T RESEARCHER	NAME PRIZE/AWARD	YEAR
Junior scientist (PostDoc, Assistant Professor)	Health	Excellence grant in clinical physiology and exercise by European Respiratory Society (ERS)	2016
		Jean Leray Award by European Society of Biomaterials	2020
		Robert Brown Award by TERMIS	2020
		NWO Rubicon grant	2019
	Applied Physics	SPIE 2023 Prism Award Quantum Tech	2023
		QTech 2018 best presentation prize	2018
		Seal of Excellence MSCA-PF	2022
		Cryogenics Best Paper Award	2017
		NWO Rubicon grant	2021
	Chemical Science and Engineering	Senior lecture prize ISIEM conference	2023
		Young Talent Grant Division of Macromolecular Chemistry of the German Chemical Society	2023
		Feodor Lynen Fellowship for Experienced Researchers Alexander von Humboldt Foundation	2021
Mid-career scientist (Associate Professor)	Health	Young Investigator Award American Association for the study of Liver Diseases	2018
		National Scholar Award United European Gastroenterology (UEG)	2017
		Junior Scholar Award Viral Hepatitis Congress	2015
		Poster of Excellence United European Gastroenterology (UEG)	2015
	Applied Physics	UT Social Media Award	2022
		Winner of the 2015 Corrsin-Kovasznay Outstanding Paper award	2016
		FOM Young Energy Scientist Award	2012-2016
		Mulholland award for excellence in cryogenic engineering	2019
	Chemical Science and Engineering	NWO Stairway to Impact award	2021
		KHMW Pieter Langerhuizen Lambertuszoon Benefit	2016
		KNCV Gold Medal	2017
		NWO Athena Award	2016
		Netherlands Society for Biomaterials and Tissue Engineering	2016
		Winner Art in Microtechnology award at MEMS 2023	2023
Senior scientist (Full Professor)	Health	Research Center of Excellence in Osteoarthritis Research award granted by ReumaNederland for a period of 5 years	2023
		Research Center of Excellence in Osteoarthritis Research award granted by ReumaNederland for a period of 5 years	2017
		UT in the Media Award	2017
		Best Pitch Prize NanoTME2021	2021

TYPE OF RESEARCHER	DOMAIN S&T RESEARCHER	NAME PRIZE/AWARD	YEAR
Senior scientist (Full Professor)	Applied Physics	Max-Planck Medal 2019 German Physics Society DPG	2019
		Balzan Prize 2018	2018
		Fluid Dynamics Prize of the American Physical Society (APS)	2017
		Member of the National Academy of Engineering (NAE) of the USA	2017
		Member of the Netherlands Academy of Technology and Innovation	2017
		Aurel Stodola medal ETHzürich	2022
		Samuel C. Collins Award	2023
		Leen van Wijngaarden Prize	2016
		Rolf Landauer Medal of the International ETOPIM Association	2021
		Descartes-Huygens Prize	2015
		IEEE Award in Applied Superconductivity	2016
		Julius Springer Prize for Applied Physics	2018
		European Center of Excellence in exascale computing "TREX"	2020
		American Physical Society outstanding referee	2018
		Outstanding reviewer 2D Materials	2016
	Chemical Science and Engineering	Gold Medal of the Royal Netherlands Chemical Society	2018
		Gordon E. Moore Medal for Outstanding Achievement in Solid State Science and Technology	2023
		Fellowship of the Institute of Advanced Study	2019

Table 6: Memberships of prestigious scientific councils or committees, sorted by research domain

DOMAIN S&T RESEARCHER	SCIENTIFIC COUNCIL OR COMMITTEE	FUNCTION
Health	Controlled Release Society (CRS) chapter for BeNeLux and France region	President elect
	European Association of Nuclear Medicine (EANM)	Member of the Oncology & Theragnostic Committee
	European Organisation for Research and Treatment of Cancer (EORTC) Imaging Group	Board member
	European Society of Artificial Organs	President elect
	European Society of Artificial Organs (ESAO)	Board member
	EUTox working group „European Society of Artificial Organs" (ESAO)	Member
	Interdisciplinary Center for Clinical Movement Sciences & Technology (ICMS)	Co-programme leader
	International Cartilage Regeneration and Joint Preservation Society (ICRS)	Board member
	KNAW	Member
	KNAW The Young Academy	Member
	National 'Organ-on-Chip' consortium	UT representative
	ZonMw/NWO/NHS	Committee member
	Finnish Academy of Science (health panel)	Member scientific advisory committee
	Lorentz center in Leiden for the Life and Medical Sciences	Member scientific advisory board
	Dutch Society for Biochemistry and molecular Biology (NVBMB)	Board member
Applied Physics	4TU Materials	Board member
	4TU HTSF programme Precision Medicine	Programme leader
	American Physical Society (APS)	7 x APS Fellows
	AMO (Atomic and Molecular Optics) section of the Dutch Physical Society	Chair of the governing board
	APS Fluid Dynamics	Chair (2021-2022)
	Burgerscentrum – Dutch Research School for Fluid Mechanics	Executive board
	Dutch Foundation for Research on Matter (FOM)	Board member
	Dutch Physical Society	Executive board
	Dutch Physics Council	Executive board
	FAIR-DI	Deputy Speaker
	FOM Advisory Committee on Phenomenological Physics	member
	General Assembly of IUTAM	Chairman
	German Academy of Science Leopoldina	Member
	HFML-FELIX	Member Scientific Advisory Council
	IUTAM Fluid Mechanics Symposia Panel	Chairman
	KHMW	3 x Appointed member
	KNAW	5 X Member

DOMAIN S&T RESEARCHER	SCIENTIFIC COUNCIL OR COMMITTEE	FUNCTION
	KNAW-NIN (NETHERLANDS INSTITUTE FOR NEUROSCIENCE)	Scientific Advisory Board Member
	Lorentz Center	Chair and member Scientific Advisory Board
	Max-Planck Society	Member
	NanoNextNL 3C Nanomedicine/Molecular Imaging	Programme director
	National Academy of Engineering (NAE) USA	Member
	Netherlands Academy of Technology and Innovation	Member
	NWO ARC–CBBC	elected member
	NWO Council for Physics	Board member
	NWO Programme Committee KIC	Member
	NWO Science Advisory Committee on Fluids and Soft Matter	Member
	NWO-ENW working groups 'Fundamentals& Methods of Chemistry' and 'Chemistry of materials'	Member
	Optical Society of America	4 x OSA Fellow
	QSOLID RESEARCH PROGRAMME GERMANY	Member Scientific Advisory Council
Chemical Science and Engineering	Aalto University School of Chemical Engineering	Scientific Advisory Board
	American Chemical Society	2 x Member
	DECHEMA	Member
	EFCE Working Party on Fluid Separations	Member and Secretary
	European Society for Molecular Imaging	Study group chair
	General assembly of the European Federation of Chemical Engineering	Representative of the Royal Dutch Chemical Society
	Global Young Academy	Chair
	Global Young Academy	Member
	Institution of Chemical Engineers (IChemE)	Member
	KHMW	Appointed member
	Leibniz Institute for New Materials	Scientific advisory board member
	Materials Research Society	Member
	NPT (Netherlands Process Technologists)	Member
	NWO Round Table Chemistry	Chair
	Royal Chemical Society	Member
	Royal Dutch Chemical Society (KNCV)	Member
	Royal Netherlands Chemical Society (KNCV)	Executive
	Royal Society of Chemistry	Fellow
	Singapore National Institute of Chemistry	Member
	Young Academy of Europe	Secretary

Table 7: Memberships of editorial boards, sorted by research domain

DOMAIN S&T RESEARCHER	JOURNAL
Health	Journal of Cartilage and Joint Preservation
	Applied Biology of Academia.edu.
	The International Journal of Artificial Organs
	Artificial Organs
	Biomedicines
	Advanced Drug Delivery Reviews
	Oncology-up-to-date
	Diagnostics
	Scientific reports
Applied Physics	Journal of Fluid Mechanics
	Annual Reviews of Fluid Mechanics
	Science Advances
	Physica D
	Nonlinearity
	Journal of Turbulence
	Journal of Statistical Mechanics - Theory and Experiment
	Physik Journal
	Zeitschrift f˙ur Naturforschung
	Energies
	Physical review A - atomic, molecular, and optical physics and quantum information
	Physical review letters
	Science Magazine
	Physical Review Fluids
	Nature Reviews Physics
Chemical Science and Engineering	Crystals
	iScience
	The Innovation Materials
	European Polymer Journal
	Molecules
	Macromolecular rapid communications
	Industrial & engineering chemistry research

Table 8: Examples of media attention aimed at a professional and/or general audience for S&T research products, use of products, and marks of recognition

ASSESSMENT DIMENSION	DOMAIN	LINK
Research product	Chemistry	De mug als patiënt in de strijd tegen malaria | BNR Nieuwsradio
Research product	Health	Een doorbraak in de zoektocht naar een artrosemedicijn: het gebruik van lamabloed! - Fragmenten - Video's - Koffietijd
Research product	Health	https://twitter.com/i/status/1582806581359480834.
Research product	Physics	QuiX Quantum featured on national television channel RTL Z: https://www.youtube.com/watch?v=QpyNcvMXycE
Research product	Health	Biotechnologiebedrijf uit Raalte hoopt met lama's medicijn te vinden tegen artrose - RTV Oost
Research product	Physics	Nederlands bedrijf maakt krachtigste fotonische kwantumcomputer ter wereld | RTL Nieuws
Research product	All	Laat je hersenen kraken in de Universitent! | Zwarte Cross
Research product	All	De line-up van de Universitent is bekend! | Zwarte Cross
Research product	Physics	UT-hoogleraar Alexander Brinkman genomineerd voor verkiezing Wetenschapstalent 2015 - RTV Oost
Research product	Chemistry	Biochemicus UT doet samen met Amerikaanse Nobelprijswinnaar onderzoek naar Alzheimer - RTV Oost
Research product	Chemistry	Empathy: Enabling students to be entrepreneurs - Features - The Chemical Engineer
Research product	Health	Synthetic Organs: We're One Step Closer to Having Bioartificial Kidneys (futurism.com)
Research product	Health	Kunstmatige alternatieven voor vitale organen | De Ingenieur
Research product	Health	Nieuwe hoogleraar UT ontwikkelt kunstmatige organen van biomaterialen | ICT&health | Het innovatieplatform van de zorg. Voor de zorg. (icthealth.nl)
Research product	Health	Implantaat helpt epilepsiebehandeling | De Ingenieur
Research product	Physics	New Dutch silicon nitride photonics company, QuiX, aims at quantum computing | Laser Focus World
Research product	Physics	Sustainable separation technology makes new applications possible (phys.org)
Research product	Chemistry	Twente helpt batterijtechniek vooruit - IO (innovationorigins.com)
Research product	Chemistry	Solar Magazine - 'Te lang te weinig aandacht voor batterijen, maar tij is gekeerd'
Research product	Chemistry	Solar Magazine - BatteryNL wil binnen 8 jaar nieuwe generatie batterijen ontwikkelen
Research product	Chemistry	New method for separating molecules - IO (innovationorigins.com)
Research product	Health	University of Twente opens new bioimaging centre | Science|Business (sciencebusiness.net)
Research product	Chemistry	Brain pulses instead of zeros and ones - our weekly recap - IO (innovationorigins.com)
Research product	Physics	UT gaat draagbaar apparaat ontwikkelen voor vroege detectie diabetes - Engineers Online

ASSESSMENT DIMENSION	DOMAIN	LINK
Research product	Physics	UT researchers use sound to filter light – Bits&Chips (bits-chips.nl)
Research product	Physics	Photonic filter enables next-generation mobile network (6G) - IO (innovationorigins.com)
Research product	Physics	Chip meet hoe goed virussen hechten aan een cel | De Ingenieur
Research product	Physics	Nano plates for solar fuels (nanowerk.com)
Research product	Chemistry	Universiteit Twente ontwikkelt zonnepaneel dat brandstof maakt van licht - Duurzaam Ondernemen (duurzaam-ondernemen.nl)
Research product	Chemistry	'Artificial tree' could help save excess solar and wind power (imeche.org)
Research product	Health	(108) Hoe data artsen helpt bij moeilijke beslissingen - YouTube (for English subtitles > Settings)
Research product	Chemistry	Professor Christian Nijhuis traint slimme moleculen als hersenen: energiezuinige primeur snelt de wereld over | Enschede | tubantia.nl
Research product	Health	Kan de screening van borstkanker nog beter? Vijf methoden waaraan Nederlandse onderzoekers werken (volkskrant.nl).
Research product	Health	Professor Marcel Karperien uit Enschede voelt hete adem; er is geen behandeling bij versleten knie | Regio | tubantia.nl
Research product	Health	1,5 miljoen euro subsidie om artrose tegen te gaan - Horses
Research product	Chemistry	Vaccineren zonder naald: een perfecte vinding van UT-docent, maar het kan nog nét niet | Enschede | tubantia.nl
Research product	Health	Nieuw hemodialysefilter verwijdert meer afvalstoffen - Nierstichting
Research product	Health	Mannen en vrouwen hebben verschillende hersenritmes - Mijn Gezondheidsgids
Research product	Physics	'Elke multinational is bezig met kwantum' (fd.nl)
Research product	Chemistry	Doorbraak in zuiveren drinkwater dankzij UT in Enschede | Enschede | tubantia.nl
Research product	Chemistry	Twentse uitvinding moet einde maken aan tijdrovende acculaden voertuigen: 'dit is een doorbraak' | Enschede | tubantia.nl
Research product	Health	Nienke Bosschaart: 'Op een congres over borstvoeding in Florence beleefde ik een aha-moment' (parool.nl)
Research product	Chemistry	Professor Christian Nijhuis traint slimme moleculen als hersenen: energiezuinige primeur snelt de wereld over | Enschede | tubantia.nl
Use of product	Physics	University of Twente important role in cryogenic cooling of the Einstein Telescope (utwente.nl)
Use of product	Physics	Hans Hilgenkamp - LINK (linkmagazine.nl)
Use of product	Health	University of Twente and University Medical Center Utrecht join forces | Science|Business (sciencebusiness.net)
Use of product	Chemistry	Empathatic Engineering – THE MISSING INGREDIENT (empathic-engineering.com).
Use of product	Physics	Nederland volgt te weinig de wetenschap als het om aerosolen gaat, vindt deze Duitse natuurkundige (trouw.nl)
Use of product	Physics	Kritische hoogleraren vinden de wetenschappelijke basis van coronamaatregelen onhelder | medischcontact
Mark of Recognition	Chemistry	Rebecca Saive | MIT Technology Review

ASSESSMENT DIMENSION	DOMAIN	LINK
Mark of Recognition	Chemistry	David Fernandez Rivas wint de Prins Friso Ingenieursprijs | De Ingenieur
Mark of Recognition	All	Vijf vrouwelijke UT-toppers in Viva-lijst van rolmodellen: 'Ik vind het een eer' | Enschede | tubantia.nl
Mark of Recognition	Chemistry	Rebecca Saive Global Innovator under 35 (utwente.nl)
Mark of Recognition	Health	Hoogleraar UT wordt ambassadeur Netherlands Heart Institute | Enschede | tubantia.nl
Mark of Recognition	Chemistry	Interview Saskia Lindhoud – 'I want to sit at the right tables' | NWO

Table 9: Spin-off companies originating S&T research groups
Font color: Health / Applied Physics / Chemical Science and Engineering

NAME SPIN-OFF COMPANY	WEBSITE	BUSINESS OF THE COMPANY	FOUNDING YEAR
PA Imaging BV	PA Imaging – Painless breast cancer diagnostics for all women (pa-imaging.com)	Developing a next-generation painless and improved breast cancer screening and diagnostics, even suitable for young women	2010
20 Med Therapeutics BV	20Med Therapeutics | polymeric Nanoparticles for RNA and DNA delivery (20medtx.com)	Developing RNA and DNA based vaccines and therapeutics based on proprietary bio-responsive polymeric Nanoparticles.	2011
VyCap BV	VyCAP | solutions to enumerate, isolate and analyze rare single cells	Equipment and in-house turn-key services to isolate, enumerate, and analyse rare single cells.	2011
My Life Technology BV	MyLife Technologies	Pioneering porous ceramic microneedles for painless and efficient vaccine delivery through the skin.	2012
H2Care BV	Hy2Care® | Hydrogel implant for enabling cartilage recovery	The CartRevive™ hydrogel implant has been developed for functional recovery of cartilage defects in joints.	2014
Solstice Pharmaceuticals BV	Home | Solstice Pharma - Ultrasound Contrast Agents	Production and commercialisation of next-generation diagnostic and therapeutic ultrasound products.	2014
Eurekite BV	Home - Eurekite	Flexiramics® is revolutionary technology that allows the creation of products that have the unique and novel characteristics of being pure ceramic and flexible.	2015
LipoCoat BV	LipoCoat - LipoCoat - Bio inspired coatings	Specialised in 'bio-inspired' coatings that improve the safety, comfort, and performance of devices with a focus on health and nutrition.	2016
NX Filtration BV	NX Filtration - NX Filtration	Sustainable solutions for filtration applications.	2016
ScarTec Therapeutics BV	ScarTec Therapeutics BV (scartec-therapeutics.com)	Developing novel therapeutics against clinical indications with unmet clinical needs, mainly focused on fibrosis and tumour stroma.	2017
SpectriS.dot BV	SpectriS-dot B.V.	Developing non-toxic semiconductor quantum dots - SQ-dots - with efficient and tuneable emission, prepared from abundant raw material resources.	2017
IamFluidics BV	Next-generation microparticles for a healthier world | IamFluidics	Microparticles for pharmaceutical, biomedical, cosmetic, and food applications.	2018

NAME SPIN-OFF COMPANY	WEBSITE	BUSINESS OF THE COMPANY	FOUNDING YEAR
Orthros BV	Orthros Medical - Exploring the VHH opportunity (orthros-medical.com)	Developing VHH based therapeutics and diagnostics for animal and human health.	2018
QuiX Quantum BV	QuiX Quantum - Home	Market leader in photonic quantum computing.	2018
Sulis Polymers BV	Home - SULIS POLYMERS	Increasing the value of polymer based products by developing additives, offering state-of-the-art analysis and Characterisation support, and enhancing properties of designer engineering plastics in areas relevant for improving life for everyone.	2018
River Biomedics BV	River Biomedics – Closer to the heart	New in vitro cardiac models for compound screening of pharmaceuticals and toxicants.	2019
Encytos BV	Encytos	In vitro cell culture platform for research, drug testing, toxicity screening, or advanced personalised medicine.	2021
EMI BV	EMI Twente – EMI Twente (emi-twente.nl)	Confidential contract research directly with industry in the field of membrane science and technology.	2021
FlowBeams BV	Home - Flowbeams	FlowBeams is developing a revolutionary needle-free injection technology that promises to transform multiple industries, including pharmaceutics and cosmetics.	2021
Aluvia Photonics BV	Aluvia Photonics	UV photonics integrated circuits.	2022
Superlight Photonics BV	SuperLight Photonics	Leading innovator in laser technology, specialises in the development of supercontinuum generation lasers.	2022
ReCarbn BV	ReCarbn | Reversing global warming using Direct Air Capture	Direct Air Capture technology to remove gigatons of CO_2 from the atmosphere.	2022
Chiron BV	Chiron | Leaders in on-chip biotechnologies (chrn.co)	Offers scalable production of custom design organ-on-chip devices.	2022

Table 10: A selection of S&T's societal partners

DEPARTMENT(S) (RESEARCH GROUP)	NAME GRANT/ PROJECT/	LINK
MolMat (BNT)	NWO TTW Perspectief ReCoVR (programme lead)	Avebe, ArcelorMittal, Aquabattery, Corbion, Dow Benelux BV, Firmenich, FTRJ, Greencovery, Hogeschool Saxion, Hoogheemraadschap Hollands Noorderkwartier, Inopor-Rauschert, Institute for Sustainable Process Technologies, KWR, NL GUTS, Plastic Soup Foundation, Proxcys, Recell, Sustainable Food Initiative, Technische Universiteit Delft, Technische Universiteit Eindhoven, TenCate Outdoor Fabrics, TKI Agri-Food, TNO, Turtle Tree Labs, Universiteit Twente, Wageningen University & Research, WaterCircle.be, Water Europe, Water Future, Waterschap Maas en Aa
MST	NWO TTW Perspectief SALTISolutions (partner)	Arcadis, ARK, Boskalis, Bureau Waardenburg, BAM, Deltares, Evides, Flanders Hydraulics, Havenbedrijf Amsterdam, Havenbedrijf Rotterdam, HKV, Hoogheemraadschap van Rijnland, Hoogheemraadschap van Schieland en de Krimpenerwaard, Hydrologic, Koninklijk NIOZ, Nortek-NL, Ministerie van Infrastructuur en Waterstaat, Rijkswaterstaat, Royal HaskoningDHV, STOWA, Svasek, Technische Universiteit Delft, Technische Universiteit Eindhoven, Universiteit Twente, Universiteit Utrecht, Van Oord, VEMW, VEWIN, Wageningen Universiteit, Waterschap Hollandse Delta, WNF
PoF	NWO-TTW Perspectief MIST (programme lead)	MARIN, NLR, Radboudumc, TNO, TU Eindhoven, TU Delft, UMC Groningen, Universiteit van Amsterdam, Arcadis, BAM, Carrier, Euromate, Greensol, Hiensch Engineering, Heinen & Hopman, I-Vention, Medspray, Novaerus, Philips, PlasmaMade, Signify, Virobuster, ArtiZ, CCN, KHN, KNHB, KNLTB, NS, PO-raad, REHVA, Rijksvastgoedbedrijf, RIVM, Sportinnovator, TVVL, VLR, VO-raad
BET (DBE)	NWO-TTW Perspectief Oainject (programme lead)	ErasmusMC, Maastricht UMC+, Radboudumc, TU Delft, Universiteit Maastricht, UMC Utrecht, Chondropeptix, DSM Biomedical, IBIS Technologies, InnoCore Pharmaceuticals, 20Med Therapeutics, Nordic Bioscience, Orthros Medical, Procore, QVQHolding, Ssens, Deventer Ziekenhuis, ReumaNederland, Stichting Proefdiervrij
NEM (ICE)	NWA-ORC Netherlands Initiative for Energy-Efficient Computing (NL-ECO) consortium (programme lead)	Radboud Universiteit, Rijksuniversiteit Groningen, TU Eindhoven, TU Delft, Fontys Hogescholen, Saxion Hogeschool, AMOLF, ASTRON, TNO, ASML, IBM Zurich Research Lab, Toyota Motor Europe, Thales, IMEC Leuven, IMEC Eindhoven, Smart Photonics, LioniX International BV, PITC, VSPARTICLE, Surf, TSST, European Space Agency, Green IT Amsterdam, Gemeente Westerkwartier, Amsterdam Economic Board, HQ Graphene, Örebro University, Uppsala University, Jülich Research Center, Max-Planck Institute for Microstructure Physics, NL Digital en Science LinX
NEM (IMS)	NWA-ORC BatteryNL consortium (partner)	University of Groningen, Fontys, Universiteit van Amsterdam, TUDelft, Hogeschool Rotterdam, Utrecht University, Eindhoven University of Technology, University of Applied Sciences Utrecht, Meet, Saxion Hogeschool, Hanze University of Applied Sciences, VDL, Energy Storage NL, Spacial ALD Innovators, Shell, ANWB, POWALL, E-magy, Air Liquide, New Energy Coalition, LionVolt, Eurosupport, Forschungszentrum Jülich, Reliance Lithium Werks, VSParticle, Holst Centre, TNO, Durapower, Solvis, Automotive Industry NL, InnoEnergy, DNV, PTG Eindhoven, LeydenJar
ANP (AQO)	National Growth Fund - Quantum Delta (partner)	QuTech (TU Delft and TNO), QuSoft (UvA and CWI), QT/e (Technische Universiteit Eindhoven), aQa (Universiteit Leiden), TNO, NanoLabNL, MinacNed, NanoNextNL, Braventure en Techleap, ministeries van Economische Zaken en Klimaat, Onderwijs, Cultuur en Wetenschap, Defensie en NWO
NEM (IMS) / MolMat (MNF) / CE (PCF, SPT)	National Growth Fund - Battery Competence Cluster NL (partner)	Brainport Development, RAI Automotive Industry NL, VDL Groep, DAF Trucks, Damen Shipyards, ELEO, NMT, TU Eindhovenn, TNO en Provincie Noord-Brabant

DEPARTMENT(S) (RESEARCH GROUP)	NAME GRANT/ PROJECT/	LINK
NEM (IMS)	National Growth Fund - SolarNL (partner)	MCPV, HyET Solar, Solarge, Exasun, Energyra, Lightyear Layer, IM Efficiency, TNO, AMOLF, universities of Amsterdam, Delft, Eindhoven, Groningen, Utrecht and Twente
TechMed	National Growth Fund - DUTCH (partner)	Amsterdam UMC, Erasmus MC, Universitair Medisch Centrum Groningen, Leids Universitair Medisch Centrum, Radboud Universitair Medisch Centrum, Universitair Medisch Centrum Utrecht, Technical university Delft, University of Twente, University of applied sciences Rotterdam, University of applied sciences Zuyd, University of applied sciences Arnhem- Nijmegen, ACTA, University of applied sciences Amsterdam, University of applied sciences Saxion, University of applied sciences Fontys, Amsterdam Skills Centre for Health Sciences, Amstel Academy, Erasmus Care academy, Health-Holland, NFU, NVZ, NVIC, Defence, Dutch Society for Surgery, Dutch Orthopedic Society, Dutch Society of Anaesthesiology, Dutch Society of Orthopedics, Dutch Society for Plastic Surgery, Microsoft, Incision Group BV, LeQuest, SyncVR MEXR, SIMtoCare, Senseglove, eX:plain, Rods & Cones, Hogeschool Saxion, Xpertise BV, Truesim BV, ACTA, Laerdal, The Simulation Crew, Stryker Netherlands BV, Amsterdam Skills Centre for Health Sciences, MLX BV, Johnson & Johnson, Medtronic, SAS Institute BV
e.g., MolMat (MNF), CE (CPM), BET (AOT, AST), NEM (IMS, XUV), PoF, MI&D (M3I), BET (DBE), MolMat (BNT) (different projects)	National Growth Fund - NXTGEN Hightech	MEC, Malvern Panalytical, ASML, Demcon High Tech Systems, Demcon Multiphysics, Seno Medical, ReumaNederland Foundation, RadboudUMC, Sint Maartenskliniek Research, Reumastichting Sint Maartenskliniek, Roessingh R&D, ATRO Medical, Moveshelf, Twente Graduate School, Dutch Ministry of Defence, Hogeschool Saxion, LionX, AviVet B.V.
NEM (XUV)	different projects	closely involved with high-tech research and development at, for example, ASML Research, Carl Zeiss SMT, Malvern Panalytical, TNO and SolMateS
NEM (EMS)		e.g., ITER, CERN, ESA, ET, EUROFusion, Demcon, VDL, Thales, Cool SES, Demaco, Cryoworld, Airbus DS, ASML
PoF	industrial partners/ different projects	e.g., Canon, ASML, Schering AG, Bracco, Bosch AG, ITER on nuclear fusion), Shell, DSM, Corus, Akzo Nobel, Philips Medical Systems, TNO, LAM
ANP	PhotonDelta (partner)	e.g., Synopsys, ASML, AIXTRON, Solmates, Tyndall, IMS, CITC, MicroAlign, LioniX
MST	many co-operations via, for example, Europeon Membrane Institute	e.g., AGFA, Aquaporin, Arla Foods Ingedients, Chevron, Eastman, Fuji Film, SOLARDEW, NX Filtration
CE		e.g., DSM, Johnson Matthey, BASF, BioMCN, Shell, Micromeritics, Exxon Mobil, Micronit Microfluidics, Avantium

Table 11: S&T memberships of civil society advisory bodies

DOMAIN	ADVISORY BODY
Health	Nizo food research
	PUM
	Ministry of Health, the Hague
	European Commission on Public Health, Brussels
	Dutch Cancer Society
	Prix Galien MedTEch Innovation Award
	Bioneedle
	Clinical Science Systems
	Netherlands Heart Institute ambassador
	ReumaNederland
Applied physics	European Technology Platform Photonics21
	NextGen HighTech supervisor board
	FLUXONICS Board member
	De Maatschappij
	Syllabus Physics Committee (secondary education)
	Aplife Biotech
	Ecsens
Chemical Science and Engineering	Start4big ambassador
	MinacNed
	COAST
	Beroepenveldcommissie / Occupational Field Committee Saxion
	Stichting TOF (education)
	Schering Foundation
	BEON foundation
	ReCarbn
	Royal Dutch Institution for Engineers (KIVI)

Table 12: Public Prizes for S&T staff members

Prizes & awards by society	Health	Hind Rattan Award	2019
		Indonesia Endowment Fund for Education (LPDP) fellowship	2015
	Applied physics	The Photonics 100 list as the industry's most innovative people	2022
		Academic Startup Competition (ASC)	2022
		Engineering talent KIVI institute for engineers	2018
		Viva 400	2018
		Google Cloud for Research Award	2023
		FOM Valorisation Section Prize	2016
		Best Poster Award ASML Networking Event	2018
	Chemical Science and Engineering	Magic 50 Award Dutch Innovation Days	2022
		ACEEU Triple E Awards Finalist “Male Entrepreneurial Leader of the Year"	2022
		Prince Friso Engineering Prize Royal Institute of Engineers (KIVI)	2021
		KIJK Top Tech Ideas for eNose for the early detection of potato rot	2019
		HiTMaT Technology Award for eNose in early detection of animal diseases	2019

APPENDIX D (c) CHAPTER 5 - PARAGRAPH 5.4 STATE-OF-THE-ART RESEARCH FACILITIES

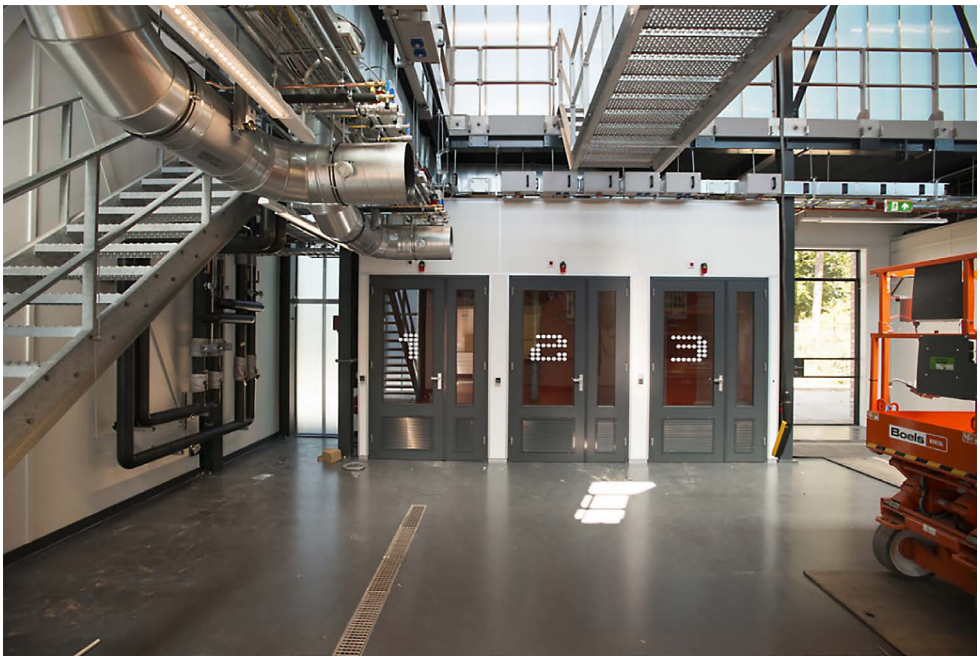
MESA+ NANOLAB

The MESA+ Institute for Nanotechnology is one of the world leading institutes in the field of nanotechnology, focusing on societal challenges in the fields of Health, AgriFood & Water, Security and Energy & Sustainability. To do so, research is performed on key enabling technologies, such as nanotechnology, advanced materials, micro- and nano-electronics, lab-on-a-chip, photonics, biomolecular and polymer science, microfluidics, novel cross-overs and devices with TRL 4-6. The MESA+ Institute hosts over 500 researchers and delivers high quality, frequently groundbreaking research. MESA+ is keen on collaboration with external partners and actively searches for such collaboration. It is part of NanoLabNL, the Dutch facility for nanotechnological research and development, which offers facilities and expertise to universities, research institutes, startups and industry at one of its five locations, Twente being one of them. The embedment of MESA+ within NanoLabNL allows for connection to an extensive network of companies and institutions for innovation and commercialisation.

Many of the research groups within the S&T faculty are part of the MESA+ Institute for Nanotechnology. As such, they can make use of both the hard and the soft infrastructure the MESA+ Institute provides. One of the most important facilities employees can make use of is the MESA+ NanoLab. It compromises a 1250 m2 cleanroom (ISO 5/ ISO 7) and an area of 1000 m2 containing both specialised analysis equipment and dedicated research group labs in a well-controlled environment. 800 m2 of the NanoLab has a vibration-free floor (VC-G), eliminating influences from the environment such as vibrations and electromagnetic disturbances. The cleanroom hosts five process platforms for research and pilot production: electronics, 3D nanoshaping, photonics, MEMS/NEMS and fluidics. S&T faculty members can make use of the cleanroom facilities at an hourly rate. Outside of the cleanroom, high quality characterisation tools are available as well, including a high-resolution SEM, a high-resolution (S)TEM, a dual-beam FIB, a state-of-the-art XPS instrument and high-resolution XRD. Many of these equipment tools are operated by specialised operators. Employees of the faculty of S&T can make use of these facilities as well at a cost. Finally, there are labs dedicated to research groups who benefit from the well-controlled conditions of the NanoLab building. 4 out of 5 research chairs are part of S&T, and the last one (part of the EEMCS faculty) has strong connections to S&T.

HIGH PRESSURE LAB

In addition to the NanoLab and the TechMed Centre, the UT hosts a separate building for a High Pressure Lab. This state-of-the-art research facility is unique within the Netherlands (equipped with e.g., a high-pressure hydrogen network operating at 600 bar) and allows for research at more extreme process conditions in eight concrete high pressure boxes, as well as hosting larger, pilot plants in a larger process hall, next to several low pressure boxes for smaller units. The High Pressure Lab is available to all UT research groups and is being run by the Sustainable Process Technology (SPT) group. Research focusses amongst other things on plastic recycling, biomass liquefaction and upgrading to chemicals and materials, thermo-chemical conversions, CO2 capture (esp. from air) and conversion to e.g., methanol, etc. The High Pressure Lab with its flexible team of technicians allows researchers to realise their envisaged processes through custom-built lab-units at (typically) a scale of around 1 kg/h.



TECHMED CENTRE (INCLUDING BIOIMAGING CENTRE)

The Technical Medical Centre (opened in 2019) has state-of-the-art infrastructure to support its research and education of the faculty of S&T on Health-related topics. Its facilities range from high-tech research labs for early-stage research & development activities to simulated healthcare environments with real medical equipment that can be used for training of professionals or as a testbed for preclinical studies. The TechMed Centre can also facilitate access to the medical facilities of an extensive network of clinical partners that can be used for research and training. In this way, it is possible to support the development of MedTech innovations from very early (TRL 1-2) to pre-production maturity levels (TRL-5-6). The Zuidhorst and the Technohal buildings at the UT campus accommodate the great majority of this infrastructure.

The bioengineering labs are based in the Zuidhorst Building. They are comprised of 650 m2 of class ML1 and ML2 cell biology labs, 550 m2 chemical labs and approximately 600 m2 physics labs. These labs are fully equipped for experimental work with new biomaterials, applied stem cell technologies, development of injectable hydrogels and artificial organ technologies. The combination of the bioengineering lab infrastructure and MESA+ nanotechnology expertise and cleanroom facilities provide an excellent breeding ground for organ-on-a-chip developments.

A specific example of novel shared infrastructure is the BioImaging Centre, a ML1/ML2 facility for advanced microscopy of living cells. Four S&T research groups form the core of this facility, while other UT and external researchers have access to the facility for a cost-covering hourly rate. Highly qualified, specialised research support is offered for specific research lines, for example on experimental high-resolution microscopy of live tissues, which is made possible by the pooling of resources and expertise from the different contributing chairs.

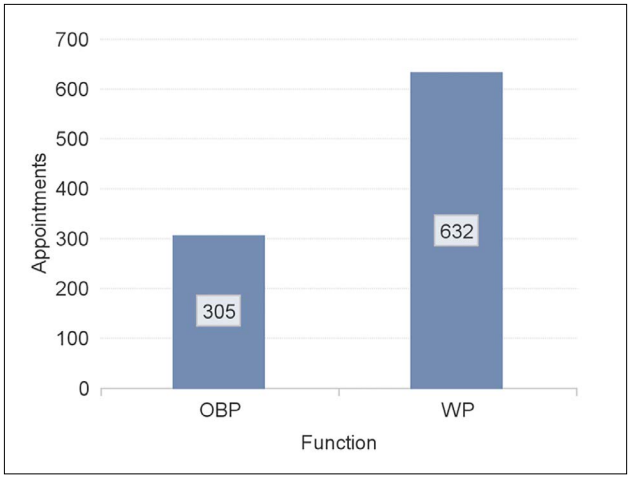
The Technohal building houses a multi-role simulation centre, which is used for research, education, and innovation activities. It is comprised of realistic, simulated healthcare environments (eHealth House, 2 hybrid operating theatres, 2 intensive care units, medical imaging facilities) and fully equipped simulation rooms with a variety of part task trainers and video observation and debriefing facilities.

ORGAN-ON-A-CHIP CENTRE

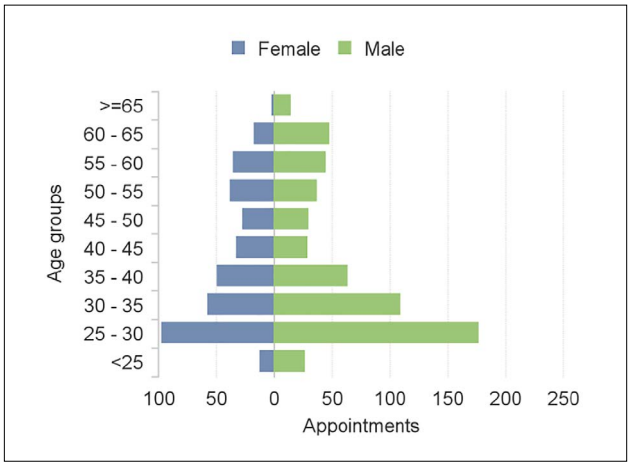
Recently, the University of Twente has received a funding of 3 million Euros to set up a unique national facility for an Organ-on-Chip Centre. The application for this funding was made by members of the faculties of S&T and EEMCS. The centre is supported both by the MESA+ Institute as well as the TechMed Centre. The facility, abbreviated as OoCDev, will aim for designing, prototyping and testing Organ-on-Chip devices by realising facilities for bioprinting, microfluidics, cell culture, advanced imaging and sensing. The OoCDev can be used by Organ-on-Chip developers and users within the Dutch consortium Human Organ and Disease Model Technologies (via the hDMT INFRA programme).

APPENDIX D (d) CHAPTER 5 – PARAGRAPH 5.6 HR POLICY

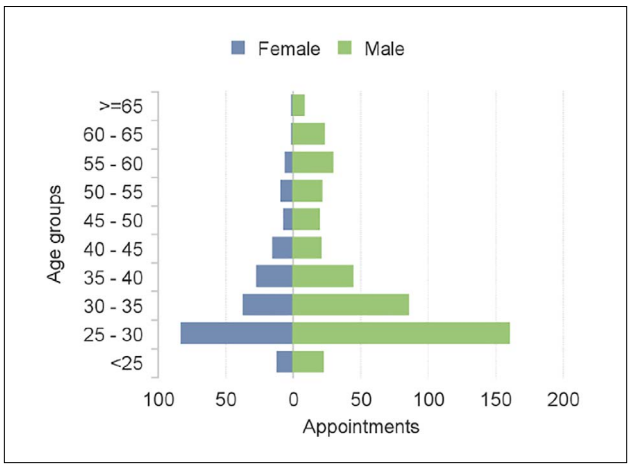
DEMOGRAPHICS S&T FACULTY



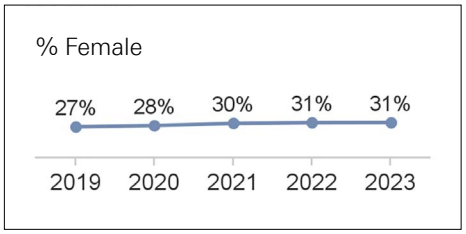
a) Distribution of the number of appointments of support staff (OBP) and scientific staff (WP)



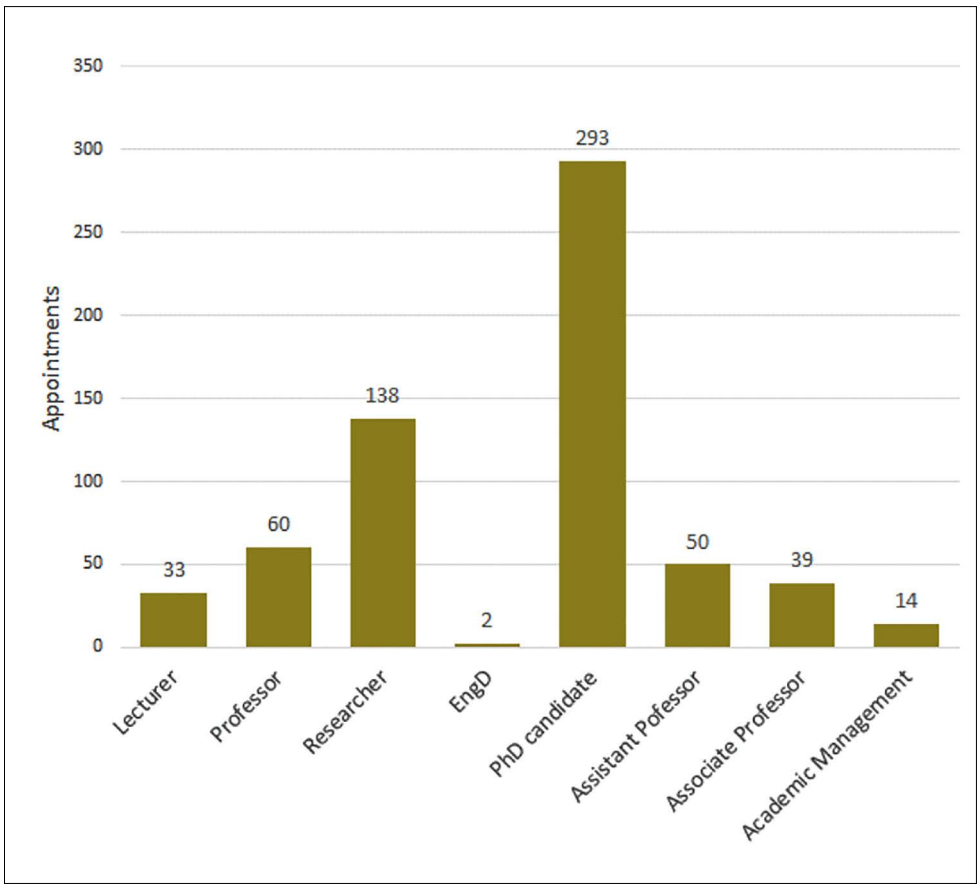
b) Distribution of the total S&T staff population by age groups and gender



c) Distribution of S&T scientific staff by age groups and gender



d) Evolution of the percentage of total female scientific staff in the period 2019-2023



e) Distribution of appointments by function of the scientific staff of S&T

Figure 1: Demographics of the S&T faculty in figures. Source: Demographics S&T Faculty, TNW HR 01.01- HR Dashboard 30-09-2023, BI-Studio, UT

APPENDIX D (e) CHAPTER 5 - PARAGRAPH 5.8 PHD POLICY AND TRAINING

Table 1: Number of graduated PhD candidates in S&T groups in the period 2015-2022, sorted by domain and cultural background, according to RIS Utwente (August 2023)

GLOBAL REGION	CHEMICAL SCIENCE AND ENGINEERING	HEALTH	APPLIED PHYSICS
Africa	3	2	2
China	36	12	23
EU[a]	37	13	35
India	14	3	29
Latin America	8	2	9
Middle East	19	6	10
North America	2	1	1
Netherlands	70	67	82
Eastern Europe	5	3	22
Pacific region/Far East[b]	15	3	7
Not provided	16	8	10

[a] Excluding Netherlands, including UK
[b] Excluding China

Table 2: Number of PhD theses in S&T groups in the period 2015-2022 and the associated SDG's, according to RIS Utwente (August 2023)

SDGA	CHEMICAL SCIENCE AND ENGINEERING	HEALTH	APPLIED PHYSICS
2	2		
3	12	61	5
6	2		
7	42		1
12	3		
13	7		2
16	1		
Multiple			
Total	**69**	**61**	**8**

[a] The meaning of the SDG's is as follows: 2) No hunger. 3) Good health and well-being. 6) Clean water and sanitary. 7) Affordable and clean energy. 12) Responsible consumption and production. 13) Climate action. 16) Peace, law and strong public services.

Table 3: Migration of PhD graduates based on original background, according to info provided by research groups and LinkedIn (September 2023)

FROM \ TO	AFRICA	CHINA	EU (EXCLUDING NL)	INDIA	LATIN AMERICA	MIDDLE EAST	NORTH AMERICA	NOT DETERMINED	EASTERN EUROPE	FAR EAST/PACIFIC	NETHERLANDS
Africa							2				4
China		30	11				5	7		3	16
EUa			42				4	1		1	36
India			6	7			2	2		2	26
Latin America			6		1		2			2	8
Middle East			3			4	3	1			24
North America			1				1				2
Not determined		4	11	1		1	3	3		3	11
Eastern Europe			4				2	1	5		18
Pacific Region/Far Eastb			3				1	4		11	6
Netherlands			14				1	6		1	191

[a] Excluding Netherlands, including UK
[b] Excluding China

Tabel 4: Domains in which PhD graduates continue their career, according to info provided by research groups and LinkedIn (September 2023)

FROM\IN	CHEMICAL SCIENCE AND ENGINEERING	HEALTH	APPLIED PHYSICS
Africa	3	1	2
China	36	12	24
EUa	37	13	34
India	14	2	29
Latin America	8	2	9
Middle East	19	6	10
North America	2	1	1
Not Determined	17	8	12
Eastern Europe	5	3	22
Pacific Region/Far Eastb	15	3	7
Netherlands	69	73	71

[a] Excluding Netherlands, including UK
[b] Excluding China

APPENDIX FOR CASE STUDIES

CASE STUDY 1 POF (PHYSICS OF FLUIDS)

In our approach to science and innovation, S&T sees great value in creating very synergetic combinations of fundamental and application-oriented research. Bringing these closer together was also one of the considerations in the cluster/department formation. On the one hand fundamental research can provide the knowledge and techniques of use to tackle problems of a more applied or societal kind, and on the other hand the problem statements that arise from applications or society can be excellent starting points for fundamental knowledge development. Exemplary for this approach is the research in Physics of Fluids, which acted as a research cluster avant la lattre. Several senior and early career principal investigators and their teams are working closely together and stimulate each other in their research on fluid physics and flow phenomena.

Fundamental experimental and theoretical studies are for example being pursued on multiphase flows and turbulence, with the Rayleigh-Bénard and Taylor-Couette flows as the paradigmatic model systems. The former is the flow in a container heated from below and cooled from above, the latter is the flow between two coaxial, independently rotating cylinders. New insights into the heat and momentum transport in such complex flow systems have been derived, for example taking into account the physics of boundary layers and deformability of bubbles. Decades old predictions on the heat flux in the asymptotic regime of 'ultimate turbulence' have been tested. Other studies involve evaporation, melting/freezing and wetting phenomena. These basic studies are typically being published in reputed fundamental physics journals like Physical Review Letters and Journal of Fluid Mechanics.
The insights acquired are actively being employed in the Physics of Fluids research related to (I) Climate, (II) Environment, (III) Energy Transition, (IV) High-Tech, (V) Health and (VI) Food & Agriculture. Example are; (I): Melting of icebergs, thermohaline convection and clouds; (II): Flotation and drag reduction by bubbles in maritime transport; (III): Electrolysis, CO2 sequestration, thermal energy storage, LNG transport, and wind farms; (IV): Lab-on-a-chip diagnostics, immersion lithography, and inkjet printing; (V): Ultrasound diagnostics, medical imaging, aerosol spreading and ventilation; and (VI): Drop impact on leaves and droplet impact on sand.

The applied research results also in publications in a wide range of journals, in widespread fields such as physics, chemistry, medicine, energy and climate, geophysics, and many others, as well as in patents, spin-off companies and collaborative programmes with industry. Overall, the S&T Physics of Fluids research is lauded with the highest recognitions existing in this field.

CASE STUDY 2 ENERGY MATERIALS RESEARCH

Key staff involved: Monica Morales-Masis, Rebecca Saive, Mark Huijben, Andre ten Elshof, Payam Kaghazchi. Further links inside NEM to: Chris Baeumer, Linn Leppert, and Menno Bokdam.

Research on energy materials is a topic that gained strong momentum in the past 5 years in the NEM department. Here, two successful developments of **materials for energy** within the department are showcased: **battery materials** and solar **energy materials.** These two cases are chosen as example of research that started with a single group within the NEM department, but that currently are developing into an interdisciplinary research programme across groups and even faculties, resulting in twin research centres (**Battery Centre Twente** and **Solar Centre Twente**) and large national programmes (**BatteryNL** and **SolarLabNL**). This is a result of excellent research at the fundamental (materials) level (NEM research groups within S&T faculty) in direct collaboration with applied and technology driven research (groups at ET and EEMCS faculties). This demonstrates vision, strategy and impact, without compromising the curiosity-driven research by the NEM research groups.

CONTENT OF THE RESEARCH

1. Battery materials. Development of novel battery materials based on in-depth understanding by advanced materials synthesis, (operando) characterisation and modelling of materials performance.
Solid state battery thin film growth and design of interfaces for future microbattery applications.
Beyond-lithium sustainable battery materials based on non-critical elements.
2. Solar energy materials. Within the NEM department two pillars of solar energy materials were established within the past 5 years:
Optoelectronic thin film materials: novel material design and growth, validated by proof of concept solar cells with power conversion efficiencies above 19%.
Photonic materials systems: enhancing use of the solar energy reaching the Earth with improved light management. This includes developing novel physical concepts which are verified by computational simulations and experimental demonstrations taking advantage of MESA+ clean room and characterisation facilities.

RELATION TO STRATEGY:

Materials science including synthesis and functionality of novel electronic/optoelectronic materials is the central focus of our cluster, and the research in **materials for energy** is one of the 3 strategic research lines of NEM. Battery materials and photovoltaics materials, are key examples of how research in new materials development and study of fundamental phenomena (e.g., electronic transport) lead to the development or improvement of current and future technologies.

KEY OUTCOMES (ENTIRE NEM DEPARTMENT): GRANTS AND PUBLICATIONS

Grants (selection): 2x Veni, 3x Vidi, 3x Vici, 2x ERC-Starting Grant, 1x ERC Proof of Concept, 2x NWA-ORC, 3x National Growth Fund (NXTGEN Hightech Equipment, Circular Batteries, SolarNL), and NWO KIC.
Invited presentations: cumulative > 50 per year at top international conferences (MRS, EMRS, ACS, ECS, IUPAC)

1. Fast and Durable Lithium Storage Enabled by Tuning Entropy in Wadsley–Roth Phase Titanium Niobium Oxides, J. Zheng, …, P. Kaghazchi, J.E. ten Elshof, M. Huijben, **Small**, 2023 (https://doi.org/10.1002/smll.202301967)
2. Self-Assembled Epitaxial Cathode–Electrolyte Nanocomposites for 3D Microbatteries. D.M. Cunha, … ,M. Huijben - **ACS Applied Materials & Interfaces**, 2022. (https://doi.org/10.1021/acsami.2c09474)
3. Nickel Niobate Anodes for High Rate Lithium-ion Batteries, R. Xia, …, P. Kaghazchi,

J. E. ten Elshof, M. Huijben, **Advanced Energy Materials** 2022 (https://doi.org/10.1002/aenm.202102972)

4. Single-Source Vapor-Deposition of MA1–xFAxPbI3 Perovskite Absorbers for Solar Cells. T Soto□Montero, S Kralj,… M.Morales-Masis, **Advanced Functional Materials**, 2023 (https://doi.org/10.1002/adfm.202300588)
5. Scalable pulsed laser deposition of transparent rear electrode for perovskite solar cells. Y Smirnov, ,…, M. Morales-Masis, **Adv.Mat. Tech.** 6 (2), 2022 (https://doi.org/10.1002/admt.202000856)
6. Free-Space Diffused Light Collimation and Concentration. LM Einhaus, GC Heres, J Westerhof, S Pal, A Kumar, JY Zheng, R Saive. **ACS photonics** 10 (2), 508-517 (https://doi.org/10.1021/acsphotonics.2c01652)

CASE STUDY 3 HEART2BEAT

Cardiovascular diseases are the number one cause of death worldwide. In 2022, BET department colleagues Robert Passier and Jeroen Leijten, and partners received an EIC-Pathfinder Challenge grant (two grants for research on human miniature hearts (utwente.nl)). The project will be led by Passier and Leijten and River Biomedics (Spin-off company of UT) as a consortium with NanoScale Systems and University of Málaga. This consortium will develop a pumping human – mini-heart and swimming human Bio-Robot. Flat cell cultures of heart tissue are not capable of producing a pumping motion, which is the main function of the heart. In the research project '*Engineering a living human Mini-heart and a swimming Bio-robot*', Leijten, Passier, and partners will develop a pumping mini-heart and swimming human bio-robot. "We're working on a real miniature heart with a beating chamber. It will be able to eject fluid and enables us to study the pumping function of the heart", explains Passier. "Excitingly, this project allows us to combine cutting-edge stem cell protocols with advanced biofabrication technologies such as an innovative casting technique and next-generation 3D bioprinting to create truly functional living matter" expands Leijten.

In 2022, Passier and partners also received a NWO XL Grant develop a screening platform of miniature human hearts for studying heart disease and testing drugs using advanced microfluidic droplet technology. Finally, in 2023 Passier was also able to convince the ERC Advanced Grant panel members that he is all about 'a heart for the heart': his project 'Heart2Beat' was awarded. The ERC advanced grant Heart2Beat focuses on innovative approaches to combat cardiovascular disease (CVD), which remains the leading cause of mortality and morbidity worldwide. Traditional experimental models, such as *in vitro* and animal models, have limitations in predicting outcomes, hindering the development of new CVD treatments. Consequently, there is an urgent need to establish realistic human models that can enhance our understanding of CVD and facilitate the identification and validation of potential drug targets. In Heart2Beat, Prof. Dr. Passier will employ an innovative in-air microfluidic platform for high throughput encapsulation of human pluripotent stem cells in microgels. This process will generate self-organised multicellular 3D human cardiac organoids that mimic the structural characteristics of the human heart. Additionally, advanced technologies from the fields of human stem cell biology and engineering will be developed to create 3D (micro)-engineered heart tissues. These tissues will be coupled with a versatile and automated microfluidic platform, enabling comprehensive analysis of various functions such as contraction, relaxation, metabolism, and morphology.

CASE STUDY 4 FIGHTING MALARIA BY CURING THE MOSQUITO

Key staff involved: Naomi Hamelmann, Jan-Willem Paats, Jos Paulusse

Over the past decade we have been developing single-chain polymer nanoparticles as versatile drug carriers. Within the Department of Molecules and Materials, we have developed the technology to prepare nanoparticles from individual polymer chains. This means that nanoparticle size is directly related to the precursor polymer, which can be accurately controlled. The nanoparticles have highly uniform sizes of around 10 nm, resembling the sizes of proteins and small viruses. We developed the required crosslinking chemistry, which can now be carried out under very mild conditions, and we came up with different strategies to include different functionalities, such as groups that help find diseased cells and ways to encapsulate therapeutics. In our approach, the sensitive nanoparticle formation process is decoupled from its functionalisation. This leaves the structure of the nanoparticles unaltered (e.g., size, dispersity), while we can control the type of surface groups and their density on the nanoparticles.

In 2019, the EuroNanoMed project 'NANOpheles' was granted and in collaboration with researchers from Spain, Greece, Belgium and Portugal, we set out to develop nanoparticles for targeting malaria parasites in mosquitoes. Malaria is an infectious disease that affects millions worldwide, with annually over half a million deaths. Due to climate change and developing resistance against antimalaria agents, concerns regarding malaria are increasing. The malaria parasite goes through many different development stages, both in humans and in mosquitoes. Our partners in Spain already identified a bottleneck in these parasite stages, where only a handful of ookinetes are present in mosquitoes, as compared to thousands in the following development stages. Considering that the parasites have an affinity with human red blood cells, we reasoned that negatively charged nanoparticles might target the ookinetes. Using our earlier developed strategy to rapidly functionalisation nanoparticles, we prepared a set with increasing negative surface charge. Isolated ookinetes exposed to our negatively charged nanoparticles confirmed uptake and internalisation of the nanoparticles. Preliminary experiments on mosquitoes confirmed that they eat our nanoparticles, when presented as a sugar solution. Together with our collaborators, we decided to equip the nanoparticles with the antimalarial agent atovaquone. However, we did not observe any parasite killing activity. Most likely, this agent works well in humans, but not in mosquito parasite stages. We are now working on a follow up study that uses different antimalarial agents.

More information:
Highlighted in De Ingenieur
https://www.deingenieur.nl/artikel/nanodeeltjes-tegen-malaria; Highlighted on BNR News Radio on 20th Dec. 2022; https://www.bnr.nl/podcast/wetenschap-vandaag/10498446/de-mug-als-patient-in-de-strijd-tegen-malaria; Interview in UToday 16th May 2023
https://www.utoday.nl/science/72882/the-versatility-of-nanoparticles-from-curing-diseases-to-improving-materials

Key results:
Hamelmann, Paulusse et al. "Single-Chain Polymer Nanoparticles Targeting the Ookinete Stage of Malaria Parasites." *ACS Infectious Diseases* **2023**, 9 (1), 56–64. https://doi.org/10.1021/acsinfecdis.2c00336.
The startup company IntriS b.v. has been founded in 2023, and commercializes single-chain polymer nanoparticles for a variety of applications.
Our expertise in drug delivery and our entrepreneurial nature can make a difference in fighting malaria.

CASE STUDY 5 HOLLOW FIBRE NANOFILTRATION

Key staff involved: Wiebe de Vos, Joris de Grooth, Erik Roesink, Rob Lammertink, Nieck Benes, Walter van der Meer, and Antoine Kemperman

Surface water in the Netherlands is increasingly polluted with pharmaceutical residues, pesticides, and hormones, including those from contraceptive pills. Such micro-pollutants are already found to have a clear negative impact on our aquatic life and are also found in drinking water sources. Moreover, their small size makes them difficult, and thus expensive, to remove from our water supply. Building on existing expertise, researchers from the MST cluster / department developed a promising solution: hollow fibre nanofiltration (NF) membranes. These membranes rely on a very thin polymer layer applied through a simple but versatile process, making them cost-effective for large scale application.

A ten-year success story

The development of this new type of membrane, from fundamental beginnings to commercialisation and use in full-scale processes, spans a period of just ten years. Many of the current staff members of MST contributed to the successes achieved, highlighting the cluster's strong collaborative atmosphere. This case also highlights how our drive to contribute to a more sustainable society, and our strong connection to industry, allow for fast transitions from fundamental work to full-scale applications. Moreover, this study fits closely to our ambition of a comprehensive membrane cluster, where our integrated approach to materials science, mass transport, and process design allows us to remain world leading within membrane research and development.

From fundamental research to practical application

Research on the use of polyelectrolyte multilayers (PEMs) as membrane coatings started with the arrival of tenure tracker Wiebe de Vos at UT in 2012. In this approach, extremely thin polymer coatings are built layer-by-layer, or nm-by-nm, making it well embedded within the MESA+ institute for nanotechnology. Research by De Vos and (then) PhD candidate Joris de Grooth quickly yielded important fundamental insights that have by now become the foundation for much of the international research in this field. In a highly cited paper (>160 citation) in the Journal of Membrane Science they showed how PEM coatings could be used to fabricate novel hollow fibre nanofiltration membranes, where the ionic strength during coating allowed control over the separation properties. In subsequent years (2014–2016), Erik Roesink inspired an important possible application for these PEM-based hollow fibre nanofiltration membranes: the removal of small organic pollutants (micro-pollutants) from wastewater and drinking water. Initial studies on the hollow fibre nanofiltration membranes demonstrated a removal rate of 40–60% for a mix of these challenging pollutants, but also their reduced tendency to fouling. This directly led to their first commercialisation by the UT spin-off company Pentair X-flow, marking a crucial milestone in their practical implementation.

Further breakthroughs

In the early years of the current evaluation period (2016-2018), several projects further advanced the development of these membranes. A project led by Rob Lammertink involved a detailed investigation of mass transport in HF-NF membranes, allowing predictive models for their performance. In a project led by Nieck Benes the high pH stability of the HF-NF membranes was shown, opening up many alternative applications. Moreover, a project led by Wiebe de Vos resulted in a new Asymmetric PEM design, which achieves micro-pollutant removal rates exceeding 98% while demanding minimal energy for operation. Together these projects strongly widened the application window for hollow fibre NF membranes, also marking a breakthrough in their PEM-based membrane design.

Capitalising on these successes, a joint NWO-TTW proposal of UT and Wageningen University & Research headed by Wiebe de Vos was granted in 2019, allowing for the further development of asymmetric PEM membranes. Supported by a very strong consortium of institutes, companies and waterboards, this project (2019-2026) involved six staff members of MST. Here Walter van der Meer and Antoine Kemperman played a key role in developing a highly novel process, where the hollow fibre nanofiltration membranes could be used to remove micro-pollutants from municipal wastewater. In 2021-2022, a pilot installation was established at the municipal wastewater treatment centre in Enschede to study the removal of micro-pollutants through this process at a large scale (1m3/hour).

Spin-off success: NX Filtration

Amidst these advancements, Erik Roesink initiated spin-off company NX Filtration in 2016, facilitated by a patent transfer from the UT to NX Filtration. Swiftly, the first full-scale installations of this cutting-edge technology were successfully established. The significance of NX Filtration was evident when the company went to the stock market in 2021, raising approximately 160 million euros in equity for 30% of the company shares. This remarkable feat positioned NX Filtration as one of the largest water technology companies in the Netherlands, amplifying economic benefits for the Twente region. As recent as 2023, a new collaboration between MST and NX Filtration started the development of a possible next breakthrough, hollow fibre RO membranes.

Media attention

Along the way, MST research attracted considerable media attention for the applications of its hollow fibre nanofiltration research. Progress was reported on specialised and professional news platforms (Waterforum; Engineering.net; Materials Today), in regional media (Tubantia, below; RTV Oost) and national media (Kijk, below). Researchers also engaged in outreach activities aimed at wider audiences. Wiebe de Vos, for example, explained the technology at the Zwarte Cross festival as well as in a short video on Eye-openers.nl.

Summarizing the Impact

In a recent review paper (2023), authors from MST report that by now at least twenty full scale HF-NF installations and fifty pilot installations are running worldwide. Hundreds of thousands of people now receive clean drinking water produced by hollow fibre nanofiltration membranes designed and made in Twente. This market is expected to grow substantially in the coming years, also focusing on the removal of micro-pollutants from municipal waste water. Worlwide societal impact, with clear economic benefits for the Netherlands.
But the academic impact has also been large. This research has positioned the MST cluster as the leading knowledge centre worldwide in this field. This leads to many new collaborations, and new research projects, with as a highlight a recently awarded ERC consolidator grant for Wiebe de Vos to drive forward the advancements in this field.

CASE STUDY 6 QUIX QUANTUM

Key staff involved: Jelmer Renema, Pepijn Pinkse, and Klaus Boller

The story of this case study is one of collaboration, coincidental meetings, serendipity and open mindedness. It started with Tom Wolterink, who obtained his PhD from the UT in 2016 where he worked in two S&T groups, namely COPS (chaired by Willem Vos) and LPNO (chaired by Klaus Boller) under the daily supervision of Pepijn Pinkse. That project was one of the showcase examples of successful collaboration between the photonics research groups organised in Applied NanoPhotonics (ANP), which had started off in 2009 in a MESA+ Strategic Research Orentation. Wolterink's PhD was on the use of controlling quantum interference in massively multichannel networks. After his PhD he went to Oxford to the group of Ian Walmsley, where he met Jelmer Renema. Jelmer was working on the interference of single particles of light-photons- in large programmable networks. The Oxford team had long been looking for a piece of hardware but could not find it, until Tom mentioned that in Twente they had an integrated photonic chip in a box standing around that could do exactly what was needed: an integrated photonic processor, in the lab of Klaus Boller. This processor is something like a universal switchboard that allows all combination between the input channels to be made. After some brainstorming and mutual visits, it was arranged that Caterina Taballione, who was doing a PhD with Klaus Boller, would do an experiment with the Twente chip in Oxford. After two visits Caterina had demonstrated the potential and wrote a thesis partly on these results, with Boller as promotor and Pinkse as co-promotor.

Meanwhile Jelmer Renema started a new position with Pepijn Pinkse. In Twente Jelmer gave a presentation at Lionix, the established Twente integrated photonic spin-off. He explained what kind of beautiful quantum experiments were possible with the early version of the integrated photonic processor made by Lionix. For the experiments you can buy commercial sources and detectors, Jelmer explained, but not yet the processor that forms the heart of a class of special-purpose photonic quantum computers. This triggered entrepreneur Hans van de Vlekkert to set up a company to sell exactly that. In part thanks to rapid action from S&T, it was possible to start the spin-off with Jelmer as CTO in 2019. The company is growing fast and now employs well over 30 highly skilled professionals, among which many who graduated from the UT. It recently obtained the prestigious Prism award from Optica (formely OSA) for the development of a 20x20 processor and it won a tender bid in Germany to build a universal quantum computer.

Apart from being a successful spin-off company, QuiX Quantum plays an important role in the Twente integrated photonic ecosystem. By collaboration with groups at the UT – first and for all the AQO group (chaired by Pinkse), it enables scientific research at the forefront of technology. This has put Twente on the map as the place to be for photonic quantum computing. A growing number of European collaborative projects testify from the growing reputation. It inspires students to choose quantum optical topics, e.g., by following the popular Quantum Information Course from Renema or Quantum Optics from Pinkse and Klärs. The presence of QuiX Quantum helped the formation of the Centre for QUAntum Nanotechnoly Twente (QUANT), which helps to advertise the UT quantum successes and attract more talent. The story also shows how important it is to be open minded for unexpected opportunities and the importance of collaboration, all at the core of the S&T values.

The many excellent research grants currently hosted at S&T's ANP department (2x ERC Consolidators, EIC-Transition, and a host of large NWO grants) are evidence of a world-class research ecosystem. Now that QuiX Quantum is growing, they will benefit from this ecosystem and the breadth of technologies relevant for realisation of practical quantum computing including on-chip sources (LPNO Boller, NLNP Marpaung, OS Offerhaus), programmable processors (NLNP Marpaung, AQO Klaers, COPS Vos), and versatile integration platforms (IOS Garcia-Blanco).

More information
The company and AQO research group webpages: QuiX Quantum - Home; AQO | Adaptive quantum optics (utwente.nl);

News on the products and the Spin-off's success: QuiX Quantum webinar: 20-mode Quantum Photonic Processor - YouTube;
QuiX Webinar: 12-mode quantum photonic processor - YouTube, and QuiX Quantum - YouTube); Twentse kwantumcomputer verovert Europa: 'De fotonica hier is wereldtop.' (trouw.nl); Nederlands bedrijf boekt groot succes met kwantumcomputer: 'We zijn koplopers' | RTL Nieuws, QuiX Quantum bv item Doe Maar Duurzaam S16E43; Industrie - YouTube;
QuiX Quantum - QuiX Quantum wins the renowned Prism Award 2023 in the Quantum Tech category;

On Jelmer Renema: QuiX Quantum on Twitter: "Our very own CTO and Co-Founder, Dr. Jelmer Renema, made it in The Photonics 100 list as the industry's most innovative people! Congratulations to the fellow 100: https://t.co/FeuJ063NSs #ThePhotonics100 #mostinnovative https://t.co/JhYJ98w02M" / Twitter

Key results
- The company is employing already over 30 professionals, and is rapidly growing.
- The company has put Twente on the map as a world-renowned hotspot for photonic quantum computing.

UT Publications which directly involve the hardware produced by QuiX Quantum:
- 20-Mode Universal Quantum Photonic Processor C. Taballione et al., ArXiv: 2203.01801
  The prism Award was based on this publication

- Quantum photo-thermodynamics on a programmable photonic quantum processor F. H. B. Somhorst et al., ArXiv:2201.00049; Nature Communications (in press)

- Experimental demonstration of an efficient, semi-device-independent photonic indistinguishability witness
  R. van der Meer et al., arXiv: 2112.00067

- Boson Sampling in Low-depth Optical Systems
  R. van der Meer et al., arXiv:2110.05099

- Observation of open scattering channels
  R. van der Meer et al., arXiv:2110.04380

- A 12-mode Universal Photonic Processor for Quantum Information Processing
  C. Taballione et al., Materials for Quantum Technology 1, 035002 (2021).

- 8x8 Programmable Quantum Photonic Processor based on Silicon Nitride Waveguides
  C. Taballione et al., Optics Express 27, 26842 (2019)
  This paper was the results of the initial collaboration between Boller and Pinkse in Twente and Renema and Wolterink who were at that time in Oxford. This result triggered the foundation of QuiX Quantum.

CASE STUDY 7 COMA AFTER CARDIAC ARREST

Key staff involved: Monica Frega, Joost Le Feber, Marleen C. Tjepkema, Jeannette Hofmeijer, and Michel J.A.M. van Putten.

In the Netherlands, approximately 7000 patients per year are admitted to the intensive care unit after a cardiac arrest. All these patients are comatose due to a temporary insufficient supply of oxygen and glucose by the cerebral blood flow.
Our translational research is strongly motivated by our involvement in the clinical care of these patients (van Putten & Hofmeijer), and focuses on three complementary elements, with the ultimate goal to improve prognostication and personalised treatment.

Pathophysiological understanding

We explore neuronal dynamics during metabolic stress at three levels: microscopic, mesoscopic and macroscopic, focusing on dynamics of synaptic failure, network dynamics and cell swelling. We collaborate with a consortium of German neurobiologists and Hil Meijer (UT), unravelling fundamental mechanisms at the synaptic level using biophysical models. This is complemented with in vitro modelling with cultured neurons from rats and humans (using stem cell technology) on multi-electrode arrays, that we can expose (semi-automated) to different environmental conditions, using electrophysiological recordings and immunocytochemistry as readouts. This has not only resulted in an improved understanding of synaptic dynamics, but we have also identified potential treatment options to improve neuronal survival after metabolic stress. This is currently further tested in a clinical trial.
At the macroscopic levels, clinical EEG, obtained in the intensive care unit, are used for our meanfield models of brain activity during metabolic stress. Finally, we collect post-mortem materials from patients for bio-banking.

Diagnostics

Over the last decade we have collected over 1000 continuous EEG recordings from patients after cardiac arrest, and initiated multi-centre studies, to improve prognostication of neurological outcome in patients after cardiac arrest. We use advanced EEG analysis (machine learning and deep learning) to create prediction models. We, and others, have shown that early EEG can reliably predict neurological outcome within 24 h in about 50% of these patients; recently, the Dutch clinical guidelines have been modified to include early EEG.
Prediction models are being implemented in our clinical EEG software for clinical evaluation, in collaboration with Clinical Science Systems (co-founded by van Putten).
We have ongoing international collaboration, too, and recently participated in the Physionet challenge (George B. Moody PhysioNet Challenge | George B. Moody PhysioNet Challenge).

Treatment

Pre-clinically, we test and evaluate treatment options using our setup with cultured neurons on multi-electrode arrays. We also have ample experience with multi-centre, randomised, controlled clinical trials.
We recently finished a large multi-centre trial to assess if particular EEG patterns in comatose patients after cardiac arrest warrant treatment. The results were recently published, and have resulted in a change of clinical practice worldwide.
Our in vitro work has identified potential treatment targets for comatose patients after cardiac arrest, focusing on mild neuronal stimulation. We initiated a multi-centre trial was initiated, and data analysis is currently ongoing.

Recent publications

BJ Ruijter.... van Putten MJAM, Hofmeijer J., "Treating Rhythmic and Periodic EEG Patterns in Comatose Survivors of Cardiac Arrest," ***N. Engl. J. Med.***, vol. 386, no. 8, pp. 724–734, 2022.

B. J. Ruijter...van Putten MJAM, Hofmeijer J, "Early electroencephalography for outcome prediction of postanoxic coma: A prospective cohort study," ***Ann. Neurol.***, vol. 86, no. 2, 2019

MJAM van Putten... Hofmeijer, "Post histopathology of electroencephalography and evoked potentials in postanoxic coma," ***Resuscitation***, vol. 134, 2019

S. Pires Monteiro... Frega., "Neuroprotective effect of hypoxic preconditioning and neuronal activation in a in vitro human model of the ischemic penumbra," ***J. Neural Eng.***, vol. 18, no. 3, 2021

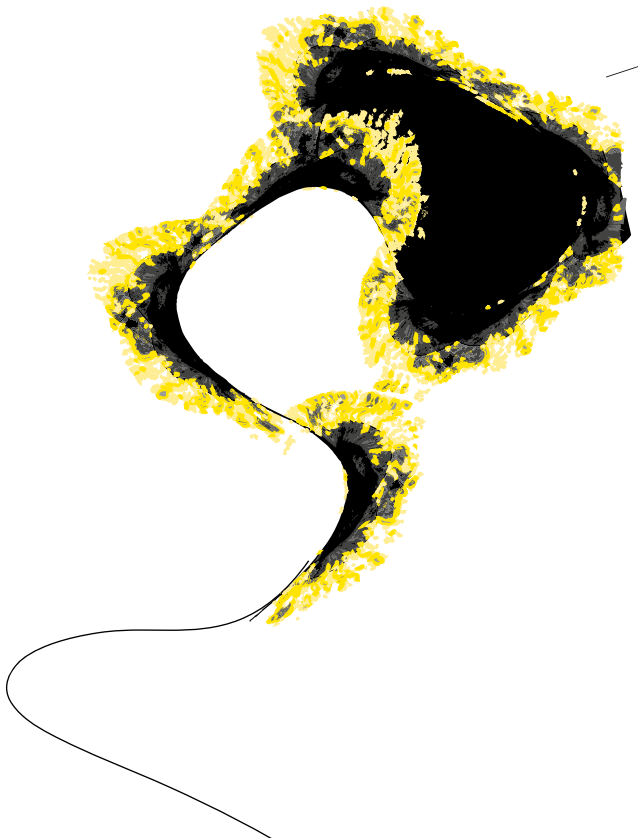
P. K. Tewarie, M. C. Tjepkema-Cloostermans, R. G. Abeysuriya, J. Hofmeijer, and MJAM. van Putten, "Preservation of thalamocortical circuitry is essential for good recovery in comatose survivors of cardiac arrest," ***PNAS Nexus***, vol. 2, pp. 1–8, 2023

M Kalia, HGE Meijer, SA van Gils, MJAM. van Putten, and CR Rose, "Ion dynamics at the energy-deprived tripartite synapse," ***PLOS Comput. Biol.***, vol. 17, no. 6, pp. 1–37, 2021,

UniversiteitNL: about coma after cardiac arrest (in Dutch).

Impact

- Dutch guidelines for prognostication of comatose patients after cardiac arrest have recently been updated based on our research
- Treatment of patients after cardiac arrest has been personalised
- We also received private funding for this research (> 700 kEURO)
- We have established an international top position in this field



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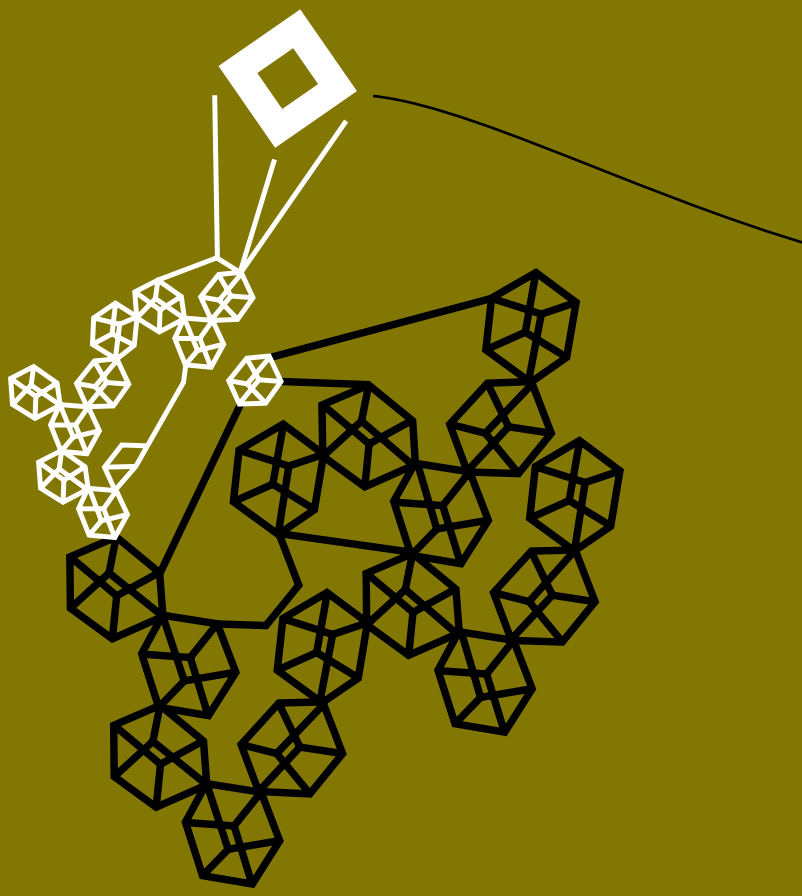

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