

## 1. CASE STUDY: FSE Faculty Themes

In 2015 the faculty introduced four faculty themes (Advanced Materials, Molecular life and health, adaptive life, and data sciences and systems complexity) to unite researchers from the different research institutes, forge larger (local or national) collaborations and better profile our research to the outside world. In 2018 the faculty introduced a fifth theme, fundamentals of the universe to address the issue that not all research institutes felt represented in the themes. The five themes collectively span all 10 research institutes and received a stimulus from the faculty in the form of 54 PhD scholarship positions to encourage interdisciplinary collaboration and financial support from the sector plans (in the form of focal areas). Currently we are evaluating the effectiveness of the faculty themes and value input from the committee on whether we are achieving our goals and can offer suggestions for moving forward.

### Advanced Materials

The faculty theme [Advanced Materials](#) unites researchers from ZIAM, ENTEG, GBB, GRIP, Stratingh, and Bernoulli Institute. The theme builds on the long-standing collaboration between researchers in the disciplines physics and chemistry within the Zernike Institute who lead research on the discovery of new materials (and their functionality), and extends collaboration with researchers in the disciplines biochemistry, molecular biology, pharmacy, AI and engineering in order to develop new materials that have the potential to transform the medical and manufacturing industries. The eight research focal areas within this theme are:

- Green Chemistry & Sustainable Materials
- Physics of Life
- Energy Materials
- Materials for Health
- Quantum Materials & Devices
- Out of equilibrium chemical systems
- Cognitive Systems & Materials - see special case CogniGron (link to second case study)
- Advanced Materials Characterization

Establishing strong collaborations through the faculty theme has led to stronger participation in larger-scale regional and national initiatives (such as University of the North (sustainable polymers and HTRIC), ARC CBBC (functional materials; coatings), Gravitation programmes (QuMAT), Growth Funds (Quantum, NanoLabNL), National Science Agenda (e.g. BatteryNL, SolarlabNL), has led to the establishment of two start-up companies (QDISystems & BioPrex), and has led to our connection with the 4TU-HTM center. Materials research in Groningen has been recognized in the [Nature Index 2021 Materials Science](#) and the [Nature Index 2021 Materials Science Top50 rising institutions](#).

### Molecular Life and Health

The theme [Molecular Life and Health](#) involves researchers from the disciplines biology, chemistry, pharmacy and physics with the aim to unravel and exploit the molecular mechanisms underlying life and health. Researchers from GBB, GRIP, Stratingh, ENTEG and ZIAM forge collaborations to tackle several societally relevant health challenges using the latest technology and computational approaches, and to transfer fundamental knowledge to a preclinical setting through collaborations with the UMCG. The five research directions within this theme are:

- Tackling Antibiotic resistance
- Metabolism from molecule to system
- Building a synthetic cell
- Design, synthesis and function of pharmaceuticals
- Technology driven innovations

Through MLH, institutes have become involved in large research initiatives (*1 NWA-ORC, BaSyc*), *EU Cofund (Alert, oLife)*, and roles in NGF programmes Pharma-NL, Biotech Booster, Cellular Agriculture), created stronger ties with UMCG (through Cofund programme PROMINENT and the [Centre for Sustainable Antimicrobials](#)) and joined as partner in the national Netherlands Centre for One Health (NCOH).

### Adaptive Life

Adaptation is a key phenomenon of all life and a full understanding of it is in turn key to solve societal challenges in this anthropogenic area of global change. As its underlying short term physiological and ecological mechanisms determine the scope for evolution and evolution in turn shapes these underlying mechanisms, [Adaptive Life](#) aims at integrating both approaches in research and education. This programme forms the foundation for GELIFES and collaborations with other FSE institutes, including GBB, Bernoulli and Stratingh. Current focus areas are:

- The Adaptive Ecosystem
- The Adaptive Organism
- The Adaptive Brain

Strategic partnerships were newly formed or strengthened with the Netherlands Institute for Sea Research (NIOZ), the Netherlands Institute for Ecological Research (NIOO) and Naturalis, in part by sharing research and teaching positions. Within the first two topics, we extended our work in the North of the Netherlands, especially the Wadden Sea, strengthening the university profile as University of the North and joining the Rudolf Agricola School for Sustainable Development. Within the 3rd theme collaboration intensified with the UMCG. We initiated or participated in several national (NWA) and international (EU) consortia, as detailed in the GELIFES self-evaluation.

## Data Science and Systems Complexity

The aim of [DSSC](#) is to understand and design complex systems and processes through massive data. Researchers from the Bernoulli Institute, Kapteyn, ESRIG, ENTEG, GRIP and UMCG develop techniques to understand and manage complex systems and tools and methods to facilitate the creation of advanced and complex instrumentation that handles big data. The three main research lines are:

- Adaptive models & big data
- Complex systems & engineering
- Advanced instrumentation & big data

This theme has high societal relevance to emerging trends in digital society. In as such, DSSC has valuable connection to the UG Jantina Tammes School of Digital Society, Technology and Artificial Intelligence with many opportunities for cross-faculty collaborations such as with DASH (UMCG), the Faculty of Arts (Digital Humanities, via NWO-ORC proposal *HAICu*), and with the Faculty of Economics and Business (who joined the DSSC in 2022).

## Fundamentals of the Universe

[Fundamentals of the Universe](#) unites researchers from Kapteyn Astronomical Institute, Van Swinderen Institute for Particle Physics and Gravity, and the Bernoulli Institute to study the fundamental forces of nature with implications for the Universe. Research spans across all length scales from the Planck scale (quantum gravity) via sub-atomic scales (particle physics) to cosmic dimensions (cosmology and astrophysics). Pivotal to our approach is the use of mathematics physics and the development of advanced instrumentation to probe and describe Nature. [Research](#) in this theme can be described in three parts:

- Building blocks of the universe (quantum universe),
- The emergent universe
- Instrumentation

Through this theme, fruitful collaborations between mathematics, high energy physics, and astronomy have been formed which has provided opportunities for national connections to the Lorentz Center as well as to NWA route 2 "Building blocks of matter and foundations of space and time", the DIEP institute in Amsterdam, and the Cluster of Excellence "Quantum Universe" in Hamburg. In the coming period we seek a connection to the NL-Euclid-SDC through joint scientific exploitation of data from Euclid and other telescopes, together with the data-scientific expertise in BI.

## 2. CASE STUDY: Engineering at FSE

Engineering in Groningen has a defining feature that is unique in the Netherlands: its research covers the entire innovation cycle on several topics, from basic science to the development of processes and products. Our engineering research is embedded in a broad University which offers unique opportunities for performing research and education in a wide array of engineering sciences. The Groningen Engineering Center (GEC) was established in October 2016, with funding from the University Executive Board, to enhance the national visibility of Engineering research and education at the University of Groningen, and to enhance existing and stimulate new research cooperation. Five of the 10 research Institutes in FSE are linked to our Engineering Programme. Engineering research is focused in the areas of:

- Bio- and Chemical Engineering;
- Cellular and pharmaceutical engineering;
- Applied physics;
- Mechanical and Industrial Engineering;
- Biomedical Engineering;
- Applied Mathematics and Computer Science and Artificial Intelligence.
- From other faculties: Operations management and research, spatial planning design, and specific groups at the UMCG.

Engineering is linked to the Faculty themes (DSSC, MLH, Advanced Materials) and other programmes such as CogniGron (in FSE), and biomedical engineering and HTRIC (with UMCG). Engineering at FSE has been strengthened through funding from the Ministry via the beta and techniek sectorplans (SBT I 2019-2024 and SBT II 2022-2028). The Director of Engineering at FSE is Prof. Jacquélien Scherpen. As director, Prof. Scherpen represents Engineering within the UG and nationally, for instance in the 4TU engineering deans meetings.

### Engineering Education:

The current educational offer in Engineering consists of several programmes where students are educated with the knowledge and skills to pursue successful careers in academia, industry or society at large.

**Bachelor programmes:** Industrial Engineering and Management; Applied Mathematics; Applied Physics; Chemical Engineering; Computing Science - Software Engineering; Artificial Intelligence; Biomedical Engineering (since 2020);

**Master Programmes:** Industrial Engineering and Management; Applied Mathematics; Applied Physics; Chemical Engineering; Biomedical Engineering; Computing Science - Software Engineering; Artificial Intelligence; Human-Machine Communication; Energy and Environmen-

tal Sciences; Water technology (joint degree); Mechanical Engineering (since 2019), Systems and Control (from 2023). We also offer **PhD programmes** in Engineering-related research under the guidance of the Graduate School of Science and Engineering (link to report). We will also start offering **Engineering Doctorates** in 2024. (see Collaboration with Industry below)

### Collaboration with Industry

The Science and Engineering Business Center (formerly the Groningen Engineering Business center) connects research with industry while taking advantage of our regional context in the Northern Netherlands. For instance we collaborate with 11 business clusters that represent about 250 technologically oriented companies in the Northern region that carry out their work largely in water, energy, healthy ageing, agrofood, HTSM and chemistry. The SEBC organises joint activities to strengthen our connections, such as the student safari's and excursions with companies. Students, PhD students and academic staff can easily link to industrial collaborators for their research and, conversely, companies can contact the SEBC to link with students and researchers on a specific topic.

### Engineering Doctorate

In 2024 we will start with Engineering Doctorates to offer an advanced engineering study for Masters students. This two-year programme will link students with industrial partners on research projects that address more application-oriented challenges. In addition to educating our students, the EngD programme will also strengthen our collaboration with our regional stakeholders who also have a need for our regional talent. The EngD programme in Groningen will initially be focused in two areas, Autonomous Systems and Sustainable Process Design, in collaboration with the [Innovation Cluster Drachten](#) and [Collaborating Companies Emsdelta](#), and will be supported with funding from our Executive Board. We anticipate that the first students will start in January 2024.

### Connections to the The 4TU Network

The RUG is involved in the 4TU network as a partner and the Director of Engineering attends the National Techniek Deans meetings. Our link with the 4TU has also been strengthened through the techniek sectorplans. During the evaluation period we have become involved in several 4TU national centers:

- [4TU plus GEC](#) joining forces in research and teaching, the 4TU.NIRICT (ICT, Vasilios Andrikopoulos, Bernoulli Institute) and 4TU.HTM (High tech management, Moniek Tromp, ZIAM). Both are aimed at improving teaching and building and strengthening the community of young researchers within the areas of research.
- 4TU.NIRICT: combines BI expertise in systems

complexity with current computer science and electrical engineering expertise.

- 4TU.HTM: combines materials science at Zernike Institute, such as mapping the properties of materials, and developing new materials to face societal challenges for instance in energy transition. We are also exploring future cooperation with the 4TU. AMI (Applied Mathematics), 4TU.Energy and 4TU.CEE (Engineering Education).

### 3. CASE STUDY: Career Paths in Science and Engineering 5

The mission of FSE can only succeed if talented staff members are attracted and retained. To this end, already in 2002, FSE introduced a career system for ambitious junior scientists that offered them a tenure track to Associate Professor and the perspective to become Full Professor within a period of approximately 10 years. Individual performance, rather than staffing configurations, became leading in the career of academics at FSE.

Career Paths in Science has been updated several times over the past 20 years. The most recent update occurred in 2023 and was inspired by two developments: (1) [the national movement on 'Recognition and Rewards'](#), which is aimed at modernising career systems at the Dutch universities, and (2) we came to believe that our tenure-track system creates unnecessary stress.

Work on the new policy started in 2020, with an evaluation of the then-current policy in the light of the principles of Recognition and Rewards. Subsequently, a steering group was installed with the task of updating the policy. As the completion of this task was expected to take some time, we decided to start experimenting with a more diverse career system by introducing a career path with a focus on education, in the context of which 20 positions for tenure-track Assistant Professors with an education profile were created and filled.



In the last few years, over a hundred staff members have in one way or another been involved in the update process, for example by joining discussion meetings, participating in one of the working groups, or giving feedback on draft documents. This eventually led to the publication of the first complete draft of Career Paths in Science and Engineering in December 2022, which was discussed throughout the faculty. The invaluable feedback received in these meetings allowed the steering group to make a large number of improvements and finalise [Career Paths in Science and Engineering](#) in April 2023.

Career Paths in Science and Engineering is undoubtedly the most extensive update since the policy was introduced in 2002. Some of the changes are directly inspired by Recognition and Rewards: the policy now includes different career paths for education, impact and research – all to the level of Full Professor, which is unique in the Netherlands – as well as the possibility to switch to another career path later in one's career; the policy has more attention for contributions to teams and the organisation; there are more explicit leadership expectations for all career stages; and criteria have been adjusted to emphasise the importance of quality over quantity. Other important changes are based on the aim to relieve work pressure. While Assistant Professors still initially receive a 6-year tenure-track appointment, they will now be evaluated for a permanent position between 1 to 3 years after their start.<sup>1</sup> Furthermore, academic positions as Assistant or Associate Professor are no longer seen merely as intermediate steps towards a Full Professorship: while making career steps is still encouraged, it is now also possible not to opt for promotion, or to postpone this to a later moment in one's career.

We trust that with Career Paths in Science and Engineering, FSE is once again optimally positioned to attract and retain talented scientists from all over the world.

<sup>1</sup> An alternative that we considered is to offer a permanent contract after a 1-year contract, as many Dutch universities do. However, our current young staff members have almost unanimously indicated to prefer that we offer 6-year contracts with an earlier tenure assessment, as this provides more security in the beginning of one's career.

#### 4. CASE STUDY: Large Collaborative Research Initiatives

At FSE we encourage staff to participate in or coordinate large research collaborations that involve other faculties within the UG, universities and external partners, and for which significant funding opportunities are available (for instance through the Dutch Research Organisation NWO the Dutch Government, and EU Horizon Europe pillar 2 funding). However as faculty we experience two major challenges, namely time and support needed for (senior) researchers to devote to coordinate these often extremely large and labor intensive undertakings, and our unique location in the Northern Netherlands and distance to the Randstad (western part of the the Netherlands), which often hinders collaborative interactions. Below we outline four major collaborative research initiatives from our Faculty.

##### **CogniGron: Groningen Cognitive Systems and Materials Center**

[CogniGron](#) is a large research programme within the Faculty that connects research from the Faculty themes DSSC en Advanced Materials (see [Case Study](#)). The Center started at the beginning of 2018 with a stimulus from a significant donation to the University. CogniGron aims to address fundamental questions of relevance for developing materials and systems for cognitive computing. This initiative connects research in the materials sciences, physics, chemistry, mathematics, computer science and artificial intelligence to address the challenge of designing the new generation of cognitive computers, from a fundamental research perspective. CogniGron is led by a Research Director (Prof. Beatrice Noheda) and is supported by a management team consisting of a programme board, supervisory board and coordinating office. For more information on CogniGron please refer to the [Annual Report 2021](#).

##### **Medical Technology: HTRIC**

[HTRIC](#) (Health Technology Research and Innovation Cluster) is a platform for research and education in the development of (new) medical technology to keep healthcare accessible and affordable in the future (slogan *Health technology for more healthy years of life*). This initiative joins partners from FSE (GBB, ZIAM, GRIP, ENTEG), [UMCG](#), Hanze Hogeschool, NHL Steden and industry (Life Cooperative) who together focus on four programmes: (1) the operating theater of the future, (2) replacing and improving parts of the human body, and (3) innovative technology with local precision and (4) point of care technology. HTRIC is also one of the five research programmes in the [University of the North](#) initiative.

##### **Raw Materials Transition: FutureCarbonNL**

[Future Carbon NL](#) is a large collaborative research programme (initiated and coordinated by Prof. Matthias Heinemann (FSE/GBB)). The aim of this programme is to become a globally leading carbon technology sector in revolutionary raw materials techniques that move away from fossil-based carbon sources, reduce CO<sub>2</sub> and convert CO into new, [sustainable raw materials](#), fuels and (animal) food. This initiative is a collective partnership between Dutch Universities, knowledge institutions, industry, SME's and start-up companies. Future Carbon NL is participating in the third funding round of the [National Growth Funds](#) from the Dutch Government (requesting K€ 720.000) of which the outcomes of this funding round will be announced later this year.

##### **Energy Transition: Hydrogen Valley Campus**

The production and use of hydrogen is part of a large ambition to establish the Northern Netherlands as a breeding ground for green energy to combat climate change and transform the fossil-based energy industry. Groningen is an ideal location for Hydrogen-based research given the effects of decades of natural gas extraction on the region (for instance the loss of human capital and damage due to [earthquakes](#)), and FSE is in a unique position to significantly contribute to this initiative. The province of Groningen has developed a [Hydrogen Agenda](#) which features proposed hydrogen activities for the region and the Northern Netherlands was the first region to be awarded an EU Subsidy as "[Hydrogen Valley](#)" (for the [HEAVENN](#) project). Additionally, [Groenvermogen](#) was one of the large investment projects awarded in the first round of [National Growth Funds](#) from the Dutch Government aiming for the industrial use of green hydrogen, where the UG is involved in all [seven work-packages](#), including several researchers from FSE. Hydrogen research has been integrated into the new UG [Wubbo Ockels School for Energy and Climate](#). Given the importance of energy transition to the northern netherlands, FSE has an opportunity and also a responsibility as the only Dutch university in the north to contribute a central role to hydrogen research and education for the region.

##### **ChemToLife**

A long standing collaboration between Groningen, Nijmegen and Eindhoven to extend the frontiers of chemical self-assembly and gain a deeper understanding of the molecular mechanisms, structures, and chemical processes that lead to living systems. Currently this collaboration is supported by a Gravitational grant (see <http://fmsresearch.nl/>). ChemToLife aims to further extend its world-leading position in the chemistry of complex systems and was recently submitted to NWO as a SUMMIT proposal on behalf of our University Executive Board.

Other large research initiatives where our Faculty is involved include:

### **NOVA: Netherlands Research School for Astronomy**

[NOVA](#) is an alliance between the astronomical institutes at the universities of Amsterdam, Groningen (Kapteyn Institute), Leiden and Nijmegen. NOVA's mission is to carry out frontline astronomical research in the Netherlands, to train young astronomers at the highest international levels, and to share our new discoveries with society.

### **ARC-CBBC**

The Advanced Research Center Chemical Building Blocks Consortium (ARC CBBC) is the Netherlands' national research center for circular and sustainable chemistry. The hub brings together Utrecht University, the University of Groningen, the Technical University of Eindhoven with the chemical industry to focus on the green transition in three research themes: energy transition, feedstock transition and materials transition. (see [SEP report Stratingh Institute](#))

### **BatteryNL**

BatteryNL is led in Groningen by Prof. Moniek Tromp (ZIAM) consists of experts within academics, high-tech startups, multinationals and societal partners. The aim is to develop the next generation of batteries based on a better understanding of material interfaces. These batteries will have higher energy densities and have a longer life-cycle – all of which are crucial for a society based on sustainable energy sources and necessary to stabilize the future power grid. BatteryNL is a €9.3 million project funded by NWO-ORC.

[Battery NL](#)

### **HAICu: digital Humanities - Artificial Intelligence - Cultural heritage**

Recently The HAICu consortium, led Prof. Lambert Schomaker at the Bernoulli Institute, has been awarded an NWA-ORC grant of EUR 10.3 million. In the HAICu project, AI researchers, Digital Humanities researchers, heritage professionals and engaged citizens work together on scientific breakthroughs to open, link and analyze large-scale multimodal digital heritage collections in context. More information can be found on the [HAICu website](#)

## 5. CASE STUDY: Science Linx

[Science LinX](#) is FSE's team for outreach and public engagement and connects the Faculty's research and our researchers to a wide and diverse range of audiences, from primary schools to societal stakeholders. The public engagement programme facilitates mutual learning and contributes to tackling today's societal challenges.

The Faculty, through Science LinX:

- interacts on- and off-campus, physically and virtually, with stakeholders and target groups, such as:
  - teachers and their pupils at primary and secondary schools to spark interest in science and engineering; we do this with [Science Truck](#), [Science Exhibitions](#), [Zpannend Zernike](#) and other public events.
  - the general public to involve in scientific developments for example through citizen science, we do this with [CURIOUS](#)
  - civil society organizations to exploit scientific results and contribute to the research agenda setting, we do this with [SCIENCE SHOP](#)
- challenges and supports staff from FSE to identify and develop professional and personal talents, through outreach, engagement and collaborative projects, we do this through our new scicomm team.

### Science Truck (since 2005)

One of our instruments to reach out to potential first generation students is the [Science Truck](#), a **mobile classroom** that is visited every year by well over 25000 pupils nationwide (and even in Germany) where experiments are carried out. For instance, pupils can build a solar cell and then measure its efficiency.

### CURIOUS (since 2019)

[CurioUs](#) shows a broad audience (young and old, higher and lower income and education) the power of (digital) technology and citizen science and inspires them to gain insight in and improve the quality of their own living environment and health.

CurioUs consists of a device library ('meet-o-theek') and citizen science actions (measuring air and soil quality, rain, climate adaptation) reaching out to thousands of curious citizen scientists.

This initiative aims to lower barriers to science and technology, especially for underrepresented groups. One of the aims is Bridging the digital gap; the device library is made up of a wide range of measuring instruments that are also accessible for people who are not so digitally literate. Manuals, workshops and 1-to-1 support help develop the digital competences of its users. CurioUs involves inhabitants



in all corners of the northern Netherlands with science from a young age onwards and from a mixed group of communities. Also those young people will be reached whose parents have no connection with science and technology yet and who cannot afford the contribution to clubs and/or tickets to museums.

### Contribute to public events

To inspire the next generation to science and engineering we contribute to public events and festivals like [Expeditie Next](#) (Franeker, Middelburg), [Noorderzon](#), [Maakfestival](#) and [Zpannend Zernike](#) (= 'Exciting Zernike'), where our laboratories are open to the general public and we organize activities for all age groups. Visitors can see or do experiments, make products (such as toothpaste), and learn about recent developments in interactive exhibits and attending mini-lectures. About 6000 people visit this event each year.

### FSE Scicomm team

The science communication (Scicomm) team makes research from FSE visible across the board regionally, nationally and internationally. The team develops a balanced set of communication tools to support scientists and to proactively report and attract attention to its research results and societal impact. We use these to improve the visibility of our research and its relation to societal challenges.