Biomolecular Sciences:
driving industrial biotechnology

university of groningen

GBB

Research on the Horizon

Adjacent Digital Politics Ltd highlights the research taking place in the Netherlands and how European Commission is supporting innovative research initiatives…

Through the Horizon 2020 initiative, research and innovation is championed by the European Commission as being of utmost importance. As well as supporting new innovative technologies, one of the main facets of the initiative is collaboration and knowledge sharing across organisations.

The goal of the initiative is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. By coupling research and innovation, Horizon 2020 is helping to achieve investments in our future with emphasis on excellent science, industrial leadership and tackling societal challenges.

In November 2013, Commissioner for Research, Innovation and Science Maire Geoghegan-Quinn announced an €80bn package of proposed measures that will give research and innovation in Europe a much needed boost. Horizon 2020 is a key project from the Commission that will help to elevate research and development to the next level and push European science harder and further than before.

Unlike previous research programmes, Horizon 2020 brings together all EU research and innovation funding under a single programme for the first time, and aims to secure Europe's science and technology base and industrial competitiveness.

"We need a new vision for European Research and innovation in a dramatically changing economic environment," said Maire Geoghegan-Quinn. "Horizon 2020 provides direct stimulus to the economy and secures our science and technology base and industrial competitiveness for the future, promising a smarter, more sustainable and more inclusive society."

Horizon 2020 launched in December 2013 with €15bn over the first two years – including €1.8bn to support leaderships in key areas such as biotechnologies. In fields such as biomolecular sciences and biotechnology, Europe is keen to remain a major player in R&D. Fundamental research in these areas helps to discover and provide solutions for a number of societal changes and to further understand food health.

From a speech Maire Geoghegan-Quinn gave in Dublin in December 2013, the Commissioner said: "Horizon 2020 will be good for the researchers who want to collaborate across boarders to develop new technologies that will help us tackle challenges like climate change, energy security or public health.

"It will enable the world's best scientist to push back the frontiers of knowledge in universities and research centres across Europe, thanks to a bigger budget. Horizon 2020 will also be good for regions that are lagging behind, with measures to spread excellence, widen participation and encourage smart specialisation." (1)

"Horizon 2020 will also be good for regions that are lagging behind, with measures to spread excellence, widen participation and encourage smart specialisation."

Maire Geoghegan-Quinn

Netherland's universities in particular are leading the way for biotechnology research. There are many that offer a stimulating environment for superior research and training to students that want to excel in fundamental biomolecular research and applications.

The Netherlands are at the top of their game when it comes to research and development (R&D). In 2009 the country spent over €10bn in the area, with almost 10,000 people getting involved. (2) The European Commission is dedicated to supporting organisations such as the University of Groningen, who offer potential future scientists the opportunity to further their knowledge in these areas.

Research and development in the country is supported by three main sources of funding: companies, the government and foreign entities. The government equates to 37% of the funding with companies making up 49%. The Ministry of Education, Culture and Science is responsible for promoting, funding and supporting research projects within the Netherlands.

Working together with universities and organisations such as the Netherlands Organisation for Scientific Research (NWO), the Ministry distribute necessary budgets to universities in order for them to excel in a certain specialism and market their knowledge.

"In the Netherlands we have an excellent knowledge infrastructure in which this is done at a large scale by world class researchers," explains Babs van den Bergh, Director Research and Policy at the Ministry of Education, Culture and Science.

The University of Groningen offers excellent research opportunities for scientists conducting top quality research in molecular biology and biotechnology. It is thanks to organisations such as this that has helped to see a growth in life science research. With extra funding from the European Commission this can only strengthen research, and ensure development in this area goes further than ever.

Maire Geoghan-Quinn is committed to ensure research and development in Europe. "I am determined that this additional money – which represents 25% increase in real terms compared to FP7 – which will be invested as wisely and efficiently as possible.

"It will fund not just the best fundamental research, but also applied research and innovation, bringing in small and large companies. This is so vital because we know that research and innovation mean growth and jobs." (3)

[1] http://europa.eu/rapid/press-release_SPEECH-13-1052_en.htm

[2] http://www.bladerbrochure.nl/brochure/code/63VR5q7W6v6A24oQqeieS6UVQrkins

[3] http://ec.europa.eu/commission_2010-2014/geoghegan-quinn/headlines/speeches/2013/documents/20131018-prague-speech_en.pdf

Biomolecular Sciences: driving industrial biotechnology

THE MICROBIAL POTENTIAL

Microorganisms are bustling with chemistry. In fact, they are the richest and most diverse reservoirs of chemical activities on our planet. Their activity is essential to sustain the elemental cycles of carbon, nitrogen, phosphorus, and sulphur.

The field of biotechnology, exploiting these microbial activities for industrial purposes, is currently thriving due to advances in genetic control of microorganisms and fermentation technologies. Experts even postulate that biotechnology will provide sustainable solutions for a number of the grand societal challenges. Further, while pathogenic microorganisms are increasingly threatening our well-being, each of us could not exist without a huge number of commensal microorganisms residing in our guts. Thus, having control over microorganisms is of eminent importance for human health.

FUNDAMENTAL SCIENCE, A PREREQUISITE

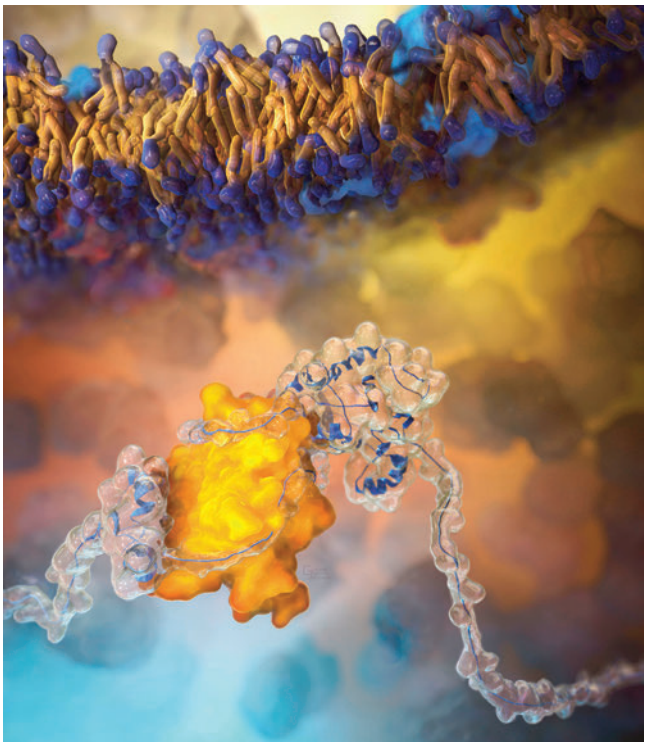
While many possibilities await us in the microbial reservoir, we are still far from truly designing, engineering, and constructing novel enzymes and ultimately robust (synthetic) cells. Key to harvesting the amazing potential of microorganisms and to gain their full control is fundamental research. Furthermore, as a guarantor for innovations, only fundamental research will allow uncovering the unknown and the unexpected.

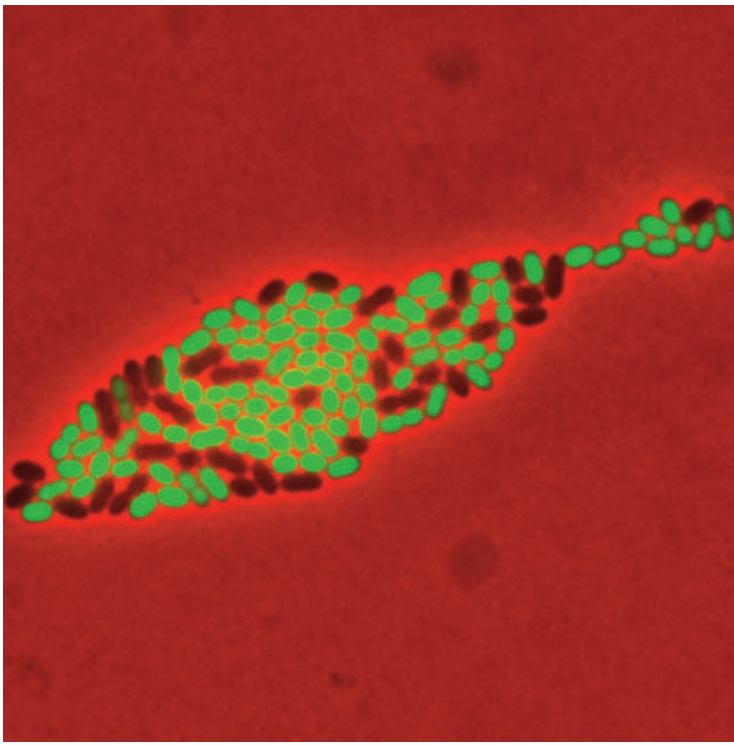
Dutch microbiology can proudly look back to an impressive more than 100-year history of excellent microbial research, spearheaded by pioneers such as Van Leeuwenhoek (already in the 17th Century and the first person to ever see microbes), Beijerinck, Kluyver and others, which has led to major breakthroughs with significant commercial value. Next to building solid foundations in science, applied research is very important, in which particular ground-breaking fundamental insights are succesfully translated into industrial applications.

TRANSLATING SCIENCE INTO INNOVATIVE APPLICATIONS

The Groningen Biomolecular Sciences and Biotechnology Institute (GBB) is a multidisciplinary research institute with an extremely strong fundamental pillar, but also uses its unique expertise to address challenges in applied research. The institute has many industrial collaborations that have directed various innovative biotechnological applications of enzymes and microorganisms. The 12 research groups of the institute – having firm roots in chemistry, biophysics, and biology – are grouped in the two focal areas:

Molecular mechanisms of bioprocesses and Physiology and systems biology, capturing the whole spectrum from molecule to cell. Specific expertise areas are gene regulation, protein engineering, membrane biology, cell biology, and systems and synthetic biology. GBB has state-of-the-art in house facilities for single cell- and single molecule analyses, high-resolution optical and electron microscopy, modern omics technologies and advanced cell engineering. Exemplary showcases of GBB's fundamental and applied research are best demonstrated by the following four examples:





Protein Transport Systems

Bacteria are ideal vehicles to produce proteins of interest. They can be grown at a large scale using cheap nutrients and, importantly, they have the ability to secrete proteins into the extracellular medium to facilitate recovery and to obtain high protein yields.

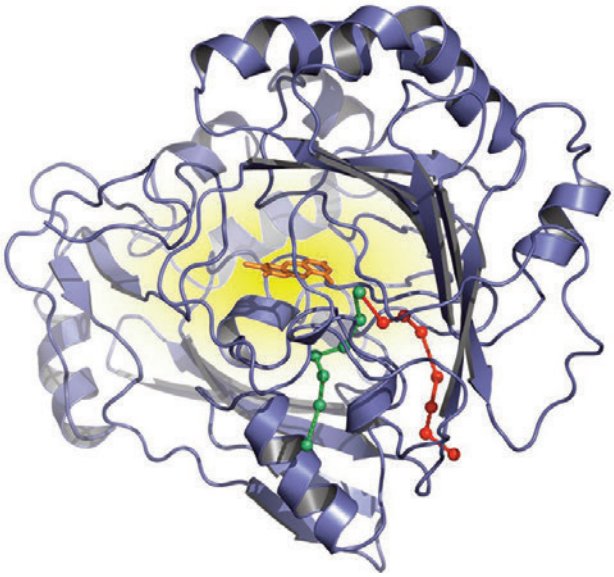
The bacterial secretion system (denoted as the Sec-system) in its minimal form consists of an energy-driven motor protein that pushes unfolded proteins through a narrow pore in the membrane whereupon these proteins fold on the outside of the cell. GBB studies the mechanism and structure of the Sec-system in detail through integrative multidisciplinary approaches combining advanced reconstitution methods with biochemical characterization and single molecule analysis.

This example of top-notch fundamental research, involves strong and productive collaborations among research groups within GBB complemented by the neighbouring partner institutes, focusing on synthetic organic chemistry and materials science. It also contributes to major research activities on other microbial transporters, from basic insight into their translocation mechanisms to innovations in membrane engineering, altogether offering unprecedented solutions for current challenges in industrial biotechnology.

Single cell analysis

For decades, biologists thought that individual cells of a microbial population are identical. With the advent of novel microscopic techniques, researchers from GBB and colleagues elsewhere have recognized that in fact, such populations can be quite heterogeneous, because of an inherent randomness in certain biological processes. Such heterogeneity has significant consequences. For instance, so-called persister cells are no longer sensitive to antibiotics and can give rise to re-occurring infections. Alternatively, if differently productive populations are present in biotechnological fermentation processes, this could have enormous consequences for production yields.

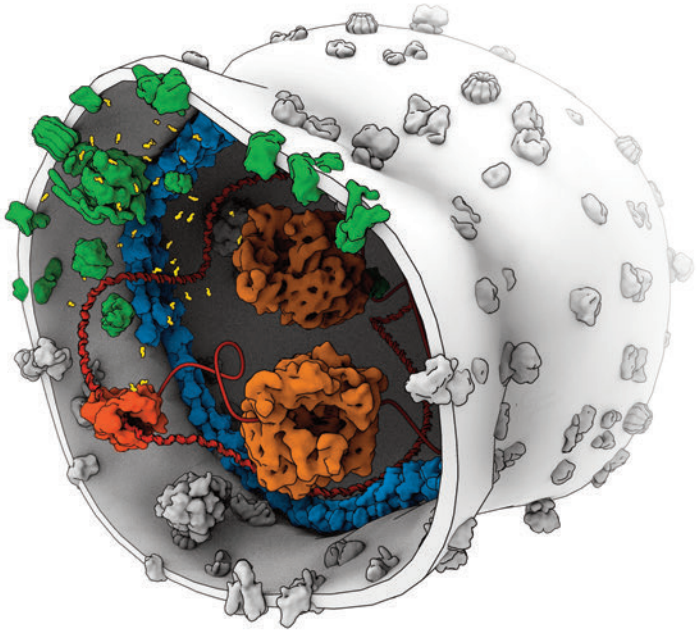
Researchers from GBB contribute by developing and implementing new analytical techniques (microscopy or single cell metabolomics) to investigate the intriguing molecular mechanisms that lead to such phenotypic heterogeneity. This research line is an excellent example of fundamental research with huge potential for application spin offs. Notably, without this research, we would still think that isogenic cells in a microbial population are identical and, thus, we would miss chances for new and improved cellular productivity and therapeutics.



Biocatalysis

Enzymes fulfil essential roles in the cell and are at the heart of each metabolic activity. Due to their tremendous rate of catalysis and exquisite chemical selectivity, enzymes are highly attractive as biocatalysts in biotechnological applications. Industrial processes often involve non-biological conditions and an advanced level of enzyme discovery and/or engineering is generally required for successful application.

Through an integrative effort of enzyme discovery and enzyme engineering extended with computational and experimental studies of their structure-function relationships, GBB develops enzymes that are highly relevant for biorefinery processes, production of platform chemicals, healthy food additives, and added-value products such as antibiotics. For instance, novel penicillin acylases have been discovered and developed at GBB that now form the basis of actual industrial processes for the manufacturing of semi-synthetic antibiotics. Glucanotransferases (GTFs) acting on starch have been engineered and are currently used for the synthesis of modified starches that are marketed for various food applications. Oxidative biocatalysts have been created specifically for the synthesis of biomass-based polymer building blocks and pharmaceuticals.



Synthetic Cell
The bottom-up assembly of a living cell from basic molecular components is emerging as a new and exceptionally exciting frontier in science and engineering. Despite increased chemical and physical understanding of biomolecules and their mutual interactions, it remains elusive how they together form a cell that can autonomously grow and replicate.

GBB and its partners collaborate in large-scale programmes to create a functioning synthetic cell from biomolecular building blocks. Such bottom-up synthesis of a cell is not only a formidable engineering challenge, but will also allow to unravel the principles of biological processes in a truly fundamental way. Such a detailed understanding will simultaneously bring unprecedented opportunities for innovative applications in health, biotechnology, and materials.

GBB foresees important spin-off results in the form of advanced drug delivery systems, drug-screening methods, and bionanodevices for multiplex detection of molecules.

HUMAN POTENTIAL AND TRAINING

GBB hosts an international team of almost 200 scientists who operate at the forefront of their research fields and additionally educate the next generations of scientists. Towards this end, GBB is formally accredited as a Research School by the Royal Netherlands Academy of Arts and Sciences. Due to its training expertise, GBB is an acknowledged partner in Master and Doctoral training networks. The institute accommodates many exchange students, amongst others being supported via Erasmus Mundus, South-American, and Asian Scholarship programmes. It also coordinates and participates in a large a number of Marie Curie Initial Training Networks of the European Union.

The high level of training is best exemplified by the successes of students at GBB. For example, students from Groningen were crowned World Champions in the International Genetically Engineered Machine (iGEM) student competition of 2012. Moreover, the students are very successful on the academic and industrial job market and have an excellent success rate of obtaining their own research grants.

PARTNERING IN SCIENCE

With its vast expertise and modern facilities GBB is an excellent partner for first-rate biomolecular and cellular science as well as for challenging demand-driven biotechnological research. Furthermore, because of its strong track record and experience in (inter)national public-private-partnerships (PPP) that are supported by various companies, GBB is well aligned to the Horizon2020 programme of the European Union. Here, GBB aims to contribute to the three defined pillars: Excellent Science, Industrial Leadership, and Societal Challenges. Of particular interest are programmes that will be funded via the European Research Council and different PPP-instruments, for instance those within Future and Emerging Technologies (FET) and Leadership in Industrial Technologies (LEIT).

Groningen Biomolecular Sciences & Biotechnology Institute

Mission
- Excel in interdisciplinary fundamental biomolecular research by advancing on new biotechnological applications
- Offer a stimulating environment for top-notch research and training with state-of-the-art infrastructure.

Focus
- Molecular Mechanisms of Bioprocesses
- Physiology and Systems Biology

Ambition
Become a recognized international Centre of Excellence for Advanced Microbial Sciences.

Key data
- Research school accredited by the Royal Netherlands Academy of Arts and Sciences
- 12 research groups
- 24 tenured Associate – Full professors, 4 tenure-track Assistant Professors
- 190 scientists (PhD students, postdocs)
- 40 supporting staff
- Modern research facilities
- 200 peer-reviewed publications per year in internationally recognized journals
- Annually ~25 PhD degrees with great perspectives for a subsequent career in policy, academia or industry
- Average turnover of 16 M€/yr
- iGEM World Champion 2012

Research groups
- Bioinformatics
- Biotransformation & Biocatalysis
- Cell Biochemistry
- Electron Microscopy
- Membrane Enzymology
- Microbial Physiology
- Molecular Cell Biology
- Molecular Dynamics
- Molecular Genetics
- Molecular Microbiology
- Molecular Systems Biology
- Protein Crystallography

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Images provided by GBB staff and the university image repository

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