Biotechnology

The BIOTECHNOLOGY programme trains students for the role of analyst in a professional field which is strongly focused on product development. The emphasis is on the link between knowledge of living organisms and technical applications for making products that people can use.

Institutions that offer the programme

- Inholland University of Applied Sciences, Amsterdam
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden

The professional field for biotechnology analysts can be divided into green, red and white biotechnology. In all these areas, the emphasis is on the link between knowledge of living organisms and technical applications. In green biotechnology, this knowledge is applied to issues arising from agriculture and horticulture. Red biotechnology is concerned with medical issues and white biotechnology is concerned with applications for industrial or laboratory analysis. A biotechnology analyst will have shown a clear preference for one of these colours during his course of study.

In a research and development environment, the BSc is involved in developing new products, organisms (including micro-organisms and plants), materials, methods and processes or improving existing ones. The BSc operates individually within a research team and is often responsible for a separate piece of research. In research, production, quality control or diagnostics, the BSc conducts complex experiments that challenge his practical skills and analytical ability and helps to find the answers to diverse questions. This can happen in laboratories in various areas, ranging from the food industry to laboratories dealing with forensic and agricultural questions. The great diversity of analyses, ranging from manual to fully automated and robotised analyses, requires the effective deployment of technologies, equipment, IT and quality assurance. The BSc can also be involved in or primarily responsible for managing and controlling some or all of a research or production process. Working as part of a team, he develops or applies new technologies or processes or improves existing processes, organisms, products or materials. All aspects of sustainability are always taken into account.

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Researcher
- Forensic laboratory worker
- Vaccine developer
- Plant breeder

Commerce and customer service
- Advisor with consultancy or research firm
- Advisor with safety or environmental consultancy

Application and production in laboratories
- Quality control in food industry or horticulture
- Production of medicines or ingredients

Engineering and manufacturing
- Bio-process engineer
- Production manager
- Reactor designer

National programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	III	II	–**	I	I	I	I	III

** Students can choose to raise the level of these competences by making certain choices in their range of subjects, internship and graduation project during the last two years of their course.

Biotechnology

KNOWLEDGE

- **Cell biology:** structure and function of eukaryotic and prokaryotic cells, metabolism, transport
- **Chemistry:** basic chemistry (atomic structure, reactions in water, kinetics), analytical chemistry (spectroscopy, chromatography), organic chemistry and synthesis
- **Biochemistry:** biomolecules, protein and enzyme chemistry
- **Molecular biology:** DNA, heredity, molecular genetics, recombinant DNA techniques
- **Mathematics:** chemical arithmetic, functions (differentiating, integrating)
- **Genetics:** basic concepts and application (e.g. population genetics, QTL analysis)
- **Statistics**: data processing, normal distribution, confidence intervals, testing
- **Bioinformatics:** sequence analysis, annotation of genomes, transcriptome analysis, Bioinformatics Web Services (e.g. EBI, NCBI)
- **Botany:** basic knowledge (evolution, anatomy, photosynthesis, genetics); optional subjects: domestication, resistance, breeding (including at molecular level), hormones, components
- **Immunology:** innate and acquired immunity; optional subjects: autoimmune diseases, immunodeficiency diseases, immunology and cancer, immunology techniques
- **Pathology:** anatomy, physiology and pathology of organ systems
- **Microbiology:** taxonomy, determining and quantifying micro-organisms
- **Sustainability**

SKILLS

- **General laboratory skills based on GLP rules:** weighing, pipetting, making solutions (buffers, culture media) and preparations, colourings, microscopy, lab journal, reporting, chemical arithmetic
- **Safe working in the laboratory, working in accordance with GMT rules (good microbiological techniques):** working in aseptic and sterile conditions, culturing micro-organisms and eukaryotic cells, using special media, biological materials (tissues and cells from plants and animals, blood, urine, etc.) and biomolecules (proteins and/or antibodies, DNA); waste processing
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, electrophoretic equipment, fume cupboard, safety cabinet, microscope
- **Molecular biology techniques:** DNA/RNA isolation, digestion, ligation, transformation, PCR, qPCR, gel electrophoresis; column chromatography; flow cytometry; HPLC and FPLC
- **Chemical analysis methods:** spectrometry, chromatography, enzyme analysis, bonding analysis
- **(Bio)chemical procedures:** fractionation methods, SDS-PAGE, preparative chromatography, western blotting, ELISA, fluorescence microscopy, flow cytometry
- **Computer skills:** word processing, spreadsheets, slide presentations, bio-informatics tools, simple imaging
- **Social and communication skills:** collaborating, meetings, reporting (lab journal, research report), oral presentation, project-based work, ethics
- **Research skills:** problem analysis, research questions, desk research, research planning and implementation

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

TYPICAL TEXTBOOKS

- *Campbell Biology*, L.A. Urry, M.L. Cain e.a.
- *Biotechnologie for beginners*, R. Renneberg, V. Berkling e.a.
- *Plant Biology*, A.M. Smith, G. Coupland e.a.
- *Essential Cell Biology*, B. Alberts, K. Hopkin e.a.
- *Biochemistry*, J.M. Berg, J.L. Tymoczko e.a.
- *Bioprocess Engineering Principles*, P. M. Doran
- *Introduction to Genetic Analysis*, A. Griffiths e.a.
- *Molecular diagnostics: Fundamentals, Methods and Clinical Applications*, L. Buckingham
- *Practical Skills in Forensic Science*, A. Langford, J. Dean e.a.
- *Statistiek, validatie en meetonzekerheid voor het laboratorium*, J.W.A. Klaessens

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Research associate Jelte-Jan Reitsma:

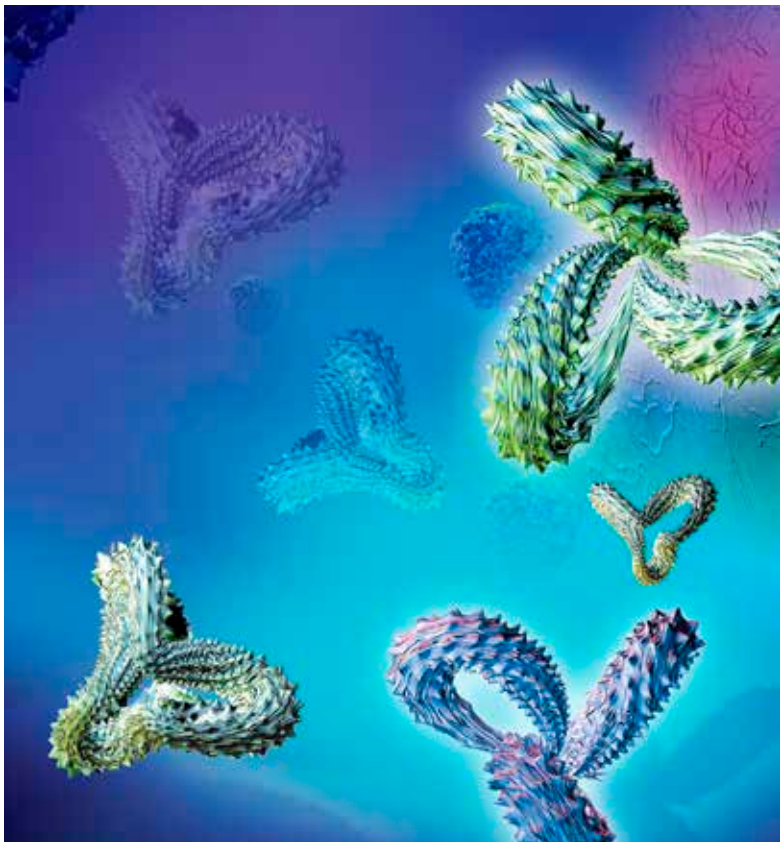
‘Collaboration may be the most important competence’

Name: Jelte-Jan Reitsma
Age: 30
Courseof study: Biotechnology
Place of employment: Genmab B.V., Utrecht
Job: Research Associate Cell and Molecular Sciences

SOP: a written work instruction that lays down in detail how a specific action must be completed.

‘I began my working life as a joiner. After about a year, I realised that I still wanted to study. I then sat an aptitude test and explored all the higher professional education programmes that aroused my interest. In the end I chose Biotechnology. It’s a programme that enables you to do a lot of good things and as a biotechnologist you collaborate much of the time – something that I really enjoy. There are also research groups you can join all over the world.

The programme lived up to my expectations, although project-based working was in its infancy at the time. You certainly noticed that there were still a lot of obstacles to be overcome. As a group, you could split up and all solve small problems.

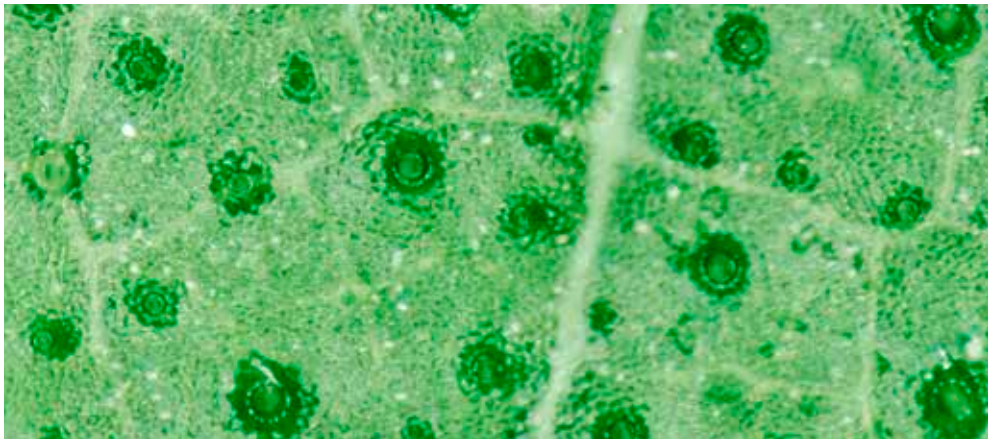


You then had to pull them all together as a coherent whole in the group. All that group work doesn’t really teach you how to work on your own, but I think the essence was that you can do more together. My specialisation (process engineering) arose from my particular interest in bioreactors. I wanted to know more about the technology behind them.

I feel that the programme prepared me quite well for real life, although I did miss out on some theoretical background. But it is, of course, a wide-ranging course. My current job mainly involves me in protein production (by means of transient and stable transfections) in bioreactors and other culture bottles. As the laboratory manager, I am also responsible for scheduling cleaning work, placing orders, equipment management and innovations. I also try out new equipment, culture methods and media and specialise in planning and producing cell banks. I discuss deadlines and quantities with project managers. With my own group I discuss who is to perform particular tasks. I enjoy this planning process and would like to be in a management job in future.

Knowing what suits you

Research and experimentation are always important to innovative people. Yet many people have absolutely no interest in them. Their strength may lie, for example, in the perfect completion of work which has to be done in accordance with precise rules (SOPs). In our company, we also use competences. I believe it is highly advisable to first find out what kind of person you are and then consider which competences are in keeping with your personality. This is, of course, difficult, and it will take weeks or months to become clear to most people. Collaboration may be the most important competence. However well you solve problems or conduct experiments on an individual basis, you also have to be able to convey the results to colleagues so that they can also use them.’ ■



Biotechnologist Pieter Nibbering:

‘As a researcher, you never stop learning’

‘After leaving secondary school, I opted for the Higher Laboratory Studies programme because I learned at an open day that the first year would be a mix of Chemistry and Life Sciences (Chemistry, Biochemistry and Medical Laboratory Research). I didn’t yet know exactly what I wanted to do and this variety during the first year was an enormous help to me. At a certain point, I decided on Life Sciences and, finally, in the third year, I opted to specialise in Green Biotechnology because that was what suited me best. I am currently busily engaged with my graduation project.

The programme met my expectations, although, if I am honest, I had a completely different idea of laboratory research before I started. I now know that Life Sciences is a very wide concept and that you can find a job anywhere in the world after completing this programme.

For my graduation project, I am working at the Umeå Plant Science Center (UPSC) in Sweden. I am conducting research into the function of a certain protein in *Arabidopsis thaliana* (scientific model organism). I am using a variety of laboratory techniques. This is my second project and I did not have any problems in either project with relating my study course to the professional field. Almost all the techniques I have used had already been covered in the programme. I also believe that I will manage to find a job after this programme, but I would rather continue my studies. After completing this BSc course, I plan to follow the Master course in Plant Biotechnology in Wageningen. I expect that my BSc will stand me in good stead.

Keeping up

To me, the most important competences for a researcher are **research**, **experimentation**, **development** and **self-management**. As a researcher, you actually never stop learning. More new articles are being published each month and more new techniques and protocols are being devised all the time. As a researcher, you have to keep up with the latest trends and that’s what makes these competences so important.
Other competences, such as **management | coordination** or **leadership | managing people** may become important in future, but that depends on career choices. As a BSc, you will not get a top job in a company, institution or university straight away, but that can change in the course of your career.

I would really like to do a PhD after my Master programme. I don’t yet know what the subject will be, but I do know that I want to stay in plant biotechnology. I still have no idea what I will do after my PhD. Time will tell!’ ■

Name: Pieter Nibbering
Age: 22 jaar
Course of study: Biotechnology
Graduating in: Green biotechnology