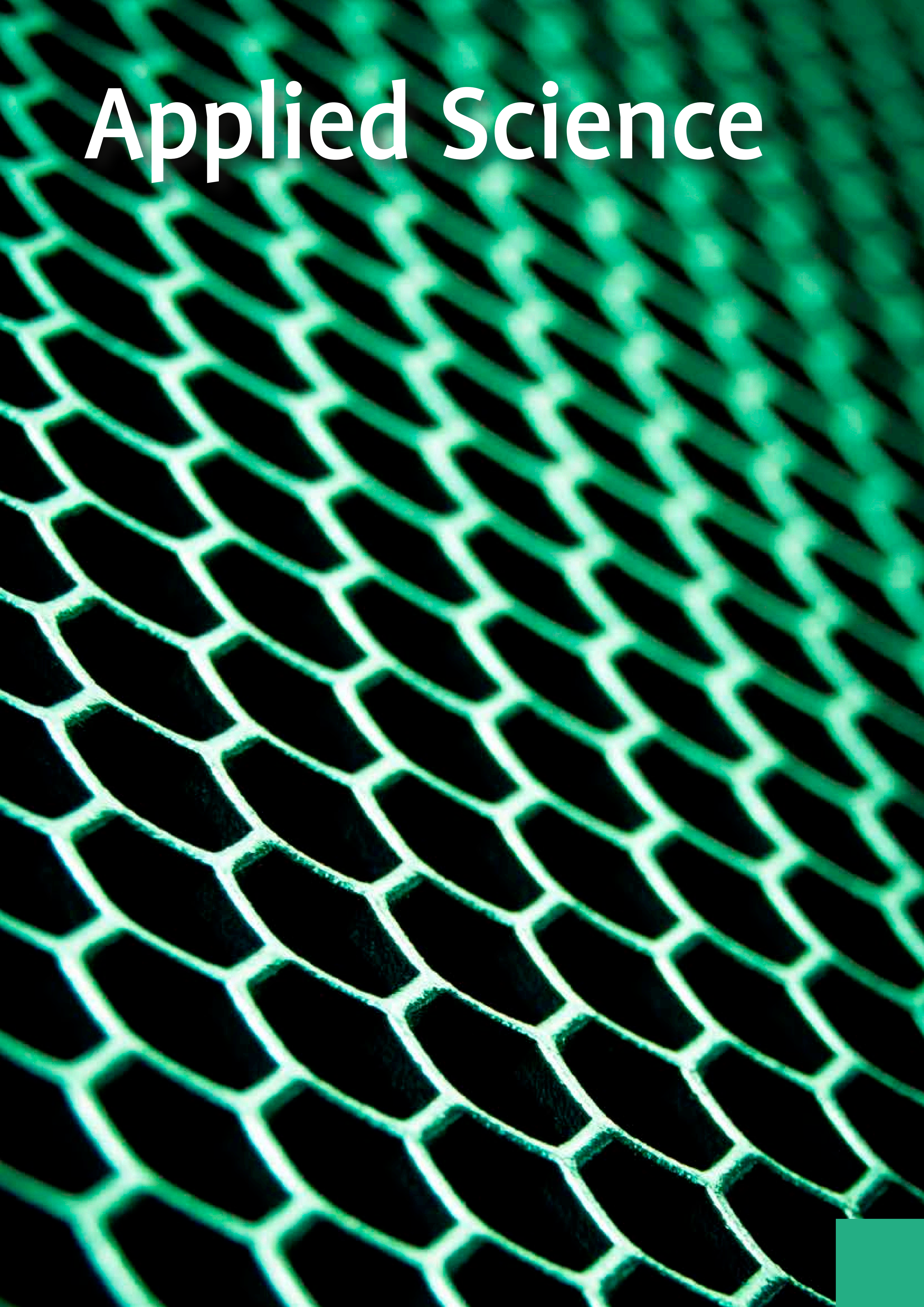
Section 5

Programme profiles

The Applied Science Domain contains nine programmes of which eight programme profiles have been established nationally through cooperation between domains. This section presents the national programme profiles for:

One programme in the Applied Science Domain is only being offered at one university within the domain. This means that there is not a programme profile which has been agreed nationally in terms of DAS. This document therefore outlines the situation at the individual university. The institutional profile for this programme is consistent with the domain profile of the Bachelor of Science in the Applied Science domain. The programme involved is:

Applied Science



APPLIED SCIENCE trains students for a range of jobs, from the microbiology to the chemistry and technology fields, from researcher to analyst. Its main features are its broad orientation in the first year in the fields of biology, chemistry, materials science and technology and a wide range of graduate project places in commercial companies, the health sector, universities and research institutes.

After the first year, students choose a specialisation that best suits their interests and ambitions. These learning specialisations are variable, which means that there is also great flexibility in the professional domains in which the graduates will find employment. A lot of attention is focused on the competence of self-management during the programme because of the wide range of choices that it offers.

Institutions that offer the programme

- Fontys University of Applied Sciences, Eindhoven
- Zuyd University of Applied Sciences

National programme profile

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

* at least one of these competences must be raised one level

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
- Biological laboratory research worker
- Chemical laboratory research worker
- Vaccine development
- Materials research
- Food research

Application and production
- Analytical chemist for quality control of products

Medical laboratory diagnostics
- Analyst in hospital or diagnostic centre

Engineering and manufacturing
- Process engineer

Commerce and customer service
- Patent law assistant

TYPICAL TEXTBOOKS

- *Chemistry*, J.E. McMurry. R.C. Fay e.a.
- *Organic Chemistry*, D. Klein
- *Principles of Instrumental Analysis*, D.A. Skoog, F.J. Holler e.a.
- *Campbell Biology*, L.A. Urry, M.L. Cain e.a.
- *Molecular Biology of the Cell*, B. Alberts, A. Johnson
- *Brock Biology of Microorganisms*, M.T. Madigan, K.S. Bender e.a.
- *Klinische Chemie en Hematologie voor Analisten*, E. ten Boekel, B.A. de Boer
- *Procestechnologie, delen 2, 3 en 4*, VAPRO
- *Kunststof- en Polymeerchemie*, R. van der Laan
- *Statistiek om mee te werken*, A. Buijs

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.

Applied Science

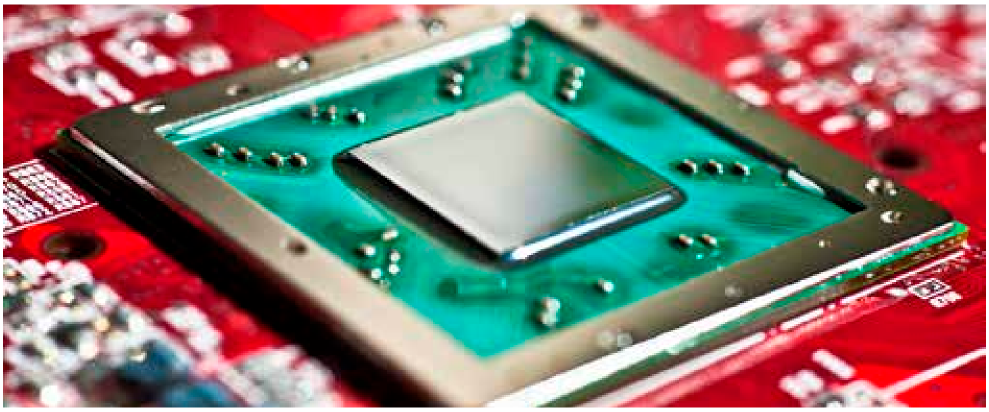
KNOWLEDGE

- **Basic chemistry:** atomic and molecular structure, hybridisation, molecular structures, molecular bonds and interactions, reaction equations, chemical balances, reaction kinetics, redox reactions, buffer solutions
- **Analytical chemistry:** spectroscopy, chromatography
- **Physical chemistry and physics:** electrochemistry, electronics, gas law, mass and energy balances
- **Organic chemistry:** synthesising functional groups, reaction mechanisms, substitution and elimination reactions, alkanes, alkenes, carboxylic acids, esters, aromatics, alcohols, ethers, alkyl halides, isomers, eniantomers, stereochemistry
- **Materials science:** monomers, polymers, biopolymers, radical polymerisation, thermal and mechanical properties
- **Statistics:** data processing, normal distribution, confidence intervals, testing
- **Mathematics:** chemical arithmetic, functions, differential calculus
- **Biochemistry:** biomolecules, DNA (structure, translation, transcription, replication), RNA, nucleic acids, proteins, cell membrane, heredity
- **Cell biology:** structure and function of eukaryotic and prokaryotic cells, cell division, metabolism, transport
- **Microbiology:** growth and classification of micro-organisms, pathogenetic mechanisms, infectious diseases
- **Health, safety and environment:** sustainability

SKILLS

- **General laboratory skills:** weighing, pipetting, making solutions (buffers), keeping a lab journal, chemical arithmetic, microscopy
- **Chemical analysis methods:** titrimetry, spectrometry (e.g. UV/VIS, IR, AAS, NMR), chromatography (e.g. GC, GC-MS, electrochemistry, enzyme analysis, bonding analysis)
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, microscope, fume cupboard
- **Laboratory techniques:** distillation, extraction, microbiological techniques
- **Safety at work:** in the laboratory and in the professional field
- **Computer skills:** word processing, spreadsheets, chemical drawing programs and presentations
- **Research skills:** problem analysis, research questions, desk research, research planning and implementation
- **Social and communication skills:** collaborating, meetings, reporting (lab journal, research report), oral presentation, project-based work, self-management

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.



R&D engineer Esther Roeven:

‘I was given time to decide what direction to take’

Name: Esther Roeven
Age: 22
Course of study: Applied science
Place of employment: Surfix BV, Wageningen
Job: R&D engineer in surface chemistry

‘When I started my course, I found it difficult to make a choice. I knew that I wanted to do a technical course but I had no specific preference for a particular subject. The first year of the applied science programme is very wide-ranging (both biology and chemistry/technology and food); as you progress through the course you can choose between four learning pathways. Because of this, I felt I had more time to make a decision about the direction I really wanted to take.

Nano

During the first year, I discovered that I liked chemistry a lot more than biology. After that first year, I chose my subjects and projects in that discipline. During my internship at TNO in the third year, I was involved in a nanotoxicology project and found out that I liked nanotechnology much more than “bulk” chemistry. The programme offers an internal “deepening minor” in which you can carry out six pieces of research into a number of subjects of your choice for six months. I used this minor to delve further into micro- and nanotechnology and then ended up in surface chemistry, which eventually also became my graduation project.

I now work at Surfix BV, a young company within Wageningen University. We develop chemical surface modifications in the form of nanocoatings for the micro-and nanotechnology markets, in particular microchips and biosensors.

I feel that study and practice fitted seamlessly together. There was already a lot of contact with the private sector during the programme. From the first year, every project was linked to a business, which quickly gives you an idea of how things are done in businesses. At the end of the day, I think that the competences you really use will very much depend on your job. I also supervise interns and graduating students, where I regularly use the competences of **instruction | supervision | teaching | coaching** and **leadership | managing people**. The competence of **management | coordination** also comes up almost every day because I work for a young company, which still requires a lot of organisation, and I think it’s really great that I’m making a contribution. The competence of **advice | procurement and sales** sometimes comes up when materials, systems or chemicals have to be sourced and ordered.

There are certainly opportunities for advancement in the company. At present, my ambition for advancement is therefore in this company but, in the long-term, it may be in another job. We are based in the organic chemistry department of Wageningen University so I can also take subjects and courses here. I’m happy to do so!’ ■

QCT Lukas Balk:

'There's a reason why there are so many competences!'

'On the prevocational course, my interest in applied science was aroused by an inspirational chemistry lecturer. Both of my parents work in education so teaching has always been in my blood. The plan was therefore to become a chemistry teacher but for that I needed at least a higher professional degree. When studying laboratory technology at senior secondary vocational level, I found that Applied science suited me; I obtained good results and it was decided that I could start the higher professional course. I wanted to gain some practical experience first and therefore decided not to start on the teacher training programme immediately but the more practice-oriented applied science programme. I wanted to study in depth what I already knew from my senior secondary specialisation (analytical chemistry) and expand my studies to include what I did not yet know (organic chemistry/process technology/ material science). During my graduation project, I conducted fundamental research into the formation of nanocrystals with fluorescent properties (quantum dots) made of semiconductor materials.

As a Quality Control Technician FP, I am currently responsible for analysing pharmaceutical and nutritional finished products in the form of gel capsules (finished product: Banner Pharmacaps EU) mainly by means of HPLC and GC analysis. I am also charged with planning and delegating in the distribution of analyses and in the near future I will be providing assistance in the establishment/acquisition of new analysis techniques. The widening of knowledge that I found in the higher professional course means that I contribute to and share ideas in many different subjects. However, I do think that the programme has a very strong emphasis on research and less, fro example, on working within strict guidelines (GMP, FDA, EP, USP, etc.). Yes, a lot of people opt for research but I myself think that graduates have greater opportunities for advancement within a quality control environment than in a research environment.

Self-management

The competence of **management | coordination** plays a great part in my job. Also, as a QC technician, I do have a lot to do with **experimentation**, a little with **research** and **development**, but mostly with **self-management**. Here, we work within very strict guidelines in which almost every operation is laid down. You aren't allowed to deviate from them and that makes self-reliance and self-management essential. As an analyst/technician, you also have to **instruct** and **train** new colleagues. There is a reason why a Bachelor of Applied Science* has such a variety of competences!

Over the next few years, I would like to progress within the QC department to a job such as senior technician and would like to concentrate on introducing new methods. After that, I would like to progress to a management position in QC/R&D or perhaps use my qualities in another company. That's all in the distant future, but a job such as QC or R&D manager also appeals to me. And teaching is always another option.' ■

Name: Lukas Balk
Age: 23
Course of study: Applied science
Place of employment: Banner Pharmacaps Europe, Tilburg
Job: Quality Control Technician Finished Products

* At the time of this interview, the title of Bachelor of Applied Science was used.

Bio-Informatics

BIO-INFORMATICS is the professional field in which computer and information technology is used to collect, store, share, analyse, interpret and disseminate data from biomedical and/or biological research.

The main subcategories of this specialisation are: genomics, transcriptomics, proteomics (including protein modelling, structures and functions), metabolomics and the integration of data from these areas. Bio-informaticians are employed to conduct biological and biomedical research in scientific institutions and in companies in the pharmaceutical, biotechnology, food and plant-breeding industries.

Institutions that offer the programme

- HAN University of Applied Sciences, Nijmegen
- Hanze University of Applied Sciences, Groningen
- University of Applied Sciences Leiden

National programme profile

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

** 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.

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
- Analysing large data sets from high-throughput laboratory research
- Scientific programmer

Application and production
- Managing gene and protein databases
- Analysing gene-sequencing data flow

Commerce and customer service
- Biotechnology data consultant

TYPICAL TEXTBOOKS

- *Campbell Biology,* L.A. Urry, M.L. Cain e.a.
- *Essentials of Genetics / Concepts of Genetics,* W.S. Klug, M.R. Cummings e.a.
- *General, Organic and Biochemistry,* K. J. Denniston, J.J. Topping e.a.
- *Starting out with Python,* T. Gaddis
- *Data Structures and Algorithms using Python,* R.D. Necaise
- *Bioinformatics and Functional Genomics,* J. Pevsner
- *Using R for Introductory Statistics,* J. Verzani
- *Data Mining, I. Witten,* E. Frank e.a.
- *Statistics for the Life Sciences,* M. L. Samuels, J.A. Witmer e.a.

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.

Bio-Informatics

KNOWLEDGE

Biology

- **General Biology:** organisms, tissues, evolution
- **Cell biology:** cell structure, energy supply, transport, cell-cell communication, mitosis, meiosis, gene regulation, signal transduction routes, metabolic routes
- **Genetics:** DNA structure, replication, code, transcription, translation, epigenetics, mutations, SNPs, structural variations, inheritance, population genetics
- **Microbiology/virology:** construction, diversity, metabolic strategies, evolution

Chemistry

- **General chemistry:** atomic structure, periodic system, molecules, nomenclature, reactions, kinetics
- **Biochemistry:** building blocks, macromolecules, carbohydrates, lipids, proteins, enzymes, metabolism

SKILLS

Informatics

- **Programming in Python:** data structures, control structures, modular approach, GUIs, Biopython, python database approach, data types, object-oriented programming
- **Programming in Java:** object-oriented programming, application of algorithms, inheritance
- **Programming in R:** scripting, data analysis, statistics, data visualisation
- **Web technology:** HTML, CSS, web services
- **Databases:** relational design, implementation, querying and programmatic interaction (MySQL)
- **Workflow tools:** e.g. Galaxy, Snakemake
- **Linux:** bash scripting, Regex

Bio-informatics

Knowledge and analytical skills of at least the subjects listed below:

- **Sequencing technologies:** NGS technologies, assembly, mapping, NGS application areas (e.g. de-novo & re-sequencing) exome sequencing
- **Algorithmic aspects of sequences:** alignment, mapping, graphs, scoring matrices
- **Sequence annotation:** BLAST and related software
- **Gene expression analysis:** RNA-seq data, Bioconductor
- **Homology and phylogenics**
- **Practical use of bio-informatics tools:** e.g. BLAST, OMIM, Genome Browsers, Genbank, Uniprot, KEGG, MSA tools, topology prediction, PFAM, PROSITE, YASARA PDBe, Gene Expression Omnibus, FASTQ, mappers & aligners & assemblers

Statistics & data analysis

- **Sampling:** data types, population and sample, errors, bias, variation, (un)certainty
- **Descriptive statistics:** e.g. average, median, standard deviation, range, interquartile range
- **Visualization:** e.g. box-plot, histogram, scatterplots, Venn diagram, trees, heatmaps
- **(Hypothesis) tests:** e.g. t-test, ANOVA, chi-squared, Wilcoxon, non-parametric
- **Cluster analysis:** distance measurements, hierarchical clustering, k-means clustering
- **Regression:** linear, non-linear, multivariate, PCA
- **Dataming/machine learning:** e.g. Decision Trees, Naive Bayes, k-Nearest Neighbour, Neural Networks, SVM

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.

Programmer Freerk van Dijk:

'A lot of data requires a lot of computing power'

Name: Freerk van Dijk
Age: 25
Course of study: Bio-Informatics
Place of employment: Genomics Coordination Centre, Genetics Department, University Medical Centre Groningen
Job: Scientific programmer

'I chose this programme because I was interested in biology. One of my hobbies is computers/gaming and I quickly made the link with this course of study. As I had a pre-university diploma, I was able to follow the fast-track bio-informatics programme. I more or less started in the second year and then had to take a number of subjects from the first year. I made up the lost ground in programming languages by putting in extra hours. A lot of attention was also focused on biology and laboratory work during the programme.

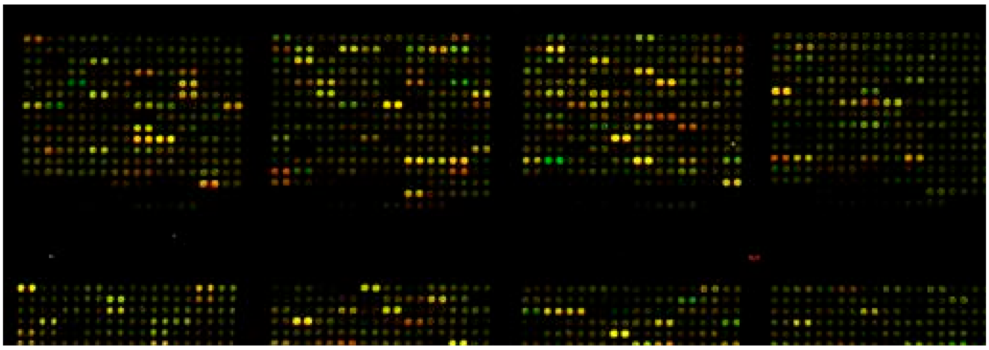
My work currently involves setting up pipelines/systems for analysing next-generation sequencing (NGS) data. This technology is used to replicate human DNA (mainly from the exons) and analyse it, which generates massive amounts of data. The analysis part requires a lot of computing power, which means that these analyses have to be performed on computing clusters. Consideration has to be given not only to the open source software required but also to ways of distributing these analyses in parallel. The ultimate goal is to detect variations in the genome and validate any causal variations in the laboratory. We are also responsible for supplying servers and storage capacity for software which the genetics department uses in different DNA analyses and assisting the researchers by providing scripts, software, etc.

Genome

I am currently working on the "Genome of the Netherlands" project, in which we have mapped out the complete genome of 250 father-mother-child trios. The aim is to provide a clear picture of all natural variation in the Dutch population. This data can be used to rule out frequently occurring variations in our population as being the cause of illness in sick people.

The programme fitted in really well with my job. Initially, I did notice that I had followed the fast-track programme: I was lacking a number of hours of programming experience, although you catch up in the course of your work. Lab technologies are also important because they are used to prepare samples for NGS. The analysis of NGS data was not included in the programme, because that technology was still new at the time.

Experimentation and research are the most important competences in my job. The professional field is still fairly new, which means that a lot of software and analyses have not been standardised. The result is that a lot of new software and analysis methods have to be designed and implemented. To me, UMC Groningen is a challenging environment where the focus is on research. This ensures that there is enough variety to keep the job interesting and there are all kinds of opportunities for advancement in the area of research.' ■



Bio-informatician Varshna Goelela:

'You always have to be eager to learn'

'I chose the bio-informatics programme because the combination of programming and biology appealed to me, partly on account of my previous ICT manager programme in senior secondary education (MBO). In addition, bio-informatics emerged from a course evaluation test as the best match for me. It was a fairly new course at the time – a lot of challenges and a lot of opportunities on the jobs market. And what I also regard as a major advantage: as a bio-informatician, you can progress in a very broad area or a very specialised area.

The programme was everything I expected it to be: a good combination of biology and programming. Now, during my day-to-day work, this combination seems to have been an ideal match. My choice of subject for my graduation project was mainly a practical and technical one. At the time, Next-Generation Sequencing was a relatively new technology that was making great advances and did not yet figure very much in the programme. I deliberately chose a graduate internship that did provide this opportunity and was able to learn how to analyse Next-Gen data. Looking back, this seems to have been a good choice as I am still making full use of the knowledge that I acquired at that time.

As a bio-informatician, I am responsible for carrying out data analysis and visualising various type of experimental data, such as transcriptomics, microbial data and metabolomics. I am also working on the development of bio-informatics pipelines and tools which are used both inside and outside our group. An example of this is a pipeline I have developed for automating quality control, preprocessing and normalisation of Illumina microarray data.

As far as I'm concerned, the programme fitted in really well with my job. During my studies, I also did various projects that provided me with the knowledge that I still use every day in my job. What the programme didn't cover so much was how important the design of a study is for data analysis. That's a pity, because the design of a study has a major impact on the performance of the analyses.

Communication
Research is an important part of a bio-informatician's job, so it's an essential competence for me. Sometimes, something will come your way that you have to learn about yourself, so I think you always have to be eager to learn. Good communication is another requirement. As a bio-informatician, you are surrounded by statisticians, scientists and ICT specialists, so it's useful to be able to communicate with each of them to streamline projects and analyses. **Self-management** is also important, for example, for enabling you to meet your deadlines.

I would still like to do a Masters degree in bio-informatics so that I can specialise further. In the professional field, I can see the way bio-informatics is playing an increasingly important part in science and advances in science ensure that tools are becoming increasingly efficient and analyses can be carried out faster and more accurately. I hope that I will be able to be part of these exciting advances in future.' ■

Naam: Varshna S. Goelela
Age: 26
Course of study: Bio-Informatics
Place of employment: TNO Zeist, Microbiology and Systems Biology department
Job: Bio-informatician

Biology and Medical Laboratory Research

BIOLOGY AND MEDICAL LABORATORY RESEARCH is a programme that trains students to work as research staff in a laboratory. The key element is biology as referred to by the term Life Sciences, a wide-ranging course in molecular biology focusing on research into bacteria, plants, animals and humans.

The course started out as two programmes and this division is still apparent in the main professional domains, with biological research and development on the one hand and medical laboratory diagnostics on the other.

As a researcher, the graduate is involved in developing new products, materials, methods and processes or improving existing ones, particularly in the pharmaceutical and food industries, academic research groups, research institutes and crop breeding and protection. Graduates participate unsupervised in research teams. They develop and build an experimental test setup, conduct and interpret experiments, draw conclusions and make recommendations. In smaller organisations, the approach is often more hands-on, with the graduate also being responsible for organising, coordinating and directing the work.

Institutions that offer the programme

- Avans University of Applied Sciences, Breda
- HAN University of Applied Sciences, Nijmegen
- Hanze University of Applied Sciences, Groningen
- HU University of Applied Sciences, Utrecht
- Inholland University of Applied Sciences, Amsterdam
- NHL Stenden University of Applied Sciences, Emmen
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden
- Rotterdam University of Applied Sciences
- Saxion University of Applied Sciences, Deventer
- Saxion University of Applied Sciences, Enschede
- University of Applied Sciences Leiden

Diagnostics laboratories in the health sector conduct research into material of human (or sometimes animal) origin. These are usually laboratories working in the fields of clinical chemistry, medical microbiology, cytohistopathology, haematology, immunology, endocrinology or clinical genetic research. Working as researchers, graduates help to find answers to clinical questions by applying scientific methods of analysis in the diagnosis, treatment and prevention of disease. They work throughout the sampling process and it is therefore important for those occupying this post to accumulate the knowledge and understanding required to include clinical data in the performance and interpretation of the research and to make connections between medical issues and (provisional) research results. The great diversity of analyses, ranging from manual to fully automated and robotised analyses, requires versatility and the effective deployment of technologies, equipment, IT and quality assurance. In a laboratory setting, graduates can progress to specialist and/or management roles.

National programme profile

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

* At least one of these competences must be raised by one level.
** 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.

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
- Laboratory researcher
- Animal testing worker
- Vaccine development

Medical laboratory diagnostics
- Analyst in hospital or diagnostic centre
- Introducing new diagnostic tests
- Developing test methods

Application and production
- Quality assurance in food industry
- Small-scale production of drugs

Biology and Medical Laboratory Research

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 (functional groups)
- **Biochemistry:** biomolecules, protein and enzyme chemistry
- **Molecular biology:** DNA, heredity, molecular genetics, recombinant DNA, simple bio-informatics
- **Anatomy/physiology/pathology:** structure and function of organ systems, blood, endocrine system etc., for research and diagnostics (clinical chemistry, haematology)
- **Immunology:** innate and acquired immunity, molecular mechanisms, practical applications
- **Microbiology:** growth and classification of micro-organisms, pathogenetic mechanisms, infectious diseases, resistance
- **Mathematics:** chemical calculations, functions (differentiating, integrating)
- **Statistics:** data processing, normal distribution, confidence intervals, testing

SKILLS

- **General laboratory skills based on GLP rules:** weighing, pipetting, making solutions (buffers, culture media) and preparations, colourings, microscopy, lab journal, chemical calculations
- **Safe working in the laboratory, working in accordance with GMT rules (good microbiological techniques):** working in aseptic conditions, culturing micro-organisms and eukaryotic cells, working with special media, biological materials (tissues, cells, etc.) and biomolecules (proteins and/or antibodies, DNA)
- **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, gel electrophoresis
- **Chemical analysis methods:** spectrometry, chromatography, enzyme analysis, bonding analysis
- **(Bio)chemical procedures:** fractionation methods, SDS-PAGE, blotting, preparative chromatography
- **Computer skills:** spreadsheets, slide presentations, bio-informatics tools, simple imaging
- **Social and communication skills:** collaborating, meetings, reporting (lab journal, research report), 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.
- *Medical Microbiology,* P.R. Murray, K.S. Rosenthal e.a.
- *Biochemistry,* J.M. Berg, J.L. Tymoczko e.a.
- *Chemistry,* J.E. McMurry. R.C. Fay e.a.
- *Molecular Cell Biology,* H. Lodish, A. Berk
- *Immunology,* D. Male, S. Peebles e.a.
- *Brock Biology of Microorganisms,* M.T. Madigan, K.S. Bender e.a.
- *Bacteriologie voor laboratorium en kliniek,* N.M. Knecht, J. Doornbos
- *iGenetics,* P.J. Russel
- *Toegepaste Wiskunde voor het hoger onderwijs,* J.H. Blankespoor

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.

Junior scientist Romy Waber:
‘You acquire real expert knowledge while you work’

Name: Romy Waber
Age: 22
Course of study: Biology and Medical Laboratory Research
Place of employment: PathoFinder BV, Maastricht
Job: Junior scientist

‘I was interested in biology from an early age and found DNA in particular extremely interesting. At the end of my senior secondary education, my subject cluster project was: CSI, what’s true and what’s not? At the time, we had the opportunity to do the practical work at Zuyd University of Applied Sciences, where I encountered pipettes, test tubes and of course DNA technologies for the first time. I thought this was so interesting and enjoyable that I decided to delve more deeply into biochemistry.

The programme met my expectations, although I thought the first year in my department was somewhat wide-ranging. I knew for sure that I wanted to go further in biochemistry and therefore found subjects like chemical engineering and process technology less interesting, although I did of course understand that a wide-ranging course can be very useful. I wanted to know more about DNA, RNA, PCR and real-time PCR but we only got the basics at university. I therefore went in search of an internship which offered a lot in terms of DNA and RNA technologies and ended up at PathoFinder: a young company which does a lot of research into the development of new molecular diagnostics. It’s not only conventional methods that are used, new technologies are also designed and tested there.

As a junior scientist at PathoFinder, I am jointly responsible for developing a point-of-care instrument for diagnosing highly contagious respiratory pathogens, resistance patterns and biomarkers. We are also developing a new generation of molecular diagnostics focusing on the rapid detection and identification of human pathogens caused by an infection. PathoFinder uses multiparameter analysis technologies which are designed to perform analyses of highly complicated samples quickly and easily. As far as I am concerned, education and work fitted seamlessly together, especially as I had completed an internship at the company. You mostly learn general theory during the programme but I think you acquire real specialist knowledge while you work.

I do of course need the competences of **research** and **experimentation** a lot because I am employed in the Research and Development department. **Development** is another important competence. PathoFinder is an ISO 13485 certified company and **management | coordination** is therefore also a frequently used competence.

Further study

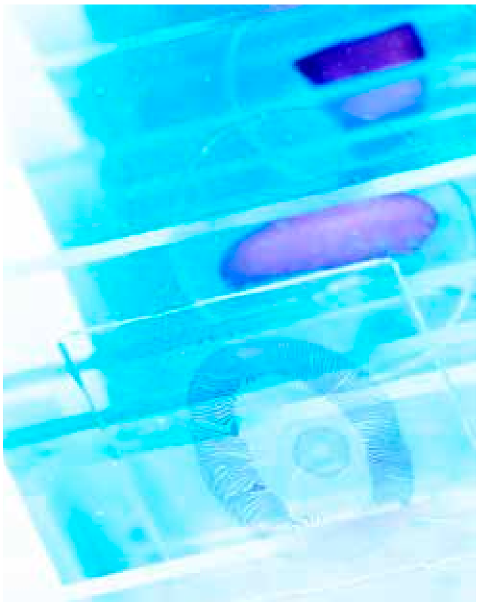
Over the next few years, I intend to study the various technologies in depth to give me a greater feel for the subject. I would also like to continue participating in international projects so that I can acquire knowledge of other companies and get to know more people in the world of molecular diagnostics. I would like to continue working at PathoFinder or its sister company PathoNostics so that my colleagues and I can put even better and even more products on the market.’

General analyst Joyce Scheerman:

'Theory provides a solid foundation'

'Chemistry and biology were my favourite subjects at secondary school. The school counsellor advised me to do a laboratory course. After attending an open day, that seemed to be a good idea. Fortunately, biology and medical laboratory research did indeed turn out to be a very enjoyable and interesting course. I decided to specialise in cyto-histopathology because I used to get good marks for that subject and the specialisation has a lot to do with the human body, which is what attracted me.

My current job involves processing tissues sent in by the hospital and external parties (general practitioners and clinics) so that the pathologists can examine them under the microscope. This means that the samples are assessed macroscopically in the cutting room to ascertain which areas are relevant for making a diagnosis. These areas are excised and processed in a machine to become a paraffin block. Very thin slices are cut from these blocks containing tissue and pasted on to a glass slide. The tissue is coloured (HE). It can then be examined by a pathologist. Further (additional) research can also be carried out on the paraffin block.



The theory part of my programme provided a solid foundation for the work I do now. On the other hand, the practical lessons were minimal in terms of histology and were actually somewhat outdated. During my internships I only used histology techniques for research purposes. Compared with a senior secondary vocational student, higher professional students know little about the practical side of diagnostics. When I came to work in the pathology department at VUmc, I had no idea of what went on in the cutting room.

Various competences

We follow Standard Operating Procedures (SOP) in our work. If we want to change procedures or if, for example, new colourings or pieces of equipment are being used, the competence of **experimentation** is of major importance. Coincidentally, the **development** competence is playing an important role at the moment. This is because we have been involved with **lean management** in the department for a little while. We also use this competence when new equipment is introduced. It is always validated in accordance with a protocol and if necessary a new protocol is written or existing protocols are amended.

We use a number of management systems (chemicals management, quality management, incidents), so I also need the competence of **management**. **Instruction** is also involved in terms of familiarising new staff and supervising interns. The competence of **self-management** also comes into play, as we all work independently and in a group.

In future, I hope to be able to work in a different unit (e.g. molecular biology) within the pathology department and combine this with histology. Maybe I will be able to follow an internal study programme. There are plenty of opportunities!' ■

Name: Joyce Scheerman
Age: 24
Course of study: Biology and Medical Laboratory Research
Place of employment: VUmc, pathology department, histology unit
Job: Histology general analyst

Lean management is a series of methods and techniques for reducing throughput times of processes and cutting costs without compromising on quality.

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.

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.

Institutions that offer the programme

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

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.

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.

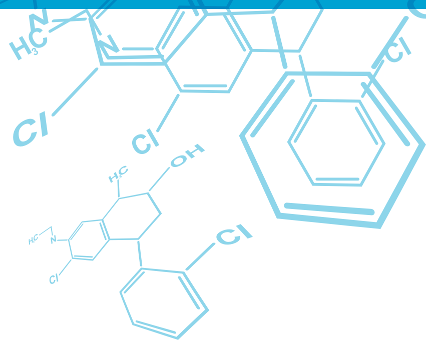
Research and development
- Researcher
- Forensic laboratory worker
- Vaccine developer
- Plant breeder

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

Biotechnology



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.

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

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:

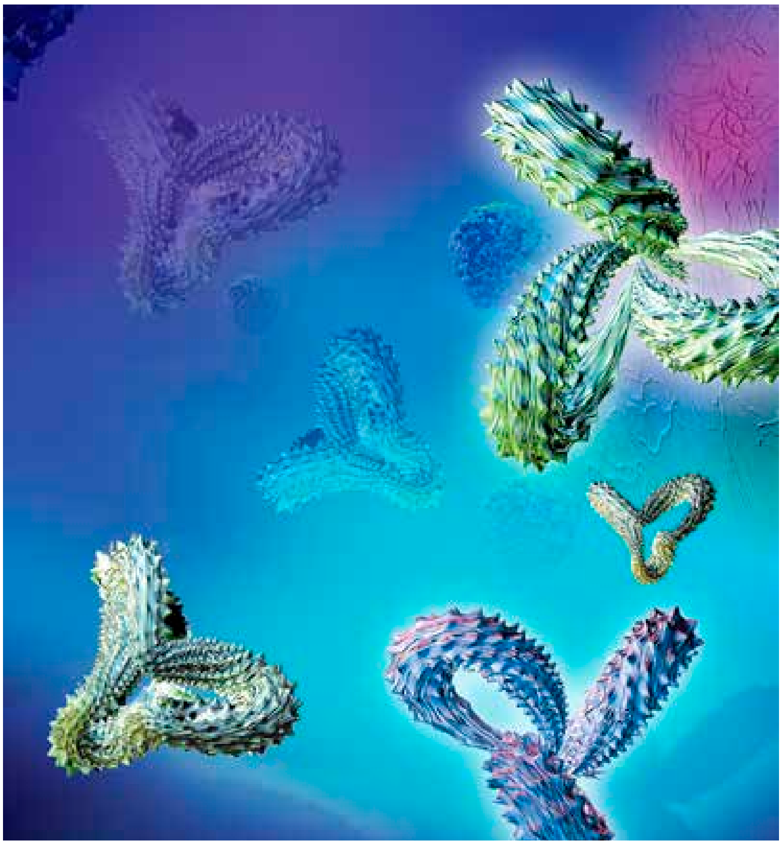
'Collaboration may be the most important competence'

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.

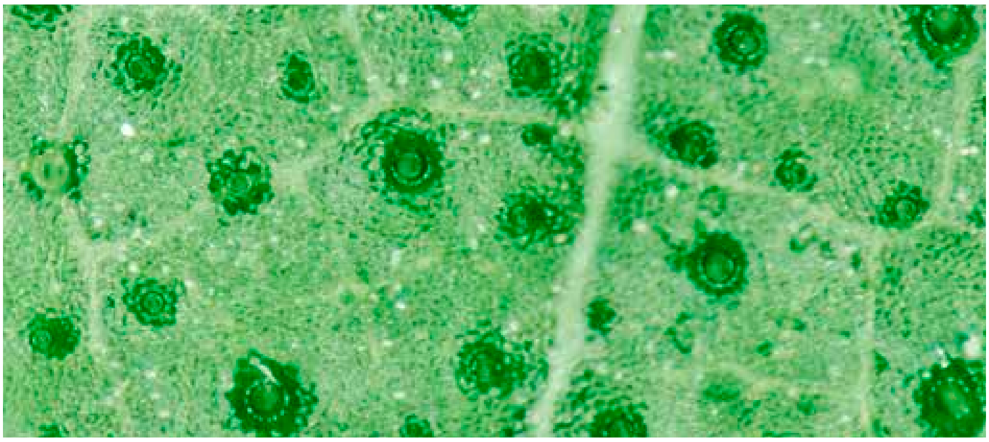


You then had to pull them all together as a coherent whole in the group. All that group work doesn't really teach you how to work on your own, but I think the essence was that you can do more together. My specialisation (process engineering) arose from my particular interest in bioreactors. I wanted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

Chemistry

The higher professional course in CHEMISTRY leads to a job as experimental laboratory worker. The professional field of chemistry is the key element. It can be roughly divided into three major components: analytical chemistry, research into and synthesis of molecules and compounds and the development of products based on functional molecules or components.

Chemists working in research laboratories in government institutions and large companies are responsible for the practical implementation of a complete or partial research project. They develop and build experimental test setups, conduct and interpret experiments (or arrange for this to be done), draw conclusions and make recommendations. In research laboratories in the SME sector, the approach adopted is often less fundamental and more applied. In this case, the chemists tasks also include directing, organising and coordinating the work.

In other domains, including application or manufacture, the chemist is mainly employed as an experimental laboratory worker. This can be in environmental laboratories or quality control and production laboratories in the organic, biochemical and analytical fields or similar laboratories. This usually involves conducting complex and intricate experiments that challenge graduates' practical skills and analytical ability. In the manufacturing domain, chemists are involved in product development and introduction, particularly the aspects completed in the laboratory.

Institutions that offer the programme

- Avans University of Applied Sciences, Breda
- Avans University of Applied Sciences, Den Bosch
- HAN University of Applied Sciences, Nijmegen
- Hanze University of Applied Sciences, Groningen
- HU University of Applied Sciences Utrecht
- HZ University of Applied Sciences, Vlissingen
- Inholland University of Applied Sciences, Amsterdam
- NHL Stenden University of Applied Sciences, Emmen
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden
- Rotterdam University of Applied Sciences
- Saxion University of Applied Sciences, Deventer
- Saxion University of Applied Sciences, Enschede
- University of Applied Sciences Leiden
- Zuyd University of Applied Sciences, Heerlen

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
- Chemical laboratory research worker
- Product development based on functional components
- Analytical chemist
- Research into new functional molecules or compounds

Application and production
- Analytical chemist in a quality control laboratory
- Laboratory-scale production of molecules or preparations for diagnostic tests or research purposes

Engineering and manufacturing
- Developing analyses for quality control
- Research into parameters of chemical reactions or processes for upscaling

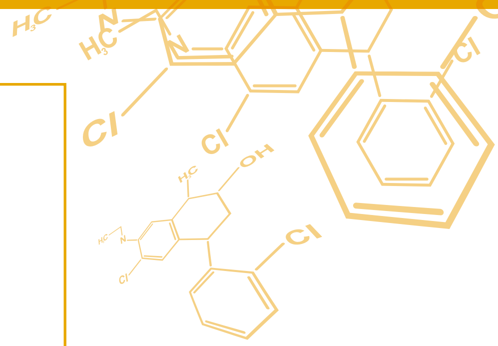
Commerce and customer service
- Safety and environmental consultant
- Sales engineer

National programme profile

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

** 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.

Chemistry



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.

KNOWLEDGE

- **Analytical chemistry:** spectroscopy, chromatography
- **Basic chemistry:** atomic and molecular structure, reactions in water, chemical balance
- **Biochemistry:** biomolecules, protein and enzyme chemistry
- **Physical chemistry** (e.g. electrochemistry, phase theory, colloid chemistry)
- **Information technology** (e.g. chemometrics, experimental design, simulation and design programs)
- **Physical applications** (e.g. optics, electronics)
- **Organic chemistry:** synthesising functional groups, reaction mechanisms
- **Polymer chemistry and materials science**
- **Statistics:** data processing, normal distribution, confidence intervals, testing
- **Thermodynamics and kinetics**
- **Health, safety and environment**
- **Mathematics:** chemical calculations, functions, differential and integral calculus

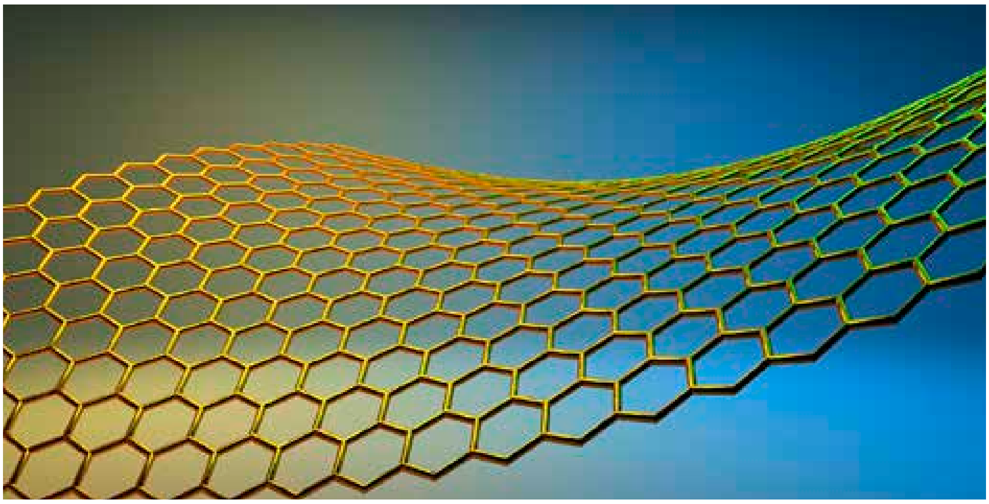
SKILLS

- **General laboratory skills:** weighing, pipetting, making solutions (buffers), keeping a lab journal, chemical calculations
- **Chemical analysis methods:** spectrometry (e.g. UV/VIS, IR, AAS, NMR, ICP), chromatography (e.g. GC, GC-MS, HPLC) and other methods such as titrimetry, electrochemistry, enzyme analysis, bonding analysis
- **Computer skills:** word processing, spreadsheets, chemical drawing programs, presentation techniques
- **Research skills and systematic approach to problems:** problem analysis, preparing research questions, desk research, research planning and implementation
- **Social and communication skills:** collaborating, meetings, written reporting (lab journal, research report), oral presentation, project-based work
- **Safe working in the laboratory in accordance with HSE rules**
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, electrophoretic equipment
- **Using setups for organic synthesis:** reflux, distillation, extraction, evaporators

TYPICAL TEXTBOOKS

- *Chemistry*, J.E. McMurry. R.C. Fay e.a.
- *Campbell Biology*, L.A. Urry, M.L. Cain e.a.
- Elements of Physical Chemistry, P. Atkins, J. de Paula
- *Organic Chemistry*, P.Y. Bruice
- *Quantitative Chemical Analysis*, D. C. Harris
- *From Polymers to Plastics*, A.K. van der Vegt
- *Principles of Instrumental Analysis,* D.A. Skoog, F.J. Holler e.a.
- *Statistics and Chemometrics for Analytical Chemistry*, J. Miller, J.C. Miller
- *Exact communiceren*, R. van der Laan
- *Wiskunde voor hoger onderwijs*, S. Kemme e.a.

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.



Support staff member Diane te Brake:

'A lot of freedom requires self-management'

Name: Diane te Brake
Age: 21
Course of study: Chemistry
Place of employment: Wageningen University
Job: Support staff member in two Chair Groups

'I chose this course because I had always been interested in natural sciences, especially chemistry. I also believed that chemistry was a course that devoted a lot of attention to research, with a good chance of a job at the end of it. Did the course ultimately meet my expectations? Yes and no. Attending Open Days and Orientation Days does give you a reasonable picture of what the programme involves in advance. But when I actually started on my chemistry programme, I had not been expecting it to contain so many different subjects within it. To that extent, it was a surprise. That's the time when you really notice how much you still have to learn and how many directions you can go in. I eventually started specialising in nanotechnology because it was a challenging and relatively new subject involving a multidisciplinary approach. Then you're no longer just a chemist – as a nanotechnologist, you also learn to communicate and cooperate with other disciplines and have to start working with biologists and physicists, for example. That's why I also chose nanotechnology for my graduation project.

I now work at Wageningen University and have a support role in the two Chair Groups, Physical Chemistry and Colloid Science and Bio-device NanoTechnology. My work is extremely varied. The support I provide is mainly in the area of organic syntheses. Another important task for me is assisting in the first year practical education programme. Of course, I didn't have much teaching experience in the beginning but I fortunately managed to pick it up quickly. I also feel that the programme and my job fit seamlessly together. Aspects such as setting up experiments and carrying out desk research frequently came up during the programme.

Growth

When I look back on the competences I learned from my programme, I can say that – because of the great diversity of my work – several competences are relevant to me. This applies in particular to the competences of **self-management** and **instruction**. Self-management because I have a lot of freedom in scheduling work and instruction because I use this competence to provide explanations to a group of students.
I see a lot of opportunities for growth in my current job. I can also take courses within the university, which organises a lot of lectures; I also find group discussions with debates very instructive.'

Chemical analyst Rudy van Eekelen:

‘Real learning begins at work’

‘At secondary school, I had most fun in chemistry. I didn’t know exactly what I wanted to do, so I just chose my strongest subject. I did a higher professional course in chemistry which, in retrospect, was a good decision. Fortunately, I still had a number of demanding teachers on that course as I’m afraid that standards are slipping at secondary level and therefore also at higher professional level.
My choice of graduation project was mostly dictated by the fact that I wanted to learn something new and use technologies that I hadn’t seen at school. At Philips I was given the opportunity to set up liquid XRF at the Materials & Analysis lab in Eindhoven.

I was taken on by Philips to carry out wet chemical analyses, especially titrimetric and ICP determinations. Because the workload was too low for me, I got myself transferred to another group in the department. I now do XRF, micro XRF and glass property determinations. I am responsible for and specialise in the micro XRF system that was purchased a year and a half ago.

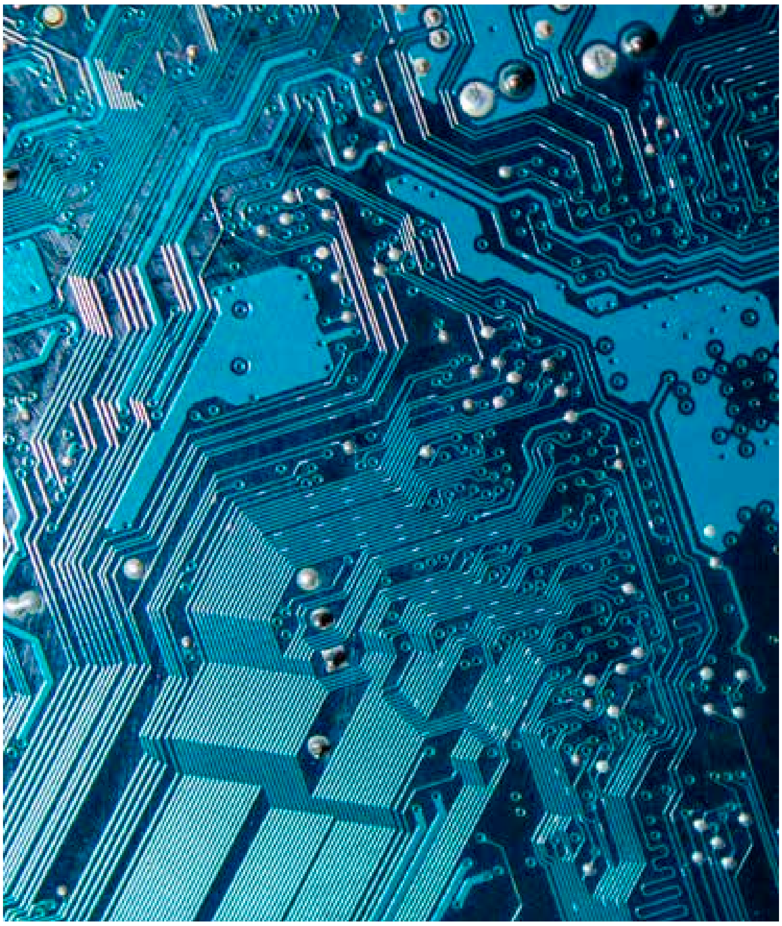
New technologies
I think a chemistry programme provides you with a relatively small foundation of knowledge. Because real learning only begins when you start work. In my case, the programme did not fit so well with the job that I eventually did, because most of the technologies I needed for my work did not feature in the programme. That’s understandable, as it’s just too expensive for a higher professional establishment to maintain technologies such as ICP (due to the high cost of argon consumption. However, learning how to write reports and network has actually been very useful in the professional field.

‘Competences’ are hardly ever used in my job. I do of course do a lot of research and experimentation, especially with establishing new measurement methodologies on the new micro XRF system. I am, to a great extent, allowed to decide for myself the working methods to use. I get help from colleagues who have a wealth of experience of the department’s commonly used working methods.

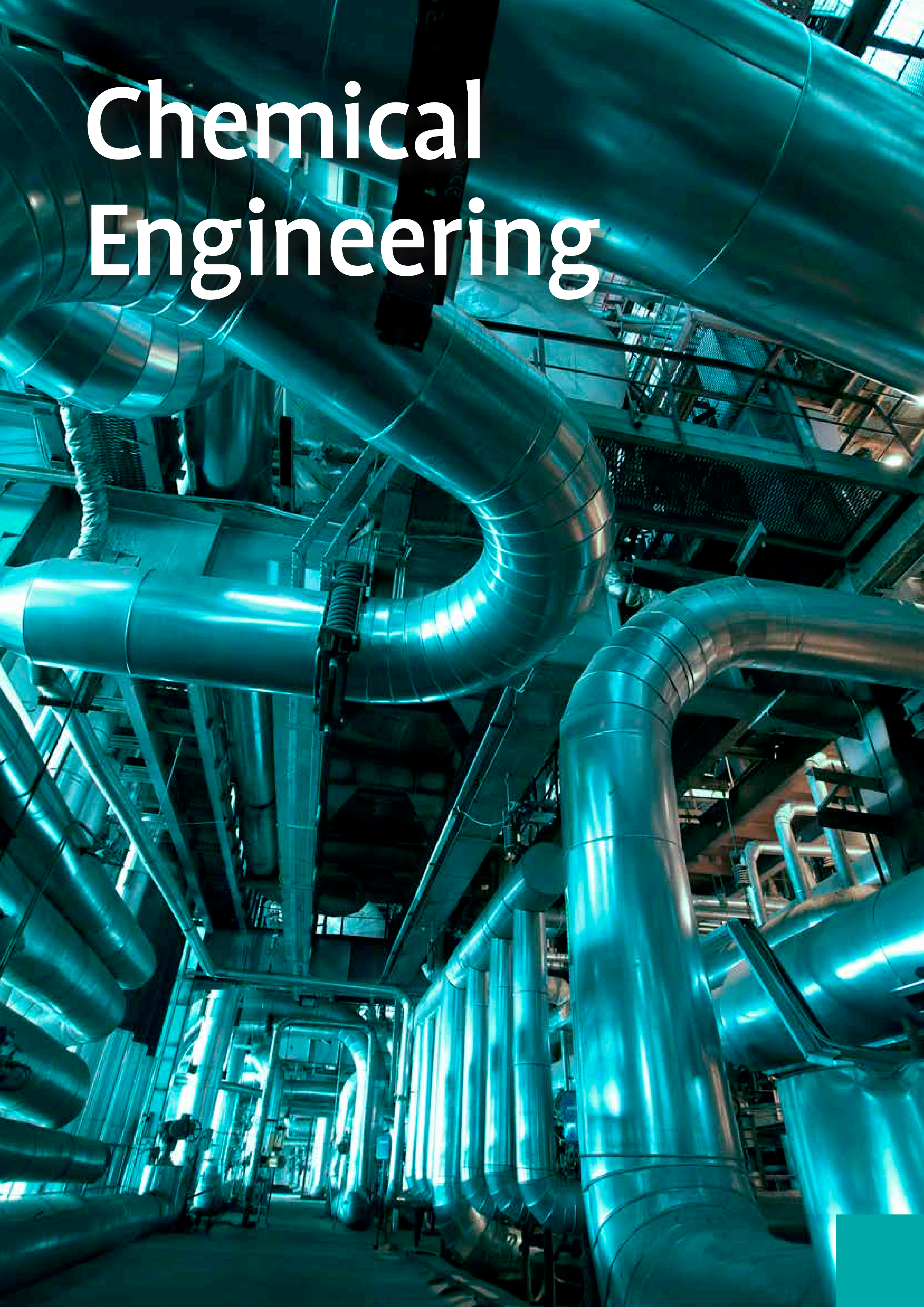
So long as I can continue to grow and learn, I am doing really well in my current job. I have agreed with my manager that the intention is for me to move on to a new and/or more senior job within six years. I’ve set my sights high!’ ■

Name: Rudy van Eekelen
Age: 24
Course of study: Chemistry
Place of employment: Philips
Job: Chemical analyst

XRF is a non-destructive, rapid quantitative analysis method for all the elements in the periodic table, from boron to uranium.



Chemical Engineering



The CHEMICAL ENGINEERING programme trains professionals involved in the production process in the process industry, with the emphasis on the chemical industry. Graduates concentrate their efforts on designing, developing, upgrading, implementing and evaluating integrated systems of plant and equipment, energy, materials, feedstocks and processes in the process industry.

The chemical engineer's objectives are to optimise reliability, ensure safety and meet product specifications while eliminating wastage of materials, energy, time and other resources. The chemical engineer knows about physical and chemical processes, product characteristics and process steps and is able to place all of this within the context of more abstract theoretical models.
Graduates are involved in or even primarily responsible for managing and controlling some or all of the production process. Working as part of a team, they develop or apply new processes or improve existing processes, products or materials. To this end, they consult both operators and senior management and external parties, take decisions on process changes or prepare for these decisions and report on the normal or abnormal progress of the process, changed process conditions and the result.

Because of the powerful focus on the process industry, graduates can also be deployed more widely throughout the process industry, including the food or paper industry, waste processing, in water supply companies and in the bio-process industry.

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.

Engineering and manufacturing
- Process engineer
- Project manager for upscaling
- Production process designer
- Production quality manager
- Production safety officer
- Process engineer and troubleshooter
- Production manager and plant manager
- Pilot plant manager
- Manager of a production line

Research and development
- Product developer for chemical products
- Product developer for production facilities such as reactors and separation technology

Commerce and customer service
- Safety and environmental consultant
- Fire officer

National programme profile

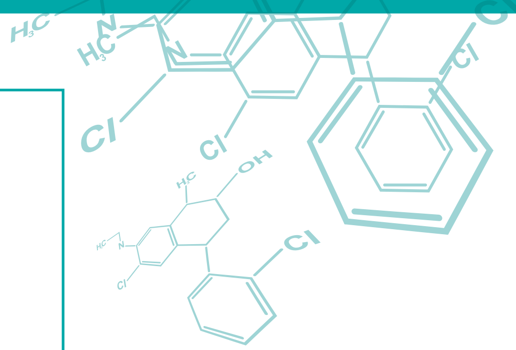
	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	II*	II	II*	I	I	_**	I	II

* At least one of these competences must be raised by one level.
** 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.

Institutions that offer the programme

- Avans University of Applied Sciences, Breda
- The Hague University of Applied Sciences, The Hague
- Hanze University of Applied Sciences, Groningen
- HU University of Applied Sciences, Utrecht
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden
- Rotterdam University of Applied Sciences
- Saxion University of Applied Sciences, Enschede

Chemical Engineering



KNOWLEDGE

- **Safety*:** personal safety, process safety (e.g. HAZOP) and environmental aspects
- **Unit operations:** heat exchangers, separation techniques (e.g. distillation and membrane technology)
- **Thermodynamics**: 1st and 2nd main law, phasing, chemical thermodynamics
- **Statistics and mathematics:** chemical calculations, differentiation, integration, differential equations, reliability of measurements, data processing and data analysis (e.g. statistical tests, statistical software)
- **Chemical reaction engineering:** model reactors (batch, CSTR, PFR), kinetics (e.g. reaction mechanisms, catalysis, enzyme kinetics)
- **Process engineering:** process design (e.g. BFD, PFD, P&ID), measurement and control technology, process control
- **Process modelling:** simulation, modelling (e.g. stationary, non-stationary), experimental design, optimisation
- **Materials science:** material properties (e.g. metals, plastics) and applications for materials (e.g. processing techniques)
- **Physical transport phenomena:** fluid dynamics, mass and energy balances, stationary and non-stationary models
- **Chemistry:** *basic* (atomic and molecular construction, reactions in water, chemical equilibrium), *analytical* (such as spectroscopy, chromatography), *organic and polymer chemistry* (such as synthesis, functional groups, reaction mechanisms)
- **Economic aspects:** e.g. cost price calculations, operational and investment costs, feasibility studies

SKILLS

- **Research skills and systematic approach to problems:** problem analysis, preparing research questions, desk research, research planning and implementation
- **Design skills/upscaling:** translating lab-scale/pilot-scale experiments to production scale, setting up process models
- **ICT skills:** use and deployment of state-of-the-art digital tools/software (e.g. simulation, design, reporting and presentation software, data analysis and processing software)
- **Experimenting with pilot set-ups:** separation equipment (e.g. distillation, extraction, membranes), flow equipment (e.g. heat exchanger, pump) or reactors
- **Morally responsible actions:** making responsible choices based on safety, sustainability, technological and economic criteria
- **Safety at work in laboratory and industrial environment**
- **Social and communicative skills:** collaborating, issuing reports and giving presentations (internationally, at all events in English and locally e.g. in Dutch), project-based work
- **General laboratory skills and chemical analysis methods:** conducting experiments at laboratory scale, performing chemical analyses (e.g. titration, spectrometry, chromatography)

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.

*The Chemical Engineering Safety Curriculum has been developed especially for the Chemical Engineering courses, in collaboration with the professional field. This is a comprehensive educational programme that is in line with the BoKS and that has been included in the curriculum by a number of programmes.

TYPICAL TEXTBOOKS

- *Chemistry*, J.E. McMurry. R.C. Fay e.a.
- *Shreve's Chemical Process Industries*, G.T. Austin
- *Elements of Physical Chemistry*, P. Atkins, J. de Paula
- *From Polymers to Plastics*, A.K. van der Vegt
- *Exact communiceren*, R. van der Laan
- *Wiskunde voor hoger onderwijs*, S. Kemme e.a.
- *Procestechnologie*, VAPRO
- *Chemical Engineering Volume 1: Fluid Flow, Heat Transfer and Mass Transfer*, J.R. Backhurst, J.H. Harker e.a.
- *Elements of reaction engineering*, H.S. Fogler
- *Statistiek om mee te werken*, A. Buijs
- *Chemical Engineering Safety Curriculum*, see https://appliedscience.nl/ veiligheidsonderwijs

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.

Chemical engineer Hanneke Bukkems:

'Social skills are very important'

Name: Hanneke Bukkems
Age: 28
Course of study: Chemical Engineering
Place of employment: Nyrstar Budel
Job: Chemical engineer

'In the first year of my studies, I opted for chemistry and subsequently, more specifically, for chemical engineering. That seemed to suit me best – abstract, a lot of working with figures, a man's world, good prospects. I discovered during my graduate internship that I had definitely made the right choice. I really wanted to do my graduate internship abroad and ended up at Nyrstar Hobart in Australia, where I was allowed to work on all kinds of assignments of my own. I got the ideas for them by talking to operators, heads of department, technicians, laboratory staff, etc. I also took a good look around me, for example at possible ways of improving the process and the business (can operations be simplified? Can test results be improved by using different analysis methods, etc?).

As a chemical engineer, I am responsible for one of Nyrstar Budel's four production departments. I look at ways of improving the current process, cutting costs, facilitating increased production, making the process more stable or, for example, extending the service life of materials. I also monitor the statutory environmental standards for emissions, waste, etc. and make adjustments where necessary. In addition, I am involved in maintenance when, for example, the catalyst in a reactor has to be inspected, replaced, etc. I then delve into the relevant history, contact contractors/experts, consider the pros and cons of the different suppliers, etc. And I have all kinds of routine duties. For example, I check a number of standard graphs (flows, pressures, temperatures, etc.) and test results every day, discuss them and, if necessary, adjust them. To do this, I work with a lot of people, including laboratory staff, mechanical engineers, technicians and operators.

Clear advice

The competences of **research**, **experimentation** and **development** are very relevant to my job; supervision, coaching, instruction and leadership | managing people less so. I have a very independent job that requires you to give properly substantiated, clear advice so that even a manager who is not familiar with the problem can understand you and take a well-considered decision. You also have to give instructions to or obtain information from operators, laboratory staff and external experts on a regular basis. Communication and social skills are therefore very important.

The theory you learn during the programme is very useful as a foundation and the practice gives you an idea of what the equipment does. The thing that was missing from the programme for me was: what happens if a graph does not follow the standard course or the analysis results are not within the specifications? What can be wrong and how can I solve the problem?

In future, I would like to work internationally, e.g. as an expert in shutdowns (overhauling production plants). Fortunately, I can continue to grow in my job with my current employer.' ■

R&D engineer Erik Heijkamp:

‘There are always processes that can be optimised’

‘I was looking for a course that featured physics and chemistry and offered good prospects of future employment. Working in projects with different companies really appealed to me and I thought it was an advantage that my programme was provided entirely in English as that is almost indispensable in this professional field. So I opted for chemical engineering. It turned out better than expected: I had fellow students from all over the world and got to know many different cultures. I did my graduation project at DSM Special Products, where I made a basic engineering design for an extraction/pertraction system. I ended up at DSM through a friend, eventually arriving here at Unilever via Dosign Engineering.

I specialise in testing detergents for the European market: setting up and running my own tests, performing analyses and reporting the results and possibly obtaining claim support from them. I also make sure that the equipment keeps working and is in good condition, and I am on the lookout for possibilities of optimising the work. In addition, I am responsible for maintaining the water plant – a plant in which all types of water (every country in the world has a different type of water) at different levels of hardness are produced. This system consists of all kinds of pumps, tanks and chemicals and is used by different departments at Unilever. Added to this is troubleshooting: you're expected to put down your work immediately when problems arise. Of course, prevention is better than cure but everything wears out eventually.

I feel that the programme and my job fitted seamlessly together. You do gain an insight into how certain processes work, which allows you to detect problems more quickly. You can also do calculations more quickly and predict reactions of certain liquids. The only thing is that I am doing less engineering now, which I do sometimes miss.

Own initiative

There are always processes or operations that can be optimised. This is done on the basis of **research** and **experimentation**. These two steps must be completed properly so that you can convince your boss of all the advantages and disadvantages. It is always appreciated when you develop certain ideas on your own initiative, **manage** them and make plans which will improve things in future. I sometimes work on projects with a number of people and sometimes alone. It is important that you should be able to **manage** your work effectively and also give responsibility to other people. This will often require some coaching, but if you do it properly you will benefit from it more later and be able to achieve more.

I am very happy with my current job, where I still have many new things to learn and organise. Eventually, I would like to progress within Unilever. I would like to **train** and **advise** more people in my professional field, which I'm doing too little of at the moment.’ ■

Name: Erik Heijkamp
Age: 24
Course of study: Chemical Engineering
Place of employment: Unilever R&D
Job: R&D engineer laundry

Forensic Science

The FORENSIC SCIENCE programme trains professionals who investigate the facts of a crime or incident. They help to solve a crime or incident with the aid of scientific, digital, investigation and detection techniques.

Forensic analysts and investigators work in all kinds of professions where the question of cause or guilt must be established. This involves not only crimes, but also incidents such as fire, fraud, accidents, or damage caused by the failure of products, materials, constructions or human actions. A forensic investigator can therefore work at an 'incident scene' or 'crime scene', but also in analytical, medical or forensic laboratories. In the legal profession or insurance industry, a forensic investigator will often act as an advisor or policy officer. In addition, forensic investigators make an innovative contribution to the field by developing new methods and techniques and/or applying existing techniques in a different context (forensic engineering). In all cases, forensic investigators are able to use their knowledge of natural sciences, investigative techniques and technology to help establish the circumstances of a crime or incident and who is (or is not) responsible for it.

Occupations, positions and roles of the Bachelor can be found in the following professional domains (for a full description of the professional domains, see Chapter 2). The professional field can be defined in 'classic' FS professions, in which forensic investigation plays a key part. Growth in the field of forensic engineering is particularly rapid. Since a detailed definition of the posts in which forensic investigators work would lead to too narrow a definition of the developing professional field, we are not attempting to do so for the time being.

Programme profile

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

Institutions that offer the programme

- Amsterdam University of Applied Sciences
- Saxion University of Applied Sciences, Enschede

Research and development
- Forensic (digital) specialist, (research) analyst or digital investigator (with the National Police, ECFO, the NFI or, for example, the NVWA)

Application and production
- Forensic crime scene investigator (operational specialist) (with the National Police)

Medical laboratory diagnostics
- Research analyst (chemical or biological) in the lab (e.g. NFI or Sanguin)

Engineering and manufacturing
- Forensic engineer, fire investigator or failure analyst (at various engineering firms)

Commercial and services sector
- Private investigator, commercial advisor or investigator (with insurance companies, in the legal profession or for one of the Dutch security regions)

KENMERKENDE STUDIEBOEKEN

- *An Introduction to Forensic Genetics,* W. Goodwin, A. Linacre e.a.
- *Essential Forensic Biology,* A. Gunn
- *Forensic Chemistry,* S. Bell
- *Fundamentals of General, Organic, and Biological Chemistry,* J.E. McMurry, D.S. Ballantine
- *Principles of Forensic Toxicology,* B.S. Levine, S. Karrigan
- *Shooting Incident Recontruction,* M.G. Haag
- *Forensic Science, A.R.W. Jackson,* J.M. Jackson
- *Introductory Statistics For Forensic Scientists,* D. Lucy
- *Seeley's Essentials of Anatomy and Physiology,* C. Vanputte, J. Regan e.a.

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.

Forensic Science

KNOWLEDGE

Biology

- **Cell biology:** structure and functioning of micro-organisms and cells, metabolism, biomolecules
- **Molecular biology:** DNA, heredity, DNA sampling and analysis, operating DNA databases
- **Anatomy/physiology/pathology:** construction and function of skeleton, skin and organ systems, blood, hormone system, consequences of injuries, autopsy
- **Entomology:** decomposition phases, succession of species on human remains

Chemistry

- **Basic chemistry:** atomic engineering, reaction equations, chemical calculations, reactions in water, kinetics, chemical equilibrium
- **Analytical chemistry:** sample preparation, spectroscopy, chromatography, gunshot residue analysis techniques
- **Organic chemistry:** nomenclature, functional groups, reaction mechanisms, narcotics
- **Toxicology:** pharmacokinetics and toxins
- **Fire and explosion:** chemistry and physics of fire, fire accelerators, flammability limits, reaction heat

Physics

- **Mechanics:** laws of motion, braking, collision and deformation
- **Strength of materials:** strength, moment, load
- **Ballistics:** determination of range and position, comparative examination of cartridges and projectiles
- **Optics:** light, imaging, image analysis
- **Materials science:** strength, fracture, deformation
- **Heat transfer:** conduction, convection, radiation

Informatics

- Computer forensics, data management, networking, internet forensics, cybersecurity, cybercrime

Statistics

- Data processing, normal distribution, confidence intervals, testing
- Using statistics/calculation of probability when determining evidential value
- Determining the evidential value of DNA analyses (Bayesian statistics)

Legislation

- Principles of Dutch law, criminal proceedings, criminal evidence law and substantiation requirements
- Lawfulness and reliability of the evidence-gathering process (e.g. expert witness in criminal cases)

SKILLS

- **Research skills and systematic approach to problems:** problem analysis, preparing research questions / hypotheses / scenarios (including for establishing the truth), desk research, research planning and implementation
- **Social and communication skills:** empathy, interviewing, collaborating, meeting, written reporting, oral presentation
- **Information skills:** word processing, spreadsheets, drawing software, presentation techniques, digital information searches and research
- **Skills at scene of crime/scene of incident:** using an (objective) description to make a sketch and a photographic record, managing the securing of biological, chemical and physical evidence, interpreting it and investigating how it relates to hypotheses / scenarios
- **Forensic examination techniques:** e.g. dactyloscopy, hair and fibre examination, scratch, impression and shape marks, presumptive tests on biological evidence
- **Identifying, securing and interpreting digital evidence**
- **Bloodstain pattern analysis**
- **Performing or arranging analyses of traces and/or physical evidence in compliance with standards**
- **Using standard laboratory equipment:** performing simple chemical, physical or biological analyses in a laboratory.

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.

Forensic Science Technician Kirsten Kooistra:

'Sometimes people have no idea what we can do for them'

Name: Kirsten Kooistra
Age: 24
Course of study: Forensic Science
Place of employment: Fiscal Information and Investigation Service (FIOD)
Position: Forensic Science Technician

The aim of **physical match analysis** is to ascertain whether material parts of a certain piece of evidence have ever formed a single unit, e.g. pieces of torn paper or tape.

'At high school, I was good at science subjects. I wanted to do something on the technical side, but had trouble choosing. I found detective work very interesting, liked watching CSI and Bones – it's a cliché, I know. My mentor suggested the Forensic Science programme. I looked into that and was allowed to spend a day at Saxion, in Enschede.

As a young girl, fresh out of high school, I had no idea what to expect from a study programme. I had hoped for more practical work, and that was a bit lacking, but I understand that this is now much more widely available. In my third year, I was able to complete an internship at the police forensic investigation department, a place where I learned so much! There I saw how I could put into practice the things I had learned at university – perhaps the most instructive experience ever. Afterwards, I consciously wanted to do my graduation internship with another organisation, to see what else the government had to offer, and so I ended up at the FIOD. After graduating, I was able to work there temporarily and was tasked with setting up an accreditation procedure for the forensic investigation laboratory. When a 'real' job became available, I naturally jumped at it! After a year spent working on accreditation, I attended the internal investigation training course. I've been running my own forensics cases since December, but I'm still working on accreditation.

I'm now a Forensic Science Technician. We focus on dactyloscopic examination (fingerprints), sampling and testing of drugs, photography, securing DNA, advice, scene of crime investigation and **physical match analysis**. Other areas of investigation are forwarded to the NFI or other agencies. One of the competences I use on a daily basis is giving **advice**. Investigative teams ask what we can do for them. Sometimes things seem obvious to us, but financial investigators often don't have a technical background and don't know what we can do for them. We are a small team, are well attuned to each other and are a so-called self-managed team. So the **self-management** competence comes in handy!

A colleague and I also take care of the intake. When enquiries come in from investigative teams, I check whether the enquiry is clear, whether the enquiry meets the intake criteria and whether it is sufficient to justify taking on an investigation. If that's the case, I'll put it out to my colleagues and take care of the administration. **Coordination** is therefore another important competence for me.

I would like to grow in my job, gain a lot of experience and try to make the Forensic Investigation team better known within the organisation. Who knows, I might be in charge someday. The most important thing? Enjoying your work and being open to new things.' ■

Operational Specialist Jurgen van Eldik:

'A crime scene is actually one big complicated jigsaw puzzle'

'After completing higher secondary education (HAVO) (NT profile) I opted for the Forensic Science programme, because detective work seemed incredibly cool to me. Luckily, the programme turned out to be highly practice-oriented, so that you are well prepared and no day is actually boring – you feel like you are already solving crimes. I was determined to graduate with the police; I felt a clear affinity with the cold case team, so I did my graduation research there.

In my current job as an Operational Specialist, I participate in the forensic investigation, which means that we go to a crime scene – of a murder, for example, or a burglary or fire – and conduct an on-site investigation to establish the truth. At the moment, I'm still in the early stages of my career. Since this job is subject to a lot of rules and legislation, you have to do a lot of internal follow-up training before you can really participate in a call-out. This sometimes requires a lot of patience, because every day you are confronted with one fascinating situation after another, which you consider to be an 'adventure' in which you want to help out.

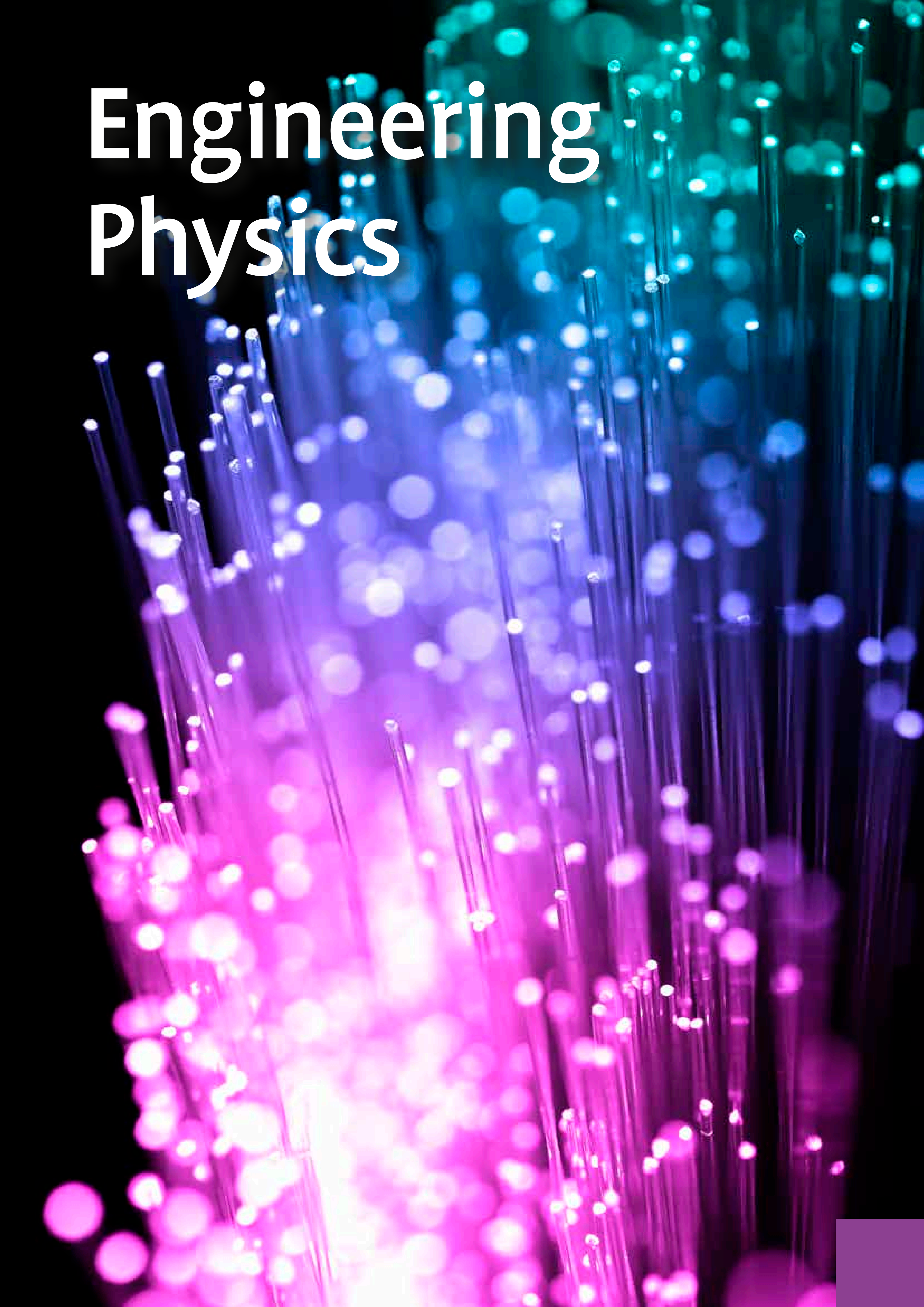
In principle, all facets of the work had been fully covered in the programme. The lessons were also always linked to a project, in the form of an actual investigation, which made the link with the real world very clear. In practice, the work is more clearly split between the call-out and the follow-up investigations in the lab. It is, of course, a higher professional (HBO) programme, so the emphasis is placed on the theory behind different methods and the investigations in the lab. In the lab, a graduate will be up to speed almost immediately, but at the crime scene you really need to gain experience to be able to participate. Of course, the knowledge you have obtained during the programme helps enormously.

The competences of **research**, **development** and **experimentation** are important in my job. A crime scene is actually one big complicated jigsaw puzzle that you try to solve through investigation. The job is constantly evolving – involving, for example, new techniques for finding and/or securing evidence. You have to stay curious all the time and be able to hang on in there. **Self-management** is important; the police is a large organisation which offers a lot of possibilities, but you have to be assertive and be able to stand your ground.

Over the next few years, I want to gain a lot of practical experience, which is very important in this job. My current position is the best fit for that at the moment, so for now I'm not thinking about anything else. It may not sound very ambitious but, actually, this is simply my dream job!' ■

Name: Jurgen van Eldik
Age: 27
Course of study: Forensic Science
Place of employment: National Police, Forensic Investigation, East Netherlands Unit
Position and responsibilities: Operational Specialist

Engineering Physics



The higher professional course in ENGINEERING PHYSICS leads to a job as an applied physicist. Through research and experimentation, this graduate amasses knowledge and information that contribute to solutions for technological problems and provide opportunities for new technological developments.

The working methods of applied physicists are characterised by the fact that they operate at the interface of theory, modelling and experimentation. They try to establish a link between the results of these approaches, verifying theories by means of experimentation wherever possible. Engineering physics as a professional field is continuously developing. A thorough knowledge and understanding of the theory of the basic sub-fields within physics is needed in order to operate in the field as an applied physicist. An applied physicist has an understanding of key physical concepts and can apply them in practical situations. The most important skills required of an applied physicist consist of the ability to carry out research, make model-based calculations and to set up, prepare and conduct experiments. Physics-related issues arise in a variety of fields of activity, including sensor technology, photonics, nanotechnology, sustainable energy and medical technology.

Institutions that offer the programme

- Fontys University of Applied Sciences, Eindhoven
- The Hague University of Applied Sciences, Delft
- Saxion University of Applied Sciences, Enschede

National programme profile

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

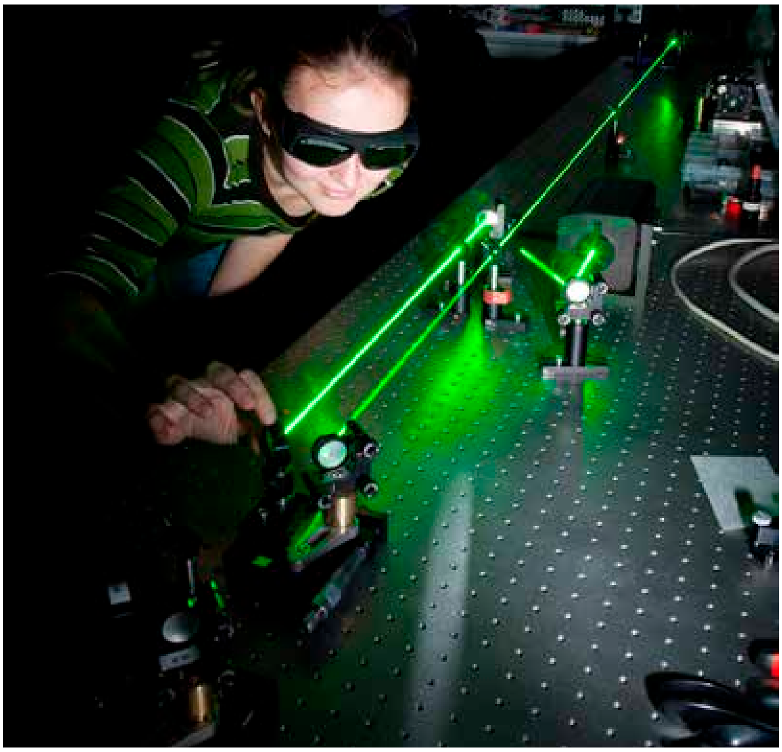


ILLUSTRATION OF PROFESSIONAL FIELD

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
- Engineering Physics researcher
- Project or development engineer
- Engineering Physics designer
- Photonician
- Metrologist

Engineering and manufacturing
- Metrologist/test engineer
- Product developer
- Process engineer
- Quality engineer

Commerce and customer service
- Medical physicist
- Service engineer
- Building physicist
- Radiation expert
- Audiologist
- Meteorologist
- Energy engineer
- Adviser/consultant

Engineering Physics

KNOWLEDGE

Physics

- Classical mechanics
- Electromagnetism
- Quantum mechanics
- Thermodynamics
- Waves and vibration
- Optics
- Properties of matter: elementary components and their interactions
- Atomic physics
- Nuclear and particle physics
- Acoustics
- Materials
- Fluid dynamics

Mathematics

- Calculus: elementary analysis and (linear) algebra
- Laplace and Fourier transforms
- Statistics and probability theory

Engineering

- Measurement and control technology
- Vacuum technology
- Energy engineering
- Electronics and signal processing
- Micro- and nanotechnology
- Laser technology
- Programming and data acquisition

SKILLS

- **General skills:** communication and collaboration, project-based work, systematic approach to problems
- **Skills relevant to the experimental approach:** building and managing test rigs and measurement systems, performing data acquisition for measurement system, programming, software including Labview, Excel, Matlab, programming languages
- **Skills relevant to the model-based approach:** using calculation and simulation software, designing a calculation or simulation program, programming, software including Matlab/Simulink, Maple, Comsol Multiphysics, Ansys

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

- *Physics for Scientists and Engineers with Modern Physic*, D.C. Giancoli
- *Optics*, E. Hecht
- *Warmteleer voor technici*, A.J.M. van Kimmenaede
- *Regeltechniek voor HTO*, J. Schrage, H. van Daal
- *Applied Statistics and Probability for Engineers*, D. C. Montgomery, G.C. Runger
- *Polymeren, van keten tot kunststof*, A.K. van der Vegt, L.E. Govaert
- *Multiphysics Modeling Using COMSOL 4*, R.W. Pryor
- *OPTO-electronics: An introduction*, J. Wilson, J.F.B. Hawkes
- *Introductory Digital Signal Processing with Computer Applications*, P.A. Lynn, W. Fuerst
- *Fundamentals of Thermal Fluid Sciences*, Y.A. Cengel, R.H. Turner e.a.

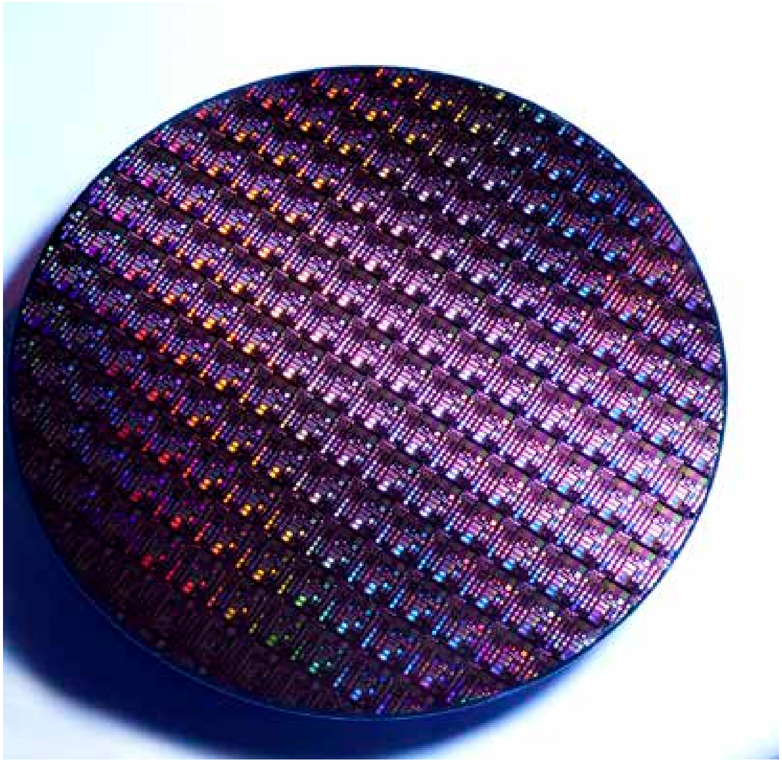
The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Operational coordinator Hans Beckers:

'The programme leaves you with technical baggage'

Name: Hans Beckers
Age: 41
Course of study: Engineering Physics
Place of employment: ASML Veldhoven
Job: Operational coordinator First Line Support NXE

'With my pre-university diploma, I initially decided to study Engineering Physics at Eindhoven University of Technology. I had a wide range of subjects, the exact sciences suited me and I thought it would be good to focus on complex issues. Thinking out of the box – that appealed to me. However, after nine months I realised that too little time was devoted to practical work, common-or-garden physics. I then switched to the higher professional course in Engineering Physics and this seemed to fit in much better with my need for everyday physics. The application of technology in the world of medicine came up during the programme. That appealed to me, so I did an internship at Verbeeten Institute in Tilburg, a specialist hospital which provides top clinical care in the area of oncology and nuclear medicine. Choosing a specialisation wasn't difficult: Engineering Physics.



I found my graduation project through my own network at Phillips, where I worked on "modelling for optical grooves". My work has contributed to the fact that the DVD is as we know it today.

At AMSL we manufacture precision lithographic machines for the chip industry. In my current job, I am responsible for managing all failures in part of the production process of ASML's most advanced machines. I make sure that the problems are solved to the internal or external customer's satisfaction within the applicable time.

Commercial thinking

After spending a few years in "technology", I am now more involved in guiding/coaching people, skills which I picked up through additional training. Another part of my job is to set up and standardise processes. This requires a more project-based approach. **Coordination | coaching | supervision** are things that I still use every day. At university, I feel, not enough attention was paid to working and thinking in a commercial way. You can come up with the most fantastic experiments or research, but they have to fit in with the customer's time and cost frame.

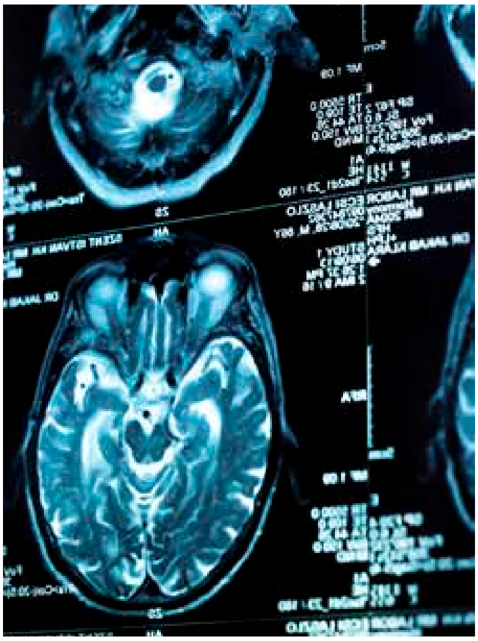
The Engineering Physics course leaves you with a certain technical baggage, and from these foundations you start to specialise in specific subjects in industry. These are almost impossible to teach in the programme as it would be too specific. Structural thinking, analysing data and transferring knowledge are things to which attention was paid in the programme and which are useful in every organisation.

There are a lot of opportunities at ASML, it's a large and diverse company. In the near future, the focus of my job will be shifting further towards the project-based delivery of processes, but my ambition still lies in the area of people management.' ■

Clinical physics assistant Ruud Cools:

'I was looking for answers to my questions'

'When I got physics for the first time at secondary school, I discovered that I found it really interesting. But I still had questions and I therefore decided to choose a course of study that could possibly answer my questions. As my interests are so wide-ranging, a wide-ranging programme was a requirement. My physics teacher told me about the Engineering Physics programme and, after I had requested information, I quickly made my choice.



Name: Ruud Cools
Age: 26
Course of study: Engineering Physics
Place of employment: Erasmus MC
Job: Clinical physics assistant

The questions that I had at secondary school were of course answered. Fortunately, they were replaced by more questions. As well as learning answers during my programme, I also learned techniques that enabled me to answer my questions myself. I enjoyed research so much that I tried to find a subject that I could research for my graduation. I had always been fascinated by light and therefore choose a subject within photonics (physics subject that focuses on interaction between photons and electrons).

I'm currently working in the radiotherapy department of the Erasmus MC, where cancer patients are treated with radiation. The quality of their treatment is very important and, as a clinical physics assistant, you have an essential role to play in this regard. The work is extremely varied. For example, we take measurements of the accelerators to ensure that they are still working properly. Sometimes, in order to take measurements, you have to develop new measurement and analysis methods. In addition, radiotherapy involves a great deal of innovation. These innovations first have to be checked and tested before we can use them in the clinic. Sometimes they are software solutions for obtaining the optimum radiation level and sometimes hardware solutions are also involved. My colleagues and I then have to devise tests to be able to guarantee that everything will work properly. There are also opportunities for working on research and innovation yourself. For example, I am currently creating a software application that will enable us to control the operation of the accelerator when it is administering a very complicated radiation treatment.

First learn physics

Every day in my work, I need the analysis technique and way of thinking I learned during my programme. However, you do acquire technical knowledge at school that you only need sporadically, if at all. My personal opinion is that as little emphasis as possible should be placed on competences other than the competence of **development**. That may sound harsh, but more than anything it is essential that students are trained to become good physicists. If someone is interested in making progress in other competences, they will pursue this interest themselves. In addition, working in industry is a very good apprenticeship for learning these "secondary" competencies, but you definitely have to have sufficient knowledge of the subject first. So learn physics first – the other competences will follow.' ■

Environmental Science

The higher professional course in ENVIRONMENTAL SCIENCE leads to a job as an environmental engineer. Essentially, this involves sustainably improving the environment, ranging from clean air, soil and water to, for example, waste recycling. This is done from a foundation of applied science, bearing in mind what is achievable in terms of society.

Environmental engineers mainly work in consulting and engineering firms, where they are responsible for conducting research. They collect data (from field work, desk research, laboratory research), analyse and interpret this data and help to formulate and design solutions. It is very important that the work is customer-oriented and project-based. Similar advisory roles are also performed in the industrial domain, as a member of a staff department focusing on improving the sustainability, environment and safety of the company. Communication skills are essential as the role involves interaction with stakeholders.

Institution that offers the programme

- Avans University of Applied Sciences, Breda

In the role of environmental technologist, there is greater emphasis on improving technologies (e.g. for a water treatment plant); as a researcher or assistant researcher, graduates collect and interpret data on the quality of the environment. In the case of government bodies, such as environmental agencies, the environmental engineer has the role of enforcing regulations, granting permits or developing policy.

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
- Environmental researcher (in research institutes)

Engineering and manufacturing
- Environmental technologist (optimising environmental technology)

Commerce and customer service
- Environmental consultant
- Sustainability (CSR) consultant
- Environmental (HSE) coordinator
- Inspector or enforcement officer
- Official responsible for issuing permits
- Policy adviser

Programme profile

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

Environmental Science

KNOWLEDGE

- **Sustainable development:** people, planet, prosperity, passing the burden in space and time, CSR, system-oriented thinking
- **Environment:** quality of the environment, sustainable design and planning, impact on our environment
- **Soil, water, air, noise:** sources of pollution, behaviour of substances, research, regulatory process, impact, measures, management
- **Nature/ecology:** basic natural principles (ecology), ecosystems, biodiversity, types of landscape, cultural heritage values
- **Climate change:** causes, effects, measures
- **Waste and raw materials:** cradle-to-cradle, circular economy (biobased and technical)
- **Energy:** sources, sustainable energy management
- **Safety:** sources, standards, risk assessment, measures, management
- **Legislation and environmental policy:** spatial planning, flora/fauna, environmental law, EIA, environmental policy (European, national, international, water, soil), policy instruments
- **Economics and management:** financial feasibility, SCBA, quality management/Deming circle, QHSE
- **Ethics:** moral dilemmas in professional practice

SKILLS

- **Research skills:** problem analysis, problem statement articulation, preparing research questions, research planning, reviewing, analysis, desk research, statistical methods, performing multi-criteria analyses
- **Consultancy skills:** holding intake and consultancy interviews, issuing quotations, carrying out stakeholder analyses, involving stakeholders in the implementation of assignments (environmental awareness, sensitivity regarding policy and political issues), effective collaboration with other disciplines, presenting recommendations
- **Specific ICT skills:** using geographical information systems, dispersion and sustainability models
- **General laboratory skills:** analysing soil, water, air in accordance with protocol
- **Fieldwork skills:** soil, water, flora/fauna, region

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.

The Body of Knowledge and Skills for Environmental Science is laid down in the national consultative document covering all Environmental Science degree programmes. All other Environmental Science programmes are outside the scope of the Applied Science Domain and are not presented here. For more information, a detailed national document is available, see reference 2 on page 75.

TYPICAL TEXTBOOKS

- *Environmental Science, A Global Concern,* W.P. Cunningham, M. Cunningham
- *Introduction to Environmental Engineering and Science,* G.M. Masters, W.P. Ela
- *Campbell Biology,* L.A. Urry, M.L. Cain e.a.
- *Chemistry the Central Science,* T.E. Brown, H.E. LeMay e.a.
- *Brock Biology of Microorganisms,* M.T. Madigan, K.S. Bender e.a.
- *Foundations Maths,* A. Croft, R. Davison
- *Managing your competencies,* R. Grit
- *Project Management,* R. Grit
- *Praktisch Omgevingsrecht,* H.M. Liedekerken

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.

Process engineer Geert van Lith:

'The most challenging projects are those in other countries'

Name: Geert van Lith
Age: 25
Course of study: Environmental Science
Place of employment: Maris Projects
Job: Process engineer

'I chose this programme at the time because it fitted in well with my previous studies: I had already completed the senior secondary vocational land, water and environmental engineering programme. I therefore knew that I wanted to have something to do with the environment. The breadth of my course provides sufficient opportunities. Eventually, I ended up – through my programme – at Maris Projects, where I have progressed from environmental technologist to process engineer. This company's practical way of working really suits me, also because of my previous studies.

My job is difficult to describe in a couple of sentences. On the one hand, I'm involved in selling new and second-hand process equipment. These are machines or components for milling, crushing, pumping, extraction, etc. I help my boss in buying, selling, issuing quotes, supervising the workshop, etc. On the other hand, I work on projects: we develop technologies, machines and plants for re-using residues (e.g. culturing algae, fermenting biomass, drying residual products), using physical, thermal or biological treatments only. I manage and supervise the projects from start to finish. They often start in the laboratory, where we determine the properties of the residues. Once the options are clear, we build a scale model (from second-hand machinery) on which we test our idea. I then help to design or develop the final solution. After being successfully tested, the plants are built full-size. My responsibilities are to supervise the workshop, help to optimise the plants and start them on the customer's premises. There are also other aspects to take into consideration in projects, such as subsidy and financing processes in which I submit applications, reports and work plans. And the practical aspects, such as arranging transport for international projects, which I never learned about at university but which still has to be done.

International
The most challenging aspects of my job are the projects in other countries. As we are developing new technologies and most waste and residual flows are often in developing countries, it is easier to implement certain projects in these countries. I myself have been to India a number of times to help build a plant for extracting oil from waste meat residues from the leather industry.

Research and experimentation are very important competences in my professional field. The way I use them now is certainly different from the way we had them at university.
I definitely see my opportunities for advancement within the company, although that also depends of course on the growth of the business. There are great opportunities nationally and internationally and I'm sure I can progress internationally. For the time being, I'm still learning so much in practice every day that no university can compete!'

Project worker Bianca Peeters:

'I can now focus on specific competences'

'I did a job aptitude test just before completing my senior secondary vocational programme. This showed that my interest lay in the environment, society and technology. After visiting an open day for the environmental science programme, I became really enthusiastic: it looked like an enjoyable and interesting programme which would be sufficiently challenging and provide a choice of professional field.

My programme was wide-ranging and involved a combination of different environmental subjects, such as water, soil, air and noise, ecology, climate change, sustainable energy, sustainable development and legislation. The subject was taught in the form of courses, training sessions and project-based work. In the third and fourth years I did two internships and gained some practical experience. During my graduation project, I conducted research into a proposal for a new Nature Conservation Act and how it compared with current nature protection legislation. I was asked by the Environmental Law and Permits department of Witteveen+Bos whether I would like to do research into this as they had a lot to do with nature protection legislation and I was interested in nature.

I have now been working in the Environmental Law and Permits department for nine months. As a Project worker I check out which permits are required for different projects, prepare permit applications, give instructions for environmental and other investigations relating to the permit applications to be carried out and submit them to the relevant governing bodies.

Wide-ranging

I think my study programme fitted in well with my current job, thanks to the wide-ranging nature of the programme. While working with permits, I now find that I have some knowledge of a variety of environmental subjects. The project-based work that I learned during my programme also fits in well with my job. This is partly because Witteveen+Bos regularly work with environmental science students in supervising and implementing all kinds of projects. I was one of them myself in the third year of my programme!

Thanks to the competence-based approach in my programme, I learned which competences I was good at and which not so good. This means that I can now focus extra hard on specific competences, such as **instruction** and **management**, in order to develop further. My ambition is first of all to become an experienced consultant on permits. Later, I would like to become a project manager in order to keep the permit process and related matters on the right track for a project.
Eventually, I would like to work as the head or manager of a department. But that's an ambition for the long term!' ■

Name: Bianca Peeters
Age: 24
Course of study: Environmental Science
Place of employment: Consultancy and engineering firm Witteveen+Bos
Job: Project worker for environmental law and permits