MASTER MOLECULAR LIFE SCIENCES

GRADUATE PROFILE

Contents

Professional profile

The aim of our programme is to educate masters that are able to plan and control a project(*) in applied research and/or product development in the bioscience sector.
(*) Projects can also be parts of projects and have a length of at least 3 months.

Professional tasks

The meet this aim, we have discerned three professional tasks for our Professional Master in Molecular Life Sciences:

1. to understand practical, economic, social and/or ecological needs of businesses, market and society that can be anticipated by biotechnology;
2. to apply fundamental knowledge in the area of molecular life sciences to find sustainable solutions for these needs;
3. to implement such solutions in a successful and efficient way by organizing their realisation in projects, considering the interdisciplinary dimension and communicating with different experts. Such projects have a duration of at least three months.

Exit qualification

Competences

To apply and translate knowledge for the realisation of innovation and implementation of projects in the bioresearch sector, the Master in Molecular Life Sciences needs to have specified competences. These core competences are defined in dialogue with representatives of the professional practice. The six competences are:

- Professional conduct and professional development.
- Designing strategies for applied research and product development
- Design, analysis and control of experiments
- Communication
- Managing Projects
- Advising

These competence indicators, together with the Body of Knowledge and Skills, form the final qualifications of the Master in Molecular Life Sciences.

The following section gives a more general description of the competences of the Professional Master in Molecular Life Sciences, and is compared with the Professional Bachelor graduates in the area of Life Sciences, and with the academic Master equivalent (see figure 3).

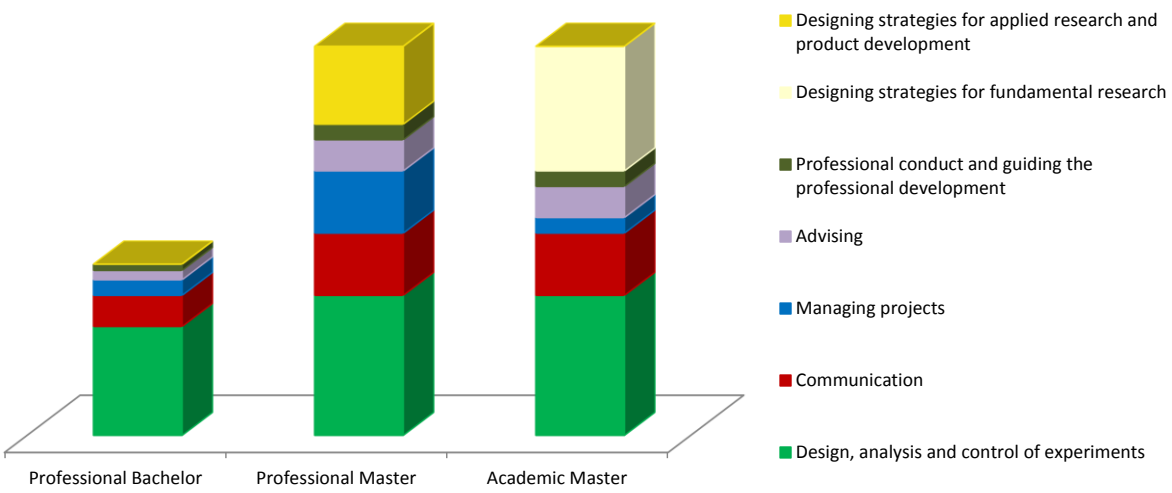

Figure 3. Schematic presentation of the competence profile of the Master in Molecular Life Sciences (a Professional Master) in comparison to the Professional Bachelor and the Academic Master in the field of life sciences.
The characteristic Competences of the Master in Molecular Life Sciences are Designing Strategies for applied research and product development and Managing Projects.

The comparison of figure 3 shows that the two competences 'designing strategies for applied research and product development' and 'managing projects' are prominent competences for the Professional Master in Molecular Life Sciences. This in sharp contrast to the Academic Master programme in which designing (fundamental) research based on theory, curiosity and new ideas is key. Below follows an evaluation of the competences of our programmes and compares them with competences of the equivalent academic masters and bachelor graduates.

1. Graduates of all three type of programmes need to be professional in terms of being pro-active, team-oriented personalities who reflect on their own actions, deal with feedback and are open to learning. Both master graduates are expected to learn autonomously. While the academic master is mostly a theory-driven curious personality however, the professional master shows an entrepreneurial attitude. As the professional master functions at the interphase between different expertise, establishing a coherent network belongs to his/her professional conduct as well. In addition, we expect that masters are able to reflect on the quality of their projects, their own role in projects, and on their own professional personality.
2. Our Professional Master designs strategies for applied research and product development in a product-, goal- and market-oriented way. He/she understands practical, economic, social and/or ecological needs, He/she is aware of the information obtained by fundamental research, but also of other factors such as costs, competitors or the patent situation and uses this information to achieve the company aims.
3. The competence design, analysis and control of experiments is important for both two compared programmes. Professional experience will increase after graduation at bachelor level but master employees are expected to conduct design, analysis and control of experiments at a higher level of quality, complexity and independency compared to bachelor trained employees.
4. Communication is another competence necessary for both bachelor and master students. However, whereas bachelors communicate predominantly over their experiments within research groups, masters are expected to have professional written and oral communication skills enabling them to communicate beyond their own group. Moreover, while for academic master, communication occurs mostly with peers through publications and presentations, communication of the professional masters often occurs in an interdisciplinary context. Communication with experts of different fields

such as biology, statistics, patents specialists, legal affairs or finance departments is important for the efficient realisation of entrepreneurial projects.

5. Managing Projects in terms of project aims, deliverables, value, risks, responsibility, communication time and costs is typical for the professional master. It is a minor competence of the bachelor graduate and of the Academic Master graduate.
6. In line with competence 4, the professional master mainly informs and advises about aims, multidisciplinary interest, project approaches and results to people within and outside their own department. In contrast, the academic master is able to provide argument-based advice about research projects to others. The Bachelor, in contrast, advises about lab equipment or experimental techniques within the research group.

Definition of the competence-indicators

Competence 1:
Professional conduct and guiding professional development

1.1. Shows a professional, pro-active, curious, scientific and entrepreneurial attitude: adapts quickly, motivates him/herself, shows initiative, is goal-oriented, and acts honestly and efficiently
1.2. Works efficiently in a team (colleagues, project leader, client) during all phases of the project through open communication and by considering the needs of others.
1.3. Pro-activity contributes to setting up and maintaining a professional network.
1.4. Critically reflects on the project with respect to scientific project management approach and results.
1.5. Critically reflect on the own role in the course of a project.
1.6. Critically reflects on the own personality and how this influences professional conduct.
1.7. Defines personal learning goals (based on project/work requirements) and guides personal development to reach learning goals

Competence 2:
Designing strategies for applied research and product development

2.1. Is able to independently acquire knowledge in a new subject by consulting specific literature and other resources; is able to identify reliable and suitable sources; Discriminates between major and side issues
2.2. Combines information from different sources in the context of the own project
2.3. Defines the project aim in terms of products and/or results based on the acquired background information
2.4. Defines the quality requirements for products and processes based on legal requirements.
2.5. Designs different approaches that could lead to the project aim. Evaluates these possibilities and justifies the choice based on scientific arguments and practical parameters such as time, costs, quality and personnel
2.6. Designs a complete strategy leading to the project aim (project of about 3-4 months; see also: managing projects)
2.7. Identifies opportunities to patent products, results and strategies

Competence 3:
Design, analysis and control of experiments

3.1. Designs experiments based on the required quality and quantity of the product or result.
3.2. Applies strict logical thinking to draw conclusions from the results and interprets them:
- in the context of the experiments
- in the context of the project aim (helicopter view)
- in comparison to other analyses, reference/theoretical values, and quality requirements.
3.3. Solves practical problems if experiments do not work as planned (trouble shooting); couples back to the theory or consults colleagues if necessary; suggests alternative experiments.

Competence 4:
Communication

4.1. Reports project plans and results in English according to the standard format used in the company/field and meets the scientific international conventions criteria.
4.2. Presents project plans and results in English to colleagues, other researchers in the field or to clients. The presentation is at a level equivalent to a presentation at an international symposium
4.3. Describes the key message of the project relevant for patenting, registration, and/or business development. Uses terminology that is understandable for experts from different departments
4.4. Organises and moderates meetings
4.5. Contributes to the efficiency of meetings by being prepared and actively participating
4.6. Keeps client and project members informed about project progress at all stages, especially when the project is not progressing as planned
4.7. Shows initiative to adapt communication styles to the others and the situation at hand

Competence 5:
Managing projects

Takes responsibility for a project by:
5.1. Defines project deliverables based on the needed quality and quantity
5.2. Identifies project risks based on the (experimental) approach and on (putative) competitors
5.3. Defines project exclusions
5.4. Organizes the project in phases and defines decision points/ milestones
5.5. Describes the project organisation including the responsibilities of all project members
5.6. Writes a communication plan concerning all project members and parties involved
5.7. Describes a schedule based on the (experimental) plan
5.8. Describes the required budget
5.9. Performs his/her responsibilities
5.10. Approaches others if they do not perform to their responsibilities
5.11. Sets priorities and works efficiently towards the defined project aim/deliverables
5.12. Is in control of the project during all phases by being pro-active if the project does not run according to the plans and initiating an alternative strategy
5.13. Is flexible with changing circumstances by adapting the experimental, project and/or communication strategy
5.14. Obtains the deliverables in time and with the described resources; if not, reasons and justifies the decisions that have been taken in the course of the project

Competence 6:
Advising

6.1. Actively involves different specialist to collect advise contributing to the progress of the project.
6.2. Actively participates in a discussion about related projects by asking critical questions and suggesting follow-up experiments.
6.3. Advises about follow-up projects of the own project.
6.4. Integrates own project results in the multidisciplinary defined goals and advises other departments
6.5. Gives advice about choosing new equipment or methods based on project goals, overall goals and available resources

Body of Knowledge and Skills of the Master in Molecular Life Sciences

Upon graduation, the student ...

Molecular biology (techniques)

- has knowledge and insight of genes, chromosomes, plasmids mutations/ SNPs
- understands the principle of all standard techniques to detect DNA (such as Southern Blot, PCR, FISH, (next generation) sequencing), RNA (such as Northern blot, RT-PCR, expression array, RNAseq, in situ hybridization) and proteins (SDS-PAGE, Western blot, immunocytochemistry, immunohistochemistry, protein array, mass spec) and can apply the appropriate technique to answer a question about the presence, quantity or localization of DNA, RNA or protein

- understands how gene expression is regulated in prokaryotes and eukaryotes and applies this knowledge to heterologous gene expression
- is able to design a strategy for gene cloning and heterologous expression
- understands the mechanisms of gene silencing by siRNA and is able to apply siRNA to downregulate gene expression
- is able to design a (conditional) knock-out strategy

Cell biology (techniques)
- has knowledge and insight of prokaryotic and eukaryotic cells, function of organelles, cell cycle regulation, DNA repair, signal transduction, protein modification and localization
- understands the principle of techniques to analyze cell proliferation, cell cycle, apoptosis, protein modification and can apply these techniques to answer question on such cellular functions
- has knowledge and insight of the molecular mechanisms that contribute to cancer development and can apply this knowledge for the design of cancer diagnostics and anti-cancer drugs

Biochemistry (techniques)
- has knowledge and understanding of the physic-chemical properties of proteins, nucleic acids (DNA, RNA), sugars, lipids, endotoxin, salt, viruses and bacteria
- has knowledge and understanding of biomolecule purification methods (such as size exclusion chromatography, ion exchange, hydrophobic interaction, ultrafiltration, affinity chromatography, precipitation, filtration, drying) and is able to choose a purification method depending on the composition of the original sample and the biomolecule to be purified
- has knowledge and understanding about methods to analyse biomolecules (such as NMR, chromatography, enzyme assays, ultrafiltration, absorption measurement, selective breakdown, enzyme immune-assay) and is able to choose an analytical method based on the biomolecule(s) to be analyzed
- has knowledge and insight of metabolic pathways, cell chemistry and biosynthesis and can apply this knowledge to optimize metabolite production (metabolic engineering)

Enzyme production
- knows the industrial applications of enzymes
- is able to set up an enzyme activity test

Vaccine discovery
- has knowledge and understanding of the immune response to pathogens (action of innate and adaptive immune system, induction and effects of cellular and humoral immunity, mechanisms for induction of memory)
- understand the mechanisms by which micro-organisms can cause disease
- knows different types of vaccines (such as attenuated, inactivated, subunit, recombinant, DNA), their mode of action and their advantages and disadvantages
- is able to choose a vaccine antigen, adjuvant and administration route depending on the immune response that is required and on practical aspect
- knows different vaccine production platforms, their advantages and disadvantages
- is able to design experiments to test the potency of a vaccine

Development of diagnostic tests
- knows different types of diagnostic tests, their principle of action and their advantages and disadvantages
- is able to define the importance of sensitivity, specificity, and practical aspects such as costs, duration or required staff training based on the desired application of the diagnostic test
- has insights in the principles, advantages and disadvantages of different diagnostic tests, e.g. serology and molecular diagnostics, such as ELISA, (M)IFA, (q),(multiplex)PCR, MFI, IB, HAI

- is able to choose a type of diagnostic test based on the required specificity, sensitivity and practical aspects such as duration, requirement for staff training

Drugs Discovery, Development and Delivery

- understands the principles of pharmacology, pharmacokinetics & drug-biotransformation, and pharmacodynamics
- knows and understands drug design principles
- knows and understands the principle of different types of drugs and treatment approaches (small molecules, antibodies, gene therapy, chemotherapy, radiotherapy, immunotherapy), their advantages and disadvantages.
- Understand the procedures and principles involved in the preparation and structural analyses of unknown substances using UV, IR, MS, and NMR.
- is able to choose one type of drug as an active pharmaceutical ingredient depending on the desired biological effect
- is able to choose a delivery system based on desired selectivity and bio-availability
- is able to design a strategy to measure the bio-availability of the drug
- is able to choose appropriate in vitro and in vivo assays to test the efficacy and the toxicology of a drug
- knows with animal models can be used to test drugs, and the advantages and disadvantages of these models

- knows the different phases of clinical studies and what is required to enter the clinical phase of drug development
- knows that structure-analysis can be used to predict the function of the biomolecule and to discover interaction partners/ drugs

Quality assurance and quality control

- is able to define quality requirement for products and processes based on regulatory guidelines (ICH guidelines)
- is able to describe a target product profile and critical quality attributes
- is able to design a strategy to validate a diagnostic test
- is aware of the requirements for entering the clinical phase, and for market entry

Process development and optimization

- knows the advantages and disadvantages of different production strains and is able to choose a suitable production strain for the production of specific proteins
- is able identify critical parameters in the process
- tests critical parameters in the production process (USP and DSP) and interprets the outcome
- is aware of the fact that scaling up or down requires process re-optimization

Biobased economy

- Is able to explain the main principles of a biobased economy and its new technological challenges
- Is able to explain the difference between first, second and third generation feedstocks
- Is able to describe the steps needed to convert plant biomass into fermentation feedstock
- Is able to describe the technological challenges by using biomass as fermentation feedstocks

Statistics and experimental design

- understands the meaning of the statistical terms: statistical hypotheses, type of variable (continuous / categorical), association versus causation, confounding variables, variation, normal distribution, population versus sample, dependent and independent observations, point-estimate and confidence interval, descriptive statistics, p-value and statistical significance, log-transformation
- understands the principle and application of statistical hypothesis, hypothesis test, one- or two-tailed test, p-value; adjustment for multiple testing

- is able to translate the research question into an appropriate statistical question, experimental setup and corresponding statistical analysis
- has awareness of power and sample size calculations
- understands the meaning of experimental design and the terms: completely randomized design, randomized block design, controlled experiment, case-control study, cross-over design, factorial Design, screening design, comparative designs, optimization design
- is able to design and analyze a process optimization experiment using experimental design
- understands the differences between superiority versus equivalence testing
- Is able to choose the appropriate statistical method (e.g. t-test, ANOVA, regression) to analyze continuous data
- is able to determine the accuracy, sensitivity and specificity of a diagnostic test; is able to interpret chi2 tests, logistic regression, odds ratios and ROC curves
- is able to interpret a Kaplan Meier curve
- is able to report the results with tables and graphics
- is able to use statistical software (e.g. SPSS or minitab)

Bioinformatics

Databases en analysis tools

- The student is familiar with biological databases Databases (such as Uniprot, Genbank, PDBe, PFAM, PROSITE, CDD, PubMed, KEGG.EBI, EMBL, NCBI and tools (such as Analysis of restriction sites, Primer design and characterisation, BLAST, MSA tools (Clustal), protein characterization tools)

Sequence annotation (DNA and protein sequences)

- Is able to use the principles of transcription, mRNA processing, translation, post-translational modifications and protein structure/domains to read sequence annotation.
- Knows the principles of gene prediction.
- Knows method to verify sequence annotation and is able to apply these methods.

Sequence alignment and score matrices

- Knows the concepts to make (multiple) sequence alignments.
- Is able to explain the concept of alignment score and e-value.
- Knows the features of a qualitatively good alignment.
- Is able to perform BLAST-searches and analyse the results in a correct way.
- Is able to explain the difference between a local, semi-global and global alignment.
- Is able to illustrate the use of (multiple) sequence alignments.
- Is able to use multiple sequence alignment tools in a correct way.

Homology and Phylogeny

- Is able to explain the concept of homology.
- Is able to explain the difference between homologues, orthologues and paralogues.

High-throughput data analysis

- understands the principle steps in analyzing high-throughput data obtained by –omics approaches.
- has analyzed and interpreted a limited number of high-throughput data and is able to communicate to specialists about such analyses

Intellectual properties

- is aware of the rights derived from intellectual properties and understands which implications these have for the production of generics and biosimilars
- is able to use patent databases to identify patent blocks
- is aware that he/she needs to contact patent experts if he/she is not sure how to interpret patent databases

Bio-business

- understands the meaning of the terms business models and business development, business value and financing
- is able to translate his/her projects plans in a concise business plan

Inter-personal skills

- is aware of his own cognitive style and recognizes the styles of team members
- has insight in different factors that contribute to an effective communication process
- knows the principles of situational leadership
- knows how to deal with possible conflicts
- is aware of intercultural differences

Position of the Master Molecular Life Sciences in the bio-research sector

The professional master is responsible for the realisation of projects in applied research and product development. In this role, our professional master is of added value for organisations as he/she supports senior project leaders by creating a short and effective link between company policies and hands-on projects operational at bench level. The Master in Molecular Life Sciences graduates can take position in the interphase between research/innovation and standardised processes (such as production, analysis and diagnostics). Such functions can be for instance scientific QC support or technical operations support. The function name of our masters varies within companies. Examples are Senior Researcher, Junior Scientist, Assistant Project Leader, Associate Project Leader or Junior Project Leader. Some graduates have decided to continue his/her career with a PhD project in applied or translational research or product development.