



# Degree Program Documentation

Master's degree program

*Agricultural Biosciences*

TUM School of *Life Sciences*, Technical University of Munich

Study Program Division *Agricultural and Horticultural Science*

<b>Name</b>	Agricultural Biosciences
<b>Administrative responsibility</b>	TUM School of Life Sciences Study Program Division Agricultural and Horticultural Science
<b>Degree</b>	Master of Science
<b>Standard Duration of Study &amp; Credits</b>	4 semesters (120 ECTS)
<b>Form of study</b>	Full time
<b>Admission</b>	Aptitude assessment (EFV/EV)
<b>Start</b>	Winter term 2020/21
<b>Language(s) of Instruction</b>	English
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# 1 Degree Program Objectives

## 1.1 Purpose of the Degree Program

Agricultural sciences offer solutions to major societal challenges. Securing food supplies, preserving natural resources, and mitigating the effects of climate change are only few out of many examples where agricultural sciences make significant contributions. Research and development in agricultural sciences has undergone a paradigm change through the adoption of pivotal innovations during the last decade. A broad spectrum of molecular, biochemical, physiological and biostatistical developments have opened new avenues. Among them are developments in functional analyses leading to a mechanistic understanding of plant and animal metabolism and physiology, behavior as well as disease resistance. Advances in computational methods and predictive analytics allow integration of heterogeneous data from molecular, physiological, and metabolic analyses as well as a more profound understanding of the genetic diversity of crop and livestock species. Precision phenotyping yields novel insights on how plants and animals respond to environmental cues and on their interactions with antagonistic and beneficial microorganisms.

For translation of these developments into innovation and agricultural production, it is pivotal to educate and train agricultural Master students in basic research in biology and data science. The program aims to equip students with a comprehensive spectrum of methods that enables them to address and implement key innovations in agricultural biosciences such as targeted genetic and genomic improvement of crop and livestock species, advances in stress physiology, cell biology and immunology in managed populations, and developments in research on animal and plant health. Therefore, this master program forms experts with molecular, biochemical, physiological, genetic and genomic knowledge for sustainable crop and livestock production. Alumni of this program will be qualified to develop strategies that help to mitigate the effects of climate change. In comparison to other programs in the life sciences this Master degree is dedicated to crop and livestock species that serve as production entities and as model organisms for basic research.

## 1.2 Strategic Significance of the Program

The TUM School of Life Sciences is dedicated to education and research in agricultural sciences. The Master's program Agricultural Biosciences complements the portfolio of agricultural programs at TUM School of Life Sciences with its focus on biological research as the basis of efficient and environmentally friendly agricultural production. It aims to understand the behavior of crop and livestock species from the level of cells up to whole organisms and populations and profits from the broad spectrum of basic research in the life sciences on the TUM School of Life Sciences campus.

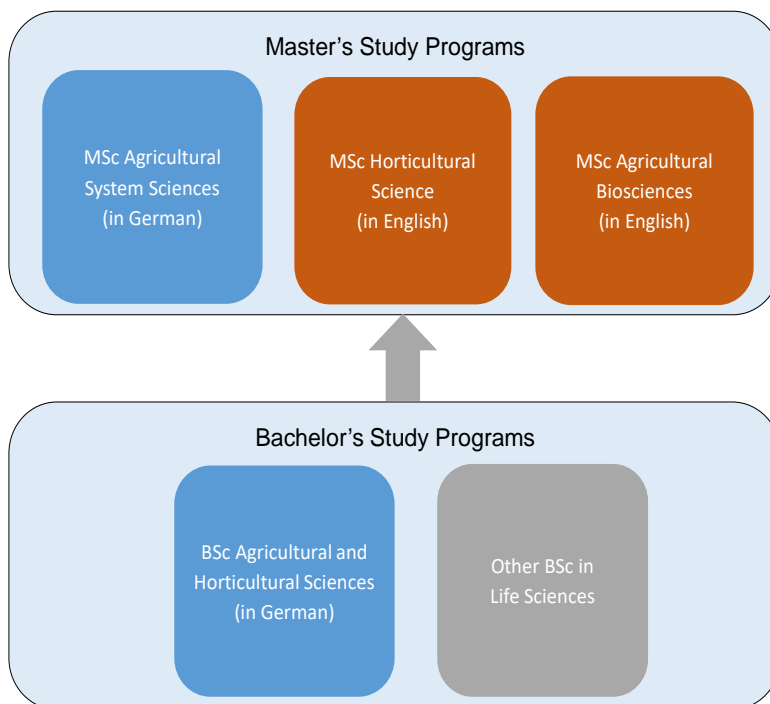
Addressing key issues of biological processes in agriculture the Master's program plays a major role for the TUM School of Life Sciences "One health" concept which is devoted to the production of healthy food and feed in an environment providing high quality of life. Agricultural Biosciences are linked to human and veterinary medicine, nutrition and pharmaceutical biotechnology through common research interests leading to extensive synergies between disciplines and faculties. The demarcation of these disciplines originates from different translational targets.

Providing a Master's program with a strong focus on methods relevant for the biosciences reflects the TUM overall strategy to value innovative technologies as the basis for knowledge gain as well as for creating impact and translation of results into practice. Methods relevant for the Agricultural Biosciences encompass a broad spectrum from basic biochemistry to biostatistics. It is the integration of methods offering a mechanistic understanding of biology with quantitative data science that makes the Agricultural Biosciences program unique and links it to other seminal disciplines like molecular biology and bioinformatics.

The Master's program Agricultural Biosciences is part of the Study Division Agricultural and Horticultural Sciences. While the Master of Agricultural Science Systems covers agricultural production with a focus on systemic interaction of many factors (biological, technological, economic) the Agricultural Biosciences program offers disciplinary depth in the biological disciplines relevant for crop and livestock production. It covers a broad spectrum of organisms (plants, animals, microbes) and quantitative and computational ap-

proaches in addition to molecular and cellular biology. Agricultural Biosciences are currently redefined through major technological breakthroughs (e.g., genome editing, machine learning) and programs that integrate these diverse research disciplines make best use of available technologies and high-dimensional experimental data. An overview of the Master's programs offered by the Study Division Agricultural and Horticultural Sciences is given in Figure 1.

**Figure 1:** Consecutive Program offer by the Study Division Agricultural and Horticultural Sciences (blue German Study Programs, Red = English Study Programs, Grey = Study Programs by other Study Divisions/Universities)



## 2 Qualification Profile

Students graduating from TUM Agricultural Biosciences understand the biological processes underlying agricultural crop and livestock production. They have a profound

knowledge of molecular, biochemical and physiological processes contributing to production increase. Based on their methodological repertoire they are able to optimize processes leading to genetic improvement of crops and livestock and optimize production environments through knowledge on the genotype-phenotype relationship. They can integrate heterogeneous data from different disciplines, are able to handle large experimental data sets and have a good knowledge of predictive analytics. The students can evaluate the acquired methods with respect to their impact and trade-offs in practice and can communicate their relevance for agricultural production in a livable environment.

The students have a profound **understanding of the scientific basis** of biological processes relevant for agricultural production. They

- know and understand plant and animal metabolism, animal behaviour and their interaction with the environment
- know, understand and develop methods for functional analysis, genetic modification and selection of crop and livestock species
- know, understand and develop quantitative methods employed in biological data science
- can handle and analyse big data volumes in a scientific context

The students are able to **perform research** in the field of Agricultural Biosciences and can link their knowledge and results to other disciplines. They

- are able to formulate research questions, design and analyze experiments and research projects
- can integrate heterogeneous methods and data from different disciplines
- can recognize knowledge gaps and can adapt and advance seminal technologies from flanking fields (e.g., biology, bioinformatics, nutrition) for research and development in agricultural bioscience
- can perform independent research on a clearly defined project
- collect, analyse, document and discuss data from their own experiments

The students are aware of **societal challenges and demands** in the context of Agricultural Biosciences and possess the **social skills** to communicate across disciplines and cultures. They

- can evaluate novel methods adopted by agricultural research and development for their scientific and societal impact
- are able to evaluate their state of knowledge in an international context

- have a clear idea how the acquired knowledge and methods can be implemented in practice and are able to translate their knowledge into practice by devising applied projects
- can present and communicate their research results to a scientific as well as a general audience
- can act in an intercultural environment and work solution-oriented within international scientific teams
- have advanced science communication skills in English
- can manage project and take on coordinating leadership roles

The students have developed their **self-competencies** for navigating in a changing environment and managing complex projects. They

- can set their individual goals based on an analysis of their talents and interests and have learned to work strategically towards these goals and building an individual profile, e.g., by choosing electives in their curriculum
- have shown their capability of perseverance in long-term projects by completing their Master's thesis

## 3 Target Groups

### 3.1 Target Groups

The main target group of the MSc Agricultural Biosciences are national and international students that hold an above average bachelor degree in the field of life sciences, such as agricultural sciences, bioinformatics, horticultural sciences, life sciences biology or molecular biotechnology, from a national or international university with a duration of study of at least six semesters.

### 3.2 Program Prerequisites

The above mentioned entry qualifications ensure that the students have sufficient basic knowledge and academic skills in the field of life sciences to continue their academic education at Master-level. Students have successfully completed at least 50 credits in fundamentals and methods of biological sciences (e.g., cell biology, genetics, ecology). At least 5 credits of these credits should have been gained in bioscience methods and another 5 credits in applied animal or plant sciences, preferable in relation to the agricultural sector. Moreover, students have completed during their bachelor studies at least 10



credits in mathematics, statistics and data sciences and at least 5 credits in chemistry. Students should be highly interested in deepening their knowledge at the interface of agricultural sciences and biosciences (focus on plant and/or animal science in a managed environment) and its linkage to the agricultural production. They should be highly motivated to take part in further developing the agricultural biosciences by taking into account methodological and practical innovations and current societal challenges that need to be addressed by academia (see e.g. the "One health" concept). Furthermore, the students should have prior knowledge in handling data and quantitative data analysis and need to have very good English language skills. Proof of first research experience as shown via a Bachelor thesis or equivalent research projects are advantageous for the admission (for more details see appendix two (aptitude test) of the master's program's Examination and Academic Regulations).

### **3.3 Target Numbers**

The target number of students for this program is 30 students per academic year (admission is only possible in winter term). This target number is based on potential job-market assessments and on the other hand on capacities to assure best conditions for high-level mentoring and supervision that are necessary to provide optimal support to the students that have to pass a significant amount of research-oriented examinations.

## **4 Analysis of Need**

The TUM School of Life Sciences is devoted to the strategic research concept „One health“. One pillar of this research concept is the development of agricultural biosciences focusing on the environmentally friendly production of natural resources and healthy foods and feed. The sustainable development of this research field within and beyond TUM requires education and training of young talents passionate for the application and advances of the life sciences.

Employment opportunities for students graduating from the Agricultural Biosciences Master's program will be found in tenure-track academic organizations and to a large extent in biotech, breeding and life science companies. Graduates with combined expertise in molecular biology and quantitative and computational methods are highly sought after in

the job market and as in other MINT disciplines the demand of qualified personnel is not met by the number of graduates. It can be expected that the demand will increase as molecular methods and machine intelligence will fundamentally change the agricultural sector and increase the demand for research and development. New skills, such as programming and handling data rich challenges and digital information, are on high demand. As there is a strong trend towards diversification in the job market, more and more young scientists with expertise in agricultural biosciences are finding employment in smaller companies and startups in areas such as biotechnology and machine intelligence providing technologies or service to the agricultural sector. Due to their competence in quantitative analyses, graduates from the Agricultural Biosciences Master's program will also find employment opportunities outside the agricultural context, e.g., in the field of human genetics research and development with a different research focus but highly related research methods and tools.

## 5 Structure of the Degree Program

The Master's program Agricultural Biosciences offers lectures, lab courses, seminars, and independent study projects in biological disciplines relevant for agricultural production. It comprises four semesters including the Master's thesis (Figure 2).

A total of 25 credit points (CP) has to be obtained in five required core courses during the first and second semester. In four of the required modules (Physiology, Plant and Animal Cell Biology, Immunology: Crop and Livestock Health and Disease, Genetics and Genomics) a profound understanding of the scientific basis of biological processes relevant for crop and livestock production will be offered as a lecture covering generic and specific topics of plant and animal sciences complemented by seminars allowing students to specialize on plants or animals. In the fifth required course "Statistical Computing and Data Analysis" students will learn advanced quantitative methods as employed in biological data science and predictive analyses.

After completion of the five compulsory modules during the first and second semester, students possess solid knowledge in basic biological concepts relevant for agricultural production. They have advanced knowledge of plant and animal metabolism, understand

determinants and consequences of animal behavior and the interaction of plants and animals with their managed environment. A total of at least 65 credit points has to be obtained in the elective modules. Thereof, at least one method-oriented lab course (5 CP), counting as elective module, is required. Students can choose from a list of different lab courses that cover either molecular or computational techniques.

In addition, at least two research tools counting as elective modules have to be successfully completed with at least 10 CP. These courses offer independent study projects and enable students to perform research in the field of agricultural biosciences. Students learn how to formulate research questions, design and analyse experiments, interpret results and present them orally and in writing.

The core modules train students for additional elective modules. These elective modules enable students to integrate heterogeneous methods and data and to link research topics and methods to adjacent fields in, e.g., nutrition, medicine, bioinformatics, and data science. They provide orientation to students inclined to choose a field of specialization and at the same time prepare them to link their knowledge across several disciplines. Electives convey knowledge of molecular, biochemical, physiological, genetic and statistical concepts contributing to sustainable production growth in agriculture. In addition, the broad spectrum of elective modules trains students for multiple career paths. Students can choose the necessary 50 CP or less (depending on credits of the research tools chosen) from a list of lectures, practical courses and independent research projects offering a balanced selection of molecular, biochemical, physiological, biostatistical, bioinformatic and computational topics. Here, students learn how to perform research on selected topics. Through their individual choices they can build a highly focused study program developing in-depth expertise in one area of specialization (e.g., molecular animal science, computational plant science, horticultural science) or they can build an interdisciplinary program in which they acquire profound knowledge and analytical skills in seminal technologies from adjacent fields and combine them with profound knowledge on agricultural research questions. Through seminars they learn to critically evaluate novel methods adopted by agricultural research and development for their scientific and societal input.

**Figure 2:** Sample curriculum of the Master's program Agricultural Biosciences

Semester	Module						Credits
1.	Plant and Animal Cell Biology (required)  written exam 5 CP	Immunology: Crop and Livestock Health and Disease (required)  written exam 5 CP	Statistical Computing and Data Analysis (required)  written exam 5 CP	Lab Course Immunology (elective)  written exam 5 CP	Plant Biotechnology (elective)  written exam 5 CP	Marker - assisted Selection (elective)  oral exam 5 CP	30
2.	Practical Course: Computing for Highthroughput Biology (elective)  research paper 10 CP		Physiology (required)  written exam 5 CP	Genetics and Genomics (required)  written exam + presentation 5 CP	Reproductive Biotechnology and Basic Molecular Developmental Biology (elective)  oral exam 5 CP	Crop Genomics (elective)  written exam 5CP	30
3.	Mobility window	Research Project: Chemical Genetics (elective)  report 10 CP	Plant Epigenetics and Epigenomics (elective)  presentation 5 CP	Evolutionary Genetics of Plant and Microorganisms (elective)  oral exam 5 CP	Transcriptional and Posttranscriptional Regulation in Eukaryotes (elective)  written exam + presentation 5 CP	Genetic Engineering of Livestock (elective)  oral exam 5 CP	30
4.	Master's Thesis (27 CP) + Thesis Colloquium (3 CP)						30
Key:	dark blue = final thesis blue = elective modules grey = required modules						

Students can choose elective courses from the TUM-wide offer (maximum 15 CP) or from other international institutions (maximum 30 CP) as long as they are not redundant to already completed courses and in line with the goals and qualification profile of the TUM Master's program Agricultural Biosciences.

By opening a mobility window in the third semester students are encouraged to gain international study experience through exchange programs such as Erasmus+ or TUM-exchange. If approved by the Examination Board and under the supervision of a professor within the TUM School of Life Sciences they can take up a research internship outside TUM, e.g. with a qualified industry partner or in an external research organization (e.g. Max Planck institute). Students can complete one course (5 CP) in general knowledge offering them an interdisciplinary perspective on their field of studies.

The fourth semester is devoted to preparing the Master's thesis that concludes the study program. In their thesis, students identify and address a research question in the agricultural biosciences by choosing and implementing appropriate molecular, experimental or data methods. They develop an appropriate research design and show their competence to interpret the research outcome. By choice of a topic, the thesis raises the professional profile of the student. The thesis is defended in a colloquium.