Structure

The structure of the program is based on the HBRS regulations and the corresponding PhD regulations and is schematically shown in Figure 1.

The individual timetable is compiled by the thesis committee together with the doctoral candidate according to the prior knowledge of the respective candidate. The intention here is to align the accompanying program closely to the individual needs of the respective candidate with the aim of efficient further qualification.

To satisfy the requirements, the doctoral candidate has to submit a thesis and prove successful participation in a structured program of a minimum of 300 hours of lessons (1 hour of lesson corresponds to 45 minutes of time) as shown in Table 1. Participation in courses with relevant content from other graduate programs or university lectures of partner institutions may also be accepted upon request.

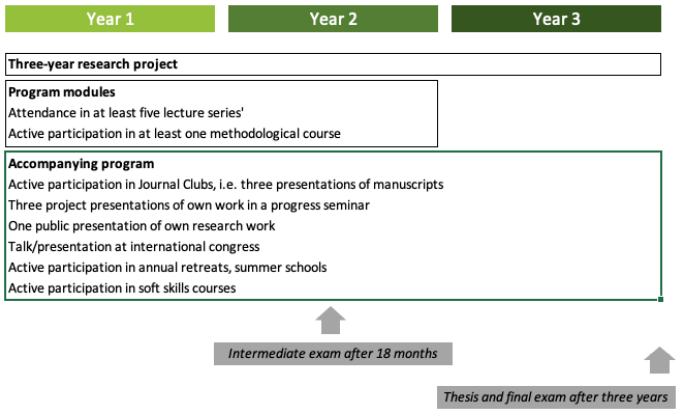

Figure Structure of the BIOMEDAS program.

Table 1 Exemplary structure of a doctoral candidate's individual timetable within BIOMEDAS

General specifications	Student's schedule (example)
Three-year research project	Research project selected
Program modules • Successful participation in **lecture series** [attendance in at least five lecture series'] • Active participation in **methodological courses** attendance in [at least one course]	• Attendance of six lecture series', each 7x1.5h → 84 lessons • Attendance of two courses, each 2 full days → 40 lessons
Accompanying program • Participation in a **Journal Club** with at least three presentations of publications • Participation in a **Progress Seminar** with presentations of own work • **Conference participation** with own contribution (oral or poster presentation) [at least one conference participation] • Active participation in **annual retreats** [attendance at at least one retreat] • Active participation in **soft skills courses** [attendance in at least one course]	• Attendance and contribution to JC, annually 20x45min, 3 years → 60 lessons • Attendance and contribution to PS, annually 20x45min, 3 years → 60 lessons • Attendance and contribution to an international congress, 2 full days → 20 lessons • Attendance and contribution to annual retreat, 2 times, full day → 20 lessons • Attendance of soft skills courses, 2 times, each full day → 20 lessons

Based on the provided curriculum, BIOMEDAS students will develop the following competencies, required to model biomedical problems and analyzing biomedical data using mathematical and computational approaches:

- Computational thinking by training computer science skills to address problem-solving effectively.
- Mathematical and statistical modelling and analysis to provide a universal language essential for producing reliable and reproducible results from real-world problems and data.
- Conceptual knowledge in translational bioinformatics, clinical informatics, consumer health informatics and public health informatics.
- Improving the ability to make ethical choices necessary for responsible conduct of research.

Program modules

The offered lectures and courses are organized in different clusters, which illuminate different areas and aim at diverse knowledge and skills.

Biological and Medical Concepts

The cluster “Computational Biology” is organized by Anke Kraft and Annett Ziegler.

The modules for this cluster aim at understanding the principles of biological and medical concepts incl. sample preparation, experimental design and data generation. The skills developed include:

- Introduction into basic concepts of biology, virology, microbiology, immunology and genetics
- Conceptual understanding of how samples are generated, experiments are designed and data generated to be able to assess the impact for data analysis

Computational Biology (CB)

The cluster “Computational Biology” is organized by Andreas Klötgen and David DeLuca.

The modules for this cluster aim at understanding of data format, representation and analysis in biomedical sciences and complex concepts for understanding the biological system as a whole. The skills developed include:

- Introduction into basic bioinformatics concepts & statistics
- Bioinformatics methods for data representation and visualization using networks and graphs
- Training in concepts and techniques for evolutionary analyses
- Assessing quality of bioinformatics data for reliable and robust data analysis
- Computational approaches for sequencing data analysis and integration, from alignment over filtering to downstream analyses
- Advanced approaches for complex data integration of various sequencing types and computationally predicted sequence features
- Conceptual understanding and practical introduction to systems biology approaches

Computational Method Development (CMD)

The cluster “Computational Method Development” is organized by Maria-Esther Vidal and Sören Auer.

The modules for this cluster aim at enhancing the competencies of computational thinking and mathematical and statistical modelling. The skills developed include:

- Mathematical languages to formalize biomedical problems and solutions.
- Algorithmic techniques to effectively solve biomedical problems.
- Computational data structures to efficiently store biomedical data.
- Data models and ontologies to formally represent biomedical knowledge.
- Data management techniques to devise pipelines to collect and integrate biomedical data.
- Visual literacy to devise meaningful and self-interpretable visual representations of the main features of biomedical data and knowledge.
- Data management techniques for assessing, tracking, and improving data quality.

Machine Learning and Data Mining (MLDM)

The cluster “Machine Learning and Data Mining” is organized by Frank Klawonn and Tim Kacprowski.

The primary objective of these modules is to enhance computational thinking and mathematical and statistical modelling of the students. The skills to be reached in these courses are:

- Statistical methods to analyse, describe, and curate biomedical data.
- Data analysis for feature selection in biomedical data.
- Artificial intelligence approaches to empower statistical techniques with the ability to learn and predict patterns from biomedical data.
- Machine learning methods for modelling predictive biomedical problems, as well as explaining the outcomes of these methods in biomedical problems.

Interdisciplinary (I)

The cluster “Interdisciplinary” is organized by Maria-Esther Vidal and Roland Seifert.

These modules aim to add overarching topics to the curriculum. The skills to be reached in these courses are:

- Principles that support ethical choices (Responsible conduct of research)
- Principles that guide the publication and management of research data
- Methods to conduct and report research studies to ensure reproducibility
- Open science and the development of services for research data management
- Formalisms based on Open Research Knowledge Graphs to transform document-based scientific literature review into knowledge-based information flows