CURICULUM DOCUMENT 2021

STUDY PROGRAM
DOCTORATE BIOTECHNOLOGY

GRADUATE SCHOOL

UNIVERSITAS GADJAH MADA

2021

FOREWORD

This curriculum document has been meticulously prepared as part of the periodic curriculum evaluation process, which is conducted every five years in accordance with the academic quality standards of Universitas Gadjah Mada. It is the objective of the Doctoral Program in Biotechnology at the UGM Graduate School to guarantee that it sustains the highest standards of academic excellence and remains adaptable to the changing requirements of science, technology, and society.

A thorough SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of the previous curriculum has been conducted to assess its effectiveness in meeting the Learning Outcomes (LO) for doctoral students. The revised curriculum has been designed to enhance students' intellectual and professional development, aligning with national and international biotechnology education standards. Each course is tailored to specific learning outcomes, ensuring that students acquire knowledge, skills, and competencies relevant to the biotechnology sector.

In response to the growing demand for specialized research skills, the program now includes a "by research" track in addition to the regular program. This new option is designed for researchers who wish to focus primarily on research outcomes, allowing them to further hone their research capabilities. The establishment of this track addresses the increasing need for researchers capable of producing high-impact results, particularly in the rapidly evolving field of biotechnology.

The curriculum integrates innovative teaching methods, cutting-edge research, and strong partnerships with industry. These elements are crucial in preparing graduates to contribute meaningfully to both academic and industrial biotechnology sectors. With this revised curriculum, we aim to continually enhance the quality of education and the employability of our graduates.

This document reflects the collaborative efforts of faculty, stakeholders, and industry experts, ensuring that the Doctoral Program in Biotechnology remains a leader in the field. We are confident that this curriculum will foster ongoing success and sustain UGM’s vision of becoming a world-class institution.

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CHAPTER 1. INTRODUCTION

1.1 Background of the Study Program

The Doctoral Program in Biotechnology is one of the study programs within the Graduate School of Universitas Gadjah Mada. The establishment of this program originated from the founding of the Inter-University Center (PAU) for Biotechnology at UGM, which was part of Indonesia's Biotechnology Development Project under the Directorate General of Higher Education. The PAU for Biotechnology at UGM was established in 1985, based on the Decree of the Minister of Education and Culture of the Republic of Indonesia No. 909/D/T/1986 dated May 15, 1986, funded by the World Bank XVII from 1986 to 1995. UGM's PAU for Biotechnology was one of three such centers in Indonesia. Subsequent funding for UGM's PAU for Biotechnology was obtained through the URGE IBRD Loan No. 3754-IND grant from the 1994/1995 fiscal year until 1998/1999.

Based on its experience in conducting various research and educational activities, and due to significant interest from other universities in developing biotechnology in Indonesia, in 1995, UGM's PAU for Biotechnology proposed the establishment of a Doctoral Program in Biotechnology. Initially, the doctoral program was a concentration within the Doctoral Program in Mathematics and Natural Sciences (MIPA) in 1995.

Since the issuance of the UGM Rector's Decree No. 25/P/SK/HKTL/2001 on July 3, 2001, regarding the Change/Establishment of Centers within Universitas Gadjah Mada into Study Centers, UGM's PAU for Biotechnology transformed into the Biotechnology Study Center at UGM. The Doctoral Program in Biotechnology was subsequently formalized as an independent study program in 2003, following the Director of Graduate School's Decree No. 01/J01.4/OT/SK/3. The Doctoral Program in Biotechnology involves various scientific disciplines and educators from UGM's supporting faculties in biotechnology, solidifying its categorization as a multidisciplinary program under the management of UGM's Graduate School, based on the UGM Rector's Decree No. 89/P/SK/HT/2006. The existence of the Doctoral Program in Biotechnology was further strengthened by the UGM Rector's Decree No. 525/P/SK/HT/2008 on November 21, 2008, regarding the Arrangement and Reconfirmation of the Authorization for Study Programs at Universitas Gadjah Mada. The program's authorization has been renewed twice, valid until November 20, 2017, through the UGM Rector's Decree No. 791/P/SK/HT/2013 and No. 605/P/SK/HT/2015.

Since its establishment, the Doctoral Program in Biotechnology has undergone three accreditations by the National Accreditation Board for Higher Education (BAN-PT). Based on BAN-PT's decision No. 018/BAN-PT/Ak-X/S3/XI/2011, dated November 18, 2011, regarding the status, score, ranking, and validity period of doctoral program accreditations in higher education, the Doctoral Program in Biotechnology at UGM was accredited with an “A” rating. From then until 2016, the program consistently received an “A” rating. In its latest accreditation cycle in 2021, the program achieved an "excellent" rating, as per BAN-PT Decree No. 13382/SK/BAN-PT/Akred-PMT/D/XII/2021.

The Doctoral Program in Biotechnology at Universitas Gadjah Mada is located in the UGM Graduate School’s Inter-University Center Building, Southwest Wing, with the address Jl. Teknika Utara, Barek, Yogyakarta, telephone (274) 902284 and (274) 564305, fax (274) 520842, email: biotech.sps@ugm.ac.id, and website addresses https://doktoralbioteknologi.pasca.ugm.ac.id/ and https://www.biotech.ugm.ac.id/.

1.2 Vision, Mission, and Objectives of the Study Program

1.2.1 Vision

To become a pioneer in internationally recognized doctoral biotechnology education in Indonesia, serving the interests of the nation and humanity, inspired by the cultural values of the nation and based on Pancasila.

1.2.2 Mission

a. To provide an internationally recognized doctoral education in biotechnology that fosters graduates' career success and improves the quality of life of the nation.

b. To support the advancement of biotechnology research that underpins education, scientific progress, and the enrichment of national culture.

c. To initiate and carry out national and international cooperation programs with educational institutions, research bodies, government, industry, businesses, and the community.

1.2.3 Objectives of the Study Program

a. To realize the vision and mission of the Doctoral Program in Biotechnology.

b. To produce graduates who are qualified educators and researchers in biotechnology and capable of competing at a global level.

c. To produce graduates who possess academic, moral, and ethical integrity in biotechnology research and engineering.

1.2 Background of Curriculum Revision

The National Standards of Higher Education (SN-DIKTI), as outlined in the Minister of Research, Technology, and Higher Education Regulation No. 44 of 2015 Article 1, defines the curriculum as a structured plan and arrangement concerning the learning outcomes of graduates, study materials, processes, and assessments that serve as guidelines for study program implementation. The Higher Education Curriculum is an institutional mandate that must be continuously updated to meet the changing needs and advancements in science and technology (Ristekdikti, 2016).

The revision of the Doctoral Program in Biotechnology curriculum is driven by the need to align with scientific and technological developments, as well as the requirements set by SN-DIKTI. Beyond compliance, the revision also aims to enhance the quality of the educational process and learning outcomes, producing graduates equipped to tackle increasingly complex global challenges.

A significant addition to this curriculum revision is the establishment of a "by research" track, designed to meet the growing demand for specialized research skills in the biotechnology sector. The inclusion of this option responds to the need for researchers who wish to focus primarily on producing high-impact research results. This track allows students to further refine their research expertise and directly contribute to advancements in biotechnology. The "by research" track is essential in addressing the increasing demand for high-caliber researchers capable of driving innovation and solving real-world problems through biotechnology. This revision not only enhances the program's adaptability but also ensures that it remains relevant to both academic and industrial needs.

In summary, this curriculum revision seeks to uphold academic excellence while adapting to the latest trends in science, technology, and society, ultimately preparing graduates to meet future challenges and opportunities.

1.3 Objectives of the New Curriculum

a. To respond to feedback from stakeholders during the curriculum workshop, which included input from alumni, employers, students, and faculty.

b. To adjust the curriculum load in accordance with UGM Rector Regulation No. 11 of 2016 concerning Graduate Education.

1.4 Foundations for the Revision and Reference Documents

The curriculum development process takes into consideration Presidential Regulation of the Republic of Indonesia No. 8 of 2012 on the Indonesian National Qualifications Framework (KKNI), Minister of Education and Culture Regulation No. 73 of 2013 on the Implementation of the KKNI in Higher Education, and Minister of Research, Technology, and Higher Education Regulation No. 44 of 2015 on the National Standards of Higher Education. Additionally, it adheres to UGM's Academic Policies, the Academic Standards for Learning Processes issued by UGM's Quality Assurance Office, Law No. 12 of 2012 on Higher Education, UGM Rector Regulation No. 11 of 2016 on the Basic Framework of the Curriculum, UGM Rector Regulation No. 16 of 2016, and the results of meetings held by the academic development team of the Doctoral Biotechnology Study Program.

Process of Developing the New Curriculum

The development of the new curriculum was guided by the Higher Education Curriculum Development Handbook, prepared by the Directorate General of Learning and Student Affairs, Ministry of Research, Technology, and Higher Education, as outlined in Figure 1.

The process began with a curriculum workshop held on July 5-6, 2021, by the Graduate School, involving stakeholders from each study program, including faculty, students, staff, alumni, employers, and partners. Feedback from these stakeholders was used to enhance the curriculum. The next step involved determining graduate profiles, which define the roles graduates can take on or the specific fields they can work in after completing their studies. The graduate profiles of the Doctoral Biotechnology Program were formulated through survey data (tracer study) collected from alumni of the program. The survey was conducted using an online form (Google Form) and targeted UGM Biotechnology Master's Program alumni from the past five years. Based on the survey data, the graduate profiles for UGM's Doctoral Program in Biotechnology were identified as follows:

1. Higher Education Educators
2. Biotechnology Researchers

From these profiles, the skills and qualifications required for each role were determined. These qualifications encompass four key elements that form the basis of learning outcomes: attitudes, knowledge, general skills, and specific skills. The learning

outcomes (CPL) were then formulated with reference to the Indonesian National Qualifications Framework (KKNI), particularly focusing on the specific skills and knowledge mastery components. Attitudes and general skills are based on the standards outlined in SN-DIKTI, which serve as the minimum benchmark.

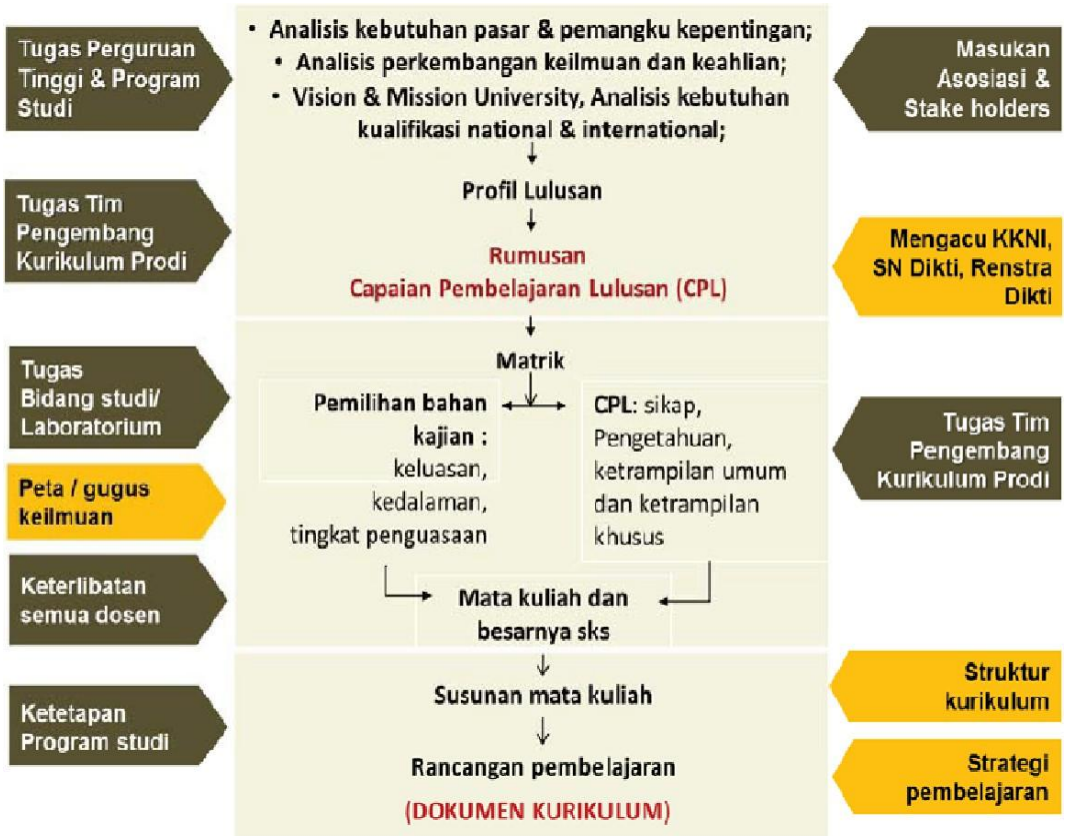

Figure 1. Curriculum Design Stages

The next stage is the formation of courses. At this stage, the first step is to compile study materials. Study materials are developed according to the development of science and technology and the direction of the development of Biotechnology. Then the courses are determined along with the number of credits.

CHAPTER II. OLD CURRICULUM

2.1 Old Curriculum

The field of biotechnology continues to experience rapid and significant advancements. The demand for biotechnology products and services in the areas of health, food, industry, and environment is steadily increasing. Indonesia still faces a pressing need to enhance its human resources capable of mastering and applying biotechnology knowledge in these four sectors. The Biotechnology Study Program at Universitas Gadjah Mada (UGM) has been implementing an educational curriculum for its Doctoral Program (S-3) since 2006. In line with the ongoing developments in biotechnology, the curriculum has been continuously evaluated and improved.Until the 2017 academic year, the program continued to use the 2013 curriculum, which focused on training doctoral graduates to become educators and researchers in the field of biotechnology, a focus that remains relevant to current needs. The newly revised curriculum has been designed primarily to align with the format set by the Ministry of Research, Technology, and Higher Education (Kemenristekdikti) and to further refine the courses to ensure that the graduates' competencies meet the desired standards.

2.1.1 Compulsory and Elective Courses

Compulsory courses

No.	Code	Courses	Credit
1	SPSBT-801	Scientific Research Methodology	3
2	SPSBT-802	Special Topics in Biotechnology	3

Elective course

No.	Code	Courses	Credit
1.	SPSBT 8103	Plant Molecular Biology	2
2.	SPSBT 8104	Molecular Biology of Rhizobium	2
3.	SPSBT 8105	Molecular Microbial Ecology	2
4.	SPSBT 8106	Microbial Physiology	2
5.	SPSBT 8107	Elucidation Structur	2
6.	SPSBT 8108	Enzym Biochemistry	2
7.	SPSBT 8109	Molecular Carcinogetics	2

2.1.2 Curriculum Stucture

Semester	Courses Category	Credits	Offered Credits
1	Compulsory course	8	8
	Elective course	2	25
2	Elective course	4	25
3 & 4	Disertasi	32	32
	Total Credits	**46-48**	**90**

2.1.3 **SWOT Analysis of the Old Curriculum**

Strength

a. The curriculum has been designed in accordance with the latest scientific developments in the field of biotechnology.

b. The curriculum implemented is able to produce graduates who have international standard academic abilities.

2.1.4 Weakness/ Threat

a. The curriculum has not been compiled according to the format required in the 2016 university curriculum compilation guidelines (Kemenristekdikti)

b. The curriculum still needs to be supplemented with courses on the use of software for metadata analysis.

c. The curriculum does not include a by research track, even though BRIN (the National Research and Innovation Agency) had already started offering scholarships specifically for by research programs

2.1.5 Strategy to overcome

a. Developing a curriculum that is in accordance with the format required in the 2016 university curriculum development guidelines (Kemenristekdikti)

b. Organizing the mandatory course Bioinformatics and Data Analysis in Biotechnology

BAB III. REVISED CURRICULUM

3.1 Introduction

Recent global events, such as the COVID-19 pandemic and climate change, have accelerated the development of biotechnology at an unprecedented pace. The demand for biotechnology products and services in the health, food, industry, and environmental sectors continues to grow rapidly. Indonesia, however, still faces the challenge of strengthening its human resources who are capable of mastering and applying biotechnology knowledge comprehensively across these four sectors. The Biotechnology Study Program at Universitas Gadjah Mada has been implementing its doctoral (S3) curriculum since 2006. In line with advancements in biotechnology, the curriculum has undergone continuous evaluation and improvement. Until the 2021 academic year, the program used the 2018 curriculum, which focused on producing graduates prepared to become educators and researchers in biotechnology — a focus that remains highly relevant today.

The 2021 curriculum was designed primarily to align with the framework established by the Ministry of Research, Technology, and Higher Education (Kemenristekdikti). Importantly, it introduced the by research track to accommodate the increasing need for a more research-intensive pathway, especially in response to opportunities provided by BRIN (the National Research and Innovation Agency), which has begun offering scholarships for by research doctoral programs. This track enables students to focus more deeply on research activities and to contribute directly to the development of biotechnology through innovative discoveries and applications. Furthermore, the 2021 curriculum includes bioinformatics as a compulsory course. Mastery of bioinformatics has become an essential skill for doctoral students in biotechnology, as it supports the analysis and interpretation of large-scale data generated through omics approaches (such as genomics, transcriptomics, proteomics, and metabolomics). Bioinformatics also plays a crucial role in advanced statistical analysis, data integration, and modeling — all of which are necessary to strengthen research quality and relevance in biotechnology.

Additionally, supporting courses for dissertation research have been comprehensively evaluated and refined to ensure they are more closely aligned with current research trends and dissertation topics. These improvements aim to enhance the competencies of graduates, enabling them to meet the dynamic demands of the biotechnology sector and to make significant contributions at both national and global levels.

3.2 Graduate Profile and Competencies

3.2.1 Graduate profile of the study program

a. Higher Education Educator

   An educator or lecturer in higher education who possesses comprehensive knowledge in biotechnology and is well-versed in the latest scientific developments in the field.

b. Biotechnology Researcher

   A researcher in the field of biotechnology who is capable of providing solutions to various problems through the application of biotechnology knowledge.

3.2.2 Major Competencies of Graduates

The Major competencies of graduates from the study program are as follows:

a. Mastering the general concept of academic integrity, including the concept of plagiarism, the consequences of violations, and strategies for its prevention.

b. Mastering the scientific philosophy in the fields of molecular biology, molecular and cellular engineering, the interactions between cells, tissues, organs, and living organisms with their environment, as well as the ability to analyze biomass and biomolecules.
c. Graduates are expected to understand the concept of cell, tissue, and organ propagation for the advanced production of biotechnology products.
d. Understanding the regulations regarding the use of genetically engineered organisms/microorganisms, both for commercial purposes and research purposes.
e. The ability to deepen and expand scientific knowledge and produce innovative biotechnology products by designing, implementing, and appropriately developing research methods. This includes the integration of laboratory equipment and software to enhance the quality of human life.

3.2.3 Supporting Competencies of Graduates

The supporting competencies of graduates from the study program are as follows:

a. The ability to communicate ideas, concepts, and research findings both orally and in writing to the international scientific community and the general public.
b. The capability to apply research findings to develop technologies that can be utilized

by society.

c. The ability to act as a principal researcher, leading a research project in the field of biotechnology.

3.2.4 National and International Demand for Graduates

There are approximately 30 research institutions in Indonesia, both government (such as BRIN) and private. It is assumed that each institution requires at least one graduate. In addition, there are over 300 academic programs related to biotechnology across various universities in Indonesia. Assuming that each program requires one graduate, the total national demand for biotechnology graduates is estimated to be around 330 individuals.

According to Hunt and Solberg (2008), biotechnology graduates can occupy a wide range of positions within companies, such as Laboratory Assistant, Research Associate, Health and Safety Specialist, Research and Development, among others. There are approximately 23 potential positions for biotechnology graduates. In the United States, there are more than 100 biotechnology companies and over 50 research institutions. Assuming that each company and research institution requires one biotechnology graduate, the demand for biotechnology graduates in the United States is estimated at around 3,450 individuals.

3.3 Graduate Competency Standards and Graduate Learning Outcomes (Learning Outcome)

Aspect	Learning Outcome	Description
1. ATTITUDE	LO 1	Contribute to the improvement of the quality of life in society, the nation, and the state, as well as the advancement of civilization, based on the principles of Pancasila
	LO 2	Demonstrate honesty, responsibility, confidence, emotional maturity, ethical behaviour, and a commitment to lifelong learning
2. KNOWLEDGE	LO 3	Master and contribute to the development of theories or concepts in Biotechnology and Molecular Biology, including the interactions between cells, tissues, organs, and living organisms with their environment.
	LO 4	Master advanced knowledge of the interactions between cells, tissues, organs, and living organisms with their environment.

Aspect	Learning Outcome	Description
	LO 5	Master the concept of cell, tissue, and organ propagation for the advanced production of biotechnology products
3. GENERAL SKILL	LO 6	Able to formulate scientific arguments and solutions to societal challenges and translate them into research designs in biotechnology.
	LO 7	Able to manage research data effectively and communicate findings to the scientific community through publications and conferences.
	LO 8	Able to develop new theories, concepts, or scientific ideas that advance knowledge and technology while upholding biotechnology values in their field of expertise.
4. SPECIFIC SKILL	LO 9	Able to design, implement, and refine research methods integrating laboratory experiments and software for effective data collection and management.
	LO 10	Able to develop research proposals to gain funding for the creation of technologies that benefit society.

3.4 The Structure of Revised Curriculum

3.4.1 Compulsory and Elective Courses

No.	Code	Courses	Credits for reguler	Credits for by research
1	SPSBT213101	Scientific Research Methodology	3	3
2	SPSBT213102	Selective Topics in Biotechnology	3	3
3	SPSBT213103	Bioinformatics and Data Analysis in Biotechnology	2	-
4	SPSBT213104	Disertation	34	38

Elective Courses

No.	Kode	Nama Mata Kuliah	Jumlah SKS
1	SPSBT213201	Advanced Bioinformatics	2
2	SPSBT213202	Advanced Molecular Biology and its analysis	2
3	SPSBT213203	Advanced Immunology	2
4	SPSBT213204	Molecular Immunology	2
5	SPSBT213205	Molecular Genetics	2
6	SPSBT213206	Enzyme Engineering	2
7	SPSBT213207	Genetic Engineering	2
9	SPSBT213202	Molecular Physiology	2
10	SPSBT213208	Phytochemistry	2
11	SPSBT213209	Analysis and Elucidation of Metabolite Structure	2
12	SPSBT213210	Secondary metabolites and the analysis	2
13	SPSBT213211	Biology of Tropical Diseases	2
14	SPSBT213212	Human Physiology	2
15	SPSBT213213	Medical Microbiology	2
16	SPSBT213214	*ONE HEALTH*	2
17	SPSBT213215	Virology	2
18	SPSBT213216	*Antimicrobial Resistance*	3
19	SPSBT213217	Lactic Acid Bacteria and applications	2
20	SPSBT213218	Bacteriology of Plant Pathogens	2
21	SPSBT213219	Molecular Biology of Yeast	2
22	SPSBT213220	Microbial Genetics	2
23	SPSBT213221	*Gut Microbiome*	2
24	SPSBT213222	Molecular Microbiology	2
25	SPSBT213223	Molecular Biology of Streptomyces	2

No.	Kode	Nama Mata Kuliah	Jumlah SKS
26	SPSBT213224	Parasitology	2
27	SPSBT213225	Molecular Biology of Plants	2
28	SPSBT213226	Fish Physiology	2
29	SPSBT213227	Molecular Plant Pathology	2
30	SPSBT213228	Fish Nutrition	2
31	SPSBT213229	Pourlty Nutrition	2
32	SPSBT213230	Host Plant and Pathogen Interactions	2
33	SPSBT213231	Integrated Pest Management	2
34	SPSBT213232	Biological Control	2
35	SPSBT213233	Biochemical Signaling System	2
36	SPSBT213234	Biocatalysts and Bioconversion	2
37	SPSBT213235	Bioprocess	2
38	SPSBT213236	Fermentation Kinetics	2
39	SPSBT213237	Enzyme Technology	2
40	SPSBT213238	Molecular Microbial Ecology	2
41	SPSBT213239	Metal Analysis	2
42	SPSBT213240	Environmental Toxicology	2
43	SPSBT213241	Epigenetics and Regulation of Gene Expression	2
44	SPSBT213242	Molecular Biology of Cancer	2
45	SPSBT213243	Artificial Intelegent	2
46	SPSBT213244	Advanced Pharmaceutical Biotechnology	2
47	SPSBT213245	Cancer Treatment	2
48	SPSBT213246	Biology of Tumor	2

3.4.2 Course Structure

Sem	Course Category	Credits for reguler	Credits for by research	Offered Credits
1	Compulsory	8	6	8
1-2	Elective	4-10		104
3-6	Disertation	34	38	34
	Total Credits	**46-50 SKS**	**44-48**	**146 SKS**

3.4.3 Curriculum Map

No.	Course type	Courses	credits		Sem	Learning Outcome									
			W	P		LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10
1	Compulsore	Scientific Research Methodology	3		1	K					K	K		K	
2		Selected Topics in Biotechnology	3		1			K	K	K	K	K			
3		Bioinformatics and Data Analysis in Biotechnology	2		1			K	K			K		K	
4		Disertation	34			K	K	K	K	K	K	K	K	K	K
5	Elective	dissertation supporting courses I		2-3	2			K	K	K					
6		dissertation supporting courses II		2-3	2			K	K	K					
7		dissertation supporting courses III (if needed)		2-3	2			K	K	K					
8		dissertation supporting courses IV (if needed)		2-3	2			K	K	K					

Note: elective courses supporting the dissertation are determined based on the student's academic background as determined during the promoter team meeting with the study program.

3.4.4 Admission of Students

The admission process for the Doctoral Biotechnology Study Program follows the application procedures and timelines set by Universitas Gadjah Mada's admissions office, which can be accessed via the website https://um.ugm.ac.id. Applicants are required to follow the university's official guidelines during the admission period. For the by research track, the admission criteria differ from the regular track. Prospective students applying for the by research program must meet the following requirements:

a. A minimum GPA of 3.25 from their Master's Program.
b. The Master's degree program must be accredited with at least a B rating.
c. A TPA (Academic Potential Test) score of at least 550.
d. An English proficiency score equivalent to TOEFL ITP ≥ 500 (accepted test

types must follow UGM regulations).

e. A study permit or study assignment letter from their current employer.
f. A pre-research proposal document outlining their research interests, which must be approved by a prospective co-supervisor from their current institution.
g. This structure ensures that candidates for the by research track are well-prepared and supported in their academic and research endeavors.

3.4.5 Evaluation or Assessment System for Each Course and its Relation to LO of the Study Program

The evaluation of each course is aligned with the Learning Outcomes (LO) of the Master's Program in Biotechnology. Several evaluation methods are implemented in the Master's Program in Biotechnology, including both summative and formative assessments. These evaluations may take the form of quizzes, individual assignments, final exams, presentations, papers, and participation. The rubrics for each type of course evaluation can be found in the Course Modules.

3.4.6 Graduation Requirements (Judicial Examination)

a. A minimum cumulative GPA of 3.25
b. No grades of D and/or E
c. Successfully passed the comprehensive examination
d. Successfully passed the dissertation defense
e. Submitted a dissertation manuscript approved by the Dean/Head of Department/Head of the School of Science
f. Conducted two result seminars at international seminars
g. Has scientific publication or manuscript accepted by a publisher in an international journal indexed in a database periodically determined by the University, originating from dissertation research results at least 1 (one) for reguler or 2 (two) for by research track

3.4.7 Syllabus for Each Course

Scientific Research Methodology (3 credits/COMPULSORY/Semester 1 atau 2)

This course aims to facilitate students' comprehension of essential aspects of

scientific research methodology. Initially, students will examine core scientific principles and critical foundational elements pertinent to the life sciences. They will acquire an understanding of the scientific principles underlying molecular biology, as well as contemporary insights into biotechnology research. This course covers fundamental scientific methodologies applicable to both quantitative and qualitative research, emphasizing data analysis and interpretation. Students will learn the principles of research ethics and publication standards, ensuring comprehension of the significance of ethical conduct in research and the dissemination process of their findings. Students will enhance their written communication skills through the application of diverse theories, concepts, and techniques to produce and assess effective written work. Focus will be directed towards composing for varied audiences within a particular field or discipline, while conforming to relevant standards and conventions. The course will promote critical thinking, enabling students to apply it to the writing process, which includes revising and refining their work to improve clarity and effectiveness.

Selected Topics in Biotechnology (3 credits /COMPULSORY/Semester 1/ 2)

The course covers the scientific knowledge underlying the dissertation research topics of students. It provides an in-depth discussion of the specific areas of science closely related to each student's dissertation topic. This design aims to help students identify gaps in the current knowledge related to their research, enabling them to pinpoint the key problems they will address in their studies. By the end of the course, doctoral students will have a comprehensive understanding of the topic they will explore in their dissertation, providing a solid foundation for drafting their research proposal.

Bioinformatics and Data Analysis in Biotechnology (3 credits /COMPULSORY/Semester 1/ 2)

This course covers bioinformatics and the internet, including NCBI data models and the GenBank sequence database. It discusses DNA sequence submission to databases, the structure of databases, genome mapping, and the information retrieved from these databases. Additionally, the course addresses multiple protein analysis and creation, sequence prediction methods using DNA and protein sequences, expressed sequence tags (ESTs), sequence assembly and completion methods, large-scale genome

analysis, and the use of Perl for biological data analysis.

Advanced Molecular Biology (2 Credits/Elective/Semester 1/2)

This course covers the organization of genetic material, including nucleic acids as the genetic material, the structure and function of DNA and RNA, DNA replication, gene structure, transcription and translation, and their regulation, as well as the transfer of genetic material.

Advanced Immunology (2 Credits/Elective/Semester 1/2)

This course delves into the basic concepts of the immune system and immunity, as well as the components of the immune system. Topics include cellular and molecular structures, the effector functions of humoral and cellular immunity, antigen and immunogen recognition, cellular and molecular interactions, and soluble factors such as cytokines in antigen handling. It also covers immunogenetics, MHC, and common immunological techniques, including immunoglobulin and lymphocyte isolation, and hybridoma technology.

Enzyme Engineering (2 Credits/Elective/Semester 1/2)

This course explores the basics of enzymes, including their function, mechanism, and nomenclature. It also covers enzyme production, recovery, purification, the calculation and identification of enzyme inhibitors (enzyme kinetics), and enzyme applications in industries and biosensors.

Phytochemistry (2 Credits/Elective/Semester 1/2)

This course introduces the technologies in phytochemical studies, including methods for extracting bioactive compounds, instruments for analysis and identification, and techniques for the isolation and purification of bioactive molecules from plants. Structural clarification of bioactive molecules and their applications using UV-visible spectroscopy, infrared spectroscopy, and nuclear magnetic resonance (NMR) spectroscopy are also discussed.

Metabolite Analysis and Elucidation (2 Credits/Elective/Semester 1/2)

This course focuses on the elucidation of the structure of organic compounds using fundamental concepts of UV, IR, NMR, and MS spectroscopy for the identification of organic molecular structures.

Secondary Metabolites and Their Analysis (2 Credits/Elective/Semester 1/2)

This course discusses the biosynthesis of secondary metabolites, emphasizing the acetate, shikimate, and mevalonate pathways and their regulation.

Molecular Biology of Yeast (2 Credits/Elective/Semester 1/2)

This course covers the organization of genetic material in yeast, DNA replication, gene structure, transcription, translation, and their regulation.

Gut Microbiome (2 Credits/Elective/Semester 1/2)

This course explores the science of the microbiome, including its definition, general introduction to microbiomes in everyday life, types and origins, and their interactions. It also addresses microbiome applications in biotechnology, including health, agriculture, and molecular applications, along with bioethics, microbiome research methodologies, OMIC technologies, microbiome engineering, and the basic calculations for microbiome research modeling.

Molecular Biology of Streptomyces (2 Credits/Elective/Semester 1/2)

This course explores the molecular biology of Streptomyces, focusing on the organization of its genetic material, including DNA replication, gene structure, transcription, and translation mechanisms. It also covers the regulation of gene expression and secondary metabolite biosynthesis, emphasizing the pathways responsible for antibiotic production. Students will learn about genetic manipulation techniques, including gene editing and recombinant DNA technology, to study Streptomyces' metabolic capabilities. Additionally, the course will highlight the role of Streptomyces in biotechnology, particularly in drug discovery and industrial applications, and explore methods for optimizing production through molecular engineering.

Fish Nutrition (2 Credits/Elective/Semester 1/2)

This course discusses the nutritional value of feed, protein, fat, carbohydrate, vitamin, and mineral metabolism in fish, the selection of nutrients, and the effects of nutrient excess or deficiency, providing a reference for selecting nutrition in feed production.

Host-Plant and Pathogen Interaction (2 Credits/Elective/Semester 1/2)

This course covers the fundamentals of plant health management, biotechnology applications, innovation considerations, examples of biotechnology in solving key pest issues, and the monitoring and evaluation of

plant health management techniques. It also discusses the status of transgenic pest-resistant crops, such as transgenic cotton.

Biochemical Signaling Systems (2 Credits/Elective/Semester 1/2)

This course addresses the theories and concepts of phytoalexins, elicitors, biosynthesis, accumulation, isolation, characterization, toxicology, degradation, metabolism, detoxification, and their roles in resistance mechanisms against pathogens, as well as their use as raw materials for medicines.

Fermentation Kinetics (2 Credits/Elective/Semester 1/2)

This course discusses topics related to fermentation processes, from raw material preparation to the recovery of bioethanol fermentation products. It covers fermentation processes aimed at producing biomass, metabolites, enzymes, and biochemical products, focusing on bioethanol fermentation preparation.

3.5 Several Strategies in Implementing the New Curriculum

3.5.1 Strategy for Preparing Comprehensive Knowledge for Graduates

a. Encourage students to form study groups or journal discussions related to research topics.

b. Conduct monitoring evaluation meetings since students finish semester 2 at least one once a year monitored by study program, and once a year by promotor team and program coordinator.

3.5.2 Strategy to Increase On-Time Graduation

a. Communicate research topics owned by lecturers early during the meeting to determine candidate promoter teams

b. Provide information about dissertation research scholarships

c. Complete laboratory facilities at the UGM Biotechnology Study Center

d. Implementing monitoring of study progress at least 3 times a year, attended by the promoter team and head of study program

e. Presentation of research progress attended by all doctoral students

f. Organizing workshops for journal writing

g. Providing workspace for doctoral students that supports comfortable

working in the laboratory

3.5.3 **Strategy to Improve Course Quality**

a. Providing access to reference books and electronic journals
b. Encouraging students to read the latest Biotechnology research journals
c. Encouraging lecturers to always update course materials
d. Conducting evaluation of course implementation