BIOSCIENCE PROGRAM

Aims and Scope of the Graduate Program
The Bioscience Program curriculum provides a strong introduction to cell biology and biophysics of living matter.

Master's Degree

The M.S. degree has both a Thesis and a Non-Thesis option. Both options require the completion of at least 36 credits. At least 24 credits must be earned from coursework (core courses and elective courses). Details of the program are listed below.

1. Core Curriculum: (9 credits) Students are required to take three of the following four courses: B 201 Biophysics, B 204 Genomics, B 209 Molecular Genetics, B 224 Fundamentals of Cell Biology
2. Elective Curriculum: (15 credits) Students must register for a combination of courses and research experience that is approved by the student's advisor.
3. Research/Capstone Experience: (12 credits) The requirements for the research experience are based on which M.S. degree option is being pursued.

All students are required to attend the graduate seminar while enrolled in the program. Graduate seminars do not carry degree credit, but attendance is required.

Thesis Option
A minimum of 6 credits of thesis research (B 297) is required although it is expected that a student will enroll in 12 credits of M.S. thesis work. With permission of the M.S. thesis advisor, a student who enrolls in only 6 credits of thesis research may use one of the following options to earn the six remaining credits of degree requirements:

- **Internship:** 6 credits of research-based summer internship (administered as directed research, B 299)
- **Non-Technical Broadening Experience Courses:** 3 to 6 credits of courses that broaden a student's M.S. experience.
- **Ph.D.-Level Courses:** 6 credits of Bioscience courses numbered 300 or greater. Any course in the Ph.D. core requirements that is passed with a minimum grade of B- may be used towards meeting the core Ph.D requirements of the Bioscience program if the student chooses to continue for a Ph.D. degree in Bioscience at KAUST.

Students are permitted to register more than 12 credits of M.S. thesis research as necessary and with the permission of the thesis advisor.

Evaluation of satisfactory completion of MS thesis work is performed by a committee comprising the M.S. thesis advisor and two other faculty members. The chair of the committee must be a faculty member within the Bioscience program. The evaluation of M.S. thesis credits is through a pass or a fail grade. The requirement of a public Bioscience seminar based on the student's work is left to the discretion of the M.S. thesis advisor. For additional details on thesis requirements and committee formation, see General Degree Program Guidelines.

The student is responsible for scheduling the thesis defense date with his/her supervisor

and committee members. It is advisable that the student submits a written copy of the thesis to the thesis committee members at least two weeks prior the defense date.

Non-Thesis Option

Research requirement: A minimum of 6 credits of directed research credits (B 299) is required. Summer internship credits may be used to fulfill the research requirement provided that the summer internship is research-based. Summer internships are subject to approval by the student's academic advisor.

Students must complete the remaining credits through one or a combination of the options listed below:

- **Two Courses:** Any two 3-credit graduate-level courses in any program at KAUST.
- **Non-technical Broadening Experience Courses:** 6 credits of courses that broaden a student's M.S. experience.
- **Ph.D.-Level Courses:** 6 credits of Bioscience courses numbered 300 or greater. Any course in the Ph.D. core requirements that is passed with a minimum grade of B- may be used towards meeting the core Ph.D. requirements of the Bioscience program if the student chooses to continue for a Ph.D. degree in Bioscience at KAUST.
- **Internship:** 6 credits of research-based summer internship (administered as directed research, B 299)

It should be noted that a student may also mix and match courses to satisfy the six-credit requirement. For example, a student could take one Ph.D.-level course and one graduate-level course in another program. A student may not enroll in two summer internships.

Degree of Doctor of Philosophy

In the Bioscience Program, a Ph.D. typically is centered around an experimental program in close association with the Research Advisor. During his/her doctoral studies, a student will learn how plan and execute an experimental program in molecular life sciences, critically interpret the data and present the findings in a substantial written document.

Coursework Requirements

The PhD student is required to take two 300-level courses.

Designation of a Research Advisor

For a student to be admitted to the Ph.D. program, a faculty member must be willing to become their Research Advisor and provide supervision and necessary financial support. Once such agreement is reached, it must be documented by submitting a form with appropriate signatures to the Registrar's Office. It is in the nature of research in the experimental molecular life sciences that the candidate will work closely with the research advisor and it is therefore essential that the student choose an advisor before starting the PhD.

Bioscience Comprehensive Examination

There will be no Comprehensive examination in the Biological Sciences.

Dissertation Committee

The dissertation committee consists of 3 Faculty from Bioscience program (or 2 from the Bioscience program and one from outside KAUST in a biology department), one from a different program (but not necessarily outside the division) and the supervisor and must be

approved by the Program Chair and Dean. It is expected that the members of the dissertation committee reach consensus in their recommendations and decisions. The supervisor is a non-voting member on the committee.

Candidacy Status
Candidacy status is conferred once the Ph.D. student has successfully defended his/her Research Proposal.

Research Proposal Defense
The PhD student will prepare a document that outlines the scope of the thesis, reviews the current literature in the subject, describes the planned experimental approaches and rationale for them. The Dissertation Committee will review the document and examine the candidate on the presented proposal.

Dissertation
A doctoral dissertation is a substantial document, typically consisting of several chapters that are approximately equal in content and depth to scientific articles in highly regarded journals in the field of the candidate's research.

Dissertation Defense
The Dissertation committee will examine the dissertation and the candidate will subsequently defend the dissertation *viva voce* in front of the committee. The decisions must be unanimous from the four voting members of the committee.

BIOSCIENCE (BIOS) COURSE DESCRIPTIONS

Core

B 201 Biophysics
Conservation of mass and momentum, physiological mass transport, membrane structure, carrier proteins and active membrane transport, ion channels, intracellular vesicular transport, diffusion in reacting systems, heat and mass transfer in bioreactors, culture aeration. Lectures and laboratory.

B 204 Genomics
Prokaryotic versus eukaryotic genome structure, conservation (gene order/sequence/structure, regulatory sequences), approaches to mapping/sequencing genomes, DNA sequencing, DNA sequencing technologies, approaches to genome annotation, SNPs, microarray technology, gene expression microarrays, antibodies, chromatin immuno-purification, high throughput perturbation studies. Problem-solving/data-handling/critical thinking/journal-club sessions. Possible interactions with Genomics Research Core facility.

B 209 Molecular Genetics
Essentials of Mendelian and molecular genetics as the basis for current models of prokaryotic and eukaryotic genetic exchange and gene expression. Introduction to molecular biology. Chromosome organization; mechanisms and consequences of recombination; gene organization, operons/regulons, control of transcription, translation and epigenetics. Data handling and problem solving; critical essays and discussion of literature.

B 224 Fundamentals of Cell Biology

Types of microorganisms (e.g., viruses, microbes, yeast, mammalian and stem cells); cell physiology, structure and function; gene expression and protein synthesis; protein folding; post-translational modification; cell cycle; molecular biology techniques. Lectures and laboratory.

Electives

B 202 Plant Biology

Review of cellular structure function, diffusion and active transport limitations and benefits on plant cell systems. Membrane structures translocation and transport. Energy and primary metabolism, secondary metabolism in microbes and plants.

B 205 Protein Structure and Function

Introduction to protein structure and technologies used to study protein structure, X-ray crystallography, protein NMR. Protein folding, post translational modification, protein sorting. Enzyme structure and function. Study of differential protein expression, proteomics. Protein interactions, methods to study the interactome. Problem-solving/data handling/critical-thinking/journal-club sessions. Possible interactions with Genomics Research Core facility.

B 206 Synthetic Biology and Biotechnology

Introduction to genetic circuits in natural systems; engineering principles in biology; BioBricks and standardization of biological components; numerical methods for systems analysis and design; fabrication of genetic systems in theory and practice; transformation and characterization; examples of engineered systems; hands-on experiments.

B 207 Physiology and Metabolic Engineering

Introduction to regulation of metabolism and physiology of microbes and plants; hands-on analytical techniques for measuring metabolite and ion levels; mechanisms for homeostasis; influence of environmental changes, including nutrition, salt stress, temperature and drought; genetic pathways for stress response and adaptation in plant and microbial systems, crop improvement and biotechnology. Gene expression and cell-based expression systems for protein and small molecules; gene cloning and expression laboratory; gene over-expression strategies. Bio-catalysis and metabolic engineering.

B 210 Plant Abiotic Stress Responses

In-depth examination of how plants respond to adverse environmental conditions such as extreme temperatures, soil water deficit, soil salinity, high light intensity, UV, ozone, increased atmospheric carbon dioxide, soil nutrient deficiency and metal toxicity. Emphasis will be on the molecular and genetic basis of stress responses as well as the methodology for breeding or bioengineering of stress-tolerant plants.

B 239 Stem Cells

This course covers stem cell biology and therapeutics. It is intended to provide a comprehensive overview of current understanding of embryonic and adult stem cells, including their basic properties and interactions within organisms. Stem cell isolation methods, experimental models and potential biomedical therapeutic applications will be encountered through research of literature. A basic background in biology is required.

B 297 Thesis
Master-level research leading to a formal written thesis (minimum 12 credits)

B 299 Directed Research
Master-level supervised research (minimum 6 credits)

B 301 Computational Biology and Bioinformatics
Computational Biology is an advanced and practical course with a hands-on approach to the field of computational biology. The course is recommended for both molecular biologists and computer scientists desiring to understand the major issues concerning analysis of genomes, sequences and learns large-scale modeling of complex systems. Various existing methods will be critically described and the strengths and limitations of each will be discussed. There will be practical assignments utilizing the tools described. Prerequisites include genomics I (B204/CBE209) and genomics II (B204). A final paper will be required for the course that critically and constructively analyzes any area of computational molecular biology, bioinformatics or genomics. The final project may also present a novel application of existing tools or the development of some new or improved method.

B 303 Advanced Topics in Plant Development
This course will address the general developmental stages of Arabidopsis thaliana and other model systems. Students will review physical aspects of angiosperm development while focusing on the molecular and genetic mechanisms underlying these processes. The primary focus of this course will be to provide students an environment to develop writing and presentation skills while focusing on critical analysis of the primary literature.

B 305 Advanced Topics in Evolution
Given that the principle of evolution is a key to understanding modern biology, and in particular genomics, we will briefly cover some of the fundamentals as well as current research methods. The course will be centered around the study and discussion of the classical works by Darwin, Wallace and Lamarck as well as the contemporary literature. Each student will have to do a research project using literature studies and computational methods to critically discuss a biological argument in evolutionary biology.

B 306 Advanced Topics in Pathogen Genomics I
Pre-requisite: A degree in biological sciences or consent of instructor. Knowledge in basic molecular biology is essential. Overview of global impact of pathogens on human, animal and plant health, basic concepts in microbial pathogenesis, overview of pathogen genome analysis and visualization tools, comparative genomics, hands-on training in pathogen genome analysis using popular tools such as the Artemis and Artemis Comparison Tool (ACT), application of second-generation sequencing technologies in pathogen genomics, overview of web-based genomic resources for pathogen research.

B 308 Advanced Topics in Pathogen Genomics II
Overview of a microbial genome sequencing project in the modern era; Pathogen genome analysis and visualization with the Artemis and Artemis Comparison Tool (ACT); Application of second- and third-generation sequencing technologies in pathogen genomics; Application of mass spectrometry-based technologies in pathogen genomics; Overview of web-based genomic resources for pathogen research. Pre-

requisite: Pathogen Genomics I. A degree in biological sciences or consent of instructor is required. Knowledge in basic molecular biology is essential.

B 312 Advanced Topics in Biochemistry

This course focuses on applying biochemical and biological methods to understanding the importance of carbohydrate biochemistry in the control of biological systems. Using glycobiology as an example, this course is intended to provide a comprehensive overview of the techniques and experiments used in biomedical research.

B 397 Dissertation

Ph.D.-level research leading to a formal written dissertation (minimum 60 credits)