Doctor of Philosophy in Food Biotechnology

Course Description

I. Elective Courses

FB 5101 Aspects in Biotechnology 3(3-0-6) Credits
Role and significance of biotechnology in the everyday life, concepts and application of biotechnology techniques, DNA, protein, bioinformatics and fermentation technologies as well as medical, environment and agricultural biotechnology. Legal issues and public concerns with the biotechnology research, application, and impact on economy.

FB 5102 Economics of Resources, Agriculture, and Food 3(3-0-6) Credits
Principles of microeconomics, demand and supply, production function, cost theory, competitive markets, comparative advantage, consumer behavior, environmental economics, macroeconomic concepts on inflation, unemployment, international trade, financial markets, fiscal policy and monetary policy used in the analysis of decision making on individual problem related to agricultural and food products.

FB 5103 Food and Agribusiness Management 3(3-0-6) Credits
Overview of management in the food and agribusiness sector, the introduction to the food and agribusiness sector, the environment of the firm, fundamentals, structural design, and change in organizations, leadership, motivation, communication, planning and control and current issues.

FB 5105 Global Food Production Web 3(3-0-6) Credits
Global web involved in the production of food consumed on a daily basis, selected ecosystems of plants, people, and cultures in Asia, Africa, and Latin America, the origin and biology of plants, their evolution with humankind in various cultures, the spread and economic importance of crops around the world, current hunger and environmental issues resulting from the global food web, interactive communications with selected scientists, producers, and traders around the world through the World Wide Web and email system of the INTERNET.

FB 5106 Advanced Food Processing 3(2-3-5) Credits
Existing technologies to increase processing efficiency, improve products’ quality and safety, produce new products and reduce environmental effects. New technologies from researches for physical processing including high pressure, pulse electrical field, ultrasound, high-intensity light and membrane filtration technologies, use of natural antimicrobial and antioxidant substances, active intelligent packaging, microencapsulation of food ingredients and edible film and coating, and corresponding laboratory sessions.
FB 5107 Principles of Sustainable Agricultural Products Management 3(3-0-6) Credits
Development and experiment with analytic and process skills necessary for effective decision-making in the agriculture and agribusiness sector, identification and analysis of strategic issues in the sector, in-depth dialogue with executives-in-residence from the agribusiness sector as an integral part of the experience.

FB 6103 Research Methods in Agricultural and Consumer Economics 3(3-0-6) Credits
Observations and the use of theory in the formulation and resolution of research problems in agricultural and consumer economics including criteria for choice in modeling options and observational methods.

FB 6106 Management of Farm Enterprises 3(3-0-6) Credits
Economic principles applied to management of farms, budgeting, crop and livestock systems, record analysis, financial management, farm leases, and problems in resource appraisal and business reorganization, and field trip required.

FB 6109 World Food Economy 3(3-0-6) Credits
Global food production, consumption, and trade, problems of hunger and population, the role of agricultural development, trade, and aid in relieving hunger.

FB 6110 Consumer Economics 3(3-0-6) Credits
Introduction to the study of the consumer in the Thai economy sources of consumer information and consumer protection, and examination of current consumer issues within an economic

FB 6113 Economics of Food Marketing 3(3-0-6) Credits
Economic performance of food system, marketing margins, transportation, processing, advertising, and retailing of food products, structure, conduct, and performance of food marketing firms and industries, government and public interest in the food system.

FB 6114 Commodity Futures and Options Markets 3(3-0-6) Credits
Development of futures trading, operation and governance of commodity exchanges, economic functions of futures trading, operational procedures and problems in using futures markets, public regulation of futures trading, and evaluation of market performance.
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FB 6115 Strategic Marketing in Food and Agribusiness  3(3-0-6) Credits
Application of the strategic marketing process to the food and agribusiness sector, integrating methods and models with analysis of socioeconomic variables that affect strategic decision-making in that sector, the dynamic nature of the decision environment in the agri-business sector.

FB 6118 International Trade in Food and Agriculture  3(3-0-6) Credits
Trends and patterns of exports and imports of major agricultural commodities, and evaluation of the economic and institutional factors having a bearing on this trade.

FB 6119 Economic Policies and Programs Affecting Agriculture  3(3-0-6) Credits
Economic analysis of province, national, and international policies and programs, including proposed legislation having important bearing on the well being of farm people.

FB 6120 Environmental Economics: Theory and Applications  3(3-0-6) Credits
Theory and policy applications in the environmental area, selective literature review to provide a framework for understanding the relevant economic relationships and the criteria appropriate for policy assessment, the characteristics of major environmental problems and policy choices, and the evaluation of environmental amenities and the conflict between environmental quality and economic growth.

FB 6121 Research in Futures Markets  3(2-3-5) Credits
Research literature on commodity futures and options markets, both theoretical and empirical, supply of storage, basic models, theory of the firm and hedging under uncertainty, optimal hedging, speculative returns, market performance, pricing efficiency and option pricing, and corresponding laboratory sessions.

FB 6128 Agricultural Engineering  3(3-0-6) Credits
Agricultural engineering discipline and career opportunities including using network software, practicing technical communication and problem-solving skills as well as career planning.

FB 6130 Soil and Water Conservation Structures  3(3-0-6) Credits
Hydrology, hydraulics, design, construction and cost estimating of structures for the conservation and quality control of soil and water resources, relationship of topography, soils, crops, climate, and cultural practices in conservation and quality control of soil and water for agriculture.

FB 6131 Food and Process Engineering Design  3(3-0-6) Credits
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Design of equipment, processes, and facilities for food, pharmaceutical, biotechnology, and related process industries.

**FB 6132 Grain Drying and Conditioning**  
3(3-0-6) Credits  
Cereal grain drying and storage principles including equilibrium moisture, psychometrics, and drying rates, modern drying and conditioning techniques, such as in-bin counter flow drying and combination drying, estimating fixed and variable drying costs, aeration of stored grain, and maintenance of grain quality.

**FB 6133 Biology of Reproduction**  
3(3-0-6) Credits  
Principles of reproduction, lactation, growth, and hormone regulation of domestic and non-domestic animals as well as humans including biotechnological methods of reproductive control, manipulation, performance enhancement of lactation and growth, and disease control.

**FB 6135 Biotechnology in Agriculture**  
3(3-0-6) Credits  
Progress in plant biotechnology, plant genome and plant genes for crop improvements, plant tissue and organ culture and their applications, plant genetic engineering technology, plant transformation and control of gene expression in plant, application of plant biotechnology for improving plant of quality, increasing yield and preserving environment.

**FB 6136 Plant Biochemistry**  
3(3-0-6) Credits  
Enzymes and pathways involved in plant intermediary metabolism, basic cell physiology, bioenergetics, and hormonal regulation of metabolism.

**FB 6137 Food Management**  
3(3-0-6) Credits  
Application of food preparation principles and techniques in the preparation of standard food products: principles of food management and their application in the planning and preparation of meals.

**FB 6138 Applied Food Service Sanitation**  
3(3-0-6) Credits  
Dangers, causes and prevention of food-borne illness as well as the training and motivation of food service employees in sanitary food handling and quality assurance practices.

**FB 6139 Sensory Evaluation of Foods**  
3(2-3-5) Credits  
Physiology, psychology, and chemistry of flavor and flavor perception, tactual, visual, and auditory components affecting food acceptability, principles and application of preference and discrimination testing, and interpretation of panel evaluation data, and corresponding laboratory sessions.
FB 6141 Raw Materials for Processing 3(3-0-6) Credits
Physical, chemical and microbiological properties of raw material used in food processing including procurement, harvesting, handling, and storage of fruits, vegetables, cereal grains, dairy products, meat, poultry, fish, and eggs.

FB 6145 Membrane Separation Technology 3(3-0-6) Credits
Most important aspects of membrane technology, theory and applications of synthetic semi-permeable membranes in reverse osmosis, ultra-filtration, micro-filtration, and electro-dialysis processes, thermodynamics of bio-separations, membrane chemistry and physical properties, process engineering, equipment design, fouling of membranes and selected applications.

FB 6146 Advanced Food Microbiology 3(2-3-5) Credits
Three major components of food microbiology: foods, microorganisms and human, food-borne microorganisms, their interactions with an environment and host, critical pathways and mechanisms for microorganisms to survive the environment and the host, their implication to human health, microorganisms and industrial significance. Genetics and molecular biology approaches important for studying food-borne microorganisms and cutting edge techniques in solving industrial food microbial problems, and corresponding laboratory sessions.

FB 6148 Malting and Brewing Science 3(2-3-5) Credits
Practical working knowledge of analytical methods used in malting and brewing and experience with brewing material and processes, a responsible manner to beer as a major international beverage and to brewing as a traditional yet highly controlled and innovative industrial process, the description of the nature of the world's brewing business, how it has evolved and what the factors are which influence its shape and dynamics, brewing as a good example of the application of a microbial process to the needs of mankind, how a range of sciences including plant physiology, chemical engineering, biochemistry, microbiology also impinge on the conversion of barley and hops into beer, and to the sensory and psychophysics dimensions of beer quality, and corresponding laboratory sessions.

FB 6150 Technology of Milk and Dairy Products 3(2-3-5) Credits
Chemical and physical properties of milk and dairy products including microbiological quality and classes of milk, processing of fluid milk and many dairy products, quality control in milk and dairy products, field studies, progress and problems in dairy products, such as casein,
lactalbumin and cheese production, changes of dairy products during processing and storage, and utilization of waste products, i.e., whey and corresponding laboratory sessions.

FB 6151 Freezing Preservation of Food
3(3-0-6) Credits
Freezing of model systems and food with emphasis on physicochemical aspects, consequences of food freezing and thawing, modeling of freezing for predictive purposes, visualization and characterization of frozen materials.

FB 6152 New Food Product Ideas
3(3-0-6) Credits
Initial stages of food product development, including definition and articulation of a problem, generation of ideas to solve the problem, screening of ideas, and the formal presentation of a new product concept.

FB 6155 Chemical and Physical Changes in Food
3(3-0-6) Credits
Food components in molecular level: water, carbohydrates, proteins, lipids and dispersed systems such as emulsions and foams, application of the fundamental principles of chemistry and physics to study changes in food, chemical reactions that occur in food, effects of storage conditions such as pH and temperature on changes in food chemical and physical properties.

FB 6157 Advanced Industrial Microbiology
3(2-3-5) Credits
Use of microorganisms for producing important industrial products such as amino acids, peptides, enzymes, antibiotics and organic acids, metabolic regulation of pathways leading to fermentation products, yeast fermentation, and on genetic manipulations (including recombinant DNA techniques) of industrial microorganisms, and production of alternative energy resources by microorganisms, and corresponding laboratory sessions.

FB 6158 Advanced Sensory-Instrumental Analysis
3(3-0-6) Credits
Basic principles of measurement of color, texture, and flavor of foods by sensory and instrumental methods. Advanced statistical analysis of relation of colorimetry, texturometry, and chemistry of volatile compounds to perception of appearance, texture and flavor.

FB 6160 Chromatographic and Electrophoretic Methods
3(3-0-6) Credits
Theory and practice of gas and liquid chromatography and electrophoresis for analytical and preparative applications. Choice and optimization of separation methods, detection systems, and recovery of purified sample components including a field trip.

FB 6161 Advanced Research Conference
3(3-0-6) Credits
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Critical presentation of evaluation of original research by graduate students, planning of research programs and proposals, and discussion led by individual major instructors for their research group. (S/U grading only)

**FB 6162 Recombinant DNA Technology** 3(2-3-5) Credits
Core methodologies of recombinant DNA technology, molecular cloning strategies, generation and analysis of recombinant DNA clones, vectors, host cells, examples of standard and advanced procedures, and the application of bioinformatics, application of Recombinant DNA technology to different field of study including biology, biochemistry, genetics and also biotechnology industry, and corresponding laboratory sessions.

**FB 6164 Agricultural Systems Analysis** 3(3-0-6) Credits
Application of theory and methods of cost-benefit analysis, bioresource and environmental economics to appraisal of development projects and economic programs, willingness to pay, willingness to accept, project appraisal, social benefit-cost analysis, dynamic models, ecological economics and non-market valuation.

**FB 6165 Food Biotechnology** 3(3-0-6) Credits
Application of recombinant DNA technology to agriculture, methods for the introduction of foreign DNA into plant and animal cells and generation of stably transformed plants and animals which will be used for food products, specific examples of the use of transgenic plants and animals in biotechnology, which can provide protection against insects, diseases, and tolerance to specific herbicides, how recombinant growth hormones can result in leaner meat, greater milk yield, and better feed utilization and environmental safety issues.

**FB 6166 Bioinformatics** 3(3-0-6) Credits
Use of computation techniques on the management of biological data or solving the biological problems on the molecular level, genomic sequence analysis, biodiversity, protein structure prediction and analysis, information retrieval from biological database, and comparative genomics and gene expression.

**FB 6167 Scientific Methods and Experimental Designs** 3(3-0-6) Credits
Concepts of scientific methods and experimental designs, corresponding statistic models and the data analysis techniques with application to food science and biotechnology in research profession and sensory evaluation, and statistical data analysis software, e.g. SPSS and Statistica.

**FB 6168 Agro-Industry Plant and Equipment Design** 3(3-0-6) Credits
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Factors important for plant and equipment design such as economics, cost estimation, process selection, plant location and safety.

**FB 6169 Food Plant Layout Design**  
3(2-3-5) Credits
Design and construction of food plants to optimize efficiency and production in a safe and sanitary manner, selection and cost estimates for the appropriate equipment and corresponding laboratory.

**FB 6170 Yeast Biotechnology**  
3(2-3-5) Credits
Yeast biology, molecular biology, yeast genome, biodiversity, ecology, growth and cultivation, conventional and non-conventional yeasts, importance of yeast to human community, yeast in industrial fermentation (food and beverage, biomass and commodity products, bioethanol, pharmaceutical and bioactive products, and recombinant products), recombinant DNA of yeast for industrial application, genetic modification system of *Saccharomyces cerevisiae, Pichia pastoris*, and *Schizosaccharomyces pombe* as model.

**FB 6171 Algae Technology**  
3(2-3-5) Credits
Biological, ecological, environmental as well as applicable aspects of algae, algal biodiversity, molecular biology, cultivation technology, roles of algae in the ecosystems, current and future of algae applications, algae as alternative energy source, cases study of commercial algae products, examples of different cultivation systems and future trend.

**FB 6172 Environmental Biotechnology**  
3(3-0-6) Credits
Integration of fundamental aspects of microbiology and biotechnology with practical applications towards process design, utilization of microorganisms to improve environmental quality and scale-up, advantages of biotechnological methods for environmental problems, global environmental problems, energy and their impact, approach for energy management, basic concepts/issues/types of environment pollution, methods for pollution monitoring, methodology of environment management-the problem solving approach and its limitations via biotechnology knowledge, role of biotechnology in energy production, bioconversion of agro wastes by microbial process including bioenergy economics and operation costs.

**FB 6173 Rice Biotechnology**  
3(3-0-6) Credits
Rice in Thai society and the world, rice as a staple food and world food situation, biology of rice, biodiversity of rice and related species, germ line collection and traditional breeding technology, tissue cultures of rice, molecular biology of rice, rice genome, genetic modification

**FB 6174 Advanced Food Dehydration** 3(2-3-5) Credits
Theory, methods and equipment, changes of foods during drying, packaging of dried foods, properties of powdered foods include glass transition, spoilage of dried foods, changes of dried food during storage and corresponding laboratory.

**FB 6175 Biotechnology for Fuels and Chemicals** 3(3-0-6) Credits
History and roles of biotechnology in fuel and chemical industries, advanced biotechnology of bioproducts, diversity of products and their economical importance, techno-economical challenges, biological systems for chemical production, screening and selection process, strains improvement and preservation, the renewable resources as substrate for production, alternative sources of substrate, production technology, molecular engineering, metabolite engineering, current and future challenges in fuel and chemical industry.

**FB 6176 Biotechnology in Functional and Nutraceutical Foods** 3(2-3-5) Credits

**FB 6177 Advanced Food Chemistry and Analysis** 3(2-3-5) Credits
Chemistry and analysis of volatile food components; qualitative and quantitative analysis, fractionation of proteins, starch and its derivatives, non-starch polysaccharides, dietary fiber constituents and lipids using advanced methods; detection and measurement of mycotoxins; analysis of selected vitamins; application of advanced separation techniques.

**FB 6178 Instrumental Methods in Food and Beverage Analysis** 3(2-3-5) Credits
Rheological methods in the characterization of food biopolymers, destructive and non-destructive analytical methods in starch analysis, specific methods for the analysis of identity and purity of functional food polysaccharides, analytical near-infrared spectroscopy, analysis of fatty acids, GC-MS data bank analysis of flavors and fragrances, gas chromatographic technology in analysis of distilled spirits.

**FB 6179 Curative Ingredients in Traditional Foods** 3(3-0-6) Credits
Traditional food as functional food/medicine, history and stories, food mythology, dissecting traditional curative food ingredient: chemical and pharmaceutical aspect, case study in Chinese, Japanese, Thai and other traditional food, science and technology in traditional curative food, current knowledge on the function of traditional curative ingredients, modern application of traditional curative food ingredients, modern food processing and the way of traditional curative food.

**FB 6180 Food Irradiation** 3(3-0-6) Credits
Processing of food by ionizing radiation, radiation absorbed dose, level of application, methods and equipment, irradiation food in market place, safety and regulators of food irradiation.

**FB 6181 Nutrient Metabolism** 3(3-0-6) Credits
Nutrients from foods and bacterial production in gut, nutrients for energy production, nutrients for helping in metabolisms, nutrients for building body structures and nutrients for serving in a specific cellular functions including intake regulation, absorption, transport and retention.

**FB 6182 Nanotechnology in Food** 3(3-0-6) Credits
Description of nanotechnology, nanotechnology in food science and technology, evolution of food technology, novel food, consumer acceptance of novel food, public acceptance of nanotechnology in food, natural food nanostructures, nanotechnology applications for food ingredients/additives/supplements, nanotechnologies in food packaging, potential benefits and market drivers for nanotechnology, applications in the food sector, engineered nanoparticles and food: an assessment of exposure and hazard, potential risks of nanofood to consumers, regulatory perspectives on nanotechnologies in foods and food contact materials, an outline framework for the governance for risks of nanotechnologies in food.

**FB 6183 Wine Production, Tasting and Analysis** 3(3-0-6) Credits
Grape varieties, viticulture basic and its effect to wine, regional/signature variety, basic vinification, winery design, effect of vinification method on wine, red wine/white wine/sparkling wine production, wine aging, wine bottling, specific and distinctive wine styles, classification of wine, wine analysis, sensory perception, fundamental wine tasting, wine pairing, wine quality assessment, wine laws/authentication, and geography, health and wine.

**FB 6184 Thermal Food Processing** 3(2-3-5) Credits
Thermal food processing, conventional methods including retort technology and continuous heat process, measurement and control, pressure and temperature measurement, validation of heat process, modeling and simulation of thermal processes, thermal processing and food quality,
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and new methods, including radio frequency heating, microwave processing, infrared heating, instant and hi-heat infusion and ohmic heating and corresponding laboratory sessions.

**FB 6185 Food Allergy**

3(3-0-6) Credits

Allergic compounds in food, allergic responses including dermatitis, gastrointestinal and respiratory distress, life-threatening responses, treatment consisting of either desensitisation or avoidance, and the scope of problem.

**FB 6186 Bioremediation**

3(3-0-6) Credits

Description of bioremediation, multidisciplinary evolving technology encompasses microbiology, genetic, chemical and physiological principles in the design and use of enzymes and microorganisms for bioremediation, the understanding and awareness of the occurrence of global pollution, the usage of biological agents, microorganisms and plants to develop basic biotechnology skills and knowledge to identify appropriate contaminant protection, bioremediation strategies for restoring contaminated and waste disposal activities, new technologies to address contemporary environmental problems as well as detoxification of hazardous chemicals, environmental biomonitoring, and microbial genetic engineering for bioremediation of air, water and soil.

**II. Advanced Elective Courses**

**FB 7000 Advanced Concepts in Sensory Evaluation**

3(3-0-6) Credits

Primary source materials in sensory evaluation, including recent advances in sensory methods, historical perspectives, psychophysics, perceptual biases, and multivariate statistical approaches to sensory data. A major independent research project is conducted on a current issue in sensory evaluation.

**FB 7001 Properties of Water in Biological Materials**

3(3-0-6) Credits

Principles involved in processing, handling, and storage of frozen, dry and intermediate moisture biological materials, including foods, drugs, and other biological materials, with emphasis on the physiochemical properties of water in the biological materials.

**FB 7002 Functional Foods: Regulations and Technology**

3(3-0-6) Credits

Design and regulation of functional, nutraceutical and special dietary foods, both Thailand and international perspectives. Students will evaluate current products on the market and design a product.
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FB 7003 Advanced Topics in Food Biotechnology 3(0-0-9) Credits
In-depth study on a relatively short-term library or laboratory project and preparation of a final annotated paper, or a specially arranged course of a visiting investigator in topics related to Food Biotechnology.

FB 7004 Reaction Kinetics of Food Deterioration 3(3-0-6) Credits
Basis for use of applied chemical kinetics to deteriorative reactions occurring in processing and storage of foods and drugs including enzymatic reactions, lipid oxidation, non enzymatic browning, acid base catalysis, and microbial growth and death, application of kinetics to study of accelerated shelf-life testing of foods, drugs, and other biological materials.

FB 7005 Carbohydrate Chemistry in Food 3(3-0-6) Credits
Current methods of carbohydrate and polysaccharide analysis, including structural and chemical characterization methods, polymerization, and modifications.

FB 7006 Lipid Chemistry and Rancidity of Foods 3(3-0-6) Credits
Chemistry of food lipid oxidation and rancidification, and protective functions of antioxidants.

FB 7007 Food Proteins 3(3-0-6) Credits
Use of proteins and enzymes in the food industry, functional properties of proteins and enzymes in food systems.

FB 7008 Advanced Cereal Science 3(3-0-6) Credits
Physiochemical properties of major constituents in cereal grains, relationship of constituent structures to functionality in the processing of cereal grains into food products, with emphasis on wheat.

FB 7009 Food Rheology 3(3-0-6) Credits
Definition, analysis, and measurement of rheological properties from steady and dynamic shear to describe flow and viscoelastic behavior of biological materials with comparison on food textures, industrial applications of rheological methods with emphasis on fluid and semi-solid foods.

FB 7010 Polysaccharide Structure and Function 3(3-0-6) Credits
Chemical structures, molecular structures, and physical properties of polysaccharide such as starch, pectin, gellan, xanthan, galactomannan gum.

FB 7011 Aseptic Processing Technology 3(3-0-6) Credits
Aseptic processing and packaging systems, thermal processing and fluid flow in continuous heat exchangers, food microbiology, food chemistry, and food packaging as applied to aseptic processing, establishing processes for aseptic processing of liquid and particulate foods.

**FB 7012 Biochemistry and Molecular Biology of Eukaryotes** 3(3-0-6) Credits
Research in biological sciences, biochemical principles, processes common to all eukaryotic cells such as transcription, translation, and the cell cycle, and mechanism of cell-cell signaling.

**FB 7013 Microbial Molecular Genetics** 3(3-0-6) Credits
Prokaryotic molecular biology and genetics, regulation of gene expression, roles of extrachromosomal elements, modern molecular genetic approaches to define complex biological phenomena, and the application of novel technology in microbial genetics, the discussion of recent researches in microbial molecular genetics as cases study for the discovery of new processes and/or mechanisms.

**FB 7014 Food Colloids** 3(3-0-6) Credits
Food colloidal interactions, emulsions, suspension and foams, properties and stabilities of food colloids, food emulsifiers and stabilizers, experimental techniques in this area and technology in industrials.

**III. Seminar Courses**

**FB 5208A Graduate Seminar For Type 1** Non-Credit
Design and implementation of multi-media tools for effective scientific presentation together with the discussion of topics in biotechnology by graduate students, faculty, and external experts.

**FB 5208B Graduate Seminar For Type 1** Non-Credit
Detailed study and discussions of current literature and related graduate research projects. External experts from governmental and private sectors will be invited to give presentation weekly.

**FB 5208C Graduate Seminar For Type 1** Non-Credit
Oral presentation, discussion, and critical evaluation of topics in biotechnology by graduate students, faculty, and external experts.

**FB 5209A Graduate Seminar For Type 2** 1(1-0-2) Credit
Design and implementation of multi-media tools for effective scientific presentation together with the discussion of topics in biotechnology by graduate students, faculty, and external experts.
FB 5209B Graduate Seminar For Type 2 1(1-0-2) Credit
Detailed study and discussions of current literature and related graduate research projects. External experts from governmental and private sectors will be invited to give presentation weekly.

FB 5209C Graduate Seminar For Type 2 1(1-0-2) Credits
Oral presentation, discussion, and critical evaluation of topics in biotechnology by graduate students, faculty, and external experts.

IV. Dissertation

FB 9011 Doctoral Dissertation Research 1 (Type 1.1) 9(0-0-27) Credits
Literature review to explore topics for research and proposal preparation.

FB 9012 Doctoral Dissertation Research 2 (Type 1.1) 9(0-0-27) Credits
Literature review, experimental design and research proposal writing.

FB 9013 Doctoral Dissertation Research 3 (Type 1.1) 9(0-0-27) Credits
Literature review and research proposal writing.

FB 9014 Doctoral Dissertation Research 4 (Type 1.1) 3(0-0-9) Credits
Research proposal presentation and passing the qualifying examination.

FB 9015 Doctoral Dissertation Research 5 (Type 1.1) 9(0-0-27) Credits
Hands-on experiment and research manuscript preparation.

FB 9016 Doctoral Dissertation Research 6 (Type 1.1) 9(0-0-27) Credits
Hands-on experiment, research report writing and submission, and advisor’s approval of the research results.

FB 9021 Doctoral Dissertation Research 1 (Type 1.2) 9(0-0-27) Credits
Literature review to explore topics for research and proposal preparation.

FB 9022 Doctoral Dissertation Research 2 (Type 1.2) 9(0-0-27) Credits
Literature review, experimental design and research proposal writing.

FB 9023 Doctoral Dissertation Research 3 (Type 1.2) 9(0-0-27) Credits
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Literature review and research proposal writing.

**FB 9024 Doctoral Dissertation Research 4 (Type 1.2)**
Research proposal presentation and passing the qualifying examination.

**FB 9025 Doctoral Dissertation Research 5 (Type 1.2)**
Hands-on experiment.

**FB 9026 Doctoral Dissertation Research 6 (Type 1.2)**
Hands-on experiment.

**FB 9027 Doctoral Dissertation Research 7 (Type 1.2)**
Hands-on experiment and research manuscript preparation.

**FB 9028 Doctoral Dissertation Research 8 (Type 1.2)**
Hands-on experiment and research manuscript preparation.

**FB 9029 Doctoral Dissertation Research 9 (Type 1.2)**
Hands-on experiment, research report preparation and submission, and advisor’s approval of the research results.

**FB 9031 Doctoral Dissertation Research 1 (Type 2.1)**
Literature review to explore topics for research and proposal preparation.

**FB 9032 Doctoral Dissertation Research 2 (Type 2.1)**
Literature review, experimental design and research proposal writing.

**FB 9033 Doctoral Dissertation Research 3 (Type 2.1)**
Research proposal presentation and passing the qualifying examination.

**FB 9034 Doctoral Dissertation Research 4 (Type 2.1)**
Hands-on experiment and research manuscript preparation.

**FB 9035 Doctoral Dissertation Research 5 (Type 2.1)**
Hands-on experiment, research report writing and submission, and advisor’s approval of the research results.
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**FB 9041 Doctoral Dissertation Research 1 (Type 2.2)**
3(0-0-9) Credits
Literature review to explore topics for research and proposal preparation.

**FB 9042 Doctoral Dissertation Research 2 (Type 2.2)**
9(0-0-27) Credits
Literature review, experimental design and research proposal writing.

**FB 9043 Doctoral Dissertation Research 3 (Type 2.2)**
3(0-0-9) Credits
Research proposal presentation and passing the qualifying examination.

**FB 9044 Doctoral Dissertation Research 4 (Type 2.2)**
9(0-0-27) Credits
Hands-on experiment.

**FB 9045 Doctoral Dissertation Research 5 (Type 2.2)**
9(0-0-27) Credits
Hands-on experiment.

**FB 9046 Doctoral Dissertation Research 6 (Type 2.2)**
9(0-0-27) Credits
Hands-on experiment and research manuscript preparation.

**FB 9047 Doctoral Dissertation Research 7 (Type 2.2)**
6(0-0-18) Credits
Hands-on experiment, research report writing and submission, and advisor’s approval of the research results.