Graduate Interdisciplinary Program in

Applied Biosciences

(ABS-PSM)

Student Handbook
2013-2014

Important note: The requirements and policies specified in this handbook only apply to students who enroll in the ABS-PSM program after April 2011. Students who entered the program prior to that time are governed by the 2008-2009 handbook. You can get a copy of the 2008/2009 by going to the webpage http://appliedbiosci.arizona.edu.

Table of Contents

1.0 INTRODUCTION

The Applied Biosciences program at the University of Arizona is a Graduate Interdisciplinary Program leading to the Professional Sciences Master's (PSM) degree. The program is designed to prepare students to enter a competitive, scientific workforce. It consists of foundational and practical training in various areas of applied biosciences, along with a professional component that includes internships and "cross-training" in workplace skills, such as business, research and regulatory affairs. During the two-year course of study, students will gain a strong understanding of the applications of the biological sciences to real world problems, including those faced by public institutions and private industry.

2.0 CONTACT INFORMATION

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3.0 ADMISSIONS

3.1 Prerequisites

Students who wish to apply for the PSM degree in Applied Biosciences must have the minimum qualifications:

- A Bachelors (or equivalent) degree with a major in an area of biosciences from an accredited institution
- A minimum 3.0 GPA
- A desire to pursue a professional career in the applied biosciences
- The GRE is not required although if taken please submit your scores

3.2 Admissions Procedures

Students should apply directly to the specific track in the program they wish to pursue. The application should be submitted online (only) via the Graduate College website (http://grad.arizona.edu). Be prepared to submit the following materials:

- All transcripts (official versions must be sent to the Graduate College)
- GRE scores (not required)
- TOEFL scores (required for non native English speakers)
- GPA for all undergraduate (and graduate) work
- A one-page statement of interests, which outlines your background (including any professional experience), your professional goals and why you are a strong candidate for the program
- At least 2 letters of recommendation, preferably from course professors and/or research directors
- Up to 12 units of graduate level coursework may be transferred into the Applied Biosciences PSM program/degree. This includes units earned as a non-degree

graduate student and other graduate level work competed at other institutions. See the UA Graduate College policies for transfer credit.

4.0 OVERALL PROGRAM STRUCTURE

The ABS PSM program is designed specifically to prepare students to competitively enter the scientific workforce. During the two-year course of study, students will gain a strong understanding of the applications of the biological sciences to real world problems, including those faced by public institutions and private industry. A minimum of 36 unit hours is needed for this degree; 6-9 of these units are for the research internship and report. Students have a maximum of 6 years to complete the degree. Students may apply for, and be admitted to, any of the 4 tracks ("sub-plans"). Each track has its own specific core requirements and electives (Section 5).

Applied Biosciences Tracks:

- Medical and Diagnostic Laboratory Sciences
- Molecular and Cellular Biology
- Industrial Microbial Biotechnology
- Controlled Environment Agriculture

4.1 Curriculum

All Tracks have the following general structure. The number of units per category varies depending upon the track.

Core Science Units	12 units
Professional/Business Plus Courses	12 units
Science Electives	3-6 units
Internship (includes final report)	6-9 units
Total:	36 Units

Please refer to the tables below for a list of courses approved for each of the 4 Tracks in Applied Biosciences. For new students, please contact the Director of Graduate Studies (DGS) of your track for advice in the selection of your first semester courses.

4.2. Steps Toward the ABS-PSM Degree

1. ***Meet with the DGS of the chosen ABS PSM track***
   The ABS PSM program requires that before the first day of classes there will be a meeting held with each student and the respective ABS PSM DGS.
   a. When first admitted, the student's initial advisor will be the DGS of that track to determine goals and courses to take in the first semester.
2. ***Student must select primary advisor (second semester)***
3. ***Selection of committee members (second semester):***
   a. The committee is composed of the primary advisor and at least two other faculty members. The primary advisor should be a member of the Applied Biosciences faculty. Other committee members may be ABS faculty, other UA faculty, or mentors at local industries and internship

locations. A special member request for a non-ABS faculty committee member can be submitted to the primary advisor and DGS of the sub plan. The composition of the committee must be approved by the DGS and must follow Graduate College rules: http://grad.arizona.edu/academics/program-requirements/mastersdegrees

b. More than 3 advisors/mentors can sit on the graduate student committee. Many students have UA Applied Biosciences faculty, other faculty and mentors from local biotechnology industry partners. For examples, students doing internship projects at sites including Roche Ventena or MSDx may consider inviting the research mentor(s) to sit on the committee as well.

c. A two-thirds committee vote is needed to pass the student in the areas of the Oral Defense and Internship Report.

d. Submit the Committee Member request form in GradPath.

4. Plan of Study (first semester)

a. Students will seek the advice and approval of the primary advisor and DGS to select a Plan of Study

b. See the list of courses for the Applied Biosciences track (section 5.0, Track Descriptions and Coursework requirements).

c. The student Plan of Study lists the specific courses (and Track) requested by the student for completion of the Applied Biosciences PSM degree.

Curriculum:

Core Science Units.....12 units
Professional/Business Plus Courses.....12 units
Science Electives .....3-6 units
Internship (includes final report) .....6-9 units
Total: 36 Units

d. Submit the Plan of Study request form in GradPath.

5. Timeline for Applied Biosciences 2-year PSM Curriculum

First semester
9 units coursework
Select primary advisor, develop Plan of Study
Second semester
9 -12 units coursework
Submit Plan of Study
Develop committee, Submit Committee Member Approval
Summer
Internship project
Third semester
6-9 units coursework
Internship project
Fourth semester
6-9 units coursework

Submit Internship Report to committee
Oral Defense
Submit Master's Completion of Degree, Graduate College

Many students complete the Applied Biosciences curriculum as part-time students over a period not to exceed 6 years, as per the UA Graduate College.

6. Internship

Students typically seek out their internship project during the second semester. However, the timing of this is flexible to meet the needs of the hosting agency and the student. Students should discuss the timing of the internship with the track Director of Graduate Studies, their primary advisor and their committee. Students must work 45 hours for each unit of internship credit (ABS 593a) earned. Six to nine units (6-9 units) of ABS 593a internship are needed for the Applied Biosciences PSM Curriculum. Please keep in mind that many internship advisors may require additional training time in procedures specific to their lab and research. Consider this an investment of your time if it helps secure an internship project.

The internship is taken as the major experimental/research component. The internship project may be conducted in a variety of settings including a UA research lab, a local and/or new industry partner or in other settings approved by the student committee. A master's thesis quality internship report is written and submitted for defense to the student committee. All the units of the internship need not be taken at the same time or with the same hosting agency. It may be broken down into smaller projects with 45 hours of research for each 1 unit of internship credit.

Regulatory Training

Training for research with human subjects, animal subjects, biological samples, radiation, recombinant DNA/RNA species, chemicals and special population groups may be required before the start of the research internship project. Speak with your primary advisor and research mentors. Most training is available in UAccess (http://www.uaccess.arizona.edu/).

Required Internship Forms

- ABS PSM Internship Application Form
- Internship Letter Template
- Assumption of Risk and Release Form
- ABS PSM Supervisor Evaluation Form
- ABS PSM Internship Student Evaluation Form

7. Final Internship Report

A concise report detailing the goals of the project(s), significance, methodology, results and discussion. This report must emphasize the

academic achievements of the work performed in the internship research project. The report should be of a minimum of 15 pages, but preferably not exceeding 30 pages if the internship was performed in a single block. If the internship was divided into work contracts with different hosting agencies, then the report should be subdivided into concise chapters describing each contract.

The format of the internship report is specified by the student committee and/or research advisors. Some committee members may require a student to submit their internship report in the same format required by the University of Arizona Graduate College for Masters of Science theses, while others may require the report to be written in the format needed for publication in the scientific literature. Again, *formatting requirements for the internship report are determined by the student committee and research advisors.* The final report must be evaluated and approved by the student's committee before the degree can be awarded. Upon satisfactory completion of the written project report, students will present and defend their work in the Oral Defense.

The Applied Biosciences PSM internship report is not required to follow the format of the University of Arizona Master's of Science thesis (unless the student graduate committee specifies so). Acceptable formats for the Applied Biosciences Internship Report include: 1) the UA Master's of Science thesis, 2) format required for publication in a peer-reviewed journal, appropriate for the field of research, or 3) in other formats requested by the committee.

8. Oral Defense

Students are required to give a 45 minute Oral Defense of their internship report. Applied Biosciences graduate students are required to attend the defenses of their peers, schedules permitting. Faculty, committee members and other guests are welcome and strongly encouraged to attend the presentation component of the Oral Defense. In the Oral Defense students are to describe the environment and significance of the internship project, present the methods and discuss the outcomes and impact of the study. The Oral Defense is meant to assess the ability of the student to discuss ideas, think through scientific pitfalls and defend experimental design and rationale. Students are encouraged to seek out input from other students and faculty in preparing for the oral exam through practices, lab meetings, journal clubs, etc. It is the responsibility of each student to schedule the Oral Defense with the committee. Following the oral presentation, students will defend their written proposal and answer questions on general knowledge posed by the committee in a period not to exceed 2 hours. The graduate student committee issues a grade of pass, pass with revisions, or fail at the end of the Oral Defense. Please see the academic calendar for specific due dates and the graduate college website for instructions on the Oral Defense and other steps necessary for matriculation of the PSM degree (http://grad.arizona.edu/academics/degree-certification/gradpath).

5.0 TRACK (SUBPLAN) DESCRIPTIONS AND COURSEWORK REQUIREMENTS

5.1 Controlled Environmental Agriculture

The Controlled Environment Agriculture (CEA) sub plan of the PSM in the Applied Biosciences GIDP is designed to prepare students who wish to possess a graduate-level education that integrates science and engineering-based approaches to provide specific controlled environments for plant productivity while optimizing resources including water, energy, space, capital and labor, and more specifically incorporates knowledge in management and business. Graduates of this track will be prepared for careers in the controlled environment agriculture industries, academia and government.

The CEA is an agricultural production practice for year round continuous production of nutritionally high quality foods, with crop yields that can exceed field production by as much as 10-fold, and with the potentials to utilize local renewable energy resources, and optimize water, energy, space, capital, and labor resources with efficiency well above field traditional capabilities. This production technology, can employ crop production systems, provide harvest much less dependent on the season, and can generate higher crop yields, quality, safety, and nutritional value with consistency and predictability, while utilizing less land in an environmentally friendly way.

There has been significant advancements in agriculture due to enhanced cultivars by plant breeding, minimized use of chemicals and effects of pests by integrated pest management, improved production quality, produce uniformity and reduced labor via automation and mechanization. These continuous advancements in production practices and technology have maintained an acceptable food quality and low cost food supply, however, resulted in more demand for highly educated and skilled employees. The controlled environment agriculture systems are integrated systems consisting of hydroponics, mechanization and automation, climate control and production management processes, which demand continuous system monitoring and control. Thus, technical understanding and crop production skills are needed for specific crop needs and through understanding of plant and microclimate interactions are needed so the systems can be effectively operated and precisely controlled to improve growth, production quality, and resource use efficiency. This necessitates potential graduates to acquire technical, production, management, people and business skills.

Therefore, the CEA PSM track will prepare students for rewarding employment in the controlled environment agriculture sector with technology, science and engineering, business and management oriented education and training to prepare current and future employees to meet the needs of this important industry segment to successfully compete in the global market place.

In common with other ABS tracks, the CEA track requires the successful completion of 36 units (credit hours), within the course of a minimum of 2 years and a maximum of 6 years. The CEA track includes a wide selection of courses. Other classes may be substituted for the classes listed in the attached Table with the agreement of the Director of the Graduate Studies (DGS), the Advisor and the Committee of the student. Initial selection of the appropriate courses within each cluster and for the study plan in

general will be done by agreement between the student and the DGS, based on a draft study plan assembled by the student and submitted to the DGS. This plan should be based on the particular needs and interests of the student, considering the career path the student is pursuing. Fine-tuning and other necessary changes of the course plan will be made by the Advisor and the student's Committee, in agreement with the DGS.

Curriculum: PSM in Applied Biosciences - Controlled Environment Agriculture (CEA) Track			
Number	**Title**	**Units**	**Crosslisted**
Core Science Courses (12 Units Required)			
Required (9 Units)			
ABE575a	Physiology of Plant Production under Controlled Environment	3	PLS
ABE579	Applied Instrumentation in Controlled Environmental Agriculture	3	PLS
ABE583	Controlled Environment Agriculture Systems	3	PLS
Other Core (3 Units from the following list)			
ABE523	Biosystems Analysis and Design	3	
ABE547	Sensors and Controls	3	
ABE556	Irrigation System Design	3	CE
ABE581A	Engineering of Biological Processes	3	CHEE
ABE584	Advanced Biosystems Transport Phenomena	3	
AME545	Renewable Engineering Systems	3	NEE
CHEE574	Environmental Transport Processes	3	CE
CHEE577	Microbiology for Engineering	3	
EIS597C	Greenhouse Pest Management: Methods and Practice	3	ABE, AGTM
MATH509C	Statistics for research	3	
MATH522	Advanced Applied Analysis	3	
PLS508	Crop Ecology	3	
PLS563	Postharvest Physiology Technology and Produce Safety	3	
SIE531	Simulation Modeling and Analysis	3	
SIE545	Fundamentals for Optimization	3	
SIE570	Intelligent Control Systems and Applications	3	
SWES525	Environmental Microbiology	3	IMB, MICRO, SW
SWES553	Remote Sensing of the Environment	3	
SWES573	Monitoring Biosphere Processes	3	
Plus Course (Choose 12 Units)			
BNAD510	Foundations of business for scientists	3	
BNAD521	Project Management and Consulting Skills	3	MIS559

	for Innovation		
ENGR512a	Management of Technology I	3	MAP, MGMT, MIS
ENGR512b	Management of Technology II	3	MAP, MGMT, MIS
ENGR520r	Innovation Principles and Environments	3	ENTR
ENGR554	Law for Engineers/Scientists	2-3	CHE
ENGR567	Financial Modeling for innovation	3	SIE

ENTR501	Basics of Intellectual Property Management and Environments	3	
ENTR506	Principles of Entrepreneurship	3	
ENTR595f	Topics for Entrepreneurship for Scientists	3	PHYS, MATH, MCB
GRAD595d	Regulatory Issues for Laboratory Management	3	
LAW655g	Law and Science	2-3	
LAW655r	Intellectual Property Law	1	
MIS578	Project management	3	
PCOL595B	Scientific Writing Strategies, Skills and Ethics	2	BME, CBIO, NRSC, PHCL, PS
Electives (Choose 3-6 Units)			
Includes any courses from the Core Science and Plus Courses listed above. At least 18 units of the total degree must come from a combination of Core Science and Science Electives.			
Internship (6-9 Units Required)			
ABE 599	Independent Study		
ABS 593A	Internship	6-9	

5.2 Industrial Microbial Biotechnology

The Industrial Microbial Biotechnology (IMB) sub plan of the PSM in Applied Biosciences GIDP is designed to prepare students for careers in the biotechnology industries where microorganisms are used as either tools for manufacturing chemical or biological products, or as environmental or agricultural agents.

Since ancient times, microorganisms have been utilized for what we now recognize as biotechnology applications, starting with beer and wine-making, leavening dough for bread and pastries, and preserving food by pickling. The multibillion dollar modern fermentation and biocatalytic industries that grew out of these practices produce small molecule “natural products” to be used as drugs, pesticides and fine chemicals including biodegradable plastics, and provide us with amino acids, vitamins, solvents and other industrial chemicals. Microbial fermentation and biocatalysis (the use of microorganisms as catalysts for chemical reactions) also represent our best hopes to produce sustainable, environmentally responsible biofuels, and constitute a fast growing segment of the biotechnology industry. Microbial fermentation is also used to produce recombinant proteins such as drugs or industrial enzymes, and can be used to manufacture antibodies and nucleic acids for the diagnosis and treatment of disease. Drug discovery in the pharmaceutical and agribusiness industries, and the development

of novel or cheaper industrial chemicals and reagents are unimaginable without utilizing microbial “chemical factories”.

Microorganisms are also used for environmental biotechnology applications, utilizing the unrivaled ability of microbes to biodegrade a wide variety of compounds. Bioremediation of contaminated former industrial sites, cleanup after natural disasters including oil spills, or everyday applications like waste water treatment, rely on chemical reactions catalyzed on the spot by live microorganisms. Similarly, integrated pest management in agribusiness can take advantage of biocontrol by live microorganisms to kill or suppress microbial, insect or nematode pests in an environmentally conscious manner that does not involve toxic chemicals.

The IMB track will prepare students for gainful employment in the fermentation, biocatalysis, drug discovery and manufacture, agribusiness, chemical manufacture, and environmental biotechnology industries where experts with knowledge of microbiology, microbial genetics and biochemistry are in demand. Just like other tracks in the Applied Biosciences program, the IMB track involves a strong component of developing professional skills and understanding the legal and business environment of these industries, and involves a required internship in a professional biotechnology laboratory environment.

In common with other ABS tracks, the IMB track requires the successful completion of 36 units (credit hours), within the course of a minimum of 2 years and a maximum of 6 years.

The IMB track includes a wide selection of courses relevant to the mission of the Applied Biosciences PSM program and the IMB track. These courses are listed in the attached Table. Other classes may be substituted for the classes listed in the attached Table with the agreement of the DGS, the Advisor and the Committee of the student. Initial selection of the appropriate courses within each cluster and for the study plan in general will be done by agreement between the student and the DGS, based on a draft plan assembled by the student and submitted to the DGS. This plan should be based on the particular needs and interests of the student, considering the career path she or he is pursuing. Fine-tuning and other necessary changes of the course plan will be made by the Advisor and the student’s Committee, in agreement with the DGS.

Curriculum: PSM in Applied Biosciences - Industrial Microbial Technology (IMB) Track			
Number	**Title**	**Units**	**Crosslisted**
Core Science Courses (Choose 12 Units)			
BIOC548B	Plant Biochemistry and Metabolic Engineering	3	CHEM, ECOL, MCB
BIOC565	Proteins and Enzymes	3	CHEM
BIOC568	Nucleic Acids	4	GENE, INSC, MCB, NFS, NSC
BIOC696C	Informatic and Comparative Analysis of	1-3	ECOL, MCB, PLS

	Genomes		
CBA570	Molecular Genetics	3	GENE, IMB, MBIM, MIC
ECOL575	Freshwater and Marine Algae	4	SWES, WFSC
ISTA554	Informatics in Biology	3	
MATH509C	Statistics for Research	3	GENE, PCOL
MCB516A	Statistical Bioinformatics and Genomic Analysis	3	ABE, BIOC, ECOL, GENE
MCB528R	Microbial Genetics	3	ECOL, GENE, MIC, PLP, SWES
MCB580	Introduction to Systems Biology	3	ABE, CE
MCB600	Computer Concepts and PERL programming	3	BIOC, ECOL, GENE, PLS
PLP527R	General Mycology	3	VSC
PLP575	Advanced Mycology	3	
Plus Courses (Choose 12 Units)			
BNAD510	Foundations of Business for Scientists	3	
BNAD621	Project Management and Consulting Skills for Innovation	3	MIS559
ENGR512A	Management of Technology I	3	MAP, MGMT, MIS
ENGR512B	Management of Technology II	3	MAP, MGMT, MIS
ENGR520R	Innovation Principles and Environments	3	ENTR
ENGR554	Law for Engineers/Scientists	2-3	CHE
ENGR567	Financial Modeling for Innovation	3	SIE
LAW550	Patent Law for Non-lawyers	1	
LAW655G	Law and Science	2-3	
LAW655R	Intellectual Property Law	1	
LAW664	Biotech Start-up	1-3	
MIS578	Project Management	3	
PCOL595B	Scientific Writing Strategies, Skills and Ethics	2	BME, CBIO, NRSC, PHCL, PS
Electives (Choose 3-6 Units)			
BIOC573	Recombinant DNA Methods and Applications	4	GENE, MCB, MIC, MICR, PLS
BIOC665	Analysis and Purification of Proteins	3	ANS, NFS, N SC
CHEE581A	Engineering of Biological Processes	3	ABE
CHEE542	Bioremediation of Inorganic Contaminants	2	
CHEE573	Biodegradation of Hazardous Organic Compounds	3	CE
CHEM523A	Bioanalytical Chemistry	3	
GENE539	Methods in Cell Biology and Genomics	3	MCB, PCOL, PLS, PSIO
ECOL553	Functional and Evolutionary Genomics	4	BIOC, MCB
ECOL553L	Functional and Evolutionary Genomics Lab	1	BIOC

ECOL596V	Microbial Meta-omics and Ecosystem function	2	
EIS546	Insect Pathogens: Biocontrol Agents and Biological Models	4	ENTO, INSC, MIC, PLP, VSC
MCB528L	Microbial Genetics Laboratory	2	ECOL, MIC, PLP, SWES, VSC
MIC552	Antibiotics: A Biological Perspective	3	ARL, PLP
PCOL530	Proteins and Nucleic Acids as Drug Targets	3	CBIO, CHEM, PHSC
PCOL536A	Chemotherapy of Infectious Diseases	3	
PLP550	Principles of Plant Microbiology	4	
PLP551	Biology and Characterization of Plant Pathogenic Agents	4	
PLP621	Molecular Plant-Microbe Interactions	3	BIOC, MCB, PLS
SWES525	Environmental Microbiology	3	IMB, MBIM, MICR, SW
SWES546	Environmental Microbiology	2	IMB, MBIM, MICR, SW
Internship (6-9 Units Required)			
ABS599	Independent Study		
ABS593a	Internship	6-9	

5.3 Medical and Diagnostic Laboratory Sciences

The Medical and Diagnostic Laboratory Sciences (MDLS) sub plan of the PSM in the Applied Biosciences GIDP is designed to prepare students for professional careers in laboratory medicine or the biosciences surrounding *in vitro devices* (IVDs), a term used to describe diagnostic laboratory test methods regulated by the US Food and Drug Administration (FDA). Graduates will be eligible for employment in a wide variety of medical and scientific disciplines, including the diagnostics and pharmaceutical industries, bio industries, clinical and translational research units, and government agencies. Emphasis topics may include development of laboratory management skills, acumen in the legal and business environment of laboratory medicine, compliance to federal regulations for healthcare or the diagnostic industry, or knowledge of the *in vitro* device processes and regulations. The track requires an internship in a medical laboratory, diagnostic or translational research environment, university compliance programs for industry-funded research, or one of the associated bioscience companies.

Students will work closely with faculty in the College of Medicine. These faculty direct translational research programs, collaborating with diagnostic bio industry research partners to develop novel testing methods for disease detection, as well as basic science research programs that investigate mechanisms of disease, characterization of diseases such as cancer, autoimmune disease and infection, or disease interventions such as vaccines and antitoxins.

In addition, some of the faculty of the Pathology department oversees hospital laboratories and clinical laboratory scientists who perform diagnostic testing in hospitals and clinics. If students are motivated toward this type of career, they may discuss

options with their faculty mentors to couple their PSM degree with online courses in the Clinical Laboratory Scientists (CLS) program at the University of North Dakota (UND). In clinical laboratories are key members of the healthcare system who are board-certified to practice diagnostic laboratory medicine. These lab members are Medical Laboratory Technicians and Medical Laboratory Technologists, depending on their level of certification. Despite their increasingly vital role in the diagnosis and prevention of disease, national predictions indicate a 10% shortfall in qualified lab members in Arizona and across the United States. Should a student pursue both the ABS PSM and CLS educational options, the student must apply to the University of North Dakota separately as a non-degree seeking student and complete their preferred category/program separate from the UA PSM program. Through the UND program, the student can choose to complete the certificate program in Clinical Chemistry/Urinalysis, Hematology/Hemostasis, Immunohematology, or Microbiology and be eligible to sit for the American Society of Clinical Pathology board exam to become a certified MLT. As the student goes through the UND program, they may transfer 12 credits back to the UA to be counted in the electives portion of the PSM program. For more information on the programs offered by UND, please refer to http://pathology.med.und.nodak.edu/cls/ and contact a UND advisor. More information on clinical laboratory professions is available on http://www.ascp.org/ and http://www.ascls.org/.

Curriculum: PSM in Applied Biosciences –Medical and Diagnostic Laboratory Sciences (MDLS) Track			
Number	**Title**	**Units**	**Crosslisted**
Core Science Courses (12 Units)			
Courses marked UND are offered via distance education from the University of North Dakota. Additional costs apply for UND courses.			
Required			
CBIO515	Basic Human Pathology	4	
Choose 8 (or more) units from the following			
BIOC568	Nucleic Acids	4	
CBA525	Cells and Organs	4	
CBIO552	Cancer Biology	4	
CBIO565	Cancer Immunology and Immunotherapy	3	
CBIO589	Cancer Genetics	3	
CBIO595a	Oncogenes and Signal Transduction	1	
CBIO595h	Cancer Biology Series	1	
CBIO596j	Frontiers in Medical Research	1	
CBIO597a	Experimental Design		
CBIO631	Pharmacogenetics/Pharmacogenomics	2	
CPH 576a	Biostatistics for Public Health	3	EPI
CPH 576b	Biostatistics for Research	3	EPI
MATH509c	Statistics for Research	3	
MCB572	Cell Systems	3	BIOC
IMB533	Medical and Molecular Virology	3	MIC
MIC552	Antibiotics: A biological perspective	3	

MIC595a	Critical Evaluation of Scientific Literature	1	VSC
NRSC588	Principles of Cellular and Molecular Neurobiology	4	
PATH515	Basic Human Pathology	4	
PHCL601a	Epigenetics in Development and Disease	1	
PHCL501a	Pharm Basis/Therapeutics I	3	
PHCL501b	Pharm Basis/Therapeutics II	3	
PHCL512	Intro to Pharmacology	3	
PSIO511	Physiology/Biomed Engineering	3	
RNR613	Applied Biostatistics	4	
PLP528r	Microbial Genetics	3	ECOL, MIC, MCB
VSC543	Research Animal Methods	3	
Plus Courses (Choose 12 Units)			
You may take courses from the UND graduate program for transfer, but note that additional costs may apply.			
BNAD510	Business Fundamentals for Scientists	3	
ENGR514	Law for Engineers/Scientists	3	
ENGR552	Globalization, Sustainability Innovation	3	
ENGR567	Financial Modeling for Innovation	3	SIE
GRAD595d	Regulatory Issues in Laboratory Management	3	
LAW664	Biotech Startup Co: Law, Science, and Business Issues	1-3	
PHSC513	Health Technology Assessment	3	
PSYV571	Phycology of Leadership	4	
SIE515	Technical Sales and Marketing	3	
UND: MLS501	Quality Assurance in the Clinical Laboratory	2	
UND: MLS505	Financial Management of the Clinical Laboratory	2	
UND: MLS508	Leadership and Conflict Resolution in the Health Sciences	2	
UND: MLS509	Laboratory Education Methodologies	2	
UND: MLS517	Health Administration for the Clinical Laboratory Professional	2	
Electives (Choose 3-6 Units)			
Choose 3-6 units from the following list or any units listed above in the Core Science and Plus courses.			
BIOC568	Nucleic Acids and Metabolic Biochemistry	3	
BIOC578	Signal Transduction in Molecular Medicine	3	CBIO, MCB, PCOL, PSIO
BIOC585	Biological Structure I	4	MCB, CHEM
BIOC597a	Recombinant DNA Techniques	2	MCB
CBIO510	Gene Therapy and Molecular Engineering	3-4	IMB, MBIM
CBIO515	Mechanisms of Human Disease	4	PATH, PCOL

CBIO530	Proteins and Nucleic Acids as Drug Targets	3	CHEM, PCOL, PHSC
CBIO550	Drug Disposition and Metabolism	2	PCOL, TOX, PHCL
CBIO562	Tumor Immunology	3	IMB, MBIM
CBIO567	Cancer Immunology and Immunotherapy	3	IMB
CBIO595a	Oncogenes and Signal Transduction	1	BIOC, SURG
CBIO595b	Scientific Writing Strategies, Skills and Ethics	2	PHCL
CBIO596h	Cancer Biology GIDP Seminar Series	1	
CBIO596j	Frontiers in Medical Research	1	CBA, CMM, MCB
CBIO602a	General and Systems Toxicology	3	CPH, PCOL
CBIO615a	Cancer Epidemiology and Prevention	3	CPH, EPID, RONC
CBIO630a	Cellular Communication and Signal Transduction	3	PCOL
CBIO630b	Cellular Communication and Signal Transduction	3	PCOL
CBIO631	Pharmacogenetics/Pharmacogenomics	2	PCOL
CBIO695c	Readings in Cancer Immunology	1-2	IMB, PCOL
CMM501	Human Gross Anatomy	4	
CMM510	Human Histology	3	CBA
CMM556	Developmental Biology	3	ANS, MCB
CMM565a	Fundamentals of Light Microscopy and Electronic Imaging	3	
CMM/CBA570	Molecular Genetics	3	GENE, IMB, MIC
CMM577	Principles of Cell Biology	4	MCB
CMM579	The Art of Scientific Discovery	3	CBA, ECOL
CMM595a	Departmental Journal Club	1	
CMM595h	Problems in the Biology of Complex Diseases	2	GENE, IMB, MCB, PCOL
CMM596a	Seminar in Cardiovascular Development	1	
CMM696a	Departmental Faculty Seminar	1	
CMM696b	Graduate Student Seminar	1	
CMM695d	Human Genetic Disease Colloquium	3	BIOC, CBA, GENE
CPH573A	Basic Principles of Epidemiology	3	EPID
CPH576a	Biostatistics for Public Health	3	EPID
CPH576b	Biostatistics for Research	3	EPID
CPH660	Infectious Disease Epidemiology	3	EIS, EPID, VSC
ECOL538	Biogeography	3	GEOG
ECOL557	Medical-Veterinary Entomology	3	EIS, VSC
ECOL565	Phylogenetic Biology	3	EIS, MCB
ECOL583	Herpetology	4	WFSC
ECOL595b	Insect Biodiversity and Land Use in Sonora	3	ENTO
ECOL596u	Molecular Phylogenetics	2	EIS, PLS, RNR

ECOL597b	Phylogenetic Workshop	2	EIS
EEB509	Evolution of Infectious Disease	3	CPH, ECOL, VSC
EIS596m	Exploring Life on the WWW	3	ECOL, IRLS
EIS613	Applied Biostatistics	4	ECOL
GENE533	Human Genetics	3	ANTH, ECOL, MCB
IMB501	Graduate Medical Microbiology	4	
IMB520	Pathogenic Bacteriology	3	MIC, VSC
IMB529	General Virology	3	VSC, MCB
IMB552	Molecular Mechanisms of Microbial Pathogenesis	3	
IMB599	Independent Study	1-6	
MCB500	Computer Concepts and Perl Programming	3	GENE, PLS
MCB516a	Bioinformatics and Genomic Analysis	3	ABE, GENE, BIOC
MCB572	Cell Systems	3	
MCB573	Recombinant DNA Methods and Applications	4	BIOC, GENE, MIC, PLS
MCB577	Principles of Cell Biology	4	CMM
PHCL501a	Pharmacologic Basis of Therapeutics	3	
PHCL553	Neuropharmacology	3	
PHCL582	Immunotoxicology and Immunopharmacology	3	IMB, MIC
PHCL586A/B	Introduction to Medical Pharmacology	3	
PLP528l	Microbial Genetics Laboratory	2	ECOL, MCB, MIC, VSC, PLS, SWES
PLP528r	Microbial Genetics	3	ECOL, MCB, MIC, PLS, SWES, VSC
PLS539	Methods in Cell Biology and Genomics	3	GENE, MCB, PCOL, PSIO
VSC519	General Immunological Concepts	4	MIC, IMB
VSC595a	Critical Evaluation of Scientific Literature	1	MIC
UND: MLS502	Erythrocytes in Health and Disease	2	
UND: MLS503	Leukocytes in Health and Disease	2	
UND: MLS513	Advanced Clinical Immunology for Laboratory Professionals	2	
UND: MLS518	Molecular Diagnostics	2	
UND: MLS522	Clinical Bacteriology	2	
UND: MLS523	Clinical Virology, Mycology and Parasitology	2	
Internship (6-9 Units Required)			
ABS599	Independent Study		
ABS593a	Internship	6-9	

5.4 Molecular and Cellular Biology

The Molecular and Cellular Biology (MCB-PSM) subplan of the Professional Science Master's in Applied Biosciences GIDP is designed for students who wish to possess a graduate-level education that integrates knowledge in the biological sciences, management, business, and law. Students graduating in this track will be prepared for professional careers in government, academia, or in industry in such fields as biotechnology, pharmaceuticals, bioinformatics, medical research, and agriculture.

The discipline of Molecular and Cellular Biology is the study of life processes. What types of activities are carried out by cells, and how do cells make these activities work? Students develop a deep understanding of current ideas and problems in molecular and cellular biology and to build foundational skills in logic, reasoning, self-expression, and communication.

MCB researchers utilize model systems that allow them to query the most basic of questions about nature, whether they be at the molecular level, at the level of a cell or organism, or in the development of clinical application of new human disease therapies. Faculty with specializations in MCB represents a diverse group of faculty members' research interests including cancer biology, neurobiology, heart development and disease, plant development, evolutionary biology, cell signaling, gene expression, RNA biology, genetic networks and systems biology, and genome stability. Professional Science Master's students in the MCB-PSM track will be able to select courses corresponding to these fields and other course work for the track, to tailor their studies to their personal preferences and career goals.

Curriculum: PSM in Applied Biosciences - Molecular and Cellular Biology (MCB) Track			
Number	**Title**	**Units**	**Crosslisted**
Core Science Courses (Choose 12 Units)			
BIOC 565	Proteins and Enzymes		
BIOC 567	Computational Biophysics		
BIOC 585	Biological Structure		
BIOC 568	Nucleic Acids		
CBIO 552	Cancer Biology		
CBIO 553	Advanced Topics in Cancer Biology		
CBIO 589	Cancer Genetics		
CMM 556	Developmental Biology		
CMM 577	Principles of Cell Biology		
MATH 509c	Statistics for Research		
MCB 516a	Statistical Bioinformatics and Genomic Analysis		
MCB 546	Genetic and Molecular Networks		
MCB 572	Cell Systems		
MCB 573	Recombinant DNA Methods and Applications		
MCB 580	Introduction to Systems Biology		

MCB 595a	Journal Club and Seminar		
PLP 528	Microbial Genetics		
Plus Courses (Choose 12 Units)			
BNAD 510	Business Fundamentals for Scientists		
ENGR 512a	Management of Technology I		
ENGR 512b	Management of Technology II		
ENGR 567	Financial Modeling for Innovation		
LAW 655G	Law and Science		
LAW 664	Biotech Startup Co: Law, Science, and Business Issues		
Electives (Choose 3-6 Units)			
Includes any courses from the Core or Plus courses. Additional courses may be chosen by a student in collaboration with their PSM committee.			
Internship (6-9 Units Required)			
ABS599	Independent Study		
ABS593a	Internship	6-9	

6.0 OTHER PROGRAM REQUIREMENTS

6.1 Advising

When admitted to a track, the student's initial advisor will be the DGS of that track.

By the beginning of the 2nd semester, the student must select a primary advisor (who may be the DGS of the track) and at least two other faculty members who will form his/her committee. The composition of committee must be approved by the DGS and must follow Graduate College rules: http://grad.arizona.edu/academics/program-requirements/masters-degrees/masters-committees

6.2 Master's plan of study

Working with their advisor, students must start a Plan of Study in their first semester and submit it no later than the end of the 2nd semester. (http://grad.arizona.edu/degreecert/mpos)

6.3 Credit Requirements

The Graduate College places limits on the number and kind of transfer credit that can be applied to this degree. See the following for details:
http://grad.arizona.edu/academics/program-requirements/masters-degrees/credit-requirements

No more than 12 units of coursework taken in graduate non-degree seeking status may be used toward a master's degree. Transfer work may not exceed 20% of the required number of units for the master's degree being sought. (Example: For a degree that requires 30 units, no more than 6 units of transfer work may be used.)

A UA student can apply to The University of North Dakota (UND) graduate school as a "non-degree" student, and then sign up for any of the courses. The non-degree application would be filed with UND and credits transferred to UA. If there is no enrollment at the University of Arizona, the student will need to file a Leave of Absence (LOA). Not more than 6 units of University of Arizona undergraduate coursework at the 400 level can be accepted into a master's program, and only if they were not used toward the undergraduate degree. Please refer to the Transfer Credit policy for specifics about which courses can be used as transfer credit.

6.4 Graduate College Paperwork

See the following URL for additional Graduate college requirements on Masters degrees, including important information about paperwork that needs to be filed on a regular basis.
http://grad.arizona.edu/academics/program-requirements/masters-degrees/completion-of-masters-requirements

GradPath (http://grad.arizona.edu/GradPath) is the UA Graduate College electronic degree audit process that makes tracking and monitoring simple. Students are able to fill in and submit forms online through UAccess Student. For example, the Plan of Study and Committee request forms are submitted through gradpath. The automated workflow engine routes the electronic forms to everyone who needs to see or approve them (primary advisor, DGS, Committee, graduate College, …). Each approver is notified by email when a form is awaiting review and approval. To access GradPath, you will need to have completed FERPA training. You can do your training online or see the bottom right of the UAccess log-in page.

6.5 Satisfactory Academic Progress

Each semester, students in the Applied Biosciences PSM must demonstrate satisfactory academic progress towards their degree.

a) Students must maintain a minimum 3.0 GPA. If the student falls below this level for two semesters in a row, they will be disqualified.
b) Required courses must be completed with a minimum B grade. Students achieving a C or lower in a required class must take that class again.
c) Students may not take more than 6 years to complete the degree.
d) Students must show that they are making progress towards completing the degree in a timely manner. Students should regularly meet with their advisors (at least once a semester, preferably more). The following benchmarks are a good guide. Petitions to vary from this plan should be with good cause and be submitted in writing for consideration by the Executive Committee of the program. Core required courses should be completed as early as possible in the course of study (See Steps to Degree).

6.6 Professionalism Requirements

As this is a professional degree, students are also expected to prepare and submit certain professional documents to be used for applications to internships and jobs:

- A resume and/or curriculum vitae
- A statement of interests and professional goals (usually about 1 page)

These documents must be filed with Program Coordinator no later than the end of the 2nd semester.

Students are also expected to pursue professional opportunities when possible, such as attending talks by industry leaders, volunteering and participating in both academic and industry conferences etc. Potential employer's value engaged employees and participating in these ways demonstrates your engagement.

7.0 FACULTY IN THE APPLIED BIOSCIENCES GIDP

7.1 Applied Biosciences Faculty

Director of Graduate Studies			
Adelman, Miranda	Research Assist Professor, Medicine	mka@u.arizona.edu	626-5027
Fares, Johnny (Hanna)	Professor, Molecular and Cellular Biology	fares@email.arizona.edu	626-3759
Kacira, Murat	Associate Professor, Agricultural-Biosystems Engineering	mkacira@cals.arizona.edu	626-4254
Molnar, Istvan	Associate Professor, Arid Lands	imolnar@cals.arizona.edu	621-9932
Applied Biosciences Faculty			
Briehl, Margaret	Professor, Pathology		
Camenisch,Todd	Associate Professor, Pharmacology and Toxicology	camenisch@pharmacy.arizona.edu	626-0240
De, Barun	Professor, Dept of Pathology	bkde@email.arizona.edu	626-2517
Gutenkunst, Ryan	Assistant Professor , Molecular and Cellular Biology	rgutenk@email.arizona.edu	626-0569
Thorn, Jennifer	Assistant Clinical Professor, Pathology	jthorn@email.arizona.edu	626-6830
Tsao, Tsu-Shuen	Assistant Professor, Chemistry and Biochemistry	tsushuen@email.arizona.edu	626-9755
Wertheimer, Anne	Assistant Professor, Medicine	awerth@email.arizona.edu	626-5850
Yao, Guang	Assistant Professor, Molecular & Cellular Biology	guangyao@email.arizona.edu	621-7345
Zarnescu, Daniela	Assistant Professor Molecular and Cellular Biology	zarnescu@email.arizona.edu	626-1478

7.2 2013-2014 Executive Committee

Name	Email	Affiliation
Adelman, Miranda	mka@email.arizona.edu	Medicine (Research Scholar Track)
Dussor, Greg	dussorg@email.arizona.edu	Pharmacology
Fares, Johnny (Hanna)	fares@email.arizona.edu	Molecular and Cellular biology
Kacira, Murat	mkacira@cals.arizona.edu	Agricultural Biosystems Engineering
Molnar, Istvan	imolnar@cals.arizona.edu	School of Natural Resources
Ossanna, Nina	nossanna@email.arizona.edu	BIO5 Strategic Development
Palanivelu, Ravi	rpalaniv@ag.arizona.edu	School of Plant Sciences
Schmelz, Monika	schmelz@email.arizona.edu	Pathology (Research Scholar Track)
Whitfield, Natalie	nnw@email.arizona.edu	Pathology

8.0 INDUSTRIAL ADVISORY BOARD

Name	email	Title/ Affiliation
August, Paul	paul.august@sanofi.com	Director, US Head of Early To Candidate Unit, Sanofi
Brigham, Lindy	Lindy.Brigham@buffelgrass.org	Executive Director, Southern Arizona Buffelgrass Coordination Center
Foust, Jay	jay.fouts@ventana.roche.com	Senior Director, Strategic Marketing, Translational Diagnostics, Ventana Medical Systems, Inc.
Ossanna, Nina	nossanna@email.arizona.edu	Chair, BIOSA (Bioindustry Organization of Southern Arizona)
Papp, Sandor	sandor.papp@ventana.roche.com	Principal Scientist, Ventana Medical Systems, Inc.
Richman, Ron	rjrichman@inno-tech.org	Chairman, Innovative Technology Development Center
Wesselhoft, Marie	mwesselhoft@msdx.com mwesselhoft@gmail.com	President, Southern Arizona Buffelgrass Coordination Center
Bell, Anita	anitab@azinnovation.com	Acting Director, Arizona Center for Innovation