Term Information

Effective Term	Summer 2016

General Information

Course Bulletin Listing/Subject Area	Microbiology
Fiscal Unit/Academic Org	Microbiology - D0350
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	4150
Course Title	Immunobiology Laboratory
Transcript Abbreviation	Immunobiology Lab
Course Description	This course will provide an introduction to the experimental approaches and laboratory methods commonly used in Immunology research. Topic areas include the purification, characterization and applications of antibodies, the characterization and responses of cells and organs of the immune system, and cell culture techniques for the use of eukaryotic cells in immunology research
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 7 Week, 12 Week (May + Summer)
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Laboratory
Grade Roster Component	Laboratory
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus

Prerequisites and Exclusions

Prerequisites/Corequisites	Micrbiol 4110, or Micrbiol 5122, or permission of the Instructor
Exclusions	

Cross-Listings

Cross-Listings	

Subject/CIP Code

Subject/CIP Code	26.0502
Subsidy Level	Baccalaureate Course
Intended Rank	Sophomore, Junior, Senior

Requirement/Elective Designation

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Students gain practical experience in immunological techniques and understand the theory and mechanics behind the techniques
- Students acquire a perspective on how immune cells and molecules are applied to investigations in research as well as their application in in industry
- Students acquire knowledge of how cells and molecules of Innate and Adaptive immunity work together to eliminate pathogens from the host body.
- Students develop a scientific approach to critical thinking, problem solving and data analysis
- Students acquire the ability to evaluate scientific methods and experimental data presented in scientific journal articles and analyze it in the context of techniques learned

Content Topic List

- Experiments based on Humoral Immunity
- Experiments based on applications of Antibody
- Experiments based on Innate Immunity
- Experiments based on cell culture

Attachments

- Lett_M4150.pdf: Cover Letter

  (Cover Letter. Owner: Daniels,Charles John)
- M4150_ImmunobiologyLab.pdf: Syllabus

  (Syllabus. Owner: Daniels,Charles John)
- LG_Map_M4150.pdf: Mapping Learning Goals

  (Other Supporting Documentation. Owner: Daniels,Charles John)

Comments

- The proposed course is a re-envisioned and expanded version of the quarter course, Immunobiology Laboratory, Microbiology 522.02 (3 quarter credit hrs.). *(by Daniels,Charles John on 08/22/2015 10:14 AM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Daniels,Charles John	08/22/2015 10:14 AM	Submitted for Approval
Approved	Daniels,Charles John	08/22/2015 10:15 AM	Unit Approval
Approved	Fink,Steven Scott	08/27/2015 04:22 PM	College Approval
Pending Approval	Nolen,Dawn Vankeerbergen,Bernadette Chantal Hanlin,Deborah Kay Jenkins,Mary Ellen Bigler Hogle,Danielle Nicole	08/27/2015 04:22 PM	ASCCAO Approval

THE OHIO STATE UNIVERSITY

College of Arts and Sciences
Division of Natural and Mathematical Sciences

Department of Microbiology

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August 21, 2015

Dear Colleagues,

The Department of Microbiology is requesting approval for a new undergraduate-level course, Microbiology 4150, entitled “Immunobiology Laboratory”.

The proposed course is a re-envisioned version of the quarter course, Immunobiology Laboratory, Microbiology 522.02 (3 quarter credit hrs.). As part of the revised BS degree curriculum developed for the transfer to semesters, we introduced a new laboratory course Molecular Microbiology Laboratory, MICRBIOL 4140. This course covers topics from two previous (quarter) laboratory courses: Microbial Genetics Laboratory, MICRBIOL 581.02 and Immunobiology Laboratory MICRBIOL 522.02.

The 4140 course was designed as a project based laboratory, differing from the previous technique-driven courses taught under quarters. This student driven approach was well received by the students and gave students, especially those who weren’t enrolled in an independent research class, the opportunity to participate in a “mini”-research project. This new format had a couple of unexpected benefits: several faculty members, not formally involved in the class, offered projects ideas stemming from their work, broadening the scope of the class; and Dr. Sandman, who is the lead instructor for the course, recently published a peer-reviewed paper (*Journal of Microbiology & Biology Education* (*JMBE*) Vol. 15, No 2 (2014) describing one of the project modules.

The success of this approach in the areas of microbial physiology and genetics, coupled with the increasing demand from our students for laboratory experiences in immunology, has led us to propose reintroducing our class focusing on Immunology research. The proposed course is an updated version of the previous quarter course, MICRBIOL 522.02 (three quarter-credit hrs.) and will be expanded (three semester-credit hrs.) to accommodate new experimental techniques. Immunology is an essential component of our program and a recommended topic area for the undergraduate curriculum by the American Society for Microbiology, our parent organization. Having this course strengthens our offerings in the area and allows our students to stay abreast of the new and exciting opportunities in the field.

MICRBIOL 4140 will continue its focus on Physiology and Genetics, and the transition of the immunology section to the new course will allow MICRBIOL 4140 to add new exercises in the area of environmental microbiology, a new research focus in the department.

The new course will be an elective for our majors and be offered in the summer term to accommodate staffing. Dr. Pradhan, will be the lead instructor in the course; she has developed the initial MICRBIOL 522.02 course and participated in the MICRBIOL 4140 class and is well qualified.

We look forward to your response.

Sincerely,

Charles J. Daniels, Ph.D.
Professor
Vice Chair for Teaching and Undergraduate Affairs

Draft Syllabus

Immunobiology Laboratory
Microbiology 4150
(3 Credit Hours)
Summer 2016

Instructor: Madhura Pradhan, Ph.D.
Assistant Professor
Department of Microbiology
Office: 372 Biological Sciences Building
Email: pradhan.2@osu.edu
Phone: (614) 292-1196
Office hours: Wednesday/Thursday (times TBA) or by appointment.
Students are encouraged and are welcome to meet with their instructor

Course Description: This course will provide an introduction to the experimental approaches and laboratory methods commonly used in Immunology research. Topic areas include the purification, characterization and applications of antibodies, the characterization and responses of cells and organs of the immune system, and cell culture techniques for the use of eukaryotic cells in immunology research. The course is intended for undergraduate students majoring in Microbiology or a related life science program. A strong background in the principles of Immunology is essential.

Class meetings: (The initial offering of the course will be in the seven week summer term.) Class will meet 10 hrs per week in three laboratory sessions: Tuesday (4 hrs), Wednesday (3 hrs) and Thursday (3 hrs). Students should also expect an additional 5-6 hrs per week of out-of-class activities for reading and data analysis.

Prerequisite: Microbiology 4110, or permission of the Instructor.

Materials needed for course

Laboratory Manual: Laboratory exercises for the course will be presented in a custom laboratory manual. Copies will be available for purchase in print form at campus bookstores and students can download the pdf version from the course Carmen site. Additional reading and reference materials will be available on Carmen.

There are a number of Immunology texts are available for students seeking additional background. Recommended texts include:

- Murphy, K.. *Janeway's Immunobiology*. New York, NY: Garland Science, 8th ed. 2011. ISBN: 978-0815345312.
- Abbas, Abul K., and Andrew Lichtman. *Cellular and Molecular Immunology*. 6th ed. Philadelphia, PA: Saunders, 2005. ISBN: 9781416023890.

Learning goals of the course

1) Students gain practical experience in immunological techniques and understand the theory and mechanics behind the techniques.
2) Students acquire a perspective on how immune cells and molecules are applied to investigations in research as well as their application in in industry.
3) Students acquire knowledge of how cells and molecules of Innate and Adaptive immunity work together to eliminate pathogens from the host body.
4) Students develop a scientific approach to critical thinking, problem solving and data analysis.
5) Students acquire the ability to evaluate scientific methods and experimental data presented in scientific journal articles and analyze it in the context of techniques learned.

GRADING

Laboratory Quizzes: 25%
Homework Assignments: 25%
Laboratory Report: 7%
Oral Presentation: 8%
Written Final exam: 25 %
Lab Notebook: 5%
Participation and Technique points: 5%

Laboratory Quizzes: Throughout the semester, pre-announced laboratory quizzes will be given to assess student learning. These quizzes will be offered during the regular lab periods. Students can drop one lowest quiz score. There will be no make-up quizzes offered in this lab. If a student misses a quiz, the missed quiz will be considered as the dropped one.

Homework Assignments: Some of the homework assignments are to be submitted prior to the actual lab experimentation, such as pre lab assignments. A pre lab assignment can be an experimental protocol in a flow chart or a table format with appropriate details to allow a reader to replicate and understand the experiment performed. Some homework assignments may involve, but not limited to, acquired data analysis and interpretation of results using graphs, interpretation of microscopic observations, readings associated with the experiments performed etc.

Written Final exam: At the end of the semester, there will be a written final exam based on the material covered throughout the semester. The final will consist of different types of questions to evaluate a student's numeracy skill, problem solving and critical thinking skills, data interpretation and scientific reasoning skills, and to assess one's understanding of the immunological principles behind experimental techniques.

Laboratory Report: There will be a written laboratory report based on some of the experiments performed in the lab. Students will receive a handout with written instructions regarding what is expected in the lab report. Though most of the experiments will be performed in pairs, each student needs to work on the report independently.

Oral Presentation: Each student pair will present a scientific journal article relevant to the techniques learned in the class.

Lab Notebook: For each experiment conducted in class, students will record their observations and data in their lab notebooks. For each experiment the following should be included: Title, objective, method (or prelab), results, conclusion. Lab instructor will assess the notebook periodically (unannounced) to make sure that students are developing the skill of scientific recording.

Late Policy: All assignments (including reports) are due on the dates stated in the syllabus. The assignments are due at the beginning of the lab within the first 10 mins of the lab period. An assignment turned in by the end of the laboratory period of the due date, will incur 50% of loss of points. All other late assignments will not be graded for credit. If a student has an excused absence, arrangements should be made to deliver the assignment in time.

Attendance policy: Attendance in the laboratory is mandatory. It is necessary for course completion to participate in every laboratory exercise. Due to the nature of this course, there will be no make-up labs. Only one excused absence is allowed to students with a valid medical excuse or reasons acceptable to instructors (valid documentation required). For an excused absence from lab, student needs to provide a valid written document within 2 days of the missed lab. Each additional absence will result in deduction of five percentage points from the final total percentage.

Missing one or more labs without a valid excuse will result in losing course points, which will influence overall grade. Students also lose 2.5% of total course points for being over 15 minutes late to lab. If a student is late to lab by 30 minutes or more, it will count as a missed lab.

Please note that if absences are due to a documented illness or other valid excused reasons, you may be eligible for an incomplete grade. (NOTE: Written records of your reason must be submitted.)

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QUESTIONS CONCERNING GRADING OF COURSE MATERIALS

If you have any questions or concerns regarding grading of any of the assessments offered in this course, you must submit them in writing to the instructor within two days from the date the grade for the exam is available. You must address all the concerns regarding the final exam before the final grade is posted on Carmen. Once the final grade is posted, no questions from the final will be addressed.

Disability Statement

Any student who feels s/he may need an accommodation based on the impact of a disability should contact the Instructor privately to discuss your specific needs. Please contact the Office for Disability Services at 614-292-3307 in room 150 Pomerene Hall to coordinate reasonable accommodations for students with documented disabilities.

Academic Misconduct Statement

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand

the University's Code of Student Conduct, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow

the rules and guidelines established in the University's Code of Student Conduct and this syllabus may constitute "Academic Misconduct."

The Ohio State University's Code of Student Conduct (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the University, or subvert the educational process." Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the University's Code of Student Conduct is never considered an "excuse" for academic misconduct, so we recommend that you review the Code of Student Conduct and, specifically, the sections dealing with academic misconduct.

If we suspect that a student has committed academic misconduct in this course, we are obligated by University Rules to report our suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the University's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the University. If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact the Instructor.

Schedule for Immunobiology Laboratory			
Week	**Date**	**Exercise in Immunobiology**	**Assignments**
1		Exercise 1: Blood cells 1. Lecture: Cells and organs of the Immune System 2. Observation of Blood slides Exercise 2: Antibody Purification 1. Affinity column chromatography 2. Abs 280 and Ab concentration 3. Bradford Assay: Bradford Std curve and Ab conc	1. Record the purified Ab conc based on Abs @280nm and Bradford assay 2. Bradford Pre-lab due 3. Bradford graph due at the end of the period (record the conc. values)
1		Exercise 3: Radial Immuno Diffusion 1. Lecture: RID 2. Preparation of protein dilutions 3. Loading RID plates Exercise 4: ELISA- A : Quantitative 1. Coating ELISA plates with antigen	1. RID pre-lab due 2. ELISA-A pre lab due
2		Exercise 3: RID 1. Measurement of Zone of Ppt 2. RID Graph on semi-log paper 3. Calculation of AB conc based on RID 4. Abs @280 VS. Bradford VS. RID Exercise 4: ELISA- A : Quantitative 1. Lecture: ELISA-A 2. Washing & Blocking ELISA plates	1. RID graph due at the end of the period (record the conc. values) 2. ELISA-A Graph and calculation of Ab Titer due at the end of the period 3. ELISA-B pre lab due

		3. Incubation with primary and secondary Ab Exercise 5: ELISA- B : Qualitative Identification of Purified Unknown antibody 1. Coating ELISA plates with antigens	
2		Exercise 5: ELISA- B : Qualitative 1. Washing and Blocking ELISA plates 2. Incubation with primary and secondary Ab 3. Lecture: Interpretation of Results and Graph Ab specificity vs. cross-reactivity Identification of Purified Unknown antibody Exercise **7** - Antibody Reactions Ouchterlony 1. Set up ouchterlony plates using the purified antibodies and antigens 2. Discuss cross reactivity, partial identity of antigens as determined by ouchterlony technique. 3. Compare data from ELISA-Part B and Immunoblotting to ouchterlony	1. ELISA-B graph due at the end of the period 2. Ab specificity vs. cross-reactivity 3. Identification of Purified Unknown antibody
3		Exercise 6: Immunoblot/Western 1. Loading and running protein gel 2. Setting up protein gel transfer 3. Blocking of membrane 4. Incubation with primary antibody until the next lab period	

		Exercise **8** – Introduction to Tissue Culture Technique: **Part A** 1. Video (20 minutes) 2. Introduction to aseptic cell culture technique using laminar air flow hood 3. Set up the culture of A20/RAW cell line, using RPMI 1640 medium 4. Observe suspension vs. adherent cell cultures using inverted microscopes 5. Stain different cell types provided to you on a slide and observe them under the microscope	
3		Exercise 6: Immunoblot/Western 1. Washing the blot after primary 2. Incubation with secondary Ab 3. Development of blot 4. Discussion of results 5. ELISA vs Immunoblot vs oucterlony discussion Exercise **8 contd**. – Introduction to Tissue Culture Technique: **Part B** 1. Harvest RAW cells from the cultures set up in the previous lab period 2. Determine cell number and viability using a hemocytometer Exercise **9** – Phagocytosis 1. Introduction to phagocytic cells of the immune system 2. Introduction to the endocytic pathway and the phagosome. Bactericidal activity of phagocytic cells	1. Purified unknown Ab ID based on Immunoblot

		3. Infect macrophages with microbe 4. Gram stain of infected macrophage	
4		Exercise **10** - Measuring the Bactericidal Activity of macrophages Greiss Reaction 1. Set up Raw cells for Greiss reaction experiment by starting the activation treatment with LPS and/or IFN Exercise 11: Applications of Ab A) Virus Hemagglutination B) Rheumatoid Factor Agglutination test C) Precipitation test	1. Virus and antivirus Ab Titer calculations
4		Exercise **10** - Measuring the Bactericidal Activity of macrophages: Greiss Reaction 1. Production of nitric oxide – Run Greiss Reaction 2. Prepare standard curve using data Exercise **11** - Lymphocyte Signal Transduction: **Part A** 1. Stimulate A20 cells for various lengths of times 2. Lyse the stimulated cells and control cells 3. Freeze the lysates until the next lab period	
5		Exercise **11** Lymphocyte Signal	

		Transduction: **Part B** 1. Separate lysates by SDS-PAGE 2. Set up transfers for Western Blot analysis for phosphorylated proteins Exercise 12 – Complement mediated cell lysis	
5.		Exercise **11** Lymphocyte Signal Transduction: **Part C** 1. Probe membranes with anti-pY antibody to detect phosphorylated proteins in the signal transduction pathway Exercise **12** – Flow Cytometry 1. Introduction and DEMO	
6		Exercise 13 – Immunofluorescence Exercise 14 – Apoptotic cell death assay	
6		**Student presentations**	
7		**Student presentations**	
7		**Final written exam**	

Learning Objectives associated with experiments listed in the lab schedule:

Experiments based on Humoral Immunity: Antibody purification, quantitation and Identification

1. Antibody Purification using Affinity Chromatography: Students will purify antibodies from one of the three unknown antiserum samples provided, using Affinity Chromatography Technique.
   Students will learn the chromatography principle based on the affinity between Protein A column and Fc region of antibody proteins. Students will learn the structure of a typical antibody molecule, different classes/isotypes and functions of antibodies.
2. A) Students will quantitate the amount of purified antibody protein present in collected fractions using UV Spectrophotometer.
   B) In a separate experiment, students will perform Bradford Assay to more accurately quantitate the concentration of purified antibody protein.

C) In the next experiment, students will perform RID (Radial Immuno-Diffusion Assay) to accurately quantitate the concentration of purified antibody protein. There are three experiments designed to measure the purified Antibody protein concentration with various degrees of efficiency and accuracy. Students will learn the limitations and usability of different techniques under different circumstances. Using Data acquired from three experiments, students will be able to calculate the efficiency of Affinity chromatography technique and purity of the Antibody.

3. ELISA technique will be introduced to quantitate (measure Titer of) the purified unknown antibody. Students will learn the difference between the 'concentration' of purified antibody and 'Titer' of purified antibody. A quantitative ELISA will be used for finding the Titer of the purified unknown antibody.
   Using the Data from Quantitative ELISA, another ELISA (qualitative) will be performed to identify the purified unknown antibody.
   Students will learn how ELISA technique can be applied in various ways, the need to perform two types of ELISA in order to find two different data sets and common application of ELISA in medical, pharmaceutical and food industry. Students will also learn how to design different types of positive and negative controls for these experiments.

4. Immunoblotting/Western: this technique will be used to confirm the identity of the purified antibody protein.
   Students will be introduced to the concepts of protein structure, denaturation, SDS-PAGE and immunoblotting. Students will learn the principles behind denaturing gel, transfer of proteins from SDS gel to a membrane, probing the membrane with polyclonal vs. monoclonal antibody and development of the probed membrane. Students will learn about the specificity and cross-reactivity of probing antibodies, primary and secondary antibodies and affinity vs. avidity of an antibody.

Experiments based on applications of Antibody: Agglutination, Precipitation, and Viral Hemagglutination (ELISA and Western blot techniques described previously will also be discussed in the context of how antibodies can be applied in day to day life).

5. Rheumatoid Factor Test: Students will perform an agglutination test using sera, with appropriate controls, to detect Rheumatoid Arthritis. Sera from RA + and RA – will be provided and latex agglutination test will be performed. Students will learn the limitations of the test wrt false positive and false negative results.
6. Precipitation Test: Bovine serum albumin and anti-BSA antibodies will be used for the test. Students will learn the difference between agglutination and precipitation and will understand what interactions lead to these outcomes and the significance of these outcomes. Students will also be introduced to the concept of zone of equivalence
7. Viral Hemagglutination and Inhibition of Viral Hemagglutination: two experiments will be performed to calculate the titer of the virus and the titer of the anti-viral antibodies. Students will also learn how this technique can be used for detection of viral infection or detection of prior exposure to the virus or even to evaluate the efficacy of a vaccine.

Experiments based on Innate Immunity

8. Blood cells: students will observe prepared slides of stained blood smears and identify different immune cells.

Students will learn about the cells and organs of the immune system and general architecture of the immune system. Students will be able to identify different blood cells and explain the specific immune function carried out by different cell types.

9. Greiss reaction: Measuring the bactericidal activity of macrophages. Students will be provided with a macrophage cell line that will be stimulated with different ligands. The activation of the macrophages will be measured in terms of nitric oxide production using a colorimetric assay.
   Students will learn about the phagocytic cells, the signals required for their activation and the resulting mechanism of phagocytosis used for the destruction of an engulfed pathogen.
10. Phagocytosis and Evasion of phagocytosis: Students will be provided with a macrophage cell line. Macrophages will be incubated with non-capsulated and capsulated bacterial cells and the difference in the efficiency of phagocytosis will be observed under the microscope. Students will learn about the details of the process of phagocytosis and bacterial pathogenesis: different mechanism by which bacteria can evade the innate immune mechanism of phagocytosis.

Experiments based on cell culture

11. Cell and Tissue culture: Students will set up the eukaryotic cell culture using Aseptic technique. Students will grow these cells over a period of time and will use a hemacytometer to calculate the density of cells and the percent of viable cells in the culture.
    Students will learn: what is cell culture, different types of cell lines (primary vs. transformed), laminar flow hood, CO2 incubator, cell culture media, cell enumeration, applications.
12. Depending on the approval of the cell culture approach and the success of cell culture, the following experiments can be offered using the cell line established by students:
    1) The cell surface markers can be used for Immunofluorescence experiment.
    2) These cells can be used for Flow cytometry experiments if within the financial budget. Otherwise, a demo will be used to teach students FACS data analysis.
    3) Apoptosis assay can be performed using these cells to teach students the concept of programmed cell suicide and autoimmune disorder.
    4) Signal Transduction: The cells established by students will be activated and the pathways activated during signal transduction will be measured in terms of tyrosine phosphorylation of proteins/transcription factors.

Mapping Microbiology 4150 Learning Goals to BS Degree Program Learning Goals

Microbiology BS Degree
Program Learning Goals (B, beginning; I, Intermediate; A, Advanced)

1. Students acquire the ability to interrelate and apply the fundamental concepts of chemistry, physics and mathematics to the functions of living cells.

2. Students understand the chemical properties of biological molecules and how these molecules function in the molecular mechanisms underlying physiological processes in microbial cells.

3. Students understand evolutionary processes, the diversity of microorganisms, and how microorganisms impact their environment, including their roles in human health and disease.

4. Students acquire the ability to design experiments to test hypotheses, perform analyses, interpret and analyze data, and present scientific information in written and oral formats.

5. Students acquire the ability to appraise scientific data presented in the popular press for accuracy and scientific merit and understand issues and ethical conflicts associated with applications of biotechnology.

Microbiology 4150 Learning Goals (Mapped to BS Degree Program Learning Goals)

1. Students gain practical experience in immunological techniques and understand the theory and mechanics behind the techniques. **(PLG 1&2 Intermediate; PLG 4 Advanced)**

2. Students acquire a perspective on how immune cells and molecules are applied to investigations in research as well as their application in in industry. **(PLG 3 Advanced)**

3. Students acquire knowledge of how cells and molecules of Innate and Adaptive immunity work together to eliminate pathogens from the host body. **(PLG 3 Advanced)**

4. Students develop a scientific approach to critical thinking, problem solving and data analysis. **(PLG 4 Advanced)**

5. Students acquire the ability to evaluate scientific methods and experimental data presented in scientific journal articles and analyze it in the context of techniques learned. **(PLG 5 Advanced)**

Mapping Microbiology 4150 Learning Goals to BS Degree Program Learning Goals

Microbiology BS: Learning Goal Map

Required Prerequisites for the Major — Learning Goals

Semester Course Number		Course Title	Semester hrs	1	2	3	4	5
BIOL 1113		Biological Sciences: Energy Transfer and Development	4	B			B	
BIOL 1114		Biological Sciences: Form, Function, Diversity, and Ecology	4	B			B	
MATH Requirement 1	MATH 1151	Calculus 1 (5 Hrs)	5	B				
	or							
	MATH 1156	Calculus for Biol. Sciences (5 Hrs)						
MATH Requirement 2	MATH 1152	Calculus 2 (5 Hrs)	3 - 5	B				
	or							
	MATH 1157	Math. Modeling for Biol. Sciences (5 Hrs)						
	or							
	STATS 1450	Intro. to the Practice of Statistics (3 Hrs)						
	or							
	STATS 2480	Statistics for the Life Sciences (3 Hrs)						
CHEM 1210		General Chemistry 1	5	B				
CHEM 1220		General Chemistry 2	5	B				
CHEM 2510		Organic Chemistry 1	4	B	B			
CHEM 2520		Organic Chemistry 2	4	B	B			
CHEM 2540		Organic Chemistry Lab 1	2	B	B		B	
PHYS 1200		Mechanics, Thermal Physics, Waves	5	B			B	
PHYS 1201		E&M, Optics, Modern Physics	5	B			B	
		Total Hrs.	**46 - 48**					

Goal: B: Beginning; I, Intermediate; A, Advanced

Required Core for the Major — Learning Goals

Semester Course Number		Course Title	Semester hrs	1	2	3	4	5
MICRBIOL 4100		General Microbiology	5	I	I	I	I	I
MICRBIOL 4110		Pathogenesis and Immunobiology	3	A	A	A		
MICRBIOL 4120		Microbial Physiology and Diversity	3	A	A	A		
MICRBIOL 4130		Microbial Genetics	3	A	A	I		
MICRBIOL 4140		Molecular Microbiology Laboratory	3	I	I	I	A	A
BIOCHEM 4511		Biochemistry	4	I	A			I
		Total Hrs.	**21**					

Goal: B: Beginning; I, Intermediate; A, Advanced

Electives: Total Required 9 hrs
Group 1: 3-9 hrs — Learning Goals

Semester Course Number		Course Title	Semester hrs	1	2	3	4	5
MICRBIOL 4150		Immunobiology Laboratory	3	I	I	A	A	A
MICRBIOL 4193		Individual Studies	1-3					
MICRBIOL 4194		Group Studies	1-3					
MICRBIOL 4591S		DNA Finger Printing Workshops in Columbus PS	1				A	A
MICRBIOL 4797		Study at a Foreign Institution	1-19					
MICRBIOL 4798		Study Tour Domestic	1-19					
MICRBIOL 4998		Undergrad Research in Microbiology	1-5				A	A
MICRBIOL 4998H		Honors Research	1-5				A	A
MICRBIOL 4999		Undergrad Research in Microbiology-Thesis	1-5				A	A
MICRBIOL 4999H		Honors Research-Thesis	1-5				A	A
MICRBIOL 5122		Immunology	2			A		
MICRBIOL 5129		Cellular and Molecular Biology of Pathogenic Eukaryotes	3		A	A		
MICRBIOL 5147		Eukaryotic Pathogens	3		A	A	A	
MICRBIOL 5149		Introductory Virology	3		A	A		
MICRBIOL 5150		Microbial Ecology	3	A	A	A		
MICRBIOL 5155		Environmental Microbiology	3	A	A	A		
MICRBIOL 5161H		Bioinformatics and Molecular Microbiology	3	A	A	A		A
MICRBIOL 5169H		Microbial Evolution	3			A		
MICRBIOL 5170		Microbes and Evolution	3			A		
MICRBIOL 5536		Food Microbiology Lecture	3		A	I		A
MICRBIOL 5546		Food Microbiology Laboratory	3		A	I	A	A
		Total Hrs.	**3-9**					

*Indicated graduate-level course. Requires special permission to enroll.

Goal: B: Beginning; I, Intermediate; A, Advanced

Electives: Total Required 9 hrs
Group 2: 0-6 hrs — Learning Goals

Semester Course Number		Course Title	Semester Hrs.	1	2	3	4	5
MICRBIOL 3300		The Biology of Pollution	2	B				I
BIOCHEM 5621		Intro Biological Chemistry Laboratory	4	I			I	
MOLGEN 4500		General Genetics	3		I			
MOLGEN 4606		Molecular Genetics I	4		I			
MVIMG 5000		Evolution of Emerging Viruses	2			A		
PLPATH 5010		Phytobacteriology	2		I	A		
PLPATH 5020		Introduction to Plant Virology	2		I	A		
PLPATH 5040		Science of Fungi: Mycology Lecture	3	I	I	A		
ANSCI 6090*		Anaerobic Microbiology	3		A			
ENR 5263		Biology of Soil Ecosystems	3	I	A			
ENR 5266		Field Soil Investigations	3	I			A	
		Total Hrs.	**0-6**					
		Total Hrs. for the Major	**30**					

*Indicated graduate-level course. Requires special permission to enroll.

Goal: B: Beginning; I, Intermediate; A, Advanced