BASIC CHARACTERISTICS OF THE EDUCATIONAL PROGRAM

Brief description of the disciplinary purpose and significance of proposed degree

We are seeking approval for a graduate program to award students a Master of Science degree in Immunology and Microbial Pathogenesis. The program's primary goal is to supply highly-skilled individuals to the biomedical workforce in Ohio. Graduates will support ongoing academic and private sector research needs within the state and serve as a talented labor pool to attract and meet future growth in these areas. The program will offer focused, formal education with focused, hands-on research training for people seeking careers in academic, pharmaceutic, biotech, agriculture, government, and public health fields while benefiting from Ohio State University's environment of diversity, education, ethics, honesty, integrity, personal and professional growth, professionalism, and responsibility.

The program will be offered at the Columbus campus and will fill a geographical need for students who wish to pursue relevant scientific careers. Graduates of the program will gain a highly marketable skillset in the practicalities of working within a top-tier research environment along with a foundational knowledge of health-related human immunology and microbial pathogenesis. Graduates will be prepared to contribute to the State of Ohio's efforts especially in this time of emerging pathogens and need for rapid development of diagnostics and therapeutic interventions. Similarly, the current revolution of cancer immunotherapy research and discovery predicts a need for talented labor in these fields as well.

Definition of the focus of the program

The focus of the program will be to educate and train students in the areas of Immunology and Microbial Pathogenesis with a particular focus on becoming proficient at working within a laboratory-based setting. The required curriculum will be a combination of didactic, journal club, seminar, and research-based coursework culminating in the successful defense of a master's thesis. The curriculum will be consistent with the program's mission to provide the practical knowledge necessary to be employed in a research-related environment and contribute to the health needs of the people of Ohio. In particular, students will have the option to concentrate their curriculum in one of the two focus areas by selection of advanced core courses and electives in immunology or microbial pathogenesis.

Rationale for degree name

The Master of Science degree in Immunology and Microbial Pathogenesis has been chosen for this program as it reflects that the student has, as a culminating experience, completed their thesis research and is prepared to carry out original research in Immunology and Microbial pathogenesis and their associated fields.

Duration of the program

Total Credit Hours: A minimum of 40 semester credit hours will be required to earn the Master of Science in Immunology and Microbial Pathogenesis. This minimum is higher than some statewide alternatives for an MS in related fields (similar however to U. of Akron and U. of Toledo, Appendix E) it is reflective of the hands-on, research component necessary for completion of a culminating thesis document. These credit hours consist of

30 hours core courses (including 15 from laboratory research practicum) and 10 hours of elective courses (see Table 1 and Appendix A).

Length of Time for Completion: The curriculum is designed to be completed in five terms initiating in Autumn of Year 1 (AuY1) and culminating with Spring of Year 2 (SpY2). Students can elect to begin early by enrolling in their research laboratory rotation course during the summer term prior to AuY1.

Admission timing

The program is expected to be implemented beginning Autumn 2021. It is anticipated that the program will admit one cohort of six students per year until a planned rolling average enrollment of 12 students is reached.

Primary target audience for the program and admission requirements

The program consists of five terms of 8-credit hours each, delivered on campus with a required research-based component. For these reasons we project the primary target audience to be students with proximity and availability to the Columbus campus during daytime hours, Monday-Friday. Although the program is formally full-time at 8-credit hours per term, it is conceivable that a student may have time to maintain part-time employment while pursing the degree.

Students accepted to the program would be expected to hold a Bachelor's degree in the biological sciences and seeking to advance their knowledge and skills to increase their chances for employment and/or increase their earning potential in relevant research positions.

Recruitment and admissions are to be handled through the Office of Graduate Education and adhere to an application process with the following qualifications:

- A personal statement of why the applicant is applying to the program
- An official transcript with proof of completed Bachelor's Degree (or higher) in any of the biological sciences or related areas, or a combination of related major along with successful completion of relevant prerequisite for the curriculum (see Table 1 for core-course requirements)
- Three letters of recommendation.
- All international applicants whose native language is not English will be required to take the Test of English as a Foreign Language (TOEFL) and have an official score report sent directly to the Associate Dean for Graduate Studies from Educational Testing Service. The recommended minimum TOEFL scores are 560 (written) or 220 (electronic) or 89 (internet based).

Evaluation of applicants for admission to the program will adhere to the principles of individualized holistic review. Therefore, GPA and test scores will be considered as but single metrics in the admissions process, with no score to be considered a sole criterion for admission into the program.

Special efforts to enroll and retain underrepresented groups

We plan to work with our collaborating institutions to facilitate recruitment and retention of minority students. Special efforts will be made to recruit and retain underrepresented groups in the Immunology and Microbial Pathogenesis Master of Science degree program. The Institution's Office for Diversity and Cultural Affairs is committed to enhancing the recruitment, admission and retention of students from underrepresented groups. This office currently offers services including professional and personal guidance, summer research

opportunities, career development and pipeline programs, visiting student programs, interaction with other minority students, and networking and mentorship opportunities throughout the Institution's affiliations.

We also plan to reduce costs through fee-waivers and tuition scholarships/offsets for URM students. The program will seek funding for these efforts through re-investment of program capital, College and University assets, and private-sector industry partners.

INSTITUTIONAL PLANNING FOR THE PROGRAM

Physical facilities, equipment and staff needed to support the program

The Immunology and Microbial Pathogenesis graduate program will be housed in The Ohio State University College of Medicine and implemented through the Department of Microbial Infection and Immunity. The department currently has 27 principal investigator-led laboratories which will serve the physical research needs of the program. Facilities include over 23,000 square feet of well-equipped laboratory space within the OSU Biomedical Research Tower (Appendix C).

One PhD-level, OSU appointed faculty member will serve as the Program Director and will oversee and administer the program. One part-time (50% FTE) Administrative Assistant will be needed to help with program-related responsibilities such as general communications, course and room scheduling, and recruiting.

Projected additional costs associated with the program and evidence of institutional commitment and capacity to meet these costs.

We have developed a five-year budget projection with the assistance the OSU College of Medicine for the Master of Science degree (Appendix D). The budget includes the standard state subsidy for graduate programs. The program is predicted to be self-sufficient by year 2 and revenue generating in year 3.

Availability and adequacy of the faculty and facilities for the new degree program.

OSU is one of the largest research universities in the nation with more health sciences colleges and extensive laboratory and clinical infrastructure located in close proximity to one another than any other U.S. university. The Master of Science Graduate Program in Immunology and Microbial Pathogenesis will have an excellent infrastructure to support training and research. The OSU College of Medicine's Department of Microbial Infection and Immunity is currently located within the Biomedical Research Tower on the Medical Center Campus. Our teaching and research operations are at the intersection of all fields relevant to immunology and infectious diseases, including but not limited to, bacterial, viral, and parasitic infectious diseases, emerging pathogens, cancer immunotherapies, transplant immunology, autoimmune diseases, basic immunology, and neurodegenerative diseases. The Department's faculty researchers work in close collaboration with, for example: clinical faculty, faculty from the Department of Biomedical Engineering, the College of Veterinary Medicine, and industrial partners in all relevant fields (see appendices B and D for detailed descriptions of the facilities and faculty). Additionally, numerous University Institutes, such as the Infectious Disease Institute, the Pelotonia Institute for Immuno-Oncology, the Dorothy M. Davis Heart & Lung Research Institute, and OSU Centers such as the Center for Biostatistics, Center for Retrovirus Research, the Battelle Center for Science, Engineering and Public Policy, and the OSU Comprehensive Cancer Center all have research efforts that will complement and support the program.

Students will also have access to the OSU Medical Library, providing physical and electronic resources that include many of the books, periodicals, journals, and other learning resources needed to support the teaching and scholarly activities of this proposed program.

Evidence that a market exists for a new program

Scientists trained in the fields of Immunology and Microbial Pathogenesis are actively engaged in research and developing technologies to benefit the health and wellness of Ohio's residents. The need to ensure a safe food supply, the development of advanced immunology drugs for cancer and chronic inflammatory diseases, for combating the threat of infectious diseases caused by emerging pathogens, and antimicrobial resistance of existing pathogens are just a few examples of ongoing efforts within the state.

Accordingly, research and expertise in these fields are of increasing demand. According to the 2019 report by the state's bioscience organization, BioOhio: "Ohio's bioscience industry continues its strong history of innovation and discovery, with at least 3,300 organizations manufacturing products, providing essential services, or researching the next breakthrough at nearly 4,100 facilities around the state. This is an increase of 215 (6%) locations in the last five years and 889 (28%) since 2001." The report categorizes this industry into six areas, all of which employ workers trained in the fields of microbiology and/or immunology: agricultural biotechnology, medical and testing laboratories, medical devices & equipment, medical product distribution, pharmaceuticals & therapeutics, and research & development. Additionally, the report projects nearly 5,000 new jobs in these areas and workers in these fields earn well above the average living wage for Ohio. For example, according to the most recent data released by the U.S. Bureau of Labor Statistics (May 2018), microbiologists in central Ohio earn an average annual salary of $68,030.

Students earning the MS degree will also be competitive for higher compensation and supervisory roles in the workforce. According to the American Society of Microbiology, the addition of a Master of Science to a relevant Bachelor's degree will afford the graduate the opportunity to enter at a higher pay-scale and be considered for non-entry level specialties such as Clinical or Research Laboratory Managers, Biosafety Officers, and Instructor/laboratory coordinators (ASM publications, Careers in Microbiology and Microbial Sciences, 2019).

To maximize career prospects, it is expected that each student will interface regularly with the OSU Office of Student Life – Career Counseling and Support Services (https://ccss.osu.edu). This office provides counseling and support services, both on and off campus, to assist graduate and professional students in their career decision making processes. Additionally, the Program Director will meet with each student individually at the beginning of each term to discuss progress and career related goals.

STATEWIDE ALTERNATIVES

The program is highlighted by a laboratory-focused approach to graduate training that will serve a growing pool of students without detracting from existing programs across the state or local-partnership graduate programs. Students will benefit from education in laboratory management skills, host-pathogen interactions, infection and immunology-based bioinformatics, a world-class seminar series, and the variety of research carried out in the laboratories of our outstanding faculty. Additionally, MI&I provides significant interaction with PhD graduate students and post-doctoral scientists in an engaging training environment.

A comparison of related MS programs offered through University System of Ohio Institutions is outlined in Appendix E. The MS in Microbiology offered by the Department of Microbiology, College of Arts and Sciences at Ohio State University is offered on the Columbus campus and will serve as an alternative choice for prospective OSU students. The two programs differ however as the proposed program is designed specifically as a research-based, Thesis-awarded MS with a biomedical focus. Microbiology also offers a Thesis-MS as a terminal degree but also allows a non-thesis option for students (see attached letter of support and concurrence from the OSU Department of Microbiology, Appendix I). Relevant to this degree's area of focus, within the University System of Ohio's 14 four-year research universities, nine schools (including OSU) offer MS programs in microbiology and/or immunology related areas, only three of which are offered through university units conferring medical degrees (University of Cincinnati and University of Toledo). Geographically, the MS in Immunology and Microbiology at Wright State University is nearest at approximately 60 miles from the greater

Columbus metropolitan area. For this program, the proximity and relationship to a major academic medical center will afford trainees significant opportunity in clinical research. One ongoing example is the Department ofMicrobial Infection and Immunity's recent collaboration with the OSU Wexner Medical Center's Department of Pathology in leading the design and implementation of serological and micro diagnostic assays during the COVID-19 pandemic.

This program is unique, however, as it addresses the need for a work-force not only trained in the specialized knowledge of these areas of biomedical research, but also in the skill-set necessary to oversee and manage a productive research laboratory. Through required course content, graduates will gain knowledge of lab management practices such as staffing, purchasing, and safety oversight. This will set these graduates apart as they prepare to enter the work-force.

GROWTH OF THE PROGRAM

Current and future demand

Given the proximity to some of the state's largest bioscience employers (e.g. OSU, Abigail Wexner Research Institute at Nationwide Children's Hospital, Abbott, Battelle, Cardinal Health), we expect our program to be in demand. Based on estimates of laboratory space, classroom availability, and the 27 full-time faculty conducting research within the department, we believe the program is well-positioned to achieve a running average enrollment of 12 students. The program plans to admit 6 new students each academic year and, based on a budget estimate, to be financially self-sufficient by year 3. To meet these projections, we do not anticipate the need for additional faculty, staff, or space. However, If the program interest exceeds expectations, further review of enrollment limits and institutional needs will take place.

Program assessment

To maximize the success of each enrolled student, graduate, and future student, the program will maintain an active self-assessment process (Appendix F) This will include: annual recording of application and admission data; student academic performance indices; student evaluations of instruction (course satisfaction), semester-based student performance evaluations (reviewed by the program director and a committee of program faculty); annual evaluations of the program by member faculty; annual student evaluations of the program; exit surveys; time-to-degree tracking; and career recording of alumni. These assessment data will be reviewed annually by the program committee and used to continually refine the program. These data will also serve as support of applications seeking program funding.

CURRICULUM AND INSTRUCTIONAL DESIGN

Curricular content

The coursework for the proposed Master of Science in Immunology and Microbial Pathogenesis is designed to provide foundational learning through a defined set of required core courses (Table 1) delivered within a proposed 5-term series initiating each Autumn term, with an optional early Summer start to laboratory rotations (Appendix A). The curriculum will further concentrate sub-disciplines through recommended elective courses offered at Ohio State University (Appendix B) and thesis research mentorship by program faculty (Appendix H). Therefore, the curriculum is designed to provide a solid educational, technical, and experiential foundation for graduate students entering their choice of academic, industrial, regulatory, or related work forces. To accommodate the individual scheduling and health-related needs of each student, with the exception of the necessary lab-based learning, all coursework is compatible with Meeting OSU guidelines for optional, remotely accessed asynchronous learning should that be necessary.

Mixed mode of delivery

Given the hands-on, research experience mission of this program, a full, distance-learning option is not planned to be offered at this time and the preferred mode of delivery for the program is designed as an on campus, in-person learning format. In the event however that in-person learning is limited due to public health concerns, all lecture-based courses, with the exception of laboratory-based learning (MEMCIM 7998) will be offered via an online, synchronous mode of delivery. Currently all existing lecture-based core courses are being taught in a synchronous, online format (BSGP 7240, MEDMCIM 7500, 7010, 7400, and 8010) following the OSU Office of Distance Education and eLeanrning's Best Practices For Online Teaching Checklist (https://odee.osu.edu/instructors/distance-education/best-practices-online-teaching). In-person, laboratory research courses, which are an essential component of the intent of this program will be necessary and coordinated with guidance from the OSU College of Medicine and the Graduate School.

Table 1 – Master of Science in Immunology and Microbial Pathogenesis required courses

Additional core and elective courses are available within appropriate programs at OSU (Appendix B).

Course #	TITLE	CREDITS
MEDMCIM (# TBD)	MI&I Laboratory Scientific and Management Skills	2
MEDMCIM (#TBD)[a, c]	MI&I Laboratory Rotations	2[a]
MEDMCIM 7998[a, c]	MI&I Graduate Research	13[a]
MEDMCIM 7500[c, d]	Recent Discoveries in Immunology and Microbial Pathogenesis	4
BSGP 7240/MICRBIO 7724 [d]	Molecular Pathogenesis	3
MEDMCIM 7010 [d]	Molecular and Cellular Immunology	3
MEDMCIM 7400[b, d]	Advanced Topics in Microbial Pathogenesis	2[b]
MEDMCIM 8010[b, d]	Advanced Topics in Immunology	2[b]
MEDMCIM (#TBD)[c, d]	Thesis Writing	1
	Total core credit hours	30
Elective courses relevant to degree		≥10
	Total elective credit hours	10
	Total credit hours required for degree	40

a. Indicates research-based laboratory practicum course.

b. Students are required to select either 7400 or 8010 based on individual thesis focus under advisement of their research mentor/PI.

c. Course is graded pass/no pass

d. Meets OSU guidelines for remotely accessed asynchronous learning

Description of a required integrated, or culminating learning, experience

All students will be required to complete the OSU CARE Training in Responsible Conduct of Research Program (https://cehv.osu.edu/caretrainingprogram) or equivalent. This is a workshop-format program involving 8 discussion-based training sessions led and moderated by faculty ethicists from the OSU Center for Ethics and Human Values with expertise in research ethics and integrity. Participants will watch a video of a related CARE panel discussion and read a curated set of readings prior to engaging in substantive face-to-face (or remotely-arranged equivalent) discussions of case studies that highlight the distinctive ethical challenges facing researchers. Topics covered in this training include: Conflicts of interest, protection of human subjects, mentorship relationships, collaborative research, authorship and publication, data sharing and privacy, the researcher as a responsible member of society, and environmental and societal impacts of research.

A thesis project culminating with a written thesis document and successful defense will be required to educate students in research, professional writing, and continued self-education to promote their personal and professional growth. As part of the core curriculum, students will enroll in a laboratory rotation course (MI&I Laboratory Rotations, MEDMCIM XXXX) during AuY1 to aid in choosing a research mentor who will direct their project and guide them in developing their thesis. A thesis-writing core course will be required during SpY2 (MEDMCIM XXXX).

Should a student not be able to successfully complete their curriculum requirements during the five-term academic period, they will be allowed to petition the Immunology and Microbial Pathogenesis Program's Curriculum Committee to request additional time in which to complete their proposed project. If the petition is approved, the student will be required to enroll in additional laboratory research and thesis writing courses as necessary. Their degree will not be conferred until they have completed their research project and successfully defended their thesis document.

Appendices (Selective appendices are included for senate. All appendices are available on request).

Appendix A: Proposed Curriculum for the Master of Science in Immunology and Microbial Pathogenesis Degree Program

Summer 2021 (Optional)

MEDMCIM XXXX:	MI&I Laboratory Rotations	(2 credits)
		Semester Total: 2 credits

Autumn 2021

MEDMCIM XXXX:	MI&I Laboratory Scientific and Management Skills	(2 credits)
MEDMCIM 7020:	Molecular Pathogenesis	(3 credits)
MEDMCIM XXXX:	MI&I Laboratory Rotations (possible summer start is optional)	(2 credits)
MEDMCIM 7500:	Recent Discoveries in Immunology and Microbial Pathogenesis	(1 credit)
		Semester Total: 8 credits

Spring 2022

MEDMCIM 7010:	Molecular and Cellular Immunology	(3 credits)
MEDMCIM 7998:	MI&I Graduate Research	(2 credits)
MEDMCIM 7500:	Recent Discoveries in Immunology and Microbial Pathogenesis	(1 credit)
Elective		(2 credits)
		Semester Total: 8 credits

Summer 2022

MEDMCIM 7998:	MI&I Graduate Research	(5 credits)
Elective (or possibly required bioethics online)		(3 credits)
		Semester Total: 8 credits

Autumn 2022

MEDMCIM 7998:	MI&I Graduate Research	(3 credits)
BSGP 7400	Advanced Topics in Microbial Pathogenesis	(2 credits)
Or		
MEDMCIM 8010	Advanced Topics in Immunology	(2 credits)
MEDMCIM 7500:	Recent Discoveries in Immunology and Microbial Pathogenesis	(1 credit)
Elective		(2 credits)
		Semester Total: 8 credits

Spring 2023

MEDMCIM 7998:	MI&I Graduate Research	(3 credits)
MEDMCIM XXXX:	Recent Discoveries in Immunology and Microbial Pathogenesis	(1 credit)
MEDMCIM XXXX:	Thesis Writing	(1 credit)
Elective		(3 credits)
		Semester Total: 8 credits

Appendix B: Selected Relevant Elective Course offerings at Ohio State University

Department of Microbiology, OSU College of Arts and Sciences

MICRBIOL 5147 (3 credits): Eukaryotic Pathogens
MICRBIOL 5161 (3 credits): Bioinformatics and Molecular Microbiology
MICRBIOL 5270 (3 credits): Antibiotics and Natural Products
MICRBIOL 6010 (2 credits): Principles of Microbiology
MICRBIOL 6020 (3 credits): Microbial Physiology and Biochemistry
MICRBIOL 6080 (3 credits): Advanced Microbial Genetics
MICRBIOL 6155 (3 credits): Microbial Ecology and Evolution
MICRBIOL 7536 (2 credits): Advanced Food Microbiology

Department of Bioethics, OSU College of Medicine

BIOETHC 6010 (3 credits): Biomedical Research Ethics

Department of Biomedical Informatics, OSU College of Medicine

BMI 5710 (3 credits): Introduction to Biomedical Informatics
BMI 5760 (3 credits): Public Health Informatics
BMI 5770 (3 credits): Health Analytics: Data to Discovery to Dissemination

Appendix C: Physical Research Needs of the Program

OSU is one of the largest research universities in the nation with more health sciences colleges and extensive laboratory and clinical infrastructure located in close proximity to one another than any other U.S. university. The Master of Science Graduate Program in Immunology and Microbial Pathogenesis

The Department of Microbial Infection and Immunity is located within the Biomedical Research Tower of the Wexner Medical Center at The Ohio State University (OSUMC). The MI&I laboratories occupy approximately 23,000 sq. feet on the seventh floor of the Biomedical Research Tower, a 403,000-square-foot state-of-the-art building, across the street from the Medical Center. Major themes of the department are respiratory infectious diseases, intracellular parasitism, granulomatous inflammation, immunology, epigenetic control of innate and adaptive immunity.

MI&I Departmental Space and Resources
MI&I space includes several common user areas, with 2 cold rooms and multiple procedure rooms outfitted for molecular and tissue culture work, as well as rooms dedicated to microscopy (including live imaging microscopy) and radioactive studies (including one certified radioactive procedure room with 4 large working stations).

MI&I Core Equipment
Core MI&I equipment in the BRT includes: Class IIA 6 feet Biosafety Cabinets, double water-jacketed CO_2 incubators, multiple incubators and shakers for bacteria culture, a Sheldon Bactron anaerobic chamber, a Beckman Optima L-100 XP Ultracentrifuge with numerous rotors, a Beckman Optima™ TLX Ultracentrifuge, an Avanti J-25I High Performance centrifuge, a Beckman J2-21 centrifuge, low-speed Beckman Coulter X-14R/X15R refrigerated centrifuges, refrigerated microcentrifuges, several non-refrigerated microcentrifuges, a Molecular Devices SPECTRAmax M2e and a Molecular Devices SPECTRAmax M5 Multi-Mode spectrophotometer/luminometer/fluorometer microplate reader, a BioRad Bioplex Luminex-based multiplex system, a BioRad Tetrad 2 thermocycler, three eppendorf Mastercycler gradient thermocyclers, two BioRad MyCycler thermocyclers, BioRad iCycler thermocycler, two BioRad CFX96 and one Applied Biosystems real-time PCR systems, a BioRad Molecular Imager ChemiDoc XRS Imaging system, a Fotodyne Imaging system, a BD FACS Canto II Flow Cytometer, a Purelab and a Millipore Ultra water purification systems, a Beckman Biomek 2000 robotic system, two NanoDrop Spectrophotometers, a Savant speed-vac and gel dryer system, a size-exclusion chromatography system consisting of a HPLC connected to different sizing columns to perform lipoglycan purifications, silica gel column chromatography systems for lipid purifications, thin layer chromatography systems to allow for visualization and identification of lipids and carbohydrates, inverted microscopes with cameras, Olympus fluorescence microscope with DIC optics and software for camera, an IVIS Lumina Camera system, an Olympus FV10i confocal camera capable of life cell imaging, liquid nitrogen storage system, ATR/Heto Freeze-dryer lyophilizer, a BioRad Experion Automated Electrophoresis Station, liquid chromatography systems, a UV-crosslinking oven, UV transilluminator, a blue light transilluminator, two electroporators, two pH meters, water baths, shaking incubators, refrigerators, -20^{o}C and -80^{o}C freezers, balances, phosphoroimager, two autoclaves, and two automated dishwashers.

Additional Core Research Resources

The Department of Microbial Infection and Immunity has access to many state-of-the-art shared core research facilities (see https://medicine.osu.edu/research/resources/core-facilities for a full listing). Some examples relevant to the proposed degree program are:

OSU BSL-3 Research Core

Research projects involving risk group 3 (RG3) pathogens, such as ongoing SARS-CoV-2 takes place in the BSL3 facilities/resources available at The Ohio State University (OSU) and the OSU College of Medicine (OSU

COM). The BSL3 Facility focuses on RG3 respiratory pathogens including emerging pathogens (e.g. SARS-CoV-2), and pathogens that can cause worldwide chronic and antibiotic-resistant infections (e.g. *Mycobacterium tuberculosis)*. BSL3 facilities available for research include: a 3350 sq. ft lab space located in OSU Biomedical Research Tower (BRT), which consists of 6 separate laboratories for safely handling and processing infected tissues and cultures. These laboratories contain biosafety cabinets, centrifuges, microcentrifuges, light and fluorescent microscopes, ELISA and microplate readers, CO_2 and humidified incubators. Computer stations facilitate the safe removal of notes and data from the facility.

Access to BSL3 facilities is granted only when personnel receive thorough biosafety training and appropriate on-site training. Training materials are reviewed by the BSL3 Program leadership, Institution Biosafety Officer, and EH&S leadership. Biosafety training emphasizes the facility design and systems in place and the current rules for best practices and regulations that users must follow. Refresher training is provided on an annual basis and time sensitive issues are discussed in the monthly BSL3 user group (BUG). Further emphasis on administrative controls (e.g. BSL3 protocols), alongside on-site training focused on demonstrating proper application of personal protective equipment (PPE), facility features, and proper usage of equipment is given before authorization. Junior scientists must be accompanied and supervised by senior scientists who are experienced in BSL3-related techniques to ensure proper handling of infectious materials. The BSL3 program at OSU ensures that all BSL3 users are fully trained and supported by operational staff.

OSU University Laboratory for Animal Resources (ULAR)
Animals to be used for this study are covered by an institutional protocol. The basement level of the Biomedical Research Tower (BRT) houses the animal facility. This facility provides resources for the performance of experiments involving animal models of human diseases. ULAR is responsible for the animal care program that is AAALAC-accredited since 1962 (Accreditation # 028). Over 100,000 sq. ft of animal housing space in 15 facilities can accommodate rodents, rabbits, swine, ruminants, and dogs as well as other species. Rodent facilities have over 70 dedicated rooms, which include barrier housing, sterile housing, phenotyping, and GEM production facilities. ULAR consists of 3 veterinary ACLAM diplomats, 4 clinical veterinarians, and over 70 fulltime animal care staff.

OSU Flow Cytometry Shared Resource (FSCR) - This core facility assists in the analysis and sorting of cell populations according to the expression of selective cellular markers. Software available for use offline includes: WinMDI, Modfit, Cellquest Pro and FACSDiva. Imaging output software used is Microsoft office for both PC and Macintosh systems. Instrumentation includes the BD FACS Aria, and FACS Vantage and i-Cyt Reflection. Bectin-Dickinson FACS Caliber, equipped with 4 MPT's allowing for 4 color-analysis, using a 488 nm air-cooled Argon and 633 nm helium-neon laser as excitation wavelengths. The Becton-Dickinson FACS Vantage SE, capable of 6-color analysis, utilizing a Krypton 302C Inova laser for multi-line excitation 350-600 nm. This instrument has a turbo-sort option and a CLONECYT single-cell or multi-cell deposition system for microtiter plates or microscopy slides.

Campus Microscopy and Imaging Facility (CMIF, www.cmif.osu.edu) on the 2nd floor of the BRT offers a full range of microscopes, and support instrumentation allows cell and tissue preparation with immunocytochemistry, in situ hybridization, freeze-fracture, cryo-ultramicrotomy, scanning and transmission electron microscopy (FEI Nova 400 Nano SEM, FEI Tecnai G2 Bio Twin TEM). This facility also has a Zeiss LSM510 Scanning Confocal Microscope, an Olympus FV1000 Multiphoton, and a Visitech Infinity 3 Live-Cell Confocal Microscope. All microscopes are staff-operated or self-operated after training.

Laser Microdissection Pressure Catapulting Molecular Analysis Facility- This core facility contains a robotized PALM MicroLaser system with PALM MicroBeam IV instrument from Carl Zeiss MicroImaging GmbH and PALM RoboStage/RoboMover for high throughput sample collection. The facility enables molecular analyses of laser captured tissue material. Services include standardization of novel techniques related to tissue processing, staining, fixation and capture, with the goal of preserving nucleic acid and protein integrity of the laser-captured tissue. Capture and analysis of tissue down to the resolution of a single cell population (cutting

precision 0.6 micron) from *in vivo* tissue sections is routinely performed. In addition, the facility has developed a way to rapidly identify and capture human blood vessels from clinical samples in a manner that makes high-density screening of the transcriptome possible.

The Genomics Shared Resource - This resource occupies about 2,400 square feet on the 2nd floor of the Biomedical Research Tower (BRT). The Genomics Shared Resource provides both Nucleic Acid services and Microarray services. It offers instrumentation and expertise for DNA and RNA analysis using sequencing, genotyping, real-time PCR, Affymetrix GeneChips, nCounter Analysis, next-generation sequencing, DNA synthesis support and genome-wide analysis using the Illumina NGS platform and Affymetrix and customizable gene chips. Affymetrix GeneChip System including two GeneChip Hyb-Station Oven 320/640, Two Affy. Fluidics Station 450 and One Affy. GeneChip Scanner 3000. The system for in-house custom microarray including GeneMachine OminiGrid 100 Arrayer; Tecan TeMo Liquid Handling Workstation and four Tecan HS4800 Hybridization Stations; two Axon 4000B and 4200A Microarray Scanners, two MJ Tetrad thermocycler and PE 9700 PCR Machines. Applied Biosystems 3730 DNA Analyzers, Illumina Genome Analyzers IIx, 4 Applied Biosystems 7900HT sequence detection systems, NanoString Technologies' nCounter System, Sequenom Compact MassArray, Transgenomic Wave DHPLC Systems, Beckman Biomek FX liquid handler, Typhoon 9410 imager and Personal Densitometer from GE Healthcare, Agilent Bioanalyzer.

The OSU Campus Chemical Instrument Center (CCIC, www.ccic.ohio-state.edu), located on the 2nd floor of the BRT, provides state-of-the-art research facilities in three areas: Nuclear Magnetic Resonance (NMR), Mass Spectrometry (MS) and Proteomics Facility. The Mass Spectrometry and Proteomics facility is directed by Dr. Liwen Zhang and is equipped to offer a broad range of services with seven state-of-the-art mass spectrometers: a Thermo LTQ-Orbitrap, a Thermo LTQ, a Bruker Esquiere LC/MS, a Micromass LC-TOF, a Bruker Reflex III MALDI-TOF, a Thermo Trace GCMS, and a Micromass Q-TOF II. The lab is also equipped with an Ettan Spot Handling Workstation and a Dalt12 system for complete proteomic analysis including gel electrophoresis separation and subsequent protein identification, post-translational modification analysis and MudPIT. These instruments provide for accurate mass determination, sequence determination of biomolecules, oligonucleotides analysis, molecular weight analysis by mass assignment (ESI, EI, MALDI), quantification using GC-MS, and peak detection and identification by LC/MS.

Comparative Pathology & Mouse Phenotyping Shared Resource (CPMPSR) Facilities- The CPMPSR provides expert, readily available and affordable experimental pathology support to investigators utilizing animal models to study human disease. Comparative pathologists affiliated with the CPMPSR are familiar with normal anatomy and physiology, as well as background age- and strain-related lesions of various animal models. Recognition of lesions and their interpretation in the context of individual investigations provides a critical component to research incorporating animal models. Services include comprehensive macroscopic and microscopic examinations of various species of laboratory animals with an emphasis on the phenotypic characterization of newly produced lines of genetically engineered mice. Additional services include hematology, clinical chemistry, radiography, routine frozen and paraffin slide preparation as well as tissue microarray preparation and special histochemical and immunohistochemical staining. The main laboratory for the CPMPSR is located on the 4th floor (467/471) of the Veterinary Medicine Academic Building (VMAB). The core has: a Euthanex SMARTBOX unit; 7' TBJ, Inc. 36-84-S down-draft, height-adjustable necropsy table; a 4' Pacific Southwest Prep Station Lab down-draft tissue trimming station; necropsy equipment; an Olympus SZ-6145TR stereozoom microscope with attached Altra 20 digital camera; Hewlett Packard Faxitron Series Cabinet Xray System; and, photographic equipment (Nikon D90 digital SLR with Nikon 60 2.8 micro lens, photo stand and lighting). The necropsy room is also equipped with a MOPEC LD500 ventilated tissue storage cabinet. The clinical pathology laboratory is equipped with automated benchtop hematology (FORCYTE Autosampler 10 with OSI Data Management System) and chemistry (VetAce) analyzers, as well as an Aerospray hematology slide stainer-centrifuge with Cytopro rotor. The laboratory also includes a Fisher double door refrigerator, 2 Thermo Forma freezers (-70^{o}C), and, 2 refrigerated centrifuges (Beckman Allegra X-22, Eppendorf). In addition, the lab has a doubled-headed Olympus BX41 light microscope with attached Altra 20 digital camera for performing blood differential counts and evaluation of urine/fluid/cytology samples. The histology laboratory (302 Goss Laboratory)

occupies approximately 1160 sq. ft. and includes Tissue Tek VIP and Fischer Histomatic 266 MP tissue processors; Shandon HistoCentre 2 and Tissue Tek embedding stations; 6 microtomes (Olympus 4055 micro, Leitz 1512, HM315); a Dako Universal Training Center autostainer with Seymour slide labeler; a Leica IPS modular histology slide printer; Microm HM500 OM and Leica CM1950 cryostats; and, an Olympus BH2 immunofluorescence light microscope. Other support equipment includes pH meter, balances, centrifuges, FG-311 refractometer and vortex mixers. Room 933 in the Biomedical Research Tower is used for image analysis and discussing pathologic findings with investigative staff. The room includes a 6-headed Olympus BX51 light microscope with attached Altra 20 digital camera and MicroSuite software linked to a 42" Panasonic plasma television. Reference laboratories, including AniLytics, Incorporated in Gaithersburg, MD and Rules Based Medicine in Austin, TX provide specialized testing such as hormone and cytokine assays.

OSU Human Tissue Resource Network (HTRN)**, Pathology Core Facility.** The core has: Microtomes (4), Cryostat (1), Tissue Processor (1), Water Baths (5), Automated Slide Stainer (1), Automated Immunohistochemistry Instrument (DAKO) (2), Automated Slide Labeler (TBS) (1), Tissue Matrix Array (Beecher Instruments) (1), Vacuum Processor (1), Refrigerators (2), Freezers (3), Real(time PCR (Roche) (1), ABI(3130XL DNA Sequencer (1), Microcentrifuge (2), Balances (2), Bioview Accord Semi(automated ScanningSystem (1), Biosafety Hood (1), Incubators (3), Drying Oven (1), Thermomixers (2).

The Center for Biostatistics, Department of Biomedical Informatics, is located at 1800 Kenny Rd, Columbus, OH, 43210. The Center for Biostatistics is equipped with a diverse palette of statistical software including SAS 9.4 (SAS Institute Inc., Cary, NC), STATA 13 (StataCorp, College Station, TX), Minitab (Minitab, Inc., State College, PA), R (open resource) and PASS 12 (NCSS, Kaysville, UT),) and specialized freeware Bio-conductor. The support of the office management software includes site-licensed Microsoft Office Professional. Through the Medical Center computer network, statisticians are provided with e-mail support, access to the Internet, and immediate back- up of all files.

The BRT is connected by an enclosed walking bridge with the **Dorothy M. Davis Heart and Lung Research Institute (DHLRI)**, which contains several additional core research laboratories (Bioinformatics, Microarray-Genetics, EPR-NMR, Proteomics, and Integrative Cardiovascular Physiology). Each of these Cores is directed by a faculty scientist who is a leading expert in the specific technology of the Core. Each also has an experienced full-time manager who supports the application needs of the scientific users. **DHLRI Animal Core**- This core offers support for mouse colony management as well as performing specialized procedures and providing technical assistance for experiments. Our collaborator, Dr. Amer oversees the breeding of transgenic animals. Services also provided, but not limited to, include administration of reagents via various routes; tissue, blood, and bone marrow isolation; procedure training; genotyping; and special feeding._**DHLRI Microscopy Core-** This microscopy core laboratory with several fluorescent microscopes, time-lapse video microscopy and multi-channel visualization of fluorescence cellular antigens and other cell markers. (Nikon Eclipse 800 with DIC optics microscope and a Zeiss LSM510 multiphoton confocal inverted microscope).

Also, within the BRT is The Ohio State University **Comprehensive Cancer Center** (OSUCCC, www.osuccc.osu.edu). Located on the 8th and 9th floors, and part of the 10th floor, the OSUCCC houses core facilities for DNA sequencing radiochemistry, biostatistics and informatics, real-time PCR, Transgenic Animal Shared Resources, microarray, spectroscopy, electrophoresis, centrifugation, liquid scintillation counters, gamma counter chromatography (including HPLC), and microscopy.

Next to the BRT is the Biological Sciences building, which contains the Department of Microbiology (undergraduate Microbiology) and the Plant-Microbe Genomics Facility (PMGF, pmgf.osu.edu). The Plant-Microbe Genomics Facility provides services for DNA sequencing, DNA microarray work, and proteomics protocols.

The Research Institute at **Nationwide Children's Hospital** (10 minutes from OSU) has a Vaccine and Immunity Research Group with core facilities containing DNA sequencing, Microarray, and Transgenic capabilities.

Appendix D: Five-year Projected Master's Program Budget

Master of Science (MS) in Immunology and Microbial Pathogenesis

	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028
Tuition Revenue							
Full Time Track							
Number of Students	6	12	12	12	12	12	12
Average Annual Credit Hours per student	24	20	20	20	20	20	20
Total Annual Credit Hours	144	239	239	239	239	239	239
Average Annual Hours (prior 2 year window)		72	192	239	239	239	239
Tuition per student, Au + Sp (in-state, 5% annual increase)	12,425	13,046	13,698	14,383	15,102	15,858	16,650
Tuition per student, Summer (in-state, 5% annual increase)	6,134	6,441	6,763	7,101	7,456	7,829	8,220
Tuition per FT student (assume year 2+ 0.83 FTE, 5% annual increase)	18,559	16,174	16,983	17,832	18,723	19,660	20,643
Full Time Totals	111,353	194,088	203,792	213,982	224,681	235,915	247,711
University Tax on Tuition (35% per Dan Clinchot)	27,838	48,522	50,948	53,495	56,170	58,979	61,928
Revenue from Tuition	**83,515**	**145,566**	**152,844**	**160,486**	**168,511**	**176,936**	**185,783**
Subsidy Revenue							
Effective Rate (estimate, 2% annual increase)	270	275	281	287	292	298	304
Subsidy Generated	0	19,829	53,800	68,491	69,861	71,258	72,683
Tax on Subsidy (35%)	0	6,940	18,830	23,972	24,451	24,940	25,439
Revenue from Subsidy	**0**	**12,889**	**34,970**	**44,519**	**45,410**	**46,318**	**47,244**
Student Fee Revenue							
Annual Lab Supply Fees (40 hour week)	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Research hours/week	12	12	12	12	12	12	12
Revenue from Fees	4,500	7,470	7,470	7,470	7,470	7,470	7,470
Expenses							
Personnel							
Program Director (assuming 75% FTE +24.6% fringe, 2.5% annual increase	93,450	95,786	98,181	100,635	103,151	105,730	108,373
Administrative Assistant (assuming 50% FTE + 32.3% fringe, 2.5% annual	33,075	33,902	34,749	35,618	36,509	37,421	38,357
Graduate/Postdoc TA Stipends (5% annual increase)	3,000	3,150	3,308	3,473	3,647	3,829	4,020
Misc. (5% increase)	2,000	2,100	2,205	2,315	2,431	2,553	2,680
Marketing (5% annual increase)	3,000	3,150	3,308	3,473	3,647	3,829	4,020
Travel (5% annual increase)	3,000	3,150	3,308	3,473	3,647	3,829	4,020
Total Expenses	**137,525**	**141,238**	**145,058**	**148,987**	**153,030**	**157,191**	**161,471**

	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028
~~Total Revenue (tuition, subsidy, fees)~~	~~88,015~~	~~165,925~~	~~195,284~~	~~212,476~~	~~221,390~~	~~230,724~~	~~240,497~~
Total Expenses (personnel, misc.)	137,525	141,238	145,058	148,987	153,030	157,191	161,471
Total Income	**-49,510**	**24,687**	**50,226**	**63,488**	**68,360**	**73,534**	**79,026**

Budget estimate is based upon:

Completion of the required minimum of 48 credit hours for the MS

6 students in year 1 with a total enrollment of 12 thereafter

Full time students complete in 5 semesters (minimum 8 credits/semester)

Fees for supplies based on the projected weekly research credit hours relative to a current departmental estimate of $2,500/year for a full-time PhD trainee

75% effort by Program Director

50% effort by Administrative Assistant

Appendix E: Statewide Alternatives

Institution	Degree Designation	Required Credit Hours	Research requirement?	Thesis?
Kent State Univ.	MS in Biology w/ microbiology emphasis	≥32	Yes	Yes
Miami of Ohio	MS in Microbiology	≥30	Optional	Optional
OSU (Dept. of Microbiology)	MS in Microbiology, thesis MS in Microbiology, non-thesis	>44 >30	Yes	No
Ohio University	MS in Biological Sciences	≥30	Yes	Yes
Univ. of Akron	MS in Biology	≥40 (≥12 in research)	Yes	Optional
Univ. of Cincinnati	MS in Molecular Genetics, Biochemistry & Microbiology	≥30	Yes	Yes
Univ. of Cincinnati/Cincinnati Children's	MS in Immunology	≥30	Yes	Yes
Univ. of Toledo	MS in Medical Immunology and Microbial Pathogenesis	≥40	Yes	Yes
Wright State Univ.	MS in Immunology and Microbiology	≥30	No	No
Youngstown State	MS in Biological Sciences with specialization in Immunology or Microbial Pathogenesis	≥36	Optional	Optional

Appendix F: Program Goals and Plan for Program Assessment

The goal of the MS Program in Immunology and Microbial Pathogenesis is to provide focused, formal, hands-on research training for Ohio residents seeking careers in academic, pharmaceutic, biotech, agriculture, government, and public health fields. At the completion of the degree, students will be able to demonstrate a depth of knowledge and practical skill-set in the following key areas:

- Laboratory management practices including the day-to-day logistics of laboratory operations (e.g. scheduling, ordering, personnel management, safety guidelines)
- Foundational and advanced knowledge of the fields of immunology and microbial pathogenesis
- Capacity to properly design, conduct, interpret, and present independent research experiments and projects
- Ability to convey, in written form, scientific hypotheses, research proposals, and findings as demonstrated through the successful completion of a written thesis

The program will have an active self-assessment process as outlined in Table 2 with data to be maintained in a secure database administered by the program, accessible by only the Program Director and Administrative Assistant. Relevant public data will also be posted on the program's website. These assessment data will be reviewed annually by the program committee to continually refine the program and identify weaknesses in meeting the program's overall goal of providing a student the highest possible chance for a rewarding career following graduation. These data will also serve as support for applications seeking program funding sources to aid in enrollment in the form of student scholarships. The program will track direct measures of student learning (e.g. course and cumulative GPA, graduation rates, time-to completion) to serve as indicators of ongoing program performance and program quality. For example, research-related measures of student authorship on scientific publications as well as oral and poster-based research presentations will be collected and evaluated as an indicator of both student and program faculty performance and enthusiasm. Similarly, advisors and program leadership will monitor student academic performance regularly through advisory one-on-one meetings each semester with both the student and research mentor. Advising sheets will be completed to summarize and record these meetings and signed by the student, their research advisor (if applicable), and the program director.

Table 2 – Program Assessment

Assessment	Primary Metrics	Reporting/Review Frequency	Administered by	Reviewed by	Alignment between Program Goals and Assessments
Program application and enrollment data	Tracking of of applications, applicant GPAs, applicant diversity, offer and acceptance rates	Annually, Sp term	Program Director/Administrative Assistant	Program Faculty Committee and posted on Program website	Assessment of program strengths and weaknesses in recruitment (e.g. low applicant diversity, trends in average GPA) to help meet program enrollment goals
Program academic performance	Time-to-degree tracking, average GPA, publication and presentation data	Annually, Sp term	Program director/Administrative Assistant	Program Faculty Committee	Assessment to evaluate program performance (e.g. employment/placement rates) to meet quality of program
Student academic performance	GPA, research advisor and thesis committee evaluations	Beginning of each academic term (Au, Sp, Su)	Administrative Assistant	Program Director	Assessment of student progress to meet GPA and expected graduation date.
Student satisfaction	Student evaluations of instruction (SEIs), one-	Beginning of each academic term (Au, Sp, Su) and upon	Administrative Assistant and Program Director	Program Faculty Committee	Assessment used by the program to provide feedback to the

	on-one advisory meetings, exit surveys	graduation (exit surveys)			program and course directors to ensure student expectations are met
Faculty satisfaction	Program faculty reviews	Annually, Sp term	Administrative Assistant	Program Faculty Committee	Assessment to monitor and maintain faculty enthusiasm and support of the program to continually improve the student course and lab research experience
Program Performance	Alumni career recording	Annually, Au term	Administrative Assistant	Program Faculty Committee, Posted on Program website	Assessment to evaluate program graduate employment success to help meet the overall goal of the program.

Appendix G: Course Descriptions/Syllabi (Individual Course syllabi removed for brevity for senate, but are available upon request)

Advising Sheet: OSU Master of Science in Immunology and Microbial Pathogenesis
Total Credits Required: 40

Date: _____
Student Name: _____
OSU email address: _____
Entering Term: _____
Research Advisor _____

A: Core Courses (27 credits – complete all courses)

Course	Hours	Term and Year	Grade
MEDMCIM 7XXX: MI&I Scientific and Laboratory Management Skills	2		
MEDMCIM 7XXX: MI&I Laboratory Rotations	2		
MEDMCIM 7010: Molecular and Cellular Immunology	3		
MEDMCIM 7020: Molecular Pathogenesis	3		
MEDMCIM 7500: Recent Discoveries in Immunology and Microbial Pathogenesis	4 (total hours)		
MEDMCIM 7998: MI&I Graduate Research	13 (total hours)		

B: EMPHASIS AREA CORE COURSES (2 credits – choose one course from the following list)

Course	Hours	Term and Year	Grade
BSGP 7400: Advanced Topics in Microbial Pathogenesis	2		
MEDMCIM 8010: Advanced Topics in Immunology	2		

C: ELECTIVE COURSES (≥10 credits selected from list below or relevant courses by permission of advisor)

Course	Hours	Term and Year	Grade

MICRBIOL 5161: Bioinformatics and Molecular Microbiology	3		
MICRBIOL 5270: Antibiotics and Natural Products	3		
MICRBIOL 6010: Principles of Microbiology	2		
MICRBIOL 6020: Microbial Physiology and Biochemistry	3		
MICRBIOL 6080: Advanced Microbial Genetics	3		
MICRBIOL 6155: Microbial Ecology and Evolution	3		
MICRBIOL 7536: Advanced Food Microbiology	2		
BIOETHC 6010: Biomedical Research Ethics	3		
BMI 5710: Introduction to Biomedical Informatics	3		
BMI 5760: Public Health Informatics	3		

Appendix I: Letters of Concurrence and Support

Letters from the followlng departments and programs were supportive and available upon request.

1. Dr. Igor Jouline, Chair
   Department of Microbiology
   OSU College of Arts and Sciences

2. Dr. Prosper Boyaka, Chair and Microbial Biology Program co-director
   Department of Veterinary Biosciences
   OSU College of Veterinary Medicine

3. Dr. Jeffrey Parvin,
   Associate Dean for Graduate Studies
   Director, Biomedical Sciences Graduate Prog.
   OSU College of Medicine

Appendix H: Program Faculty (curriculum vitae of program faculty omitted for senate but are available upon request