



New Program Report

Date Submitted:

11/19/2021

Institution

University of Missouri-Columbia

Site Information

Implementation Date:

8/1/2022 12:00:00 AM

Added Site(s):

Selected Site(s):

University of Missouri-Columbia, 105 Jesse Hall, Columbia, MO, 65211

CIP Information

CIP Code:

261401

CIP Description:

A program that focuses on the scientific study of the molecular and cellular basis of disease, and the application of this knowledge to the development of new clinical and diagnostic tools, medications, and therapies. Includes instruction in cell biology, molecular biology, physiology, pharmacology, biochemistry, genetics, pathology, molecular immunology, research and quantitative methods, and biomedical research computing.

CIP Program Title:

Molecular Medicine

Institution Program Title:

Translational Biosciences

Degree Level/Type

Degree Level:

Doctoral Degree (Research PhD)

Degree Type:

Doctor of Philosophy (Ph.D.)

Options Added:

Collaborative Program:

N

Mode of Delivery

Current Mode of Delivery

Classroom

Student Preparation



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Special Admissions Procedure or Student Qualifications required:

Students who enter the Translational Biosciences PhD program must have earned a BS or BA degree in a relevant discipline from an accredited institution of higher education. We recommend that students have taken undergraduate coursework in disciplines that are relevant for biomedical research, including calculus, statistics, physics, chemistry, biology, genetics, biochemistry and physiology. Prior experience in research is highly recommended. We recognize that students with diverse undergraduate educational experiences will matriculate into the program. Thus, one goal of the first-year coursework is to provide all students with basic understanding of the language of biomedical research, particularly in the areas of genetics, biochemistry and data analysis.

Specific Population Characteristics to be served:

n/a

Faculty Characteristics

Special Requirements for Assignment of Teaching for this Degree/Certificate:

All faculty members who are course instructors must have a terminal degree (PhD or MD) in an appropriate biomedical or clinical discipline. Faculty members who serve as members of a student’s Doctoral Program Committee (DPC) must have Graduate Faculty Status “A”, as determined by the MU Graduate Faculty Senate. Faculty members who serve as Chair of a student’s DPC must have Doctoral Faculty membership, as determined by the MU Graduate Faculty Senate.

Estimate Percentage of Credit Hours that will be assigned to full time faculty:

100% of all credit hours of instruction will be assigned to full-time faculty.

Expectations for professional activities, special student contact, teaching/learning innovation:

Faculty mentoring is a critical component of all research training programs. We will work with the MU Graduate School to develop a faculty mentor training program. Faculty that do not participate in faculty mentor training will not be eligible to serve on a student’s DPC, as either a regular member or chair.

Student Enrollment Projections Year One-Five

Year 1	Full Time: 8	Part Time: 0	
Year 2	Full Time: 11	Part Time: 0	
Year 3	Full Time: 14	Part Time: 0	Number of Graduates: 0
Year 4	Full Time: 17	Part Time: 0	
Year 5	Full Time: 20	Part Time: 0	Number of Graduates: 0

Percentage Statement:

n/a

Program Accreditation



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Institutional Plans for Accreditation:

There are no national or state organizations that specifically provide accreditation for biomedical PhD programs. At the institutional level, the University of Missouri-Columbia is accredited by the Higher Learning Commission (<https://www.hlcommission.org>). The Higher Learning Commission is one of six regional accreditors in the United States that accredits degree-granting post-secondary institutions. The most recent accreditation of the University of Missouri-Columbia was completed in 2015. The next accreditation will occur in 2024-2025.

To maintain its accreditation by the Higher Learning Commission, the University of Missouri-Columbia requires that all degree-granting programs establish learning objectives for the program and individual courses and track the educational outcomes of the students. The University of Missouri-Columbia has a program review process that ensures all accreditation standards are met.

Program Structure

Total Credits:

72

Residency Requirements:

n/a

General Education Total Credits:

0

Major Requirements Total Credits:

72

Course(s) Added

COURSE NUMBER	CREDITS	COURSE TITLE
	6	Emphasis Area Coursework
	23	Dissertation Research
	2	Rotation Research
	18	Seminars and Journal Clubs
	11	Program-specific Coursework

Free Elective Credits:

3

Internship or other Capstone Experience:

A PhD dissertation is required. A PhD dissertation describes new findings, including field observations and experimental data, that address a previously unanswered question in an area of human inquiry. Students in the Translational Biosciences PhD program are required to write a dissertation and to present a public defense of the dissertation. All dissertations that are successfully defended will be published by MU. In addition, the research results described in the dissertation must be published in one or more scientific journals as peer-reviewed manuscripts. The Translational Biosciences PhD program will require that all PhD graduates have at least 1 first-author research publication related to the dissertation research.

Assurances

I certify that the program is clearly within the institution's CBHE-approved mission. The proposed new program must be consistent with the institutional mission, as well as the principal planning priorities of the public institution, as set forth in the public institution's approved plan or plan update.

I certify that the program will be offered within the proposing institution's main campus or CBHE-approved off-site location.



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I certify that the program will not unnecessarily duplicate an existing program of another Missouri institution in accordance with 6 CSR 10-4.010, subsection (9)(C) Submission of Academic Information, Data and New Programs.

I certify that the program will build upon existing programs and faculty expertise.

I certify that the program can be launched with minimal expense and falls within the institution's current operating budget.

I certify that the institution has conducted research on the feasibility of the proposal and it is likely the program will be successful. Institutions' decision to implement a program shall be based upon demand and/or need for the program in terms of meeting present and future needs of the locale, state, and nation based upon societal needs, and/or student needs.

Contact Information

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Kent

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Appendix C: Translational Biosciences Program Course Information

Syllabus for MPP 8500 (basis for Molecular and Cellular Biosciences I)

Syllabus for Data Design and Analysis

Syllabus for MPP 8550 Skills in Translational Biosciences I and II

Syllabus for LAB AN 9476

Summary of Coursework

Year 1: Fall Semester. All first-time students will take all of the courses listed below. During Fall Semester of Year 1, graduate students will take a total of 9 credit hours.

Course numbers for existing courses are provided below. When the Translational Biosciences program is approved, the course numbers for Program-specific courses will be changed from a departmental prefix (i.e., MPP or MICROB) to a program-specific prefix (TRABIO).

1. Molecular and Cellular Biosciences I: (MPP 8500; cross-listed as BIOCHM 8240); 3 credit hours: This will be a 3 credit-hour course that will cover the core concepts of genetics and biochemistry in the context of selected human diseases. Specific human diseases will be selected on the basis of how they exemplify particular aspects of genetics and biochemistry. This course will focus on the experimental approaches and data analyses as described in recent literature articles. Over the past three years, we have taught this course as 5-credit hour, one-semester course. The content of the existing course will be trimmed to fit into a 3-credit hour, one-semester course. A syllabus, a list of participating instructors and the required literature reading list for Fall 2020 Semester for the existing 5 credit-hour format of MPP 8500 is included in Appendix C.

2. Data Design and Analysis I: (Course is being developed; course number is not available); 3 credit hours: This new 3 credit-hour course will cover core concepts of statistical design and data analysis. The course will cover fundamental aspects of statistics as applied to biological problems and emphasize computational approaches, including R and Python, for data analysis. The instructors for this course will be Dr. Bartlett and Dr. Greg Petroski, a PhD statistician in Family and Community Medicine and the Medical Research Office. This course, which is being developed, will be modeled after a similar course (FMED 505) that Dr. Bartlett developed at McGill. A syllabus for Data Design and Analysis I is included in Appendix C.

3. Professional Skills for Translational Bioscientists: (MPP8550); 1 credit hour. This course will introduce students to a wide range of technical and professional skills that biomedical scientists need to have. This course will include 8 hours of class time devoted to Research Ethics, a component of research training required of all NIH training grants. The co-instructors of this course will be Dr. Alan Parrish and Dr. Gillian Bartlett. A syllabus of this course is included in Appendix C.

4. Rotation Research: (MICROB 8450); 1 credit hour: The goal of research rotations is to allow first-year graduate students to gain experience in the research laboratories that they are considering as potential mentors. Each rotation experience will be 8 weeks and each student will rotate in two different laboratories during their first semester. All faculty in the School of Medicine who have Doctoral Status or Graduate Faculty Status "A" are potential mentors for rotation research experiences. Each rotation experience is 1 credit-hour. A list of the 198 faculty members in the School of Medicine who have Doctoral Status or Graduate Faculty Status "A" is provided in Appendix E.

5. Research Seminar: (MPP 8412); 1 credit hour: The goal of the 1 credit-hour research seminar course is to expose first-year graduate students to the diverse research programs of faculty mentors at MU. There will also be a number of invited research seminars presented by faculty from other universities. All first-year students in each cohort will take the Research Seminar both semesters. This seminar will be directed by one or more members of the Executive Committee (Dr.

Gillian Bartlett, Dr. Mark Hannink, Dr. Mark Daniels, Dr. Charlotte Phillips, Dr. James Amos-Landgraf, Dr. Alan Parrish, and Dr. Chris Hardin).

Year 1: Spring Semester: Students will continue with the Professional Skills class, as well as continuing with Rotation Research and Research Seminar. Students will also take introductory 8000-level coursework offered by the different Emphasis Areas. All other courses listed below will be taken by all first-year students.

1. Professional Skills for Translational Bioscientists: (MPP8550); 1 credit hour. This course will introduce students to a wide range of technical and professional skills that biomedical scientists need to have. In the second semester, this course will emphasize how to communicate across disciplines. The co-instructors of this course will be Dr. Alan Parrish and Dr. Gillian Bartlett.

2. Rotation Research (MICROB 8450): 1 credit hour: In the Spring Semester, students will participate in one research rotation experience of 8 weeks, for one credit hour. At the semester midpoint, students will choose their primary faculty mentor and may begin their dissertation research. Students will be allowed to do a fourth research rotation, if needed. Students who are unable to identify a primary faculty mentor after four rotations will not be allowed to continue in the PhD program. All faculty in the School of Medicine who have Doctoral Status or Graduate Faculty Status "A" are potential mentors for rotation research experiences. A list of the 198 faculty members in the School of Medicine who have Doctoral Status or Graduate Faculty Status "A" is provided in Appendix E.

3: Research Seminar (MPP 8412): 1 credit hour: The goal of the 1 credit-hour research seminar course is to expose first-year graduate students to the diverse research programs of faculty mentors at MU. There will also be a number of invited research seminars presented by faculty from other universities. All first-year students in each cohort will take the Research Seminar both semesters. This seminar will be directed by one or more members of the Executive Committee (Dr. Gillian Bartlett, Dr. Mark Hannink, Dr. Mark Daniels, Dr. Charlotte Phillips, Dr. James Amos-Landgraf, Dr. Alan Parrish, and Dr. Chris Hardin).

4: Emphasis Area Coursework; 6 credit hours (multiple courses): The Emphasis Area-specific courses that will be taken by first-year graduate students will be literature survey courses that introduce graduate students to the current research topics in each Emphasis Area. Students who are interested in multiple Emphasis Areas will be encouraged to take courses offered by different Emphasis Areas. The faculty in each Emphasis Area will be responsible for determining the specialized coursework for graduate students in a given Emphasis Area, such that the students will become experts in the relevant domain(s) of knowledge. Sample courses of study for five of the six Emphasis Areas is included in Appendix D. The Population and Precision Health Emphasis Area course of study is being developed. All of the courses listed in the Appendix are currently offered on the MU campus and one or more of the current instructors will be associated with the appropriate Emphasis Area. The number of Emphasis Area-specific credit hours will vary from 6 to 15 credit hours.

5. Selection of Emphasis Area: By the start of the second semester of their first year, graduate students will choose their Emphasis Area. In most cases, we anticipate that the students' primary research advisor will be a member of the Emphasis Area selected by the student. Students will be expected to choose the members of their Doctoral Program Committee by the end of their first year. Each Doctoral Program Committee will consist of at least four faculty, including one

faculty member with Graduate Faculty Status “A” who is from outside the School of Medicine. The student’s primary faculty mentor will serve as chair of the Doctoral Program Committee. Throughout the course of their graduate training, the Doctoral Program Committee will have the primary responsibility for guiding the student’s dissertation research.

Year 2: Fall Semester. Students will begin to take specialized courses appropriate for their respective Emphasis Area during their second year of graduate study. Further information on Emphasis Area-specific courses is listed in the Appendix. In addition to didactic coursework, the second-year students will also participate in a weekly Emphasis Area seminar series that brings together the faculty and students in that Emphasis Area. To develop the ability of students to communicate across disciplines, the students in each cohort year will also participate in a Translational Biosciences Journal Club.

1. Emphasis Area Coursework; 3-6 credit hours: The faculty in each Emphasis Area will be responsible for determining the specialized coursework for graduate students in a given Emphasis Area, such that the students will become experts in the relevant domain(s) of knowledge. Sample courses of study for five of the six Emphasis Areas is included in the Appendix. The Population and Precision Health Emphasis Area course of study is being developed. All of the courses listed in the Appendix are currently offered on the MU campus and one or more of the current instructors will be associated with the appropriate Emphasis Area. The number of required credit hours in each Emphasis Area vary, from 6 to 15 credit hours.

2: Emphasis Area Research Seminar; 1 credit hour: The Emphasis Area seminars will feature invited speakers from outside MU as well as presentations by faculty and students. Several of the current PhD programs already have departmental Research seminars, which will be repurposed as Emphasis Area Research Seminars. The other Emphasis Areas will develop a weekly Research Seminar program. Selected faculty from each Emphasis Area will be responsible for each Emphasis Area Research Seminar.

3: Translational Biosciences Journal Club, by cohort; 1 credit hour: The Translational Biosciences Journal Club will be a student-driven journal club, in which the students in each cohort will read and discuss research articles selected by the students on a rotating basis. Each cohort will have a faculty member who will serve as a facilitator. This faculty member will stay with a specific cohort through graduation. All faculty in the School of Medicine, including clinical faculty, will be eligible to serve as facilitators of the Translational Biosciences Journal Club.

4: Dissertation Research (MPP 9090): 1 credit hour: Students will continue with their dissertation research throughout the remainder of their course of study. The number of credit hours will vary each semester, depending on the other coursework requirements and if the student has passed the comprehensive exam. After passing the comprehensive exam, the minimum number of credit hours that full-time graduate students must register for drops to 2 per Fall or Spring semester and 1 credit hour in the Summer Semester.

Year 2: Spring Semester. Students will continue to take specialized courses appropriate for their respective Emphasis Area as well as participate in the weekly Emphasis Area seminars and the weekly Translational Biosciences Journal Club. During the Spring Semester of their second year, the graduate students will take a grant writing course in order to develop the professional skill of writing grant proposals and fellowships.

1. Emphasis Area Coursework; 3-6 credit hours: Emphasis Area coursework will continue in the Spring Semester of Year 2, as determined by the course of study as required by the Emphasis Area. The student's Doctoral Program Committee may suggest additional coursework.

2: Emphasis Area Research Seminar; 1 credit hour. The Emphasis Area research seminars will be held every semester. These seminars will feature invited speakers from outside MU as well as presentations by faculty and students.

3: Translational Biosciences Journal Club, by cohort: 1 credit hour. The Translational Biosciences Journal Clubs will be held every semester.

4: Dissertation Research (MPP 9090): 1 credit hour. Students will continue with their dissertation research throughout the remainder of their course of study. The number of credit hours will vary, depending on the other coursework.

5: Grant Writing for Biomedical Scientists (similar to LAB AN 9476): 3 credit hours. The grant-writing course taken by graduate students in the Translational Biosciences PhD program will be modeled after a grant-writing course that Dr. Hannink has taught with Dr. Elizabeth Bryda in Veterinary Pathobiology. A syllabus for the existing grant writing course, LAB_AN 9476, is included in Appendix C. Dr. Hannink and Dr. Tim Domeier (MPP) will be the co-instructors for the Grant Writing for Biomedical Scientists course.

Year 3: Completion of the Comprehensive Examination and Advancement to Candidacy: The comprehensive exam is a hallmark of every PhD program. Successful completion of the Comprehensive exam indicates that the student has advanced to Candidacy for the PhD degree. Graduate students in the Translational Biosciences PhD program will be expected to pass their comprehensive exam after their Emphasis Area coursework is complete. Typically, the comprehensive exam will be taken no later than the end of their third year.

Years 3-5: During years 3-5 of their graduate study, the graduate students will complete all required coursework in their Emphasis Area, while continuing with their Dissertation Research, Emphasis Area Research Seminars and the Translational Biosciences Journal Club.

Translational Biosciences - Fall 2020

Course Number: BIOCHM 8240 or MPP 8500

Location: 171 LSC and Zoom

Time: M T W Th F 9:00 to 9:50 (five credit hours)

Instructors:

Dr. Mark Hannink (hanninkm@missouri.edu); Biochemistry
Dr. Alan Parrish (parrishar@health.missouri.edu); Molecular Pharmacology and Physiology
Dr. Charlotte Phillips (PhillipsCL@missouri.edu); Biochemistry
Dr. Steve Van Doren (VanDorenS@missouri.edu); Biochemistry
Dr. Marc Johnson (marcjohanson@missouri.edu); Molecular Microbiology and Immunology
Dr. Mark Daniels (danielsma@health.missouri.edu); Molecular Microbiology and Immunology
Dr. Margaret Lange (LangeMJ@missouri.edu); Molecular Microbiology and Immunology
Dr. Mick Calcutt (CalcuttM@missouri.edu); Veterinary Pathobiology
Dr. Peter Cornish (cornishp@missouri.edu); Biochemistry
Dr. Tim Domeier (domeiert@health.missouri.edu); Molecular Pharmacology and Physiology
Dr. Erika Boerman (boermane@health.missouri.edu); Molecular Pharmacology and Physiology
Dr. Scott Zawieja (zawiejas@health.missouri.edu); Molecular Pharmacology and Physiology
Dr. Ted Kalogeris (kalogerist@health.missouri.edu); Molecular Pharmacology and Physiology
Dr. Mark Milanick (MilanickM@health.missouri.edu); Molecular Pharmacology and Physiology
Dr. Maike Krenz (krenzm@missouri.edu); Molecular Pharmacology and Physiology

If you require assistance because of a disability, refer to **Disability Assistance** below.

Description of Course: This course is designed for first-year graduate students in the biomedical sciences. This course has two goals: (1) to provide the students with a core knowledge of fundamental biochemistry and biology that is the underpinning of current biomedical research; (2) to provide students with the tools that will allow them to read, understand and critically analyze the primary biomedical literature. To this end, the course covers aspects of biochemistry, cell biology, virology, immunology, molecular biology and physiology. The course is taught using a combination of faculty lectures and primary research articles.

Grading: Four exams will be given, with the last during finals week. Each exam is worth 100 points. A total of 12 research articles will be read and discussed during class. At the end of each paper discussion, the students will be required to write up a short (1/2 page) summary of the paper, highlighting the strengths and weaknesses. 10 points will be assigned on the basis of each student's contribution to the discussion and 10 points assigned to the written summary. A total of 240 points will be based on the literature readings.

Attendance: This course is based on student involvement and thus attendance is expected. You cannot understand this material if you do not come to class and participate.

Academic integrity: Each student will be responsible for maintaining the highest level of academic integrity during the course, including presenting his/her own work on exams.

Disability assistance: If you need accommodations because of a disability, if you have emergency medical information to share with us, or if you need special arrangements in case the building must be evacuated, please inform me immediately.

To request academic accommodations (for example, a note taker or extended time on exams), students must also register with the Office of Disability Services (<http://disabilityservices.missouri.edu>), S5 Memorial Union, 882-4696. It is the campus office responsible for reviewing documentation provided by students requesting academic accommodations, and for accommodations planning in cooperation with students and instructors, as needed and consistent with course requirements. For other MU resources for students with disabilities, click on "Disability Resources" on the MU homepage.

Weekly Schedule for MPP8500/BIOCHM 8420; Fall 2020

	Date	Faculty Topic
		Week 1 - Week 5: Metabolism and eukaryote transcriptional regulation with a focus on Diabetes
Week 1	08 24	MH Introduction to course/TD introduction to Diabetes
	08 25	Tim Domeier: Diabetes
	08 26	Erika Boerman: Diabetes, COVID19; paper discussion
	08 27	Erika Boerman: Diabetes, COVID19; paper discussion
	08 28	Scott Zawieja: Diabetes; paper discussion
Week 2		Steve Van Doren: Bioenergetics and metabolism
	08 31	Steve Van Doren: Bioenergetics and metabolism
	09 01	Steve Van Doren: Bioenergetics and metabolism
	09 02	Steve Van Doren: Bioenergetics and metabolism
	09 03	Steve Van Doren: Bioenergetics and metabolism
	09 04	Steve Van Doren: Bioenergetics and metabolism
Week 3	09 07	Labor Day
		Ted Kalogeris: Lipid Metabolism in Diabetes
	09 08	Ted Kalogeris: Lipid Metabolism in Diabetes
	09 09	Ted Kalogeris: Lipid Metabolism in Diabetes
	09 10	Ted Kalogeris: Lipid Metabolism in Diabetes
	09 11	Ted Kalogeris: Paper Discussion
Week 4	09 14	Mark Milanick: Glucose Transport and Regulation in Diabetes

	09 15	Mark Milanick: Glucose Transport and Regulation in Diabetes	
	09 16	Mark Milanick: Glucose Transport and Regulation in Diabetes	
	09 17	Mark Milanick: Paper Discussion	
	09 18	Mark Milanick: Paper Discussion	
Week 5	09 21	Maike Krenz: Transcriptional Regulation by glucose and insulin	
	09 22	Maike Krenz: Dysregulation of gene expression in diabetes	
	09 23	Maike Krenz: Dysregulation of gene expression in diabetes	
	09 24	Maike Krenz: Paper Discussion	
	09 25	Maike Krenz: Paper Discussion	
		Week 6 - Week 8: Protein structure section, with a focus on Cystic Fibrosis	
Week 6	09 28	EXAM 1 (Diabetes section)	
	09 29	CLP Genetics of single gene disorders	
	09 30	MH Cell Biology of Protein Trafficking	
	10 01	MH Paper Discussion	
	10 02	MH Paper Discussion	
Week 7		SVD: Thermodynamics, water, lipids and bilayers	
	10 05	SVD: Protein Structure	
	10 06	SVD: Protein Structure	
	10 07	SVD: Protein Structure	
	10 08	SVD: Protein Structure/Folding	Class will meet in Stanley Hall 146, from 8 to 8:40
		SVD Pymol session to analyze CFTR structures/mutations	Class will meet in Stanley Hall 146, from 8 to 8:40
	10 09		
Week 8	10 12	SVD: Transport across membranes	
	10 13	SVD: Transport across membranes	
	10 14	SVD: Molecular mechanisms for functional defects in CFTR	
	10 15	SVD: Paper Discussion	
	10 16	SVD: Paper Discussion	Class will meet in Stanley Hall 146, from 8 to 8:40
		Week 9 - Week 12 DNA Replication, Gene Transcription, Translation with a focus on Bacterial Pathogenesis	
Week 9	10 19	EXAM 2 (Cystic Fibrosis section)	
	10 20	MC: Cell Structure	
	10 21	MC: Cell Division	
	10 22	SVD: Nucleic Acid Structure	
	10 23	SVD: Nucleic Acid Structure	

Week

10	10 26	MC: DNA replication
	10 27	MC: DNA replication MC: Plasmid replication, genetic
	10 28	complementation
	10 29	MC: Paper Discussion
	10 30	MC: Paper Discussion

Week

11	11 02	SVD: Transcription (biophysical and structural aspects)
	11 03	MC: Transcription
	11 04	MC: Transcription
	11 05	MC: Paper Discussion
	11 06	MC: Paper Discussion

Week

12	11 09	MC: tRNA and Amino Acyl Transferases PC: Translation (class will be from 8 to
	11 10	8:50) PC: Translation (class will be from 8 to
	11 11	8:50) PC: Translation (class will be from 8 to
	11 12	8:50) PC: Paper Discussion (class will be from 8
	11 13	to 8:50)

Week 13 - Week 15: Virology and Immunology with a focus on HIV (coronavirus biology will also be a topic this year)

Week

13	11 16	EXAM 3 (Bacterial pathogenesis section)
	11 17	Marc Johnson: HIV
	11 18	Marc Johnson: HIV
	11 19	Marc Johnson: Paper Discussion
	11 20	Marc Johnson: Paper Discussion

THANKSGIVING

BREAK

THANKSGIVING BREAK

Week

14	11 30	Maggie Lange: Innate Immune System: Recognition of Pathogens
	12 01	Maggie Lange: Innate Immune System: Recognition of Pathogens
	12 02	Maggie Lange: Innate Immune System: Recognition of Pathogens
	12 03	Maggie Lange: Paper Discussion
	12 04	Maggie Lange: Paper Discussion

Week

15 12 07 Mark Daniels: Immunology
12 08 Mark Daniels: Immunology
12 09 Mark Daniels: Paper Discussion
12 10 Mark Daniels: Paper Discussion
12 11 STOP DAY

EXAM 4 (Virology and Immunology) during Exam week

Course Outline Data Design & Analysis I

Learning outcomes

By the end of this course students should be able to understand how statistical methods are used by others; apply them including programming to existing data; and use them as a base for more advanced biostatistics or research methods courses.

Instructional method

The course is lecture based with interactive sessions. Students are expected to actively participate and to learn statistical programming.

Recommended Texts & Resources

Modern Epidemiology by TL Lash, TJ VerderWeele, S Haneuse, KJ Rothman; 4th Edition; Publisher: Wolters Kluwer, 2021

Introduction to the Practice of Statistics by DS Moore, GP McCabe, C Craig; 9th Edition; Publisher: MacMillan, 2007.

R Archive - <https://cran.r-project.org/>

Evaluation

Evaluation will be based on a series of written assignments, R-based practical exercises, class participation, weekly quizzes and a final presentation with a written component.

Course Content

Week	Analytic Topic	Design Topic	R - Tutorial
1	Introduction to Data Analytics & Data Management: What is Statistics?	The Emergence of Epidemiology	Uploading data; browsing data; cleaning data; displaying distributions; describing distributions; normal distributions
2 & 3	Looking at Data: Relationships	Causal Inference in Epidemiology; Measures of Disease Frequency; Measures of Effect	Scatterplots; least squares regression; correlation; 2X2 tables;

4 & 5	Producing Data: Sampling and Inference	Types of study design: Experimental vs non- experimental; Standardization of Rates	Merging data; applying weights; sampling
6 & 7	Probability: Study of Randomness	Objectives of study designs: precision and validity; strategies in study design: improving precision and validity	Matrices, data frames, reading in data and R packages, missing data, tables, descriptive graphs, preparing data; Data visualization; measure of variance;
8	From Probability to Inference	The role of statistics in study design: random variability, assessment and control of confounding	Inference: proportion.
9 & 10	Introduction to Inference	Fundamentals of data analyses: hypothesis testing; analyses of crude data	Test of means, estimating confidence intervals
11	Inference for Distributions	Fundamentals of data analyses continued: hypothesis testing; analyses of crude data	t-tests, f-tests
12	Inference for Count Data	Evaluation and Control of Confounding	Proportions with confidence intervals, 2X2 tables
13 & 14	Inference for Regression	Evaluation and Description of Effect Modification; principles of matching; multivariate modelling; interactions	Linear regression, multiple regression, creating complex data sets
15	Analysis of Variance	Analysis with multiple levels of exposure	ANOVA modeling

MPP 8550: Skills in Translational Biosciences I and II

Course Directors:

Alan R. Parrish, Ph.D., Associate Professor, Medical Pharmacology and Physiology
Office: M401A, School of Medicine
email: parrishar@health.missouri.edu

Gillian Bartlett, Ph.D. Professor, Family and Community Medicine
Office: MA306, School of Medicine
Email: gillian.bartlett@health.missouri.edu

Required Text:

None

Objectives:

Upon completion of the course, students will:

1. Understand research ethics, including issues specifically related to biomedical research including experimental design, reproducibility, rigor and validation of experimental reagents and data sharing; these are key components that must be addressed in NIH application.
2. Understand how to critically review primary scientific literature, and to present key background/methods and results from recent research.
3. Understand the theory and practical application of modern research techniques; the laboratory sessions will expose students to state-of-the-art technologies

Course Schedule:

The courses will be held once per week during Fall and Spring Semesters.

Weeks 1 and 2, Fall Semester

Ethics 1: Mentor-Student Relationship & Individual Development Plans

Ethics 2: Experimental Design: Data Acquisition & Management I

Weeks 3 and 4, Fall Semester

Ethics 3: Experimental Design: Data Acquisition & Management I

Ethics 4: Publication-Authorship & Collaborative Research

Weeks 5 and 6, Fall Semester

Evaluating Literature

Bioinformatics I: Data Repositories

Weeks 7 and 8, Fall Semester

Bioinformatics II: Mutation Analysis (GWAS)

In Vitro Methods I: Cell Fractionation

Weeks 9 and 10, Fall Semester

In Vitro Methods II: Cell Culture

In Vitro Methods III: Electrophysiology

Weeks 11 and 12, Fall Semester
Genetic Manipulation I: Crispr/Cas
Genetic Manipulation II: In vivo models

Week 13 Fall Semester, Thanksgiving Break

Weeks 14 and 15, Fall Semester
Genetic Manipulation III: siRNA
Genetic Manipulation IV: Gene Delivery

SPRING SEMESTER

Weeks 1 and 2, Spring Semester
Imaging I: Cellular Imaging: Confocal/Multiphoton
Imaging II: Cellular Imaging: 2- Photon

Weeks 3 and 4, Spring Semester
Imaging III: Cellular Imaging: Atomic Force Microscopy
Imaging IV: Whole Body Imaging

Weeks 5 and 6, Spring Semester
Gene Expression Analysis- RNAseq
Bioinformatics III: Gene Network Analysis

Weeks 7 and 8, Spring Semester
Professional Skills: How to Present Your Research
Translational Biosciences: Biomarkers

Week 9 and 10, Spring Semester
Proteome Analysis: Expression of Known Targets
Proteome Analysis: Identification of Novel Targets

Week 11 Spring Semester; Spring Break

Weeks 12 and 13, Spring Semester
Bioinformatics IV: Epidemiology
Bioinformatics V: Population Health & Outcomes

Weeks 14 and 15, Spring Semester
Translational Biosciences: Precision Medicine
Papers due/Oral Presentations: Capstone Project

Grading

1. Journal Club participation: Each week, there will be an assigned paper and discussion during the second session. 150 points
2. Self-directed Learning Assignments: 150 points
3. Paper: 50 points. At the beginning of week 3, students will choose a specific disease; a paper will be due at the end of the semester in which students provide an overview of epidemiology, molecular/cellular mechanism of disease, current therapy and strategies to address current gaps in knowledge
4. Presentation: 50 points

The final grades are based on the following point scale:

A	≥ 360points
B	320-359 points
C	≤ 319

To drop the course, students must go through the registrar's office. Everyone who does so will be given a "Withdrew Passing" grade. All students on the class roster after this date must be given a grade for the course. An Incomplete (I) grade automatically becomes an F after a year; do not attempt to drop the course simply by stopping attendance at lectures, labs and exams. The academic calendar is available at

Academic Integrity

Academic integrity is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards breaches of the academic integrity rules as extremely serious matters. Sanctions for such a breach may include academic sanctions from the instructor, including failing the course for any violation, to disciplinary sanctions ranging from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, collaboration, or any other form of cheating, consult the course instructor.

University of Missouri policies and procedures related to Students Rights & Responsibilities may be found at ossr.missouri.edu/index.html

Students with Disabilities:

If you anticipate barriers related to the format or requirements of this course, if you have emergency medical information to share with me, or if you need to make arrangements in case the building must be evacuated, please let me know as soon as possible.

If disability related accommodations are necessary (for example, a note taker, extended time on exams, captioning), please register with the Disability Center (<http://disabilitycenter.missouri.edu>), S5 Memorial Union, 573-882-4696, and then notify me of your eligibility for reasonable accommodations. For other MU resources for persons with disabilities, click on "Disability Resources" on the MU homepage.

Intellectual Pluralism

The proper expression of both academic rights and responsibilities is required for a reasoned and respectful debate that explores a diversity of views and perspectives about

complex, and often controversial topics. This is the essence of **intellectual pluralism**. The University community is committed to intellectual pluralism in its many dimensions: political, cultural, religious, international, disciplinary, economic, lifestyles – and to encouraging and supporting robust debates over matters of academic interest. Below, please find a sample statement addressing intellectual pluralism. This statement was adopted by the Faculty Council and recommended to our office for distribution to the faculty.

The University community welcomes intellectual diversity and respects student rights. Students who have questions or concerns regarding the atmosphere in this class (including respect for diverse opinions) may contact the Departmental Chair or Divisional Director; the Director of the Office of Students Rights and Responsibilities [http://osrr.missouri.edu/](http://osrr.missouri.edu) or the MU Equity Office (equity@missouri.edu);

All students will have the opportunity to submit an anonymous evaluation of the instructor(s) at the end of the course.

University of Missouri System Executive Order No. 38 lays out principles regarding the sanctity of classroom discussions at the university. The policy is described fully in Section 200.015 of the Collected Rules and Regulations. In this class, students may or may not make audio or video recordings of course activity – permission must be granted by individual faculty - except students permitted to record as an accommodation under Section 240.040 of the Collected Rules. All other students who record and/or distribute audio or video recordings of class activity are subject to discipline in accordance with provisions of Section 200.020 of the Collected Rules and Regulations of the University of Missouri pertaining to student conduct matters.

Those students who are permitted to record are not permitted to redistribute audio or video recordings of statements or comments from the course to individuals who are not students in the course without the express permission of the faculty member and of any students who are recorded. Students found to have violated this policy are subject to discipline in accordance with provisions of Section 200.020 of the Collected Rules and Regulations of the University of Missouri pertaining to student conduct matters.

LAB AN 9476: Grant and Manuscript Writing for Biomedical Researchers

Spring 2021

Meeting Day and Time: Tuesdays and Thursdays, 9-10:30 am, by Zoom.

Goals: To enable students to acquire the knowledge and tools necessary to prepare successful grant proposals and fellowship applications.

Objectives: At the end of the course, the student will be able to:

1. Be familiar with the components of a grant application and the grant application process.
2. Be familiar with the components of a fellowship application and the fellowship application process.
2. Prepare a R03-style grant application which incorporates effective experimental design.
3. Be familiar with the typical grant and manuscript review process and practice appropriate methods for responding to critiques.

Course Coordinator: Mark Hannink, Biochemistry, 440 E Life Sciences Center,
Email: HanninkM@missouri.edu; Phone: 573-882-7971

Attendance: Attendance is required. One unexcused absence is allowed during the semester. In the event of circumstances beyond your control (e.g. serious illness, car accident, death in immediate family, professional meeting conflict, etc.) an excused absence may be granted at the Course Coordinator's discretion if legitimate documentation is provided.

Grading: This is a 3 credit course. Letter grades will be assigned based on attendance, timely submission of all assignments, active participation in class discussions, and importantly, the quality of all assignments.

Grant Application Assignment: Students are required to prepare a R03 style grant application to demonstrate their understanding of the material presented in this course. Detailed guidelines for this assignment will be distributed during the first class meeting. Late assignments will negatively impact the final grade. The grant applications will be evaluated by a mock study section panel consisting of faculty members and classmates and each application will be "reviewed" during mock study sections conducted during class time. In addition, students will be provided with written "critiques" of their applications and will be given the opportunity to address reviewer concerns by preparing a written response in a manner similar to that required in a revised grant application.

Schedule:

Date	Day	Topic	
1/19	Tuesday	Introduction to class and discussion of Specific Aims assignment	
1/21	Thursday	Discussion on funding sources; Rigor and Transparency	
1/26	Tuesday	Draft of Specific Aims page is due; Discussion of Rigor and Transparency	
1/28	Thursday	Specific Aims presentations	Assigned Reviewers
2/2	Tuesday	Specific Aims presentations	Assigned Reviewers

2/4	Thursday	Specific Aims presentations	Assigned Reviewers
2/9	Tuesday	Specific Aims presentations	Assigned Reviewers
2/11	Thursday	Specific Aims presentations	Assigned Reviewers
2/16	Tuesday	Biostatistics	
2/18	Thursday	Biostatistics	
2/23	Tuesday	Biostatistics	
2/25	Thursday	Biostatistics	
3/2	Tuesday	Budget and grant form pages	
3/4	Thursday	Biosketch review	
3/9	Tuesday	How to review grants and write a grant review	
3/10	Wednesday	Draft proposals are due at 5 pm on Wed, March 10	
3/11	Thursday	Dr. Fungai Chanetsa: Insights from NIH	
3/16	Tuesday	Proposal Draft Review in class	Assigned Reviewers
3/18	Thursday	Proposal Draft Review in class	Assigned Reviewers
3/23	Tuesday	Proposal Draft Review in class	Assigned Reviewers
3/25	Thursday	Proposal Draft Review in class	Assigned Reviewers
3/30	Tuesday	NO CLASS - SPRING BREAK	Assigned Reviewers
4/1	Thursday	NO CLASS - SPRING BREAK	Assigned Reviewers
4/6	Tuesday	Proposal Draft Review in class (If needed)	Assigned Reviewers
4/8	Thursday	Open class to answer any questions about proposals	
4/13	Tuesday	Open class to answer any questions about proposals	
4/15	Thursday	F31 proposals: Completed Proposals are due	
4/20	Tuesday	F31 proposals	
4/22	Thursday	Mock Study Section	Faculty
4/27	Tuesday	Mock Study Section	Faculty
4/29	Thursday	Mock Study Section	Faculty
5/4	Tuesday	Mock Study Section	Faculty
5/6	Thursday	Mock Study Section	Faculty
5/14		Revisions due	

Appendix D: Emphasis Area Course Information

Emphasis Area Coursework for Biochemistry
Emphasis Area Coursework for Cancer Biology
Emphasis Area Coursework for Infection and Immunity
Emphasis Area Coursework for Integrative Physiology
Emphasis Area Coursework for Nutrition and Exercise Physiology

Appendix A: Emphasis Area Curricula

The Translational Biosciences PhD program will be organized around six Emphasis Areas. The Emphasis Areas of the Translational Biosciences PhD program are:

- Biochemistry and Biophysics
- Cancer Biology
- Infection and Immunity
- Integrative Physiology
- Nutrition and Exercise Physiology
- Population and Precision Health

Curriculum for five of these Emphasis Areas, including Biochemistry and Biophysics, Cancer Biology, Infection and Immunity, Integrative Physiology, and Nutrition and Exercise Physiology are listed below. The curriculum for the Population Health and Precision Medicine Emphasis Area is being developed. All PhD graduate students in the Translational Biosciences program will complete a total of 72 credit hours, including formal coursework and research credit hours. A minimum of 15 credit hours of formal coursework at the 8000 or 9000 level is required. Graduate students must maintain a GPA of 3.0 in their formal coursework. Research credit hours will be graded on a S/U basis.

Biochemistry and Biophysics Emphasis Area

After completion of the Program-specific course work, the Biochemistry and Biophysics Emphasis Area will require two additional courses, for a total of 6 credit hours, selected from the courses listed below. Participation in a Research Seminar (BIOCHM 8070) is also required.

- BIOCHM 8434: Signaling in Molecular Cell Biology (3 hrs)
- BIOCHM 8432: Enzymology and Metabolic Regulation (3 hrs)
- BIOCHM 9432: Molecular Biology II (4 hrs)
- BIO_SC 7982: Inherited Human Diseases (3hrs)
- BIO_SC 8982: Advances in Human Genetic Disorders (2hrs)
- AN_SCI 8415 - 01 Survey of Epigenetics (3hrs)
- BIO_SC 8300: Advanced Plant Genetics (3 hrs)
- BIOCHM 8362: Introduction to Plant Metabolism (2 hrs)
- PLNT_S 9415: Physiology of Plant Growth Responses to the Environment (3 hrs)
- BIOCHM 9468: Molecular Biology of Plant Growth and Development (3 hrs)
- PLNT_S 9540: Genetics of the Plant-Microbe Interaction (3 hrs)
- CHEM 8150: Organic reaction mechanisms (3hrs)
- CHEM 8240: Analytical Mass Spectrometry (3hrs)
- CHEM 8160: Organic Spectroscopy (3hrs)
- CHEM 8265: Fluorescence spectroscopy (3hrs)
- INFO INST 8005: Bioinformatics Tools in Biological Research (3 hrs)
- PLNT_S 8430: Introduction to Bioinformatics Programming (4 hrs)

Cancer Biology Emphasis Area

After completion of the Program-specific course work, graduate students in the Cancer Biology Emphasis Area will be required to successfully complete one of the required courses as well as one of the elective courses listed below. Participation in a Research Seminar (to be developed) is also required.

Required (1 of 2):

BIO-SC 8460: Advanced Cancer Biology

VMS 8419: Advanced Topics in Cancer Biology and Clinical Oncology

Elective courses (at least 1 elective course is required): It is expected that students will choose courses that will complement their individualized research projects. Below is a list of acceptable courses but other courses may count toward the degree with approval from their committee.

AN_SCI 8430: Introduction to Bioinformatics Programming

AN_SCI 8415: Survey of Epigenetics

BIOCHM 8432: Enzymology and Metabolic Regulation

BIOCHM 8434: Signaling in Molecular Cell Biology

BIOCHM 9432: Molecular Biology II

BIOCHM 9462: Hormone Action

BIOL_EN 8000: Scientific Discovery Leading to Life Science Innovations

BIOL_EN 8100: Design and Development of Biomedical Innovations

BIOL_EN 8280: Advanced Biological Transport Processes

BIOL_EN 8470: Ultrasensitive Biodetection

BIOL_EN 8570: Microscopic Imaging

BIOL_EN 8870: Molecular and Cell Mechanics

BIO_SC 8320: Developmental Genetics

CHEM 8280: Bioanalytical Chemistry

CHEM 8630: Radiopharmaceutical Chemistry

CHEM 8640: Biological Radiochemistry

LAB_AN 9437: Pathology of Laboratory Animals

LAB_AN 9468: Laboratory Animal Biology

MPP 8411: Mammalian Pharmacology and Physiology

MPP 9426: Transmembrane Signaling

MICROB 9407: Advanced Immunology

INFO INST 8005: Applications of Bioinformatics Tools in Biological Research

INFO INST 8150: Integrative Methods in Bioinformatics

INFO INST 8190/8390: Computational Systems Biology

INFOINST 8310: Computational Genomics

INFOINST 8350: Integrative Methods in Bioinformatics

INFOINST 8450: Precision Medicine Informatics

PTH_AS 8090: Advanced Pathology

STAT 8410: Statistical Theory of Bioinformatics

P_HLTH 8420: Principles of Epidemiology

Infection and Immunity Emphasis Area:

After completion of the Program-specific course work, graduate students in the Infection and Immunity Emphasis Area will be required to take two Basic courses (at the 8000 level), two Advanced courses (at the 9000 level) and one elective at either the 8000 or 9000 level. Participation in a Research Seminar (MICROB 9087) is also required.

Basic courses:

MICROB 8303 Fundamental Virology (3 credit hrs)

MICROB 8304 Immunology (3 credit hrs)

MICROB 8404 Foundations in Bacteriology and Pathogenesis (3 credit hrs.)

Advanced courses

MICROB 9303 Adv. Virology (4 credit hrs)
MICROB 9404 Adv. Bacterial Pathogenesis (4 credit hrs)
MICROB 9407 Adv. Immunology (4 credit hrs)
MICROB 9449 Infection and Immunity (4 credit hrs)

Integrative Physiology Emphasis Area:

After completion of the Program-specific course work, graduate students in the Integrative Physiology Emphasis Area will be required to take two of three Basic courses and one of three Advanced elective courses. Participation in a Research Seminar (MPP8412) is also required.

Basic courses (2)

MPP 8411 Mammalian Pharmacology and Physiology
MPP 7424 Pharmacology and Translational Medicine OR
MPP 9426 Transmembrane Signaling

Advanced Elective courses (1)

MPP 9430- Cardiovascular Physiology (1-3 hrs.)
MPP 9434- Microvascular Circulatory Function (1-3 hrs.)
MPP 9437- Neural Control of Circulation (1-3 hrs.)

Nutrition and Exercise Physiology Emphasis Area:

After completion of the Program-specific course work, graduate students in the Nutrition and Exercise Physiology Emphasis Area will be required to take 4 basic courses and 4 elective courses based on their research emphasis. Participation in a Research Seminar is also required.

Basic courses (4)

NEP 7970 Sports Nutrition (2 cr hrs)
NEP 8030 Etiology of Obesity (3 cr hrs)
NEP 8860 Exercise Endocrinology (3 cr hrs)
NEP 8870 Exercise Metabolism (3 cr hrs)

NS Emphasis Area Electives (4)

NEP 7340 Human Nutrition II (3 cr hrs)
NEP 8310 Nutritional Biochem of Lipids (3 cr hrs)
NEP 8340 Nutrition in Human Health (3 cr hrs)
AN SCI 9442 Vitamins and Minerals (3 cr hrs)

ExPhys Emphasis Area Electives (4)

MPP 7422 Medical Physiology (3 cr hrs)
NEP 8001 Cardiovascular Disease and Exercise (4 cr hrs)
NEP 8850 Advanced Exercise Physiology (3 cr hrs)
V_BSCI 9435 Molecular Exercise Biology (3 cr hrs)

New Degree Program Proposal:

**Doctor of Philosophy in
Translational Biosciences**

University of Missouri – Columbia
November 2021 Board of Curators Meeting

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Executive Summary

The School of Medicine (SOM) at the University of Missouri-Columbia (UMC) campus proposes to develop a new predoctoral training program, the Translational Biosciences PhD program. The Translational Biosciences PhD program represents a new paradigm for graduate training in biomedical research at the university. It will span the entire breadth of the biomedical research spectrum, from basic science discoveries to improved clinical outcomes. Existing departmental-based graduate programs in the basic science departments will be incorporated into it. By coordinating graduate training throughout the SOM, the Translational Biosciences PhD program will: (i) provide graduate students with research skills that will enhance the productivity of faculty research programs; (ii) increase the number of national research fellowships awarded to graduate students; (iii) increase the submission of highly competitive institutional training grants; (iv) increase the number of research-active faculty in the SOM who are involved in training and mentoring graduate students; (v) support the recruitment of additional research-active faculty with active research programs; (vi) enhance collaborative research between basic and clinical scientists.

Through close collaborations with the outstanding scientists and clinicians of the Precision Health Institute, a UM System-wide effort to translate ground-breaking biomedical research into life-changing reality for patients in Missouri and around the world, the Translational Biosciences PhD program will provide state-of-the-art research training to young biomedical scientists at the beginning of their scientific careers. By combining graduate education and training with cutting-edge research, the Translational Biosciences PhD program will enhance biomedical research at MU and help MU maintain its AAU status as leading research university.

Students who earn their PhD from the Translational Biosciences PhD program will be highly trained biomedical scientists. The societal need for biomedical scientists is illustrated by the rapid development and deployment of highly effective vaccines against the virus that causes COVID19. The Translational Biosciences PhD program will meet a growing demand for biomedical scientists in the State of Missouri, where the demand for biomedical scientists is projected to grow faster than overall job growth in the state.

The development of biomedical scientists through graduate education and research requires a multi-year investment that pays off through new scientific discoveries and research innovation. The Translational Biosciences PhD program will invest in recruitment and provide stipend/tuition support of first-year graduate students. Our goal is to increase the number of incoming graduate students to 20 per year, up from the current level of 8 per year in the existing PhD programs in the SOM. No additional faculty will be needed for instructional purposes. One new staff member will be hired to support the recruitment activities of the Program. During the latter years of graduate training (years 2 -5), stipend/tuition support will be provided by research grants, with the graduate students serving as graduate research assistants on externally funded faculty-led research projects. The research activities of graduate students will support the ability of faculty to sustain externally funded long-term research programs. Although the Translational Biosciences PhD program will not generate net revenue as a stand-alone educational program, the program will have an overall net financial benefit to the University, through increased research productivity of faculty-led teams capable of garnering competitive external grant support.

1. Introduction

Academic components of the Translational Biosciences PhD program: The academic home of the Translational Biosciences PhD program will be the School of Medicine at the University of Missouri-Columbia. The School of Medicine contains 21 departments, including 5 basic science departments and 16 clinical science departments. All Faculty in the School of Medicine who have appropriate Graduate Faculty Status, as determined by the MU Graduate School, will have an opportunity to participate in the Translational Biosciences PhD program, as classroom instructors, as research mentors and as members of doctoral program committees.

Basic Science Departments (5) in MU School of Medicine

- Biochemistry (jointly administered with College of Food, Agriculture and Natural Resources [CAFNR])
- Medical Pharmacology and Physiology (MPP)
- Molecular Microbiology and Immunology (MMI)
- Nutrition and Exercise Physiology (jointly administered with CAFNR)
- Pathology and Anatomical Sciences

Clinical Science Departments (16) in MU School of Medicine

- Anesthesiology and Perioperative Medicine
- Child Health
- Dermatology
- Emergency Medicine
- Family and Community Medicine
- Health Management and Informatics
- Medicine
- Neurology
- Obstetrics, Gynecology and Women's Health
- Ophthalmology
- Orthopedic Surgery
- Otolaryngology
- Physical Medicine and Rehabilitation
- Psychiatry
- Radiology
- Surgery

There are two PhD programs that are solely administered by the School of Medicine: the PhD program in the Department of Molecular Microbiology and Immunology (MMI) and the PhD program in the Department of Medical Pharmacology and Physiology (MPP). These PhD programs will be eliminated, once currently enrolled students have completed their training. The disciplinary areas represented by these two department-based programs will be incorporated into the Translational Biosciences PhD program as two of the six Emphasis Areas within the PhD program.

The six Emphasis Areas of the Translational Biosciences PhD program are:

- Biochemistry and Biophysics
- Cancer Biology
- Infection and Immunity
- Integrative Physiology
- Nutrition and Exercise Physiology
- Population and Precision Health

An important feature of the Translational Biosciences PhD program will be that faculty and students will not be confined within departmental silos. Instead, research-active faculty will be encouraged to participate in multiple Emphasis Areas and graduate students will be allowed to join the lab of any research-active faculty member that participates in any of the Emphasis Areas. We believe that this mechanism will enhance interdisciplinary collaborations in both research and training, as faculty from different research backgrounds and expertise will be brought together into each Emphasis Area. The use of Emphasis Areas instead of departmental PhD programs to organize research training of graduate students provides the Translational Biosciences program with the flexibility to add new Emphasis Areas or remove Emphasis Areas that fail to attract a critical mass of research active faculty and graduate students.

The Translational Biosciences PhD program will provide our PhD graduates with both a deep knowledge base of their chosen discipline and the ability to communicate and collaborate across disciplines. The six Emphasis Areas represent well-defined disciplines across the entire biomedical research spectrum and prospective employers will be able to readily identify the disciplinary expertise of our PhD graduates. We anticipate that the PhD graduates from the Translational Biosciences program will be sought after by a wide range of employers, including: research universities looking for postdoctoral scholars and tenure-track faculty; large and small pharmaceutical companies that translate basic research findings into clinically-proven treatments; government laboratories that conduct research and assess the safety and efficacy of pharmaceuticals; and a wide variety of non-governmental organizations that need biomedical expertise.

Preliminary steps toward the development of the Translational Biosciences PhD program: In 2017, Dr. Patrice Delafontaine, then Dean of the School of Medicine, initiated the development of an umbrella-type PhD program in biomedical sciences in the School of Medicine. Dr. Delafontaine had two goals for developing an umbrella program in the School of Medicine: (1) to encourage interdisciplinary training of PhD graduate students, and (2) to provide research faculty who are in clinical departments that do not have departmental PhD graduate programs with the opportunity to participate in graduate training. Dr. Delafontaine appointed a faculty committee to develop an umbrella PhD program in the School of Medicine. This faculty committee met individually with every department chair in the School of Medicine and held extensive discussions with faculty members from both basic science and clinical departments. From these discussions, a framework for a new PhD program, now called the Translational Biosciences PhD program, was developed.

The School of Medicine has begun the process of consolidating existing departmental PhD programs and developing the core curriculum for the Translational Biosciences PhD program. For example, one component of the curriculum (see Section 5) is Molecular and Cellular Biosciences, a Fall Semester 3-credit hour class. This course sequence is based on an

existing 5-credit hour class that was initiated in Fall 2018 as a collaborative course between the Biochemistry Department and the Molecular Pharmacology and Physiology (MPP) Department. After this trial run, the structure and content of the course was revised for the Fall 2019, with enrollment increasing from 9 students in Fall 2018 to 15 students in Fall 2019. In Fall 2020, 18 first-year graduate students in Biochemistry, MPP, Molecular Microbiology and Immunology (MMI) and Nutrition and Exercise Physiology (NEP) took this class.

Leadership of the Translational Biosciences Program: The Translational Biosciences program will be co-directed by Dr. Mark Hannink and Dr. Gillian Bartlett. Dr. Hannink is a tenured faculty member in the Biochemistry Department and has been a leader in graduate education on the University of Missouri-Columbia campus. Dr. Hannink has been a faculty member at MU since 1990, has served as the Director of the Life Sciences Fellowship program since 2004 and is currently the Program Director/Principal Investigator of two NIH-funded predoctoral training grants (T32 GM008396-30 and T32 GM135744-02) and one NIH-funded undergraduate training grant (T34 GM136493-02). During FY22, these three training grants will bring in \$1.3M to support undergraduate (\$491,044) and graduate (\$824,500) training in biomedical research at MU.

Dr. Gillian Bartlett is a tenured faculty member in Family and Community Medicine and serves as the Associate Dean for Population Health and Outcomes Research in the School of Medicine. Dr. Bartlett came to MU in 2020 from McGill University, where she completed a 10-year mandate as Research and Graduate Program Director and led the development and successful accreditation of three training programs that have enrolled over a hundred trainees – a MSc program in Family Medicine, a PhD program in Family Medicine and Primary Care and the Clinician Scholars Program which is an Enhanced Skills program that provides training for third-year family medicine residents to develop their research skills.

Dr. Hannink and Dr. Bartlett will be joined by a six-member Executive Committee, comprised of one representative from each of the six Emphasis Areas. As graduate training and research are closely aligned, Dr. William Fay, Senior Associate Dean for Research in the School of Medicine, will be an ex-officio member of the Executive Committee.

The current members of the Executive Committee (home department) and Emphasis Area are listed below. Copies of their NIH Biosketches are provided in Appendix A.

Dr. Charlotte Phillips (Biochemistry), Biochemistry and Biophysics
Dr. James Amos-Landgraf (Veterinary Pathobiology), Cancer Biology
Dr. Mark Daniels (MMI), Infection and Immunity
Dr. Alan Parrish (MPP), Integrative Physiology
Dr. Chris Hardin (NEP), Nutrition and Exercise Physiology
Dr. Gillian Bartlett (Fam. Comm. Med.), Population and Precision Health

External Reviews of the proposed Translational Biosciences Program: This proposal was reviewed by three external reviewers. All three reviewers are prominent biomedical scientists with extensive involvement in graduate and postdoctoral training. The reviewers were:

Reviewer #1: Dr. Gad Shaulsky. Dr. Shaulsky is Professor, Vice Chair and Program Director in Genetics & Genomics at Baylor College of Medicine (Houston, TX)

Reviewer #2: Dr. William C. Parks. Dr. Parks is Professor of Medicine and Biomedical Sciences, Director of the Doctoral Program in Biomedical and Translational Biosciences and Associate Dean, Graduate Research Education at Cedars-Sinai Medical Center (Los Angeles, CA).

Reviewer #3: Dr. Huntington F. Willard. Dr. Willard is Chief Scientific Officer, Genome Medical Inc.

Each reviewer provided a detailed list of strengths and weaknesses of the proposed program. These reviews, and detailed information on how the proposal was modified in response to these reviews, is provided in Appendix F. A summary of the major strengths and weaknesses and modifications to the proposal is provided below.

Strengths: The reviewers were unanimous in viewing the proposed Translational Biosciences program as a marked improvement over the current departmental-based format for PhD training at the University of Missouri-Columbia.

Dr. Shaulsky stated that “Overall, the proposal is very strong and I recommend that the University should consider it very favorably.”

Dr. Parks stated: “Among the many potential strengths will be expanding opportunities for graduate students and increasing collaborations among labs and groups, which will ideally lead to increased extramural funding.”

Dr. Willard compared the proposed program to umbrella-type programs that have been developed at other institutions, including UCSF, Washington University and Case Western Reserve. Dr. Willard noted that umbrella-type programs have “demonstrated benefits to the students, faculty, and institutions, as they allow for programmatic flexibility, exposure of students to a broad range of research approaches, and financial efficiencies that are not as evident in institutions with numerous small departmental programs, often of variable quality.” Dr. Willard added: “The program proposed here certainly has the potential to be successful in this same way.”

Weaknesses: All three reviewers shared the viewpoint expressed by Dr. Shaulsky: “Any negative comments made below should be considered as opportunities for improvement rather than reasons for rejection.”

One major concern was the pace of increased student enrollment. Both Dr. Shaulsky and Dr. Parks felt that it was unrealistic to increase the enrollment of students into the SOM PhD training program from 8 to 20 in one year. To address this concern, we have changed our enrollment projections, anticipating that there will be a gradual increase from 8 entering students to 20 entering students over the first five years of the program. Thus, in Year 1 (FY23), we anticipate that there will not be a net increase in enrollment, with 8 matriculating

students. Over the next four years, we anticipate a net increase in enrollment of 3 students per year, reaching 20 newly enrolled students in Year 5 (FY27). We have changed the budget projections to reflect a slower pace of increased enrollment.

A major challenge noted by all three reviewers was that the Translational Biosciences program must develop features that make the program stand out from other PhD training programs at the University of Missouri as well at other institutions across the nation. Dr. Willard noted: “A challenge will be how to emphasize the “translational” aspects of the program and thus define the field that the program intends to impact. What will distinguish this doctoral program from the current departmental programs?” To address this concern, we have modified the proposed training program to emphasize the training in translational sciences that the PhD students will experience. Following the detailed suggestions of Dr. Parks and Dr. Willard, the training program will: (1) integrate Big Data and genomic sciences into the first-year coursework; (2) involve faculty with expertise in clinical research in PhD training at multiple points, including in coursework, in the Translational Biosciences Journal Club, in clinical rotations and as members of a PhD student’s Doctoral Program Committee.

We thank the reviewers for their insightful comments and believe that the responsive changes we have made to the Translational Biosciences program will strengthen the program and allow our objectives to be met.

2. Fit With University Mission & Other Academic Programs

2.A. Alignment With Mission and Goals

Alignment with the University mission: The mission of the University is to achieve excellence in the discovery, dissemination, preservation and application of knowledge (<https://www.umsystem.edu/about-us/weareum>). The goal of the Translational Biosciences PhD program is train graduate students to become scientific leaders in biomedical research. This goal is closely aligned with the mission of the University. The Precision Health Institute is a priority of the University, and the new model for graduate training in biomedical research that will be developed by the Translational Biosciences PhD program will facilitate cross-disciplinary collaborations between basic and clinical scientists and help the Precision Health Institute achieve its goal of improving health outcomes through accelerated innovation.

Alignment with the campus goals and priorities: The strategic plan of the University of Missouri-Columbia (MU) is organized around five critical areas: Excellence in Student Success; Excellence in Research and Creative Works; Excellence in Engagement and Outreach; Inclusive Excellence; and Excellence in Planning, Operations and Stewardship. The Translational Biosciences PhD program will make substantive contributions to MU’s Strategic Plan in at least three of these areas, including: Excellence in Student Success; Excellence in Research and Creative Works; and Inclusive Excellence

In the area of Excellence in Student Success, key priorities for graduate and professional education include the recruitment of high research/creative graduate students who can support the research activities of faculty and increased funding for PhD training in strategic priority fields. The Translational Biosciences PhD program will invest significant effort and funding in the recruitment of highly qualified undergraduates to matriculate into the

program. Furthermore, the structure of the Translational Biosciences PhD program, which will provide graduate students with increased research opportunities and will facilitate collaborative interactions between basic and clinical scientists, will be highly attractive to talented undergraduates who are interested in pursuing state-of-the-art research. By providing a platform for the submission of highly competitive individual fellowships and institutional training grants, the Translational Biosciences PhD program will increase external funding for PhD training in the priority areas of biomedical and translational research.

In the area of Excellence in Research and Creative Works, one of the key priorities is to identify and capitalize on areas where collaboration can drive excellence. Team Science built on interdisciplinary collaborations will be the hallmark feature of the Precision Health Institute, a high priority of both MU and the UM System. The Translational Biosciences PhD program will facilitate collaborations between basic and clinical scientists in graduate research and mentorship and increase interdisciplinary research collaborations between faculty.

In the area of Inclusive Excellence, one of the key priorities is to increase the enrollment of graduate and professional students from underrepresented backgrounds to 15% by 2023. The Translational Biosciences PhD program is poised for leadership towards achieving the goal of increasing the number of graduate and professional students from underrepresented backgrounds. For example, the diversity of predoctoral students in the MMI graduate program more than doubled from 2011 to 2021, as the percentage of Underrepresented Minorities (URM) increased from 9.4% in Fall 2021 to 20.6% in Spring 2021. In contrast, the percentage of URM PhD students across all life science PhD programs at MU increased from 7.2% to 10.9% over that same period. Based in part on the success of the MMI PhD program in recruitment and training of PhD students from diverse backgrounds, the School of Medicine was awarded a new NIH-funded T32 training program in February 2020 that is specifically focused on increasing the number of PhD scientists from underrepresented backgrounds. Dr. Hannink is the Program Director of this new T32 training program (T32 GM135744), which will be an important component of the Translational Biosciences PhD program.

Alignment with the goals and priorities of the School of Medicine: A top priority for the School of Medicine is to increase the amount of federally funded research. To accomplish this goal requires faculty members to write competitive research proposals. A highly trained workforce is needed to generate preliminary data in support of research proposals and to carry out the research once a grant proposal is funded.

Research carried out by PhD students during their graduate training is a critical component of federally funded research, particularly in the biomedical sciences. As described in a 2011 report on National Needs for Biomedical, Behavioral and Clinical Research Personnel, “graduate students and postdoctoral fellows provide the dynamism, the creativity, and the sheer numbers that drive the biomedical research endeavor” (https://grants.nih.gov/training/research_training_biomedical.pdf). As an example of how graduate students contribute to the biomedical research enterprise at MU, the 44 PhD graduates who entered graduate school between 2004 and 2014 and participated in the training program co-sponsored by the Life Sciences Fellowship Program and T32 GM008396 contributed to a total of 216 published research articles, an average of 4.9 research articles per student.

Given the important contributions of graduate research to the ability of research universities to compete for federal research grants, reliance on a department-based graduate training model puts the MU School of Medicine at a structural disadvantage relative to other academic medical schools. For example, in FY21, of the 145 faculty in the MU School of Medicine with NIH research expenditures, 64% (93/145) were in clinical departments that do not have a department-based graduate training program. These research-active faculty in clinical departments in the MU SOM were responsible for 64% (87/135) of all NIH-funded grants that were active in the MU SOM during FY21. Yet these research-active faculty in clinical departments in the MU SOM do not have ready access to graduate students and are at a competitive disadvantage relative to faculty who have ready access to graduate students.

In contrast to the lack of access to graduate students faced by research-active faculty in MU SOM clinical departments, research-active faculty in clinical departments in the School of Medicine at Washington University in St. Louis are integrated into a campus-wide graduate training program, the Division of Biology and Biomedical Sciences (DBBS). At Washington University, there are no departmental-based graduate programs. Instead, the DBBS coordinates PhD training across the entire Washington University campus. In the Washington University DBBS program, 60% (309/515) of all faculty participants in the DBBS program are from clinical departments in the Washington University School of Medicine. These research-active faculty in clinical departments at the Washington University School of Medicine have ready access to highly qualified graduate students, which enhances the productivity of their research programs. The Translational Biosciences PhD program, by connecting research-active faculty in the MU SOM with a SOM-wide graduate training program, will enhance the ability of all faculty in the SOM to develop highly productive research teams and compete for NIH research funding.

One goal of the SOM is to double research funding over the next five years. This will be accomplished, in part, through the hiring of at least 40 new faculty with very active research programs. A robust graduate training program will be an attractive feature to new faculty recruits, who recognize the value that graduate research assistants provide to their research program.

2.B. Duplication/Collaboration Within Campus and Across System

Duplication with existing programs within the UM System or the state of Missouri: The proposed Translational Biosciences PhD program does not duplicate any other existing PhD programs within MU or the UM System. The Translational Biosciences PhD program, when approved, will be the only PhD program administered by the SOM. Existing departmental-based PhD programs in the SOM, including the Molecular Microbiology and Immunology PhD program and the Molecular Pharmacology and Physiology PhD program will no longer accept new students and these degree programs will be eliminated once the currently enrolled PhD students complete their degree.

Within the UM System, the Translational Biosciences PhD program will be uniquely positioned as the only PhD graduate program in the only state-supported four-year medical school and associated University Hospital and Clinics. The Translational Biosciences program will be the only PhD program within the UM System that spans the entire breadth of biomedical research from basic science to clinical outcomes.

In the state of Missouri, there are two broad-based, umbrella-type doctoral training programs for biomedical scientists: (1) the Graduate School of the Stowers Institute, and (2) the Division of Biology and Biomedical Sciences doctoral training program at Washington University in St. Louis.

The Graduate School of the Stowers Institute, which has 19 faculty investigators who provide research training to 70 predoctoral graduate students, is focused on foundational biomedical research and awards a PhD degree in Biology to its graduates. In contrast, the proposed Translational Biosciences PhD program will integrate training across the basic sciences/clinical sciences continuum. Furthermore, while the Stowers Institute is a stand-alone research institution, predoctoral training in the Translational Biosciences PhD program occurs in the context of a medical school that is affiliated with the teaching hospital of MU Health Care.

The Division of Biology and Biomedical Sciences at Washington University is a highly successful umbrella graduate program that brings together 515 faculty from 38 academic departments into 13 graduate training programs that, collectively, train 645 predoctoral students. The success of the Division of Biology and Biomedical Sciences at Washington University is something that we hope to emulate in the Translational Biosciences PhD program. However, the history of MU as a land-grant state-supported medical school and our goal to closely integrate the basic and clinical sciences into a single PhD training program are unique aspects of the proposed Translational Biosciences PhD program.

Collaboration with existing complementary programs on campus, across the System and the state of Missouri: The Translational Biosciences PhD program will collaborate with several graduate programs at MU, across the UM System and across the state, as described below.

Collaboration across the MU campus: One of the Emphasis Areas in the Translational Biosciences PhD program will be “Biochemistry and Biophysics”. This interdisciplinary Emphasis Area will include faculty with expertise in biophysics, structural biology, and cell/molecular biology. Many of the faculty that will provide research training in this Emphasis Area have primary appointments in the Biochemistry Department. The Biochemistry Department is jointly administered by both the SOM and College of Agriculture, Food and Natural Resources (CAFNR), with 50% of Biochemistry faculty appointed through the SOM and 50% of Biochemistry faculty appointed through CAFNR. As a strength of the CAFNR-appointed faculty in the Biochemistry Department is in plant sciences research, there is a need to maintain an independent Biochemistry PhD degree program. To avoid duplication of effort, the Translational Biosciences PhD program will coordinate coursework and training activities with the Biochemistry graduate program. A letter from Dr. Michael Chapman, Chair of Biochemistry, is included in Appendix B.

The Translational Biosciences PhD program will coordinate graduate recruitment, education and training activities with the MU Institute for Data Science and Informatics (IDSI), particularly in training graduate students in quantitative skills. There are strong collaborations between the MU Informatics Institute PhD program and existing department-based PhD training programs in the SOM. For example, faculty from both MU IDSI and MMI participate as faculty mentors in an NIH-funded training program for biomedical PhD graduate students (T32 GM008396). Because of the importance of quantitative skills in biomedical research, we anticipate that these existing interactions will

be strengthened in the Translational Biosciences PhD training program. A letter from Dr. Chi-Ren Shyu, Director of the MU Institute for Data Science and Informatics, is included in Appendix B.

The Translational Biosciences PhD program will coordinate coursework and training with the Department of Veterinary Pathobiology in the College of Veterinary Medicine (CVM). The Department of Veterinary Pathobiology and the MMI Department in the School of Medicine have a joint graduate program, the Molecular Pathogenesis and Therapeutics (MPT) program. Many of the faculty who are currently part of the MPT program will be included in the Infection and Immunity Emphasis Area. Others, including Dr. James Amos-Landgraf, will be included in the Cancer Biology Emphasis Area. A letter from Dr. Brenda Beersten, Interim Chair of Veterinary Pathobiology is included in Appendix B.

The Translational Biosciences PhD program will coordinate coursework and training with the PhD program in the Department of Nutrition and Exercise Physiology, which is jointly administered by CAFNR and SOM. There are foundational aspects of nutrition and of exercise physiology that are shared by other disciplines, including biochemistry, physiology, immunology and microbiology. The Translational Biosciences PhD program and the Department of Nutrition and Exercise Physiology will coordinate coursework and training to minimize redundancy in faculty effort. In addition, some of the faculty in the Department of Nutrition and Exercise Physiology will participate as faculty mentors in the Translational Biosciences PhD program. A letter from Dr. Jill Kanaley, chair of Nutrition and Exercise Physiology, is included in Appendix B.

The Translational Biosciences PhD program will coordinate coursework and training with the PhD program of the Division of Biological Sciences, in the College of Arts & Sciences. The Division of Biological Sciences hosts one of the largest graduate PhD programs in the life sciences on the MU campus. Several faculty members with academic appointments in Biological Sciences are faculty mentors in the MPT program and the Biological Sciences PhD program is a key partner in two SOM-led NIH predoctoral training grants (T32 GM008396 and T32 TM135744). A letter of support from Dr. Dave Schulz, Chair of Biological Sciences, is included in Appendix B.

Collaboration across the UM system: The Precision Health Institute, comprised of experts and scientists from the four UM universities, will translate ground-breaking biomedical research into life-changing reality for patients in Missouri and around the world. Through close collaborations with the outstanding scientists and clinicians of the Precision Health Institute, the Translational Biosciences PhD program will provide state-of-the-art training to young biomedical scientists at the beginning of their scientific careers.

Collaboration across the state of Missouri: There are no immediate plans for formal collaborations with other biomedical PhD programs across the state of Missouri. However, future collaborations with other broad-based biomedical PhD programs in the state of Missouri can be envisioned. As mentioned above, both the Stowers Institute in Kansas City and Washington University in St. Louis have broad-based training programs in biological and biomedical research. Potential collaborations between the Translational Biosciences PhD program could include research symposia that provide PhD students in these three programs to present their research or professional development/career development workshops that provide students with networking opportunities with potential employers.

3. Business-Related Criteria and Justification

3.A. Market Analysis

3.A.1. Need for Program

Students who earn their PhD from the Translational Biosciences PhD program will be highly trained biomedical scientists. Biomedical scientists are employed by a wide range of employers, including academia, non-profit organizations, government and business/industry. The importance of biomedical scientists to the U.S. economy is highlighted by the fact that research and development (R&D) expenditures for health or biomedical applications constituted 26% of total R&D expenditures across all industries in 2018, according to the National Center for Science and Engineering Statistics (<https://nces.nsf.gov/pubs/nsf21316>). Collectively, the companies engaged in health and biomedical-related applications spent more than 3X on R&D than companies engaged in defense-related applications, the next largest R&D application area.

Consistent with the high levels of investment in biomedical research by both private companies and the federal government, the employment prospects for highly trained biomedical scientists are excellent. The U.S. Bureau of Labor Statistics (<https://www.bls.gov>) classifies Medical Scientists as PhD-level scientists who work in offices and laboratories, typically on research projects aimed at improving overall human health. According to the Occupational Outlook Handbook published by the U.S. Bureau of Labor Statistics (<https://www.bls.gov/ooh/life-physical-and-social-science/medical-scientists.htm#tab-7>), the number of Medical Scientists with a PhD degree is projected to grow 6% over the next 10 years, from a base of 138,300 Medical Scientists in 2019 to 146,700 in 2029. In contrast, the average rate of job growth for all jobs in the US economy during the 2019-2029 time frame is projected to be 4%.

In Missouri, the rate of growth of Medical Scientists is projected to be higher than the national average, according to Projections Central (<http://www.projectionscentral.com>), which predicts a growth rate of 8.7% in the number of PhD-level Medical Scientists, from 1,840 in 2018 to 2,000 in 2028.

We expect that the majority of the students who earn their PhD from the Translational Biosciences PhD program will develop a career in a research-intensive or research-related field. For example, 33 of the 39 (85%) graduate students who participated in the training

program funded by T32 GM008396 and who have earned their PhD degree over the past 15 years are continuing their career in research-intensive occupations in academia (N = 22), industry (N = 10) or government labs (N = 1). Of the remainder, 5 (13%) are working in research-related positions in industry or private foundations, typically in positions that involve program management or sales. Only 1 of the 39 graduate students is not working in a research-intensive or research-related position. In terms of where these PhD graduates found suitable employment, the largest number (16, or 41%) stayed in Missouri while the remainder were scattered throughout the US. As we anticipate that approximately 20% of the PhD students in this program will be from the State of Missouri, this program will result in a net influx of highly trained biomedical scientists that will help grow Missouri's economy.

3.A.2. Student Demand for Program

Student Demand: Supported by comments made by the external reviewers, we anticipate that there will be robust demand by students for the Translational Bioscience PhD program. The Translational Bioscience PhD program will merge the two existing PhD programs that are currently offered by the School of Medicine, which are housed in Molecular Microbiology and Immunology (MMI) Department and the Medical Pharmacology and Physiology (MPP) Department, respectively. Over the past 5 years, these two PhD programs have received an average of 46 applications per year, yielding an average of 8 matriculating students per year. As the breadth of the Translational Biosciences PhD program includes additional disciplines, including Cancer Biology, Population Health and Precision Medicine, we anticipate receiving approximately 120 applications, yielding 20 matriculating students, by Year 5.

Student Enrollment Projection: To project the student enrollment in this program, we have made a number of assumptions: (1) We assume that the applicant pool will increase from 46 per year to 120 per year over the course of five years; (2) From the applicant pool, we assume that the number of matriculating students will increase at the rate of 3 per year, such that the number of entering students increases from 8 in Year 1 to 20 in Year 5; (3) We assume a PhD completion rate of 87% and a time-to-degree of 5.5 years, based on our historical data with the existing biomedical PhD programs at MU (see Table 1C, page 14; and Table 4, page 21). These assumptions are modeled in Table 1A. As students are discrete entities, only whole numbers are included in the table. In year 5, this model predicts that, from the Year 1 cohort of 8 students, 7 of those students will still be enrolled in the program during the Fall Semester of Year 5 and complete their degree during Year 6. In Years 6 through Year 10, we assume that 20 students per year will matriculate into the program.

Table 1a. Student Enrollment Projections (anticipated total number of students enrolled in program during the fall semester of given year).

Year	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Full-Time	8	11	14	17	20
Part-Time	0	0	0	0	0
Total	8	19	32	48	67

Projections for new-to-campus student enrollment: We assume that student matriculation into this program will increase from 8 students in Year 1 to 20 students in Year 5. Given that the average enrollment in the existing SOM PhD programs (MMI and MPP) is approximately 8 per year, a cohort of 20 entering students per year would include 12

students per year that would not otherwise have matriculated into an existing PhD program at MU. Thus, we project that the new-to-campus enrollment will be 12 per year by Year 5.

Table 1b. Student Enrollment Projections (anticipated number of students enrolled during the fall semester of given year who were new to campus).

Year	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Full-Time	0	3	6	9	12
Part-Time	0	0	0	0	0
Total	0	3	6	9	12

Projections for PhD degrees awarded. Using the assumptions described for Table 1A, which include an overall PhD completion rate of 87%, we anticipate that 62 degrees will be awarded over the first ten years of this PhD. All the PhD degrees will be awarded in years 6-10. The number of PhD degrees awarded per year will increase from 7 in Year 6 to 18 in Year 10. After Year 10, we anticipate that there will be a steady-state enrollment of 20 new students per year and 17-18 PhD degrees awarded per year.

Table 1c. Projected Number of Degrees Awarded

Year	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
# of Degrees Awarded	0	0	0	0	0	7	10	12	15	18

3.B. Financial Projections

3.B.1. Additional Resources Needed

- No new faculty or facilities are needed. The School of Medicine Umbrella PhD program will utilize existing facilities and faculty resources to facilitate the instruction and infrastructure of the program. The facilities and faculty resources available to the Translational Biosciences PhD program include the Roy Blunt NextGen Precision Health Building and the faculty-led research programs housed therein. The Roy Blunt NextGen Precision Health Building will open on the MU campus in Fall of 2021.
- One new staff person will be hired, with primary responsibility for graduate student recruitment. As two existing PhD programs (in MMI and MPP) are being consolidated into the Translational Biosciences PhD program, the responsibilities of one existing staff person will be re-assigned to the Translational Biosciences PhD program to administer the educational and training activities of the program.
- Once the Translational Biosciences PhD program is established, no new graduate students will matriculate into the existing SOM PhD programs. After the current graduate students in the existing SOM PhD programs complete their degree, the existing SOM PhD programs will be consolidated into the Translational Biosciences PhD program.
- We anticipate that the Translational Biosciences PhD program will increase the number of PhD graduate students in the SOM. Currently, the SOM brings in an average of 8 new graduate students per year. We anticipate that, starting in Year 2 of the program, the number of new graduate students will increase by 3 per year.

- The projected increase in the number of PhD graduate students will require an increased financial commitment to graduate student support. MU competes with highly ranked public and private universities located throughout the Midwest (University of Wisconsin, Northwestern University, Washington University, etc) and on both coasts (University of California campuses, Johns Hopkins University, etc) for well-prepared and highly motivated undergraduates who are committed to pursuing a career in biomedical research. It is standard practice to offer competitive stipends as well as to waive all tuition and fees for graduate students in biomedical PhD programs. For example, the FY22 stipend level for Biochemistry graduate students at the University of Wisconsin is \$31,000, with all tuition and fees waived. To be competitive in student recruitment, MU must offer a competitive stipend as well as waive all tuition and fees not supported by research grants, training grants or fellowships. Tuition and fees that are waived are identified as Program Costs in Table 2.
- Federal research and training grants allow tuition and fees to be paid from the grant. Currently, in the SOM, about 40% of all tuition and fees are provided by grant funds, except for first-year students, who are typically not supported by research grants. We anticipate that the percentage of tuition and fees paid by research grants will increase to 60% by Year 5 of the Translational Biosciences program. Tuition and fees paid from grant sources is listed as Program Revenue in Table 2. The dollar amount of tuition and fees that are not recovered from grants is listed as Program Costs in Table 2.
- All first-year graduate students will be hired as 0.5 FTE Graduate Research Assistants (GRA). This 0.5 FTE GRA appointment will continue for the duration of their PhD training. In Year 0 (FY22), the current GRA stipend for SOM graduate students is \$30,000 per year. We anticipate a 3% annual inflation increase in graduate student stipends per year, such that the amount of a graduate student stipend in Year 2 (FY24) will be \$31,827. During their first year, graduate students will be funded by the Translational Biosciences program. The cost of stipends for new students, is included in the budget, starting in Year 2 (FY24) and continuing through Year 5 (FY27). During their subsequent training years, graduate student stipends are provided from research grants to the faculty mentors, training grants or fellowships.

3.B.2. Revenue

- Revenue is driven by students enrolling in a total of 72 credit hours during their 5-year graduate education, including 23 credit hours per year during their first two years; 16 hours during their third year and 5 hours during years 4 and 5. Tuition is based on FY22 Board approved rates and then inflation adjusted each year after. Student fees are based on \$120 per credit hour starting in FY22 and inflation adjusted going forward. We anticipate that the amount of tuition and fees that are recovered from research and training grants will increase from the current level of 40% to a projected level of 60% by Year 5.

3.B.3. Net Revenue

- Graduate Education and Training is and will continue to be a non-revenue generating mission. Because a high-quality biomedical PhD graduate training program is synergistic with strong faculty-driven biomedical research programs,

recruitment of students into biomedical PhD programs is highly competitive across the nation. To be competitive in student recruitment, MU must offer a competitive stipend as well as waive all tuition and fees not supported by research grants, training grants or fellowships. Graduate education aligns with the School of Medicine's missions of research and education. As described below, graduate students make substantive contributions to the research productivity of faculty-led research teams. In the absence of a high-quality PhD training program, the ability of faculty to conduct research and compete for research grants would markedly diminish.

Table 2. Financial Projections for Proposed Program for Years 1 Through 5.

The Financial Projections outlined in Table 2 were developed by Jess Berkey, Director of Finance for the School of Medicine, with input provided by Victor Arnold, Associate Dean for Finance and Practice Plan Management. This is a pro forma budget, in which only new expenses and income is stated. This budget reflects the net cost of expanding the number of incoming PhD graduate trainees in the SOM from 8 per year in Year 1 to 20 per year in Year 5, with an anticipated increase of 3 PhD trainees per year, starting in Year 2 (FY24).

In Year 0 (FY22), the year before any students matriculate into the Translational Biosciences PhD program, we anticipate that operating expenses will be \$253,000 per year to cover the cost of a new staff member and costs associated with the recruitment of new students. Funds for recruitment are included in each of the subsequent years. In Year 1 (FY23), which is the year we anticipate that 8 students will matriculate into the Translational Biosciences PhD program, we are not including additional expenses or income for these 8 students, because the current graduate programs in the SOM bring in an average of 8 students per year. In Year 1, no students will enter the existing departmental-based programs of MPT and MPP. Instead, all 8 will enter the Translational Biosciences program, with no net gain of PhD students in SOM graduate programs. Starting in Year 2 (FY24), we anticipate an increase of 3 new PhD students per year, such that a steady-state level of 20 first-year PhD students per year is achieved by Year 5 (FY27).

Table 2

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
	FY22	FY23	FY24	FY25	FY26	FY27
1. Expenses per year						
A. One-time						
<i>New/Renovated Space</i>	0	0	0	0	0	0
<i>Equipment</i>	0	0	0	0	0	0
<i>Library</i>	0	0	0	0	0	0
<i>Consultants</i>	0	0	0	0	0	0
<i>Others</i>	0	0	0	0	0	0
Total one-time	0	0	0	0	0	0
B. Recurring						
<i>Faculty</i>	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0
<i>Staff</i>	\$ 60,000	\$ 61,200	\$ 62,424	\$ 63,672	\$ 64,946	\$ 66,245
<i>Benefits</i>	\$ 18,000	\$ 18,360	\$ 18,727	\$ 19,102	\$ 19,484	\$ 19,873
<i>Equipment</i>						
<i>Library</i>						
<i>Computing and Supplies</i>	\$25,000	\$12,000	\$11,000	\$12,450	\$14,153	\$16,156
<i>Travel and Training</i>	\$150,000	\$165,000	\$181,500	\$199,650	\$219,615	\$241,577
<i>Stipends</i>	\$0	\$0	\$93,000	\$192,000	\$297,000	\$408,000
Total recurring	\$253,000	\$256,650	\$366,651	\$486,874	\$615,198	\$751,851
Total expenses (A+B)	\$253,000	\$256,650	\$366,651	\$486,874	\$615,198	\$751,851
2. Revenue per year						
<i>Tuition/Fees</i>	\$0	\$0	\$14,208	\$47,893	\$123,323	\$211,705
<i>Institutional Resources</i>						
<i>State Aid – CBHE</i>						
<i>State Aid – Other</i>						
Total revenue	\$0	\$0	\$14,208	\$47,893	\$123,323	\$211,705
3. Net revenue (loss) per year	(\$253,000)	(\$256,650)	(\$352,444)	(\$438,982)	(\$491,784)	(\$540,146)
4. Cumulative revenue (loss)*	(\$253,000)	(\$509,650)	(\$862,004)	(\$1,300,955)	(\$1,792,859)	(\$2,333,005)

Please provide responses to the statements below.

1. What are the specific sources of funds to support the new proposed program?

Response: With the consolidation of current PhD program, the School of Medicine will continue to use graduate research assistant (GRA) funds or campus allocated funds to cover staff salaries. Graduate stipends will come from operating fund dollars as well as CARTS R dollars allocated to the SOM from MUHC for strategic research initiatives.

2. If the new program is being funded through the 'core institutional budget,' what amount of funds will be reallocated and from which areas? (i.e., if existing resources are being used, please provide details.)

Response: With the consolidation of current PhD programs, the School of Medicine will continue to use GRA funds or campus allocated funds to cover staff salaries associated with the new program.

3. Are there any programs that will be deleted as a result of implementing this new program?

Response: The intent of this program is to consolidate current PhD programs that are administered by the SOM into the Translational Biosciences program while phasing out the old programs and students. The two current PhD programs that will be consolidated are housed in the Department of Molecular Microbiology and Immunology and the Department of Molecular Pharmacology and Physiology.

4. If the program will be supported by external funds, have the funding agency, the amount of funds, and whether they are one-time or ongoing funds been identified?

Response: The School of Medicine is the academic home of two current NIH T grants. Collectively, these two grants (T32 GM008396 and T32 GM135744) provide stipends and partial (60%) tuition recovery for 16 graduate students per year. We anticipate that Translational Biosciences PhD program will provide a training infrastructure that will allow the SOM to obtain additional T grants that will provide partial support of the program.

3.B.4. Graduate Training increases the Research Productivity of Faculty

- The ability of faculty to successfully compete for external grant funding is inextricably linked to their prior publication record. Research publications provide the foundational premise for the research described in a grant proposal. Graduate students, through their dissertation research, make substantive contributions to research publications. For example, the 44 PhD graduates who entered graduate school between 2004 and 2014 and participated in the training program co-sponsored by the Life Sciences Fellowship Program and T32 GM008396 contributed to 216 published research articles, an average of 4.9 research articles per student.
- The ratio of graduate students to grant-funded faculty in the School of Medicine is low compared to peer institutions in the State of Missouri. The Graduate School of the Stowers Institute has a student/faculty ratio of 3.7 (70 students/19 faculty investigators). The Division of Biology and Biomedical Sciences at Washington

University has a student/faculty ratio of 1.25 (645 students/515 faculty). In contrast, the student/faculty ratio in the MU SOM is 0.37 (53 students/145 faculty with NIH-funded research expenditures in FY21).

- A significant number (64%, 93/145) of SOM faculty who have NIH-funded research expenditures do not have access to a departmental graduate PhD program. By aligning research-active faculty with graduate student training, the Translational Biosciences PhD program will enhance the research productivity of SOM faculty.
- One goal of the SOM is to double research funding over the next five years. This will be accomplished, in part, through the hiring of at least 40 new faculty with very active research programs. A robust graduate training program will be an attractive feature to new faculty recruits, who recognize the value that graduate research assistants provide to their research program.

3.B.5. Financial and Academic Viability

The Translational Biosciences PhD program will not achieve stand-alone financial independence. However, a high-quality PhD training program is closely aligned with both the research and educational missions of the SOM. The current size of PhD graduate programs in the SOM provides a minimum level for the number of PhD graduate students needed for academic viability of the Translational Biosciences PhD program. Over the past five years, the average number of entering PhD graduate students into the two current SOM graduate programs (the MPT and the MPP graduate programs) has totaled 8 per year. Projected over the next five years and assuming a retention rate of 97.5% per year and a PhD completion rate of 87%, there would be 38 PhD graduate trainees in SOM graduate programs at the end of five years. If enrollment in the Translational Biosciences program does not exceed this projection based on the current size of the existing SOM graduate programs, we will, in consultation with the Dean, Provost and UM Office of Academic Affairs, decide if any changes and/or investments designed to enhance the program are needed or if the program should be placed on an inactive status. If additional changes or investments are made, the program will then be reviewed on an annual basis to assess progress.

Table 3a: Enrollment at the End of Year 5 for the Program to Be Financially and Academically Viable.

Viability	Minimum Enrollment
Financial	Not applicable
Academic	38

Table 3b. Enrollment at the End of Year 5 for the Program to Be Financially and Academically Viable.

Enrollment Status	Full-Time	Part-Time	Total
Number of Students	38	0	38

3.C. Business and Marketing Plan: Recruiting and Retaining Students

Sustained, substantive and coordinated recruitment activities are critical for the success of the proposed program. Several recruitment activities are outlined below. Many of these activities are currently being used by participating departments and by the Life Sciences Fellowship Program. The goal of these recruitment activities will be to attract qualified students who are interested in biomedical research in any department or program at MU. These recruitment activities will be directed by a staff person (to be hired), who will report directly to the co-Directors of the Translational Biosciences program (Dr. Mark Hannink and Dr. Gillian Bartlett). Our recruitment activities will involve multiple faculty members, graduate students and staff. The Translational Biosciences program will collaborate with the Life Sciences Fellowship Program, with non-SOM departmental PhD programs in Biochemistry (CAFNR), Biological Sciences (Arts & Sciences), Biomedical Sciences (College of Veterinary Medicine), and with interdisciplinary graduate programs administered by MU's Graduate School (Genetics, Interdisciplinary Neuroscience Program, and Informatics) to identify and attract highly qualified students to pursue a PhD in biomedical research at MU.

A notable feature of the Translational Biosciences PhD program, that differentiates this program from most biomedical PhD graduate programs, is the emphasis on training in the translational sciences. Two of the external program reviewers (Dr. Parks and Dr. Willard) noted that this emphasis on “translational sciences” would be very attractive to undergraduate students who are interested in biomedical research. Both reviewers emphasized the need to clearly communicate the long-term career benefits that derived from being trained in a broad translational sciences program to prospective students. The success of our program requires a dedicated effort to reach out and communicate with prospective students. We will devote substantial resources to recruitment, as described below.

Recruitment personnel and expenses: Starting in FY22, which is Year 0 of the program (the year before any students will matriculate into the PhD program) and in all subsequent years, we will devote approximately \$250,000 for recruitment activities, including the salary of a staff person dedicated to recruitment, travel expenses associated with various recruitment activities described below and stipends to support undergraduate research experiences with faculty. The size of the recruitment budget is justified by the multi-disciplinary nature of the Translational Biosciences PhD program, the need to recruit highly qualified students into this program and the highly competitive nature of biomedical PhD programs across the nation.

Faculty visits to regional colleges and universities: We will maintain strong relationships that have been developed between MU and undergraduate institutions such as Truman State University, Lincoln University, Central Methodist University, Grinnell College, Calvin College and Hope College. We will develop similar relationships with other small colleges that have strong science departments, particularly those institutions who have faculty members who earned their PhD from MU. The development of relationships between MU faculty and the faculty at these small, undergraduate-focused institutions has been critical to our past successes in recruitment of outstanding graduate students.

Recruitment of underrepresented minority students:

- a. We will continue with a successful strategy of recruiting at undergraduate recruitment

conferences, including Annual Biomedical Research Conference for Minority Students (ABRCMS) and the annual meeting of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS). The Life Sciences Fellowship Program has developed a robust recruitment effort at these conferences over the past 15 years, in which faculty, graduate students and staff members from multiple departments and colleges/schools attend these undergraduate recruitment conferences. For example, at the 2019 ABRCMS conference, the last in-person conference before the COVID19 pandemic, the team of MU recruiters talked to more than 500 undergraduates interested in pursuing their graduate studies at MU. These initial contacts led to more than a dozen applications, with four of these students matriculating in Fall 2020 as first-year graduate students at MU.

b. Faculty visits to Historically Black Colleges and Universities (HBCU's) and Minority Serving Institutions (MSI). The Life Sciences Fellowship Program has a strong relationship with New Mexico State University and Medgar Evers College. We will develop similar relationships with other institutions that have URM-focused undergraduate training programs such as RISE or MARC. The National Name Exchange and existing contacts through the McNair program will also be utilized.

Campus visitation program: In collaboration with the Graduate School, we will use a campus visitation program (Tigerview) that is designed to promote diversity and inclusion in graduate education. This program will provide an opportunity for historically underrepresented and underserved undergraduate students to visit campus and meet with faculty and students in the Translational Biosciences PhD program. These visits will take place early during the Fall semester, so that the visiting students will have an opportunity to learn about research opportunities in our program before the December 1 application deadline.

Providing research opportunities for undergraduates:

a. Academic Year Research for Undergraduates: We will support MU undergraduates in faculty-mentored research during the academic year through partnerships with existing undergraduate research programs on campus, including the Initiative to Maximize Student Development-EXPRESS program (IMSD EXPRESS), the NIH-funded MARC program, the LS-AMP program and the McNair program.

b. Summer Research for Undergraduates: We will support up to 10 undergraduates from a variety of institutions, including MU, to participate in a 10-week faculty-mentored summer research experience. These students will participate in MU's Summer Research Program that is directed by the Office of Undergraduate Research.

Online application: We will develop a website with an online application using the Slate system through the Graduate School. This application will students to provide their undergraduate course record, including GPA. Prospective students will not be allowed to provide GRE scores. As part of the application, applicants will be asked to identify one or two Emphasis Areas that are most relevant to their research interests. Applications will be reviewed by representatives from the individual Emphasis Areas and final decisions on acceptances will be made by the Executive Committee of the Translational Biosciences program.

We will use a holistic review process to evaluate applications. A holistic review is one that places less importance on traditional quantitative measures, such as GPA, and more emphasis on what the applicant has accomplished with the opportunities provided by the applicant's environment, the potential for a career in research and the quality of the

references. Guided by the published work of Roger Chalkley at Vanderbilt on factors that predict success in graduate school (<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0166742>), our review process will emphasize (1) the breadth of a applicant's academic preparation for graduate school; (2) what the applicant learned from prior research experiences; (3) non-cognitive competencies, including initiative, perseverance, conscientiousness and self-awareness/self-appraisal; and (4) inclusion and equity.

Recruitment weekend. A recruitment weekend will be held in late January, after the initial review of applications. In which highly applicants will be invited to visit campus and meet both faculty and students. Over the past 9 years (except during the COVID19 pandemic), several life science departments at MU have collaborated with the Life Sciences Fellowship Program to host a joint recruitment weekend. This joint recruitment weekend has been very successful in showcasing the diverse strengths of life science research at MU. The Translational Biosciences will continue this collaboration with the Life Sciences Fellowship Program.

Plans to ensure program enrollments are achieved. The Executive Committee of the program will conduct an annual review of recruitment and retention efforts. The yield of student inquiries and applications from the past year's recruitment activities will be determined and a cost-benefits analysis will inform planning for recruitment activities for the next year. New strategies, including social media approaches, for reaching out to prospective students will be tested. The minimum number of incoming students per cohort that is needed for the academic vitality of the Translational Biosciences PhD is 15 students per year. If enrollment does not reach this threshold by the end of Year 5, we will consider inactivation of the program.

Historical retention of PhD students in biomedical training programs at MU: A nationwide analysis of PhD-level research training programs in the biomedical sciences, published in 2011 by the National Research Council (NRC), revealed that six-year completion rates for biomedical PhD students ranged from 42% to 56%, depending on the discipline. This analysis is available at: https://researchtraining.nih.gov/sites/default/files/pdf/biomedical_sciences.pdf. A similar study that was published in 2015 and focused on students from underrepresented minority (URM) students, revealed that the seven-year PhD completion rate for URM PhD students across all life science disciplines was 52%. This study, from the Council of Graduate Schools, is available at: https://cgsnet.org/ckfinder/userfiles/files/DIMAC_2015_final_report_PR.pdf

Table 4 provides a summary of retention and PhD completion rates for biomedical PhD students associated with one or more of the training programs directed by Dr. Hannink, including two different T32 training programs (T32 GM008396 and T32 GM135744) and the Life Sciences Fellowship program. The data in Table 4 covers the time period of 2004 to 2019. During this period, 134 students matriculated into the various departmental PhD programs across campus, including the current PhD programs in the SOM (in the MMI and MPP departments) as well as PhD programs in other departments (Biochemistry in CAFNR and Biological Sciences in A&S). Of these 134 students, 71 completed their training and earned a PhD degree, 11 dropped out of the program before completing their PhD degree, and 52 were still in training during the 2019-2020 academic year.

The data in Table 4 provide clear evidence that the historical training record of biomedical PhD students is well above the national average for both PhD completion rates and time-to-degree. This historical record also indicates that there is not a substantive difference in outcome between URM and non-URM students. We anticipate that the Translational Biosciences PhD program will continue the strong training record established by the current biomedical PhD training programs at MU.

Table 4. Completion, Retention and time-to-degree of Biomedical PhD students from 2004-2019

	PhD Completion (2004-2019)	Retention (2004-2019)	Attrition (2004-2019)	Time to Degree
URM (N = 59)	27/32 (84%)	54/59 (92%)	5/59 (9%)	5.3 years
Non-URM (N = 75)	44/50 (88%)	69/75 (92%)	6/75 (8%)	5.6 years
Total (N =134)	71/82 (87%)	123/134 (92%)	11/134 (8%)	5.5 years

Plans to retain students through graduation: A PhD training program represents a significant financial investment by the institution as well as a significant time investment by faculty, staff and students. These investments of time and money are lost when students drop out of a PhD training program. Student attrition from PhD programs is driven by multiple factors, including academic, culture/climate, and personal factors. Interventions to address the factors that cause students to drop out of PhD programs have been studied by Wilson and co-authors (<https://www.lifescied.org/doi/full/10.1187/cbe.17-09-0210>). The Translational Biosciences PhD program will incorporate best practices for retention that have been described in the literature. These best practices include: (1) personalized on-site interviews during Recruitment Weekend to increase the level of understanding by the applicant regarding the nature and expectations of the program; (2) a cohort-based social support network among the students through student-driven journal clubs that start in their first year and continue for the duration of their PhD training; (3) academic support, including peer tutoring by senior graduate students; (4) a consistent grant proposal-based format for the comprehensive exam, along with courses that emphasize professional skill development, particularly in the area of grant-writing; (5) the use of individual development plans and career planning workshops to help students identify and develop competencies, including but not limited to their research skills, that will help them achieve their long-term career goals; (6) as suggested by Dr. Parks, a student support center that addresses personal issues, including financial issues, relationship/marital issues and stress management.

The Executive Committee will conduct an annual review of student progress and outcomes. The purpose of this review is to identify areas of concern and to develop appropriate interventions to enhance student success.

4. Institutional Capacity

Institutional capacity for training graduate students: The Translational Biosciences PhD program will replace two existing PhD programs that are currently administered by the MMI and MPP departments within the School of Medicine. The disciplinary content of the existing PhD programs will be incorporated into one or more of the Emphasis Areas of the Translational Biosciences PhD Program. The prospective students that would otherwise matriculate into the PhD programs of the MMI and MPP departments will, instead, matriculate into the Translational Biosciences PhD program. In the past, 8 students per year matriculate into the PhD training programs offered through either MMI or MPP. At the end of five years, we anticipate that an average of 20 students per year will matriculate into the Translational Biosciences PhD program. This net increase of 12 students per year is easily accommodated by the number of research-active faculty in the SOM who hold Doctoral status, as determined by MU's Graduate School. Faculty with Doctoral status can be primary research advisors of PhD graduate students by serving as the Chair of the student's Doctoral Program Committee. In the School of Medicine, there are 71 faculty who hold Doctoral status. An additional 121 faculty in the School of Medicine have Graduate Faculty Status A, as determined by MU's Graduate School. Faculty with Graduate Faculty Status A can serve as members of a PhD students Doctoral Program Committee and can serve as co-chairs of a student's Doctoral Program Committee. Collectively, the presence of 198 faculty across the School of Medicine who have been approved by MU's Graduate School to mentor PhD graduate students indicates sufficient capacity to accommodate a steady-state number of approximately 100 PhD students per year.

Impact of the Translational Biosciences PhD program on the research capacity of the School of Medicine: There is a well-established interdependence between research funding of faculty and training of PhD graduate students. Research grants to faculty provide the funds for research supplies and personnel, including graduate student stipends, while data generated by graduate students provide the basis for research publications and subsequent grant funding by their faculty mentors. In addition, robust research funding to faculty and well-organized graduate training programs are prerequisites for training grants, including NIH-funded T32 training grants.

We believe that the Translational Biosciences PhD program will have a strong positive impact on the research capacity of the School of Medicine. For example, in FY2021, total research expenditures in the School of Medicine were greater than \$34M, representing the research activity of 145 faculty with primary appointments in 21 School of Medicine departments. However, 64% (93/145) of these research-active faculty in the School of Medicine do not have direct access to graduate students enrolled in a departmental PhD graduate training program. By replacing department-focused training programs with a broad umbrella program that is open to all research-active faculty in the School of Medicine (and to many faculty members outside the School of Medicine), the proposed Translational Biosciences program will provide an efficient mechanism to match graduate students with research-active faculty. Furthermore, several of the Emphasis Areas of the Translational Biosciences program, including Cancer Biology, Integrative Physiology and Population and Precision Health, are closely aligned with the research foci of the NextGen Precision Health Institute. By both increasing the number of PhD graduate students in the SOM and by providing a SOM-wide mechanism for connecting graduate student training to research-active faculty, the Translational Biosciences PhD program will have a positive impact on faculty research

activities. Furthermore, the Translational Biosciences PhD program will provide an infrastructure that will result in increased T32 training grants at MU.

5. Program Characteristics

5.A. Program Outcomes

Learning outcomes: To earn their PhD degree, the graduates from the Translational Biosciences program must write and defend a dissertation that describes previously unknown findings revealed by their laboratory experiments or clinical observations. During their research training, the graduates from the Translational Biosciences program will have acquired in-depth expertise in a biomedical discipline and will have learned how to be effective communicators across disciplines. The graduates from the Translational Biosciences program will be independent scientists who are adept at using interdisciplinary and collaborative approaches to solve complex problems that adversely affect human health.

Special skills of graduates specific to the program: As a result of their coursework and research training, the PhD graduates will have acquired the following skills that will allow them to develop successful careers as biomedical scientists.

- Technical skills in state-of-the art experimental and computational approaches used in modern biomedical research.
- Operational skills of hypothesis generation, independent knowledge acquisition, and rigorous analysis of experimental data.
- Professional skills of ethical leadership, communication and teamwork and research program management that allow for productive interdisciplinary collaborations.
- Proficiency in problem-solving skills relevant for finding solutions to both old and new problems in human health and disease.

5.B. Structure

Overview: The curriculum of the Translational Biosciences program was developed with a singular goal in mind: to facilitate the transition of the PhD students from consumers of existing knowledge into producers of new knowledge. The curricular components include formal coursework, research rotations, journal club seminars, research seminars, professional development workshops and dissertation research.

The curriculum of the Translational Biosciences program has both Program-wide components, which all PhD students will participate in, and Emphasis Area-specific components, which will involve PhD students who have selected a particular Emphasis Area of research. The Program-wide components include the first-year coursework, rotation research, professional development courses and workshops, and a cohort-based journal club which will be continued through all years of the training program. The Emphasis Area-specific components include specialized coursework in appropriate discipline(s) relevant for a given Emphasis Area, research seminars and dissertation research under the mentorship of one (or more) faculty members. The balance between Program-wide components and Emphasis Area-specific components will shift over the proposed five-year course of study, with the Program-wide components predominately occurring during the first two years of graduate study and Emphasis Area-specific components becoming predominate during the latter years of graduate study.

5.C. Program Design and Content

PROGRAM STRUCTURE

1. Total credits required for graduation: 72

2. Residency requirements, if any: No residency requirements.

3. General education: Total credits for general education courses: Not applicable for a PhD degree.

4. Major requirements: Total credits required: 72

Process used to design the curriculum to meet the program outcomes: The process of developing the Translational Biosciences PhD program began in 2017, when Dean Delafontaine asked Dr. Mark Hannink (Biochemistry) and Dr. Alan Parrish (Medical Pharmacology and Physiology) to lead an effort to develop an umbrella PhD program in biomedical sciences in MU's School of Medicine. Dr. Hannink and Dr. Parrish led a faculty committee that spent two years in the planning and development of the proposed Translational Biosciences PhD program. Drs. Hannink and Parrish met individually with every department chair in the School of Medicine, including 5 basic science department chairs and 16 clinical department chairs. Extensive discussions were held with the leaders of existing PhD programs in the School of Medicine and with extended groups of faculty members from both basic science and clinical departments.

There were three guiding principles that came out of these discussions:

1: that all biomedical disciplines share a common language based on the foundational sciences of genetics and biochemistry and that mastery of this common language is important to facilitate communication by scientists across disciplinary boundaries.

2: that all biomedical scientists use a common set of operational and professional skills; and that the development of these skills needs to be a major component of research training. These operational and professional skills include:

- Synthesizing information across multiple disciplines
- Understanding strengths and limitations of experimental approaches
- Using appropriate statistical analyses
- Interpreting data
- Identifying gaps in the knowledge base
- Generating novel hypotheses
- Communicating the impact of their research findings, including translational implications of research

3: that the development of an in-depth knowledge base and technical expertise in any biomedical research discipline builds on the common language of genetics and biochemistry and on the operational and professional skills outlined above.

Sequence of courses: The three principles, outlined above, have guided curriculum development of the Translational Biosciences PhD program. The initial Program-wide

coursework, taken by all students, will emphasize the common languages of genetics and biochemistry, as well as the common skills of experimental design and data analysis, particularly for large datasets that are increasingly generated and used by biomedical scientists. As the students make progress through the program and begin to define the problem(s) that will be the focus of their dissertation research, the coursework becomes more specialized within each Emphasis Area. As a counterbalance to increased specialization, students in the Translational Biosciences program will also be required to take one 3 credit hour elective course in a different Emphasis Area or in a different PhD program. Students will be encouraged to take additional elective courses that fit their broader interests. The Translational Biosciences Journal club, which will be taken by students from each entering year as a cohort, will also counterbalance research specialization through continued exposure to research outside of their area of expertise.

Consistent with the requirements of the MU Graduate school for full-time enrollment of graduate students, all of the students in the PhD Translational Bioscience program will be full-time graduate students and will register for 9-12 credit hours per Fall or Spring semester and 5 credit hours in Summer semester until they pass their comprehensive exam. Students will take their comprehensive exam during their second year. After completing their comprehensive exam, students will take a minimum of 2 credit hours per Fall or Spring semester and 1 credit hour in the Summer Semester. The schedule of courses assumes a five-year plan of study for PhD students. A total of 72 credit hours of graduate coursework (including both didactic coursework and research) is required to earn a PhD.

The 72 credit hours of graduate coursework required for a PhD degree in the Translational Biosciences PhD program is divided into five categories: (1) Didactic coursework required of all students, including at least one elective course; (2) Didactic coursework specific to each Emphasis Area; (3) Seminars and Journal Clubs, including both Program-specific and Emphasis Area-specific; (4) Rotation Research; (5) Dissertation Research. Although the amount of didactic coursework required for each individual Emphasis Area varies, an average coursework across all Emphasis Areas was used to determine the distribution of credit hours between these different categories for an “average” student who takes 5 years to complete the PhD, as shown in the Table below.

Type of course	Average credit hours required over 5 years
Program-specific Didactic Coursework	14
Emphasis Area-specific Didactic Coursework	6 - 15
Seminars and Journal Clubs	18
Rotation Research	2
Dissertation Research	23 - 32
Total credit hours	72

Year 1 Coursework (23 credit hours): All PhD students in their first year will take a common set of courses, including coursework in molecular/cellular biology, data design and analysis, a professional skills course, and a seminar course. In addition, all PhD students will participate in research rotations with at least three different research laboratories during their first year. After completing research rotations with three different faculty mentors, the

students will select their primary faculty mentor and initiate their dissertation research during the Spring Semester of their first year.

Fall Sem. Yr. 1		Spring Sem. Yr 1		Summer Sem. Yr 1	
Course	Hrs	Course	Hrs	Course	Hrs
MPP 8500/BIOCHM 8240 Molecular and Cellular BioSciences	3	Emphasis Area Introductory Course	3	Dissertation Research	5
Data Design and Analysis I	3	Emphasis Area Introductory Course	3		
Professional skills for Translational Bioscientists I	1	Professional skills for Translational Bioscientists II	1		
Rotation Research	1	Rotation Research	1		
Research Seminar	1	Research Seminar	1		
TOTAL CREDIT HOURS (Fall)	9	TOTAL CREDIT HOURS (Spring)	9	TOTAL CREDIT HOURS (Summer)	5

Year 2 Coursework (23-32 credit hours): There will be two program-wide requirements of all PhD students during years 2 – 5, including a grant-writing course during their second year and a yearly journal club with other members of their cohort. By the end of their second year, most of the PhD students will have completed didactic coursework for their Emphasis Area. The PhD students will have completed their comprehensive exam by the end of Year 2.

In the tables below, the Emphasis Area-specific coursework is identified as such, without specifying the Emphasis Area or the title of the specific courses. Additional information on the coursework components of the individual Emphasis Areas is provided in the Appendix. The elective coursework will typically be courses offered by other Emphasis Areas, although courses taught by other departments across campus will also qualify as elective coursework, provided that the course is taught at the appropriate graduate (8000 to 9000) level.

Fall Sem. Yr 2	
Course	Hrs
Translational Biosciences Journal Club (by cohort)	1
Emphasis-Area Coursework	3-6
Elective	0-3
Emphasis-Area Research Seminar	1
Dissertation Research	1
TOTAL CREDIT HOURS (Fall)	9-12

Spring Sem. Yr 2	
Course	Hrs
Translational Biosciences Journal Club (by cohort)	1
Grant-writing for Biomedical Scientists	3
Emphasis-Area Coursework	3-6
Elective	0-3
Emphasis-Area Research Seminar	1
Dissertation Research	1
TOTAL CREDIT HOURS (Spring)	9-15

Summer Sem. Yr 2	
Course	Hrs
Dissertation Research	5
TOTAL CREDIT HOURS (Summer)	5

Years 3-5 Coursework (7-25 credit hours per year): During years 3-5, the PhD students will focus on their dissertation research while continuing to take the Translational Biosciences Journal Club and Emphasis Area-specific seminars. During years 3-5, the PhD students may take additional elective coursework that are relevant to their interests. Students in their sixth year (or later) of the PhD program will continue to register for Dissertation Research, Translational Biosciences Journal Club and Emphasis Area Research Seminar until they defend their dissertation.

Fall Semester Yrs 3-5		Spring Semester Yrs 3-5		Summer Semester Yrs 3-5	
Course	Hrs	Course	Hrs	Course	Hrs
Translational Biosciences Journal Club (by cohort)	1	Translational Biosciences Journal Club (by cohort)	1	Dissertation Research	1
Emphasis-Area Coursework	0-4	Emphasis-Area Coursework	0-4		
Elective	0-3	Elective	0-3		
Emphasis-Area Research Seminar	1	Emphasis-Area Research Seminar	1		
Dissertation Research	1-3	Dissertation Research	1-3		
TOTAL CREDIT HOURS (Fall)	3-12	TOTAL CREDIT HOURS (Spring)	3-12	TOTAL CREDIT HOURS (Summer)	1

5. Free elective credits: Total free elective credits: One 3 credit elective is required; up to 9 elective credits will be allowed.

6. Requirement for thesis, an internship or other capstone experiences: A PhD dissertation is required. A PhD dissertation describes new findings, including field observations and experimental data, that address a previously unanswered question in an area of human inquiry. Students in the Translational Biosciences PhD program are required to write a dissertation and to present a public defense of the dissertation. All dissertations that are successfully defended will be published by MU. In addition, the research results described in the dissertation must be published in one or more scientific journals as peer-reviewed manuscripts. The Translational Biosciences PhD program will require that all PhD graduates have at least 1 first-author research publication related to the dissertation research.

7. Any unique features such as interdepartmental cooperation: Interdepartmental cooperation is at the heart of the Translational Biosciences PhD program. By joining together into a single PhD program rather than attempting to develop individual PhD programs in each of the 21 departments within the School of Medicine, the departments have recognized the

advantages of working together, across departmental and disciplines, to create a novel research training program that will integrate training across the basic and clinical biomedical sciences.

Integration of research training across the basic and clinical biomedical sciences will occur through a PhD student's career. During the first-year coursework, both the Molecular and Cellular BioSciences course and the Data Design and Analysis course will emphasize mechanisms of disease and Big Data science as well as the use of diverse genomic and biomedical databases including the Cancer Genome Atlas (<https://www.cancer.gov/about-nci/organization/ccg/research/structural-genomics/tcga>) and the UK Biobank (<https://www.ukbiobank.ac.uk>). Research rotations with clinical scientists will be encouraged. The Translational Biosciences Journal Clubs, which all PhD students will participate in during Years 2-5, will be led by faculty from both the basic and clinical sciences. We will encourage clinical scientists to become participating members of the Emphasis Areas, including serving as members of Doctoral Program Committees of the PhD students.

5.D. Program Goals and Assessment

Didactic Coursework: A variety of methods, including quizzes, homework assignments, group assignments, exams and participation in class discussions will be used to assess learning outcomes for didactic courses. Instructors of individual courses will determine the relative contribution of each learning outcomes to the grade that a student will receive after completing each of the courses. Didactic courses will use the traditional letter grade scale (A = 4.0, B = 3.0, etc.). At MU, all graduate students are required to maintain a 3.0 grade point average (GPA). Students who do not maintain a 3.0 GPA will be put on academic probation for the following semester. Students on academic probation who fail to bring their cumulative GPA above 3.0 will be dismissed from the program.

Research Rotations and selection of a research advisor(s): One goal of the three required research rotations is for the PhD student to gain exposure to the research interests of different faculty mentors. A second goal is for the PhD student to gain exposure to the different mentoring style(s), expectations and cultural environments of faculty mentors and their research groups. Rotations with clinical scientists will be encouraged. Both the PhD student and the faculty mentor will be required to provide the Program Directors with a short description of the rotation experience. The research rotations will be graded on a Pass/Fail basis.

Following three research rotations, selection of a research advisor for PhD students will be based on mutual consent of the PhD student and the faculty mentor. Dual mentorship of PhD students by, for example, a basic scientist and a clinical scientist, will be encouraged.

Research Seminars and Journal Clubs: All students will be required to attend Research Seminars and Journal Club courses. Attendance and participation will be used to assess learning outcomes for seminars and journal clubs. These courses will be graded on a Pass/Fail basis.

Research Progress: Rotation Research courses and Dissertation Research credits will be graded on a Pass/Fail basis. Each student is required to meet with their Doctoral Program

Committee at least once per year. At each meeting, the student will present their research progress to their DPC. Students are also required to submit an annual assessment report of their research progress to the Graduate Education Committee of each Emphasis Area. Both the primary research advisor as well as another member of the DPC will write independent assessments of the student's research progress. The research progress reports should clearly outline how the student's research is progressing towards one or more publishable manuscripts.

Completion of the Comprehensive Examination and Advancement to Candidacy: The comprehensive exam is a hallmark of every PhD program. Successful completion of the Comprehensive exam indicates that the student has advanced to Candidacy for the PhD degree. Graduate students in the Translational Biosciences PhD program will be expected to pass their comprehensive exam before the start of their third year. The Comprehensive Exam will have a written component and an oral component. The written component will be a research proposal written in the format of an NIH F31 proposal. The oral component will be a presentation and defense of the proposed research to the student's DPC. Following successful completion of the Comprehensive Exam, the student's F31 proposal will be submitted to NIH.

Assessment of the Comprehensive Exam: The Comprehensive Exam process will evaluate (1) the student's knowledge of core concepts in the discipline(s) relevant to the Emphasis Area; (2) the student's knowledge of core concepts in the discipline(s) relevant to the research project(s) of the student; and (3) the ability of the student to develop, write and orally defend a hypothesis-driven research proposal that outlines a series of experimental approaches to test the validity of the hypothesis. The written and oral components of the Comprehensive Exam will be assessed separately, on a Pass/Fail basis. Students must receive a Pass on both components to have passed the Exam. Students who fail the Comprehensive Exam will have one opportunity to retake the Exam, which must be completed by the end of the following semester.

Research Dissertation: To earn their PhD degree, the graduates from the Translational Biosciences program must write and defend a dissertation that describes previously unknown findings revealed by their laboratory experiments or clinical observations. The standard expectation of all students in the Translational Biosciences program is that they must submit 2 publications, 1 of which must be a first-author publication, that describe the outcomes of their dissertation research to peer-reviewed journals prior to defending their dissertation. A public oral defense of their dissertation is required.

Goals for retention and graduation rates: As described above (Table 2, Section 3 and Table 4), biomedical training programs at MU, including those in the School of Medicine, have a historical PhD completion rate of 87% and a time-to-degree of 5.5 years. While we aspire to increase the PhD completion rate to 90% while maintaining a time-to-degree of 5.5 years or less, the historical PhD completion rate has been used in all projections.

Projection of graduates per year: We anticipate that the average time-to-degree will be 5.5 years. Thus, we do not anticipate any PhD graduates until Year 6 of the program. In year 6, we anticipate that 7 of the 8 students who joined the program in Year 1 will complete their PhD. In Year 5, we anticipate that new enrollment will plateau at 20 incoming students per year. Thus, by Year 10, with an entering cohort of 20 students per year and a PhD completion

rate of 87%, we anticipate that there will be, on average, 18 PhD graduates per year starting in Year 10.

Projection of Placement rates: We anticipate that 98% of all graduates will be employed in research-intensive or research-related careers within 6 months of completing their PhD. The remaining 2% of PhD graduates will seek and find employment in careers such as law or journalism that are neither research-related nor research-intensive. This projection is based on 20 years of historical outcomes of students who have earned PhD degrees in biomedical disciplines at MU.

5.E. Student Preparation

Recommended preparation for entering students: Students who enter the Translational Biosciences PhD program must have earned a BS or BA degree in a relevant discipline from an accredited institution of higher education. We recommend that students have taken undergraduate coursework in disciplines that are relevant for biomedical research, including calculus, statistics, physics, chemistry, biology, genetics, biochemistry and physiology. Prior experience in research is highly recommended. We recognize that students with diverse undergraduate educational experiences will matriculate into the program. Thus, one goal of the first-year coursework is to provide all students with basic understanding of the language of biomedical research, particularly in the areas of genetics, biochemistry and data analysis.

5.F. Faculty and Administration

Leadership of the Translational Biosciences PhD program: The Co-Directors of the Translational Biosciences PhD program are Dr. Mark Hannink and Dr. Gillian Bartlett. Dr. Hannink and Dr. Bartlett will each devote 15% of their effort to administration of the program. Both Dr. Hannink and Dr. Bartlett will devote additional time to the instructional and training activities of the program. Dr. Bartlett is a Professor in Family and Community Medicine and serves as the Associate Dean for Population Health and Outcomes Research in the School of Medicine. Dr. Hannink is a Professor in the Biochemistry Department. Dr. Bartlett and Dr. Hannink will report directly to Dr. Steven Zwiag, Dean of the School of Medicine. Dr. Bartlett and Dr. Hannink will serve as co-Directors of Graduate Studies for the Translational Biosciences PhD program.

The training programs within each Emphasis Area are similar in size and scope to traditional departmental-based PhD programs, but with several important differences. First, faculty membership within any given Emphasis Area will be determined by scientific interests of any given faculty member rather than the academic home of that faculty member. Second, although faculty membership in traditional departmental-based PhD programs is typically weighted towards basic science faculty, faculty membership in the Emphasis Areas will be inclusive to clinical faculty with appropriate clinical research interests relevant to a given Emphasis Area.

Each Emphasis Area will be led by a Graduate Education Committee (GEC), chaired by a faculty member who will serve as Director of Graduate Studies (DGS) for that Emphasis Area. The GEC of each Emphasis Area, led by a DGS, will be responsible for the discipline-based education and research training of graduate students in each Emphasis Area. To account for

the time and effort that is required of a Director of Graduate Studies, we have allotted 10% FTE to the DGS for each Emphasis Area. This is allocated effort and does not represent an increase in compensation to the Directors of Graduate Studies.

The initial selections of faculty to serve as DGS for a given Emphasis Area were based on the current role(s) or interest(s) of the faculty members. Once the Translational Biosciences PhD program is established, the leadership of each Emphasis Area will be determined by faculty members in each Emphasis Area.

Conflict resolution: Conflicts between the Emphasis Areas will be brought to the Executive Committee. Dr. Hannink and Dr. Bartlett will have the final say in determining the resolution of such conflicts. Conflicts between Dr. Hannink and Dr. Bartlett will be brought to Dr. William Fay, Senior Associate Dean for Research in the School of Medicine, who will have the authority to resolve conflicts between the leadership of the Program.

Staff support: personnel and expenses: In our budget (see Section 3B), we have allotted \$250,000 per year for staff support for recruitment and instructional activities. One staff person will be primarily responsible for recruitment while the other staff person will be primarily responsible for interacting with enrolled students and assisting with instructional activities. These two staff people will cross-train so that they can assist each other during peak activity periods. The activities involving enrolled students and instruction include student registration, graduate assistantship appointments in HR, assisting faculty with organization and administration of courses and assisting the leadership team in program oversight and evaluation.

Leadership and Administrative Positions in the Translational Biosciences PhD Program			
Name	Role	Academic Department	Administrative FTE
Dr. Gillian Bartlett	Co-Director	Fam. Comm. Med.	15%
Dr. Mark Hannink	Co-Director	Biochemistry	15%
Dr. Gillian Bartlett	DGS, Pop. & Prec. Health	Fam. Comm. Med.	10%
Dr. James Amos-Landgraf	DGS, Cancer Biology	Vet. Pathobiology	10%
Dr. Mark Daniels	DGS, Infection & Imm.	Mol. Micro. & Imm.	10%
Dr. Chris Hardin	DGS, Nutr. Ex. Phys.	Mol. Pharm. & Phys.	10%
Dr. Alan Parrish	DGS, Integrative Phys.	Mol. Pharm. & Phys.	10%
Dr. Charlotte Phillips	DGS, Biochem & Biophys,	Biochemistry	10%
Total Faculty FTE for Leadership and Administrative Roles			90%
To be named	Program manager	SOM Dean's Office	100%
To be named	Recruitment manager	SOM Dean's Office	100%
Total Faculty and Staff FTE for Leadership and Administrative Roles			290%

Instructional needs of the Translational Biosciences Program: There are four categories of instructional needs of the Translational Biosciences PhD program: (1) Didactic coursework; (2) Research seminars and journal clubs; (3) Rotation research; and (4) Dissertation Research.

The Full-Time Equivalents (FTEs) needed to meet the instructional needs for didactic coursework, for research seminars and for journal clubs, can be estimated based on the assumption that teaching a one-semester, 3-credit course is 10% of a given faculty member's annual effort. Based on this assumption, the didactic coursework, for research seminars and for journal clubs will require a total faculty effort of approximately 4 Full-Time Equivalent faculty positions. See tables below for detailed breakdown of FTEs needed for each of these instructional activities.

The FTEs needed to meet the instructional needs for Rotation Research credits and Dissertation Research credits is not easy to determine, as the research training of graduate students overlaps with the research activities of faculty and it is difficult to make accurate distinctions between the activities of mentoring and research. However, as described below, the School of Medicine has more than sufficient capacity, in terms of research-active faculty members, to provide a rich training environment for the graduate students enrolled in the Translational Biosciences PhD program.

1: Instructional needs for didactic coursework: The instructional needs for didactic coursework include both Program-specific components and Emphasis Area-specific components.

Program-specific: The Program-specific components for didactic coursework require students to take four (out of five offered) courses of three credit hours each, for a total of 12 credit hours. The table below lists the instructors for the program-specific didactic courses, along with their academic home department and the %FTE per faculty member for each course. The %FTE is based on a %FTE of 10% for a three-credit hour course. Total faculty effort for the two-semester sequence of Molecular Bioscience I and II is 20%; the total faculty effort for the two-semester sequence of Data Design and Analysis is 20%; the total faculty effort for the one-semester Professional Skills course is 10% and the total faculty effort for the one-semester Grant-writing for Biomedical Scientists course is 10%.

Program-specific Instructional Needs for Didactic Coursework			
Faculty member	Academic Department	Program-specific Courses Taught	% FTE devoted to Program-specific instruction
Bartlett, Gillian	Fam. Com. Med.	Data Design I	5%
		Professional Skills	1.7%
Calcutt, Mick	Vet. Path	Mol Cell BioSciences I	3%
Cornish, Peter	Biochemistry	Mol Cell BioSciences I	1%
Daniels, Mark	Mol. Micro. & Imm.	Mol Cell BioSciences I	1%
Domeier, Tim	Mol. Pharm. & Phys.	Mol Cell BioSciences I	1%
		Grant-writing class	5%
Hannink, Mark	Biochemistry	Grant-writing class	5%
Krenz, Maike	Mol. Pharm. & Phys.	Mol Cell BioSciences I	1%
Parrish, Alan	Mol. Pharm. & Phys.	Professional Skills	1.7%
Petroski, Greg	Fam. Com. Med.	Data Design I	5%
Van Doren, Steve	Biochemistry	Mol Cell BioSciences I	3%
Total FTE for Program-specific Didactic Instruction			33.4%

Emphasis Area-specific: The instructional needs for the Emphasis Area-specific didactic coursework varies between the different Emphasis areas. The table below describes the number of credit hours of didactic coursework required by each Emphasis Area. Detailed information on the specific didactic coursework for each Emphasis Area is provided in the Appendix.

Emphasis Area-specific Instructional Needs for Didactic Coursework			
Emphasis Area	DGS of the Emphasis Area Graduate Education Committee	Number of courses and credit hours of didactic coursework	Total % FTE devoted to Emphasis Area-specific courses
Biochemistry & Biophysics	Dr. Charlotte Phillips	2 elective courses; 6 credit hours total	20% total FTE
Cancer Biology	Dr. James Amos-Landgraf	1 required course and 1 elective course; 6 credit hours total	20% total FTE
Infection & Immunity	Dr. Mark Daniels	4 required courses and 1 elective course; 15 credit hours total	50% total FTE
Int. Physiology	Dr. Alan Parrish	2 required and 1 elective courses; 9 credit hours total	30% total FTE
Nutr. & Ex. Physiology	Dr. Chris Hardin	4 required courses and 4 elective courses; 23-24 credit hours	80% total FTE

Pop. & Precision Health	Dr. Gillian Bartlett	Three courses are planned for this new Emphasis Area	30% total FTE
Total FTE for Emphasis Area-specific Didactic Instruction			230% total FTE

2: Instructional needs for Research Seminars and Journal Club: Every student will take one Research seminar per semester, for one credit hour. The % FTE for a one credit hour class is 3.3%. During their first year, all students will take the Program-specific Research Seminar each semester (2 per academic year). The first year Research seminar will be directed by one or more members of the Executive Committee (Dr. Gillian Bartlett, Dr. Mark Hannink, Dr. Mark Daniels, Dr. Charlotte Phillips, Dr. James Amos-Landgraf, Dr. Alan Parrish, and Dr. Chris Hardin). During subsequent years (Yrs 2-5), all students will take an Emphasis Area-specific Research Seminar every semester. The course directors of the Emphasis Area Research Seminars will vary from year to year. Across the entire Program, there will be 6 Emphasis Area-specific Research Seminars per semester (12 per academic year). In addition, during Years 2-5, each class cohort will take one Translational Biosciences Journal Club per semester, for one credit hour. At steady state, when there are cohorts of 20 students per year across all five years of the program, there will be 4 Journal Clubs per semester (8 per academic year). The Translational Biosciences Journal Clubs will include one faculty member as a facilitator, and the same faculty member will stay with each cohort through graduation. The faculty who will direct the Journal Clubs will include faculty with expertise in clinical research. At steady state, when there are cohorts of 20 students per year, the total Faculty Effort required for Research Seminars and Journal Clubs will be: $3.3\% \text{ FTE} \times (2 + 12 + 8) = 72.6\% \text{ total FTE}$.

Seminar or Journal Club	Courses/year	%FTE
Translational Biosciences Research Seminar (1 each semester, first year)	2	6.6%
Emphasis Area Research Seminar (6 EAs x 2)	12	39.6%
Translational Biosciences Journal Club (4 cohorts x 2)	8	26.4%
Total FTE for Seminars and Journal Clubs		72.6%

3: Instructional needs for Rotation Research: Each student, in their first year, will complete three Research Rotations, for 1 credit hour each. The total credit hours of Research Rotations for all students in their first year will be 60 credit hours per cohort of 20 students. A total % FTE of 200% will be required across the entire Program for Rotation Research. This faculty effort will be spread across all faculty members who have either Doctoral Faculty status or Graduate Faculty "A" status, as determined by the MU Graduate School. As of March, 2021, there are 198 faculty members in the School of Medicine who have either Doctoral Faculty status (71) or Graduate Faculty "A" status (127). In the Appendix, a complete list of faculty in the School of Medicine who have Doctoral Faculty status or Graduate Faculty "A" status is provided. A total of 60 credit hours per year will be needed for all 20 students to have 3 research rotation experiences.

4: Instructional needs for Dissertation Research: The formal credit hours of Dissertation Research taken by each student will depend on the Emphasis Area and

the specific program of study of each student, as determined by the student's Doctoral Program Committee. Some students will have fewer course credits for didactic coursework, seminars and journal clubs and consequently, have more credit hours of dissertation research in order to reach the 72 total credit hours required for a PhD degree. Other students will have more course credits for didactic coursework, seminars and journal clubs and consequently fewer credit hours of dissertation research. Assuming that students are equally distributed across the Emphasis Areas, an "average" student will take 26.5 credit hours of Dissertation Research.

A more relevant way to assess the instructional needs for Dissertation Research is based on the number of graduate students, assuming that each graduate student will have one faculty member who serves as the primary mentor for the student and is chair of the student's Doctoral Program Committee. With a steady-state graduate student population of approximately 100, and as only faculty with Doctoral Status are able to serve as a chair of the student's Doctoral Program Committee, a total of 100 faculty with Doctoral Status will be needed to serve as chairs of the student's Doctoral Program Committee.

Of course, faculty typically serve as primary research advisors to more than one student at a time, so the number of faculty with Doctoral Status needed is less than the steady state number of graduate students in the program. As of March 2021, there are 71 faculty in the School of Medicine who have Doctoral Status and 127 faculty in the School of Medicine who have Graduate Faculty "A" status. Doctoral Status is limited to faculty who have academic appointments in departments with PhD graduate programs. However, nearly all of the faculty who have Graduate Faculty "A" status would be eligible for Doctoral Status once the Translational Biosciences PhD program is approved. During the first year of the program, we will work with the MU Graduate Faculty Senate and individual faculty members to increase the number of faculty with Doctoral Faculty status. We anticipate that the current research-active faculty who will be associated with the Translational Biosciences PhD program will be more than sufficient to meet the need for Dissertation Research Advisors.

Special requirements: Faculty participation in the Translational Biosciences PhD program will occur at several levels, including as a course instructor for either the Program-specific courses or the Emphasis Area-specific courses; as a member of a student's Doctoral Program Committee (DPC); or as a Chair of a student's DPC (i.e., serve as the primary research advisor of PhD graduate student). All faculty members who are course instructors must have a terminal degree (PhD or MD) in an appropriate biomedical or clinical discipline. Faculty members who serve as members of a student's DPC must have Graduate Faculty Status "A", as determined by the MU Graduate Faculty Senate. Faculty members who serve as Chair of a student's DPC must have Doctoral Faculty membership, as determined by the MU Graduate Faculty Senate.

Credit hours that will be assigned to full-time faculty: 100% of all credit hours of instruction will be assigned to full-time faculty.

Faculty requirements for involvement in professional activities or teaching/learning innovations: Faculty mentoring is a critical component of all research training programs. We will work with the MU Graduate School to develop a faculty mentor training program. Faculty

that do not participate in faculty mentor training will not be eligible to serve on a student's DPC, as either a regular member or chair.

Faculty CVs: In the appendix, we have included an NIH biosketch for the faculty members who will serve as Chairs of each Emphasis Area. We have also included a list of likely faculty members for each Emphasis Area.

5.G. Alumni and Employer Survey

Annual Surveys of Alumni: We will maintain an email list of all alumni who have graduated from the program. This list will be kept up to date through email or phone contact with alumni as well as social media sources such as LinkedIn. We will coordinate our tracking efforts with the Graduate School to minimize duplication of effort. Once per year, we will send a short survey to all alumni on the list, asking for updated information on their career path and their level of satisfaction with their PhD training. Based on similar outreach activities that have been carried out in association with current PhD training programs, we anticipate a response rate of 80% and a satisfaction rate of 90% or greater.

Annual Surveys of Employers: We do not plan to obtain feedback from employers of our PhD graduates. Such surveys are not commonly performed by PhD graduate programs.

5.H. Program Accreditation

There are no national or state organizations that specifically provide accreditation for biomedical PhD programs. At the institutional level, the University of Missouri-Columbia is accredited by the Higher Learning Commission (<https://www.hlcommission.org>). The Higher Learning Commission is one of six regional accreditors in the United States that accredits degree-granting post-secondary institutions. The most recent accreditation of the University of Missouri-Columbia was completed in 2015. The next accreditation will occur in 2024-2025.

To maintain its accreditation by the Higher Learning Commission, the University of Missouri-Columbia requires that all degree-granting programs establish learning objectives for the program and individual courses and track the educational outcomes of the students. The University of Missouri-Columbia has a program review process that ensures all accreditation standards are met.