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Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	The Johns Hopkins University

Each action below requires a separate proposal and cover sheet.

- ○ New Academic Program
- ○ New Area of Concentration
- ○ New Degree Level Approval
- ◉ New Stand-Alone Certificate
- ○ Off Campus Program
- ○ Substantial Change to a Degree Program
- ○ Substantial Change to an Area of Concentration
- ○ Substantial Change to a Certificate Program
- ○ Cooperative Degree Program
- ○ Offer Program at Regional Higher Education Center

Payment Submitted: ◉ Yes ○ No | Payment Type: ○ R*STARS # 12090144 ◉ Check # 12090144 | Payment Amount: $850 | Date Submitted: 05/02/202

Department Proposing Program	Bloomberg School of Public Health	
Degree Level and Degree Type	Post Baccalaureate Certificate	
Title of Proposed Program	Infectious disease dynamics,analytics, and modeling	
Total Number of Credits	24	
Suggested Codes	HEGIS:	CIP: 26.1309
Program Modality	◉ On-campus ○ Distance Education (*fully online*) ○ Both	
Program Resources	◉ Using Existing Resources ○ Requiring New Resources	
Projected Implementation Date	○ Fall ◉ Spring ○ Summer	Year: 2026
Provide Link to Most Recent Academic Catalog	URL: https://e-catalogue.jhu.edu/	
Preferred Contact for this Proposal	Name: Westley Forsythe	
	Title: Academic Compliance Officer	
	Phone: (410) 516-0188	
	Email: wforsythe@jhu.edu	
President/Chief Executive	Type Name: Ray Jayawardhana	
	Signature: Ray Jayawardhana	Date: 04/29/2025
	Date of Approval/Endorsement by Governing Board:	

Revised 1/2021

JOHNS HOPKINS
UNIVERSITY

May 14, 2025

Sanjay Rai, PhD
Secretary
Maryland Higher Education Commission
217 E. Redwood Street, Suite 2100,
Baltimore, MD 21202

Dear Secretary Rai,

On behalf of Provost Jayawardhana, I write to request your review and endorsement of the enclosed proposal. The university proposes a new **Post Baccalaureate Certificate in Infectious disease dynamics, analytics, and modeling.**

The program is designed for full-time graduate degree students across JHU schools who wish to augment their degree with coursework in modeling infectious disease dynamics. The target student population and the curriculum design of the certificate program reflect the intrinsically interdisciplinary nature of infectious disease modeling and the diverse workforce backgrounds.

The proposed program is consistent with the Johns Hopkins mission and the State of Maryland's Plan for Postsecondary Education. The proposal is endorsed by The Johns Hopkins University.

Should you have any questions or need further information, please contact Westley Forsythe at (410) 516-0188 or wforsythe@jhu.edu.

Thank you for your support of Johns Hopkins University.

Sincerely,

Janet Simon Schreck, PhD
Senior Associate Vice Provost for Academic Affairs

cc: Dr. Ray Jayawardhana

Dr. Westley Forsythe

Enclosures

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The Johns Hopkins University
Bloomberg School of Public Health
Proposal for Post-Baccalaureate Certificate in Infectious Disease Dynamics, Analytics, and Modeling

A. Centrality to Institutional Mission Statement and Planning Priorities

1. Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission.

The Johns Hopkins University Bloomberg School of Public Health (BSPH) proposes a Post-Baccalaureate Certificate program in Infectious Disease Dynamics, Analytics, and Modeling. This certificate program provides students from diverse academic backgrounds with the specialized skills to analyze and predict the spread of infectious diseases using advanced mathematical, statistical, and computational models.

The mission of BSPH is the improvement of health through discovery, dissemination, and translation of knowledge and the education of a diverse global community of research scientists and public health professionals. This new certificate program enhances this mission by training students at the intersection of infectious disease epidemiology and data science, which can advance our understanding of the drivers of infectious disease transmission and guide the design of optimal control measures. Johns Hopkins University (JHU) is home to a world-renowed community of infectious disease epidemiologists, modelers, and data scientists, and hosts the co-coordinating center for a national CDC-funded network for disease forecasting. Since the introduction of COVID-19, the demand for advanced predictive models for outbreaks has increased dramatically, but training opportunities in this field remain limited, even at JHU. This certificate program aims to fill that gap by providing graduate sudents across the university with a rigorous yet flexible curriculum to advance their expertise in infectious disease dynamics and analytics.

Students in the Certificate in Infectious Disease Dynamics, Analytics, and Modeling will take coursework covering i) the foundational epidemiological principles of infectious diseases, ii) advanced mathematical, statistical, and computational techniques relevant to analyzing infectious disease data, and iii) a specialized course on applied infectious disease modeling. They will be able to calculate metrics describing disease transmission, create mechanistic models of disease transmission, clinical progression, and control, use statistical methods to estimate model parameters and forecast disease dynamics, critically evaluate disease models in the scientific literature, and communicate model results to diverse stakeholders.

The program is designed for full-time graduate degree students across JHU schools who wish to augment their degree with coursework in modeling infectious disease dynamics. The target student population and the curriculum design of the certificate program reflect the intrinsically interdisciplinary nature of infectious disease modeling and the diverse backgrounds of the current workforce. JHU already has a robust system for students to enrolled in courses in different divisions fron their home programs and has a unified academic calendar across schools.

The proposed onsite program will require successful completion of a minimum of 24 credits of course work.

2. Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority.

The proposed program advances the Johns Hopkins University's *Ten for One* strategic goals in a number of significant ways.

This certificate program welcomes students from degree programs across the university, and specifically educates students at the intersection of strengths of our public health and medical schools (infectious disease epidemiology) and our engineering school (data science, modeling, and computational methods). This aligns with *Goal 2: Embark on an ambitious series of major cross-university initiatives that build on our achievements as One University and lower the barriers to collaboration so that our faculty, students, and staff can pursue their ideas wherever they take them.*

By providing a pathway to formally train students to participate in a research area pursued by many of our current faculty as well as those to be recruited in planned cluster hires, this certificate aligns with *Goal 4: Retain, recruit, and inspire the very best faculty in the world by ensuring we have competitive resources, state-of-the-art facilities, and outstanding support services that nurture research and discovery at the vanguard of each field of inquiry*.

In creating a training program in infectious disease modeling, an increasingly popular career aspiration of students across the university, we are contributing to *Goal 5: Honor our legacy as the nation's first research university by developing ambitious reforms so that every graduate student and postdoctoral fellow receives an experience that is rigorous, innovative, and tailored to their career aspirations*.

Training students in the application of advanced methods in data analytics and modeling to the transmission and control of infectious diseases, we directly align with *Goal 8: Create the leading academic hub for data science and artificial intelligence to drive research and teaching in every corner of the university and magnify our impact in every corner of the world*.

Infectious disease modeling is a powerful and sought-after tool to inform public health policy towards established and newly-emerging infectious diseases. By training students in this area, we are contributing to *Goal 9: Develop new pathways to help us translate our cutting-edge research into meaningful policy ideas, and become the preeminent source of academic expertise for evidence-based policymaking in service to the nation and the world*.

The Bloomberg School of Public Health has developed its own strategic plan, and our proposed certificate contributes to the vision outlined in "The Power of Education", which strives to "*evolve our research-focused education to better prepare our graduates for interdisciplinary, team-based scientific discovery and implementation*" and "*enrich our practice-focused education by ensuring students have the knowledge, skills, and tools to work across sectors and tackle multifaceted global public health challenges*".

3. Provide a narrative of how the proposed program will be adequately funded for at least the first five years of program implementation.

BSPH sets aside a portion of its tuition revenue each year as part of its budgeting process to fund the development of new programs and new courses. In addition, the tuition revenue from enrollments in the courses in any program is used to cover the instructional costs of the program before

any excess is used for other BSPH efforts. If a new program finds that its instructional costs are greater than the tuition revenue, funds are allocated from elsewhere in the overall BSPH budget to cover the startup program's shortfalls during the first five years. Additional information is in Appendix C.

4. Provide a description of the institution's commitment to:

a) Ongoing administrative, financial, and technical support of the proposed program.

BSPH's ongoing administrative, financial, and technical support for this program is reflective of the 100 years this school has been supportive of public health programs that have educated many generations and individuals all over the world. BSPH does a careful program viability study for new programs based on prospective student enrollment, in addition to addressing global health concerns. The proposed program would receive the same sort of administrative, financial, and technical support as the other academic programs in BSPH's portfolio.

b) Continuation of the program for a period of time sufficient to allow enrolled students to complete the program.

BSPH is committed to providing all enrolled students the opportunity to complete the certificate program, including under circumstances of low demand. Programs are evaluated by the departments and determinations are made as to whether they should continue to admit students. If a program ceases to admit new students, the school remains committed to see the current student through their program of study. This certificate program is 24 term credit units, which students should be able to complete within one year.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

1. Demonstrate demand and need for the program in terms of meeting present and future needs of the region and the State in general.

The COVID-19 pandemic highlighted the demand for model-based guidance for decision makers during public health emergencies. Forecasts and scenario projections of COVID-19 spread were used by local, state, and national public health agencies as well as healthcare systems and private businesses to anticipate disease burden and plan responses. Based on the perceived successful use of models as well as the clear need for continued advancement of modeling methods, the US government created the Center for Outbreak Forecasting & Analytics ("CFA") within the CDC. The CFA advances research, education, and translation of infectious disease modeling and has granted $250 million so far to universities and their partners to develop this emerging field. As part of the coordinating center for this effort, JHU is developing additional educational opportunities in this space for the public health researchers of tomorrow.

Numerous surveys of the public health workforce have demonstrated the increasing use of infectious disease modeling and the unfilled demand for employees capable of conducting these analyses. The Association of State & Territorial Health Officeres (ASTHO) conducted a needs

assessment of their members and found that 68% of member agencies were using disease forecasting, but 60% of those had to rely on outside academic collaborators to do this work. The Council of State & Territorial Epidemiologists (CTSE) conducted their own survey, finding that while 83% of their members belonged to teams using some sort of disease modeling, only 2% had the capacity to do this work in-house, and the majority relied completely or partially on external collaborators. Respondents expressed difficulties finding qualified candidates for jobs in infectious disease modeling and commented on the lack of this training in existing public health degree programs.

In the most recent Epidemiology Capacity Assessment Survey (also conducted by CTSE), results highlighted the large unfilled demand for epidemiologists trained in infectious diseases (estimated 37% growth required to fill needs) or in informatics (estimated 84% growth required). The top identified training priority for epidemilogists was "data analytics". In ASTHO's Public Health Workforce Interests and Needs Survey, "data-based decision making" was identified as a top training need by 28% of respondants.

In response to the increased demand for infectious disease modeling expertise during the COVID-19 pandemic, faculty in the Johns Hopkins Infectious Disease Dynamics Group received funding to create two online and open to the public courses on the platform Coursera. Released in summer 2022, "*Infectious Disease Transmission Models for Decision-Makers*" has had nearly 30,000 learners enrolled, while a more technical follow-up, "*Infectious Disease Modeling in Practice*", released in spring 2024, has had over 1700 learners.

Overall, these results highlight the demand from public health professionals across the country for graduates with training in infectious disease modeling and analytics. The proposed certificate program will expand the workforce trained in this emerging area, with the capacity to improve public health in Maryland and beyond.

2. Provide evidence that the perceived need is consistent with the Maryland State Plan for Postsecondary Education.

The 2022 Maryland State Plan for Higher Education articulates three goals for postsecondary education: 1.) Access: Ensure equitable access to affordable and quality postsecondary education for all Maryland residents. 2.) Success: Promote and implement practices and policies that will ensure student success. 3.) Innovation: Foster innovation in all aspects of Maryland higher education to improve access and student success. The proposed program addresses each of these goals.

Johns Hopkins University strives to educate exceptional students regardless of financial means. Students in PhD programs across the university are guaranteed funding to cover their tuition as well as a generous stipend for the duration of their programs, which is covered by a mix of grants, scholarships, university funding, and teaching assistantships. For professional masters students (e.g. Master of Public Health), scholarships and loans are available. For scientific masters students (e.g. Master of Health Science), funding is available through scholarships, research assistantships, teaching assistantships, student employement, and loans. Some students are sponsored by employers to attend graduate school. Student Affairs and Financial Aid offices in each university division are available to counsel students on funding options. Participating in this certificate program will not be associated with any additional costs for participating students. This is consistent with Goal 1 (Access).

Johns Hopkins University offers an array of services to ensure success of student learners. This includes career counseling, disability services, mental health resources, 1:1 (student:faculty) academic advising, peer-to-peer mentorship programs, and opportunities for mentored research and practica. Students participating in the certificate program will additionally be offered group and 1:1 advising by program faculty with specific overlapping interests. Students in multi-year research programs regularly complete Individual Development Plans and discuss them with faculty advisors. Individual programs use Courseplus and other platforms to share detailed program plans of study and guidebooks with students as well as progress checklists and timelines. This structure is consistent with Goal 2 (Success).

This proposed certificate program in Infectious Disease Dynamic, Modeling, and Analytics aims to prepare highly-trained scientists and public health professionals to work in organizations where they can contribute to reducing the burden of infectious diseases. This program is specifically designed to meet the growing need for skilled professionals trained in the integration of advanced data modeling techniques with infectious disease epidemiology, with the goal of informing public health decision making in Baltimore, the State, across the country, and beyond. This is the only certificate program of this type we are aware of in the country and one of the few formal training opportunities in this field of any type nationally. This is consistent with Goal 3 (Innovation) of the State Plan.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State

1. Describe potential industry or industries, employment opportunities, and expected level of entry (ex: mid-level management) for graduates of the proposed program.

In recent years, the recognition of the massive social, economic, and health impact of emerging infectious diseases like COVID-19 has led to increased demand for expertise relevant to evidence-based policy-making in the face of uncertain and rapidly-changing disease burden. This certificate program will train students to apply advanced data analytics and modeling to infectious diseases, with the goal of predicting spread, healthcare utilization, and the impact of proposed interventions. Graduates are expected to enter specialized and highly compensated roles in government public health agencies (e.g. local, state, national), other government offices (e.g. national labs, defense, budgeting), academic centers (e.g. as research staff or faculty), private industry (e.g. consulting firms, healthcare organizations, pharmaceutical companies), or non-profits (e.g. research institutes, humanitarian organizations, international health organizations).

2. Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program.

In the US Bureau of Labor Statistics' most recent published Employement Projections, high growth over the next decade was expected for Data Scientists (36%), Epidemiologists (19%), and Statisticians (12%). Similarly, the State of Maryland's Occupational Projections predicted high growth for Data Scientists (39%), Epidemiologists (35%), and Statisticians (31%) (all within the top 10 fastest growing fields). The proposed post-baccalaureate certificate program in Infectious Disease Dynamics, Analytics, and Modeling will uniquely train students at the intersection of data science, statistics, and epidemiology, positioning them to take advantage of the projected growth in these areas.

3. **Discuss and provide evidence of market surveys that clearly provide quantifiable and reliable data on the educational and training needs and the anticipated number of vacancies expected over the next 5 years.**
   The statistics above describe the projected growth in vacancies in data science, statistics, and epidemiology over the next 10 years. More specifically, in the most recent Epidemiology Capacity Assessment Survey (conducted by the Council of State & Territorial Epidemiologists), results highlighted the large unfilled demand for staff trained in infectious diseases epidemiology (estimated 37% growth, or 500+ individuals nationally, required to fill needs) or in informatics (estimated 84% growth, or 150+ individuals nationally, required to fill needs). The top identified training priority for epidemilogists was "data analytics". Specific surveys focused on capacity for infectious disease forecasting by both the Council of State & Territorial Epidemiologists and the Association of State & Territorial Health Officers found that while the majority of agencies were interested in or already using disease forecasts, only a small minority had the employees with the required training to conduct this work and that finding suitably trained candidates was a major challenge to work in this area.

4. **Provide data showing the current and projected supply of prospective graduates.**
   We expect that participants in this certificate program will be a mix of masters students, including Master of Public Health (MPH) and Master of Health Sciences (MHS) or Master of Science in Public Health (MSPH) through BSPH and Master of Science in Engineering (MSE) through the School of Engineering, and doctoral students, including PhD candidates through the JHU schools of public health, medicine, and engineering. We expect that the duration of time required to complete the certificate will depend on the student's home program, which determines the degree of overlap between core required courses and certificate courses, and the expected balance of coursework, research, and teaching during the student's first few years of graduate school. For example, we expect that Master's students from any JHU school will be able to complete the certificate program during their regular 9 or 12 month term of full-time coursework. We expect that PhD students in Epidemiology or International Health would complete the certificate by the end of their second year of study. For students in Biomedical Engineering, Systems Engineering, or Applied Mathematics, we expect they will be likely to complete the certificate coursework while engaged in thesis research, and take three years. Overall we estimate that 13 students admitted in 2026 will complete the program in 2027, 15 in 2028, and and 20 annually in subsequent years.

D. Reasonableness of Program Duplication

1. **Identify similar programs in the State and/or same geographical area. Discuss similarities and differences between the proposed program and others in the same degree to be awarded.**

   The University of Maryland School of Public Health offers MPH and PhD degrees with the opportunity to specialize in Epidemiology and subspecialize in infectious disease epidemiology. However, no courses or programs focusing on infectious disease modeling/analytics are offered. They additionally offer a Certificate in Health Data Analytics, which focuses on biostatistics but not mathematical modeling and not on infectious disease data. Within the University of Maryland School of Medicine, the Department of Epidemiology & Public Health offers additional degrees in Epidemiology (MPH, PhD), but limited coursework in infectious disease epidemiology and none in modeling are available.

At the George Washington University Milken Institute School of Public Health, students in MS, MPH, or PhD degree programs can concentrate in (among others) Epidemiology, Global Health Epidemiology & Disease Control, or Health Data Science. These programs offer multiple course options covering infectious disease epidemiology and statistics, but not focusing on advanced mathematical and computational models for infectious disease forecasting and analysis.

At George Mason College of Public Health, MPH and PhD programs offer the ability to specialize in Epidemiology, but opportunity for further specialization in infectious disease epidemiology or modeling is not possible. The Public Health Informatics track focuses on analytics for data types more common in biomedical research and other fields of public health (such as clinical and insurance data), but not on the epidemiological data common for infectious diseases.

Morgan State University offers a Public Health Program within the School of Community & Public Health, offering professional degrees only (MPH and DrPH) and does not offer specialized coursework or certification in infectious disease epidemiology or modeling.

Coppin State University does not have a public health school or any graduate programs in this field. Students doing a BS in Health Sciences or the Doctor of Nursing program have the opportunity to take an epidemiology course.

Towson University, Salisbury University, and University of Maryland Baltimore County offer a major and minor in public health to undergraduates which includes a course in epidemiology but nothing more specifically in infectious disease epidemiology or modeling.

Bowie State University offers bachelor's degrees and a certificate in Public Health Informatics & Technology but this focuses mainly on data management, not on advanced modeling nor on infectious diseases.

The proposed certificate program in Infectious Disease Dynamics, Analytics, and Modeling, is unique from existing programs in several ways:

- Housed within and supported by a large epidemiology department at the Bloomberg School of Public Health, the certificate program is open to graduate degree students across the entire university

- Johns Hopkins offers over 20 specialized infectious disease epidemiology courses which students can choose from to satisfy certificate requirements. Courses cover a range of disease causes (e.g., virus, bacterial, parasitic), transmission models (e.g., respiratory, water-borne, sexual contact, vector-borne), burden patterns (e.g., seasonal, endemic, emerging), and control measures (e.g. vaccination, chemotherapeutics, vector control, hygiene & sanitation)

- Johns Hopkins offers specialized courses in infectious disease modeling, covering state of the art methods used by pracitioners and scientists working in the field

- Certificate participants have access to courses covering a wide range of advanced modeling techniques for complex and dynamic data, such as machine learning, network modeling, stochastic processes, monte carlo methods, and Bayesian statistics.

2. Provide justification for the proposed program.

This certificate program is designed to provide students from diverse academic backgrounds with the skills to use mathematical and statistical modeling techniques to describe the spread of infectious diseases. Students will take coursework covering the foundational epidemiological principles of infectious diseases, on advanced mathematical, statistical, and computational techniques relevant to analyzing infectious disease data, and a specialized course on infectious disease modeling. Students completing the certificate will be qualified to contribute to model-guided decision making for infectious disease threats in positions in government, academia, or industry.

E. Relevance to High Demand Programs at Historically Black Institutions (HBIs)

There are no known similar programs in any of the Historically Black Institutions in Maryland and do not ancitioate and impact on high demand programs at HBIs.

Morgan State University offers epidemiology education through their the School of Community & Public Health, including MPH and DrPH degrees but not PhDs or other masters program. It does not offer specialized courses or programs in infectious disease epidemiology or infectious disease modeling. Coppin State University does not offer public health programs, and general epidemiology is only available as a course in the Bachelors of Science program in Health Sciences or through the Doctor of Nursing Practice program.

F. Relevance to the identity of Historically Black Institutions (HBIs)

1. Discuss the program's potential impact on the uniqueness and institutional identities and missions of HBI'S.

There is no anticipated impact on the uniqueness and institutional identities and missions of HBIs.

G. Adequacy of Curriculum Design and Delivery to Related Learning Outcomes (as outlined in COMAR 13B.02.03.10)

1. Describe how the proposed program was established and describe the faculty who will oversee the program.

During the COVID-19 pandemic, JHU was recognized as a leading provider of expertise in data analytics, modeling, and epidemiology to help guide public health decision-making. Our faculty were closely involved in the creation of the new Center for Outbreak Forecasting & Analytics within the CDC, and are recipients of multiple government contracts with an aim of advancing public health education in this emerging subfield. Our faculty conceived this certificate program based on several observations from their decades of collective experience in this field: i) Trainees contributing to infectious disease modeling at JHU, as well as experts around the world, come from an incredibley diverse set of academic backgrounds – ranging from physics, mathematics, and computer science to basic biology, medicine, and public health. ii) Opportunities to receive formal training in both infectious disease and in advanced data analytics and modeling are extremely rare, even at universities producing leading research in this area. Even if courses in both areas are offered, they are in distinct divisions of universities with barriers to student enrollment. iii) Public health agencies are increasingly interested in using models to project infectious disease burden and assess control measures, but current employees and candidates applying to posted jobs lack the training to do this advanced analytic work. There is a strong demand for candidates with formal training in this field.

The faculty who conceived of and will oversee the certificate program are members of the Johns Hopkins Infectious Disease Dynamics Group, and are primary members of the departments of Epidemiology, International Health, Civil & Systems Engineering, and Biomedical Engineering. The faculty have produced leading research in the field of infectious disease dynamics and participated in educating the next generation of leaders in this field through formal coursework and research mentorship. See Appendix B for a list of faculty associated with this program.

2. Describe educational objectives and learning outcomes appropriate to the rigor, breadth and (modality) of the program.

Educational Objectives:

This certificate program will provide students from diverse academic backgrounds with the skills to use mathematical and statistical modeling techniques to quantify and predict the spread of infectious diseases.

Student Learning Outcomes:

Upon completion of the program, students will be able to:

- Describe the observed epidemiological patterns for important infectious diseases around the world and their biological, sociological, and environmental drivers;
- Understand the predominant methods of infectious disease control and the pathogens to which they apply;
- Be familiar with the metrics used to quantify disease transmissibility and the methods used to estimate;
- Translate biological, epidemiological, and medical features of an infectious disease into a mechanistic mathematical models;
- Develop and apply statistical methods to estimate model parameters and predict disease spread or outcomes;
- Understand the different types of infectious disease models (e.g. mathematical vs statistical, stochastic vs deterministic, well-mixed vs network) and the different uses of models (e.g. inference vs forecasting vs scenario projection);
- Understand the common challenges of real-world infectious disease data and methods to deal with data limitations;
- Critically evaluate infectious disease models in the scientific literature;
- Communicate the results of models - including their critical assumptions and uncertainty - to both technical and non-technical audiences.

3. Explain how the institution will:

a) Provide for assessment of student achievement of learning outcomes in the program

BSPH's Center for Teaching and Learning has a staff of Instructional Designers that assist faculty in the design and delivery of their courses. These Instructional Designers assist the faculty in preparing learning assessments (projects, papers, exams) that are linked to the program and course learning outcomes. These assessments are graded by the instructors and the students' grades reflect their knowledge of the matter.

b) Document student achievement of learning outcomes in the program

Grades are kept in a gradebook in the school's CoursePlus system and grade distributions are shared with the department chairs and the Committee on Academic Standards (CAS). If learning outcomes are not met in a given year, the program is expected to address these issues for the next offering.

4. Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements

A full list of courses that satisfy requirements of the certificate is provided in Appendix A.

Program Requirements

Students are required to succesfully complete 24 term credits, which are grouped into several categories of expertise described below. All required and elective courses must be taken for a letter grade; a minimum grade of C is required in all certificate coursework and students must maintain a 2.75 or better overall GPA for all certificate coursework. There is no limitation on the number of credits that are counted both towards the student's main degree and the certificate program. In addition to the coursework listed below, students must attend at least 4 resarch seminars in the "Infectious disease dynamics research seminar" series.

Table 1: Curriculum Overview

Course Number	Course Title	Credits	Required or Elective	Term Offered	Format
Basic epidemiological methods: Students must select 1 of the following courses					
PH.340.601	Principles of Epidemiology	5 credits	Elective	Summer	In-person
PH.340.751	Epidemiologic Methods 1	5 credits	Elective	1	In-person & Online
PH.340.721	Epidemiological Inference in Public Health	5 credits	Elective	1	In-person & Online
PH.340.761	Epidemiologic Methods for EPI Doctoral Students I	5 credits	Elective	1	In-person
Infectious disease epidemiology: Students must take 1 of the following courses					
PH.340.627	Epidemiology of Infectious Diseases	4 credits	Elective	2	In-person
PH.340.668	Topics in Infectious Disease Epidemiology	3 credits	Elective	Summer	Online
Infectious disease modeling: Students must take 1 of the following courses					

Course Number	Course Title	Credits	Required or Elective	Term Offered	Format
PH.340.677	Infectious Disease Dynamics: Theoretical and Computational Approaches	4 credits	Elective	4	In-person
EN.580.673	Dynamic Modeling of Infectious Diseases in Patients and Populations	3 credits	Elective	2	In-person
Specialized topics in data analytics and modeling: Students must take at least 2 half semester courses (6 term credits) from this list					
PH.340.609	Concepts and Methods in Infectious Disease Epidemiology (EPI)	4 credits	Elective	3	In-person
PH.140.628	Data Science for Public Health I (BIOSTAT)	4 credits	Elective	3	In-person
PH.140.629	Data Science for Public Health II (BIOSTAT)	4 credits	Elective	4	In-person
EN.580.475	Biomedical Data Science (BME)	3 credits	Elective	1	In-person
EN.553.636	Introduction to Data Science (AMS)	6 credits	Elective	Spring	In-person
EN.601.675	Machine Learning (CS)	4.5 credits	Elective	Spring	In-person
EN.601.682	Machine Learning: Deep Learning (CS)	6 credits	Elective	Fall	In-person
EN.601.788	Machine Learning for Healthcare (CS)	4.5 credits	Elective	Fall	In-person
EN.553.740	Machine Learning I (AMS)	4.5 credits	Elective	Fall	In-person
EN.553.741	Machine Learning II (AMS)	4.5 credits	Elective	Spring	In-person
EN.560.617	Deep Learning for Physical Systems (CSE)	4.5 credits	Elective	Spring	In-person
PH.140.644	Statistical Machine Learning: Methods, Theory, and Application (BIOSTAT)	4 credits	Elective	1	In-person
AS.171.749	Machine Learning for Scientists/Physicists (PHYS)	4.5 credits	Elective	Spring	In-person
PH.221.660	Systems Science in Public Health: Basic Modeling and Simulation Methods (IH)	3 credits	Elective	4	In-person
PH.380.603	Demographic Methods for Public Health (PFRH)	4 credits	Elective	1	Online
PH.380.755	Population Dynamics and Public Health (PFRH)	2 credits	Elective	1	Online
EN.560.653	An Introduction to Network Modeling (CSE)	4.5 credits	Elective	Fall	In-person

Course Number	Course Title	Credits	Required or Elective	Term Offered	Format
EN.553.692	Mathematical Biology (AMS)	4.5 credits	Elective	Spring	In-person
EN.580.680	Precision Care Medicine (BME)	6 credits	Elective	Fall	In-person
EN.580.640	Systems Pharmacology & Personalized Medicine (BME)	6 credits	Elective	Spring	In-person
EN.553.650	Computational Molecular Medicine (AMS)	6 credits	Elective	Spring	In-person
EN.540.633	Pharmacokinetics and Pharmacodynamics (CBE)	4.5 credits	Elective	Fall	Online
AS.020.674	Quantitative Biology and Biophysics (BIO)	6 credits	Elective	Spring	In-person
EN.553.691	Dynamical Systems (AMS)	6 credits	Elective	Fall	In-person
EN.560.657	System Dynamics (CSE)	4.5 credits	Elective	Spring	In-person
EN.520.621	Introduction To Nonlinear Systems (ECE)	4.5 credits	Elective	Fall	In-person
EN.553.736	System Identification and Likelihood Methods (AMS)	3 credits	Elective	Spring	In-person
EN.553.633	Monte Carlo Methods (AMS)	6 credits	Elective	Fall	In-person
EN.553.626	Introduction to Stochastic Processes (AMS)	6 credits	Elective	Spring	In-person
EN.553.632	Bayesian Statistics (AMS)	4.5 credits	Elective	Fall	In-person
PH.140.762	Bayesian Methods (BIOSTAT)	3 credits	Elective	3	In-person
PH.140.773	Foundations of Statistical Inference (BIOSTAT)	4 credits	Elective	3	In-person
PH.140.777	Statistical Programming Paradigms and Workflows (BIOSTAT)	3 credits	Elective	2	In-person
PH.140.779	Advanced Statistical Computing (BIOSTAT)	3 credits	Elective	4	In-person
Specialized topics in infectious disease epidemiology: Students must take at least 2 half semester courses (or at least 6 term credits) from this list					
PH.260.623	Fundamental Virology	4 credits	Elective	1	In-person
PH.340.654	Epidemiology and Natural History of Human Viral Infections	6 credits	Elective	1	Online
PH.340.646	Epidemiology and Public Health Impact of HIV and AIDS	4 credits	Elective	1	Online
PH.340.641	Healthcare Epidemiology	4 credits	Elective	2	In-person
PH.340.612	Epidemiologic Basis for Tuberculosis Control	2 credits	Elective	1	In-person

Course Number	Course Title	Credits	Required or Elective	Term Offered	Format
PH.182.640	Food- and Water- Borne Diseases	3 credits	Elective	3	Online
PH.260.656	Malariology	4 credits	Elective	4	Online
PH.223.682	Clinical and Epidemiologic Aspects of Tropical Diseases	4 credits	Elective	4	Online
PH.340.651	Emerging Infections	2 credits	Elective	4	Online
PH.380.761	Sexually Transmitted Infections in Public Health Practice	4 credits	Elective	4	Online
PH.260.650	Vector Biology and Vector-Borne Diseases	3 credits	Elective	3	In-person
PH.260.631	Immunology, Infection and Disease	3 credits	Elective	1	In-person
PH.223.680	Global Disease Control Programs and Policies	4 credits	Elective	4	In-person
PH.223.662	Vaccine Development and Application	4 credits	Elective	2	In-person
PH.180.623	Infectious Disease Threats to Global Security	3 credits	Elective	3	Online
PH.260.636	Evolution of Infectious Disease	3 credits	Elective	1	In-person
PH.223.663	Infectious Diseases and Child Survival	3 credits	Elective	3	In-person
PH.340.744	Advanced Topics on Control and Prevention of HIV/AIDS	4 credits	Elective	2	In-person
PH.260.655	Pandemics of the 20th Century	1 credits	Elective	1	In-person
PH.260.635	Biology of Parasitism	5 credits	Elective	2	In-person
PH.223.688	Clinical, Epidemiologic, and Climate Change factors of Enteric Infections in the Tropics	4 credits	Elective	Summer	In-person & Online
PH.340.653	Epidemiologic Inference in Outbreak Investigations	3 credits	Elective	1	In-person & Online
PH.340.693	Investigation of Outbreaks	2 credits	Elective	Summer/ Winter Intersession	In-person & Online
ME.300.716	Pathology for Graduate Students: Immunology/Infectious Disease	1.5 credits	Elective	Spring	In-person & Online
ME.250.633	Organ Systems Foundations of Medicine: Infectious Disease and Microbiology	7.5 credits	Elective	3	In-person
ME.250.714	HIV Biology	1.5 credits	Elective	Spring	Online

5. **Discuss how general education requirements will be met, if applicable.**

Not applicable

6. **Identify any specialized accreditation or graduate certification requirements for this program and its students.**

Not applicable

7. **If contracting with another institution or non-collegiate organization, provide a copy of the written contract.**

Not applicable

8. **Provide assurance and any appropriate evidence that the proposed program will provide. students with clear, complete, and timely information on the curriculum, course and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and cost and payment policies.**

   BSPH's CoursePlus system https://courseplus.jhu.edu/core/index.cfm/go/home/ contains all the course offerings including a course description, requirements, nature of faculty/student interaction, assumptions about technology competence and skills, and technical equipment requirements. These details are listed on the syllabus for a course. All program related information (degree requirements, learning management systems, academic support, financial aid, records, and policies) can be found on the School's web site https://publichealth.jhu.edu/.

9. **Provide assurance and any appropriate evidence of advertising, recruiting and admissions materials will clearly and accurately represent the proposed program and the services available.**

   The BSPH web site https://publichealth.jhu.edu/ contains the same marketing, recruiting and admission materials that are used in print. We are transparent with students on requirements, services and policy at time of admission through the life cycle of a student to alum.

H. Adequacy of Articulation

Not applicable.

I. Adequacy of Faculty Resources (as outlined in COMAR 13b.02.03.11)

1. **Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of faculty with appropriate type, terminal degree title and field, academic title/rank, status, (fulltime, part-time, adjunct) and the course(s) each faculty member will teach (in this program).**

See Appendix B for a representative list of faculty who will teach in the proposed program. Each faculty is a distinguished and experienced professionals and all have advanced degrees (either PhD or MD). 100% of the faculty are full time. They have produced leading research in infectious

disease epidemiology and modeling, supervised hundreds of student research projects, and developed innovative courses for enrolled university students, online non-degree learners around the world, and public health practitioners. These faculty all have research programs funded by US government agencies as well as international and non-governmental organizations. Together, hundreds of manuscripts have been published in peer reviewed journals by the faculty who are teaching in this certificate program. They serve on advisory committes for public health research and interventions around the world. These faculty are considered to be the leading experts in their field of study. Specific relevant experience of our program faculty include running the Johns Hopkins COVID-19 Data Dashboard and serving as leaders of the coordinating center for the CDC's network of university centers of excellence in disease modeling.

2. **Demonstrate how the institution will provide ongoing pedagogy training for the faculty in evidenced-based best practices, including training in a. Pedagogy that meets the needs of students, b. the learning management system and c. Evidenced-based best practices for distance education, if distance education is offered:**

For certificate courses offered through the BSPH, the Center for Teaching and Learning (CTL) supports faculty in the design, development and delivery of courses and supports the teaching experience. CTL offers workshops and 1:1 faculty consultations on topics such as course consultations, Faculty and TA development and using CoursePlus. Such workshop topics include: using Case Studies and Case Examples, Getting the Most Out of Your Live Talk, Using the Course Management System to Its Fullest Potential in the Education Process and Authentic Assessment.

CTL has a staff of Instructional Designers that are assigned to faculty developing or teaching a course. Instructors receive direct support and guidance from the instructional designer and the multimedia staff, which may take the form of course design, course production support, and audio and video recording support. CTL supports faculty in the refinement of the course by updating content and the quality of the students' educational experience.

For courses offered through the Whiting School of Engineering, parallel services are offered through the Johns Hopkins Center for Teaching Innovation and Excellence. Courses offered through the School of Medicine are serviced by the Institue for Educational Excellence.

J. Adequacy of Library Resources (as outlined in COMAR 13B.02.03.12)

The book collections at the Johns Hopkins University number almost two and one-half million volumes, selected to support the studies of all departments and divisions of the University. The William H. Welch Medical Library collects current scholarly information, primarily electronic, which supports the research, clinical, administrative, and educational needs of its clients. The collection covers health, the practice of medicine and related biomedical and allied health care disciplines, public health and related disciplines, nursing, research literature, methodological literature, reviews or state-of-the-art reports, and in-depth, authoritative analyses of areas influencing biomedicine and health care. The library's emphasis is on providing materials at point of need. As a result, the collection includes more than 7,200 electronic journals, more than 400 databases, and more than 13,000 e-books. The library has staff members assigned to each department to aid in research and best practices for library services.

K. Adequacy of Physical Facilities, Infrastructure and Instructional Equipment (as outlined in COMAR 13B.02.03.13).

1. **Provide an assurance that physical facilities, infrastructure and instruction equipment are adequate to initiate the program, particularly as related to spaces for classrooms, staff and faculty offices, and laboratories for studies in the technologies and sciences. If the program is to be implemented within existing institutional resources, include a supportive statement by the President for adequate equipment and facilities to meet the program's needs.**

BSPH has 26,567 square feet of classroom and student study space. Each classroom has a computer and LCD projector. The School has robust student support services, including a fully staffed information technology team and over 1000 computers located in computer labs and throughout main buildings for student use. The central computing resource for BSPH, the Office of Information Technology (IT), provides students with reliable computing infrastructure, location, and device independence, and critical software tools. Additionally, an enterprise service desk offers support for faculty, staff, and students. Assistance is provided over various channels, including phone, desktop, and FIPS 140-2 compliant remote-control support. Customer satisfaction is monitored and benchmarked against other higher educational institutions and industries. For this program, no additional facilities, infrastructures or laboratory or computer resources will be required.

2. **Provide assurance and any appropriate evidence that the institution will ensure students enrolled in and faculty teaching in distance education will have adequate access to: a) an institutional electronic mailing system, and b) a learning management system that provides the necessary technological support for distance education.**

a) All JHU students receive an Office 365 account including email capabilities (built on Outlook Live), as well as 25GB of online storage, and collaboration, blogging, photo-sharing, event-planning, instant messaging, and other tools. The email account is accessible from a variety of browsers on both the PC and Mac, including full support for Internet Explorer, Firefox, and Safari.

b) Courses can be taken through BSPH's CoursePlus course management system. These technologies are supported by the Center for Teaching and Learning (CTL) and the university's IT infrastructure which provides password-protected online course sites and community management systems that enable ongoing collaborative exchange and provide convenient channels for synchronous and asynchronous learning. JHU is also outfitted with suitable technical and professional staff and a help desk to provide technical assistance to the students taking online courses. All of the student services such as application processes, course registration, bookstore, ID service, and advising are currently provided online as well.

L. Adequacy of Financial Resources with Documentation (as outlined in COMAR 13B.02.03.14)

See Appendix C for detailed financial information.

M. Adequacy of Provisions for Evaluation of program (as Outlined in COMAR 13B.02.03.15)

1. **Discuss procedures for evaluating courses, faculty and student learning outcomes.**

As part of the program design and approval process, student learning outcomes and assessments have been aligned with the academic goals of the BSPH and approved by the BSPH's Committee on

Academic Standards. Student course evaluations, conducted at the end of each term, provide feedback about both courses and faculty. The evaluations include questions addressing the course overall, the instructor and the assessments of learning.

The program committee consisting of Shaun Truelove, Lauren Gardner, Derek Cummings, Emily Gurley, Amy Wesolowski, Saki Takahashi, Kate Grabowski, Eili Klein, Alison Hill, and David Dowdy will meet annually to assess course evaluations and other feedback provided by students, faculty and other stakeholders in the program. Program level evaluation activities will include an annual assessment of program inputs, processes and outputs to generate a report on program applicants and admitted students, course enrollment, faculty participation, pedagogical innovations and program accomplishments/recognition.

Evaluation of student learning and achievement will focus on the early identification of students' goals/objectives and individualized learning outcomes; students' acquisition of knowledge and skills and the degree to which the program is fostering students' achievement of the degree competencies. The Educational Program Committee in the department reviews student course evaluations and will reach out to program faculty when problems arise.

Finally, post-degree professional and academic accomplishments of graduates will also be tracked. Adjustments to the program will be made accordingly.

2. Explain how the institution will evaluate the proposed program's educational effectiveness, including assessments of student learning outcomes, student retention, student and faculty satisfaction, and cost effectiveness

The procedures that will be used to evaluate these matters are noted in section M.1. The department Chair, working closely with administrative staff and the Associate Dean for Education, will routinely evaluate performance and initiate corrective action plans, if necessary.

N. Consistency with the State's Minority Student Achievement Goals (as outlined in COMAR13B.02.03.05).

Any student meeting the admissions requirements can apply to the program, which will work to help all accepted students improve their workplace competitiveness and reach their professional goals, an aim consistent with the State's minority student achievement goals.

O. Relationship to Low Productivity Programs Identified by the Commission:

Not applicable.

P. Adequacy of Distance Education Programs (as outlined in COMAR 13B.02.03.22)

1. Provide affirmation and any appropriate evidence that the institution is eligible to provide Distance Education.

While some of the courses included in the proposed certificate program can be completed entirely online, other courses are only offered onsite. This certificate program will require students to complete their coursework at least partially on-campus at this time, since not all of the courses can be completed online. We have completed Section P to describe those courses that can be completed entirely online.

BSPH has decades of experience administering successful online courses and programs. This program will be supported in the same way our other programs are supported. BSPH's Center for Teaching and Learning (CTL) has the instructional knowledge and staff to support our faculty and successful student learning.

2. Provide assurance and any appropriate evidence that the institution complies with C-RAC guidelines, particularly as it relates to the proposed program:

a) Online learning is appropriate to the institution's mission and purposes:

Refer to Section A.1 in the main body of the proposal.

b) The institution's plans for developing, sustaining, and if appropriate, expanding online offerings ate integrated into its regular planning and evaluation processes.

BSPH has a commitment to online teaching as demonstrated by the resources of its Center for Teaching and Learning, which provides course development, instructional, and technical support to new and current faculty.

c) Online learning is incorporated into the institution's systems of governance and academic oversight.

At BSPH, any new proposed academic program is subjected to a review by the School's Committee on Academic Standards, a faculty body with representation from all departments and school-wide programs. If approved by the Committee, the proposal is then forwarded to the School's Advisory Council, comprised of the School's leadership and Department Chairs, for review and approval. Once approved at the School level, new programs must be approved by Johns Hopkins University, which reviews new online program proposals using the same systems of governance and academic oversight as for new on-site programs. Before being shared with the deans of all JHU academic divisions, all proposals must first undergo a review by internal academic bodies, including discussions of fit with the School's mission, program viability, program rigor, instructor quality, and redundancy with existing programs. Once a program is launched, its courses will enter the course evaluation system. Students in all BSPH courses complete a course evaluation. These evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary reports are reviewed by the faculty member, the program chair, and the BSPH administration to determine whether changes are necessary.

d) Curricula for the institution's online learning offerings are coherent, cohesive, and comparable in academic rigor to programs offered in traditional instructional formats.

Some of the courses that satisfy requirements for this certificate are offered in online format. Online courses are conducted and evaluated using the same academic standards as tradiational onsite courses. While the program can be completed with only traditional format courses, the optional online courses give students additional flexibility in scheduling their courseload around the requirements of the certificate (for example, by taking courses during the summer term).

All online courses adhere to CTL's course development process with support from experienced instructional designers. Online coursework follows well-established curriculum

development standards, tailoring delivery methods, content, and assessments to learning objectives.

e) The institution evaluates the effectiveness of its online learning offerings, including the extent to which the online learning goals are achieved, and uses the results of its evaluations to enhance the attainment of the goals.

As part of the online course design process, course assessments are required to be aligned with stated courses learning objectives. The proposed program will incorporate authentic assessments that demonstrate students' application of learned skills. Program faculty have experience with developing individual and collaborative assessments for measuring the acquisition of relevant knowledge and skills through online learning.

f) Faculty responsible for delivering the online learning curricula and evaluating the students' success in achieving the online learning goals are appropriately qualified and effectively supported.

Online programs are supported by CTL, which offers a number of opportunities and resources for faculty instructors and teaching assistants to become more familiar with online teaching and best pedagogical practices. In addition to maintaining an extensive catalog of resources on teaching and learning via an online Teaching Toolkit, CTL regularly offers events, workshops, and one-on-one office hours to introduce and provide updates on the latest advances in teaching technology and pedagogy.

Prior to teaching their first courses, all new online instructors are required to participate in training that conveys, among other things, principles of best practices for online education.

The Bloomberg School, through CTL, maintains an innovative course management system and provides faculty support and training for online education through a staff of more than 30 individuals who specialize in instructional design, audio production, technical writing, web development, production management and quality control.

g) The institution provides effective student and academic services to support students enrolled in online learning offerings.

The Bloomberg School maintains numerous web-based resources to inform prospective students on the information they may need as an online student. These resources include the BSPH website https://publichealth.jhu.edu/ and the Course Catalog. These resources offer detailed programmatic information, academic support services, financial aid, costs, policies, etc. and specific information for online learning. As new online students are admitted and enrolled, they receive timely emails with important information to help them prepare to become an online student. These emails include information on technical requirements, available academic support services, and a required orientation course (Introduction to Online Learning) for new online students.

BSPH online students have access to the following academic support services:

Academic advising. Students are assigned an advisor when accepted. Students work individually with the advisor to develop a course of study that meets the requirements of the program and the career goals of the student. The advisor regularly contacts the students to

check on progress and answer questions. Courses that deviate from the program plan and have not been approved by an adviser may not count toward degree requirements.

Library services. Students have online access to the William H. Welch Medical Library and the Milton S. Eisenhower Library on the Homewood campus. The interlibrary loan department allows students access to resources at any other university in the nation. The University's library system provides easy access to a wide selection of electronic information resources, including an online catalog, and numerous electronic abstracting and indexing tools. Many of the databases are accessible remotely. Librarians are available to assist students remotely and the library maintains an extensive web site to take visitors through all its services and materials.

Disability Support Services. The Johns Hopkins University is committed to making all academic programs, support services, and facilities accessible to qualified individuals. Students with disabilities who require reasonable accommodations can contact the BSPH Disability Services' Senior Director.

Career Services. The Career Services Office at the Bloomberg School helps students, alumni, faculty, staff, and employers navigate the world of public health jobs.

Johns Hopkins Student Assistance Program. The Johns Hopkins Student Assistance Program (JHSAP) is a professional counseling service that can assist students with managing problems of daily living. Stress, personal problems, family conflict, and life challenges can affect the academic progress of students. JHSAP focuses on problem solving through short-term counseling. Accessing the service is a simple matter of a phone call to arrange an appointment with a counselor. Online students contact the service by phone for consultation and are directed to the appropriate resource or office. JHSAP services are completely confidential. The program operates under State and federal confidentiality legislation and is HIPAA compliant.

Transcript Access. Students may view and print unofficial transcripts at any time. Official transcripts will be mailed upon request of the student at minimal charge.

Student Login IDs. The University issues each student a Johns Hopkins Enterprise ID (JHED ID) and the School issues a BSPH ID. The JHED ID grants students a JHU email address and secure access to many online services including course registration, bill payment, official grades, library services, and the online learning platform CoursePlus. Students are also issued a BSPH ID that provides access to the School's intranet (My.jhsph) where students can locate additional resources including research and administrative tools as well as the School's policy and procedures manual.

h) The institution provides sufficient resources to support and, if appropriate, expand its online learning offerings.

BSPH has a commitment to online teaching as demonstrated by the resources of its Center for Teaching and Learning, which provides course development, instructional, and technical support to new and current faculty. See Appendix C for detailed financial information regarding the proposed program. If additional sections of a courses are needed to support the program, the department will offer an additional section.

Each year during the budget development period, additional resources such as faculty, staffing, teachings assistants and other instructional needs are taken into consideration with program growth. In turn, the CTL will devise budgets to increase personnel for the following fiscal year if needed to support the online course growth.

i) The institution assures the integrity of its online offerings.

The Higher Education Opportunity Act (HEOA) enacted in 2008 requires that an academic institution that offers distance education opportunities to students 1) has a process established to verify that the student who registers is the same student who participates in and completes the offering and receives academic credit for it, 2) has a process established to verify that student privacy rights are protected, and 3) has a process established that notifies the student about any additional costs or charges that are associated with verification of student identity. In BSPH programs, the following actions have been taken to satisfy these requirements: 1) students may only enter the academic website for the online courses they take by providing the unique student ID and password assigned after admission, 2) all FERPA privacy rights are preserved by limiting access very specifically in the University student information system to only those permitted by law to have access to restricted student information, and 3) there are no additional costs assessed to the student for the measures we use to verify student identity.

As referenced, all new BSPH students are enrolled in a mandatory Academic Ethics and Research course -- a zero-credit, zero-tuition course that is geared towards helping students avoid behaviors linked to plagiarism, cheating and other violations of academic integrity.

Appendix A - Course List and Descriptions

Note: This certificate program does not propose to introduce any new courses – it is based on existing course offerings across Johns Hopkins University.

PH.140.628 Data Science for Public Health I (4 credits)
Presents the basics of data science primarily using the python programming language. Teaches basic unix, version control, graphing and plotting techniques, creating interactive graphics, web app development, reproducible research tools and practices, resampling based statistics and artificial intelligence via deep learning, focusing on practical implementation specifically tied to computational tools and core fundamentals necessary for practical implementation. Culminates with a web app development project chosen by student (who will come out of this course sequence well-equipped to tackle many of the data science problems that they will see in their research).

PH.140.629 Data Science for Public Health II (4 credits)
Presents the basics of data science using the python programming language. Teaches basic unix, version control, graphing and plotting techniques, creating interactive graphics, web app development, reproducible research tools and practices, resampling based statistics and artificial intelligence via deep learning, focusing on practical implementation specifically tied to computational tools and core fundamentals necessary for practical implementation. Culminates with a web app development project chosen by student (who will come out of this course sequence well-equipped to tackle many of the data science problems that they will see in their research).

PH.140.644 Statistical Machine Learning: Methods, Theory, and Application (BIOSTAT) (4 credits)
Introduces statistical and computational foundations of modern statistical machine learning. Acquaints students with modern statistical machine learning models and their statistical and theoretical underpinnings. Includes topics: regression and classification, resampling methods (cross-validation and bootstrap), model and variable selection, tree-based methods for regression and classification, functional regression models, unsupervised learning, support vector machines, ensemble methods, deep learning, visualization of large datasets. Includes example applications of cancer prognosis from microarray data, graphical models for data visualization, and a prediction of survival using high-dimensional predictors.

PH.140.762 Bayesian Methods (BIOSTAT) (3 credits)
Illustrates current approaches to Bayesian modeling and computation in statistics. Describes simple familiar models, such as those based on normal and binomial distributions, to illustrate concepts such as conjugate and noninformative prior distributions. Discusses aspects of modern Bayesian computational methods, including Markov Chain Monte Carlo methods (Gibbs' sampler) and their implementation and monitoring. Bayesian Methods I is the first term of a two term sequence. The second term offering, Bayesian Methods II (140.763), develops models of increasing complexity, including linear regression, generalized linear mixed effects, and hierarchical models.

PH.140.773 Foundations of Statistical Inference (4 credits)
Investigates the foundations of statistics as applied to assessing the evidence provided by an observed set of data. Topics include: law of likelihood, the likelihood principle, evidence and the likelihood paradigm for statistical inference; failure of the Neyman-Pearson and Fisherian theories to evaluate evidence; marginal, conditional, profile and other likelihoods; and applications to common problems of inference.

PH.140.777 Statistical Programming Paradigms and Workflows (3 credits)
Covers the basics of statistical programming and other workflow skills required for the research and application of statistical methods. Includes programming with unix and the command line, git/github, working with Python, SQL, APIs, HTMLs, and interactive dashboard. Includes topics in statistical data analysis provide working examples.

PH.140.779 Advanced Statistical Computing (3 credits)
Covers the theory and application of common algorithms used in statistical computing. Includes topics: root finding, optimization, numerical integration, Monte Carlo, Markov chain Monte Carlo, stochastic optimization, and bootstrapping. Discusses specific algorithms: Newton-Raphson, EM, Metropolis-Hastings algorithm, Gibbs sampling, simulated annealing, Gaussian quadrature, Romberg integration, etc. Discusses applications of these algorithms to real research problems.

PH.180.623 Infectious Disease Threats to Global Security (3 credits)
Introduces students to the major health security threats that face the US and other countries and the strategies, policies and organizations that are in place to defend against them. Makes notes of areas where approaches to health security have evolved. Examines where important gains in health security preparedness have been made and identify areas in which progress is still needed. Focuses on preparedness for and response to biological threats to health security will be a large focus of this class. Discusses other health security threats and sharing of experiences from students are welcome.

PH.182.640 Food- and Water- Borne Diseases (3 credits)
Discusses food- and water-borne intoxicants and infections, diseases linked to eating and drinking, and prevention of food and water-borne diseases. Includes topics: transmission of disease via food and water, disease processes in food- and water-related illness, microbial toxins, mycotoxins, chemical toxins, bacterial infections (salmonellosis, shigellosis, vibrio, listeria, etc.) virus and parasitic infections, organizing safe food and water supplies, and issues in food and water safety.

PH.221.660 Systems Science in Public Health: Basic Modeling and Simulation Methods (IH) (3 credits)
Introduces students to mathematical and computational modeling and simulation methods that can help public health decision makers better understand and improve various systems in public health. Addresses the basic concepts of mathematical and computational modeling and simulation. Covers probability theory, decision analysis, Markov models, compartment models, and systems dynamics models, as well as basics of economic and operational modeling. Introduces TreeAge, and VenSim software. Offers examples of public health systems including both communicable and non-communicable disease control programs (e.g., vaccines, medications, and non-pharmaceutical interventions), dietary and physical activity behaviors and interventions, and healthcare systems and healthcare policy.

PH.223.662 Vaccine Development and Application (4 credits)
Reviews the processes used to evaluate all aspects of vaccine development and the use of immunizations for disease prevention. Emphasizes in-depth understanding of vaccines successfully introduced into routine immunization schedules. Discusses procedures and oversight at each step in the process, including post-licensure policy making and monitoring for safety and effectiveness.

PH.223.663 Infectious Diseases and Child Survival (3 credits)

Reviews the major causes of global childhood morbidity and mortality, and introduces intervention strategies. Reviews infectious disease problems contributing to childhood morbidity and mortality worldwide, including (but not limited to) HIV, TB, hepatitis, diarrheal disease, ARI, helminth infections, and measles. Emphasizes epidemiology, strategies for prevention and control, and differences based on available resources.

PH.223.680 Global Disease Control Programs and Policies (4 credits)
Presents the history, social and political context, organization, technical content, funding and evaluation of current, major, global initiatives for disease control. Emphasizes programs focused on health problems of the developing world and includes, initiatives for vaccines and immunization, non-communicable diseases, safe motherhood and reproductive health, malaria, Neglected Tropical Diseases, HIV, emerging infectious diseases, TB, tobacco control, nutritional interventions and injury control. Examines the process of policy formulation and resource allocation to international health and disease control.

PH.223.682 Clinical and Epidemiologic Aspects of Tropical Diseases (4 credits)
Focuses on infectious diseases that disproportionately affect those in developing countries. Addresses some of these are major killers, others are neglected tropical diseases not covered in other courses. Discusses the epidemiological and clinical aspects of each disease, including diagnosis and treatment. Introduces students to the major infectious diseases that are prevalent and of public health importance in tropical and developing countries**.**

PH.223.688 Clinical, Epidemiologic, and Climate Change factors of Enteric Infections in the Tropics (4 credits)
Provides an overview of the epidemiology, presentation, and effects of microbial, protozoan, and viral intestinal infections, including Salmonella, Shigella, cholera, typhoid, rotavirus, amebiasis, dysentery, H. pylori, Campylobacter, Cryptopsoridium, Cyclospora, and Giardia. Addresses clinical presentation, life cycle, distribution, prevention, and treatment of intestinal helminthes, including Ascaris, Trichuris, Strongyloides, and hookworm. Addresses interactions between parasites, diarrhea, and malnutrition along with treatment, prevention and control strategies, and oral rehydration therapy. Covers Cysticercosis and hydatid disease. Includes laboratory sessions and practical lab experience.

PH.260.623 Fundamental Virology (4 credits)
Discusses cellular, molecular, genetic, and immunological principles that govern viral infection. Presents a survey of main virus groups with a detailed discussion of several representative human pathogens. Includes topics: replication strategies, pathogenesis, carcinogenesis, vaccination, and the use of viruses as tools in molecular and cell biology. Emphasizes interactions of viral and host cell processes**.**

PH.260.631 Immunology, Infection and Disease (3 credits)
Presents the fundamental cellular, molecular and genetic mechanisms that initiate and control immune responses elicited during pathogen challenge and vaccination**.**

PH.260.635 Biology of Parasitism (5 credits)
Presents a biological basis of parasitic lifestyles with concurrent laboratory including host responses and parasite evasion of host defense mechanisms, transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment, and control of the major helminthic and protozoan infections of man

PH.260.636 Evolution of Infectious Disease (3 credits)
Introduces students to the concept of how bacteria, parasites, viruses and even fungi have evolved and are still evolving to persist, emerge, and re-emerge in both the developed and developing world. Enables public health workers to develop new strategies and approaches that can be used to aid in the control of the major infectious disease epidemics that continue to threaten both the developed and developing world.

PH.260.650 Vector Biology and Vector-Borne Diseases (3 credits)
Presents the principles of transmission of human and animal pathogens by insects, mites and ticks. Covers basic arthropod biology with special attention to biological properties of vectors and their interactions with pathogens, basic components of arbopathogen disease cycles and principles of pathogen transmission dynamics. Special topics include emerging pathogens, vector genetics, traditional and next generation control strategies and venomous arthropods.

PH.260.655 Pandemics of the 20th Century (1 credits)
Focuses on major pandemics in the human population that have occurred in the 20th century and in particular, the 1918 influenza pandemic, the severe acute respiratory distress syndrome (SARS) outbreak of 2002-03 and the emergence of HIV. A discussion of ongoing concerns regarding research into viruses with pandemic potential (Gain of Function experiments) also forms part of the content. For each pandemic, discussion groups cover readings centered around a clinical- or public health-topic and a pathogen-oriented topic in order to give students a broad understanding of the pandemic, as well as to compare and contrast the key aspects of each disease. Compares and contrasts pandemics resulting from acute and chronic diseases, as well as diseases with different routes of transmission and incubation times. Provides a comprehensive overview of how each pandemic emerged, what key factors dictated spread in the population, and how each pathogen induced disease.

PH.260.656 Malariology (4 credits)
Presents issues related to malaria as a major public health problem. Emphasizes the biology of malaria parasites and factors affecting their transmission to humans by anopheline vectors. Topics include host-parasite-vector relationships; diagnostics; parasite biology; vector biology; epidemiology; host immunity; risk factors associated with infection, human behavior, chemotherapy, and drug resistances; anti-vector measures; vaccine development; and management and policy issues**.**

PH.340.601 Principles of Epidemiology (5 credits)
Introduces principles and methods of epidemiologic investigation of infectious and noninfectious diseases. Illustrates methods by which studies of the distribution and dynamic behavior of disease in a population can contribute to an understanding of etiologic factors, modes of transmission, and pathogenesis. Presents different types of study design, including randomized trials, case-control and cohort studies, risk estimation, and causal inferences. Demonstrates the relationship between epidemiology and the development of policy. Laboratory problems provide experience in epidemiologic methods and inferences, illustrating a common-vehicle epidemic; the spread of infectious disease in school, home, and community; epidemiological aspects of a noninfectious disease; vaccination; the epidemiological approach to health services evaluation; rates of morbidity and mortality; sensitivity and specificity; and life table methods.

PH.340.609 Concepts and Methods in Infectious Disease Epidemiology (4 credits)
Develops deeper understanding of the concepts and quantitative methods unique to infectious disease epidemiology. Builds upon the concepts and methods of general epidemiology and knowledge of specific infectious diseases. Includes topics: disease emergence, transmissibility and the basic

reproductive number, transmission patterns and serial intervals, seasonality, virulence, heterogeneity in hosts and pathogens, herd immunity, diagnosis of infectious diseases, co-infections, and phylodynamics.

PH.340.612 Epidemiologic Basis for Tuberculosis Control (2 credits)
Considers subjects and epidemiologic principles relevant to control measures against tuberculosis. Includes the following topics: diagnosis of TB infection and disease; risk factors and epidemiology; prevention by case-finding and treatment, vaccination, and preventive therapy; pediatric TB; TB modeling; and elements of control programs in low-, middle-, and high-income settings. Offers lectures, group discussions, and review of the tuberculosis literature as the primary components.

PH.340.627 Epidemiology of Infectious Diseases (4 credits)
Introduces the basic methods for infectious disease epidemiology and case studies of important disease syndromes and entities. Includes definitions and nomenclature, outbreak investigations, disease surveillance, case-control studies, cohort studies, laboratory diagnosis, molecular epidemiology, dynamics of transmission, and assessment of vaccine field effectiveness. Focuses case studies on acute respiratory infections, diarrheal diseases, hepatitis, HIV, tuberculosis, sexually transmitted diseases, malaria, and other vector-borne diseases.

PH.340.641 Healthcare Epidemiology (4 credits)
Prepares students for a career in healthcare epidemiology, examines the epidemiology, pathogenesis and prevention of healthcare associated infections and the evidence behind interventions to control these infections. Uses analytic tools to answer important research questions and practical skills such as conducting root cause analyses, utilizing CUSP methodology for process improvement, performing surveillance, and evaluating outbreaks.

PH.340.646 Epidemiology and Public Health Impact of HIV and AIDS (4 credits)
Provides an overview of the historical and public health aspects of the AIDS epidemic with review and analysis of virology, immunology, clinical and laboratory manifestations, legal issues, clinical management, coinfection, economic impact, and needs for future research and intervention for global control of the HIV

PH.340.651 Emerging Infections (2 credits)
Explores the factors promoting the emergence of new infectious diseases and the re-emergence of some of the more traditional infections. Evaluates agent, host, environmental and ecological factors in the emergence of infectious diseases. Presents methods of surveillance and early recognition of several important emerging infections. Includes discussions from lecturers with considerable experience in the investigation of specific emerging infections on the issues specific to emerging infections. Presents and discusses a paper describing an investigation of an Emerging Infection following each one-hour lecture. Presents, describes, and analyzes the factors related to the emergence of infectious diseases, new and old, that have emerged as important public health problems, or which have the potential for major epidemic spread. Explains possible methods for the rapid recognition, prevention, and control.

PH.340.653 Epidemiologic Inference in Outbreak Investigations (3 credits)
Using lectures, seminars, and lab discussions provides students with practical understanding and set of epidemiologic tools to detect, investigate, and interpret infectious disease outbreaks. Provides skills for examining field data and deriving inferences from infectious disease epidemics and outbreak investigations. Discusses steps in investigating an outbreak and reviews some large and small outbreaks, mostly from the distant past. Focuses on the application of epidemiologic skills to real infectious disease outbreak case studies.

PH.340.654 Epidemiology and Natural History of Human Viral Infections (6 credits)
Emphasizes biology, epidemiology and pathogenesis of diseases caused by human viruses. Discusses virus interaction with host, diagnostic methodologies, immunization and treatment of viral infections. Examines relationships between oncogenesis and viral infections, such as Hepatitis/liver cancer, HPV/cervical cancer, EBV/Burkitt's lymphoma and HTLV/leukemia. Covers the biology and natural history of major viral families (such as retroviruses, rabies, and others). Also covers Prion diseases, which are similar to, but not viral infections.

PH.340.668 Topics in Infectious Disease Epidemiology (3 credits)
Introduces the basic methods for infectious disease epidemiology and case studies of important disease syndromes and entities. Methods include definitions and nomenclature, outbreak investigations, disease surveillance, case-control studies, laboratory diagnosis, molecular epidemiology, and dynamics of transmission. Case-studies focus on acute respiratory infections, diarrheal diseases, hepatitis, tuberculosis, sexually transmitted diseases, malaria, and other emerging infections.

PH.340.677 Infectious Disease Dynamics: Theoretical and Computational Approaches (4 credits)
Focuses on the dynamic processes that affect the spread of infectious disease. Presents basic conceptual approaches and a survey of specific theoretical and computational methods for simulating the spread of diseases. Includes specific topics: simulations of disease in small populations, and of the impacts of interventions; social networks and the links between transmission dynamics and the evolution of pathogens. Includes methods: deterministic, stochastic, age-structured and spatially structured models, social network theory, and other tools of systems epidemiology. Focuses on simple models of transmission and estimation of parameters describing the dynamics of transmission. Constructs students' own simulations of disease transmission. Applies concepts and methods to historical epidemics, current emerging diseases, and diseases of international public health importance.

PH.340.693 Investigation of Outbreaks (2 credits)
Teaches how to detect, investigate, and interpret disease outbreaks. Focuses on application of epidemiological skills to develop hypotheses relevant to understanding source or reservoirs of infection, modes of spread and possible control measures. Includes simple epidemiological approaches for examining field data on outbreaks and deriving inferences. Reviews the main factors involved in the occurrence of an outbreak and steps in investigating an epidemic. Uses data from large and small epidemics to illustrate the main concepts and terminology.

PH.340.721 Epidemiological Inference in Public Health (5 credits)
Introduces principles and methods of epidemiologic investigation of disease and other health states. Presents different types of study designs, including randomized trials, cohort and case-control studies; measurement of exposures and outcomes; risk estimation; surveillance; program evaluation; and causal inference. Discusses evaluation measures for screening programs and health interventions. Links epidemiologic inferences with the development of policy. Offers activities that provide experience in applying epidemiologic methods, interpreting findings, and drawing inferences**.**

PH.340.744 Advanced Topics on Control and Prevention of HIV/AIDS (4 credits)
Focuses on directed readings and discussion on the science and pathogenesis of HIV/AIDS. Covers dynamics of the HIV epidemic in the populated world, difficulties and contrasts between clinical management of HIV/AIDS in developed and developing countries, prevention and control modalities

against HIV/AIDS, and predicting patterns of future growth of the HIV/AIDS epidemic with special reference to global economic impact of HIV vaccine and eradication issues of HIV/AIDS.

PH.340.751 Epidemiologic Methods 1 (5 credits)
Presents as the first course in the Epidemiologic Methods sequence. Introduces students to the principles and concepts used in epidemiologic research. Presents material in the context of an epidemiological framework with three major areas: populations and an introduction to study designs; measurement, including measures of accuracy and disease occurrence; and methods used for comparing populations. Illustrates synthesis lectures on how these elements come together in modern epidemiological research. Provides experience using laboratory exercises and assignments with applying concepts and calculations to problems drawn from real epidemiological data and published literature**.**

PH.340.761 Epidemiologic Methods for EPI Doctoral Students I (5 credits)
Introduces epidemiologic methods to doctoral students in the department of epidemiology (first in a four-term sequence). Delves into the role of epidemiology in public health, clinical and population health research, epidemiologic study designs, and measurement of exposures and health outcomes (validity, reliability, information bias).

PH.380.603 Demographic Methods for Public Health (PFRH) (4 credits)
Teaches students the basic methods demographers use to describe populations and analyze population change. Introduces the concept of a population, describes the demographic approach to populations, and identifies sources of population data. Covers four sets of methods with broad applicability in public health: 1) techniques for describing population composition, distribution, and growth; 2) methods to compare populations (age-period-cohort approaches and standardization and decomposition of rates); 3) single-decrement life tables; and 4) the cohort-component method for population projection. Covers the basic tools used to study the fundamental population processes of fertility, mortality, and migration.

PH.380.755 Population Dynamics and Public Health (PFRH) (2 credits)
Provides an introduction to population dynamics, the processes by which populations change, as a foundation for understanding population health. Demonstrates how births, deaths, and migrations determine the size, growth, age-sex structure, and geographic location of populations. Reviews the proximate and indirect causes of population change. Covers the calculation and interpretation of basic measures used to describe population dynamics and the major sources of demographic data.

PH.380.761 Sexually Transmitted Infections in Public Health Practice (4 credits)
Provides a comprehensive and current synthesis of sexually transmitted infections (STIs) in the United States and globally. Examines biologic, behavioral, social, and epidemiologic aspects of sexually transmitted infections (STIs). Focuses, throughout the course, on the diverse factors that contribute to STI prevention and control. Discusses how biologic and behavioral factors influence preventability and control of STIs. Introduces a number of STI prevention and control interventions with an emphasis on evaluation of these interventions. Data-focused and driven by current research study findings and surveillance data. Particularly focuses on considering strengths and weakness of various data sources and study designs and on thinking critically about what's going on 'behind the numbers.

EN.520.621 Introduction To Nonlinear Systems (ECE) (4.5 credits)
Nonlinear systems analysis techniques: phase-plane, limit cycles, harmonic balance, expansion methods, describing function. Liapunov stability. Popov criterion. Recommended Course Background: EN.520.601 or equivalent.

EN.540.633 Pharmacokinetics and Pharmacodynamics (4.5 credits)
This is a one-semester version of the courses in Pharmacokinetics and Pharmacodynamics that were offered as a two-semester sequence in the past. The course (and software to be developed) will cover the spectrum of ways in which pharmaceuticals affect human physiology. The goal is to develop process models of the human body that will predict pharmaceutical effects as a function of time and organ (or cell) type that will work for a wide variety of pharmaceuticals including small molecules, biologics, and chemotherapy agents. This course is organized to replicate group project work as it is practiced in industry. The class is divided into groups (typically 3 or 4 students) and each group meets separately each week with the instructor. Hence, there is no regularly scheduled class times; student groups sign up for a weekly meeting time at the beginning of the semester. These meetings typically will be 90 minutes long. The expectations and assignments for this course are quite different from most other courses. There are no weekly lectures by the instructor. Rather, each week each group will make a PowerPoint presentation on the week's topic or their progress on their project. This section may be cross-listed with other sections in the same course. Sections are cross-listed to enrich student learning and enhance collaboration opportunities.

EN.553.626 Introduction to Stochastic Processes (AMS) (6 credits)
Mathematical theory of stochastic processes. Emphasis on deriving the dependence relations, statistical properties, and sample path behavior including random walks, Markov chains (both discrete and continuous time), Poisson processes, martingales, and Brownian motion. Applications that illuminate the theory. Students may receive credit for EN.553.426 or EN.553.626. Recommended course background: (EN.553.291 OR AS.110.201 OR AS.110.212).

EN.553.632 Bayesian Statistics (AMS) (4.5 credits)
The course will cover Bayesian methods for exploratory data analysis. The emphasis will be on applied data analysis in various disciplines. We will consider a variety of topics, including introduction to Bayesian inference, prior and posterior distribution, hierarchical models, spatial models, longitudinal models, models for categorical data and missing data, model checking and selection, computational methods by Markov Chain Monte Carlo using R or Matlab. We will also cover some nonparametric Bayesian models if time allows, such as Gaussian processes and Dirichlet processes.

EN.553.633 Monte Carlo Methods (AMS) (6 credits)
The objective of the course is to survey essential simulation techniques for popular stochastic models. The stochastic models may include classical time-series models, Markov chains and diffusion models. The basic simulation techniques covered will be useful in sample-generation of random variables, vectors and stochastic processes, and as advanced techniques, importance sampling, particle filtering and Bayesian computation may be discussed. Recommended Course Background: EN.553.630.

EN.553.636 Introduction to Data Science (AMS) (6 credits)
Today the term Data Science is widely used covering a broad range of topics from mathematics and algorithms to actual data analysis and machine learning techniques. This course provides a thorough survey of relevant methods balancing the theory and the application aspects. Accordingly, the material and the discussions alternate between the methodology along with its underlying assumptions and the implementations along with their applications. We will cover several supervised methods for regression and classification, as well as unsupervised methods for clustering and dimensional reduction. To name a few in chronological order, the topics will include generalized linear regression, principal component analysis, nearest neighbor and Bayesian classifiers, support vector machines, logistic regression, decision trees, random forests, K-means clustering, Gaussian mixtures and Laplacian eigenmaps. The course uses Python and Jupyter Notebook and includes visualization techniques throughout the

semester. Time permitting, an introduction to the Structured Query Language (SQL) is provided toward the end of the semester.

EN.553.650 Computational Molecular Medicine (AMS) (6 credits)
Computational systems biology has emerged as the dominant framework for analyzing high-dimensional "omics" data in order to uncover the relationships among molecules, networks and disease. In particular, many of the core methodologies are based on statistical modeling, including machine learning, stochastic processes and statistical inference. We will cover the key aspects of this methodology, including measuring associations, testing multiple hypotheses, and learning predictors, Markov chains and graphical models. In addition, by studying recent important articles in cancer systems biology, we will illustrate how this approach enhances our ability to annotate genomes, discover molecular disease networks, detect disease, predict clinical outcomes, and characterize disease progression. Whereas a good foundation in probability and statistics is necessary, no prior exposure to molecular biology is required (although helpful). Recommended Course Background: EN.553.620 AND EN.553.630.

EN.553.691 Dynamical Systems (AMS) (6 credits)
Mathematical concepts and methods for describing and analyzing linear and nonlinear systems that evolve over time. Topics include boundedness, stability of fixed points and attractors, feedback, optimality, Liapounov functions, bifurcation, chaos, and catastrophes. Examples drawn from population growth, economic behavior, physical and engineering systems. The main mathematical tools are linear algebra and basic differential equations.

EN.553.692 Mathematical Biology (AMS) (4.5 credits)
This course will examine the mathematical methods relevant to modeling biological phenomena, particularly dynamical systems and probability. Topics include ordinary differential equations and their simulation; stability and phase plane analysis; branching processes; Markov chains; and stochastically perturbed systems. Biological applications will be drawn from population growth, predator-prey dynamics, epidemiology, genetics, intracellular transport, and neuroscience. Recommended Course Background: EN.553.620 AND (AS.110.201 OR AS.110.212) AND (AS.110.302 OR AS.110.306 OR EN.553.291)

EN.553.736 System Identification and Likelihood Methods (AMS) (3 credits)
The focus of this roundtable-format course will be stochastic modeling as relates to system identification and maximum likelihood. The principles and algorithms being covered in this course have tremendous importance in the world at large. For example, maximum likelihood is arguably the most popular method for parameter estimation in most real-world applications. System identification is the term used in many fields to refer to the process of mathematical model building from experimental data, with a special focus on dynamical systems. The system identification process refers to several important aspects of model building, including selection of the model form (linear or nonlinear, static or dynamic, etc.), experimental design, parameter estimation, and model validation. This course will cover topics such as the maximum likelihood formulation and theory for dynamical systems, the EM (expectation-maximization) algorithm and its variants, Fisher information, common model structures, online versus offline estimation, the role of feedback in identification (i.e., open-loop versus closed-loop estimation), standard and extended Kalman filtering, and uncertainty characterization (e.g., confidence regions). Recommended Course Background: Undergraduate-level matrix theory and ordinary differential equations; graduate-level course in probability and statistics (e.g., 553.430 or equivalent; in particular, students should have prior exposure to maximum likelihood and Bayes' rule). Prior experience in data analysis and algorithms will be helpful.

EN.553.740 Machine Learning I (AMS) (4.5 credits)
This course is the first part of a two-semester sequence that focuses on theoretical and practical aspects of statistical learning. After introducing background material on inner-product spaces, reproducing kernels and on optimization, the course discusses fundamental concepts of machine learning (such as generalization error, Bayes estimators and the bias vs. variance dilemma) and studies a collection of learning algorithms for classification and regression. The topics that are discussed include linear and kernel regression, support vector machines, lasso, logistic regression, decision trees and neural networks. Students will need a solid background in multivariate calculus, linear algebra, probability and statistics to complete the course. Recommended Course background: 553.620 and 553.630 or higher, and prerequisites for these courses.

EN.553.741 Machine Learning II (AMS) (4.5 credits)
This course is the second part of a two-semester sequence on Machine Learning. It discusses, in a first part, generative methods in statistics and artificial intelligence, with a short introduction to the theory of Markov chains and Monte-Carlo sampling. It will also address standard unsupervised learning problems, such as dimension reduction, manifold learning and clustering. This content of Machine Learning II is, to a large extent, independent from that of Machine Learning I. Recommended course background: Linear algebra, Multidimensional calculus, Probability (e.g., 553.620).

EN.560.617 Deep Learning for Physical Systems (CSE) (4.5 credits)
The primary objective of this course is to foster a deep and holistic comprehension of the concepts surrounding deep learning, as well as their practical applications within engineering systems. This course encompasses a broad spectrum of methodologies, notably emphasizing the utilization of physics-informed and data-driven techniques for both time-dependent and static Partial Differential Equations (PDEs) and Ordinary Differential Equations (ODEs). We delve into the study of multi-layer perceptrons, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and autoencoders, exploring their roles in discerning patterns within data, providing solutions even in scenarios with limited data availability, and learning a family of equations using one network architecture. Through this course, students will acquire the skills to proficiently employ these methods in tackling a wide-ranging spectrum of computational challenges prevalent in domains like solid mechanics, biomechanics, and systems engineering. Proficiency in Python coding is essential for this course. To make the most of this course, it's important to have a basic understanding of Linear Algebra and Probability.

EN.560.653 An Introduction to Network Modeling (CSE) (4.5 credits)
Many real-world problems can be modeled using network structures, and solved using tools from network theory. For this reason, network modeling plays a critical role in various disciplines ranging from physics and mathematics, to biology and computer science, and almost all areas of social science. This course will provide an introduction to network theory, network flow algorithms, modeling processes on networks and examples of empirical network applications spanning transport, health and energy systems.

EN.560.657 System Dynamics (CSE) (4.5 credits)
System dynamics is a versatile analytical framework to understand and tackle problems which involve complex interactions among multiple variables and constraints. This course introduces the basics of systems thinking and system dynamics modeling and analysis. Qualitative and quantitative tools are discussed. Students will learn to identify and formulate system's structure and simulate their behavior using specialized software in order to develop potential intervention strategies. Fields of applications include engineering, climate change, resilience, logistics, public policy analysis, business, and decision-making.

EN.580.475 Biomedical Data Science (BME) (3 credits)
This course provides an introduction to data science and machine learning for biomedical engineering. The lectures cover topics in biomedical data processing (convolution, denoising, filtering, edge detection, template matching), biomedical data reduction (feature extraction, principal component analysis), and biomedical data regression, classification (including deep learning), and clustering. Background: Signals and Systems

EN.580.640 Systems Pharmacology & Personalized Medicine (BME) (6 credits)
We have moved beyond the 'one-size-fits-all' era of medicine. Individuals are different, their diseases are different, and their responses to drugs are different too. This variability is not just from person to person; heterogeneity is observed even between tumors within the same person, and between sites within the same tumor. These levels of variability among the human population must be accounted for to improve patient outcomes and the efficiency of clinical trials. Some of the ways in which this is being explored include: drugs are being developed hand-in-hand with the tests needed to determine whether or not they will be effective; tumor fragments excised from patients are being cultured in the lab for high-throughput testing of drugs and drug combinations; data-rich assays such as genomics and proteomics identify thousands of potentially significant differences between individuals; and computational models are being used to predict which therapies will work for which patients. This course will focus on the applications of pharmacokinetics and pharmacodynamics to simulating the effects of various drugs across a heterogeneous population of diseased individuals. Such computational approaches are needed to harness and leverage the vast amounts of data and provide insight into the key differences that determine drug responsiveness. These approaches can also explore the temporal dynamics of disease and treatment, and enable the modification of treatment during recovery. Recommended background: 110.201 Linear Algebra, 110.302 Differential Equations, and 553.311 Probability and Statistics (or equivalent).

EN.580.673 Dynamic Modeling of Infectious Diseases in Patients and Populations (3 credits)
Infectious diseases remain a major threat to health globally, and the risk of emerging pandemics like HIV/AIDS and SARS-CoV-2/COVID-19 persists. This course will equip students with the tools to effectively use models to guide clinical and public health decision making for infectious diseases. Topics covered include understanding the complex systems that govern disease transmission, designing and interpreting mathematical models of disease processes at individual patient and population scales, stochastic and deterministic model formulation, use of networks in disease modeling, computational approaches to model simulation, statistical inference methods for timeseries, and data science methods for dealing with common limitations of infectious disease data. Examples will be taken from a range of endemic and epidemic diseases and will include disease evolution and drug resistance. Students will develop and analyze models to inform disease prediction, development of therapeutics, implementation of vaccination, and other control programs. Recommended background: Students should have prior college-level coursework in calculus, linear algebra, probability, statistics, and differential equations. Being comfortable coding in a language such as Python, R, or Matlab is required. No specific academic background in biology or epidemiology is required, but a strong interest and willingness to learn is. Co-listed with EN.580.473

EN.580.680 Precision Care Medicine (BME) (6 credits)
Precision Care Medicine is a two-semester project-based learning course. Projects will use methods of machine learning and mechanistic and statistical modeling to develop novel data-driven solutions to important health care problems that arise in various areas of medicine including critical care medicine. The scope of such problems is vast and solutions can improve the delivery of patient care. Examples

include data- and modeling-driven approaches to: optimal selection of patients to be admitted to ICUs; optimal determination of when it is safe to discharge a patient from an ICU; early prediction of pending changes in the clinical state of patients in an ICU; data-driven optimal selection of patient therapy; and others. In the first semester, students will assemble into teams of 5-6, and will work with their project mentors (clinical faculty in Johns Hopkins Medicine; Drs. Greenstein and Taylor) to develop a project work plan. In the remainder of the course, students will apply engineering approaches to solve the important health care problems in their projects. Class time will include: lectures and tutorials covering the physiology, medicine, and engineering principles relevant to each project; project work in a setting where faculty are available to assist students with challenges. HIPAA regulations and use of human subjects data will be covered. Each team will present project updates to the entire class at regular intervals so that every student becomes familiar with each project. Teams will be charged with designing, validating and deploying their model and an application that delivers the computational method for solving the underlying healthcare problem to the user. The goal is to generate results and one or more manuscripts to be submitted for publication by the end of the second semester.

EN.601.675 Machine Learning (CS) (4.5 credits)
Same material as 601.475, for graduate students. Machine learning is subfield of computer science and artificial intelligence, whose goal is to develop computational systems, methods, and algorithms that can learn from data to improve their performance. This course introduces the foundational concepts of modern Machine Learning, including core principles, popular algorithms and modeling platforms. This will include both supervised learning, which includes popular algorithms like SVMs, logistic regression, boosting and deep learning, as well as unsupervised learning frameworks, which include Expectation Maximization and graphical models. Homework assignments include a heavy programming components, requiring students to implement several machine learning algorithms in a common learning framework. Additionally, analytical homework questions will explore various machine learning concepts, building on the pre-requisites that include probability, linear algebra, multi-variate calculus and basic optimization. Students in the course will develop a learning system for a final project. Required course background: multivariable calculus, probability, linear algebra, intro to computing

EN.601.682 Machine Learning: Deep Learning (CS) (6 credits)
Deep learning (DL) has emerged as a powerful tool for solving data-intensive learning problems such as supervised learning for classification or regression, dimensionality reduction, and control. As such, it has a broad range of applications including speech and text understanding, computer vision, medical imaging, and perception-based robotics. The goal of this course is to introduce the basic concepts of deep learning (DL). The course will include a brief introduction to the basic theoretical and methodological underpinnings of machine learning, commonly used architectures for DL, DL optimization methods, DL programming systems, and specialized applications to computer vision, speech understanding, and robotics. Students will be expected to solve several DL problems on standardized data sets, and will be given the opportunity to pursue team projects on topics of their choice. Required course background: Data Structures, Linear Algebra, Probability, Calc II required; Statistics, Machine Learning, Calc III, numerical optimization and Python strongly recommended.

EN.601.788 Machine Learning for Healthcare (CS) (4.5 credits)
This course surveys the technical and practical challenges of applying machine learning in healthcare, focusing on two themes: The first theme will cover applications of machine learning to a wide range of healthcare data modalities (e.g., medical imaging, structured health records, etc). Beyond reviewing specific modeling approaches, we will focus on navigating pitfalls in model development and evaluation that arise in a healthcare context. The second theme will cover methodological approaches to developing safe and effective machine learning systems in healthcare, including topics such as (but not limited to)

causality, fairness, and distribution shift. This course is designed for students who have a solid existing background in machine learning, and who are interested in both the technical and practical nuances of applying machine learning in healthcare. Grading will be done on the basis of homework assignments as well as a final project. Required course background: EN.601.475/675 Machine Learning or equivalent.

AS.020.674 Quantitative Biology and Biophysics (6 credits)
Students will be given instruction in the concepts of physical and quantitative biology. Students will learn to simulate biological processes, identify the relationship between data and models, and will learn to fit biological data.

AS.171.749 Machine Learning for Scientists/Physicists (PHYS) (4.5 credits)
Neural networks have changed the ways we interact with data and think about statistics. For scientists, it is important to understand the fundamental concepts behind these systems, why they work, what their potential and limitations are. This course will open the black box of neural networks and address some of the theoretical foundations of Machine Learning. It will include aspects of statistics in high dimensions, information theory, optimization, architectures, as well as concepts from neuroscience. We will alternate between theory and applications in python.

ME.250.633 Organ Systems Foundations of Medicine: Infectious Disease and Microbiology (7.5 credits)
4-week course with a focus on lecture, laboratory (both virtudal and "wet" labs), small group exercises, team based learning and clinical correlations on bacteria, viruses, fungi, and parasites. Goal is for the student to build a strong foundation in infectious diseases.

ME.250.714 HIV Biology (1.5 credits)
This course will review clinically relevant aspects of HIV biology including the discovery of HIV, the steps in the HIV life cycle, the dynamics of HIV replication in vivo, HIV pathogenesis, the immune response to HIV, the pharmacology of antiretroviral drugs, and the statues of efforts to cure HIV infection and develop an HIV vaccine.

ME.300.716 Pathology for Graduate Students: Immunology/Infectious Disease (1.5 credits)
Pathology for Graduate Students: Immunology and Infectious Disease will concentrate on the basic mechanisms of Immunology and Infection in human diseases. The format will include lectures, discussion of research papers, and review of histological slides.

Appendix B – Faculty associated with the program

Note: This certificate program does not propose to introduce any new courses – it is based on existing course offerings across Johns Hopkins University. We have listed faculty for all course options listed in Appendix A.

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Ahmed Abdullah Hassoon	Assistant Research Professor	Epidemiology	Full-time	MBBS, MPH	Data Science for Public Health I / PH.140.628 Data Science for Public Health II / PH.140.629
Aisha Dickerson	Associate Professor	Epidemiology	Full-time	PhD, MSPH	Epidemiologic Methods 1 / PH.340.751
Alan L. Scott	Professor	Molecular Microbiology & Immunology	Full-time	PhD	Immunology, Infection and Disease / PH.260.631 Biology of Parasitism / PH.260.635
Alison Hill	Assistant Professor	Biomedical Engineering	Full-time	PhD	Dynamic Modeling of Infectious Diseases in Patients and Populations / EN.580.673 / EN.580.473
Amber D'Souza	Professor	Epidemiology	Full-time	PhD, MPH	Epidemiologic Methods 1 / PH.340.751
Amy Wesolowski	Associate Professor	Epidemiology	Full-time	PhD	Infectious Disease Dynamics: Theoretical and Computational Approaches / PH.340.677
Andrea Ruff	Associate Professor	International Health	Full-time	MD	Infectious Diseases and Child Survival / PH.223.663
Andrew Gordus	Assistant Professor	Biology	Full-time	PhD	Quantitative Biology and Biophysics / AS.020.674
Andy Pekosz	Professor	Molecular Microbiology & Immunology	Full-time	PhD	Fundamental Virology / PH.260.623

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Anne Marie Rompalo	Professor	Medicine	Full-time	MD, ScD	Sexually Transmitted Infections in Public Health Practice / PH.380.761
Arun Venkatesan	Professor	Medicine	Full-time	MD, PhD	Organ Systems Foundations of Medicine: Infectious Disease and Microbiology / ME.250.633
Babak Moghadas	Research Associate	Biostatistics	Full-time	PhD	Data Science for Public Health I / PH.140.628 Data Science for Public Health II / PH.140.629
William Moss	Professor	Epidemiology	Full-time	MD	Epidemiology of Infectious Diseases / PH.340.627
Brian Caffo	Professor	Biostatistics	Full-time	PhD	Biomedical Data Science (BME) / EN.580.475
Brice Ménard	Professor	Physics & Astronomy	Full-time	PhD	Machine Learning for Scientists/Physicists (PHYS) / AS.171.749
Caitlin M Rivers	Associate Professor	Environmental Health & Engineering	Full-time	PhD, MPH	Infectious Disease Threats to Global Health Security / PH.180.623
Carolina Cardona	Assistant Scientist	"Population, Family and Reproductive Health"	Full-time	PhD, MHS	Population Dynamics and Public Health / PH.380.755
Casey Overby Taylor	Associate Professor	Biomedical Engineering	Full-time	PhD	Precision Care Medicine (BME) / EN.580.680
Chizoba Barbara Wonodi	Associate Scientist	International Health	Full-time	MBBS, DrPH, MPH	Global Disease Control Programs and Policies / PH.223.680
Conor James McMenimaan	Associate Professor	Molecular Microbiology & Immunology	Full-time	PhD	Vector Biology and Vector-Borne Diseases / PH.260.650

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Corinne E Joshu	Associate Professor	Epidemiology	Full-time	PhD, MPH, MA	Epidemiologic Methods for EPI Doctoral Students I / PH.340.761
Crystal R Watson	Associate Professor	Environmental Health & Engineering	Full-time	DrPH, MPH	Infectious Disease Threats to Global Health Securit / PH.180.623
Damian Ekiert	Associate Professor	Biology	Full-time	PhD	Quantitative Biology and Biophysics / AS.020.674
David Allen Sack	Professor	International Health	Full-time	MD	Clinical and Epidemiologic Aspects of Tropical Diseases / PH.223.682
David Celentano	Professor	Epidemiology	Full-time	ScD, MHS	Epidemiologic Inference in Public Health I / PH.340.721
David Dowdy	Professor	Epidemiology	Full-time	MD PhD	Concepts and Methods in Infectious Disease Epidemiology / PH.340.609
David Sullivan	Professor	Molecular Microbiology & Immunology	Full-time	MD	Malariology / PH.260.656 Biology of Parasitism / PH.260.635
Donald J Geman	Professor	Applied Mathematics & Statistics	Full-time	PhD	Computational Molecular Medicine (AMS) / EN.553.650
Douglas Norris	Professor	Molecular Microbiology & Immunology	Full-time	PhD	Vector Biology and Vector-Borne Diseases / PH.260.650
Eliza O'Reilly	Assistant Professor	Applied Mathematics & Statistics	Full-time	PhD	Introduction to Stochastic Processes (AMS) / EN.553.626
Emily Gurly	Distinguished Professor of the Practice	Epidemiology	Full-time	PhD, MPH	Epidemiology of Infectious Diseases / PH.340.627

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Feilim MacGabhann	Associate Professor	Biomedical Engineering	Full-time	PhD	Systems Pharmacology & Personalized Medicine (BME) / EN.580.640
Gary Rosner	Professor	Medicine	Full-time	MD	Bayesian Methods (BIOSTAT) / PH.140.762
Gary Ketner	Professor	Molecular Microbiology & Immunology	Full-time	PhD	Pandemics of the 20th Century / PH.260.655
Gira Bhabha	Associate Professor	Biology	Full-time	PhD	Quantitative Biology and Biophysics / AS.020.674
Gonzalo L.Pita	Associate Scientist	Civil & Systems Engineering	Full-time	PhD	System Dynamics (CSE) / EN.560.657
Gyanu Lamichhane	Associate Professor	Medicine	Full-time	PhD	Pathology for Graduate Students: Immunology/Infectious Disease / ME.300.716
Homayoon Farzadegan	Professor	Epidemiology	Full-time	PhD	Epidemiology and Public Health Impact of HIV and AIDS / PH.340.646
Jacky Jennings	Professor	Epidemiology	Full-time	PhD, MPH	Epidemiologic Inference in Outbreak Investigations / PH.340.653
James Spall	Research Professor	Applied Mathematics & Statistics	Full-time	PhD	Monte Carlo Methods (AMS) / EN.553.633
Jennifer A Deal	Associate Professor	Epidemiology	Full-time	PhD, MHS	Epidemiologic Inference in Public Health I / PH.340.721
Jonathan E Golub	Professor	Medicine	Full-time	PhD, MPH	Epidemiologic Basis for Tuberculosis Control / PH.340.612
Joseph B Margolick	Professor	Molecular Microbiology & Immunology	Full-time	MD, PhD	Immunology, Infection and Disease / PH.260.631

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Joseph Greenstein	Senior Lecturer	Biomedical Engineering	Full-time	PhD	Biomedical Data Science (BME) / EN.580.475
Karen Carroll	Professor	Pathology	Full-time	MD	Organ Systems Foundations of Medicine: Infectious Disease and Microbiology / ME.250.633
Kari M Debbink	Associate Teaching Professor	Molecular Microbiology & Immunology	Full-time	PhD	Fundamental Virology / PH.260.623
Kasper Hansen	Assistant Professor	Biostatistics	Full-time	PhD	Advanced Statistical Computing / PH.140.779
Kawsar R. Talaat	Associate Professor	International Health	Full-time	MD	Clinical and Epidemiologic Aspects of Tropical Diseases / PH.223.682 Infectious Diseases and Child Survival / PH.223.663
Kellogg Schwab	Abel Wolman Professorship in Water and Public Health Professor	Environmental Health & Engineering	Full-time	PhD, MSPH	Food- and Water-Borne Diseases / PH.182.640
Khalil G Ghanem	Professor	Medicine	Full-time	MD, PhD	Organ Systems Foundations of Medicine: Infectious Disease and Microbiology / ME.250.633
Kim Aizire	Associate Research Professor	Epidemiology	Full-time	MD, PhD, MHS	Epidemiologic Methods 1 / PH.340.751
Kwame Sanwu Kutten	Senior Lecturer	Biomedical Engineering	Full-time	PhD	Biomedical Data Science (BME) / EN.580.475

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Laura L Hammitt	Professor	International Health	Full-time	PhD	Vaccine Development and Application / PH.223.662
Lauren Gardner	Alton & Sandra Cleveland Professor	Civil & Systems Engineering	Full-time	PhD	An Introduction to Network Modeling (CSE) / EN.560.653
Laurent Younes	Professor	Applied Mathematics & Statistics	Full-time	PhD	Machine Learning I (AMS) / EN.553.740
Luhao Zhang	Assistant Professor	Applied Mathematics & Statistics	Full-time	PhD	Bayesian Statistics (AMS) / EN.553.632
Mary Elizabeth Hughes	Associate Scientist	"Population, Family and Reproductive Health"	Full-time	PhD	Demographic Methods for Public Health (PFRH) / PH.380.603 Population Dynamics and Public Health (PFRH) / PH.380.755
Marc Donohue	Professor	Chemical and Biomolecular Engineering	Full-time	PhD	Pharmacokinetics and Pharmacodynamics / EN.540.633
Mathias Unberath	John C. Malone Associate Professor	Computer Science	Full-time	PhD	Machine Learning: Deep Learning (CS) / EN.601.682
Maunank Shah	Associate Professor	Medicine	Full-time	MD, PhD	Organ Systems Foundations of Medicine: Infectious Disease and Microbiology / ME.250.633
Michael Oberst	Assistant Professor	Computer Science	Full-time	PhD	Machine Learning for Healthcare (CS) / EN.601.788
Pablo Iglesias	Edward J. Schaefer Professor	Electrical & Computer Engineering	Full-time	PhD	Introduction To Nonlinear Systems (ECE) / EN.520.621
Pablo Martinez Amezcua	Assistant Professor	Epidemiology	Full-time	MD, PhD	Epidemiologic Inference in Outbreak Investigations /

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
					PH.340.653 Epidemiologic Methods for EPI Doctoral Students I / PH.340.761
Poonum Korpe	Associate Research Professor	Epidemiology	Full-time	MD	Healthcare Epidemiology / PH.340.641
Prajakta Bedekar	Postdoctoral Fellow	Applied Mathematics & Statistics	Full-time	PhD	Mathematical Biology (AMS) / EN.553.692
Qingfeng Li	Assistant Professor	International Health	Full-time	PhD	Systems Science in Public Health: Basic Modeling and Simulation Methods (IH) / PH.221.660
Rakhi Naik	Associate Professor	Medicine	Full-time	MD	Organ Systems Foundations of Medicine: Infectious Disease and Microbiology / ME.250.633
Raman Arora	Associate Professor	Computer Science	Full-time	PhD	Machine Learning (CS) / EN.601.675
Richard B Markham	Professor	Molecular Microbiology & Immunology	Full-time	MD	Evolution of Infectious Disease / PH.260.636
Richard Chaisson	Professor	Medicine/Epidemiology	Full-time	MD	Epidemiologic Basis for Tuberculosis Control / PH.340.612
Robert Scharpf	Associate Professor	Medicine	Full-time	PhD	Bayesian Methods (BIOSTAT) / PH.140.762
Robert Gilman	Professor	International Health	Full-time	MD	Clinical, Epidemiologic, and Climate Change factors of Enteric Infections in the Tropics / PH.223.688
Robert Silicano	Professor	Medicine	Full-time	MD, PhD	HIV Biology / ME.250.714

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Rosa Crum	Professor	Epidemiology	Full-time	MD	Principles of Epidemiology / PH.340.601
Ruth Karron	Professor	International Health	Full-time	MD	Vaccine Development and Application / PH.223.662
Sabra L Klein	Professor	Molecular Microbiology & Immunology	Full-time	PhD	Pandemics of the 20Th Century / PH.260.655
Saki Takahashi	Assistant Professor	Epidemiology	Full-time	PhD	Infectious Disease Dynamics: Theoretical and Computational Approaches / PH.340.677
Shaun Truelove	Associate Scientist	International Health	Full-time	PhD	Topics in Infectious Disease Epidemiology / PH.340.668 Global Disease Control Programs and Policies / PH.223.680
Somdatta Goswami	Assistant Professor	Civil & Systems Engineering	Full-time	PhD	Deep Learning for Physical Systems (CSE) / EN.560.617
Stephan Ehrhardt	Professor	Epidemiology	Full-time	MD, MPH	Epidemiologic Methods for EPI Doctoral Students I / PH.340.761
Stephanie Hicks	Associate Professor	Biostatistics	Full-time	PhD	Statistical Programming Paradigms and Workflows / PH.140.777
Subhra Chakraborty	Associate Professor	International Health	Full-time	PhD, MPH	Clinical, Epidemiologic, and Climate Change factors of Enteric Infections in the Tropics / PH.223.688
Taha Taha	Professor	Epidemiology	Full-time	MBBS, PhD	Epidemiologic Inference in Outbreak Investigations / PH.340.653

Faculty Lead(s)*	Rank	Discipline	Status	Degree	Course/number
Tamas Budavari	Associate Professor	Applied Mathematics & Statistics	Full-time	PhD	Introduction to Data Science (AMS) / EN.553.636
Vadim Zipunnikov	Associate Professor	Biostatistics	Full-time	PhD	Statistical Machine Learning: Methods, Theory, and Applications / PH.140.644

TABLE 1: RESOURCES

Fill in items highlighted in blue only

Resources Categories	(Year 1)	(Year 2)	(Year 3)	(Year 4)	(Year 5)
1. Reallocated Funds[1]	**0**	**0**	**0**	**0**	**0**
2. Tuition/Fee Revenue[2]	**445,874**	**529,904**	**727,735**	**749,567**	**772,054**
a. Annual Full-time Revenue of New Students					
Number of Full-time Students	13	15	20	20	20
Annual Tuition Rate	$34,298	$35,327	$36,387	$37,478	$38,603
Subtotal Tuition	$445,874	$529,904	$727,735	$749,567	$772,054
Annual Fees					
Subtotal Fees	$0	$0	$0	$0	$0
Total Full-time Revenue of New Students	$445,874	$529,904	$727,735	$749,567	$772,054
b. Annual Part-time Revenue					
Number of Part-Time Students	0	0	0	0	0
Credit Hour Tuition Rate	$0	$0	$0	$0	$0
Annual Fees Per Credit Hour	$0	$0	$0	$0	$0
Annual Credit Hours Per Student	0	0	0	0	0
Subtotal Tuition	$0	$0	$0	$0	$0
Subtotal Fees	$0	$0	$0	$0	$0
Total Part Time Revenue	$0	$0	$0	$0	$0
3. Grants, Contracts & Other Sources[3]	**$0**	**$0**	**$0**	**$0**	**$0**
4. Other Sources	**$0**	**$0**	**$0**	**$0**	**$0**
TOTAL (Add 1 - 4)	$445,874	$529,904	$727,735	$749,567	$772,054

Resources Narrative:

Revenue is based on 24 credits of Bloomberg School of Public Health FT tuition which is $1429 per credit. Tuition increases of 3% each year. Goal is to have 13 students in first year, 15 students in second year and 20 students in subsequent years.

Expenditure Categories	(Year 1)	(Year 2)	(Year 3)	(Year 4)	(Year 5)
1. Total Faculty Expenses	$332,500	$342,475	$352,749	$363,332	$374,232
(b + c below)					
a. #FTE	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**
b. Total Salary	**250,000**	**257,500**	**265,225**	**273,182**	**281,377**
c. Total Benefits	82,500	84,975	87,524	90,150	92,854
2. Total Administrative Staff Expenses	103,500	106,605	109,803	113,097	116,490
(b + c below)					
a. #FTE	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
b. Total Salary	**75,000**	**77,250**	**79,568**	**81,955**	84,413
c. Total Benefits	28,500	29,355	30,236	31,143	32,077
3. Total Support Staff Expenses	0	71,760	73,913	76,130	78,414
(b + c below)					
a. #FTE		**1.0**	**1.0**	**1.0**	**1.0**
b. Total Salary		**52,000**	**53,560**	**55,167**	**56,822**
c. Total Benefits	0	19,760	20,353	20,963	21,592
4. Equipment					
5. Library					
6. New or Renovated Space					
7. Other Expenses					
TOTAL (1-7)	$436,000	$520,840	$536,465	$552,559	$569,136

Expenditures Narrative:

Faculty Salaries: Equivalent of 2.0 FTE Faculty effort totally $250k to teach 24 credit of course work each year. Annual merit increase of 3%. FB rate of 38%. Equivalent of 1.0 FTE Faculty in Administrative role @75k a year. with a 3% annual merit increase and 38% FB rate. Administrative Staff support in Years 2-5 with the equivalent of 1.0 FTE. Salary based on Year 1 of $52k with a 3% annual merit increase and 38% FB.