THE GRADUATE SCHOOL
UNIVERSITY of WASHINGTON

ACADEMIC PROGRAM REVIEW
Self-Study Report

Interdisciplinary Doctoral Program in Pathobiology
University of Washington Graduate School
University of Washington | Seattle, WA

Year of Last Review: 1998-1999
Director: Lee Ann Campbell, PhD
Date Submitted: February 5, 2016

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PART A — BACKGROUND INFORMATION

SECTION I: OVERVIEW OF ORGANIZATION

A. Mission and Organizational Structure

Pathobiology mission and values

The Pathobiology Doctoral Program was established in 1990 in the Department of Pathobiology and was granted Interdisciplinary status in 2006, when the Department was dissolved due to restructuring within the School of Public Health (SPH). The Interdisciplinary Doctoral Program in Pathobiology (IDPP) is formally housed in the Graduate School. However, because of our Program's strong focus on diseases of global health importance, upon the establishment of the Department of Global Health (DGH) in 2007, DGH has been the administrative home for our Program. Indeed, DGH has provided a *de facto* home for the IDPP, including administrative and curricular infrastructure, financial support, as well as a community of colleagues and wealth of opportunities for our students.

The specific mission of the IDPP is to train graduate students in basic sciences related to the etiology, pathogenesis, prevention, and cure of globally important diseases. The vision of the program as a link between molecular approaches and global health is supported by our formal training in molecular & cellular biology, epidemiology, global health, biochemistry, genetics, and immunology. This is precisely the reason that many students choose our program over more traditional basic science programs (See Appendix D for student input when queried why they chose our program). Our classroom instruction and laboratory training emphasize state-of-the-art scientific approaches to address these disease-related issues. Our research training is hypothesis-driven and is targeted to understanding host-pathogen interactions and disease processes. The expertise and interaction of the participating faculty meld basic, translational, and clinical research opportunities to train our future leaders in global biomedical research.

There are several aspects that distinguish our training program from other laboratory-based PhD training programs at the University of Washington and elsewhere:

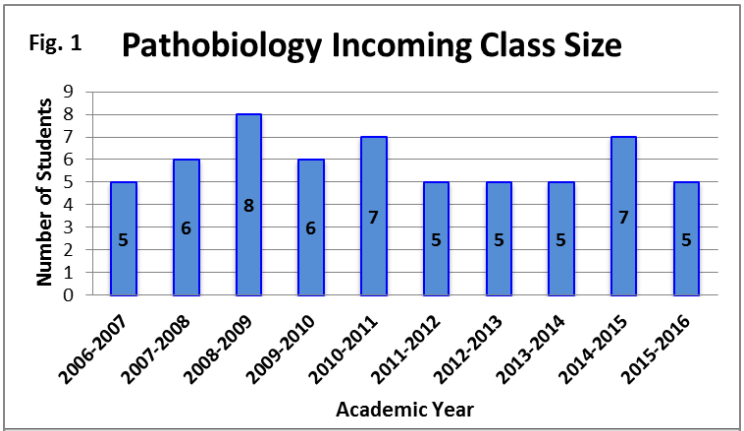
- A focus on pathogens that are relevant to global health (e.g. parasitic infections, STDs including HIV, and tuberculosis)
- An interdisciplinary approach to understanding both infectious and host contributors to chronic diseases (atherosclerosis, cancer)
- A relevance to maternal and child health (HIV, chlamydia, malaria, syphilis)
- An emphasis on global health issues (antibiotic resistance, HIV, malaria, HCV)
- A focus on new tools for prevention and intervention (vaccine development for HIV, malaria, and syphilis; drug discovery for tuberculosis, malaria, African trypanosomiasis, leishmaniasis) to alleviate disease burden
- A focus on identification of biomarkers for diagnosis (cancer and infectious disease)

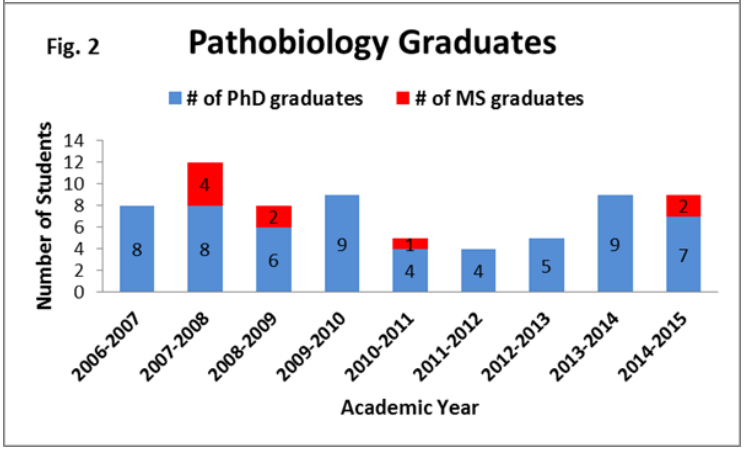
Our values include the following:

- *Rigor and scientific excellence:* We train our students by giving them a firm foundation in the fundamentals of basic science knowledge and experimental analysis methods. We are committed to training in scientific integrity.
- *Potential in diversity*: We value research that is multidisciplinary, recognizing that science advances when individuals with diverse expertise and backgrounds work together.
- *Continuum of science*: Our faculty is committed to teaching the next generation of scientists and empowering them to communicate their research to our broader communities.
- *Global Impact:* Our program values research that explores the fundamental mechanisms underlying globally important diseases, as well as research that seeks to implement basic discoveries to improve health through improved clinical and population level interventions.

Degree program

Prior to 2006, we admitted students into masters or doctoral pathways. Since achieving interdisciplinary status, we accept students only into the Doctoral Program because we have chosen to focus our training resources in this capacity. However, a terminal master's degree is an option for those students whose goals change once enrolled in our Program.





When the Doctoral Program began in the early 1990s, it averaged 16 applications per year and admitted 1 to 6 students. The average number (range) of applicants for the past 5 years has been 68 (66-74) per year. The Program sets high minimum requirements for GPA and GRE scores, which limits the total number of applications. For the last 15 years, the average (range) incoming class size has been 7 (5-11) students. The exact number of students each year will vary depending upon the proportion of students accepting our offer of admission. For example, in 2004, the entering class size was significantly higher, with 11 students, because of a particularly high proportion of acceptances. Experience indicates that a class size of 5-8 students is appropriate for ensuring placement of students in Pathobiology training faculty labs and provides a sufficient cohort for interactions among students. With this incoming class size and senior students completing their degrees, the Program has maintained a roster of approximately 30-32 students at any given time. Due to the high proportion of students that completed their training in the last two academic years, our current student number is 25. Summaries of enrollment and graduates since interdisciplinary status was granted are shown in Figs. 1 and 2.

Administrative structure

The organization of the IDPP is shown in Appendix A. The IDPP is officially housed in the University of Washington (UW) Graduate School, which provides neither administrative nor financial support for the program. The DGH has been fulfilling those roles since 2007, and our goal is to have the IDPP officially moved into the DGH.

DGH is jointly housed within the Schools of Medicine and Public Health. The chairs of DGH, formerly Dr. King Holmes and currently Dr. Judith Wasserheit, have been highly supportive of the IDPP. Within the organizational structure of DGH, all DGH degree programs including the IDPP report to the DGH Associate Chair of Education and Curriculum (Dr. Stephen Gloyd, transitioning to Dr. Carey Farquhar). Directors of Educational Programs, as well as student representatives and representatives from each School serve on the DGH Curriculum Committee, which has ensured close ties for the IDPP with DGH curriculum development and implementation. Dr. Lee Ann Campbell, IDPP Director, and Dr. Sheila Lukehart, an IDPP faculty member representing the SOM's Office of Research & Graduate Education, serve on this committee. Dr. Campbell also interacts with leaders of the 27 other DGH Centers, Programs, and Initiatives through bi-monthly meetings with Dr. Wasserheit to discuss DGH policies and strategic planning. The Director of Research and Faculty Development (Dr.

Holmes) and the Director of Finance and Administration (Dr. Sally Weatherford) are also active in the administration of the IDPP.

Shared governance

Dr. Lee Ann Campbell has served as the Director of the Doctoral Program (0.25 FTE) from 1996 to the present. She has direct responsibility for coordinating program governance, developing resources, meeting reporting requirements, oversight of student academic progress, and resolution of student issues. Governance within the IDDP is shared among faculty through the Steering Committee and a number of topic-focused faculty committees. Members of the Steering Committee include Drs. Marilyn Parsons, Nina Salama, and David Sherman. The IDPP Steering Committee meets monthly to discuss issues including program policies, student progress, curriculum, and appointment of faculty.

Four topic-focused committees facilitate specific functions within the program. Dr. Campbell chairs the Graduate Student Advisory Committee (GSAC) which oversees the course scheduling and academic progress of students during their first year, as they conduct laboratory rotations and before they select a primary mentor. The Admissions Committee (Chair, Dr. Jenny Lund) evaluates applications to the program, conducts applicant interviews, and makes enrollment offers to selected applicants. The Curriculum Committee (Chair, Dr. Jaisri Lingappa) evaluates the quality and relevance of courses within the IDPP, recommends new courses, and assists in developing teaching skills of the faculty. The Student Affairs Committee (Chair, Dr. Gael Kurath) coordinates the twice-yearly Student Research Symposia, at which students present their work-in-progress to a combined faculty and student audience, and the annual Pathobiology Retreat held alternately at off-campus and on-campus locations. With the exception of the GSAC, a student member serves on each committee. These committees report to the Steering Committee. The entire IDPP faculty meets quarterly to discuss program issues, including program goals and direction, curriculum, proposed new faculty, student progress, and other timely topics.

The Pathobiology Program Manager, Ashley Zigler (1.0 FTE), whose salary is provided by DGH and T32 funds, is responsible for managing the day-to-day working of the program. She provides program information and admission policies to prospective applicants and arranges visits to the program by prospective students. She provides information to current students on course offerings, registration procedures, and program procedures and policies. The Program Manager oversees the budget and makes financial arrangements for student and Pathobiology postdoc trainee appointments, tuition, stipends, and insurance needs. She is responsible for updating, production, and distribution of the Graduate Student Handbook, providing updates for the IDPP web page to the Communications Specialist in DGH (see http://globalhealth.washington.edu/education-training/phd-pathobiology), and for communications within the program. She attends all IDPP committee meetings, providing continuity and a common set of ears for all committees. To maximize interaction and promote cohesiveness with other Programs in DGH, the Program Manger is physically housed within DGH at the Harris Hydraulics Building. She interacts regularly with members of the DGH academic program staff, who meet monthly to work on DGH projects such as coordinating orientation, admissions activities, graduation, the web site, the alumni initiative, metrics for DGH, and diversity initiatives.

The DGH administrative team (see http://globalhealth.washington.edu/faculty/Department%20Staff) is overseen by Dr. Sally Weatherford, the DGH Director of Finance and Administration. This team provides support for the IDPP in operations, human resources, and fiscal and regulatory oversight. DGH also assists in interpreting University policies and procedures. Ms. Zigler meets monthly with the educational coordinators in DGH and quarterly with the DGH administrative team to provide cohesion in programmatic function and administration.

Program faculty

The IDPP has 55 faculty members who actively participate in course teaching, mentoring of students and Program Administration (See Appendix C). The faculty are drawn from top quality scientists with

primary affiliations at the UW, as well as from select Seattle-based research institutions including Fred Hutchinson Cancer Research Center (FHCRC), Center for Infectious Diseases Research (CIDR, formerly Seattle Biomedical Research Institute), Infectious Disease Research Institute (IDRI), and Seattle Children's Research Institute (SCRI), as summarized in Table 1.

Table 1. Institutions involved in the IDPP

Institution	Faculty
University of Washington	20
Fred Hutchinson Cancer Research Center	13
Infectious Diseases Research Institute	7
Center for Infectious Disease Research	9
Seattle Children's Research Institute	3
USGS Western Fisheries Research Center	2
Institute for Systems Biology	1
Grand Total	**55**

The faculty are united by a commitment to, and research focus on, diseases that affect people globally. The richness that arises from the diversity across sites provides our trainees with opportunities to experience the environments in academic and private non-profit research institutes. Each of these institutions is highly supportive of the IDPP, and their intellectual and financial contributions to the program are critical to its success. It should be noted that the University policy on faculty appointments mandates that faculty located at affiliated off-campus sites (such as CIDR and IDRI) must be at the Affiliate level. Thus, all of our IDPP faculty at affiliated institutions have Affiliate Faculty appointments in the DGH, are endorsed by the UW to chair doctoral committees and serve as members of the Graduate Faculty of the UW, and have assumed the same level of responsibilities and commitment to all aspects of training in our graduate program as UW-based faculty. This makes our Interdisciplinary Program atypical in that most of the Affiliate faculty members are as active in teaching and training as regular faculty. The specific expertise and contributions of program faculty are discussed in ***Section III.***

Soliciting advice of external constituents

External advice on scientific and academic criteria is obtained in a number of ways:

1. One of the major benefits of our affiliation with DGH has been the unlimited accessibility of Drs. Holmes, the former Chair of DGH, and Wasserheit, the current Chair, for guidance on programmatic direction, integration into DGH, recruitment of faculty, and strategic planning. The Program Director and Chair of the Curriculum Committee also seek advice on course planning and navigating the impact of UW's relatively new activity based budgeting process from Dr. Gloyd, the Associate Chair of Education and Curriculum of DGH.
2. The teaching effectiveness of our faculty is measured annually by students and by periodic peer review. The DGH Curriculum Committee reviews the student evaluations quarterly, and the IDPP Curriculum Committee reviews the peer evaluations. We also undergo yearly teaching consultations with the UW Center for Teaching & Learning, including interviews with students and faculty plus teaching workshops, which has been implemented over the past three years.
3. In addition to formal reviews (such as this) by the Graduate School, our programs are externally reviewed by NIH study sections that review the competing renewal applications of the multiple NRSA Institutional Training Grants that can support our students. One of those training grants, directed by Dr. Campbell, is specifically focused on IDPP predoctoral and postdoctoral trainees working with IDPP faculty.
4. The scientific excellence of the IDPP faculty is externally reviewed by NIH and other foundation study sections and is reflected in the grant support held by IDPP faculty.
5. The private research institutions that contribute faculty to the IDPP receive regular evaluations and advice from their Boards of Directors or External Advisory Committees.
6. The IDPP steering committee is comprised of senior faculty members within the program who have extensive networks of colleagues throughout the UW and peer institutions, from whom they can acquire best practices in interdisciplinary graduate education.

B. Budget and Resources

Programmatic costs for the IDPP

DGH has provided financial support to the IDPP in several categories described below. Between FY2011-15, the average total cost for the program was ~$354,000 per year. The major programmatic costs are shown in Appendix B, and are detailed below.

- 25% FTE for the Program Director. When the Department of Pathobiology was dissolved in 2006, former Dean Patricia Wahl moved Dr. Campbell's faculty position to the Department of Epidemiology, along with a portion of a Pathobiology FTE to support her role as the IDPP Program Director. Through mid-2015, Dr. Campbell's 25% FTE for directing the IDPP has been supplied through Epidemiology. On June 1, 2015, Dr. Campbell's primary faculty appointment was moved to DGH, which now provides this support.
- Salary support for teaching by non-tenured faculty. Through AY2015-16, teaching salary was calculated at 4% FTE/credit, paid annually. A currently pending revision to the DGH teaching salary policy will result in a reduction in the level of salary support for most graduate teaching in subsequent years, thus a decrease in teaching costs for the program. Teaching support is provided for all PABIO courses and GH580, which are requirements for Pathobiology students (although often taken by students from other programs in SPH or SOM). Note that teaching by state-supported faculty (Lingappa, Campbell) is not separately reimbursed.
- Laboratory rotations for the first year students. (3 quarters of stipend, no tuition costs have been incurred in the past because these students were supported on General Operating Funds of DGH). The lab rotations provide first-year students with exposure to three different research topics, labs, and potential mentors; rotation laboratories are selected by the students.
- Staff salaries. DGH supports 75-90% of the salary for the Program Manager (depending upon the availability of funds from the Diseases of Public Health Importance training grant) and partial effort for a budget analyst. In addition to the staff salaries mentioned above, additional DGH administrative time (estimated to be ~$3500 per year) had been required for processing of graduate student appointments and oversight of payroll for students. In 2015, these costs were shifted to mentor's departments/institutions (except for first-year students).

Sources of revenue for the IDPP

There are multiple sources of support for the Pathobiology Program, listed below:

- State funds for faculty support: When the Department of Pathobiology was dissolved, 1.0 faculty FTE was allocated for the IDPP by Dean Wahl: 0.5 for Jaisri Lingappa was transferred to DGH, where she is now Professor of Global Health, and 0.5 for Lee Ann Campbell was transferred to Epidemiology, where she was Professor of Epidemiology and Pathobiology Graduate Program Director (0.25 of Dr. Campbell's FTE was assigned for directing the Pathobiology Graduate Program). Dr. Campbell appointment transferred to DGH on June 1, 2015, and DGH is now providing 0.25 of Dr. Campbell's FTE for directing the IDPP.
- Research cost recovery: The UW returns a portion of faculty research grant indirect costs to Schools as Research Cost Recovery (RCR). The UW-based Pathobiology faculty members with primary faculty appointments in DGH are Jaisri Lingappa, Lee Ann Campbell, and Jairam Lingappa. RCR resulting from their research grants returns to DGH per SPH formula. RCR from research grants of faculty with non-DGH primary appointments are paid to their respective Schools, Departments, or Institutions.
- Activity-based budgeting (ABB) revenues: Beginning in AY2012-13, tuition revenues have been distributed to Schools based on the number of student credit hours (SCH) taught in the previous year. In SPH, a portion of these funds is returned to the departments. Student credit hours and ABB revenues returned to DGH, based upon classes designed for the IDPP, are

shown in **Table 2**. As mentioned above, compensation is provided by DGH for teaching by non-tenured faculty. *It should be noted that tuition for up to 32 SCH of lab research per student per year in Years 2-5 (or 6) of graduate training is supported by training grants and mentors' research grants; this tuition brings ABB to the school and the department.*

- Contributions to the graduate program by participating institutions: The presence of graduate students contributes substantially to the scientific environment of a laboratory or institute, and student research accomplishments are instrumental in the ability of their mentors to compete successfully for research grants. Because these grants directly benefit the mentors' primary institutions, it is reasonable that the institutions should contribute to the costs of operating the graduate program. These arrangements are specified through Affiliation Agreements between the UW and the institutions, and are based upon a *pro rata* formula that takes into account the general support costs for the graduate program (e.g. recruiting costs, rotation costs for first-year students, retreat, seminar program, etc.) as well as the proportion of graduate students pursuing their degrees with faculty based at each participating institution. In the 2015-16 academic year, the participating institutions are estimated to provide approximately $214,000 to support general program costs. Teaching costs are borne by DGH. Pathobiology graduate students work with mentors located at UW or at a number of research institutes in Seattle. The current lab location of the 25 students is as follows: FHCRC (5), CIDR (4), UW (5), SCRI (5), and IDRI (1); the 5 first-year students are conducting research rotations.

Table 2. ABB revenues for Pathobiology courses

Academic Year	Total PABIO Student Credit Hours	Income*
2011-12	1012	No ABB
2012-13	952	$182,160
2013-14	821	$171,360
2014-15	992	$180,164
2015-16	992	$180,164**

*Based upon $180/SCH through AY14-15.
**SCH and income for 2015-16 are projected.

- Administrative support: The Diseases of Public Health Importance Training Grant (T32AI007516), directed by Lee Ann Campbell, provides partial salary for the Pathobiology Program Manager. Because ongoing salary support for the Program Manager was committed by Dean Wahl, DGH has provided the balance of the Program Manager's salary since 2006.

Costs of the IDPP that are NOT borne by DGH or partner institutions

Students who matriculate into the IDPP are guaranteed support for the period of their PhD training. This is standard practice nationally for predoctoral trainees in the biomedical sciences and is necessary to attract highly qualified students. The support includes a stipend (at the standard rate used for all lab-based predoctoral trainees in SOM), benefits, and tuition.

During the 3 quarters of lab rotations during the first year, predoctoral students in Pathobiology are supported by DGH, as described above. After the first year rotations, graduate students are

Table 3 Annual cost of student support provided by mentors' research grants, training grants, or fellowships*

	2010	2011	2012	2013	2014
Cost of students from end of rotation program to completion of PhD	**1,116,070**	**1,319,871**	**1,379,217**	**1,455,308**	**1,296,010**

*Includes stipend, benefits, and tuition

supported by NIH T32 training grants, individual NIH or foundation fellowships, or by the mentor's research grants (Table 3). Thus, an additional ~4-5 years of support (for stipends, benefits, and tuition) to completion of the PhD is obtained from non-departmental funds. All IDPP trainees have

been supported for the duration of their training. The non-departmental costs for students after their rotations has averaged ~$1.3 million per year, and is supplied from sources described below.

- NIH training grants and individual fellowships: There are four NIH T32 grants whose scientific focus makes them available (based upon application and competition) for support of select Pathobiology students (Table 4). It is noteworthy that 4 of our training faculty are T32 Directors, attesting to the high quality of our training faculty. The longevity of the training grants is indicated in the left column.

Table 4. Training Grants available for Pathobiology student support *

	Title	Director
T32AI007509-16	Diseases of Public Health Importance	Lee Ann Campbell
T32AI007140-38	STD/AIDS Research Training Program	Sheila Lukehart
T32AI083203-07	Viral Pathogenesis Training Program	Julie Overbaugh
T32AI055396-11	Interdisciplinary Program in Bacterial Pathogenesis	Ferric Fang
T32CA080416-17	Interdisciplinary Training in Cancer Research	Barry Stoddard

* Support by these TG's is highly competitive, and eligibility is dependent upon the area of research of the applicants. Except for T32AI007509-16, applicants from other PhD training programs also apply for support by these TGs.

- Individual Fellowships: Four (16%) of our 25 current trainees are supported by T32s, 2 are supported by individual NIH fellowships (F31), 1 (3%) is supported by a National Defense Science & Engineering Graduate Fellowship, and 1 is supported by a scholarship from the US Army. Because NIH training grant and individual training fellowships are highly competitive, the fact that as high as 40% of our students in a single year have been supported by such mechanisms attests to the high quality of our trainees. Some of our students (8%) are not eligible for these sources as they are international students.

- Support from research grants: The remaining students are fully supported by their mentors' research grants. Our training faculty are well-funded, even in these difficult times for NIH funding, with >$70,000,000 (direct costs) in 2014 research support as reported by the faculty. The training grants fail to cover the full cost of stipend, benefits, and tuition for the trainees, and these trainees often conduct additional work to fund the ~$9000 annual gap; this usually comes from mentor's or institutional funds. Given the fact that already-trained, more productive postdoctoral fellows can be hired for approximately the same amount as graduate students, the willingness of faculty to supply ~$1.3 million annually for graduate student support, through increasingly competitive training grants or research grants, speaks volumes for their commitment to graduate training and the Pathobiology Program.

Contributions by Pathobiology faculty that financially benefit DGH

Pathobiology faculty have sought ways to contribute intellectually and financially to DGH, and one of the most effective ways to contribute is through teaching undergraduate courses. ABB reimbursements accrue to DGH for these courses. These courses are described below:

- **GH 201. (formerly PABIO 201)** *Newly Emerging Infectious Diseases in Public Health.* Pathobiology faculty members originally developed and have taught this undergraduate course since 2001. Recently, Dr. Rhea Coler taught the course, which was very popular, typically enrolling >300 students per year, earning 740 SCH ($133,200) for Autumn 2013. This course was discontinued in 2013 because it was considered too rigorous for a 200-level course, and was replaced by GH 410 and GH210, described below.

- **GH 410.** *Advanced Biologic Principles of Global Diseases* (3 credits) was first taught by Dr. Coler in Fall, 2014, with an enrollment of ~50 students. This is one of two courses that can be taken to fulfill the biological principles requirement for the GH minor, and is intended for students with a stronger science background.

- **GH 210.** The other course that meets the Biology requirement for the GH Minor is a new course, *Confronting Global Diseases: Introductory Biologic Principles and Context* (3 credits), which is taught by Dr. Marilyn Parsons). The first year enrollment, in 2014, was 120 students.
- **New course**. Dr. Jaisri Lingappa has proposed teaching a new DGH course on research approaches to biological questions in global infectious disease for undergraduate students. Details of this course will be developed in the coming months, and if approved by the DGH Curriculum Committee, it is anticipated that it will be offered Fall 2017 or 2018. Because of the novel focus of this course, we expect that it will be widely subscribed.

We anticipate that more IDPP faculty will be involved in teaching undergraduate Global Health courses in coming years, given the strong interest among undergraduates in the biological basis of global health.

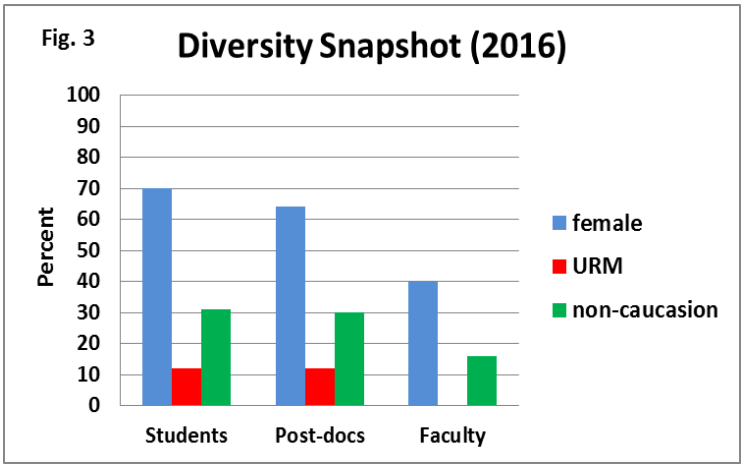
Strategies for expanding department funding sources

One of our unit-defined questions focuses on the best model for financial sustainability and strategies for possible expansion. These are outlined in PART B. III.

C. Diversity in the Pathobiology Program

Our diversity plan has focused on enhancing recruitment of under-represented minorities (URMs) and continuing our strong retention record, as well as training international students. The current (winter quarter 2015) diversity of the IDPP (students, post-docs and faculty) is illustrated in Fig. 3. The IDPP Program Manager is a URM. In addition to our history of training URMs and international students, the Pathobiology Program has significant strength in training female students. Since 1990, 119 women (70%) have enrolled in the Program and 95 women (PhD and MS) have graduated to date. We are currently training 19 predoctoral women (76% of students). Female applicants account for 60 to 70% of all applications, and this is represented in the high proportion of female students in our program. Many female students have said that the high percentage of female faculty has been an important factor in their selection of the Pathobiology Program. Our faculty and trainees also include LGBT members, individuals with disabilities, and disadvantaged persons. Our Program has clearly developed an environment where URM, women, and LGBT persons can and do succeed. We will continue to reinforce this commitment. The DGH has a Diversity and Inclusion Committee encompassing recruitment and retention efforts at all levels in its Centers and Programs, including the IDPP. This committee is comprised of 3 faculty, 4 staff, and 3 students. In addition, the IDPP has representation on the SPH Diversity Committee discussed below.

Fig. 3



Recruitment and retention of underrepresented minority students

The IDPP attracts a diverse student population. Overall, from 1990 to present, 11% of the entering students have been URMs. From 1998-2003, only 5.1% of enrolled students were URMs. Since 2004, however, focused diversity recruitment efforts have been developed and strengthened. We have applied for, and received, institutional support targeted to recruitment of URMs (GO-MAP, ARCS, and the Presidential fellowship) to assist in recruitment of our top URM applicants. We actively recruit qualified URM applicants through multiple contacts by phone and e-mail prior to recruitment visits, with subsequent follow-up contacts after admission is offered. In concert with the SOM's Office of Research & Graduate Education, our URM applicants are able to meet current students, postdocs, and faculty of color at special breakfast events during the recruitment visits. One of our faculty members, Dr. Sheila

Lukehart, was instrumental in beginning these ongoing recruitment events a decade ago. During the past 10 years (2005-2014), 14.8% (9/61) of our enrolled students have been URM.

Just as the DGH welcomes the opportunity to train international students, the IDPP also provides PhD training for qualified international students. International students, including students from developing countries, add considerable diversity to the graduate program. Since the program began, 20% (20/100) of PhD degrees have been awarded to students from overseas: Kenya (4), Malaysia, Taiwan (2), Nepal, Russia, India (3), China (5), Korea, Japan, and Israel. Two current students are from Sri Lanka and Canada. Students from Trinidad, Kenya, China (4), Indonesia, Mexico, Iran, and India have received MS degrees from the program. The faculty have embraced this pool of students as part of our mission to train future leaders in global health. Our international students bring a range of perspectives that enhances the experience of all of our students. The international flavor of the Pathobiology Program creates an outstanding environment for training all students interested in diseases and global health.

The IDPP continues to improve diversity and access through additional participation in expanded university initiatives and committees:

- In collaboration with other biomedical research programs at the UW, the IDPP participates in the Biomedical Minority Recruitment Task Force that strategizes about best practices for recruitment of underrepresented students in biomedical research programs at UW.
- Pathobiology faculty members and students participate in the URM recruitment by attending annual SACNAS (Society for Advancing Chicanos/Hispanics & Native Americans in Science), ABRCMS (Annual Biomedical Research Conference for Minority Students), AISES (American Indian Science and Engineering Society) and HBCU-UP (Historically Black Colleges and Universities, Undergraduate Programs) meetings that attract large numbers of highly qualified students from under-represented groups. Contacts made at these meetings are very effective in recruiting students of color to UW. The UW SACNAS chapter has been named Best Chapter multiple times and hosted the annual SACNAS meeting in Seattle in 2012. ABRCMS was held in Seattle in 2015. Pathobiology faculty participated in the planning and conduct of these meetings.
- A major goal of the SPH Strategic Plan (2012-2020) is to improve diversity. PhD candidate Laura Martinez is our representative on the SPH Diversity Committee, which is charged with developing and advocating for policies and initiatives to enhance diversity of the School. Our Program Manager serves on a subcommittee to optimize recruitment materials to augment enrollment of URM.

Throughout our Program's history, all underrepresented minority students and all international students have completed their degrees. We are especially proud that since 2003, three of our four students who were award the Gil Omenn Award, which is given to the most outstanding doctoral student in the School of Public Health, were URM or international students. Thus, the Program is highly successful in retaining minority students. If issues arise for our minority students, the Program Manager directs them to individual faculty or to the appropriate Program, School, or University offices for academic counseling or assistance with programmatic concerns. Our URM students also are supported by the Office of Student Affairs in the School of Public Health and the Office of Multi-cultural Affairs in the SOM, who are dedicated to the enhancement of the under-represented student's graduate career by providing both nonacademic and academic counseling in coordination with the student's graduate program.

Recruitment and retention of underrepresented minority faculty

Because the IDPP is an interdisciplinary program that draws faculty from multiple institutions and departments, the program does not conduct external recruitment of new faculty members. We do, however, encourage faculty of color whose interests align with the scientific focus of IDPP to apply to become a member of our training program.

SECTION II: TEACHING AND LEARNING

A. Student Learning Goals and Outcomes

Learning Goals

The strong focus of Pathobiology graduate courses on infectious and non-communicable diseases and aspects of molecular medicine makes Pathobiology a natural fit for both the Schools of Medicine and Public Health. Likewise, because of our strong emphasis on global infectious diseases such as HIV, malaria, and tuberculosis, our courses nicely complement existing courses in the DGH as well as other departments in the SOM. Our curriculum, coupled with hypothesis-driven laboratory-based research, fulfills the learning objectives summarized below:

- Develop a fundamental understanding of basic cellular and molecular processes and techniques important in the application of basic biomedical research to diseases of global public health interest. Specifically, this includes
    - familiarity with the paradigms for control, prevention, and treatment of infectious and non-communicable diseases of public health importance,
    - an understanding of the epidemiology and processes of diseases of national and international importance,
    - an understanding of how biomedical research addresses such diseases and basic methodologies used in this type of research, including relevant areas of molecular biology, genetics, biochemistry, cell biology, immunology, epidemiology, and biostatistics.
- Become an independent scholar capable of conducting independent research leading to the expansion of knowledge of Pathobiology. This includes developing the skills to understand an unfamiliar experimental system, to identify important questions concerning pathogenesis and infection, and to design experimental strategies to address those questions.
- Learn to collect, analyze, interpret, and use data for solving problems in Pathobiology.
- Develop advanced research skills and expertise in the area of research concentration.
- Develop skills in communicating research findings to scientific audiences through publications and oral presentations.

Training Experience

The predoctoral program in Pathobiology includes the following requirements, which are described below. Evaluation methods are described in each area as well as in Section C. under “Ensuring student academic progress”.

Didactic coursework. Students who enter the Pathobiology PhD program take a mix of required and elective courses, primarily in their first year. Among the required courses is a series of core courses that covers fundamental topics: PABIO 551 (Biochemistry and Genetics of Pathogens and their Hosts) and PABIO 552 (Cell Biology of Pathogens and their Hosts) and GH580 (Global Health Doctoral Seminar: Diseases in Global Health). In these core courses, doctoral students gain a strong foundation in biochemistry, genetics, cell biology, and public health through studying infectious diseases of global importance, from the perspectives of both pathogen and host. Emphasis is placed on acquisition of knowledge through research and the application of principles and theories of modern biotechnology to specific disease problems of global importance. Complementing these core courses are other required courses that provide training in specialized areas and practical skills, such as the first year Survival Skills course (PABIO 553), as well as Critical Thinking (PABIO 582), Pathobiology topical mini-courses (PABIO 590), and Literature Review (PABIO 581), which are taken for three to four years. Pathobiology students also obtain a strong background in allied disciplines by taking Immunology 441 and/or 532, Epidemiology (EPI 511), and Biostatistics for Laboratory Scientists (UCONJ 510). Course descriptions are provided in Appendix E.

Experience in teaching and oral presentation. All students are required to have experience in undergraduate or graduate-level teaching (PABIO 598) as discussed below in Section B. under

"Teaching opportunities for students". Training in research presentations starts the first year in PABIO553, in which students prepare abstracts and posters, as well as an oral presentation. From the second year on, all students are required to present their research-in-progress at the Student Research Symposia, which are held during winter and spring quarters. All students, faculty and postdoctoral fellows are expected to participate in this symposium. Each student (2nd year and beyond) is given 10 (junior students) to 15 minutes (senior students) to present his/her work, followed by a 5 minute discussion. The presentations are expected to be equal in quality to those given at a scientific meeting. The students are counseled on their presentation before the symposium by their mentors. Each student presentation is reviewed by at least three faculty members other than the mentor; these evaluations are provided to both the student and mentor. Our students value this constructive evaluation process and have requested that fellow students also have the option to provide feedback. In addition, all students (2nd year and beyond) and are expected to present a poster at the annual Pathobiology Retreat (fall quarter). These forums are designed to promote critical thinking, interdisciplinary interactions, and cross-fertilization of ideas, providing outstanding training opportunities for graduate and postdoctoral fellows in the Program.

Research experience. All first-year PhD students are required to participate in three laboratory rotations to assist in identifying their doctoral thesis advisor. The rotations are designed to provide students with the opportunity to gain experience interacting with faculty, students, postdoctoral fellows, and staff in different research groups and facilities. These rotations are funded by DGH and the affiliated institutions to enable freedom of choice for the student in experiencing different laboratory environs and mentoring styles. To maximize opportunities for identifying a permanent advisor, in the summer before they start our Program, students are provided with information about faculty who plan to accept a student into their labs. As an integral part of the research rotation, students participate in laboratory meetings, presenting and discussing the results of their individual research projects. At the end of each rotation, the students present their accomplishments to the laboratory group. The rotation mentor provides a written evaluation of the student's rotation performance. In spring of the first year, each student selects a laboratory in which he or she will conduct doctoral research.

General examination. The general examination must be completed by the end of the 3rd year. This oral examination, administered by the Doctoral Supervisory Committee, consists of a brief (~20-minute) formal presentation of the ongoing dissertation research, followed by 1.5 - 2.0 hours of questioning by the committee. The student's Dissertation Research Proposal, which must be submitted to the committee at least 3 weeks prior to the oral exam, forms the basis of the exam. The student is expected to demonstrate an in-depth knowledge of background literature and current research in the field. The committee probes the ability of the student to conduct critical analyses of research findings, discuss their relevance, as well as define unresolved research questions. In addition, the exam may explore areas less closely related to the student's specific research. For this exam, a person on the Supervisory Committee other than the mentor is chosen to serve as Chair.

Completion and defense of a dissertation. After the student's Doctoral Supervisory Committee has determined that the student has completed research comprising a body of work sufficient for a PhD degree, the student will prepare a dissertation including sections required by the Graduate School of the UW. At least one publishable article must result from the work contained in the dissertation, and the article must be submitted for publication prior to the dissertation defense. Our PhD students have averaged 3 publications per student from their dissertation research.

Mechanisms for assessing student learning and satisfaction. Assessment of student learning includes course grades, student course evaluations, an exit summary and the alumni survey recently developed by DGH. Our most valuable assessment of student satisfaction that guides and directly impacts improvement in programmatic strength is the feedback received at the annual retreat. At the retreat, the students meet separately from the faculty, then join faculty for a frank and lively joint discussion. Recent examples of changes that have occurred as a result of these discussions include the following: 1) The written preliminary exam, offered at the end of the first year, was discontinued

for students who meet academic expectations in first year course work; 2) The "Global Health Doctoral Seminar: Biology, Systems and Measurement" a required course series totaling 8 credits was restructured to three sequential courses (GH580 A, B, and C), the first focusing on Diseases in Global Health, followed by Principles of Implementation Science and Health Metrics. The first of these is now required for our students while GH580 B and C, are electives; 3) The requirement for the Critical Thinking Course (initially required each year for 4 years) was altered so this course is mandated only until students pass their oral examinations; 4) The length of talks at the student symposia was increased from 10 to 15 minutes for senior students, and 5) Mini-courses focused on scientific writing skills and grant writing were added to the curriculum in alternating years.

B. Instructional Effectiveness

Evaluating Quality of Instruction

Our Program views course improvement as a dynamic and ongoing process. The IDPP utilizes three mechanisms to evaluate and improve course instruction: working with the UW Center for Teaching and Learning (CTL), peer reviews, and student course evaluations. On a yearly basis, our Curriculum Head coordinates an assessment with Karen Freisem in the CTL. This formal evaluation includes the following components: 1) Ms. Freisem leads a discussion with students and obtains feedback on strengths and weaknesses of specific courses and overall curriculum; 2) Subsequently, Ms. Freisem meets with the Program Director, Curriculum Head, and the Student Representative on the Curriculum Committee to discuss a summary of the student discussion and to determine the topics on which to focus for faculty discussion; and 3) In the faculty discussion, Ms. Freisem summarizes the student feedback and leads an informative and interactive discussion on best teaching practices and innovative approaches. These informal workshops have resulted not only in significant changes and improvements to our courses and instruction, but also have enhanced communication among course instructors and increased faculty cohesion. In recent years, these workshops have been used to educate our course instructors in active learning strategies supported by recent research on adult learning. These new strategies for improving learning and engaging students are now commonly used in many of our courses. Additionally Ms. Freisem is available to assist in course planning, to visit class sessions, and to provide individual instructor feedback.

The IDPP Curriculum Committee, in consultation with the Program Director, is responsible for oversight of peer review of courses by faculty. All new courses are peer-reviewed in the first year and courses taught by Assistant Professors are peer reviewed on a yearly basis. Otherwise, courses are peer-reviewed every 3 years. Two reviewers are assigned per course and each is expected to attend two class sessions. Reviewers are responsible for reviewing all course materials to assist in determining whether learning objectives are being met. Following the classroom observations, the reviewers and instructor meet to discuss strengths, weaknesses, and any suggestions for course improvement. The peer reviews are reviewed by the Curriculum Head, Director of the Program, and the DGH Associate Chair of Education and Curriculum.

Formal student course evaluations are administered through the UW Office of Educational Assessment. Evaluations are completed at the end of each quarter by students enrolled in all UW courses. These evaluations provide an opportunity for students to provide feedback on both courses and instructors via a Likert-type scale, as well as through written responses to customized questions about the course. For each course, a quantitative summary and the written comments are available on-line for review by the instructor. The Director of the IDPP, the Curriculum Head, and the Associate Chair for Education and Curriculum in DGH receive the quantitative summary only and review them quarterly. The Director of the IDPP and the Chair of the IDPP Curriculum Committee provide feedback to instructors of high- and low-rated courses. On a yearly basis, evaluations and the instructors' responses to them are discussed by the DGH Curriculum Committee.

Teaching opportunities for students

A core degree requirement of our program is Didactic Pathobiology (PABIO 598), which provides the opportunity for students to gain experience in undergraduate or graduate-level teaching. Students

enrolled in PABIO 598 work closely with course instructors. Students enrolled in PABIO 598 are evaluated for their teaching by the course director, and receive course credit for completing their didactic assignments. Students are expected to complete the Didactic Pathobiology course requirement in their third year so that their remaining time in training is focused on research. Students who wish to obtain additional teaching experience are encouraged to do so and, in consultation with course instructors, they can provide "guest lectures" in designated courses. Informal teaching opportunities to develop supervisory skills and mentoring skills abound in the laboratory environment, where doctoral students participate in undergraduate research training. Other training opportunities include participation in the Bioquest science education program at CIDR, which provides hands on training opportunities for high school students in molecular biology of infectious disease through an intense two week-long course. The Bioquest program also leads Teacher Workshops, which are designed to target curriculum needs in the areas of basic immunology and vaccine research and development. The Biology Education Research Group at UW also is an excellent resource open to those students interested in data-driven analysis of learning in the biological sciences. Collectively, these opportunities enhance development of the ability to abilities to communicate the research problem and results to less-experienced individuals.

C. Teaching and Mentoring Outside the Classroom

Faculty Involvement in Learning Outside the Classroom

All IDPP faculty members are required to participate in graduate training, including formal classroom teaching and research training, although the individual effort varies. These expectations are outlined in a faculty-approved document, which is provided to new faculty as they join the program. Faculty members rotate responsibilities with respect to organizing seminar series, conducting journal clubs, mentoring rotation students, and serving on Program committees. IDPP faculty members enrich our students' research experience by serving on doctoral committees, which are established in the student's second year. In addition to their faculty advisor, at least two of the committee members are required to be IDPP faculty providing scientific expertise complementing the doctoral mentor's. Faculty also participate in graduate training by providing didactic training opportunities and mentoring in classroom teaching, feedback on student yearly oral and poster research presentations, and training/guidance on specialized research methods. Other non-classroom opportunities that foster faculty/student interactions and networking include faculty research overviews at our annual retreat, our Pathobiology seminar series, as well as the multitude of seminar series offered by our affiliated institutions (FHCRC, CIDR, IDRI, and SCRI), DGH, and other departments (e.g. Microbiology, Immunology, Pathology) within the University community.

Ensuring Student Academic Progress

Student progress is nurtured and monitored is several ways. On entry into the program, students are assigned a temporary advisor, who is a member of the Graduate Student Advisory Committee (GSAC). On a quarterly basis, Dr. Campbell reviews student performance in the class room and meets with any student who is not meeting programmatic expectations to determine ways in which the program can assist. Each year a progress "check list" is sent to the student and their advisor as a means of assessing whether students are "on track." Annually, the GSAC reviews student progress and Dr. Campbell provides feedback to students and their mentors. All students are required to complete or annually update an Individual Development Plan (also known as an IDP) that is discussed with their mentor and Doctoral Supervisory Committee to aid in helping the student to set career goals and take steps to achieve them. Students are required to meet at least once per year with his/her committee, which provides written evaluation of research progress and expectations. Depending on student progress and interaction with committee members, the doctoral committee or the Program Director, may request that a student hold additional meetings with the committee.

As noted above, student research symposia are held twice a year. These symposia fulfill multiple functions of allowing the entire faculty to view student progress, providing student opportunities to practice presentation skills, and enhancing research design and collaboration. Students are highly

encouraged to present their research at national/international meetings and are supported in this endeavor by mentors' grants, training grants, and travel awards from the Graduate School. Academic excellence is recognized with Annual Department of Global Health Awards and with SPH awards. Examples of recent recipients include Caitlin Milligan (DGH Outstanding Doctoral Student Award, 2015), Chung Dang (Global Healthy Award for his research, 2015) and Corrie Ortega (the prestigious Gil Omenn Award, 2014, recognizing the most outstanding doctoral student in the SPH).

Preparation for Future Academic & Professional Success

A key component of our curriculum is focused on development of skills to provide our students with the tools for career development. These include mini-courses on scientific writing and on grant writing, an "apprentice" didactic teaching course, a course on critical thinking and research design, and a course emphasizing specific skills needed for a scientific career. The latter includes such topics as writing manuscripts, giving oral and poster presentations, preparing for a postdoctoral position, establishing collaborations, and ethical issues in research. It also includes a session in which PhDs who have chosen different career pathways (e.g. academia, government, and biotech) discuss opportunities, expectations, and balancing one's professional and personal life. Also open to our students is the student-run UW Bioscience Careers series, which offers monthly seminars on various career paths. As mentioned previously, our students are expected to prepare/revisit their IDP on a yearly basis and to discuss their professional development with their mentor and doctoral committee. To improve scientific communication skills, students present their research at laboratory meetings, shared interest groups, and more formally, at the student symposium, and at scientific meetings. Scientific writing skills are enhanced through writing a formal research proposal as a component of the oral examination, manuscript preparation, applying for positions on training grants which involves writing a research proposal, and writing grant applications for fellowships.

SECTION III: SCHOLARLY IMPACT

Impact of faculty research

The IDPP stands at an interface between fundamental biology, global health, and translational medicine. A major focus of faculty research efforts is on preventive as well as curative approaches to disease problems, with attention paid to both the causative agent and the host. A summary of research areas and brief description of each faculty member's research program are provided in Appendices G and H, respectively. Many of the faculty focus on infectious diseases of global importance, and their research ranges from understanding fundamental biology to translational work in the development and testing of new diagnostics, vaccines, and drugs. Many of these infectious agents lead to chronic infection and serious late sequelae, including cancer. The focus on global diseases - spanning etiological agents, host responses, and epidemiology - distinguishes us from a typical Microbiology or Immunology department. The disease agents being studied include viruses, bacteria and parasites. Much research focuses on the "big three" (HIV, malaria, and tuberculosis), but many other diseases with disproportionate impact on the world's poor are also being addressed, including a number of neglected tropical diseases. Pathobiology faculty members' research has long included chronic diseases in addition to infections; this is very important, as the global burden of disease shifts in proportion from infections to chronic diseases. Our faculty's research includes atherosclerosis, liver disease, and several types of cancer. Our faculty have strong publication records and have been recognized for their achievements through the receipt of various honors and service on NIH study sections. For example, from 2000-2015, our faculty published over 1575 publications in journals such Science, Nature, J Exp Med, J Immunol, Nat Med, PLoS Pathogens, and New Eng J Med; 14 faculty were standing members of a study section and 31 served as ad hoc members. A few very recent examples of honors received by faculty include:

- Julie Overbaugh – NIH Director's Pioneer/Avant Garde Award, 2015-2020
- Denise Galloway – NCI Board of Scientific Counselors-Basic, 2015-2019
- Jaisri Lingappa – Distinguished Faculty Member for Teaching, SPH excellence award, 2015

- Chris Fox – Pioneers in Global Health Rising Leader Award, WGHA, 2015

Student accomplishments

Measures of the quality of our students are underscored by their competitiveness in securing external funding, being awarded positions on training grants, presenting their research at international meetings, and publication records. Our students have a strong history of obtaining external funding. Recent examples are given below:

- Liana Wood and Catlin Milligan, both of whom graduated in 2015, received NRSA F30 Predoctoral Fellowships.
- Katie Brempelis and Laura Martinez are recipients of NRSA F31 Individual Predoctoral Fellowships.
- Laura Austin was awarded a National Defense Science and Engineering Fellowship.
- Katherine Wuertz was awarded the Long Term Health Education and Training Scholarship from the US Army Medical Department.

Our students are encouraged (and expected) to present their research work at Scientific meetings. A few recent examples include:

- Jay Vorhagen presented his work at the Lancefield International Symposium on Streptococci and Streptococcal Disease at the UW-Kobe University Symposium on Cell Signaling.
- Tara Reid was an invited speaker at the Gordon Research Conference on Biology of Spirochetes.
- Andreia Costa presented her work at the Keystone Symposium on Viral Immunity.
- Lauren Spadafora presented her work at the Oak Ridge conference on Emerging Technologies for the 21rst Century Diagnostics.
- Laura Austin presented her work at the Gordon Research Conference on Malaria, the Molecular Parasitology Meeting in Woods Hole, and the Seattle Parasitology Meeting.
- Andrew Soerens presented his work at the Keystone Symposia on T cell regulation.
- Justine Levan presented her work at the 30th International Papilloma Conference and Clinical Public Health.
- Chloe Slichter presented her work at the 53rd and 54th Midwinter Conference of Immunologists.

In the past 5 years, 35 students have completed their doctoral studies. Of these, 34 have published their research and the remaining student has 2 manuscripts under review. A total of 111 manuscripts (a mean of 3.2 per student, ranging from 1-6 publications per student) have been published, including many in top ranked journals such as J Exp Med, J Immunol, J Virol, PLoS Pathogens, Nat Med, Science, PNAS, and J Hepatol.

Postdoctoral fellow participation in research and teaching activities

Because teaching is likely to be an important responsibility for any trainee entering academia, postdoctoral trainees have the opportunity to participate in teaching in courses. Postdoctoral trainees serve as a valuable resource for our graduate student research projects and are active in providing individual mentoring on specific research projects. Most also take an active role in training undergraduate researchers in the laboratory, providing valuable experience to both the postdoctoral scientist and young researcher. Our postdoctoral fellows serve as role models for our students providing guidance in experimental design, technical approaches, ethical conduct of science, data analysis, presenting research and securing a postdoctoral position. Postdoctoral fellows are encouraged to participate in evaluation of students talks at the student symposia and programmatic activities such as recruitment, orientation, and the annual retreat.

Alumni impact

Our graduates have a unique orientation, which combines biotechnology, biology, and public health. A key metric of the success of our training program is job placement. A typical pathway after achieving a doctoral degree in the biomedical sciences is to further augment research expertise by training as a postdoctoral fellow prior to obtaining permanent position. As shown in Appendix F, our graduates have been highly successful in obtaining positions in academia, biotechnology, non-profit

organizations and government agencies. Many of our "senior" alumni hold leadership positions. We are especially proud that two of our former students, Dr. Michael Gale and Dr. Rhea Coler, are now faculty members in our IDPP.

- Dr. Thayer White, is the CEO and CSO of SBH Diagnostics and CEO and President of Glycozyme
- Dr. Mark Stroud is Principal Scientist at Blaze Biosciences, Zymequest, Beverly, MA
- Dr. Rhea Coler is Vice President of Preclinical Biology at the Infectious Disease Research Institute (*currently a member of IDPP Faculty*)
- Dr. Thomas Arroll is Associate Director at Seattle Genetics.
- Dr. Michael Gale is Professor of Immunology at UW, and is Director of the new UW Center for Innate Immunity (*currently a member of IDPP Faculty*)
- Dr. Darcie (Roe) Carpenter, is the Director of Clinical Studies at Beckman Coulter
- Dr. Vicki Luna is Chief Molecular Microbiologist, Center for Biological Defense USF-COPH-EOH, FL Dept. Health, Bureau of Laboratories, Tampa, FL
- Dr. Chris Mehlin is the Director of Peptide Drug Discovery at the FHCRC.
- Dr. Brandon Leader is Scientific Program Officer, Program for Appropriate Technology in Health (PATH)

Key influences on unit research, scholarship and creative activity

Our research areas are driven by diseases and problems that are the most prevalent or most impactful globally. Our scholarship is influenced by the collaborative nature of our faculty. Creative activity is stimulated thought the many opportunities for cross-fertilization of ideas through seminars, retreats, symposia, and interest groups

Collaborative and interdisciplinary efforts

One of the strengths of the Seattle area is the highly collaborative nature of scientific research with innumerable interactions among labs and among institutions involved in biomedical research and training. Many of the participating faculty members in this program have a long history of collaborations and joint research meetings. Scientific interactions among faculty members are based on research interests rather than sites of the laboratories. Multiple research collaborations exist within the Program, with other faculty members at the University, and among scientists at various research institutions and biotechnology companies in Seattle. Several interest groups exist and several Pathobiology faculty members hold joint laboratory meetings, often including faculty from outside of the IDPP. Examples include Drs. Campbell, Hybiske, and Rosenfeld on chlamydial research; Drs. Campbell, Maggio-Price, Hsu, and Rosenfeld on infectious agents and atherosclerosis, Drs. Lukehart, Marra, and Giacani on treponemal infections; Drs. Rajagopal and Adams Waldorf on streptococcal/staphylococcal infections; Drs. Emerman, Frahm, Lee, Lingappa, Klatt, McElrath, Overbaugh, Sodora, and Stamatatos on Retroviruses; Drs. Lund, Prlic, and Taylor on immunology research; Drs. Sherman, Grundner and Urdahl on mycobacteria; Drs. Myler, Parsons and Stuart on neglected tropical diseases; Drs. Klatt, Fuller, and Sodora on mucosal immunology; the labs of Galloway, Geballe, Jerome, and Lagunoff, and Smith on DNA viruses; and Drs. Kappe, Smith, Van Voorhis, Gelb, Wang and Hol on malaria; Drs. Van Voorhis, Fan, Maly, Parsons, and Merritt on drug discovery. Examples of other interest groups are the biweekly meeting of the Infectious Disease research group at SCRI, the Bacterial Pathogenesis Work-in-Progress series at UW, the Mycobacteria Interest Group, the Vaccine Interest Group, the Pathogen Interest Group at CIDR, and the "Lunch and Learning" monthly meeting at CERID. These gatherings provide opportunities for data presentations by students, postdoctoral scientists, and clinical fellows (and occasionally faculty), thereby promoting research interactions, improving critical thinking, and providing opportunities to hone presentation skills. Frequent free shuttle service connects the main UW campus with its South Lake Union and Harborview Medical Center Campuses, SCRI, FHCRC, CIDR, and ISB, thus enabling students, postdocs, and faculty to readily attend activities at all sites.

Support of junior faculty

As an Interdisciplinary Program, we have leveraged our affiliation with DGH and partnering institutions to recruit top junior faculty that receive the dual benefit of their institutional appointment and the opportunity to participate in graduate training in our Program. Financial support of junior faculty is provided through their Institution/Department. This concerted effort has been highly successful and has resulted in recruitment of 14 junior faculty to our Program since 2008, when DGH became our administrative home. Three additional appointments of junior faculty are in progress. Faculty members who have primary appointments in DGH and are members of our IDPP are able to fulfill their University teaching requirements and service responsiblities via participation in our Program. Junior faculty members at partnering institutions who wish to join our IDPP simultaneously apply to our program and for affiliate appointments in DGH, enabling appointment to the graduate faculty. A major strength of our Program is the expectation of strong participation by affiliate faculty in graduate training. Our Program is highly supportive of our junior faculty. Senior faculty serve as mentors as needed and provide teaching/training opportunities to enable fulfillment of requirements for promotion without overburdening junior faculty members at early stages of their appointments while they are establishing their research program.

As previously mentioned, the IDPP does not directly recruit through faculty searches, but interacts with DGH and affiliated Institutions in their recruitment efforts. DGH uses the SPH Diversity Committee process for faculty searches and works with the SOM Chief Diversity Officer to apply for diversity supplements to aid in recruitment.

SECTION IV: FUTURE DIRECTIONS

As emphasized below, our immediate goal is to formalize our integration into DGH. Continuing and future goals consistent with this integration are to expand our focus on chronic disease, both communicable and non-communicable, through enhancement of collaboration with faculty in the SOM and SPH.

Education, training and mentoring

The Pathobiology program has a high profile in terms of attracting international trainees, a profile that will undoubtedly be enhanced by its formal integration into DGH. This integration will broaden the opportunities that DGH can offer to international students. Because the focus of most faculty in the Pathobiology program is on diseases of global importance, the training program is particularly attractive to international students from countries with a significant burden of infectious diseases. The training of Kenyan PhD students represents a perfect example of the close integration of the Pathobiology Program with DGH that enables unique synergies. DGH faculty have a rich history of collaboration with Kenyan scientists, and this collaboration has led to opportunities for aspiring Kenyan basic scientists to purse their PhD degrees in Pathobiology. In fact, the Pathobiology Program embraced the training of scientists from developing countries at a time when other graduate programs declined to consider this opportunity. As a result, four Kenyan PhD students and one Kenyan MS student have graduated in the past decade. Three of these students trained with Dr. Overbaugh and received partial support through the NIH Fogarty training program led by Dr. Carey Farquhar in DGH. A notable feature of the dissertation research of these students was the integration of basic research with population-based studies in Kenya, which was conducted in collaboration with Kenyan scientists.

Pathobiology trainees benefit from the additional opportunities afforded by affiliation with DGH including 1) DGH course offerings highlighting the multifaceted determinants impacting global health, challenges to Global Health, and research methods; 2) numerous lecture series concentrating on diseases of global health importance and approaches to solving global health problems; and 3) research opportunities and collaborations at DGH-affiliated international sites. Our training program significantly benefits from the broad perspective on health represented in the DGH including demography, health policy, law, and economics, in addition to epidemiology and international health

services; the wealth of seminars focused on global disease; and the strong administrative and financial support. As a single example, the affiliation of Pathobiology with DGH has had immediate benefits to one of our recent graduates, Melanie Gaspar, who applied for and received a Global Health Fellowship funded by the NIH Fogarty Center, to obtain postdoctoral research training at a clinical research program in Peru.

Although the Pathobiology Graduate Program originated within and has longstanding ties with SPH, Pathobiology also has a long history of collaboration and training with the School of Medicine (SOM). One example is Adjunct Professor, Wes Van Voorhis MD PhD, who is also Head of Allergy and Infectious Diseases in the Department of Medicine. Dr. Van Voorhis has mentored or co-mentored 7 PhD students and 2 MS students from Pathobiology. Another example is Professor Sheila Lukehart PhD, (Joint in Medicine and Global Health), who has been very active in the Pathobiology Graduate Program and is also Associate Dean for Research & Graduate Education in SOM. Dr. Lukehart has mentored 7 Pathobiology PhD students and 3 international PhD students. The Graduate School appointment afforded by DGH and the Pathobiology Program allow Drs. Van Voorhis and Lukehart to participate in graduate training. Thus, one of the unique aspects of Pathobiology is its focus on translation of basic science to human needs, which attracts an excellent class of students year after year. Many SOM faculty focus on research problems directly informed by the clinical disease, and thus are ideal mentors for many Pathobiology students. In the future, we envision that collaboration with the SOM faculty will expand. To date, most Pathobiology researchers have focused on infectious diseases, but it is clear that non-communicable diseases are having an increasing impact on global health impact. Thus, researchers in endocrinology/diabetes/obesity and cardiology/atherosclerosis in SOM are at the forefront of non-communicable global health priorities. Pathobiology will actively recruit outstanding mentors in SOM to train our students in bench science to investigate non-communicable diseases of Global Health relevance.

New opportunities and goals

Because of the interdisciplinary nature of the program, it attracts students who want training in both basic sciences and public health research. Several applicants have expressed a strong interest in dual training to simultaneously obtain a MPH in Global Health to complement the PhD in Pathobiology. This dual training offers a great future direction for enhancing graduate training in Pathobiology within DGH. DGH is particularly strong in Epidemiology, and the creation of a dual degree program would foster more interactions between lab-based scientists and epidemiology faculty within DGH, with the students serving as catalysts for interactions and collaborations.

There is considerable interest in this type of training, not only among students, but among funding agencies. For example, the Burroughs Wellcome Fund has an established institutional training award entitled “Institutional Program Unifying Population and Laboratory-based Sciences”. This award seeks to better prepare students to tackle more complex problems in medicine and public health and supports graduate education in programs that will train students for both lab-based and population-based research. Thus, the development of a dual training program may provide the foundation for submission of a new training grant to support these training activities.

An increasing interest of our students and applicants to our Program is to have the opportunity to gain field experience in an international research setting. DGH coordinates international experiences in affiliated training programs for medical and public health students, medical residents, and pre- and postdoctoral fellows. Our formal integration into DGH will facilitate identification of experiences tailored to our trainees and will provide access to established global infectious disease research sites. The DGH Global Health Resource Center staff has considerable experience in coordinating the very complex logistical aspects of international experiences and also provides pre-travel orientation to the local culture, health, and research contexts. Students who have had this opportunity view it as transforming experience that greatly influences their career paths.

Programmatic impact

As discussed further in the Unit Defined Questions, our programmatic impact is at the level of the SPH and SOM, the university, and the global health community. Our programmatic impact is underscored by the diversity of jobs secured by our alumni (research institutions, academia, government, global health-focused nonprofits, and biotechnology) and by their leadership roles. The recognition by our peers of the quality of our training program, faculty, and leadership is indicated by our success in obtaining training grants and by their longevity. The scientific rigor and opportunities of our training are due to the research excellence of our faculty, indicated by their prominence in the field, productivity, and grant support.

PART B – PATHOBIOLOGY-DEFINED QUESTIONS

Historical overview of the program.

The Department of Pathobiology (formerly the Division of Experimental Laboratories in the Dept. of Preventive Medicine) was founded in 1970 as one of the five founding departments of the new SPH. The formal doctoral training program in Pathobiology was approved by the UW Graduate School in 1990. Since then, we have graduated 110 doctoral students and awarded 34 terminal MS degrees (Appendix F). Prior to 1990, graduate trainees entered the MS program (54 MS graduates) or participated in the Special Individual PhD Program (19 PhD graduates) administered by the Graduate School. In 2005-2006, a significant restructuring of the departmental composition in the SPH was undertaken by then Dean Patricia Wahl. The Department of Pathobiology was dissolved, and the plans for the DGH, a joint venture between the Schools of Medicine and Public Health, were announced. The intent was that the outstanding doctoral program in Pathobiology would be continued within DGH, and Drs. Lee Ann Campbell, Sheila Lukehart, Marilyn Parsons and David Sherman were appointed by the Dean to facilitate the transition of the Program into DGH. However, an unanticipated delay in the appointment of the inaugural DGH Chair delayed this transition. Because of the extraordinary strength of our graduate training program and the excellence of our faculty, the interim establishment of the Pathobiology graduate program as an Interdisciplinary Program within the Graduate School was given top priority by the Dean. Our Interdisciplinary Status was enthusiastically approved by the Graduate School and the Board of Regents in 2006, and the transition team became the Steering Committee of the IDPP. The Program was financially supported by SPH until the Program became administered in DGH in 2007, following Dr. King Holmes' acceptance of the chairmanship of DGH. During this period of transition, the considerable anxiety felt by both students and faculty about the future of the program negatively impacted our applicant pool and the recruitment efforts. The resolution of these uncertainties, coupled with the abundant new opportunities through association with DGH, resulted in a return of a high quality applicant pool and recruitment of our top applicants in the entering class of 2008. It is a sign of the resilience and vigor of our faculty and students that the quality and integrity of our Program not only weathered this difficult transition, but has been strengthened through the strong dedication and interactions of the faculty and students and the commitment of DGH to the success of the Pathobiology Graduate Program.

To realize the original intent to move the Pathobiology Program into DGH, along with Dr. Holmes' vision to develop a novel Doctoral Program in Global Health grounded in Metrics and Implementation Science, Dr. Holmes assembled the DGH PhD Committee in 2009. Drs. Campbell and Lukehart served on this Committee, along with Dr. Diane Martin of the Department of Health Services and Dr. Emmanuela Gakidou of DGH (Institute for Health Metrics & Evaluation). The Committee met with members of the Graduate School to explore options (e.g. one PhD program with different tracks vs. two Doctoral Programs in DGH) and the protocols required for each. Ultimately, Drs. Holmes, Judith Wasserheit (then DGH Vice-Chair, presently Chair), and Stephen Gloyd (DGH Associate Chair for Education and Curriculum), in consultation with the PhD Committee, determined that DGH would first seek Higher Education Coordinating Board approval of a new Doctoral Program in Metrics and

Implementation Science and, once that program was approved, then the Pathobiology Program would move into DGH. The inaugural class entered the Doctoral Program in Metrics and Implementation Science in Fall 2012. Dr. Holmes met with the Pathobiology faculty to discuss formally moving the Pathobiology Program into DGH, and the faculty unanimously voted in favor of the move to DGH. This transition was again delayed when Dr. Holmes stepped down and DGH focused on the search for a new chair. The faculty is hopeful that the current PhD program assessment is the final step to precede our formal assimilation by DGH.

I. PROGRAM STRUCTURE - What are the challenges and benefits of our academic program structure? How do we ensure robust faculty participation and promote program cohesion? What benefits/challenges do we anticipate when/if the Program formally moves into the Department of Global Health?

Challenges: Our Program is officially housed in the Graduate School, while administered by DGH, a department housed jointly in the SOM and SPH. Major challenges have arisen from the painfully long transition that our Program has endured following early assurances of integration into DGH as our permanent home. Because of our interdisciplinary program structure, it is unclear how graduate student policies that differ among the Schools should be applied to our Program. As an example, the tuition tier for our students was set by the SPH to be higher than the tier of similar interdisciplinary lab-based PhD programs in the Graduate School and in the basic science PhD programs in the SOM. This policy puts our students at a disadvantage when faculty members are determining which of equally competitive students from different programs (e.g. Molecular and Cell Biology, Immunology, Microbiology) to accept into their labs. This issue is particularly acute when grant funds are limited.

Another challenge is that our faculty are located at multiple sites. Inherent in the interdisciplinary nature of the program is the fact that many faculty members have primary appointments in departments other than DGH. Thus, the teaching and service obligations in their home Departments, and what is deemed applicable toward promotion, may diminish their participation in our Program. A challenge (and equal benefit) is the attraction to our program of students with diverse educational backgrounds, which may put some students on “different playing fields” in the first year curriculum.

Benefits: Even with our shared focus on global health, the IDPP has remarkable research diversity, ranging from basic science discovery to translational science, thus providing a wealth of different opportunities for our students. In turn, our broad ranging faculty interests attract students from diverse areas. Equally appealing to our students is the variety of scientific environs available, including University labs, research institutes, and clinical venues. In choosing rotations, we encourage students to experience these different environments in order to identify a match that works best for them. Our flexibility and academic breadth are particularly appealing to outstanding students in the Medical Science Training Program (MSTP) at the UW who are pursuing MD/PhD degrees. In the last ten years, six MSTP students have received their PhD degrees from our Program.

Our Program has been instrumental in forging partnerships with internationally renowned institutions within the Seattle community, harnessing their wealth of expertise and expanding the opportunities for our students to engage in basic as well as translational research, as well as providing state of the art training facilities. This has occurred despite the University’s current policy that faculty appointments of individuals at affiliated institutions must be made at the Affiliate level, which inherently does not encourage intense participation in programmatic activities. However, our Program structure and governance promotes faculty cohesion by insuring that all faculty members, regardless of UW faculty title, have equal votes in programmatic changes and policies. This has empowered Affiliate Faculty to be highly participatory.

Assuring robust participation: All of our program faculty have specifically requested to be part of our program, and are passionate about its unique focus and the very attractive diversity of its students. There is a cohort of senior faculty who are highly vested in the Program because they participated in its development, growth, and transition over the past 20+ years. Because of their personal dedication and the recognition that this torch will need to be passed, we have made a concerted effort to involve

junior faculty in specific programmatic roles to nurture their development as future program leaders, equally committed to the program. Our junior faculty have embraced these opportunities. To promote participation and cohesion, committee membership and committee chair appointments are rotated, typically every three years.

A document outlining expectations for faculty participation has been approved by the Steering Committee and faculty. For example, all faculty are expected to periodically sit on an IDPP committee (such as Admissions or Student Affairs), to attend one or more student symposia per year, and to participate in the teaching program. These expectations are presented to, and discussed with, prospective program faculty before they apply. The steering committee developed a framework to review faculty member participation and to define specific ways to assure that under-participating faculty augment participation.

Promoting student and faculty cohesion: Because the IDPP is geographically distributed across many institutions and campuses, we hold a retreat and two research symposia, in addition to our seminar series. The all-day retreat includes short talks by faculty; parallel faculty and student business meetings; a combined faculty–student meeting where faculty can share ideas about policy changes and receive feedback from students regarding possible improvements to the program; and a poster session featuring research of all current students with the exception of the newly entering class. The winter and spring half-day symposia consist of student talks. Thus, faculty members become familiar with the research of students outside their labs or institutions, and students benefit from getting feedback from the breadth of IDPP faculty. Additionally, the program sponsors a winter quarter seminar series that includes both internal and external speakers, forming an additional nexus for intra-program communications.

Assimilating into DGH: Overall, we do not anticipate significant programmatic changes when/if the IDPP is formally moved into DGH. During the past 7 years of affiliation with DGH, we have already assimilated into DGH in multiple ways. First, although several faculty have primary appointments in Departments/Institutions other than DGH, the majority (50 of 55 faculty) have primary, joint, adjunct, or affiliate appointments in DGH. After moving into DGH, appointments would be requested for the remaining 5 faculty. Second, our Program worked in concert with Dr. Holmes during his tenure as chair and with Dr. Baeten (the current vice-chair of DGH) in recruitment and appointment of faculty members that mutually benefit the IDPP and the DGH. Currently, although occurring synergistically, the formal appointment process to DGH and the IDPP are separate. With IDPP movement into DGH, this process will be streamlined to be simultaneous. Third, based on the structure of the current graduate academic programs in DGH, which also have Program Directors and Program Mangers, a governance responsibility, and program-specific admission criteria and curriculum planning, we do not anticipate overt changes in the IDPP academic structure. Fourth, Dr. Campbell is a member of the Centers Program and Initiatives leadership group within DGH that meets regularly with Dr. Wasserheit to discuss policies and strategies. During this transition time, IDPP has adhered to departmental policies that apply to all Centers and Programs. As examples, Dr. Campbell meets with and performs annual and merit reviews of IDPP faculty members with appointments in DGH. Proposed new Pathobiology-focused courses are initially discussed with the DGH Associate Chair of Education and Curriculum and approved by the DGH Curriculum Committee, which has IDPP faculty and student representation. As mentioned previously, Pathobiology course and peer teaching evaluations are reviewed by the DGH Curriculum Committee. This Curriculum Committee also discusses student recruitment efforts. IDPP faculty have participated, and will continue to actively participate in DGH course development and teaching in addition to our program specific courses. IDPP faculty will also be participating in a DGH strategic planning retreat, spearheaded by Dr. Farquhar, who currently chairs the Curriculum Committee, focused on maximizing the strength of DGH academic programs. Lastly, in the DGH initiative introduced by Dr. Holmes, Pathobiology alumni were included in a survey and in the database of all DGH alumni. These efforts reinforce the already tight integration of IDPP faculty into the DGH family.

II. TRAINING QUALITY – Are we adequately preparing our students with the fundamental scientific knowledge as well as other skill sets needed for a scientific career? Are we adequately preparing our students for changing dynamics in academic as well as non-academic careers?

Our program excels in training future PhDs with the expertise in basic science to elucidate molecular mechanisms of disease processes, understand biological systems and host/pathogen interactions, and exploit state-of-the art technology to develop clinical and public health interventions. There are multiple strengths of our curriculum that we believe provide our students with fundamental knowledge as well as skill sets necessary for a scientific career, regardless of whether our students choose an academic or non-academic career pathway. This expertise is blended with our distinctive inclusion of global and public health training. Our core courses are unique in comparison to other basic science programs and cover 3 very broad areas of Pathobiology that are relevant to fundamental scientific knowledge: biochemistry/molecular biology, cell biology, and public health, made distinctive by their focus on pathogens and diseases that disproportionately affect global communities and developing countries. These courses provide core knowledge of basic science with a focus on the application of these principles to host pathogen-interactions and disease processes. These courses are well-liked by our students and attract a wide variety of students from other programs such as Molecular & Cellular Biology (MCB), Biochemistry, Bioengineering, Epidemiology, and Microbiology. Each year we offer two to three 1 credit mini-courses that are readily adapted for timely "hot topics", as are the Critical Thinking and Literature Review courses. Our program also focuses on providing our students with opportunities to develop verbal and written communication skills. Our general exam requires students to write a research proposal, present a research summary, and "think on their feet" in answering the questions of the Committee, probing the students in depth understanding of their research area as well as general knowledge of the field. Our Critical Thinking course was developed 10 years ago in response to our earlier concerns with our student's performance in the oral part of the general exam. The success of this approach is underscored by the significant improvement in the demonstrated knowledge of our students, the quality of their answers in an exam setting, and their composure and confidence. As noted above, our students are required to give oral presentations of their research at our quarterly student symposia and poster presentations at our annual retreat. The magnitude of improvement that we have seen in the professionalism of these presentations since we first implemented these requirements is attributable to their training in PABIO 553 Survival Skills, their increased experience in presenting their work to their peers and professors, and receiving feedback on those presentations. These research presentations also prepare students for presenting their research at scientific meetings. The skill sets provided by our grant writing and scientific writing mini-courses are sought by nearly every student in the program, are highly rated by students, and have clearly assisted students in developing the writing skills that they will need in any scientific career path. As emphasized earlier, training in didactic teaching is a core part of our curriculum and is another avenue to enhance communication skills in general as well as preparing students who seek academic careers. The Center for Teaching and Learning (CTL) at the UW sponsors an annual TA/RA conference to assist graduate students in preparing for their roles and responsibilities as TAs and RAs. In turn, our faculty endeavor to stay current with changing dynamics and best practices in teaching through our yearly interactive discussions on best teaching practices and improvement of teaching skills, facilitated by Karen Freisem of the CTL. A number of our faculty have also taken advantage of CTL's offer for individual evaluation of their lectures.

NIH has emphasized the need to prepare PhD students for careers other than academia. IDPP was doing this long before NIH's initiative, through several mechanisms. Our "Survival Skills" course has a session focused on career options. Our seminar series exposes students to variety of career options through inviting speakers who have chosen different career paths. Students are invited to the Bioscience Careers Group at the UW (DGH is one of the sponsors). This student organized series provides monthly seminars to inform graduate students and post-docs about many career options (http://courses.washington.edu/phd/). Additionally, our affiliated institutions offer career panels and

other professional development activities that our students can attend. As proof of the success of our efforts, our alumni have embarked on a number of career paths discussed above, and they welcome inquiries from our students. We have embraced the use of individual development plans to assist students in thinking about their long term goals and the steps required to achieve them. All of our students have completed such plans and will do so annually, assessing their progress and refining shifts in direction. The plan is discussed with the student's committee at their annual meeting.

III. FINANCIAL SUSTAINABILITY – What challenges and opportunities are associated with the current financial model for supporting a multi-institution graduate program? How can the identified challenges best be addressed?

The longevity and viability of the Pathobiology Doctoral program, through a difficult transition period, is a reflection of its programmatic strengths and the passion and commitment of the faculty to graduate training. In spite of the dissolution of the Department of Pathobiology and consequent financial challenges, the Program has not just survived, but has flourished. The Program faculty have grown from 41 in 2006 (which includes 5 who have since retired) to 55, and very highly respected faculty in other programs have requested participation in our program. In addition to the strength of the faculty, the financial, administrative, and leadership support of DGH has nurtured and sustained our Program. A detailed description of the financial aspects of IDPP is provided in Section I B. above. Programmatic support as well as generous provision of space for IDPP functions has been provided by our partner institutions. Ideally, the best financial model for our Program, as well as other interdisciplinary Graduate Programs at the UW, would be state recognition of the value of graduate education and assured state support for graduate training. However, the advent of activity based budgeting (ABB), which allocates tuition funds to Schools/Departments based on student credit hours, strongly favors undergraduate teaching, in which large class sizes are considered to be desirable and required to sustain Departmental Programs. Under this funding mechanism, graduate programs are increasingly difficult to sustain due to their requisite small class sizes, which are critical to in depth graduate education. As discussed in Section 1 B., as a mechanism to increase incoming funds to DGH to offset our programmatic costs, we converted our longstanding and highly successful PABIO 201 course to GH 201, and our faculty have subsequently developed and are currently teaching two new undergraduate DGH courses, which replace GH 201.

To retain and enhance the sustainability of the Pathobiology Graduate Program within DGH, the following recommendations are made:

- Develop and retain formal agreements with all collaborating institutions for shared pro rata contribution to the costs of administering and supporting the Pathobiology Program. *This is essential to the financial viability of the program.*
- Continue to develop and teach undergraduate and graduate courses that will meet the competency needs of affiliated programs and will attract large numbers of students outside of Pathobiology and DGH. This will increase ABB revenue to DGH.
- Develop a marketing strategy to increase the participation of students from other departments in our courses.
- Recruit global health-oriented basic scientists as primary faculty members in DGH, so that RCR from basic science faculty grants will benefit DGH. To date, none of the new faculty recruited to DGH has been in basic science. Thus, of more than 50 Pathobiology faculty, Jaisri Lingappa, Jairam Lingappa, and Lee Ann Campbell are the only faculty members whose RCR benefit the department. The remaining primary DGH basic scientists (Lampe, Lehman, Lund, and Frahm) are located at FHCRC.
- Model the optimal size of the incoming class to evaluate the financial and academic advantages of increasing from the current size. ABB from more students will help to support the costs of the program, while not increasing the teaching costs. There will need to be a balance between class size and availability of well-funded faculty mentors to support students in the lab years.

- Partner with SOM Research & Graduate Education to support the Development goal of raising enough money to support all first-year basic science students.

IV. METRICS OF SUCCESS – What niche within the University and the field does our Program fill? What metrics most appropriately measure the success of our Program?

At the level of the University, Pathobiology conducts research that is relevant to both the SOM and the SPH. Students receive formal training in topics typical of SOM-based basic science graduate programs (e.g. Molecular & Cellular Biology, Biochemistry, Immunology etc.) as well as training in disciplines more traditionally aligned with Public Health (e.g. Epidemiology and Biostatistics). Because of the interdisciplinary nature of the program, it attracts students who want to work at the confluence of basic science and public health. The critical need that our Pathobiology program fulfills is underscored in the article "Training the Next Generation of Global Health Scientists", in which Dr. Peter Hotez (Founding Dean, National School of Tropical Medicine, Baylor College of Medicine and Editor-in Chief, PLoS Neglected Tropical Diseases) emphasizes the urgent need for competencies in microbiology, infectious disease, and appropriate technology, now lacking in most current training programs in public and global health. Our UW Program in Pathobiology is highlighted as one of the few academic programs providing rigorous basic science training, from among 40 accredited Schools of Public Health (Hotez, P.J. PLOS. Negl Trop Dis 2008;2(8):e279.). Our emphases are on infectious disease agents as well as chronic diseases that represent major health challenges contributing to the global burden of disease. The rigorous course of training of the IDPP includes familiarity with the paradigms for control, prevention, and treatment of diseases of public health importance, an understanding of the epidemiology and diseases processes of important diseases, and an understanding of how biomedical research can approach such diseases, using methodologies of molecular biology, immunology, cell biology, and public health sciences. Pathobiology Graduate Program faculty contribute to the research, teaching and service missions of the DGH. Pathobiology faculty are active in developing and teaching courses, not only for Pathobiology students, but also for undergraduate and graduate students in DGH and other SPH programs. Our longstanding blend of basic science training with epidemiology and public health has long differentiated us from more traditional microbiology PhD programs, and has attracted students who are committed to global and public health**.** Uniformly, students enrolling in the Pathobiology Program mention the broad global/public health-oriented emphasis of our training as a major reason that they have selected this program.

Within the field and community, the IDPP has excelled in attracting and training future basic scientists to find solutions to the challenges of global infectious disease. Our Program has been successful at partnering with leading institutions in global health research in the Seattle community to provide unparalleled academic training opportunities for our students. The goal of our Program is to develop the next generation of scientific leaders in global infectious disease, and increasingly, other serious global diseases. Because of our shared goal to combat those diseases that disproportionately affect those who suffer the greatest health and wealth disparities, our long term intent has been to formally move our IDPP into DGH.

Metrics of success of our students include the following:

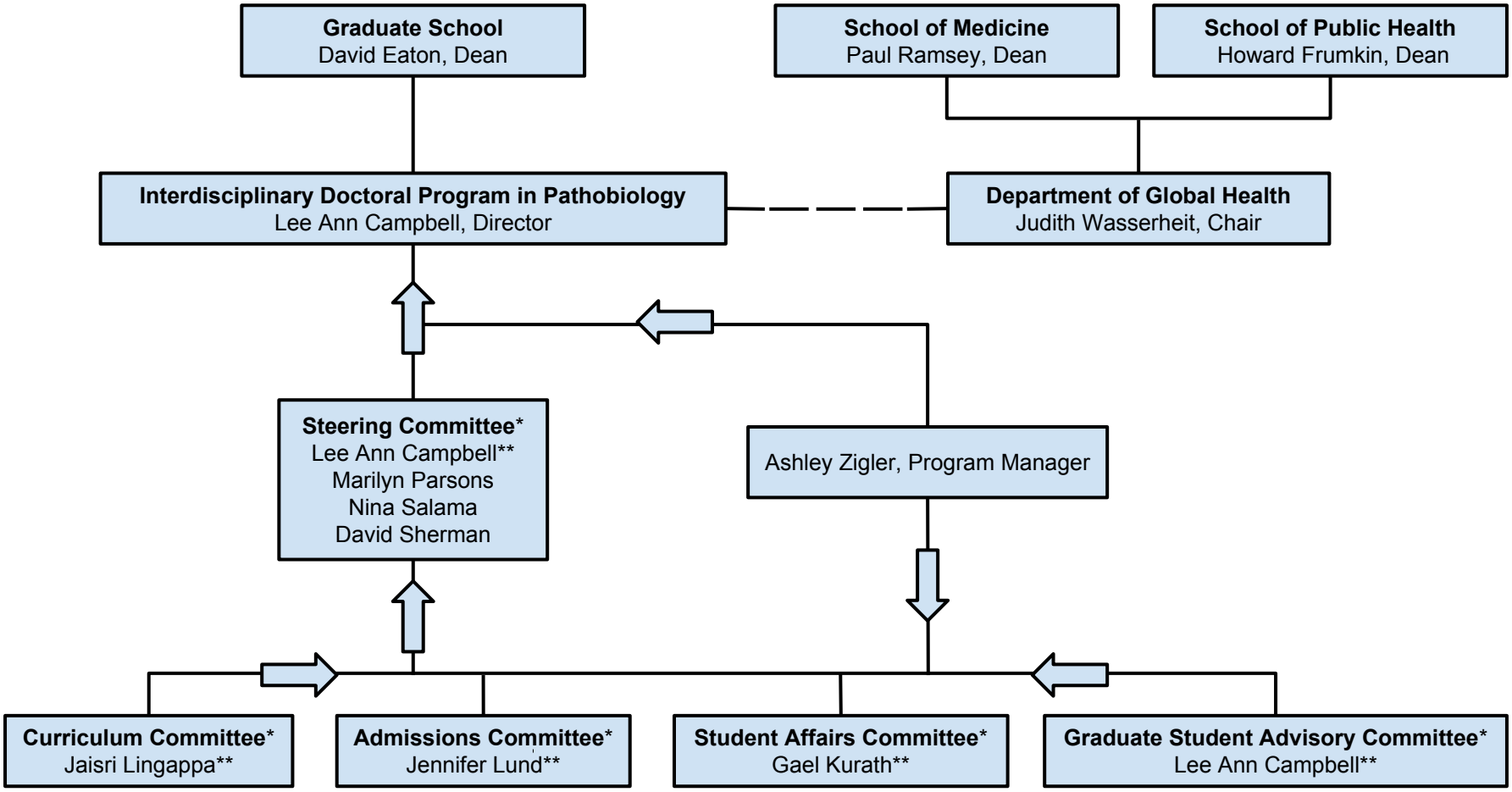
- Mastery of a broad range of knowledge, as evidenced by excellent performances in rigorous general examinations
- Competiveness of students for pre-doctoral fellowships on institutional training grants
- Ability of students to obtain external funding (e.g. NIH and NSF pre-doctoral fellowship)
- Research presentations by students at national/international scientific meetings while in graduate school
- Quality of publications
- Ready placement in a diversity of research-intensive or research-related positions at respected institutions post-graduation
- Reasonable time to completion of graduate studies

Metrics of success of our Program include the following:

- Number and high quality of applicants who apply to our program.
- Continuing to increase the quality of applicants who are accepted into our Program.
- Continuing our successful competition for training grant funding
- Attracting new faculty recruited to UW departments or affiliated institutions to affiliate with our IDPP

PART C — Appendices

Appendix A
Organizational Chart



*Program Manager provides support to this committee

** Indicates Chair of committee

Appendix B
Summary of IDPP Expenses contributed by Dept of Global Health

IDPP Expenses contributed by Dept. of Global Health						
Category	**Detail**	**FY11**	**FY12**	**FY13**	**FY14**	**FY15**
Salary for Director and for teaching PABIO courses*	Teaching supported at 4% FTE per credit for the year	192,772	168,772	164,075	152,185	169,990
Staff	Partial FTE for Program Manager, Budget Analyst	77,836	84,851	88,000	78,133	60,210
1st Year Lab Rotations**	3 Rotations per year per 1st-year student	66,187	57,635	78,216	93,956	107,064
Operations	Program retreat, Recruitment, Orientation, Seminar speakers	27,750	21,480	23,030	26,204	24,245
Total Cost		**$ 364,545**	**$ 332,738**	**$ 353,321**	**$ 350,478**	**$368,509**

***This category includes 25% FTE for the Program Director, although cost was not incurred by DGH during this time.**
****Stipends paid on state budget dollars; tuition is waived.**

Appendix C
Pathobiology Program Faculty – By Rank

Position	Name	Primary Affiliation or Appointment	Location
Director/Professor	Campbell, Lee Ann	Global Health	UW HMC
Professor	Cangelosi, Jerry	Environmental and Occupational Health Sciences	UW Roosevelt
Professor	Crispe, Nick	Pathology	UW HSB
Professor	Fang, Ferric	Laboratory Medicine	UW HSB
Professor	Gale, Michael	Immunology	UW SLU
Professor	Koelle, David	Allergy and Infectious Disease, Medicine	UW SLU
Professor	Lingappa, Jairam	Global Health	UW HMC
Professor	Lingappa, Jaisri	Global Health	1616 Eastlake
Professor	Lukehart, Sheila	Allergy and Infectious Disease, Medicine	UW HMC
Professor	McElrath, M. Juliana	Allergy and Infectious Disease, Medicine	FHCRC
Professor	Rathod, Pradipsinh	Chemistry	UW Bagley
Professor	Roberts, Marilyn	Environmental and Occupational Health Sciences	UW HSB
Professor	Rose, Timothy	Pediatrics, Medicine	SCRI
Professor	Rosenfeld, Michael	Environmental and Occupational Health Sciences, Pathology	UW SLU
Professor	Van Voorhis, Wesley	Allergy and Infectious Disease, Medicine	UW HSB
Research Professor	Galloway, Denise	Microbiology	FHCRC
Research Professor	Lampe, Paul	Global Health	FHCRC
Research Professor	Linial, Maxine	Microbiology	FHCRC
Research Professor	Totten, Patricia	Allergy and Infectious Disease, Medicine	UW HMC
Affiliate Professor	Carter, Darrick	Global Health, Medicine	IDRI
Affiliate Professor	Emerman, Michael	Global Health	FHCRC
Affiliate Professor	Kappe, Stefan	Global Health	CIDR
Affiliate Professor	Myler, Peter	Global Health	CIDR
Affiliate Professor	Overbaugh, Julie	Microbiology	FHCRC
Affiliate Professor	Parish, Tanya	Global Health	IDRI
Affiliate Professor	Parsons, Marilyn	Global Health	CIDR
Affiliate Professor	Reed, Steven	Global Health	IDRI
Affiliate Professor	Salama, Nina	Microbiology	FHCRC
Affiliate Professor	Sherman, David	Global Health	CIDR
Affiliate Professor	Stamatatos, Leo	Global Health	FHCRC
Affiliate Professor	Stuart, Ken	Global Health	CIDR
Associate Professor	Frahm, Nicole	Global Health	FHCRC
Associate Professor	Jerome, Keith	Laboratory Medicine	FHCRC
Associate Professor	Rajagopal, Lakshmi	Pediatrics, Medicine	SCRI

Position	Name	Primary Affiliation or Appointment	Location
Research Associate Professor	Lund, Jennifer	Global Health	FHCRC
Research Associate Professor	Polyak, Steve	Laboratory Medicine	UW HMC
Affiliate Associate Professor	Coler, Rhea	Global Health	IDRI
Affiliate Associate Professor	Hansen, John	Global Health	USGS
Affiliate Associate Professor	Kurath, Gael	Global Health	USGS
Affiliate Associate Professor	Smith, Joe	Global Health	CIDR
Affiliate Associate Professor	Sodora, Donald	Global Health	CIDR
Assistant Professor	Giacani, Lorenzo	Allergy and Infectious Disease, Medicine	UW HMC
Assistant Professor	Hybiske, Kevin	Allergy and Infectious Disease, Medicine	UW SLU
Assistant Professor	Katzenellenbogen, Rachel	Pediatrics, Medicine	SCRI
Assistant Professor	Klatt, Nichole	Pharmaceutics	Washington National Primate Research Center
Assistant Professor	Lee, Kelly	Medicinal Chemistry	UW HSB
Affiliate Assistant Professor	Duthie, Malcolm	Global Health	IDRI
Affiliate Assistant Professor	Fox, Christopher	Global Health	IDRI
Affiliate Assistant Professor	Grundner, Christoph	Global Health	CIDR
Affiliate Assistant Professor	Lehman, Dara	Global Health	FHCRC
Affiliate Assistant Professor	Prlic, Martin	Global Health	FHCRC
Affiliate Assistant Professor	Subramanian, Naeha	Global Health	ISB
Clinical Assistant Professor	Urdahl, Kevin	Pediatrics, Medicine	CIDR
Affiliate Assistant Professor	Orr, Mark	Global Health	IDRI
Senior Lecturer	Feagin, Jean	Pharmacy	UW HSB

Note: PABIO appointments pending for Lisa Frenkel, (Professor Pediatrics-SCRI), Heather Jaspan (Assistant Professor, Pediatrics), Alexis Kaushansky (Affiliate Assistant. Professor, Global Health-CIDR), Justin Taylor, Affiliate Assistant Professor, Global Health - FHCRC)

Abbreviations: CIDR - Center for Infectious Disease Research Institute
FHCRC - Fred Hutchinson Cancer Research Center
IDRI - Infectious Disease Research Institute
HMC - Harborview Medical Center
HSB - Health Sciences Building
ISB - Institute for Systems Biology
SLU - South Lake Union
UW - University of Washington

Appendix D
Students' Program Choice

Student replies when asked why they chose our Pathobiology Program over other doctoral programs:

"Before applying to PhD programs, I completed a masters degree in environmental health at UC Berkeley. Much of my previous research experience and coursework focused on the relationship between scientific research and public and global health. I knew that I wanted to pursue laboratory-based research on infectious diseases during my PhD, but it was very important to me to find a program that focused on diseases of global health importance. While researching many different programs across the country, I found that UW's Pathobiology PhD program was very unique in its focus on both basic research and global health. I was especially impressed with the inter-institutional nature of the program (faculty are drawn from UW as well as Fred Hutch, IDRI, the Center for Infectious Disease Research, Seattle Children's Hospital, and other premier research institutes). Though Pathobiology faculty research interests are impressively diverse, they all focus on finding answers to major problems in the fields of global health and infectious disease research. Some universities may have a small number of faculty performing this type of research within a large basic sciences program, but it is very rare to see a PhD program completely dedicated to this type of work. I really didn't come across any other programs that could offer this type of interdisciplinary education while still fundamentally performing basic research in the biological sciences. Since starting my first year this past September, the program has really met and exceeded my expectations and I've been very impressed with the quality of the faculty and my fellow Pathobiology students."

(1st year student)

"I chose the Pathobiology program at UW because of its interdisciplinary perspective. After receiving my B.S. in biology, I went on to earn a Masters in Public Health with a focus in public health practice. During my time studying for my masters, I worked at the local health department in Richmond, VA, where I gained on-the-ground experience in community-based prevention of sexually transmitted infections. During this time, I also volunteered for a non-profit, where I implemented women's health programs in a small town in Peru. My masters study, work at the health department, and experience in Peru honed my interest in public and global health problems related to women's and reproductive health, but I missed studying the biology of disease. I wanted to delve deeper into the etiology of infection by studying the pathogen and host. As I was exploring graduate programs to pursue my interests further, I learned that the Pathobiology program at the University of Washington incorporated both public/global health and biology of infectious disease into its curriculum. This stood out to me—the other programs to which I was applying did not offer this interdisciplinary perspective. Learning about the program's unique interdisciplinary perspective and about UW's outstanding academic reputation quickly made the Pathobiology program at UW my top choice. After admittance into the program, I had no doubt that it was the best fit for me. Now that I am into my second year in the Pathobiology program, I believe that joining this program what the best choice I could have made for my individual academic and career development."

(2nd year student)

“For the interdisciplinary aspect of approaching biomedical research and global health 2) because I am fascinated by pathogens, their biology and the effect on the host biology so a pathobiology program allowed me to specifically focus on studying pathogens while broadly studying diseases of global import.”

(2nd year student)

“The Program is housed in the global health department and I wanted that exposure. I have known a lot about the global health program here; 2) The Interdisciplinary nature of the program (where we could take other global health /epi related classes if we are interested as well as any science classes); and 3) UW is a top school in PNW (which is where I wanted to live).”

(2nd year student)

“I chose the Pathobiology Program because it is one of very few programs in the countries that offers a graduate degree from the Department of Global Health. Very few universities have such a department and I was really excited to hear that UW did and moreover, I was really impressed by the diverse range of faculty members affiliated with it. I knew that being part of the PABIO program will allow a very enriching and fruitful experience for me not only for the exciting research conducted here but also for the opportunity to interact and collaborate with labs across the globe studying my disease of interest. PABIO is unique in that there are several faculty members that collaborate internationally whether via clinical vaccine trials or nonprofit work in developing countries. I am hoping to learn from these faculty members’ experiences since my end goal is to work for non-profit research organization in the area of global infectious diseases. There is a lot this program has to offer to students and there are many collaborations and interdisciplinary opportunities available that can strengthen any student’s research project. It is truly amazing to know that our program involves nationally and globally-recognized leaders in the field of infectious diseases. I’m inspired by the tremendous amount of work that is being done by the faculty in our program and I am honored to be part of it. I am even more excited and proud to know that the work that is being done by our faculty is highly translatable and impacting the lives of diseased individuals by providing them hope and eventually cures. “

(**2nd year student)**

“Why I chose this program: I was looking for a research-focused program in microbiology with the opportunity to study diseases of public health importance, but none of the other programs I applied to had such a strong focus on global health. I was excited by the opportunity to gain a better understanding of where my research could go beyond the bench. I also thought connections to global health could give my work a practical edge when entering the job market.

(**3rd year student)**

“I primarily chose the Pathobiology program so that I could expand upon my basic science skills while working in an environment that would allow me to work with human samples and diseases of global health importance. The multidisciplinary approach the Pathobiology program takes works well for me as a student, as I am fully trained in basic science courses, but also have the opportunity to expand upon my education through electives as well as non-traditional methods such as presenting my work at various research institutes throughout the Seattle area or attending a diverse range of seminars. One of the main benefits of the program is the strength and breadth of faculty, ranging from basic science to directly translational research, and the institutes that support their research (Fred Hutch, Children's, IDRI, CIDR). This allows students like myself to follow their passion for research in a variety of fields, as well as form close collaborations with researchers throughout the Seattle area.

In addition to the approach the program takes to training their students, I am also quite happy with how students are treated within the program. Throughout the past four years I have had the opportunity to shape our program by acting as a member of the Student Activities Committee and the Admission Committee, as well as the Student Representative. I'm impressed with the way student is input is handled by the program, and

truly feel as though our thoughts and considerations are taken into account when making powerful changes to the program. This is very unique to the Pathobiology program, as I know that other science-based programs at the UW do not take into account student input when making admissions or curriculum decisions."

(4th year student)

"I applied to a variety of programs when looking for the right graduate program. I considered immunology programs as well as different pathobiology programs. However, I knew that I wanted to focus on the interactions between host and pathogen and not just on the vagaries of the mammalian immune system. After I narrowed my focus to pathobiology programs specifically, I found that the Pathobiology program at the University of Washington offered more diversity in study and more interdisciplinary options than any of the other programs. I knew that I wanted to focus on pathogens that had global significance and that would allow me to make a contribution to work that could affect the lives of millions of people. There was a wealth of principal investigators (PIs) working within the UW Pathobiology program that offered me opportunities to work not only on the big three (HIV-AIDS, malaria and tuberculosis) but also tropical diseases of global importance such as West Nile Virus. I was extremely impressed by how well the program took advantage of local research institutes with students being placed at the Fred Hutchinson Cancer Research Center for example. When I weighed all that the UW Pathobiology program had to offer it was an easy decision and one that I would make again given the choice."

(5th Year student)

Appendix E
Course Descriptions

Core Courses

PABIO 551 Biochemistry and Genetics of Pathogens and their Hosts (4).
(Campbell and Rajagopal)
Provides an up-to-date view of the molecular processes required by prokaryotic and eukaryotic cells, including DNA structure, replication, and repair, RNA processing, protein structure and synthesis, post-translational modification and trafficking, lipid and carbohydrate synthesis, and other aspects of metabolism. Examples emphasizing these principles are drawn from required readings of current literature on pathogenic organisms.

PABIO 552 Cell Biology of Human Pathogens, Disease, and Public Health (4)
(Grundner and Hybiske)
Focuses on principles of cell biology underlying infection. Covers eukaryotic and prokaryotic cell anatomy, organelles, physiology, membranes, and cell signaling, tissue damage, apoptosis, and pathogenic strategies for interfering with host cell functions, and identifying cellular targets for drug development. Combines didactic presentation and analysis of the current literature with emphasis on pathogen-host interactions.

PABIO 553 Survival Skills for a Science Career (2)
(Parsons and Sodora)
Provides practical learning sessions on key activities that successful students will undertake, such as writing manuscripts or proposals, and giving talks and poster presentations. Discusses ethical issues including authorship and publication, collaborations, research misconduct, and peer review are also discussed. Includes brief presentations and discussions by senior students and postdocs on important milestones in graduate student life, including the General Exam, the role of the PhD Committee, and preparing for a postdoctoral position. Discusses careers outside of universities including scientists who assumed teaching intensive positions, biotech, technical support, medical communications and government service.

GH 580A Diseases in Global Health (2)
(Lukehart)
Covers the major causes of morbidity and mortality worldwide; WHO's Millennium Goals; the Global Health Landscape; an overview of mechanisms of bacterial and viral pathogenesis, control of infection by vaccines, maternal & child health, the emergence of chronic diseases (obesity, diabetes, cardiovascular disease) as leading causes of death and disability globally; the role of the microbiome in health and disease; the politics and economics of public health, and ethical issues in public health research; combination of didactic presentations, student-run panel discussions on controversial topics, and group discussions.

Other Required Courses

PABIO 580 Pathobiology Seminar
(Polyak)
Research from students, faculty members, and invited speakers presented and discussed. Topics include immunochemistry, viruses, membranes, infectious diseases, immune response, and other related topics.

PABIO 581 Current Literature in Pathobiology (1)
(Lingappa)
Develops skills in analyzing data and assessing conclusions through an analysis of current literature in pathobiology. Focuses on breadth and analytical skills

PABIO 582 Critical Thinking and Research Design (1.5)
(Giacani)
Teaches students the importance of reading current literature and the necessity to be up-to-date with progress made in research areas included in the program. Trains students to identify scientific questions that were left unanswered by, or arise from the result of, the assigned published paper. Provides the starting point for a discussion that aims to identify meaningful future directions that are based on the manuscript's results. Ideas are listed, along with the appropriate technical approaches necessary to carry out the proposed experiments. Students are invited organize a subset of the listed ideas as the specific aims of a proposal. This course is required for all students until they pass the general exam.

PABIO 590 Minicourse Series (1)
(Varies)
Each year, students choose from among two or three topics that are presented in intensive 3-week sessions (3 hrs per week). Topics change every year and have included Rational Vaccine Design, Pathogen Variation and Evolution, Grantsmanship, Writing a Predoctoral Fellowship, Rational Drug Design, Sexually Transmitted Diseases, Innate Immunity, Scientific Writing, Translational Global Health: From Bench to Bedside and Back, Malaria, and Clinical Trial Basics. Due to their importance in providing needed skill sets for our future scientists, the mini courses on grant writing and scientific are offered more frequently.

PABIO 598 Didactic Pathobiology (2)
(Varies)
Supervised teaching experience in pathobiology courses for PhD candidates.

EPI 511 Introduction to Epidemiology (4)
(Kulkill)
Epidemiologic methods for non-epidemiology majors. Focuses on research designs and methods to describe distribution and determinants of disease and health events in populations; uses quantitative and biomedical information to infer whether causal relationships exist between potential causes and disease in populations.

IMMUN 441 Introduction to Immunology (4)
(Stetson)
General properties of immune responses; cells and tissues of immune system; lymphocyte activation and specificity; effector mechanisms; immunity to microbes; immunodeficiency and AIDS; autoimmune diseases; transplantation

OR

IMMUN 532 Intersection of Innate and Adaptive Immunity in Disease (4)
(Hammerman)
Examines the molecular and cellular basis of immune function. Topics include: hematopoiesis, innate immunity, antigen receptor structure, lymphocyte development, antigen presentation, effector T-cell functions, and immune-mediated diseases.

Highly Recommended

UCONJ 510 Introductory Laboratory Based Biostatistics (2)
(Mancl)
Introduces methods of data description and statistical inference for experiments. Covers principles of design and analysis of experiments; descriptive statistics; comparison of group means and proportions; linear regression; and correlation. Emphasizes examples from laboratory-based biomedical sciences, and provides demonstrations using standard statistical programs

PABIO 536 Bioinformatics and Gene Sequence Analysis (3)
(Rose)

Nature and relevance of molecular sequence information, computer-based protein, and DNA sequence analysis, molecular sequence and genomic databases, and methods for database accession and interrogation. Prerequisite: background in molecular biology and permission of instructor.

Appendix F
Graduates of Pathobiology Graduate Program

PhD Degrees (since 1990)

Name	Degree	Date	Current Position/Location
Soerens, Andrew	PhD	2015	Postdoctoral Fellow/University of Minnesota
Boyd, David	PhD	2015	Postdoctoral Fellow/St. Jude Children's Research Hospital
Spadafora, Lauren	PhD	2015	Relocating/seeking post-doc position
Wood, Liana	PhD	2015	Completing MD/University of Washington (MSTP Program)
Caitlin Milligan	PhD	2105	Completing MD/University of Washington (MSTP Program)
Whidbey, Christopher	PhD	2015	Postdoctoral Fellow/WSU
Ortega, Corrie	PhD	2014	Associate Scientist/Intellectual Ventures, Seattle, WA
Pattabhi, Sowmya	PhD	2014	Graduated Fall 2014, pursuing job opportunities
Reid, Tara	PhD	2014	Completing MD/University of Washington (MSTP Program)
Brownell, Jessica L.	PhD	2013	Postdoctoral Fellow/University of Washington
Cohen, Kristen W.	PhD	2013	Lab Manager/Fred Hutchinson Cancer Research Center
Davenport, Thaddeus M.	PhD	2013	Postdoctoral Fellow/National Institutes of Health
Gasper, Melanie A.	PhD	2013	Postdoctoral Fellow/Children's Research Institute
Goo, Leslie Lee Giok	PhD	2013	Postdoctoral Fellow/National Institutes of Health
Kell, Alison M.	PhD	2013	Postdoctoral Fellow/University of Washington
Murray, Sara A.	PhD	2013	Postdoctoral Fellow/University of Washington
Omenda, Maxwel Majiwa	PhD	2013	Postdoctoral Fellow/Case Western Reserve, Nairobi
Rustagi, Arjun	PhD	2013	Resident, Internal Medicine/Stanford
Sunshine, Justine E.	PhD	2013	Postdoctoral Fellow/Oregon Health & Sciences University
Chen, Hui-Ling	PhD	2012	Postdoctoral Fellow/Academia Sinica, Taiwan
Demaster, Laura K.	PhD	2012	Postdoctoral Fellow/University of Pennsylvania
Kunwar, Pratima	PhD	2012	Postdoctoral Fellow/Center for Infectious Disease Research
Maroa, Jennifer Kerubo	PhD	2012	Postdoctoral Fellow/KRITH (Kwazulu-Natal Research Institute for Tuberculosis and HIV)
Mikell, Iliyana Ventsislavova	PhD	2012	Postdoctoral Fellow/Oregon Health & Sciences University
Nixon, Molly Renee	PhD	2012	Manager of Medical Writing/ClinGenuity
Cherezova, Lidia N.	PhD	2011	Unknown
Keitany, Gladys J.	PhD	2011	Senior Fellow/Immunology, University of Washington

Name	Degree	Date	Current Position/Location
Vojtech, Lucia N.	PhD	2011	Postdoctoral Fellow/University of Washington
Bruno, Joseph Chris	PhD	2010	Postdoctoral Researcher/University of Illinois
Ching, Lance K.	PhD	2010	Intern/Artic Investigations Program, CDC, Anchorage, AK
Harrington, Whitney E.	PhD	2010	Resident/Pediatrics/Seattle Children's Hospital
Hensel, Michael T.	PhD	2010	Scientist/MedImmune Vaccines, Gaithersburg, MD
Gelsey (Jacobs-Lorena), Vanessa	PhD	2010	Investigator/FDA, Bothell, WA
Janes, Joel H.	PhD	2010	General Laborer/Dovetail General Contractors, Seattle
Speake, Catherine Cecelia	PhD	2010	Postdoctoral Researcher/Benaroya Research Institute
Greeson, Kay Ann	PhD	2009	Postdoctoral Fellow/Institute for Environmental Health, Seattle
Ng, Cherie T.	PhD	2009	Postdoctoral Researcher/Immunology, Scripps
Penaranda, Ma Michelle	PhD	2009	Assistant Professor/Philippines
Piantadosi, Anne Lauren	PhD	2009	Clinical Fellow/Massachusetts General Hospital
Pine, Samuel O.	PhD	2009	Senior Immunology Scientist/Allergen, Seattle (Biotech)
Thielen, Beth K.	PhD	2009	Resident, Pediatrics/University of Minnesota
White, John III	PhD	2009	Research Scientist Engineer 3/University of Washington
Howard (Burnside), Kellie L.	PhD	2008	Clinical Biomarker Scientist/LabCorp Clinical Trials, Seattle
Hoot, Jennifer L.	PhD	2008	Staff Scientist/Altravax, Inc, Sunnyvale, CA
Iverson Cabral, Stefanie L.	PhD	2008	Senior Fellow/University of Washington
Life, Rachel Beth	PhD	2008	Post-Doctoral Fellow/Washington Fisheries Research Center/USGS
Lin, Tsai-Yu	PhD	2008	Postdoctoral Researcher/IUPUI
Marie, Chelsea	PhD	2008	Assistant Professor/ University of Delaware
Richards, Theresa Scholz	PhD	2008	Postdoctoral Fellow/University of Florida
Chang, Jennifer C.	PhD	2007	Research Assistant Professor/University of Illinois
Chohan, Bhavna Hirji	PhD	2007	Senior Research Associate/University of Nairobi
Derby Devine, Nina Rafterman	PhD	2007	Scientist/ Population Council, New York City
Dunn, Clarence A.	PhD	2007	Cellular Imaging and Analysis-Filed Applications Specialist/ Perkin Elmer, San Francisco
Karnataki, Anuradha Vinayak	PhD	2007	Clinical Research Specialist/Axio Research
Mansfield, Bryce E.	PhD	2007	Regulatory Compliance Manager/ Gilead, Seattle
Miner, Maurine D.	PhD	2007	Technical Editor, HVTN Core/FHCRC
Saveria, Tracy Lynn	PhD	2007	Staff Scientist/Seattle Biomedical Research Institute
Puryear (Blay), Wendy M.	PhD	2006	Research Scientist/MIT

Name	Degree	Date	Current Position/Location
Brissette, Catherine Ann	PhD	2006	Assistant Professor/University of North Dakota
Eastman, Richard Thomas	PhD	2006	Research Scientist/Imclone Systems
Ho, Derek K.	PhD	2006	Postdoctoral Fellow/Academy of Finland
Jayaraman, Pushpalatha	PhD	2006	Research Assistant Professor/ University of Massachusetts Medical School
LaFond, Rebecca Elaine	PhD	2006	Technical Consultant for Biomedical Research/Miltenyi Biotec, CA
Leader, Brandon Troy	PhD	2006	Program Officer/Technology Sections Group, Program for Appropriate Technology in Health (PATH)
Silver, Peter M.	PhD	2006	Instructor/North Seattle Community College
Singh, Deepika	PhD	2006	Research Scientist/Ranbaxy Pharmaceuticals Inc.
Dooher, Julia Elizabeth	PhD	2005	AAAS Science and Technology Policy Fellow/AAAS
Klein, Kevin C.	PhD	2005	Brew master and Owner/NW Peaks Brewery
Gervassi, Ana	PhD	2004	Staff Scientist/Seattle Biomedical Research Institute
Harper (Stevens), Erin Gail	PhD	2004	Cellular Immunology Sr. Scientist, Amgen, Flow Cytometry Core Manager/Seattle
Sun, Eileen Soomie	PhD	2004	Associate/Seed Intellectual Property Law Group/Seattle
Kimball, Louise Elizabeth	PhD	2003	Clinical Research Nurse/FHCRC
Rustad, Tige	PhD	2003	Staff Scientist/Seattle Biomedical Research Institute
Seraji, Setareh	PhD	2003	Unknown
Teo, Jia-Ling	PhD	2003	Technical Grant Writer/University of Southern California
Wang, Bingbing	PhD	2003	Asst. Professor/UMDNF-Robert Wood Johnson Medical School
Cooper, Cynthia Davidson	PhD	2002	Associate Professor/Washington State University, Vancouver
Goo, Young Ah	PhD	2002	Research Assistant Professor and Associate Director of Mass Spectrometry Facility/University of Maryland
Morgan, Cecilia A	PhD	2002	Associate Director of Scientific Development, HIV Vaccine-Trials Network/Fred Hutchinson Cancer Research Center
Solan, Joell L.	PhD	2002	Research Associate, Cancer Prevention Program/Fred Hutchinson Cancer Research Center
Song, Jia Ling	PhD	2002	Assistant Professor /University of Delaware
Strand, Kurt Byron	PhD	2002	Research Scientist/Veterans Administration Hospital
Troyer, Ryan Matthew	PhD	2002	Research Scientist/Colorado State University, Grant Funds
Ambrose, Zandrea	PhD	2001	Assistant Professor/University of Pittsburgh School of Medicine
Rudolph, Karen Marie	PhD	2000	Lieutenant Commander/USPHS CDC Research Scientist
Truong, Hong-Ha Manh	PhD	2000	Associate Professor/Center for Aids Prevention USCF
Yan, Shao-Feng	PhD	2000	Pathologist/Dartmouth Hitchcock Medical Center
Chung, Whasun Oh	PhD	1999	Research Professor/Oral Biology/University of Washington Director, SURF Research Program
Lee, Jean	PhD	1999	Buck Institute

Name	Degree	Date	Current Position/Location
Luna, Vicki A.	PhD	1999	Molecular Microbiologist/University of South Florida
Nguyen, Beth Phuong	PhD	1999	US Industrial Director/Galderma
Zuo, Yuting	PhD	1999	Unknown
Arroll, Thomas W.	PhD	1998	Associate Director/Seattle Genetics
Coler, Rhea Nadine	PhD	1998	Vice President, Preclinical Biology, IDRI and Affiliate Associate Professor University of Washington
Kable Burgess D.D.S., Moffett L.	PhD	1998	Dentist/Seattle, WA
Leng, Zong Tai	PhD	1998	Homemaker
Megidish, Tamar	PhD	1998	Post-doc/Sloan Kettering Institute/NY, Current position unknown
Mehlin, Christopher	PhD	1998	Director, Peptide Drug Discovery Initiative/Fred Hutchinson Cancer Research Center
Yamamura , Soichiro	PhD	1998	Former Postdoctoral Fellow/NY, current position unknown
Laflamme, Anne Camille	PhD	1997	Associate Professor, School of Biological Sciences/Victoria University of Wellington, New Zealand
Xia, Minsheng	PhD	1997	Former Research Assistant Professor, Medicine/University of Washington, current position unknown
Adaska, John	PhD	1996	Veterinarian/Private Practice, WA
Moazed, Teresa C.	PhD	1996	Retired from Amgen/Board Member/Wenatchee River Institute
Pang, Yijun	PhD	1996	MD, Pathology/Ohio Health Marion
Roe, Darcie Elizabeth	PhD	1996	Director, Clinical Affairs at Siemens Health Care
Sweeney, Elizabeth A.	PhD	1995	Scientific Consultant and Inventor/Intellectual Ventures
Gale Jr., Michael J.	PhD	1994	Professor/Immunology University of Washington
Hardy, Charles	PhD	1993	Past President of Biovaluation and Analysis
Stroud, Mark	PhD	1993	Principal Scientist at Blaze Bioscience
White, Thayer	PhD	1993	CEO and CSO/SBH Diagnostics, CEO and President/Glycozyme

MS Degrees (since 1990)

Name	Degree	Date	Position/Location
Barlow, Russell	MS	2015	Just graduated
Mbara, Gerald	MS	2015	Seeking teaching position
Zelaya, Carmen	MS	2011	Lead Naturalist-Environmental Educator at Nature Vision
Beckett, Travis	MS	2009	Flow Cytometry Lead/Juno Therapeutics
Hudson, Sara J.	MS	2009	Research Associate III/Singulex, CA
Bosch, Katherine A.	MS	2008	Unknown

Name	Degree	Date	Position/Location
De Leon, Renee S.	MS	2008	Grad Student Johns Hopkins,/Nitze School of Advanced International Studies
Neukirch, Jodie L.	MS	2008	Program coordinator, Hasbro Hospital, Rhode Island
Phippard, David James	MS	2008	High school science teacher, Lynnwood WA
Newman, Michael Alan	MS	2006	Resident physician/University of Minnesota
Ondondo, Raphael Omusebe	MS	2006	Research Scientist/Kenya Medical Research Institute
Sciara, Erica	MS	2006	North Seattle Community College Lecturer
Harrell, Maria Isabel	MS	2004	Research Scientist/Engineer 3/ University of Washington
Guinn, Kristine Marie	MS	2002	Island Hospital, Anacortes
Kiser, Patti Kristina	MS	2002	PhD granted CSU, Dec. 2013
Koo, Kevin Kai-Wen	MS	2001	Family Practitioner Doctor/Oak Park, IL
Li, Jiangning	MS	2000	Bioinformatics Scientist/Seattle Biomed Research Institute
Behler M.D., Caroline Marie	MS	1999	Assistant Clinical Professor of Medicine/University of California, San Francisco
Mannion, Jane	MS	1999	Senior Manager, Medical Affairs/Baxter Corp.
Bohlman, Beverly Ann	MS	1997	Unknown
Pamungkas, Joko	MS	1997	Associate Professor | Director/Bogor Agricultural University | Primate Research Center
Rankin Jr., George Walter	MS	1997	Doctor, Turley Family Health Center
Kiffe (Bird), Amy	MS	1994	Environmental Health Scientist, Biorad
Godzik, Katherine Louise	MS	1994	Manager, Urgent Needs Program/Department of Health, WA
Gil, Susana Graciela	MS	1993	Scientist/Metamark Genetics
Yang, Zi-ping	MS	1993	Research Scientist, Pharmaceuticals/University of Washington
Ahmed, Mohamed	MS	1993	Physician, Private Practice
Welsh, Jennifer	MS	1993	Unknown
Zhou, Qui Hong	MS	1993	Unknown
Jejurikar, Seema	MS	1992	Faculty/Bellevue Community College
Cappuccio, Alison	MS	1991	Grant writer/Independent Contractor
Berger, Diana	MS	1991	Veterinarian
Kornak, Jodi	MS	1990	MD, Private Practice
Qui, Chun-yuen	MS	1990	Unknown

Appendix G
Areas of Faculty Research

Bacterial Infections

Lee Ann Campbell, PhD (*Chlamydia*, pathogenesis, cell biology)
Gerard Cangelosi, PhD (diagnostics)
Rhea Coler, PhD (pathogenesis, drug targets)
Ferric Fang, MD (Gram negative pathogenesis)
Lorenzo Giacani, PhD (syphilis pathogenesis, vaccines)
Christoph Grundner, PhD (drug targets, structure)
Kevin Hybiske, PhD (*Chlamydia* pathogenesis, cell biology)
Sheila Lukehart, PhD (syphilis and yaws pathogenesis, immunology, vaccines, antimicrobial resistance)
Tanya Parish, PhD (TB, drug discovery)
Lakshmi Rajagopal, PhD (Group B Strep pathogenesis, antibiotic resistance)
Marilyn Roberts, PhD (antibiotic resistance)
Steven Reed, PhD (vaccines, diagnostic development)
Nina Salama, PhD (Helicobacter pathogenesis)
David Sherman, PhD (TB pathogenesis, drug discovery)
Patricia Totten, PhD (*Mycoplasma genitalium*)
Kevin Urdahl, MD, PhD (TB immunity, vaccines)

Parasites and Fungi

Rhea Coler, PhD (pathogenesis, drug discovery)
Malcom Duthie, PhD (vaccines, diagnostics)
Kevin Hybiske, PhD (pathogenesis, cell biology)
Stefan Kappe, PhD (vaccine discovery, drug targets)
Peter Myler, PhD (genomics, structural biology, drug targets)
Marilyn Parsons, PhD (molecular biology, drug targets)
Steven Reed, PhD (vaccines, diagnostic development)
Joseph Smith, PhD (pathogenesis, vaccine targets)
Kenneth Stuart, PhD (molecular biology, drug targets)
Wesley Van Voorhis, MD, PhD (drug targets and discovery)

Vaccinology & Adjuvants

Darrick Carter, PhD (immunomodulatory agents and formulations, drug discovery)
Rhea Coler, PhD (vaccine candidates)
Malcolm Duthie, PhD (vaccine candidates)
Chris Fox, (vaccine adjuvant formulations.
Mark Orr, PhD (vaccine adjuvant formulations)
Steven Reed (vaccine candidates)
Christopher Fox (vaccine adjuvant formulations)

Chronic Diseases

Lee Ann Campbell, PhD *(Chlamydia*, atherosclerosis)
Nick Crispe, PhD, MD (liver disease)
Denise Galloway, PhD (HPV, cancer)
Rachel Katzenellenbogen (HPV, cancer)
David Koelle (cancer)
Paul Lampe, PhD (cancer)
Steve Polyak, PhD (HCV, cancer)
Michael Rosenfeld, PhD (atherosclerosis, diabetes, obesity)
Nina Salama, PhD (*Helicobacter*, cancer)
Naeha Subramanian (autoimmune disorders)

Virology

Nick Crispe, MD, PhD (liver immunology)
Michael Emerman, PhD (viral evolution)
Nicole Frahm, PhD (HIV vaccine immunology)
Michael Gale, PhD (Innate immune responses, vaccines, therapeutic targets)
Denise Galloway, PhD (viral pathogenesis, cancer)
John Hansen, PhD (immunology)
Keith Jerome, MD, PhD (viral therapeutics)
Rachel Katzenellenbogen, MD (HPV, cancer)
Nichole Klatt, PhD (HIV immunology)
David Koelle, PhD (HSV immunology)
Gale Kurath, PhD (virus evolution and variation)
Kelly Lee, PhD (structural biology, drug and vaccine targets)
Dara Lehman, PhD, MPH (HIV drug resistance, diagnostic development)
Jairam Lingappa, MD, PhD (HIV transmission, STDs)
Jaisri Lingappa, MD, PhD (viral assembly, cell biology, drug discovery)
Maxine Linial, PhD (viral assembly)
Jennifer Lund (HIV Immunology)
Julie McElrath, PhD (HIV pathogenesis, vaccine trials)
Julie Overbaugh, PhD (HIV epidemiology, genetic variation)
Stephen Polyak, PhD (HCV immunology, natural products)
Martin Prlic, PhD (T cell immunology)
Timothy Rose, PhD (KSHV biology, bioinformatics
Donald Sodora, PhD (SIV pathogenesis)
Leonidas Stamatatos, PhD (HIV vaccine discovery)

Appendix H
Faculty Research Descriptions

***Lee Ann Campbell, PhD**
Dr. Campbell's overall research emphasis is the elucidation of molecular mechanisms of chlamydial pathogenesis. *Chlamydia pneumoniae,* a human respiratory pathogen, has been associated with cardiovascular disease and found in atherosclerotic lesions. A major focus is on elucidating the role of *C. pneumoniae* in atherogenesis through the use of animal models of *C. pneumoniae* infection and atherosclerosis and *in vitro* models. Efforts are also focused on host/pathogen interactions to elucidate the mechanisms by which *Chlamydia* enters the host and the host receptors involved. Animal models are also being used to investigate therapeutic interventions and develop preventive strategies

***Gerard Cangelosi, PhD**
Dr. Cangelosi works on infectious diseases, most notably in the areas of molecular diagnostics, pathogen detection, and exposure/transmission issues. His work in the public and private sectors has addressed tuberculosis and related diseases, enteric disease, and hospital acquired infections. Recent accomplishments include the development of a novel, oral swab-based tuberculosis case finding approach, new molecular viability testing methods, and new semi-synthetic affinity reagents for molecular diagnostic testing.

***Darrick Carter, PhD**
Dr. Carter's research focuses on vaccines and innate signals targeting the immune system to modulate responses to elicit protective and therapeutic immunity. These technologies will help in providing low cost treatments and prophylactics for deployment in developing countries to address needs in Global Health. As part of this research his group is developing adjuvants based on TLR and non-TLR signaling that synergize to tune appropriate high quality immune responses. The molecules are designed based on structural and systems biologic considerations and have been moved into numerous human clinical trials. An emerging current focus is on how to use appropriate adjuvant combinations to produce lasting immune diversity and mucosal immunity. In addition to the adjuvant research, his laboratory is performing process development to further move a new vaccine for Schistosomiasis into the clinic as well as doing translational work on other vaccine candidates. A separate focus of the lab is innovative immune oncology where tumors are attacked through tumor junction openers and checkpoint inhibitor technologies targeting the complement system. Finally, the lab has medical device projects and is developing a microneedle platform for immunization and diagnostic testing as well as an inhaler for drug resistant TB.

***Rhea Coler, PhD**
The overall research emphasis is to rationally design vaccines for infectious diseases that require humoral and cellular immunity. Efforts are focused on understanding the factors affecting innate and adaptive immune responses to infectious diseases using in vivo model systems and human clinical trial samples. Host/pathogen interactions and next generation adjuvant formulations and delivery systems are also studied to elucidate the mechanisms by which effective B and T cell immune responses are conferred in experimental animal models of *Mycobacterium tuberculosis*, *Leishmania* sp., West Nile Virus and influenza.

***Ian N. Crispe, MD, PhD**
Dr. Crispe's central research mission is to understand the distinctive features of immune responses that are generated in the liver, and reveal aspects of T cell and innate immune function that are prominent in this environment. Multiple important pathogens target the liver, including viral hepatitis A, B, C and malaria. They have developed an Adeno-Associated Virus (AAV)-based model for gene delivery to hepatocytes, and find that the CD8+ T cell response to this vector may be used to study T cell-dependent hepatitis, liver injury and fibrogenesis. They are dissecting the role of T cell- and Kupffer cell-derived cytokines in the development of liver immunopathology. The lab is developing in vitro approaches to human liver immunology, including the use of purified human liver tissue cells, and viable liver slice cultures to address questions of immune cross-talk between liver cells in health and disease.

***Malcolm Duthie, PhD**
Dr. Duthie's main research interest lies in determining and examining the host/pathogen interactions that initiate and control immune responses, how these interactions can be beneficially manipulated, and ultimately, their practical application within disease control programs. An emphasis is placed on neglected tropical diseases. This research uses preclinical models of immunization and infection to determine mode-of-action of early stage vaccine candidates. It also capitalizes on an extensive collaborative network across several countries to identify vaccine candidates and develop new diagnostic tools to improve the control of leprosy, leishmaniasis and Chagas disease.

***Michael Emerman, PhD**
The Emerman lab studies host-cell interactions of the human immunodeficiency virus (HIV) and related viruses. We wish to understand the molecular and evolutionary basis of virus replication and pathogenesis. They study the evolution and function of host antiviral genes in order to determine how HIV adapted to humans, and how ancient viral infections influenced the susceptibility or resistance of humans to modern lentiviruses.

***Ferric C. Fang, MD**
The Fang Laboratory studies the pathogenesis of infections caused by *Salmonella enterica* and *Staphylococcus aureus*. Active projects include the antimicrobial actions of nitric oxide, bacterial stress responses, the evolution of transcriptional regulatory networks, and the pathogenesis of human typhoid

***Jean Feagin, PhD**
Dr. Feagin did her postdoctoral research at Center for Infectious Disease Research before becoming a principal investigator there. Her research focused on mechanisms that regulate gene expression and function in apicomplexan parasites, with emphasis on identifying differences between parasites and their human hosts that might be exploited for disease intervention. Dr. Feagin has an extensive background in regulatory issues, having served on committees that review proposed animal model and biohazard uses in the laboratory, and proposed recombinant DNA uses in clinical trials. She is interested in practical, ethical, and regulatory issues for adaptation of medical technologies to less-developed countries

***Christopher Fox, PhD**
Dr. Fox's research focuses on developing stable, biocompatible vaccine adjuvant formulations, including physicochemical characterization and cGMP production. Vaccine adjuvants are a critical component of modern vaccine development. Dr. Fox's work involves the major classes of clinical adjuvant formulations including aluminum salts, oil-in-water emulsions, and liposomes. Furthermore, Dr. Fox's research has investigated the interactions of Toll-like receptor ligands with various formulation platforms and the resulting biological effects in a variety of disease models, including tuberculosis, malaria, leishmaniasis, pandemic influenza, and amebiasis.

***Nicole Frahm, PhD**
Dr. Frahm's research addresses the influence of HIV sequence diversity on its recognition by cytotoxic T lymphocytes, as well as the factors governing the recognition of sequence variants both in HIV-infected subjects and in vaccine trial participants. Her research also includes the assessment of immune responses to viral vectors used as immunogens in HIV vaccine trials to help understand how pre-existing cellular immunity to the vector influences the quality of vaccine-induced immune responses. As the Associate Laboratory Director for the HVTN, she oversees the Endpoints Laboratory, which is responsible for the generation of validated immunogenicity data for all HVTN trials, and the R&D Laboratory, which provides ancillary and exploratory data leading to a more complete view of the immune responses generated by HIV vaccines.

***Michael Gale, Jr., PhD**
Research in the Gale laboratory is focused on understanding innate immunity to RNA virus infection, and the intracellular immune processes and virus-host interactions that govern viral replication, the immune response to infection, viral pathogenesis, and the overall outcome of infection. The laboratory is a member of the new Center Innate Immunity and Immune Disease, and is a component of the Hepatitis C virus (HCV) Cooperative Research Centers, as well as the Immune Mechanisms of Virus Control program, both supported by the NIH. Additionally, the Gale laboratory has research programs focused on understanding immune control of flavivirus

infection, HIV, HIV/HCV coinfection, Hanta virus, contemporary and emerging coronaviruses, influenza viruses, and the immunomodulatory/antiviral actions of interferons and small molecule innate immune agonists as antiviral mediators of virus infection. The lab also conducts vaccine research focused on developing innate immune agonists as adjuvants for pairing with vaccines against high path influenza virus (bird flu), HIV, HCV, and other contemporary or emerging RNA viruses.

***Denise Galloway, PhD**
The Galloway lab is interested in the mechanisms by which human papillomaviruses (HPVs) contribute to epithelial cancers. They have sought to determine how the E6 and E7 oncoproteins disrupt the cell cycle checkpoints and facilitate the immortalization of primary human cells. Current effort is directed towards understanding how and why E6 activates and increases expression of hTERT, the catalytic subunit of telomerase. The mechanisms by which other oncogenes, immortalize cells, and the tumor suppressors that constrain these activities are under investigation. Another focus is studying beta HPVs, which commonly infect skin, and may play a role in squamous cell skin cancers (SCSC). They are studying the role of E6/E7 in blocking UV-induced apoptosis, as well as other functions. A long standing interest is the natural history of genital HPV infections, and the risk factors that cause only a small subset of women infected with high risk HPVs to progress to cancer.

***Lorenzo Giacani, PhD**
Dr. Giacani's work at the University of Washington focuses on the pathogenesis of syphilis and how the causative agent of this infection, *Treponema pallidum* subsp. *pallidum* (*T. pallidum*), can successfully evade the host immune response and establish persistent infection in spite of a vigorous host immune response. Research topics in the Giacani's lab include the study of transcriptional modifications that help the syphilis pathogen counteract host defenses, the identification of putative surface-exposed antigens that could serve as vaccine candidates, functional characterization of previously identified *T. pallidum* surface antigens, the study of the host immune response to *T. pallidum*, comparative genomics of *Treponema* subspecies and strains, and the use of innovative vaccine delivery approaches based on surrogate bacteria.

***Christoph Grundner, PhD**Despite being the world's most prevalent pathogen, *Mycobacterium tuberculosis* (MTB) is still a puzzle. The Grundner lab is working toward a better understanding of MTB pathogenesis by studying the phosphosignaling network of MTB with the ultimate goal of translating these findings into better therapies

***John Hansen, PhD**
The Immunology group at Washington Fishery Research Center focuses on immune responses to infection in fish, the development of immune-related tools (mAbs) and reagents for salmonids and the impact of environmental chemicals on immune response potential. Dr. Hansen's lab is particularly interested in host-pathogen interactions and their impact on fish health & populations.

To better appreciate these interactions, they have developed specific research projects that utilize zebrafish. Zebrafish present an attractive model for studies involving fish and vertebrate health owing to the ease of breeding and maintaining stocks and the availability of specific tools including a finished genome, comprehensive DNA microarrays, gene knockouts/knockdowns and transgenic animals for specific immune-related genes. Current projects using zebrafish at the WFRC include models to assess pathogenesis mediated by *Francisella* species that infect fish and the impact of endocrine disruptors on fish health. These research efforts have translational value for human health as well, as our comparative approach can lead to the identification of key virulence factors and essential components of host immunity that are conserved across all vertebrates. Ultimately, the goal is to better understand how pathogens and host immune responses contribute to pathogenesis &/or immunity and how this information can be applied to vertebrate health

***Kevin Hybiske, PhD**
The Hybiske lab investigates the pathogenesis of *Chlamydia trachomatis* and how this bacteria interacts with host cells at the molecular level. A major research focus in the lab is to determine how intracellular pathogens, including *Chlamydia* and liver-stage malaria parasites, manipulate host cell factors to promote cell-to-cell spread and dissemination. Other active projects include defining virulence correlates for *Chlamydia*,

developing novel genetic tools for manipulation of *Chlamydia*, and studying immune responses to disseminating *Chlamydia*.

***Keith Jerome, MD., PhD**
Dr. Jerome's research interests focus on chronic and latent viral infections, and potential approaches to their eradication. Much of the research involves the use of DNA editing enzymes, including homing endonucleases, zinc finger nucleases, and TAL effector nucleases, to induce deletion of essential viral genes or cellular receptors for virus. Dr. Jerome has active projects in HIV, hepatitis B virus, herpes simplex virus, and human papillomavirus. The long-term goal is to develop curative therapies for each of these infections. Clinically, Dr. Jerome serves as Director of the University of Washington molecular virology laboratory.

***Stefan Kappe, PhD**
Dr. Kappe's research is focused on the biology, immunology and vaccinology of the malaria parasite pre-erythrocytic stages. The goal of his lab is to understand liver stage parasite development and elucidate networks of host-parasite interactions during liver stage infection. Dr. Kappe is utilizing this knowledge to develop new interventions, both drugs and vaccines. One aspect of the work is targeted at designing genetically engineered, live attenuated *Plasmodium falciparum* strains for vaccination and elucidating correlates of protection induced by live-attenuated sporozoite vaccination.

***Rachel Katzenellenbogen, MD**
Human papillomavirus (HPV) is the most common sexually transmitted infection, affecting more than 75% of the adult population. HPV is categorized as high-risk or low-risk, based on its association with cancer. Through dysregulation of normal cellular function, high-risk HPV blocks signals for DNA damage, programmed cell death, and cellular arrest, all as a part of its viral life cycle. Dr. Katzenellenbogen studies the mechanism by which high-risk HPV activates telomerase, and enzyme found normally in stem cells and almost categorically activated in cancers, Notch1, a master cell fate regulator, and the balance of growth and differentiation in keratinocytes in order to understand how HPV drives cells to become malignant.

***Nichole Klatt, PhD.**
The focus of Dr. Klatt's work is on biotherapeutics in infectious diseases and global health. The Klatt Research Lab focuses on better understanding the mechanisms by which HIV infection causes dysfunction of the gastrointestinal and reproductive tract immune systems. The ultimate goal is to use this knowledge to develop novel therapeutic interventions to prevent transmission of HIV and to treat HIV-associated disease.

***David Koelle, MD**
T-cell immunology is at the core of infectious diseases, cancer, and allergy. The Koelle lab is fortunate to be able to work in each of these areas. They have funded programs in antigen identification and prioritization for herpes simplex viruses types 1 and 2, varicella zoster virus, and vaccinia (the vaccine for smallpox). In 2008, Merkel cell polyoma virus (MCPyV) was discovered as the cause of Merkel cell carcinoma (MCC). Dr Koelle has been actively collaborating with the leading MCC clinical group to develop therapies focusing on improving the immune response to the oncogenic viral protein. For *Mycobacterium tuberculosis* (MTB), Dr. Koelle is responsible for the IGRA testing at the medical center, and has mentored several trainees interested in this unique application of T-cell immunology to clinical testing. The pathogens that he works on mostly have large genomes, so determining the antigens that elicit T-cell responses is challenging. Dr. Koelle's technical expertise is the use of genomic libraries and genome-spanning ORF s ets to interrogate CD8 and CD4 T-cell responses to a very high level of definition. A suite of modern immunology tools such as intracellular cytokine cytometry, tetramers, cell killing assays, TCR expression, etc. are in use to measure several variables in the T-cell response. HSV-1 and HSV-2 vaccine candidates have been identified and studied in mice, and some have entered phase I-II human trials. Dr. Koelle's group also performs clinical immune monitoring for clinical trials of candidate HSV vaccines. Recently, they have begun collaborative work with investigators interested in drug-related cutaneous toxicity (SJS-TEN reactions) mediated by CD8 T-cells.

***Gael Kurath, PhD**
Research on negative sense RNA virus epidemiology, pathogenesis, fitness, and evolution using a fish rhabdovirus, infectious hematopoietic necrosis virus (IHNV), as a tractable experimental model for in vivo infection of vertebrate hosts. As the earliest animals on the evolutionary tree of life to have evolved adaptive

immunity, fish provide a host with innate and adaptive responses similar to mammals, but facilitate studies with large numbers of animals to assess population-scale phenomena. Research studies focus on viral emergence and displacement in the field, mechanisms of host specificity and host jumps, evolution of virulence, host-to-host variation, and viral fitness. A major effort has been development of several in vivo viral fitness assays that assess fitness components associated with host entry, in-host replication, viral shedding, and most recently superinfection fitness. The ultimate goal is to understand drivers of viral infection as it occurs and evolves in natural infections of host populations.

***Paul Lampe, PhD**
The Lampe laboratory investigates the control of cell growth both at the cell biological/ mechanistic level and through cancer biomarker discovery. We study the cell biology connecting gap junctions and intercellular communication (GJIC) with the control of cell growth, the cell cycle and, how the relationship is disrupted during carcinogenesis.

***Kelly Lee, PhD**
Viruses undergo dramatic structural reorganizations at many critical stages of their life cycles, including during host cell invasion, genome expulsion, assembly, and cell egress. The changes often involve concerted changes among hundreds of protein components and, in the case of enveloped viruses, membranes as well. From this perspective, virions are intricate, nano-scale cell-invasion and replication machines. The dynamic structural transitions are attractive targets for anti-viral therapeutics that would "throw a spanner into the works" and arrest viral infections. Neutralizing antibodies also inhibit infection by blocking interactions with receptors and arresting conformational changes the proteins must carry out in order to mediate genome delivery. Dr. Lee's lab use a suite of biophysical, structural, and biochemical techniques including X-ray scattering, mass spectrometry, cryo-electron microscopy, and fluorescence microscopy to understand the function of viral machinery. The viruses studied include influenza A and HIV. Our work can both bring fundamental biological mechanisms to light and provide novel insights that are useful for optimization of vaccine immunogens.

***Dara Lehman, PhD**
Research interests include viral dynamics, viral reservoirs and drug resistance following antiretrovirals used as prophylaxis and treatment for HIV infection. Studies involve cohorts of HIV infected women, infants and serodiscordant couples in Kenya. In addition, Dr. Lehman has been involved in the development of multiple assays to detect HIV infection and drug resistance that work across HIV subtypes, and uses these assays in population-based studies. Currently, she collaborates on the development of a non-instrumented infant HIV diagnostic that is appropriate for use in resource-poor settings.

***Jairam Lingappa, MD, PhD**
For the last 10 years, Dr. Jairam Lingappa has focused his research efforts on identifying host factors mediating natural host resistance to and disease progression from HIV-1 infection. He has done this using samples and data prospectively collected in cohorts of African HIV-1 serodiscordant heterosexual couples (one partner HIV-1 infected and the other HIV-1 uninfected). In the context of these collaborative studies, he has coordinated integration of prospective clinical, epidemiological and behavioral data with laboratory analysis for genomic, transcriptomic, proteomic, virologic and microbiome factors. Currently, his team is primarily focused on analysis of whole human genome sequence data to identify rare genetic factors mediating altered risk of sexual HIV-1 acquisition.

***Jaisri Lingappa, MD, PhD**
The Lingappa lab studies viral host interactions involved in assembly of human immunodeficiency virus type 1 (HIV-1) and other viruses. Their group demonstrated that immature HIV-1 capsid assembly in cells occurs through a pathway of assembly intermediates, and is facilitated by the catalytic activity of the host enzymes ABCE1 and DDX6. Their recent studies show that ABCE1 binds directly to HIV Gag through an ancient binding site that is present even in the Ty3 retrotransposon Gag protein. One current direction in the lab involves understanding the evolution of the ABCE1 binding site in different retroviral Gag proteins and cellular Gag-like proteins. Other projects in the lab address how polymorphisms that arise in Gag *in vivo* can enhance ABCE1-Gag binding, thereby accelerating the kinetics of this assembly pathway and increasing virus particle production. The latter studies have important implications for viral pathogenesis, since they test the hypothesis that altering viral-host interactions during assembly could impact viral set point and viral load. The Lingappa

lab's studies have also led to development of novel antiretroviral compounds that inhibit virus replication by acting on the capsid assembly pathway.

***Maxine Linial, PhD**
The Linial laboratory is interested in the replication and biology of foamy viruses. These complex retroviruses comprise their own subfamily. Foamy viruses (FV) are prevalent in most primate species, and in some accidentally infected humans, as well as in cats, horses, and cows. These viruses are cytopathic to fibroblasts in culture, but do not have deleterious effects on the growth of some other cell types. Many FV have been molecularly cloned, and have been developed as vectors. In particular, their broad host range and lack of pathogenicity are attractive features for human gene therapy. Our lab works on the molecular biology of viral replication, as well as the biology of viral replication in macaques, and the epidemiology of zoonosis.

Foamy viruses appear to occupy a unique niche quite distinct from all other groups of retroviruses. Although their genomes are similar to other complex retroviruses, such as HIV, they have many unique features. Aspects of their replication are more similar to that of the hepadnaviruses such as HBV than to other retroviruses. For example, the mechanism of expression of their reverse transcriptase from a specific, spliced mRNA has not been seen in any other reverse transcriptase encoding virus. In addition, unlike either HIV or HBV, FV requires the Env proteins, but not the Pol proteins, to bud from cells. We have also found that the functional genome of FV is DNA rather than RNA, clearly setting it apart from other retroviruses. The Linial lab focuses on understanding the steps in FV assembly and also the unique properties of the viral reverse transcriptase, which is a highly processive enzyme whose synthesis is regulated in an interesting manner. FV assembly intracellularly near the centrioles, and assembled particles are then transported to intracellular vesicles for acquisition of envelope glycoproteins. The details of this pathway are under investigation.

Dr. Linial is also interested in determining how FV can establish lifelong persistent infections without ensuing pathology. Study in the lab of naturally FV infected rhesus macaques has revealed that there are high levels of virus in the oral tissues and in saliva (which is the route of transmission), but not in any other tissues. Interestingly, in SIV immunosuppressed macaques, FV is also found in the jejunum. The details of viral replication, and its consequences are under investigation.

In collaboration with investigators at the University of Washington Primate Center, Dr. Linial has initiated investigations of FV transmission from macaques to humans in areas of Asia where such contacts are abundant. They have found that about 3% of humans with high levels of contacts with monkeys are infected with FV. Future studies will address the issues of human to human viral transmission.

***Sheila Lukehart, PhD**
The Lukehart laboratory studies the pathogenesis of syphilis and the immune response to *Treponema pallidum* in humans and in animal models. Our current major interest is the 12-membered *tpr* gene family of *T. pallidum*, which is hypothesized to encode surface-exposed antigens that are major targets of the protective immune response, may be involved in immune evasion, and are promising vaccine candidates. We have demonstrated that one member of the Tpr family, TprK, undergoes antigenic variation; studies related to the immunological relevance and molecular mechanism of this variation are ongoing. New studies are focused on TprC and TprD, which are also surface exposed, and which differ in sequence among *T. pallidum* strains and subspecies. The laboratory is also working to identify surface molecules that are targets of opsonization and to define the kinetics of and requirements for bactericidal activity by macrophages. Many of the projects described above involve collaborations with Drs. Arturo Centurion-Lara and Lorenzo Giacani.

Additionally, our laboratory is involved in studies of clinical aspects of syphilis and other treponematoses. With Dr. Christina Marra (Neurology), the laboratory is exploring the molecular basis for neuroinvasion, the immunologic response to *T. pallidum* within the CNS, and the efficacy of recommended therapy for CNS syphilis in immunocompetent and HIV-infected patients. Other ongoing studies involve the investigation of emerging macrolide resistance in *T. pallidum*, application of a molecular typing method for *T. pallidum* to epidemiological studies of syphilis, and studies of yaws in Papua New Guinea.

***Jennifer Lund, PhD**
The focus of the Lund lab is on elucidating the basic mechanisms of immunity in the context of virus infection. Specifically, they use a mouse model to study how regulatory T-cells affect the anti-viral immune responses to genital HSV-2, influenza, and West Nile virus. Additionally, they are investigating the immune correlates of protection from HIV infection using a cohort of exposed seronegative individuals, as well as the potential immune modulatory effects of using pre-exposure prophylaxis in protection from HIV acquisition. Overall, they hope that these studies will lead to improved clinical interventions for virus infections of public health importance.

***M. Juliana McElrath, MD, PhD**
Dr. McElrath's laboratory seeks to identify the components of immunity that are important in preventing and controlling HIV-1 infection, with studies encompassing a broad range of translational research investigations in persons who experience unusual control of HIV-1. The McElrath Lab's research is focused on obtaining a better understanding of the role HIV-1-specific memory T cells play in protecting against mucosal HIV-1 transmission and determining optimal strategies to accomplish protection by vaccination

***Peter Myler, PhD**
The Myler laboratory played a key role in sequencing the "Tritryp" genomes, revealing that the protein-coding genes are arranged in long polycistronic gene clusters. Using genome-scale approaches such as microarray-based transcript mapping and chromatin immunoprecipitation (ChIP-chip), as well as more traditional molecular approaches such as electrophoretic mobility shifts assays, affinity chromatography, and in vitro transcription, we are now elucidating the molecular mechanisms involved in RNAPII-mediated transcription of protein-coding genes in *L. major*. In collaboration with Dan Zilberstein (at Technion, Israel), they are using genome-wide approaches (such as RNA-seq and tandem mass spectrometry), to identify and characterize changes in gene expression during differentiation from the insect form (promastigotes) to the mammalian form (amastigotes) of *L. donovani* and to elucidate the signaling pathways involved in this process. Dr. Myler is also PI of the NIAID-funded Seattle Structural Genomics Center for Infectious Disease (SSGCID), which includes investigators at Center for Infectious Disease Research, Emerald Biostructures, University of Washington and Pacific Northwest National Laboratories. To-date, they have solved over 250 three dimensional protein structures from NIAID Category A-C pathogens and organisms causing emerging or re-emerging infectious diseases. These protein structures serve as a blueprint for structure-based drug development, as well as facilitating vaccine development and other basic research.

***Mark Orr, PhD**
Dr. Orr's research is focused on understanding the immunobiology of vaccines and adjuvants in the support of developing new vaccines for infectious diseases impacting global health. A major focus has been on identifying the key vaccine immune responses necessary for the control of *Mycobacterium tuberculosis* using small animal models of infection. Recent work has focused on defining the mechanisms of action of formulated TLR4 agonist adjuvants that lead to robust TH1 and humoral immune response to vaccine adjuvants.

***Julie Overbaugh, PhD**
The Overbaugh lab has a long-standing interest in understanding the mechanisms of HIV-1 transmission and pathogenesis. The lab is part of a larger team, comprising researchers in both Seattle and Kenya (The Kenya Research Program). Trainees in the lab have opportunities to engage in studies of viral evolution, virus-host cell interactions, and viral immunology all within the context of this international collaboration. Studies in the lab focus on identifying correlates of protection in HIV-infected humans, including individuals who become superinfected with HIV and infants of HIV-positive mothers. Current areas of emphasis include identification of HIV specific antibodies that neutralize virus or mediate ADCC. Other projects in the lab focus on rationale design of more relevant models of HIV infection and the role of IFN and viral entry in viral restriction in model systems.

***Tanya Parish, PhD**
Tanya Parish's work focusses on the global pathogen *Mycobacterium tuberculosis*, in particular the understanding of the mode of action of anti-tubercular agents and drug resistance. Her work has a strong emphasis on drug discovery for tuberculosis, which includes drug target identification and validation, high

throughput screening and medicinal chemistry. In addition, her group works to understand the pathogenic mechanisms and basic biology of *M, tuberculosis* and using this information to inform drug discovery.

***Marilyn Parsons, PhD**
Among different disease agents, parasites are the most similar to their human host, which has made the search for drugs and vaccines highly challenging. A major focus of Dr. Parsons' laboratory is identifying differences in cell structure and function between parasites and humans. Her long-term goal is to identify differences between host and parasite that would be appropriate targets for drug development. The lab studies several parasites including *Trypanosoma brucei* (African trypanosomes), *Leishmania*, and *Toxoplasma gondii*. Currently, Dr. Parsons' research focuses on protein kinases and global assessment of protein production.

***Stephen J. Polyak, PhD**
Research in the Polyak lab focuses on virus-host interactions that lead to chronic inflammation and disease. The virus models include hepatitis C virus (HCV) and human immunodeficiency virus (HIV). An NIH-funded project focuses on using natural products as tools to protect cells from damage by viruses and chronic inflammation. They have found that natural products alter cellular metabolism, which modulates the inflammatory status of liver and immune cells. Another project studies how hepatocytes sense HCV infection to induce an inflammatory response, while the work on HIV focuses on chronic immune activation associated with virus infection.

***Martin Prlic, PhD**
The Prlic laboratory studies immune responses following infection and vaccination, using in vivo (mouse) and in vitro (human) systems. Their goal is to understand how to manipulate the immune system for therapeutic purposes. Current research directions include:

<u>Regulating CD8 T Cell Responses</u>
Many established vaccination programs depend on an efficient antibody response, but this classic approach has failed for current challenges such as malaria, HIV, and tuberculosis. CD8 T cells are key players in protecting against intracellular pathogens by eliminating infected cells and hence we believe a strong CD8 T cell response will be an integral part of a successful vaccine.

<u>Mucosal-associated invariant T (MAIT) cells</u>
Human mucosal-associated invariant T (MAIT) cells are located at critical sites of pathogen entry, but their role in the immune response is poorly understood. Their goal is to understand their role in infections, chronic inflammatory responses and other inflammation-driven pathologies.

***Lakshmi Rajagopal, PhD**
Current research projects are on Group B Streptococcus are focused toward understanding how the pathogen migrates through different host niches during infections. These include identifying the environmental cues/signals that are sensed by the pathogen for regulation of toxins and other virulence factors. Our studies on *S. aureus* are focused on elucidating on factors that regulate antibiotic resistance and virulence of the pathogen. The Rajagopal lab is also investigating how mutations in host signaling pathways affect disease susceptibility to *S. aureus*. This is particularly relevant as patients with genetic disorders such as Jobs syndrome and chronic granulomatous disease (CGD) are prone to recurrent and life-threatening infections due to *S. aureus.*

***Pradip Rathod, PhD**
Malaria causes 500 million infections and at least 500,000 deaths per year. The Rathod lab uses both chemistry-driven and biology-driven projects to help deliver new antimalarials more efficiently. Many early lessons on potency and specificity were learned from studying dihydrofolate reductase-thymidylate synthase. Based on that, the Rathod laboratory has developed antimalarials against dihydrooratate dehydrogenase (including one in human trials) and against topoisomerase II. The lab also studies how haploid malaria parasites rapidly acquire drug resistance by altering parasite DNA at the relevant locus, without large collateral damage in the rest of the parasite genome. Some of these questions have led to a large NIH Program Project to study parasite evolution in SE Asia and its consequences beyond drug resistance.

***Steven Reed, PhD**
The Reed laboratory focuses on vaccine and diagnostic development, with an emphasis on antigen discovery and the nature of specific immune responses to infection with macrophage pathogens. The emphasis is on tuberculosis, leishmaniasis, and leprosy. Another area of focus is on adjuvant discovery and development, including formulation. The basic laboratory studies are complemented by a strong emphasis on clinical studies, with clinical trials ongoing in several developing countries.

***Marilyn Roberts, PhD**
The Roberts' laboratory focuses on projects related to antibiotic resistant genes and antibiotic resistant bacteria found in man, animals and the environment. A variety of bacteria are studied from pathogenic *Neisseria gonorrhoeae* to opportunistic pathogens such as MRSA and VRE to environmental bacteria. The laboratory is also interested in determining if new antibiotic resistant genes such as KPC can be identified in environmental samples. Studies related to dental caries including clinical studies in both the US and Peru also engages the laboratory. Work with both human and animals samples looking for antibiotic resistant bacteria and genes and how human, animal and environmental bacteria interact with each other.

***Timothy Rose, PhD**
Dr. Rose's research interests lie in the identification and characterization of DNA herpes viruses implicated in cellular transformation and tumor induction, and in the study of host and viral proteins and cytokines that mediate these effects. A major focus is on the viral etiology of Kaposi's sarcoma (KS) and other AIDS-related malignancies with regards to the interactions between viruses (retroviruses and herpes viruses) and cytokines in virus activation and tumor induction. Ongoing projects include the cloning and sequence comparison of regions of the new human and macaque herpes viruses, searching for transformation- and latency-related genes and cytokine inducing genes, and developing an animal model for studying KS in humans. Another focus is on the human cytokine oncostatin M (OSM), which has been shown to be the major autocrine/paracrine growth factor for KS.

***Michael Rosenfeld, PhD**
Dr. Rosenfeld studies cardiovascular disease with an emphasis on the pathology of atherosclerosis. The current research focuses on the role of the OPG, RANK, RANKL pathway in the accelerated vascular pathologies that accompany chronic kidney disease. Research also includes the roles of air pollution and respiratory infection in the pathogenesis of atherosclerosis.

***Nina Salama, PhD**
Helicobacter pylori, establishes lifelong infection in the stomach of half the human population worldwide. Most infected individuals have asymptomatic gastritis which may progress peptic ulcer (10-20%) or stomach cancer (1-2%). This wide range of disease outcomes remains a mystery of *H. pylori* pathogenesis. The Salama lab is interested in the mechanisms by which this bacterium can establish and maintain a chronic infection in the unusual environment of the human stomach and the molecular cross talk between the host and the bacteria during the decades-long infection. The activation of host cell processes, either through direct action of bacterial products or as part of the host's attempt to contain the infection presumably causes the different diseases associated with *H. pylori* infection. To approach this complex problem, the Salama lab is using both global and molecular approaches to analyze strain diversity and progression of infection in a variety of infection models and human clinical isolates.

***David Sherman, PhD**
With about 30% of the world's population infected and 1.4 million deaths caused each year, Mycobacterium tuberculosis is the world's deadliest bacterium. The Sherman laboratory studies the bacterial and host strategies that underpin this success. They use tools of systems biology such as transcriptomics, ChIP-seq and modeling to define the TB gene regulatory network under physiologically relevant conditions, and use the modeling in turn to produce testable hypotheses about novel regulatory circuits, genes and proteins of TB. This iterative approach allows them continually to test and refine their understanding of TB pathogenesis. In addition, the lab is always looking to mine systems-level insights to identify and validate novel TB drug targets and to advance new drug candidates.

***Joseph Smith, PhD**
Dr. Smith studies the biology the malaria parasite during the blood stage. The research focus is the binding interaction between parasitized red blood cells and the host vascular system, a major virulence phenotype. We study how parasitized red blood cells attach to endothelial cells to “sequester” from blood circulation and the resulting vascular dysfunction mechanisms, in order to understand pathogenic disease mechanisms and to design disease interventions.

***Donald Sodora, PhD**
Dr. Sodora's research is focused on correlates of protection against HIV transmission and developing immune therapeutic approaches to confront HIV-induced disease progression. The laboratory utilizes HIV-infected patient samples as well as SIV-infected monkey models. The first area of research involves the assessment of the earliest events following transmission of HIV/SIV in a new host. Most of this work focuses on oral transmission (including mother-to-child transmission) that still occurs at relatively high levels in developing countries. The second area of research focuses on understanding how HIV/SIV infection results in disease progression and AIDS. Current studies are assessing dysfunctional immune responses to *M. tuberculosis* in HIV infected humans as well as employing different monkey models to provide mechanistic insights into these dysfunctions.

***Leonidas Stamatatos, PhD**
The emphasis of the Stamatatos group’s work is to develop a safe and effective vaccine to combat the spread of HIV and to investigate how HIV infection leads to AIDS. There are two major areas of research: (a) to better understand how neutralizing antibodies against HIV are developed during natural HIV-infection and (b) engineer immunogens that will elicit broadly neutralizing antibody responses against HIV. The lab seeks to: a) identify immunological pathways that lead to the development of broadly neutralizing antibodies during natural HIV infection and exploit these pathways for vaccine-related purposes, b) design immunogens that active the precursors of those B cells that give produce broadly neutralizing antibodies, and c) develop prime-boost immunization regiments to guide the maturation of those B cells clones that produce broadly neutralizing antibodies. This work encompasses the entire spectrum of basic to clinical vaccine research.

***Kenneth Stuart, PhD**
The Stuart lab investigates the molecular biology of protozoan pathogens with the intent of elucidating fundamental molecular processes and identifying drug targets, vaccine candidates and biomarkers for diagnostics. Most studies are focused on African trypanosomes that cause lethal human disease and *Leishmania* that cause mild to lethal diseases. One program focuses on RNA editing; a type of RNA processing that is unique to these organisms and hence, presents several promising drug targets. Projects include characterizing the process of editing and the multicomponent ribonucleoprotein complex that catalyzes this process and studying regulation of RNA editing during development, the protein products of edited mRNAs, and the physiological consequences of editing. A second program area is characterizing the mitochondrial proteome of *T. brucei* by identifying all the mitochondrial proteins, their suborganellar location, associations in complexes and changes during the life cycle. The intent is to identify the functions of these proteins and the functional networks.

***Naeha Subramanian, PhD**
Dr. Subramanian’s laboratory focuses on the molecular mechanisms of innate immunity mediated by a class of cytosolic sensor proteins, the NLRs (nucleotide oligomerization domain, leucine-rich repeat, receptors) that detect ligands of microbial or endogenous origin and stimulate innate immune activities. Gain of function mutations and polymorphisms in NLRs are associated with a host of severe human autoinflammatory and autoimmune disorders. Her lab aims to apply a systems approach to define NLR response phenotypes and associated signaling pathways. The goal is to provide insights into not only how NLRs normally function but to ultimately harness this information for therapeutic intervention in patients suffering from conditions related to aberrant NLR function.

***Patricia Totten, PhD**
Research in the Totten group focuses on the molecular biology and pathogenesis of the recently discovered STD pathogen, *Mycoplasma genitalium*. How this organism survives in vivo despite its extremely reduced

genome, the smallest of any free-living cellular form of life, is one of the exciting research areas being studied by this group. Their finding that *M. genitalium* can persists for months, if not years, in infected women lead to our hypothesis that this pathogen evades the host immune response, in part, by antigenically varying two of its immunogenic surface-exposed proteins. Supporting this hypothesis, they have shown that the sequences of the genes encoding these proteins evolve in vivo using a unique mechanism of reciprocal recombination with non-coding homologous DNA distributed throughout its minimal chromosome. Further, contrary to the accepted wisdom that this bacterium contains few regulatory genes, the Totten lab has shown that recombination leading to antigenic variation is regulated at the transcriptional, post transcriptional, and translational levels. The novel recombination and regulatory mechanisms of antigenic variation, the biologic significance of the resulting antigenic variants, and the immunopathology of *M. genitalium* infection in human and in experimental primate model are ongoing studies in the Totten laboratory.

In addition to the studies outlined above, they have worked closely with epidemiologists and clinicians to define the disease associations of *M. genitalium,* which include urethritis in men and cervicitis, acute endometritis, and chronic pelvic inflammatory disease as well as cervical shedding of HIV. The results of their recently completed treatment trial revealed that antimicrobial resistance of *M. genitalium* is correlated with clinical failure and persistence of this organism *in vivo*. Further, these studies have provided them with recent (and numerous) isolates of this pathogen with matched serum specimens and clinical correlates, providing a link between their basic science and translation studies.

***Kevin Urdahl, MD, PhD**
The Urdahl lab uses the highly tractable mouse model to study T cell mediated immunity against *Mycobacterium tuberculosis (Mtb),* the bacterium that causes tuberculosis*.* They aim to understand the factors that promote, as well as restrict, protective immunity against pulmonary Mtb infection, and are driven by the belief that such understanding will be critical for rationally designing an effective TB vaccine.

***Wesley Van Voorhis, MD, PhD**
There is a great need for new drugs for parasitic diseases, such as malaria, African Sleeping Sickness, Chagas' disease, and leishmaniasis, which sicken or kill over 200 million people per year. Though some pharmaceutical companies devote research effort to discover drugs to cure such diseases, there is little done given the need as the people with these diseases have little money to pay for medicine. Dr. Van Voorhis's research group uses emerging knowledge about the genomes of these parasites to aid in rational drug discovery. His research group and collaborators have developed a website called TDRtargets.org, which allows pharmaceutical companies and scientists to select optimal drug targets from the genomes. His lab has found several potential drugs, based on several enzymatic targets from the parasites' genomes that show great promise. The challenge now is to optimize these candidates to become effective and safe.

* Member of Graduate Faculty