Positioning a Medical School for Modern Biomedical Research: The Department of Genome Sciences at the University of Washington School of Medicine

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Abstract

The availability of genome sequences from a multitude of organisms, which began about a decade ago, has had enormous impact throughout the biomedical sciences. These sequence data have changed the way research studies are carried out and have led to the explosive growth of computational biology as an approach to analyze biological processes and evolution. In medicine, the completion of the human genome sequence has illuminated the function of many genes, facilitated the correlation of mutant genes to disease phenotypes, and provided a basis for the study of human variation.

At the University of Washington, the two academic departments whose overall programs were most centrally affected by the sequencing revolution were Genetics and Molecular Biotechnology. These departments were fused in 2001 to form the Department of Genome Sciences in order to best exploit these developments and to become a prototype for the basic biomedical science department of the future. The department's goal is to address leading-edge questions in biology and medicine through the application of genetics, genomics, proteomics, and computational approaches to the increasing collection of known genome sequences and their encoded products. The authors review the events that led up to the founding of this department and discuss the initiatives that have been undertaken, which include the recruitment of faculty, the establishment of a new interdisciplinary graduate program, the continued development of an outreach program, and the construction of a building to house the department. Lessons learned in crafting this department are also discussed, as well as how these might apply to other medical schools.

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That academic medical centers across the country have different complements of basic science departments testifies both to the tremendous breadth of research encompassed in modern medicine and to the diversity of approaches used to categorize this research. The creation of new departments often reflects a response to changes in science and medicine. The Department of Genome Sciences in the University of Washington School of Medicine (UWSOM) grew out of discussions among faculty and deans in two schools of the university about how we could best capitalize on the extraordinary recent progress in biological research. This progress included the determination of genome sequences for a host of organisms, including the principal model organisms and many human pathogens; the rise of computational biology as a means to interpret these sequences; and the development of powerful technologies for genomic and proteomic analysis. In medicine, the completion of the human genome sequence has been used in deciphering the functions of human genes, in mapping disease mutations, and in studying human variation. The new department was thus centered around four overlapping interests: experimental (model organism) genetics, human genetics, computational biology, and technology development. We chose to combine a strong set of existing faculty from two departments with recruits from outside the university. Currently, among the approximately 30 faculty with primary or joint appointments in Genome Sciences are nine members of the National Academy of Sciences, three investigators of the Howard Hughes Medical Institute, two winners of the Peter Gruber Foundation Genetics Prize, three of the eight winners of the Gairdner Foundation Award for their contributions to the Human Genome Project, and a Nobel laureate.

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The History of Genome Research at the University of Washington

The Department of Genetics in the University of Washington College of Arts and Sciences was founded in the late 1950s to be an environment where genetic analysis would be applied to model organisms. The department's research focus was on bacteria, yeast, the nematode worm, and the fruit fly, with its yeast laboratories in particular becoming the leading center for research on this organism. Additionally, the Department of Genetics developed a reputation for strong undergraduate and graduate training programs. By contrast, the Department of Molecular Biotechnology, founded in the early 1990s as a department in the School of Medicine,

had a different research emphasis. It was unusual in its concentration on innovating new biological technology, including mass spectrometry, flow cytometry, DNA sequencing and variation technology, and fluorescence in situ hybridization. This focus meant that not just biologists but engineers, physicists, chemists, and computer scientists were members of molecular biotechnology. In common, both departments were already distinguished in computational biology, and the computer programs they produced to analyze phylogenetic data, DNA sequence data, and mass spectra were widely distributed. These departments interacted with numerous other units within the university that carried out related research. For example, the Division of Medical Genetics in the Department of Medicine had a long history of notable studies related to clinical and molecular genetic analysis of human disease, and the Department of Bioengineering included faculty working on biomaterials, tissue engineering, and computational analysis.

The Department of Genetics and the Department of Molecular Biotechnology had open chair positions in 2000 with the prospect of extensive faculty recruitment and, for genetics, renewal of facilities. It was apparent to the two faculties and to the university that only the School of Medicine had the resources to capitalize on these openings. This led to extensive discussions about the possibility of a merger, initially among each department's faculty meeting separately and subsequently with the two faculties meeting together and then with the deans of Medicine and Arts and Sciences. The rationale for combining the two departments into one was that the merged department would have the immediate critical mass required for the University of Washington (UW) to move forward quickly and build on its strengths in the burgeoning area of genome analysis. The charge to the new Department of Genome Sciences was to recruit the next generation of faculty; to create undergraduate and graduate programs that would take advantage of the recent, far-reaching progress in these fields; to collaborate with other units within the university to exploit new tools for genome analysis; and to continue an active outreach program that addressed K–12 teachers and students. This department would blend the cultures of molecular biotechnology, with its emphasis on interdisciplinary research, and genetics, which had excelled in the analysis of specific biological problems in simple organisms. The goal, however, was to create a department around a different vision than that achievable by either of the existing units alone.

The merger of these departments with different cultures from two different schools in the university was marked by several challenges. The conversion and transfer of appointments in the College of Arts and Sciences to appointments in the School of Medicine, while maintaining a commitment to undergraduate education and the integration of scientists with large and small labs, were just a few of the issues faced in launching the new department.

Highlights of the Department of Genome Sciences

Research agenda

The central goal of the Department of Genome Sciences is to address leading-edge questions in biology and medicine through the application of genetics, genomics, proteomics, and computational approaches to the increasing collection of genome sequences and their encoded products. Scientists in the department explore fundamental biological and genetic processes such as reproduction and development using the model organisms yeast, roundworms, fruit flies, and mice. We apply and develop novel genomic and proteomic technologies to enable new insights into fundamental biological and cellular processes, not only in model organisms but also in humans. In particular, we apply sophisticated computational tools and develop mathematical and statistical approaches to further our understanding of biology and medicine. Critically, each of these foci now takes place in the context of the other disciplines. One of the important opportunities and challenges for genomics lies in the translation of these findings and approaches to medicine. We are already making rapid advances in this area by exploring the development and treatment of common diseases such as cancer and cardiovascular disease. Translational research will remain at the forefront both of our new department and of academic medicine for many years to come.

Faculty recruitment

With the launching of the Department of Genome Sciences within the School of Medicine in 2001, an effort began to attract outstanding new faculty. Search committees made up of primary and associated faculty of the department sought to identify promising young scientists. More than a half dozen faculty have been recruited over the past four years, with genome perspectives encompassing a broad range of interests, including computational biology (William Noble), mass spectrometry of proteins (Michael MacCoss), evolution of reproductive genes (Willie Swanson), population structure and genetics (Joshua Akey), human gene evolution (Evan Eichler), regulation of gene expression (John Stamatoyannopoulos), and analysis of development (Robert Waterston, as the Gates Chair of Genome Sciences). The interchange of these new faculty programs with the merged faculty has stimulated thinking in novel directions and led to much productive collaboration. Existing programs have been invigorated and new directions undertaken.

Graduate education in genome sciences

Following the merger, the department created a new PhD program, which currently enrolls about 70 students. This program is tailored to the backgrounds and goals of individual students and has welcomed many with experiences not traditional for biology graduate students. The program includes as mentors the approximately 20 faculty with primary appointments in genome sciences as well as more than 20 others whose primary affiliations are in medicine, computer science and engineering, biochemistry, biology, pathology, biological structure, statistics, or biostatistics, or at the Fred Hutchinson Cancer Research Center. The graduate program has a completely redesigned core curriculum, featuring courses in genetic analysis, genomics, proteomics, and informatics, with electives in statistical and computational genomics, population genetics, and the genetics of human disease. Students are encouraged to reach outside their area of expertise, and a substantial number are combining wet lab, experimental, and computational approaches in their degree

work. The students thrive in the interdisciplinary culture, showing a willingness to take on challenges and cultivating ties between classmates that foster collaborations across the full spectrum of the department. The program has attracted top students in growing numbers from across the world every year, each of whom brings enthusiasm and a fresh perspective to the department. Additionally, the generation of this new department played an important role in the continuing success of training grant funding in both genetics (from the National Institute of General Medical Sciences) and genomics (from the National Human Genome Research Institute). In addition to its role in graduate education, the Department of Genome Sciences has continued to offer undergraduate courses as the Department of Genetics had done previously and has initiated new courses such as Genomes and Society, and Debates in Genetics.

The department's primary mission is to continue its basic research agenda, encompassing the training of graduate students and postdoctoral fellows. However, along with these groups, medical students (generally as part of UW's Medical Scientist Training Program) and physicians (generally as fellows) have also joined the department's research efforts. In addition, some of the faculty in the department's graduate program teach in the medical school, including courses such as Human Biology–Genetics (Marshall Horwitz) and a clinical clerkship in Medical Genetics (Gail Jarvik, Peter Byers, Arno Motulsky, George Stamatoyannopoulous, and Horwitz). Finally, UW has started a Molecular Medicine Training Program that will train graduate students to apply basic science to human disease, incorporating case-based courses, clinical involvement, and dual mentorship of research by a basic scientist and a clinician scientist. Several genome sciences faculty have been instrumental in the creation of the program and more will participate as the program gets underway.

Collaborative interactions

The departmental model for interaction and collaboration has attracted others from across the university as well as from institutions throughout Seattle. From the start, the department has had close ties with the Division of Medical Genetics of the Department of Medicine, and the two units continue to work together to find ways to study human variation more effectively and to increase their impact on health care. The core of computational biologists in the department has played a central role in the creation of a university-wide computational molecular biology program, with members from seven different departments. State funds have been committed to a Center for Proteomics, based in the Department of Genome Sciences but with the participation of four other departments. Members of the department are integral components of a number of large programs funded by the NIH, including the Yeast Resource Center (National Center for Research Resources), the Center for Research in Reproduction and Contraception (National Institute of Child Health and Human Development), the Program for Genomic Applications (National Heart Lung and Blood Institute), the Environmental Genome Project (National Institute of Environmental Health Sciences), the Pharmacogenetics Research Network (National Heart Lung and Blood Institute), and the ENCODE Project (National Human Genome Research Institute).

A new building to house the department

The growth in faculty and students was made possible by the commitment of resources to this exciting area from the medical school administration and by the construction of the William H. Foege Building, a 260,000 square foot, $150 million facility, opened in 2006 and made possible by funding from the Bill and Melinda Gates Foundation and others. The building brings together all of the department's primary faculty and increases the space available by more than 50%. The design incorporates numerous features to encourage interaction, with dry and wet labs on every floor, an open connecting staircase, open doors, and common spaces on every floor. The building also houses a 200-seat auditorium. In addition to genome sciences, the Foege Building is the home to the Department of Bioengineering, a fitting connection between the two departments. The Department of Bioengineering helped recruit the initial faculty of molecular biotechnology, provided some of its first graduate students, and fostered the development of the original courses in that department, such as Technologies for Genome Analysis. Sharing a building should further the development of many collaborations between genome sciences and bioengineering faculty.

Outreach programs

The integration of the human genome sequence into biology and medicine presents unique social and ethical challenges that require everyone to understand the implications of new insights to make informed decisions. To prepare society for these challenges, the department houses an outreach group, founded in 1993 as part of the Department of Molecular Biotechnology. Outreach education in the Department of Genome Sciences brings leading-edge science and ethics to teachers and students in K–12 schools, with faculty providing guidance in project design and implementation. These programs provide interdisciplinary, hands-on science curricula, teacher training, equipment, and support to promote systemic change in schools. Staff members include Maureen Munn, PhD, Megan Brown, PhD, and Kristi Martinez. This group is funded by national agencies, including the National Institute on Drug Abuse and the Department of Energy; private foundations, including the Howard Hughes Medical Institute and the Amgen Foundation; and private donations.

The outreach programs support classroom activities and provide professional development for teachers. The StarNet Project (principal investigators Maynard Olson, Debbie Nickerson, and Gail Jarvik) provides opportunities for high school students and their teachers to participate in authentic research. The current research project involves collaboration between teachers, students, outreach scientists, and the public to develop a multiyear case-control study investigating the association of genetic and environmental factors with smoking behavior. StarNet provides teacher professional development and supply kits to support classroom participation.

Another project, titled Bringing Biotechnology to King County Teachers (principal investigator, Robert Waterston), provides a six-day teacher professional development experience for 32 teachers throughout King County that

covers the fundamentals of biotechnology and bioinformatics in the context of learning about biomedical research and drug development and discovery.

A third project, the Science Education Partnership, brings more than two dozen science teachers from Washington and more distant locations to spend part of their summer vacation at "summer school." The Science Education Partnership is a professional development program for teachers offered by the Fred Hutchinson Cancer Research Center and partner institutions, including the Department of Genome Sciences, that provides teachers with the opportunity to work beside scientists in research laboratories at sites throughout Seattle. After a jumpstart session to learn laboratory basics, the teachers spend about half of their time working one-on-one with a scientist-mentor in a research laboratory on projects tailored to their interests. This mentorship often leads to lasting partnerships that extend beyond the summer session to include classroom visits by scientists during the school year.

The outreach group also collaborates with department faculty and other UW programs on their outreach efforts. Further information is available at (http://chroma.gs.washington.edu/outreach).

General Lessons from the New Department

What lessons have we learned from the creation of the Department of Genome Sciences at UWSOM that may be applicable to other academic medical centers? First, we built the department around existing strengths within the university—in our case, faculty with excellence in genetics, technology, and computational biology. Other universities seeking to capitalize on recent developments in biomedicine may develop programs that coalesce around their own unique strengths in departments focused, for example, on specific diseases, on approaches such as physiology or pharmacology, or on technologies like imaging or bioengineering. By building on our strengths, we were able to recruit exceptional faculty who were eager to join the department.

Second, we were able on many occasions to cross the borders of the university and the larger Seattle area. The department itself combined faculty from the School of Medicine and the College of Arts and Sciences; the graduate program encompasses faculty from those units as well as the College of Engineering, the School of Public Health and Community Medicine, and the Fred Hutchinson Cancer Research Center; and the outreach programs work with other Seattle institutions and biotechnology companies. Because institutional provincialism can be the most formidable barrier to the success of a new enterprise, a spirit of collegiality is essential, especially in the early planning of such an undertaking.

Third, we crafted the department from a faculty view, rather than an administrative one, but with the enthusiastic support of university administrators. Encouraged by the deans of Medicine and Arts and Sciences, the faculties of genetics and molecular biotechnology held numerous meetings to decide whether a merger was worthwhile and then to develop a vision for what became the Department of Genome Sciences. That vision then guided the process and helped ensure that we could surmount the rocky patches that inevitably crop up in a complicated venture. Once the department was in place, the School of Medicine secured the funds to attract a chair and construct a building.

Fourth, we put a major emphasis on establishing a graduate program that attracts the best students. Graduate education is in many respects the glue that holds a research department together, as the students work in multiple labs before committing to a thesis lab, become familiar with each other's efforts through academic and social interactions, establish joint projects that involve more than one faculty member, and form thesis committees of mentors who span broad areas of science.

Finally, the department developed collaborative research projects that joined our strengths with those in other areas, especially clinicians interested in applying genomic technologies to medical problems. Given the scale and complexity of current biomedical research, no single unit could hope to tackle major problems and to garner the grant awards necessary to complete large projects.

The creation of the Department of Genome Sciences has stimulated an increased emphasis school-wide on genomic approaches to biomedical science and has brought UW to national prominence in this emerging discipline. As we complete our move into our new building and continue to attract outstanding faculty and students, the University of Washington is positioned to be a national leader in unlocking the basic code and secrets of the genome with all its implications for developing new insights into human health and its translation into preventive medicine.