Review of the Graduate Program in Genome Sciences
December 2006

Overview

The review of the graduate program in Genome Sciences took place on December4-5 2006. The review committee consisted of two external reviewers: Jasper Rine, Professor, Department of Molecular and Cellular Biology, University of California Berkeley and Barbara Wold, Professor, Division of Biology, California Institute of Technology, and three reviewers from the University of Washington (U of W): Wylie Burke, Professor and Chair, Department of Medical History and Ethics, Mani Soma, Professor, Department of Electrical Engineering, and Christopher Wilson, Professor and Chair, Department of Immunology.

This is the first review for the graduate program in Genome Sciences, which was formed following approval by the University of Washington Regents in November 2002 and admitted its first entering class in the fall of 2003. While new, this graduate program is heir to a rich history, being derived from the fusion of the graduate programs in Genetics and Molecular Biotechnology. Both of these graduate programs and the departments in which they were based were, in their day, leading centers of innovation and discovery. Then, at the dawn of the new millennium and in recognition of the opportunities provided by the availability of complete genome sequences of humans and many other species (an accomplishment to which members of these departments made important contributions), and with valuable input from the faculty and the broader scientific community, a merger of these two departments was proposed. This vision of the future was compelling to the Deans of the College of Arts and Sciences and the School of Medicine, whose willingness to compromise, share resources and take risks has been richly rewarded. In the short period since its inception in September 2001 as the new Department of Genome Sciences, based in the School of Medicine, this Department has established itself as one of the leading programs nationally and internationally in this field of endeavor. It is a unique asset to the University of Washington.

There are currently 48 training faculty in the Graduate Program in Genome Sciences. Half of the training faculty have their primary appointment in the Department of Genome Sciences, and half have primary appointments in other departments or at the Fred Hutchinson Cancer Research Center (FHCRC). Twenty-four faculty have joined the Program since 2002, including seven faculty who have been newly recruited to the Department of Genome Sciences. The overall quality of scholarship by the faculty is outstanding, as evidenced by their publications, current funding, honors, appointments to editorial boards and national committees, and the like. Eleven faculty are members of the National Academy of Sciences and six are investigators of the HHMI. The graduate students were uniform in their praise for the quality of the faculty, which was a major factor in their decision to join this program and to turn down other highly competitive programs.

The Program and Department have strong leadership. The proposal for the Graduate Program in Genome Sciences was submitted by Stanley Fields, who was Acting Chair of the Department from 2001-2002. He played an important role in achieving a harmonious merger of two distinct faculties and in developing the initial vision and structure of the program. Robert (Bob) Waterston was recruited as Department Chair in 2002. He is held in the highest regard by the faculty and students. His open, accessible and collegial style of leadership and his unquestioned integrity and devotion to the development of the Program and its multiple missions serves as an example to all. It is hard to overstate the importance of his contribution in building what appears to be a highly collegial community of scholars.

When the Department of Genome Sciences was conceived and its Graduate Program proposed, there were concerns that inequity in the quality of the facilities and in the salaries of the faculty from the two parent departments - if carried forward - could undermine this new enterprise. These concerns have been allayed. Funds to construct a new, state-of-the-art building to house the new Department were provided by a generous gift from the Gates Foundation and an infusion of funds brought the salaries of the faculty into much greater parity. These two events have done much to raise the overall esprit de corps of faculty and trainees alike and to foster the sense of community and collegiality that was evident during the review.

In brief, this Program has great strengths. The faculty are strong and well-funded, and they work in superb new facilities. The program attracts top graduate students who interact well with each other and who have a productive collegial relationship with the faculty. Unusual among departments in the School of Medicine is the breadth and depth of the Department's commitment to high-quality undergraduate teaching. In the course of reviewing this Program, we identified some opportunities for improvement. These findings and our recommendations in no way detract from our impression that this new Program and Department are an overwhelming success.

Graduate Student Recruitment

The Department has a strong applicant pool and has been able to enroll an impressive group of graduate students. In fact, the applicant pool appears to have become more competitive since the formation of the Department of Genome Sciences. The applicant pool appears to include a somewhat higher proportion of students interested in computational biology than in experimental genetics, possibly reflecting the unique profile of Genome Sciences.

The Department has been proactive in seeking minority students, resulting in a current enrollment of 5 students from underrepresented minorities out of a total enrollment of 57. The Department is to be commended for this track record, which reflects considerable success for this field of endeavor. The department has no faculty from underrepresented minorities. This is understood to be a more difficult recruitment challenge, but every effort should be made at the university

level to support the Department in its ongoing efforts to identify and recruit these rare minority scientists.

By contrast to their success in recruitment of minority students, the department has been less successful in recruitment of female students, with the proportion of women students well below half. The recruitment of female faculty has also been a problem. The Department has several senior female faculty, but no junior female faculty. In two recent searches, offers were made to two highly competitive female applicants and considerable effort by the Chair and faculty was invested in the recruitment effort. In both instances the applicants went elsewhere, in part at least as a result of better spousal offers at competing institutions. One aspect of this problem, for which no short-term solution is available, is the relatively small number of women at all stages of the educational pipeline in computer sciences and computationally intensive aspects of biology here and elsewhere. For example, a recent report showed that in 2004-2005 fewer than 25% of U of W bachelor's degrees in mathematics/statistics, computer science or engineering were awarded to female students (http://seattlepi.nwsource.com/local/295765_genderstudy13.html). Nonetheless, this problem – at both the student and faculty level - is well recognized by the Department, and current recruitment efforts are attempting to address it.

Environment for female students, post-docs and faculty

Comments during the site visit suggested that additional actions could be undertaken to support further the recruitment of female students and to increase the supportiveness of the environment for female students, post-docs and faculty. For example, it would be helpful for female applicants to have more explicit opportunities to interact with female students and faculty during the interview process. The Department already has plans do so - for this coming year's recruitment visits, candidate women and faculty will be invited to dinner at the house of one of the senior female faculty, Mary Clair King, the evening before the formal visit. As an additional approach, more support might be made available to female graduate students and post-doctoral fellows through connections with other programs within the University that are aimed at providing mentoring and support to female students and faculty, such as ADVANCE (www.engr.washington.edu/advance/) and School of Medicine mentoring and faculty development programs. Other ideas for support may emerge from the recently formed grassroots Women in Genome Sciences (WIGS) group, which is receiving well-deserved support of the Department.

Some environmental issues are beyond the scope of the Department's power to solve on its own, but are nevertheless increasingly critical. For example, on-site day care (such as exists at the FHCRC), would increase the supportiveness of the environment, for all students, post-docs and faculty with children (whether male or female) at the U of W. We strongly advocate for this resource as a significant contribution to recruitment of students and faculty, to retention of faculty, and ultimately to filling the pipeline. Our interviews with students and postdocs

revealed that making the path to high quality family life easier for couples with two demanding professional careers is key for keeping successful women in the pipeline toward faculty positions. This will clearly affect recruitment and success of both male and female faculty, though female faculty are disproportionately affected. And though onsite-care will only be achieved through action by the U of W administration, the Department is encouraged to be creative on its own, for example by helping with nearby daycare arrangements of diverse kinds, tailored to the needs of their community.

Graduate Student Progress and Advising

The faculty are seen by the students and post-doctoral fellows as strongly supportive of their academic pursuits. The environment for graduate research is very good and there is a genuine atmosphere of a scholarly community. While there have been some cases in the past where students might have fallen through a crack in the support system, these cases were rare and this issue appears to have been addressed successfully.

Two areas for possible improvement are the advising of first-year graduate students and career advising for students closer to completing the Ph.D. We recommend that the Department provide a more visible advising program for first-year students, to assist them to learn not only about academic offerings but also about expectations for graduate research training, working with different personalities, mechanisms to resolve misunderstandings between faculty and students, etc. In place of a single Graduate Program Advisor, we recommend designating a small team of two to three faculty, including at least one female faculty member, to encourage students to seek advice and guidance early on if they need it, and suggest that the students be invited to nominate faculty they think would be particularly effective. We of course expect students to be responsible and take the initiative in bringing issues to one of the graduate advisors or another appropriate faculty member. Early and frequent communication to first-year students about the availability of the advising team members will help to ensure that students seek and receive help early with any questions or problems.

Career advising for senior graduate students is also an essential issue. While the faculty are knowledgeable regarding academic career options, there should be similar resources for students to consult with respect to careers in industry, government or consulting. Considering the diversity of the biotechnology industry in the Puget Sound area, it would not be too difficult to provide these resources to assist students in career planning, especially when there are similar efforts in other departments in the School of Medicine, College of Engineering, College of Arts & Science, School of Business, etc.

Graduate Curriculum

The graduate curriculum makes innovative use of the flexibility of 5-week courses on focused topic to provide a core curriculum which all students are expected to take in their first year. In addition, all students take GS550, a literature-based

course designed to introduce them to the challenges of reading the primary literature in genomics, genetics and related technologies. The primary responsibility in the second year is to initiate the thesis projects and to prepare for and complete the qualifying exam. We are aware that the graduate curriculum should be viewed as a work in progress and that adjustments are being made. The Chair told us early on that the present focus was on revamping the undergraduate curriculum, with revision of the graduate curriculum to follow.

To evaluate the effectiveness of the current and past curriculum, we met with the graduate students in Genome Sciences in three different groups: 1st year students, 2nd and 3rd year students, and 4th year and above students. The later group was predominantly made up of students accepted initially into the former Departments of Genetics or Molecular Biotechnology, whereas the middle group was most helpful in getting a sense of the effectiveness of the current offerings.

Our chief observation is that each of the entering classes in the Genome Sciences Graduate Program is highly appreciative of the expertise of the faculty and the commitment of the faculty to the success of the students. The informal aspects of modern training in Genome Sciences, in which much of the teaching takes place outside of the classroom, seems to be on a par with that found in the top programs in the country. We were also impressed by how important the small size of these classes was to the students. When non-Genome Sciences students were let into some of these classes, doubling the size to 20, the students reported a distinctly less satisfying experience.

In the classroom, the 5 week modules are designed to allow accommodation for the varied backgrounds of the Genome Sciences students, some of whom begin with little computation or programming experience, and some of whom begin with no experimental background. We acknowledge that there can be no solution for teaching to this breadth that is optimum in each course for each student. Instead the issue is whether the correct balance has been found. We judge the present course work to be good, but in need of some attention. The single most common opinion of the students is that more training in statistics is needed and would be welcome. We agree, and we perceive this to be a common problem in biology graduate education nationwide, so the situation here is far from unique. Statistics is not even required for undergraduate math majors, so it is no surprise that biology graduate students would be, as a class, in need of more instruction. We learned that some of the students have found course work in other departments on campus to fill this gap. An undergraduate 300 level course in statistics is one example, and a biostatistics course in public health is another. These are not, however, optimal. As a first step, it would be highly desirable to find a way of integrating some offering of this type in the curriculum, perhaps by way of offering a graduate level discussion or problem session to one of these offerings, so that the course can satisfy one of the degree requirements. We are also convinced that the need for some solution to this problem is widely recognized by the faculty and that solutions can be crafted. The recruitment of John Storey to U of W, whose statistical research is on relevant biology issues,

would be a logical opportunity to devise a tailored long term solution. We believe that adding a recommendation for a background in statistics to the web site describing the graduate program for prospective applicants will start to address the problem. At the University level, we also recommend considering whether a course in statistics should be added to, or substituted for, a degree requirement for an undergraduate degree in biology. Such a move by as important an institution as U of W would likely contribute to the adoption of similar requirements at the institutions from which Genome Sciences recruits graduate students.

The concept of introductory modules was endorsed and appreciated by the students, but there seems to be a remaining unmet need between the level of expertise achieved in the current curriculum and that needed for a professional level of understanding in the field. For example the 5 week programming module taught by Noble is popular, yet students whose only exposure to programming is through this course are not adequately prepared for the graduate level offerings by Felsenstein or Green. Likewise, these offerings are not adequate for the students to understand research seminars on distant topics within Genome Sciences. This gap is well known to the faculty, and indeed the most common recommendation received at the end of the 5 week programming module is that it should be a 10 week course. It is not clear how this gap will be closed. We are agnostic regarding whether a typical Genome Sciences student can be truly trained to a professional level in both computation and experimentation in the course of one Ph.D. training period. It is clearly a worthy goal and ideal, but one that we think will typically be approximated with some measure of compromise, often defined in considerable part by the specific nature of each thesis project. This seems appropriate.

We also found that the students strongly believe they would like to see the Genome Sciences faculty teaching more in their area of expertise. The Eichler/King Human Genetics course was recognized as an outstanding example. Upon reflection, we are not sure exactly how this recommendation is compatible with the current teaching loads, but offer it as guidance and encouragement in thinking about future revisions in the undergraduate curriculum and how that impacts the graduate curriculum.

<u>The Graduate Seminar experience</u>

The graduate students in the department enjoy and value extensive interactions made through their various research seminars, journal clubs, and departmental seminars. Indeed the common participation in these experiences was important to the strong bonds enjoyed among past students in the Genetics Department. As Genome Sciences grows, especially with anticipated growth in the number of students in the proteomics facilities planned for South Lake Union and the migration of students to the FHCRC, maintaining this camaraderie will be a growing challenge. The highly respected Chair might exert an influence, in the manner of the legendary Hershel Roman, by dropping in to discuss attendance with those who need a transfusion of community spirit. Nevertheless, it is

unlikely that the same level of communion will be sustainable with the students outside the Foege Building. It would be desirable to incorporate more extensive communication technology among all sites of training to ameliorate this problem. Potentially, the visibility of the program would be attractive for donations of communication technology from leading vendors.

Graduate Fellowships

Our impression is that for students of the caliber recruited to this program, one or two should be competitive for NSF fellowships each year. Fewer than that are received. Considering the value to the program of each 3-year fellowship, and the value of the experience in grant writing (and dealing with rejection), we recommend considering whether each first and second year student should be required to submit an NSF pre-doctoral fellowship application each year. We also noted that for historical reasons students doing their thesis work in laboratories of some of the faculty from the former Department of Genetics appear not be eligible to apply for support by the Cellular and Molecular Biology training grant. The Chair may wish to address this issue with the director of that training grant, as another way of increasing opportunities for graduate student support and addressing one of the last inequities that has persisted after the merger.

Undergraduate curriculum and teaching

Undergraduate teaching in the Biology curriculum of the U of W is a major activity for all graduate students and all faculty in the Genome Sciences Department. This is quite unusual. The universality and amount of involvement in undergraduate teaching by this School of Medicine department is high compared to the norm for major research universities. All Genome Sciences graduate students are required to TA for one quarter per year over two years, and typically do so in their 3rd and 4th years. This is a benefit to undergraduate students, because relatively senior TAs have maturity and knowledge that graduate students typically lack in earlier years. It is a benefit to the graduate fellows for honing their skill as teachers and for giving them a common ground in genetics in a diverse department. The amount and types of teaching required of Genome Sciences graduate students is highly appropriate.

The largest undergraduate commitment is the Genetics course, GS371. Under a recently revised plan, all faculty and grad students from Genome Sciences participate in teaching it. The importance of this course to the University recently increased significantly due to changes in the Biology curriculum. Specifically, most genetics topic matter was removed from the first year introductory series for Biology majors. A logical and appropriate response was to make Genetics (371) a mandatory course for majors, and this is what the University did. At about the same time, Genome Sciences faculty Professors Berg and Brewer worked together to substantially redesign 371 to include a highly integrated laboratory component. The course now has nearly 700 students, a large fraction of them seniors. Teaching the course (offered all four quarters) will now be divided in a new way so that every Genome Sciences faculty member will teach it for one quarter in three successive years. Ultimately, every faculty

member will do a three-year rotation. The buy-in of faculty for this inclusive plan is extraordinary, as was the process by which the plan was made. It appears to be an example of very effective leadership and decision-making-by-consensus characteristic of this recently fused department under Bob Waterston's chairmanship. It remains to be seen how well this will work, and we urge that the department plan to evaluate its success from all three perspectives – the undergraduate students, the graduate TAs, and the teaching faculty – as it launches and during its early rotation years.

The panel drew four specific conclusions about 371. First, undergraduate teaching activity, and especially 371, is a major contribution by Genome Sciences graduate students and faculty to the university. Second, Graduate TA support for students when they are engaged in this activity is appropriate, but the panel understands none is supplied by the University. This is exceedingly difficult to understand and merits a rethinking at the University level. Third, the course needs logistic support it is not currently getting from the university. Specifically, as a required course for all Biology majors, it should have assured lab space for each of the four terms. Finally, for the benefit of undergraduate biologists, it is important that they be able to take the class late in the sophomore year or early in the junior year. It is decidedly detrimental to remain ignorant of genetics and its underlying logic until the senior year.

In addition to GS371, the Department of Genome Sciences has begun to develop and offer additional valuable undergraduate courses. The first of these is in Bioinformatics. It features both programming activities and exposition of the experimental contexts that produce the data. All major institutions should offer such a course but most do not yet do so. This is a benefit to the U of W undergraduate program. Additional courses are in contemplation, and the ideas for these sounded like very positive contributions to the curriculum. Given the power and importance that human genetics, medical genetics and genomics has in the future for all educated citizens – both in and out of Biology- these initiatives and activities should be rewarded and facilitated. We do however urge caution in matching the added workload to acquisition of additional faculty.

Summary

1. Since its formation in 2002, the Department of Genome Sciences has established itself as one of the leading programs in this field of endeavor.
2. The Department enjoys strong leadership. The Chair is highly regarded by faculty and students alike and his leadership has played a key role in the creation of a harmonious, forward-looking Department.
3. The Graduate Program in Genome Sciences attracts top students. The quality of the applicant pool and matriculated students is stronger now than ever.
4. While the Program has, for this field of endeavor, a commendable record in minority student recruitment, they have been notably less successful in recruitment of female students (and faculty).

5. While the environment for graduate research is strong, the advising program for first year students and for students nearing completion of their doctoral work is perhaps a bit too informal. While this may work well for some students, others are likely to benefit from a more pro-active approach.
6. The graduate curriculum is good, but training in statistics could be strengthened (as can be said for nearly all graduate programs in biological sciences at the U of W and elsewhere). There also remains a gap between the introductory programming course module and the more advanced offerings in this area.
7. The distribution of students into laboratories at locations other than the main campus, will likely grow in the future, presenting challenges to programmatic cohesion.
8. The commitment and contribution of the Department and its graduate students to undergraduate teaching is exceptional and commendable for a Program that is based in the School of Medicine. In particular, the plan for universal participation of all departmental faculty and students to teach in BI/GS371 is extraordinary and a grand experiment whose success for faculty and students alike should be periodically assessed.
9. Given this commitment, it is disconcerting to see that Genome Sciences must 'beg' for teaching laboratory space on a quarter-by-quarter basis, and has no financial support from the U of W for graduate TAs.

Recommendations

1. The Graduate Program in Genome Sciences should be renewed for 10 years.

   The Program is encouraged to:
2. Evaluate and consider ways to augment their efforts to recruit female graduate students. To this end, the Program's plans to increase contact between female applicants, current students and faculty are positive. This effort, and the effort to further enhance recruitment of minority students, could be positively influenced by recruitment of female and minority faculty.
3. Consider more proactive guidance of first year students, to assist in selection of first year rotations and thesis advisor and provision of additional resources for students considering non-academic careers.
4. Strengthen graduate student training in statistics and consider adding a recommendation for a background in statistics to the description of the graduate program for prospective applicants. In this regard, if statistics were added as a requirement for the undergraduate Biology major at the U of W, the benefits would have a positive impact that would extend beyond its walls.
5. Consider whether the introductory programming course module should be expanded from 5 to 10 weeks.

6. Consider ways to incorporate more extensive communication technology to address the challenge posed by an increasing fraction of graduate students working in laboratories at locations other than the main campus.
7. Teaching of GS371 merits a greater commitment from the U of W in terms of graduate TA financial support and assured teaching laboratory space for all sections.
8. The Department's proposal to add new undergraduate course offerings is positive, but the resource costs should be considered carefully before proceeding.