Self-Study for Program Review:

# Department of Genetics

# University of Washington

# November 1999

Programs under review:

Master of Science and Doctor of Philosophy in Genetics

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Chair:

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Master of Science and in Genetics

D. Brief history:

The Department of Genetics was founded in 1959 by Prof. Herschel Roman, who recruited faculty working with organisms that were crucial to the discipline at that time, including bread mold (David Stadler), fruitflies (Lawrence Sandler), bacteria (Jonathan Gallant ), and bacteriophages (Augustus Doermann and Benjamin Hall). Cooperation with the Medical School also provided for the joint appointment of two of the pioneers of human genetics (Stanley Gartler and Arno Motulsky). Roman had trained in the genetics of maize, but he initiated ground-breaking new work on budding yeast soon after his move to Seattle. Due in large part to the stimulus of his early studies, yeast has gradually emerged as one of the more powerful systems for genetical research, and it now encompasses the work of thousands of scientists worldwide. Founding members of the Department established a tradition of open communication and intellectual interaction, while focusing on the development of their graduate students as productive scientists, effective speakers, and dedicated teachers. The Department flourished as evidenced by the renown of its graduate program and by the academic positions gained by its graduates. The excellence of the original faculty has been demonstrated most clearly by the election of Profs. Roman, Doermann, Gartler, and Motulsky to the prestigious National Academy of Sciences. Among other founding members, Benjamin Hall made seminal contributions to our

understanding of gene expression and gained important biotechnology patents, while Lawrence Sandler trained key members of the current generation of Drosophila geneticists nationally. Later recruitments diversified the range of inquiry to include population genetics (Joseph Felsenstein), yeast molecular genetics (Leland Hartwell), DNA replication (Walton Fangman), and molecular cell biology (Breck Byers). Both Hartwell and Felsenstein have also been added to the roster of the National Academy of Sciences. In recent years, Leland Hartwell's decisive research into the yeast cell cycle has revealed important clues to the causes of cancer, and he now serves as Director of the Fred Hutchinson Cancer Research Center while on leave from the Department..

Further faculty additions later brought expertise in immunogenetics (Carol Sibley), bacterial protein topogenesis (Colin Manoil), neurogenetics of the roundworm (James Thomas) and of the fruitfly (Leo Pallanck), Drosophila developmental genetics (Celeste Berg), and reproductive genetics in the transgenic mouse (Robert Braun). The addition of modern laboratory facilities by the School of Medicine in the K-Wing 7 years ago provided for more effective communication with medical geneticists in the Department of Medicine and enabled us to make three major joint appointments; Stanley Fields (inventor of the powerful two-hybrid system), Maynard Olson (a leader in the human genome project) and Mary-Claire King (a renowned medical geneticist noted for discovery of the first breast cancer gene). The contributions of these new joint appointees, together with active participation by several adjunct faculty, have broadened the scope of the Department and have positioned it well to participate effectively in the current era of explosive growth in genomics and medical genetics.

## II. Unit roles and responsibilities

(A). Role of the Department:

The Department of Genetics strives to fulfill a fundamental role that should be intrinsic to all academic effort throughout the University -- to provide students with the kind of rich educational experience that can be provided by a faculty of effective scholars working at the forefront of knowledge. Succeeding in this goal depends on our maintaining a faculty of talented geneticists who have gained the respect of their peers, compete effectively for research funding, and publish significant research results in a timely manner. Graduate student training is an especially central issue for the Department's performance because fulfilling the enormous need for biological education at the undergraduate level depends ultimately upon having energetic graduate students who enliven the effort and perform much of the research. Graduate students certainly are essential to the educational effort because of the crucial role for well-informed teaching assistants, but their greater contribution may lie in the way they engender the kind of vibrant and productive research environment that stimulates the quality and timeliness of undergraduate instruction by their mentors.

The Department has no undergraduate degree of its own, but provides a substantial and crucial segment of biological science education to undergraduates majoring in various degree programs in Arts and Sciences, as well as in other units, such as Forestry, Fisheries, Oceanography, Nursing, and Public Health. The burgeoning role of genetics in all areas of the biological sciences has stimulated a massive increase in the need for genetical expertise in addressing many contemporary scientific issues, and there has been a concomitant demand for our undergraduate courses. The Department is perhaps most closely allied with the popular Biology Degree Program, as we provide half of the instruction in the first quarter of its large introductory course for majors. But we are involved to an even greater extent in providing the more advanced genetics courses that are needed not only students in the Biology Degree Program, but also by those majoring in

Zoology, Botany, Biochemistry, Microbiology, and other programs. Thus, the educational effort of the Department is truly interdisciplinary.

(B). Opportunities seized or missed:

The burgeoning increase in the demand for undergraduate education in biological sciences at the University, as elsewhere, has presented an easily justified argument for increasing the size of our department. Our past successes and current reputation for excellence have justified our arguing persuasively for additional faculty even in times when state funding has been severely limited. Over the past few years, we have gained some flexibility in funding by tapping sources that depend principally on the excellence of our faculty. First, Benjamin Hall's patented contributions to yeast transcription and related biotechnology have built a substantial nest egg for the University, and the Department has shared in this benefit, providing substantial funding that we have been able to use as needed. Second, Leland Hartwell's prominence in the field won him an American Cancer Society Professorship that freed recaptured salary for other uses. More recently, Hartwell has gone on leave to become President and Director of the Hutchinson Center. Although the loss of his direct attention to our program clearly detracts from the quality of training, we benefit from his recaptured salary, which we have used to add other geneticists to our cadre of teachers. Third, construction of the K-Wing brought significant new research space to the vicinity of the Department, and we successfully sought joint faculty support that enhances our interactions with Medical Genetics. We now have been able to add three new joint faculty members -- Stanley Fields and Mary-Claire King, who have substantial research space in the K-Wing, and Maynard Olson, who directs the genome center in Fluke Hall. Furthermore, our nomination of Stanley Fields for appointment to the Howard Hughes Medical Institute was successful and Mary-Claire King has awarded the second American Cancer Society Professorship in the Department. Thus, we have not only enhanced our leadership in the genetics community substantially by these appointments, but

have created a degree of financial independence that permits us to address some critical needs and maintain quality for the long run. Those financial resources have been of decisive benefit in recent hires, as we have been able to assume responsibility for start-up costs when the College could not.

Despite the great value to our program of our prominent new joint faculty members, we have no space available for new faculty who would be able to participate fully in the critical needs of undergraduate education. We have met the demand for increased course offerings in Genetics by hiring temporary faculty. This provisional solution is helpful but suffers badly because these instructors, however talented, cannot participate fully as independent scientists and therefore lack the mature viewpoint that a tenure-track professor gains from directing research and mentoring graduate students. In our view, a predominant risk in relying on temporary faculty is that they soon lose familiarity with the intellectual currents of the discipline and begin to present old ideas in textbook fashion rather than with the insight gained from contemporary research-based knowledge. To minimize this flaw, we have set aside some of our limited space in the research labs of tenured faculty for the temporary faculty to pursue active research in parallel with their teaching. This works marginally, but we desperately need more bona fide faculty who may teach both undergraduates and graduate students in the proper manner. This will require that we gain new research space, such as would be provided by construction of Life Sciences-I. This project gained top priority under rigorous review by campus-wide committees last year, but failed to be funded by the Legislature in light of their prior obligation to begin work on the Law School. We can only hope for a better outcome in the coming biennium.

(C). Differing viewpoints on our role within the University:

The self-study format asks how our own view of our role may differ from that of the administration. In this regard, there is perhaps no greater divergence of opinion about how the University ought to manage its limited resources as ideas and research directions

evolve. We repeatedly see evidence of an overriding opinion in the administration that departments are overly conservative and unable to adapt to change, such that limited resources must be re-directed toward "interdisciplinary" efforts, some of which appear to be of inferior quality. Our countervailing viewpoint generally is that those pursuing research on the boundaries of disciplines are perfectly capable of responding to change and reaching out to those colleagues in other departments whose expertise complements and overlaps with our own.

Faculty in the Department collaborate freely and effectively with an enormous variety of other units both within the University and elsewhere in the world. For example, when Prof. Carol Sibley turned her research interests in mid-career from immunogenetics to parasitological genetics, she simply began interacting with new research partners -- including parasitologists at the Seattle Biomedical Research Institute and in the School of Public Health, as well as with her colleagues doing field studies in Kenya. Similarly, our faculty members studying the genetics of various organisms each forge strong intellectual relationships with colleagues of similar interests across the University and at the Hutchinson Center. Prof. Robert Braun and his lab members meet weekly with others in Seattle studying the transgenic mouse, Prof. James Thomas and his students meet with those working on the nematode, and those of Profs. Celeste Berg and Leo Pallanck with other Drosophila labs, while others of us meet regularly with colleagues in the Seattle area yeast genetics community. Notably, Profs. Thomas and Pallanck also have crucial interests in neurobiology, and thus interact in many ways with the neurobiology community in addition to their respective organism-specific groups. No special interdisciplinary structures are needed to support these critically valuable interactions. In fact, drawing resources away from the Department hinders our ability to develop these natural associations, which depend more on the emerging demands of free inquiry than on any added administrative structure.

(D). Changes that affect the role of our discipline:

Genetics has emerged ever the past 15 years as perhaps the most central discipline within the burgeoning biomedical sciences. Nearly every day there is more in the press about novel genetic findings pertaining to human diseases and traits, genetic engineering of crops and livestock, and other biological phenomena. This prevalence in the news clearly reflects not only widespread interest in the findings of our field but also a remarkable increase in the number of scientists pursuing genetical issues and doing so productively. The modern flowering of genetics has clearly depended on the maturation and convergence of powerful methodologies -- DNA cloning, the polymerase chain reaction, DNA sequencing, and numerous opportunities for biotechnology. By virtue of these advances, it is now a realistic goal to solve the sequence of the entire human genome within only a few years and to use this information to define the genetic basis of many diseases and other aspects of human variation. The fortunate discovery that innumerable genes are evolutionarily conserved at the sequence level has provided a basis in many cases for discovering the functions of newly identified human genes, because the revolution in genomics has included the so-called model organisms -- *Escherichia coli* (an intestinal bacterium), *Saccharomyces cerevisiae* (Baker's yeast), *Caenorhabditis elegans* (a nematode), *Drosophila melanogaster* (the fruitfly), and certain plants. Similarity of gene sequences across species is enabling researchers to specify the roles of novel human genes by comparison with those in model organisms, where gene function can be explored by experiment.

The Department of Genetics has played a crucial role in the evolution of the research leading up to this exciting departure for the future. Our late founder, Herschel Roman, played a major role in making yeast a key model organism, while Donald Hawthorne contributed decisively to establishing its genetic map, Benjamin Hall made major advances in yeast RNA transcription, Leland Hartwell discovered cell-cycle functions in yeast that help us understand cancer, and Walton Fangman illuminated the pattern of its chromosomal

DNA replication. Similarly, Lawrence Sandler had made crucial advances in studies of the fruitfly and educated many of today's leaders in that field. Today the Department has several faculty who are productive in research with model organisms, often studying genes with direct relevance to human disease. For example, Leo Pallanck uses Drosophila to study the genetics of neurodegenerative diseases and the lab of Walt Fangman and Bonny Brewer studies in yeast a gene that affects aging in humans. Other members of the Department have taken a more genomic approach. In particular, Prof. Maynard Olson directs the University's genome center, which has set the quality standard for human genomics and has also recently completed the sequencing of *Pseudomonas aeruginosa*, a critical pathogen in cystic fibrosis patients. The Department is certainly well-positioned to continue playing a leading role in those aspects of genetics where notable advances seem most likely to occur.

(E). Criteria for evaluation:

Criteria for comparative evaluation of biomedical programs relative to those at peer institutions are compromised by the fact that the academic organization of the biological sciences is varied across institutions and is in flux. As recently as 1996, "genetics" at the University was ranked **3rd** nationally among graduate degree programs by a survey conducted by US News and World Report (see Appendix J), but subsequently it has not been listed by this source, perhaps due to redefinition of relevant programs. Regardless, it is clear that the Department has earned a strong reputation among our colleagues nationally for the quality of our graduate program. This is revealed most distinctively by the fact that the NIH Training Grant, which provides key funding for the Department's Genetics Training Program (GTP), has recently undergone competitive review successfully for a 7th consecutive 5-year renewal. Quoting from the evaluation by the review committee:

"This program has a long history of successfully training students who go on to actively pursue careers in science, with many in teaching or research tenure-track faculty positions at major institutions. The program director, Dr. Walton Fangman, is an outstanding director, a renowned and productive scientist in the area of eukaryotic DNA replication, and

an experienced trainer of graduate students and postdoctoral fellows. He has been highly involved in graduate training in genetics at this institution and previously served as the program director for this training grant. He has garnered the support and respect of the students and participating faculty members. The program director is assisted in administrating the program by the Advisory and Admission Committees, which are well conceived for the needs of this relatively small program. Beyond the formal committees, the administration of the GTP is the responsibility of the entire program faculty, who put in an inordinate amount of effort on behalf of the program and the students. During the site visit, the students uniformly lauded the responsiveness of the program to their needs. Also very ably assisting the program director is Dr. Colin Manoil, who coordinates student rotations during the first year, and Dr. Carol Sibley, who chairs the Admissions Committee.

"The training faculty is a major strength of the program. Many of the participating members are leaders in their specific fields, are productive scientists with substantial support from competitive grants, and have strong publication records. The wide spectrum of research interests of the participating faculty offers students exciting research training opportunities in a broad range of areas in modern genetics. However, the training faculty is very senior with only one assistant professor participating in the program. New, young investigators would provide a resurgence of energy to invigorate the program. While Dr. Lee Hartwell's departure is a significant loss to the program, the new additions to the training faculty of well-known senior faculty members, Dr. Stanley Fields and Mary-Claire King, provide strength in new scientific areas and bode well for the future of the program. Although the training faculty could be expanded, especially to include faculty members from the Fred Hutchinson Cancer Research Center, the program director and current faculty members feel that doing so would dilute the intensity and cohesion of the program. Requirements for faculty members from other departments to join the program are stringent, such as actively participating in all activities (journal clubs, student presentations, retreats, etc.) except teaching. These requirements ensure that the administrative responsibilities are better distributed and maximize the attention that the students receive, but can discourage faculty from other units from participating. However, this small training faculty appears to be a cohesive group whose active participation in the program is appreciated by the students."

Other criteria for evaluation reflect the quality of our faculty as individual scientists. Nearly all have gained substantial competitive grant funding from the National Science Foundation or National Institutes of Health. Perhaps most notable in this regard is the success of UW genome center directed by Maynard Olson, which is funded to a level of several million dollars per year. Finally, individual accomplishment in the natural sciences is clearly indicated by election to the National Academy of Sciences. The Department's rolls currently include five NAS members (Felsenstein, Gartler, Hartwell, Motulsky, and Olson), who have gained this significant honor and remain active in their research, while two members of the Department (Motulsky and King) have been elected to the National Institute of Medicine.

(F). Future leadership in the field:

The Department has exerted leadership in the field for many years, as described in section D above. Paradoxically, we may be most challenged for the future by the spectacular success of our discipline, which has attracted such striking increases in participation and funding that we may lose the distinctiveness that has engendered our reputation. The genetic analysis of model organisms has become so prevalent and so productive that even the most striking results may no longer be widely noted or help draw the best graduate students to our doors. We mustn't abandon those things we do well, but it is crucial that we envisage the probable future of the revolution in human genomics and develop a strategy for contributing to it. It seems inevitable that genomic sequences will provide (at great expense) a wealth of primary data that should, when fully explored, provide for a much deeper understanding of life processes in general and of human biology in particular. Exciting insights are likely to reward those scientists who master the mathematical tools needed to discern relevant patterns in these emerging sets of genomic data. Prof. Felsenstein's recent election to the National Academy of Sciences recognizes his valuable contributions to the means for testing evolutionary patterns by statistically valid methods, and his group continues to attack key issues in this area -- including ways of understanding how genetic recombination affects the conclusions that can be gained. We feel that the magnitude of crucial issues in this area easily justifies increased emphasis in the Department, and we therefore are currently engaged in a search for a new faculty member in the area of computational genetics. (Incidentally, the severe need for new research facilities contributed to this choice of area, as we could not free up enough laboratory space to provide adequately for another faculty member whose students would require much bench space for experimentation.) Bolstering our strengths in computational research will, of course, enable us to enhance this area of our graduate students' education. We expect

that both those students and the rest of faculty will benefit from learning better how to meld our core genetical thinking with better mastery of computational tools.

(G). Collaborations with other institutions:

As noted in section C above, members of the Department establish collaborative interactions as a matter of course, while the Department as a whole need not play much role in these functions, except where special funding is required. The chair is fortunate to have the Department's royalty income available when any added expenses resulting from collaborative meetings cannot be covered by ordinary research funding.

Several faculty in the Department interact with those at other institutions in a number of ways. For example, the family studies conducted by Mary-Claire King's group involve contacts and interviews of human subjects at sites distant from Seattle, and collaborations with geneticists located near the subject family members develop naturally in the course of research. Similarly, the malarial research conducted by Carol Sibley's research group entails an on-going effort to monitor the strains of the malarial organism (*Plasmodium*) where the disease is rampant. Although Prof. Sibley sometimes travels to Kenya to pursue this work directly, her collaborators in Kenya are a crucial resource for effective and timely progress in the research. Other valuable interactions with distant departments are seen in the ideas and information we gain from individual faculty members presenting seminars elsewhere and interacting accordingly with other students and faculty. This is especially valuable when the occasion is a "research day", to which our faculty member has been invited to interview and advise their students. The impressions gained and brought back to the Department provide us with valuable insights into alternative approaches in graduate education and more effective ways to deal with other challenges.

(H). Collaborations with other departments on campus:

Since individual faculty members successfully interact with laboratories of interest on campus, there is little role for the Department as a whole in these collaborative efforts. Perhaps the most important reason mitigating against any departmental role is the essential limitation of time and personal attention for the faculty. We interact extensively with our graduate students, meeting at least three hours a week as a group that includes nearly the entire faculty and graduate student body. Individual students gain additional interactions with outside labs and faculty in their respective organism-specific group meetings. A broader spectrum of weekly meetings would necessitate our devoting a less intensive focus on the interactions we currently find most valuable.

On the other hand, there are essential common interests with other departments at the faculty level, and we pay close attention to our shared interests with other departments in the biological sciences. The director of Biology and the chairs of Botany, Zoology, and Genetics meet frequently to ensure agreement on the direction of the Biology Degree Program as well as the needs of the various other majors that depend on common coursework within our departments. We frequently bemoan the absence of much opportunity for effective collaboration in undergraduate education with our colleagues in related departments in the School of Medicine, but recognize the fundamental barriers that delimit their commitment to undergraduate teaching.

## III. Degree Programs

(A). Bachelor's degrees:

The Department of Genetics offers no undergraduate degree separately from other units in the biological sciences. Although an undergraduate degree in genetics can be earned at some universities and might also be justifiable at the UW, we have adhered to the Department's original decision to focus our commitment to the overall training of undergraduates in the biological sciences. The principal degree that can be identified with

our teaching is the long-standing Bachelor of Sciences in Biology (Cell and Molecular Biology), but we are equally involved in various other programs. Our courses are also required for undergraduate degrees in Botany, Zoology, and the more recently added degree in Biochemistry, as well as other programs. Key coursework for all biological science undergraduates is initiated by the BIOL 201-202-203 series, which generally can be initiated in any quarter throughout the year and involves faculty from multiple departments. Genetics faculty currently provide three of the six units of instruction in BIOL 201, which covers genetics, cell biology, and biochemistry. Severe limitations on facilities for instructional laboratories and on teaching assistant positions preclude our offering more than one laboratory course in Genetics. This not only mitigates against our offering a separate undergraduate degree but also favors our continued participation in the Biology Degree Program, where good provision has been made for hands-on experimentation by the students.

In 1994, the Department revised its undergraduate curriculum and began offering two new Genetics courses designed to follow the BIOL 201-202-203 series (see Appendix H). Material formerly squeezed into one 4-credit course was redistributed and expanded into two 5-credit courses that are offered a multiple times per year and can realistically be taken either individually or as a series. GENET 371 emphasizes formal aspects of genetic analysis, including the emergent use of molecular markers and of mutational analysis to gain a deeper understanding of complex biochemical and developmental systems. GENET 372 focuses on the nature of gene function, including transcriptional control and the genetic analysis of gene action. We also now offer advanced courses for undergraduates in the history of genetics, in human genetics, in the genetics of cancer, and in evolutionary and population genetics. In addition, we offer a course in experimental bacterial genetics as a joint effort with the Microbiology Department, which has adequate facilities and personnel for laboratory instruction. Integral to the Biology Degree Program, we provide a large number of undergraduates with opportunities for participation in research, either as

GENET 499 students or as hourly employees (see Appendix M). Additionally, there is a research seminar taught every quarter to provide undergraduates with a forum for discussing their research experiences and for those who not engaged in research to explore the nature of the primary research literature. This seminar is a crucial component of the requirements for certain undergraduate majors.

(B). Master's Degree:

We do not offer admission to graduate students who would not be expected to progress beyond the Master's Degree except under special circumstances. Nevertheless, any graduate student who is not developing the level of commitment and independence required for the doctorate often finds the Master's Degree an attractive and useful alternative. Access to this degree provides the opportunity to round out the research experience in a satisfying manner and provide an entree into alternative positions, such as in community college education, technical research assistance, or biotechnology.

(C). Doctoral Program:

The Department enjoys an enviable reputation as a center for training those geneticists who will compete effectively in the research arena while contributing significantly to educational needs within academic institutions. During the phase of explosive growth of our field beginning in the 1970s, the Department placed its graduates on the faculties of departments at Harvard, Stanford, Wisconsin, Yale, and other leading institutions. Recently, two of those earlier Ph.D. students (Bruce Baker and Thomas Petes) were elected to the prestigious National Academy of Sciences, and many others play leading roles in our field (Elizabeth Jones, Rochelle Esposito, Mary-Dell Clinton, Henry Erlich, Michael Liskay, David Cox, Scott Hawley, Paul Russell, Gilbert Omenn, Barry Ganetzky, Jeffery Hall, Lawrence Goldstein, and many others). Given the increasing length of time between degree and first faculty appointment as our field has matured and the

rate of academic hiring has declined, it is difficult to assess the probable level of long-term success ~~of our~~ more recent graduates. Nevertheless, one may justifiably ask whether evaluations by our peers -- as evidenced in the nation-wide competition for funding -- are indicative of continued success, and the evidence certainly is favorable. On the strength of research conducted in our laboratories by these students, the faculty compete effectively for funding from the National Institutes of Health, the Department of Energy, and the National Science Foundation, as well as from private agencies (see Appendix F). Furthermore, students graduating from the Department compete successfully for postdoctoral positions in the laboratories of leading scientists, partly due to the known quality of their graduate training experience.

As growth in the number of open academic positions has subsided, the advent of biotechnology and the remarkable salaries attainable there have provided new avenues of employment for our graduates. Access by our graduates to such positions depends on two features of our program relative to the biotechnology industry. First, in the ordinary course of graduate work in our labs our students become proficient in most of the specific experimental skills and procedures that biotechnology companies require of their staff. More importantly, there is an even greater need in the industry for scientists with well-developed talents for inventiveness and critical thinking. Although there are graduate programs at other institutions designed to train specifically for biotechnology, successful traditionally-trained academic scientists have proven to be of greater value . At our latest departmental retreat, we asked George Strathmann -- founder of AmGen (the most successful biotechnology firm in the world) and now chair of ICOS -- what features are most sought by those recruiting for biotechnology, and he told us that we should continue training as we do now.

Our recruitment of graduate students from a national pool of students seeking the best opportunity for a career in the genetics depends largely on our reputation among the faculty who mentor candidates. This has provided us with a steady stream of about 250-

300 inquiries and 110-150 applications per year over the past 20 years or so. It should be noted in this regard that the recorded total numbers of inquiries and applications (Appendix A) are somewhat uninformative because we strongly discourage non-national students for completing a formal application, as they would incur significant expense with a very slight chance of being accepted. Similarly, we have now begun informing everyone who inquires about admissions that they need not file a formal application until after we informally accept them, since delays in Graduate Admissions had hindered our timely selection of the more promising candidates. Furthermore, we have discovered by post-admissions questionnaires and interviews that the expense of a formal application has frequently deterred potential applicants of promise from completing the process.

We make offers to the top 20-24 candidates in order to fill a new graduate student class of about 5-8 students. It is usually the case that all to whom we make offers also have competing offers from an elite group of other departments in our field, including those at Harvard, Princeton, Stanford, UC Berkeley, UC San Diego, UC San Francisco, Wisconsin, and Colorado. We make our selections basically as our competitors do, stressing attention to native intelligence (as evidenced by grades and GRE scores on the General Examination -- with a bias toward those who show strong quantitative skills) and evidence of talent for research. Regarding the latter, most now enter graduate school with at least one year of post-baccalaureate research experience.

We attempt to discern our stance in this competition for top students at the close of each year's recruiting season, and we generally find that we were most successful in attracting those who had a general fascination with genetics but had not yet decided on a specific area. In fact, any who arrive thinking they know the answer usually switch to another area during the first year. A principal concern for the future is our inability as yet to respond to a national trend toward consolidation of graduate admissions in the biological sciences. Because an apparent desire among the more talented of today's entering graduate students for a greater breadth of choice among potential thesis advisors, programs as

dominant as those at Harvard, Yale, Berkeley and Stanford have scrambled toward major reorganization of their graduate admissions and first-year training. Our department formerly was able to attract those seeking a breadth of choice by virtue of our membership in the Molecular and Cellular Biology Program, which had been designed as a graduate recruitment program. The more recent modification of the MCB into a PhD-granting program and its current reluctance to allow its recruits to change programs freely have diminished our ability to attract students from this source. We have responded in part to this difficulty by agreeing among our faculty that MCB students in our labs (most of whom are of excellent quality) should participate in the Department's training functions to nearly the same extent as our regular students. This ameliorates the difficulties, but does not seem an ideal solution.

A persistent difficulty in the coupling of a broad admissions policy with a particular PhD program is that it fails to provide well for those students who are principally interested in our field but not fully committed to it. Furthermore, such programs lead to the institution of graduate coursework that emphasizes breadth to the expense of depth. This is an evolving problem, but one that we feel might be resolved most suitably by returning to the model in which a student enters with broad choices but eventually commits to a sub-discipline by joining a specific PhD program. At that point, the student would gain the substantial benefit of intensive graduate coursework in that sub-discipline, rather than relying on conjoint courses that we feel are overly large and less conducive to the spontaneity and critical analysis to that should characterize graduate study.

Another challenge our training program faces is our slowness in adapting to the evolving nature of contemporary biomedical science. Although our NIH Training Grant continues to be renewed, we justifiably were criticized by NIH for the limited publication records of our students prior to graduation. We had previously felt that a student should pursue a credible thesis to completion with a significant degree of independence, whereas contemporary standards have tended toward larger research groups with emphasis on the

presentation of their joint research in numerous multi-authored papers. In addition, the emergence and growth of research institutes and medical departments (generally staffed by scientists with no educational responsibilities) has increased the rate of which one must make progress toward publication in a competitive environment. This also mitigates against independence of students and other researchers working in the laboratories of faculty members. Strategies for greater success in this environment may require a decreased level of independence in the design of graduate research and may also require faculty members to form stronger research coalitions with their colleges. By such means, and perhaps by enhanced development of an associated research faculty, it will become more realistic for those who must devote substantial time to the preparation and presentation of undergraduate courses to continue competing in the evolving research environment.

## IV. Responses to change.

(A). Educational changes:

Both graduate training and undergraduate teaching in our program have been transformed over the past decade by an emerging predominance of the biological sciences in public awareness, medical advance, and biotechnologies. Genetics is central to this revolution and therefore serves as a key component of the current curriculum for undergraduate biology education. Accordingly, we have augmented our role in undergraduate instruction strikingly. For example, the data presented in Appendix H shows that in the academic year 1988-89, we provided 300-level genetics courses for biology majors (GENET 360, 365) to 290 students. By increasing our course offerings progressively and redesigning the coursework, that total student number had risen to 799 by the 1998-99 year, or 275% of the earlier level. This was done without changing class sizes, retaining our usual maximum of about 150 students per class. Over the same decade, our contribution to the BIOL 201-2-3 series was increased from one unit of

instruction to three units, each unit serving about 250 students. These increases would not have been possible without an increased instructional commitment by tenure-track faculty as well as an increased use of non-tenure-track instructors. Given our principle that university instruction should be provided only by those who are active in research, the relevant instructors were drawn entirely from the ranks of advanced postdoctoral fellows in our research laboratories, often at the cost of reduced research productivity in projects directed by their mentors. This strategy is not sustainable for the long run, as it both erodes the quality of instruction and compromises crucial research efforts. These steps were taken only to bridge the gap until adequate research space and faculty can be added to the Department to meet the huge demand for undergraduate instruction.

Our mode of graduate education has not evolved much over the decade, but the maturation of our field has challenged our long-standing means of attracting the best students. Notably, as today's seniors are increasingly attracted to large graduate programs with a great breadth of choice of potential thesis mentors, our more parochial style of graduate student recruitment no longer meets their expectations. This is thorny problem that we shall have to address (as described further in Section III.C).

(B). Changing patterns of instruction:

The overwhelming increase in numbers of student credit hours demanded of our courses has obviated any feasible opportunity to embark on non-traditional modes of instruction. We continue to provide instruction that is strongly interdisciplinary in the sense that it contributes significantly to the education of undergraduate students in various specific areas of the biological sciences, regardless of their field or major. We also participate rather fully (as we always have) in experiential learning, as our labs continue to act as a resource for actual research experience by large numbers of undergraduates (see Appendix M).

Perhaps the greatest change in our instruction derives from access to technologies that were unavailable 10 years ago. Specifically, genetic maps, gene sequences, and other key research materials of our field are almost exclusively transmitted between geneticists by web-based technologies. Faculty teaching courses in undergraduate genetics increasingly have found effective ways to exploit the students' comfort with web-based learning to engage them in direct interaction with this rich source of information, enabling them to experience first-hand how professionals in the field approach and resolve questions. For example, web-based data from the genomic sequencing projects can be explored directly by undergraduate students, revealing the evolution of a conserved gene sequence among various organisms using software that also is web-based. The fundamental principles of genetics, as well as current initiatives in research, still must be taught in the classroom and brought to a deeper level of understanding by well-trained teaching assistants. But the potential for students to work directly with actual datasets on the web provides a great opportunity for enrichment and timeliness of the training experience, especially in light of the absence of adequate laboratory space for hands-on experience with living organisms.

(C). New developments in genetics:

The current revolution in genetics derives in large part from the on-going genomic sequencing of many organisms and the ability of all researchers in the field to interact productively with these sets of data. Whereas the genetic dissection of a complex process formerly took many years to reach fruition, the roles of individual genes in relation to one another might now be derived in a matter of weeks. Furthermore, directed mutagenesis using the polymerase chain reaction now enables one to test highly specific proposals about how a gene exerts its function. The rate of discovery and the advance of knowledge is indeed phenomenal. Happily, this revolution in our field has stimulated a great outpouring of public enthusiasm for biological research, and the NIH budget has risen accordingly, thereby providing strong funding for most of our labs.

Probably the most certain measure of our success in a competitive discipline is the success of funding sought by those doing the research, for this relies ultimately on the judgment of ones peers. These peers generally explore both the record of past contributions and the ingenuity the applicant displays in planning for research directions for the future. Competitive grant funding within the Department clearly indicates that the faculty are largely productive and have strong reputations in the research arena.

(D). Changes in service:

Facing the considerable challenges of a burgeoning undergraduate obligation and a competitive research environment, members of the Department find it difficult to conceive of any increases in other service. Many of us serve on review committees when asked to do so. For example, the current chair (Breck Byers) served on the chair search committee for the Department of Biochemistry shortly after beginning his term and has more recently served on the Academic Advising Committee on Facilities, and the past chair (Walton Fangman) directed the most recent review of the Biology Degree Program. Service to the discipline is seen in membership on national panels for grant review, such as those recently undertaken by Profs. Braun, Berg, Fields, King, Olson, and Sibley, and in the review of manuscripts by all members.

The Department has long been involved in outreach to local public schools, especially through presentations and lab visits by Carol Sibley, though the provision of Drosophila stock for experiments in area high schools by Celeste Berg, and through the training in the summer of Seattle-area school teachers how to perform simple genetic experiments that would enlighten their students. Some of these activities are outlined in text excerpted from our latest Training Grant renewal (Appendix L).

(E). Strategies for addressing other challenges:

**>>>faculty retirements:** Availability of Genetics Royalties funding derived from the Ammerer-Hall patents has enabled the Department to hire new faculty in the absence of start-up funding from the University. Furthermore, three members of the Department (Profs. Hartwell, Fields, and King) have been awarded significant private funding that replaces a major share of the University's salary commitment, so unexpended salaries also remain available. Our only greatest limitation on hiring new faculty to meet the increasing need for instruction has been the absence of adequate research space for new faculty.

**>>>increasing undergraduate numbers:** As above, we will need more research space to hire sufficient faculty . Some tenure-track faculty members object strongly to our current level of temporary faculty hiring, and they certainly would be opposed to any increase in this practice.

**>>>increasing demand for degrees for working professionals:** We feel our plate is full with what we do and there is not sufficient justification for adding another training activity. Our thesis-based graduate program is not readily adaptable to less stringent levels of training, which we feel would divert attention unnecessarily.

**>>>increased need for doctoral training for faculty at 2-year and 4-year colleges:** This already is a strength, as our intensive attention to journal clubs and research reports ensures that our graduates are competitive for faculty positions where the emphasis will be on the quality of presentation.

**>>>increased need to provide training for industry:** Again, we already are successful in this area. As mentioned above (Section III.C), leaders of industry tell us they

want accomplished scientists, not technicians. Many of our Ph.D. graduates already find employment successfully in the biotechnology industry (see Appendix E).

**>>>emerging technologies:** Our faculty are themselves at the forefront of technological innovation. For example, Maynard Olson invented a key cloning element (YACs) for the genome project and has, together with Phil Green, set the standard for processing genomic data. Similarly, Stanley Fields invented the well-known "two-hybrid" procedure, which serves as a key approach in genomics, biomedical science, and biotechnology. For this and other work, he has recently been awarded the Chiron Biotechnology Prize. In the area of teaching technologies, we rely increasingly on web access to provide undergraduates with the opportunity to interact with the databases of our discipline. Unfortunately, the sorry state of classrooms at the University has made it very difficult to bring real-time demonstrations of this technology to our lectures.

**>>>pressures on space and budgets:** Budgets are currently marginally adequate, given our continued access to royalties funds. There really is no significant solution to the space problem other than our gaining a new building in which to do our research and teaching. We need and deserve Life Sciences-I.

**>>>extended time to degree:** The Department has just undertaken a new program that we hope may help solve this perennial problem. Beginning with this year's first-year class, we intend to (a) greatly increase the rate at which we stringently evaluate new students and advise them of needed remedial activities, (b) demand a thorough written treatment of a feasible thesis plan at a substantially earlier date, and (c) move the scheduling of the general examination, with a strong focus on thesis planning, to an earlier stage of their overall training. Our intention is not only to speed completion of the thesis but also to enhance their output of published work during graduate study

(F). Demographic changes:

The Department has consistently sought to identify and recruit members of traditionally under-represented segments of our society. As recently as 1975, the faculty was entirely male, limiting the choice of role models for women and possibly causing an unfavorable gender ratio in the graduate enrollments. Societal change and determined efforts by several of our faculty over the ensuing years have led to there being 4 women among our last 9 successful faculty recruitments. Concomitantly, graduate student admissions has become biased toward more balanced recruitment, to the extent that 56% of our current graduate students are women.

Racial and ethnic diversity has been a more difficult problem throughout the natural sciences, including Genetics. We have made no progress among faculty hires, but have met with heartening success in graduate recruitments. Over the past 18 years, our graduate admissions committee has consistently flagged minority applications for special consideration and explored ways to admit those with some evidence of promise outside the usual criteria. Since 1990, Prof. Sibley has made extensive efforts to expand our visibility at the national level among potential minority applicants. Her efforts have included (a) participating in minority recruitment fairs, (b) maintaining regular communication with relevant faculty at institutions with a good track record in attracting and training talented minority undergraduates, and (c) establishing contact with those minority undergraduates who have been identified by the University's efforts (see Appendix L).

It has become clear, however, that our most effective magnet for minority students is the presence of others already working in the Department. Notably, we managed to attract Jason Wooden, our first African-American graduate student since the 1960s, from Seton Hall University in 1989 by persistent correspondence and telephone conversations extending over nearly two years. Jason's presence in the Department appeared to transform our image among minority undergraduates, leading to an increasingly favorable

stance in this regard. We have managed to recruit five more African-American graduate students over the past 7 years, enjoying by far the greatest rate of success in this endeavor throughout the natural sciences in the University. Racial diversity within our program is also favored by the developing research program in the laboratory of Prof. Sibley, whose studies of the malarial pathogen include collaboration with colleagues in Kenya, leading to frequent exchanges of personnel who are largely native Africans. Other disadvantaged minority graduate students who have done well in the Department over the decade have been a Cuban Hispanic student (Mark Fajardo; PhD, 1997) and a Pacific Islander (Eung-yung Lee; PhD 1991).

(G1). Personal productivity:

The intellectual environment of the Department and its key weekly functions (Journal Club, Research Reports, and Seminar) appear to contribute strongly to the continued excellence of the faculty in teaching and research. Except in unusual circumstances, these functions are regularly attended by all graduate students, all faculty, and many of the postdoctoral fellows and technicians. Whereas these meetings were designed primarily to enhance the graduate training experience, they play a valuable role in keeping the faculty broadly engaged in all aspects of their field. Journal club presentations by all members of the faculty, in parallel with those by the students, serve not only to keep everyone up to date in the field but also provides a shared experience that enhances collegiality.

Perhaps the strongest motivator toward personal productivity in research for all members of a science department is the fact that all are engaged in the highly competitive arena of federally funded research, where peer review is stringent and success of the faculty member depends ultimately on the success of the graduates in his/her group. A proportionally high level of funding by the National Institutes of Health throughout the Department clearly attests to its considerable success, especially in light of the fact that

faculty members increasingly compete with scientists elsewhere who do little or no teaching at the same time. Luckily, the Department has always placed a high premium on effective teaching, so the historical consensus that both undergraduate and graduate instruction are crucial to a good department encourages commitment by individual faculty members to their teaching. As a further stimulus to innovation and self-renewal in teaching, written peer reviews of teaching are conducted annually. Since the assignments for collegial review are continually altered, each faculty member gains the insight of a different colleague each year about his/her style at the podium.

In keeping with the Department's strong commitment to undergraduate education, individual faculty members have proven willing to increase their efforts in teaching over the past decade. As indicated above (Section III.A), they have willingly increased their course loads substantially by converting all of our major 3- and 4-credit courses to those with 5-credits, with attendant increases in the numbers of contact hours. In addition, we have devised new courses, such that many undergraduates majoring the biological or biochemical sciences now take two 5-credit courses in Genetics (GENET 371 and GENET 372) as well as others of our new courses at the senior (400) level.

It seems very unlikely that we realistically could hope to increase the productivity of our existing faculty without improved facilities, such as Life Sciences-I. An effective science department is composed of faculty members who compete in the scientific arena, transmitting a research-based depth of knowledge to the undergraduates while directing the research effort that trains graduate students. Those graduate students in turn are relied on for their energy and commitment to advance that research and serve as well-trained teaching assistants. Expanding on this model requires more faculty, and that will inevitably require more research space for our department as undergraduate enrollment grows and an increasing proportion opt for the biological sciences.

Junior faculty in the Department have consistently been successful and productive. Our only current assistant professor, Leo Pallanck, now has a well-equipped lab, solid

research funding, and three talented graduate students. He is mentored both by the chair and by Prof. Fangman, with whom he consults regularly to remain well-advised of expectations within the University and of opportunities for effective management and development of his career. The probability of his success both in the lab and in the classroom appears quite high.

(G2). Staff productivity:

The motivation of staff to maximize their productivity is severely hampered by our dismal salary levels, especially for clerical workers. It is difficult to compete for well-qualified employees within the booming economy of the Seattle area, and only the loyalty that is engendered by considerate and supportive personal interactions keeps them within the fold. Research staff similarly are most attracted and retained by the friendly inclusiveness of the Department and their opportunities to gain greater self-respect by contributing to the scientific endeavor and by being recognized for these contributions.

## V. GOALS:

The principal goals of the Department of Genetics arise out of consensus reached in faculty meetings and informal discussion throughout the year. They are:

**1) To achieve and maintain excellence in the full range of genetic inquiry from model organisms to humankind.**

**2) To provide a stimulating and effective educational experience in genetics for undergraduate students.**

**3) To enable our graduate students and postdoctoral fellows to master our discipline and achieve productive careers in the field.**

**4) To serve as an effective resource for timely knowledge about genetics in our schools and in our society.**