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ABSTRACT

In 1975, the Montana Board of Regents charged the Commissioner of Higher Education with reviewing the five Ph.D. programs in the state that are offered at more than one campus: microbiology, botany, zoology, chemistry, and mathematics. Teams from other universities reviewed the programs and submitted reports, with recommendations. The recommendations are that (1) both programs in microbiology be maintained; (2) both programs in botany be maintained, with major improvements required at one institution; (3) zoologists be given access to Ph.D. program in biology at each of two campuses, consolidating several existing life science programs; (4) both programs in chemistry be maintained, with no major changes; and (5) both mathematics programs be maintained, with major improvements desirable in each. The universities concerned are Montana State University and the University of Montana. The reviewers' reports are included. (Author/MSE)

MONTANA UNIVERSITY SYSTEM AND POST SECONDARY EDUCATION

OFFICE OF THE COMMISSIONER OF HIGHER EDUCATION

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FINAL REPORT ON MONTANA'S PH.D. PROGRAMS EXISTING ON MORE THAN ONE CAMPUS

SUBMITTED TO: DR. LAWRENCE K. PETTIT
COMMISSIONER OF HIGHER EDUCATION
MONTANA UNIVERSITY SYSTEM

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MONTANA UNIVERSITY SYSTEM

JULY, 1976

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P R E F A C E

Before turning to the substance of my report on Ph.D. programs which exist on more than one campus in Montana, I would like to make a few personal comments and observations.

First, I would like to compliment all nine departments which house the ten programs under review for their professional conduct. Second, I would like to thank the administrators with whom I worked for their cooperation and help, especially Dr. Irving L. Dayton, Vice President for Academic Affairs, Montana State University, and Dr. John M. Stewart, Dean of Graduate School, University of Montana.

It has been my awesome responsibility to recommend on the continuation or elimination of ten doctoral programs. In so doing, I have employed the reports of the outside review teams; conversations with administrators, department heads, and faculty about these reports; and formal departmental responses to the reports and to a draft of parts A and B of this report which I sent to the campuses before writing a final version.

This much due process has made the review process a lengthy one, but a better one. This is not a matter to be taken lightly. Wrong decisions could harm graduate and undergraduate academic programs irreparably, deny educational opportunities, affect the careers of dedicated scholars who have devoted years of hard work to their university, and discourage fine young faculty from continuing to work in Montana where rewards other than appropriate salaries are available.

People in the universities are not the only ones who could suffer from the wrong decisions. The universities serve the state in many ways; some of this service is reflected through Ph.D. program activity. We must remember,

however, that programs of suspect quality run counter to the whole concept of education at the doctoral level. A doctorate given in Montana should be a bona fide Ph.D. and a quality Ph.D. We must also be concerned with priorities in committing resources and considerations relating to role and scope in addition to the concerns I have already outlined.

This is an extremely serious matter. The report deserves a careful reading, and I know you will give it one. Everyone who is concerned with higher education in Montana must read this report and the accompanying materials with the utmost care.

A. BACKGROUND

At the September, 1975 meeting of the Board of Regents, the Commissioner of Higher Education was charged with conducting a review of the five Ph.D. programs which are offered at more than one campus. These five programs are Microbiology, Botany, Zoology, Chemistry, and Mathematics. As Deputy Commissioner for Academic Affairs, I was given this assignment as a top priority task (along with the review of teacher education programs).

During 1975, action proceeded along two fronts. I began (1) discussions with the Academic Vice Presidents and Graduate Deans of the University of Montana and Montana State University and (2) establishing contacts with professional societies to secure prestigious reviewers. The universities were permitted to challenge reviewers for just cause. Two such challenges were made. In each case, the challenge seemed warranted, and another reviewer was found.

Following a series of meetings with appropriate campus officials, I submitted my proposed review guidelines to you. After making some useful additions agreed to by the campuses, on January 2, 1976 you promulgated the final review guidelines and criteria (see attachment #1). These documents required the departments to compile extensive reports on the nature of their programs and the quality of their faculty, students, and facilities. Copies of these reports are available at the campuses and the Office of the Commissioner of Higher Education. (The bulk of these ten reports prohibits attachment to this report.)

The reports were mailed to the reviewers at least one month before they visited the campuses. Reviewers were also asked to indicate how they wanted to spend their time on campus. Emphasis varied, but the reviewers interviewed graduate students, faculty, and administrators, examined

dissertations, and otherwise conducted their reviews in a similar manner. The reviewers' reports were mailed to the campuses upon receipt in this office. All departments have responded to these reports.

I held meetings with each review team to go over the purpose and procedures of the review. I knew in advance the reviewers were men and women of professional distinction; I was further impressed by how conscientious they were in carrying out their assignments. Typically, they spent a day and one-half on each campus. In some instances, the reviewers wrote separate reports; in other cases, the reports were prepared as a joint effort.

The review teams included professors from both regional and non-regional universities. The institutions represented were Arizona, Colorado State, Idaho, Michigan State, Oklahoma State, Oregon State, Texas, Utah and Wisconsin.

No reviewer recommended elimination of a program, though two reviewers suggested program re-structuring, and nearly all specified problems. The reviewers said (some more explicitly and forcefully than others) that each Ph.D. program is of sufficient worth to warrant retention in one form or another on grounds of academic quality or service to other parts of the university, state, and region or on more than one of these counts. In some instances, however, they called for program improvements of sufficient magnitude to warrant serious consideration of whether or not it would be possible to achieve the improvements with the limited resources available to the Montana University System. It is important to note that retention was recommended as the programs now stand. The improvements were not mandatory for program continuation.

The reports of the reviewers could not be construed as efforts to

"whitewash" programs. The reviewers seemed candid and made incisive criticism, as well as laudatory comments. They pointed out both major and minor problems. They defended the general value of a Ph.D. program, but they were willing to spotlight program deficiencies. For these reasons, the reports of the outside reviewers were invaluable. No fair, meaningful, or professional effort could have been accomplished without them. This process is employed nationwide, and it would have been unthinkable to do otherwise in Montana.

The campuses will respond to my report which will give you additional information in preparing your recommendations. The campuses will also respond to your report before the September 13, 1976 Board of Regents meeting. Copies of all pertinent correspondence will be forwarded to members of the Board of Regents.

B. THE PROGRAMS AS EVALUATED BY THE REVIEWERS

As a professional educator I have the responsibility to respect the recommendation of other professionals. Briefly, here are the reviewers' recommendations. Their reports are appended as attachments two through nine.

1. Life Sciences:

   a. Microbiology (attachment 2): maintain both programs; no major improvements needed.

   b. Botany (attachment 3): maintain both programs; major improvements desirable at MSU.

   c. Zoology (attachment 4): provide zoologists at both universities with access to a Ph.D. program in Biology, which would consolidate several existing programs in the life sciences at each campus; some improvement suggested for both programs.

2. Chemistry (attachments 5 and 6): maintain both programs; no major improvements needed.

3. Mathematics (attachments 7, 8, and 9): maintain both programs; major improvements desirable at both campuses.

As a staff member of the Commissioner of Higher Education, who is the executive officer of the Board of Regents, I have the responsibility to explore the reviews further and develop alternative courses of action should it be decided that any of the programs should be discontinued. The Board of Regents governs the Montana University System as a system. The reviewers took note of the interaction of programs with related programs, but, of course, were in no position to know or to determine statewide priorities for improving higher education in Montana. Similarly, some reviewers considered the role and scope of the universities rather directly but, again, the Board of Regents and the Commissioner and his staff are more deeply concerned with this matter.

1. The Life Sciences

The Microbiology departments at both campuses received excellent reviews from a seasoned review team which earlier had recommended termination of a Ph.D. program in Microbiology in Louisiana (see attachment 3). At both universities, it may be that the Microbiology program is the strongest of the three life sciences programs which were reviewed. This seems to be the case at Montana State University. Its Microbiology program was judged to be of a quality comparable to the University of Montana's Microbiology program, but, as we shall see later, the Botany program at Montana State University was evaluated to be of lesser quality than its counterpart at the University of Montana and, on the important criterion of faculty quality as measured by publications, so was the Zoology program.

Before commenting on the programs of the individual departments the reviewers acknowledged the importance of Microbiology a. a discipline. They asserted that "the discipline of microbiology is. . . located at the 'cutting edge' of science as evidenced by Nobel laureate awards and related

recognition programs". The reviewers also considered Microbiology to be a discipline in which there is "a rather good marketplace" and claim that "students originating from quality programs are often able to choose from several opportunities" (p. 2).

The reviewers raised no serious questions about the quality of either program. To the contrary, they believed both programs to be strong. The only remarks which could be construed as critical were relatively minor. They referred to facilities at Montana State University as "adequate. . . but not overly impressive". They stated that the University of Montana's "funds for supplies and expenses, travel, equipment were inadequate" (pp. 5-9).

Laudatory comments were far more extensive. The beginning of the summation sets the tone for the more specific comments (p. 11).

> The state of Montana is fortunate to have strong doctoral programs in Microbiology in each of its two major universities. . . these two programs do not duplicate. . . but rather complement each other. As a result, a very strong research and academic base in immunology (immunology and immuno-chemistry) has been achieved and the faculty and programs are recognized regionally and nationally* in their respective areas of expertise. The programs are tied with important programs such as. . . WAMI and perhaps the future Veterinary Medicine program at Montana State University and the Infectious Disease Center and Rocky Mountain Laboratory for the University of Montana.

On all the major review criteria, except facilities, both departments received specific praise. At Montana State University, for example, the reviewers found "dedicated faculty," "high morale," "a well defined need for the doctoral program," a student demand which is "very high," "service to the people of the state," "a very capable group of young scientists," and a record for attracting outside resources that is "very good". The review of the Montana State University program concludes with a "word of caution"

*The underlining is mine. This is one of the most laudatory comments made by any reviewer or review team about any program.

that is not a critical comment: two especially well-recognized microbiologists are urged to reduce administrative and departmentally-related activities (pp. 4-7).

Specific comments of praise about the University of Montana's Microbiology program began with a comment that "The course work and content of the doctoral program. . . are adequate in breadth and strong in specialties". Faculty and students are "committed" and "well prepared" and have "good morale". The reviewers believe "the student demand is good and the quality of students indicates the overall strength. . .". The program is commended for preparing students who can find jobs, interacting well with other programs, serving the state, and attracting outside resources. Finally, "the University of Montana's research program is visibly strong" (pp. 8-9).

For a recommendation which, if followed, would affect the organizational location of the University of Montana's Microbiology program see attachment 4, page 10. Joseph Bagnara, editor of a professional journal in Zoology, and Professor Kenneth W. Cummins, an experienced reviewer, suggest one Ph.D. in Biology at the University of Montana with options for students to major in the fields of Zoology, Botany and Microbiology. The area of emphasis of the Biology Ph.D. would be different from degrees awarded at Montana State University by virtue of the faculty strengths and research interests (see the report for details). The recommendation is further supported with the following statement: "Since modern Biology is functionally oriented and highly interdisciplinary, there are both philosophical and practical advantages to a broader context within which to offer the Ph.D. degree" (p. 4). This recommendation and the reaction to it at the University of Montana are discussed in part C of my report (pp. 32-33).

The Botany program at the University of Montana received a highly laudatory review (see attachement 5). Two University of Wisconsin reviewers, one the holder of an endowed chair, state that "the program is highly respected nationally for its significant contributions to effects of pollution on the environment" and specify several other areas of excellence, such as taxonomy, systematics, and morphology (p. 5).

Specific areas of strength include a faculty "that is well oriented to its overall professional responsibility of teaching and research". They speak of "unusual strength in ecology". One faculty member is "widely recognized as an international authority" who has been of "tremendous service to the State of Montana and the nation". In addition, the reviewers compliment the University of Montana's Botany department for strong interaction with other departments and federal agencies, its capacity for obtaining external support, and for providing strong leadership at the department head level and above (pp. 5-6).

The sole weaknesses cited were, first, lack of rapport between the School of Forestry and Department of Botany. The team suggests "administrative review" of this area. Second, the Botany Department has "considerable equipment" but "inadequate" space, too few and too small laboratories, and a greenhouse situation termed "deplorable". Ten times more greenhouse space is "urgently needed".* (All citations are from pp. 6-7 of the Botany review.)

* The Botany Department concurs with the need for space (attachment 10, response iii, pp. 1-2). Administrative review of the relationships between Botany and the School of Forestry is forthcoming.

The University of Montana's Zoology program received more critical commentary than did the Botany program. The reviewers cited a lack of courses in physiology and assert that "Genetics also seems to be weak and replacement of a limnologist is required" (p. 1).* Another comment relates to the need to "increase the level of outside support for graduate level research" (p. 9). The publication record of the faculty was described as "fair", but with "promise for the future" (p. 7). On the clearly positive side, the reviewers believe that "the Ph.D. students at the University of Montana are definitely of a high quality" (p. 7).

In summary, two of the three life science departments under review at the University of Montana were reviewed in positive terms--Microbiology more so than Botany. Zoology received a mixed review, but on balance a favorable one.

Reviewers believed the Botany program at the Montana State University (which, along with the Zoology Ph.D., is offered by the Biology Department) to be clearly of lesser quality than the University of Montana program. The guidelines and criteria used in all of the Ph.D. reviews stressed quality. These criteria also address the question of the need for the program and the consequences of program elimination. Although the reviewers are critical of Montana State University's Botany program, they cite the adverse consequences of elimination and the general benefits of having a Ph.D. (whether of uncertain quality or not) to justify non-elimination. They are also optimistic about the future (see part C. p. 23 of my report for their rationale).

The reviewers specify the strengths and weaknesses of the Montana

*Vice President Bolle, Dean Solberg, and Dean Stewart assured me that the limnology situation will be rectified. Genetics is offered also in other departments. The University of Montana's Zoology Department's official response (attachment 10, response v) outlines a plan for improving its record in publication and attracting outside resources.

State University Botany program in the following way. The Botany reviewers commend the department's (1) course offerings in plant physiology, (2) two professors of high caliber, (3) ability to secure external funding, (4) facilities and (5) excellent administrative leadership (pp. 2-3). They criticize the department, however, for a lack of professional orientation in about half the faculty, a small staff and lack of balance with two areas "in critical need of competent representation", a lack of research orientation, low salaries, and need for technical help to relieve faculty of mundane chores (pp. 3-4).* At one point in the report, they call the University of Montana's program "strong" and refer to the "necessity of a strong one at Montana State University" (p. 7). In so doing, they imply comparative weakness in the Botany program at the latter institution.

The principal criticism of the Montana State University Zoology program was that only one or two faculty members approach an average of "one paper a year", which the reviewers cite as the norm for an active biologist.** (In my view, this is certainly a fair, if not permissive, norm. Both Microbiology departments and the University of Montana's Botany and Zoology departments meet it.)

The Montana State University zoologists, like those from the University of Montana, were rapped on the knuckles for not generating sufficient outside funding.

The reviewers believe that the Montana State University Zoology program needs doctoral level courses in genetics, physiology, and limnology.*** They point out that three WAMI faculty members, housed in the Biology

* For a rebuttal of these charges, see Montana State University's response to the Botany review (attachment 10, response iv).

** and *** Points rebutted by Professor James Pickett, Chairman, Biology, MSU (attachment 10, response v, pp. 3 - 5).

department for administrative purposes, could teach doctoral courses (p. 2). The three people in question are young, already productive and promising. The WAMI program, research, and plans for continuing education in medicine, however, occupy their time.

On the positive side, MSU's Zoology program was praised for the high quality of its students and the strength of invertebrate Zoology as opposed to the University of Montana where vertebrate Zoology, though called "old fashioned", is the stronger of the two fields (p. 9). The reviewers also considered the Montana State University programs to have more offerings (p. 3).

The reviewers stressed the difference in the orientation of the two Zoology programs. Montana State University emphasizes applied aspects; the University of Montana's program is more of the "older classical type" (p. 3). They further point out that Montana State's Zoology program is environmentally oriented (as is Botany). Graduates are trained to obtain positions as resource managers (p. 2).

2. Chemistry

The Chemistry review team praised the programs at both universities. The reviewers, Dr. Peter K. Freeman, Oregon State University, and Dr. Jean'ne M. Shreeve, Department Head, University of Idaho, wrote separate reports. Dr. Freeman's report is attachment 5; Dr. Shreeve's is attachment 6.

Dr. Freeman described the University of Montana faculty and program areas almost without critical commentary (pp. 1-5). He did speak of the "varied" quality of students (p. 5), but added that this was a national problem.

He recommended strongly against moving the Biochemistry group to Allied Health Sciences, an administrative cluster of disciplines currently under

contemplation at the University of Montana. He said "I doubt the doctoral program in chemistry could survive such a blow" (p. 5). The chairman of the University of Montana's Chemistry Department assures that this will not happen.* Dr. Freeman also suggested that a professor in Organic Chemistry be placed in the Environmental Studies program, since that professor has lost interest in Ph.D. chemistry research (p. 6). The opening would be filled by an organic chemist interested in research. These and other suggestions do not, however, raise serious questions about the program's quality.

Dr. Freeman is also laudatory in his comments about the Montana State University faculty and program where "there is strength exhibited in all the traditional areas of Chemistry. . .", though he did warn Montana State University against going too far in the direction of Environmental Chemistry at the expense of traditional Chemistry (pp. 9-10).

Like most other reviewers, he saw important connections between Chemistry Ph.D. programs and other Ph.D. programs. In speculating about the impact of elimination of a program, he points out that:

> A loss of research quality and competence in chemistry would cause a ripple effect across the campus in both cases due to the fact that chemistry interacts strongly with other departments such as Zoology, Geology and Microbiology at Missoula and Chemical Engineering, Physics, Plant and Soil Science, Animal and Range Science, Microbiology, Genetics, and the MHD program at Bozeman. . .The WAMI program which is off to such an excellent start might very well be hurt. . .

Professor Shreeve begins her report with some comparisons. After noting each department "does well", she comments "that Montana State University with its larger faculty, longer established Ph.D. program and built in benefits from the Agricultural Experiment Station and the WAMI program is

* See attachment 10, response vi, p.2.

involved in a greater variety and larger number of activities" (p. 1 of program comparison). She does not necessarily imply that Montana State University has a higher (or lower) quality program than the University of Montana's. She believes both are strong, with both faculties strongest in Biochemistry.

Her only criticism applied to both departments. Library holdings at the University of Montana were called "very modest and viable only because of interlibrary loans or phone calls to friends who will send xeroxed copies of journal articles by return mail" (p. 6 of UM report). In commenting on Montana State University she describes the library holdings as "modestly adequate" (p. 5 of MSU report).

3. Mathematics

The mathematics programs received reviews which included a number of suggestions for improvement. Three reviewers were used because of the existence of a statistics program at Montana State University within the Mathematics Department. Each reviewer wrote his own report. The statistician reviewer was Professor Franklin Graybill, Colorado State University. (attachment 7) The mathematicians were Professor Paul C. Fife, University of Arizona (attachment 8) and Professor William R. Scott, University of Utah. (attachment 9)

Professor Graybill's major recommendation for the University of Montana was that the "computer science department be abolished and made a part of the department of mathematics" (p. 3). He thought the University of Montana's program to be "unique" and "progressing well" (p. 4 UM report). He did, however, suggest that statistics faculty "should arrange their activities so that they can publish in

mainline statistical journals, as well as publishing joint papers with investigators in non-statistical journals" (p. 5). (Statisticians at the University of Montana, like statisticians elsewhere, devote a good deal of time to helping other faculty members write papers.) As do the other two reviewers, he labels the record of the department in attracting additional resources to the state as "very weak" (p. 7).*

Montana State University places greater emphasis on statistics than does the University of Montana and, accordingly, Professor Graybill has more to say. He describes the statistics program as "satisfactory in content, purpose and goals" but sees a need for more faculty in the program (p. 5 MSU report). He regards the "quality of the program at the two schools as comparable and adequate," but notes that they "differ somewhat because the objectives are not the same" (p. 6).

At this point the program differences should be specified. Professor Graybill said the purpose of the University of Montana's program "is principally to train students. . .to enable them to obtain teaching jobs in four-year colleges and universities" (p. 1 UM report). He describes the Montana State University program as a "conventional Ph.D. program and the main strength, in addition to mathematics, is the option in statistics" (p. 1 MSU report). In Professor Scott's words, "the University of Montana's program is now almost entirely devoted to a training program for college teachers, while Montana State has two separate programs--one in statistics and the other in mathematics, the latter usually with a minor in some applied area" (attachment 9, p. 1). The third reviewer confirms the differences, but points out that the University of Montana program "emphasizes educa-

* For rebuttal, see attachment 10, response viii, appendix 1, section II.

tion in a broad range of mathematical subjects and applications, and in teacher education (attachment 8, p. 2).

In this instance, we have a case of "apparent", as opposed to "real", duplication. Were the quality and need of the programs beyond question, little would need to be said. Reviewers Fife and Scott, however, raise some questions.

In speaking of demand for Ph.D. statisticians, Professor Scott writes that the "demand is low. . .in the purer parts of mathematics . . .and "still good in. . .applied mathematics, applied statistics" (p. 2). He goes on to state the implications for the two departments (p. 2):

> Firstly, the market for pure mathematics Ph.D.'s is down and will probably get worse, while that in applied areas is good (with a possible worsening trend in the 1980's). Secondly, this is an ideal time to fill open positions with good applicants in pure areas; but more difficult and/or costly in more applied areas.

Professor Fife notes that both academic and non-academic employment are becoming harder to obtain for Ph.D. mathematicians and refers to discussions in the science about offering students more options in applied mathematics and interdisciplinary studies (attachment 8, p. 1).

Although Professor Fife goes on to say that students from both universities are getting jobs despite the bleak market, national long range trends may sometime affect Montana. If so, by his own reasoning, students from the applied programs (the mathematical sciences option at the University of Montana and the applied statistics option at Montana State University) will have an easier time finding employment.

Turning to questions of quality, the primus inter pares of the review criteria, the two reviewers who specialize in mathematics made some pointed criticisms of both departments. Professor Fife writes that "a good part of each department is relatively unproductive".

This prompts him to recommend that "one to three senior level mathematicians should be hired in each department" and "some two or three-year rotating junior level positions should be created". He believes that the new faculty should have "strong research records" and be "currently active and knowledgeable in applications of mathematics" (p. 5).

Professor Fife believes both universities (not merely the two departments of mathematics) should immediately tighten their tenure and promotion policies and enforce these policies more stringently (p. 6). He believes that Missoula "does not seem to reward people enough for scholarly effort" and calls for codification of personnel policies at Bozeman (pp. 6-7). *

Finally, he describes the ability of the faculty, except for MSU's statisticians, to secure outside funding as poor. Again, this point is rebutted by the University of Montana.

The third reviewer also found shortcomings in the two programs. In discussing the University of Montana programs he says that "the research record of the department as a whole is not strong," and adds that one of the two strongest publishers is not now directing any theses. He admits that "sometimes people with mediocre publication records are gifted at getting students to produce research theses, and that seems to be the case here" (p. 4). In commenting on the balance between the two options at the University of Montana, he writes that "the regular Ph.D. program is minimal" (p. 4). This is not a criticism. By this he means the section of the program devoted to training college teachers constitutes nearly the whole of the program.

*The University of Montana intends to review its tenure policies in early fall.

On a positive note, he was impressed with "the strong commitment to good teaching and improving teaching on everyone's part". He also found difficult examinations, high grading standards, high student morale and improving student quality. He found the Ph.D. theses to be generally well written (all involving mathematics on the Ph.D level), but "as best as we could determine, only one published paper will result from any of the theses already completed" (pp. 5-6). *

He sees the principal problem as the small number of students (about 25). The National Science Foundation money,which launched the program,is gone and this means less money for grants for students. If there were 50% more students, Professor Scott believes the program could be more efficiently run with larger graduate classes and less teaching overload (p. 7).

As did Professor Fife, he believes that the University of Montana's tenure and promotion standards are "well below the standards of the better universities in this region" (p. 8).

Returning to positive points, he finds good relations with other departments (except computer science) and reports graduates have found teaching jobs due to the uniqueness of the program (p. 10).

Professor Scott commented only briefly on the applied statistics option at Montana State University but declared it "successful" and "useful" to the University and the State of Montana. He described his criticisms of the program as "minor". These are: (1) an inactive member in a small staff and (2) labeling the Ph.D.as Mathematics instead of Statistics.

Turning to the Mathematics program, he finds problems similar to those at the Univerity of Montana. These include a "low research

* For an analysis of the publish ability of theses results, see attachment 10, response viii.

output of the department as a whole. . .although not to the same degree as at the University of Montana". He uses the word "minimal" to describe the Montana State University program, just as he did for the University of Montana program, only in this instance it is the statistics program which he feels overshadows the regular Ph.D. program (p. 14).

Professor Scott finds the same problem in low student numbers as that which exists at the University of Montana only "slightly worse" and calls for the hiring of more graduate students as the "first financial priority," even before the hiring of new faculty (pp. 14-15).

In his summary and conclusions (pp. 16-18) he called one of the theses he read "old fashioned" and pointed out that except for statistics there were "very few grants and contracts". The research output of the department as a whole is "below standard" but there are a "few bright spots". He made some positive comments about the library, relations with other departments, administrators above the departmental levels, past success in producing Ph.D.'s, and the fact that several members are actively involved in applications of Mathematics. Most of his criticisms have been described above excepting need for a codification of rules and departmental decision-making. He found that about half of the theses lead to publications. Finally, he recommended that Statistics graduates be given a Ph.D.in Statistics--not Mathematics.

Summary

The reviewers leave two major impressions:

(1) The two programs are not duplicates. The University of Montana's Mathematics program is designed to prepare college teachers.

(especially in small colleges), as well as to turn out "regular" Ph.D.'s. Montana State University has both a standard Ph.D.program and an applied statistics component. In each case the "unique" aspect of the program seems to be its strongest point.

(2) The quality of both programs should be improved. Senior-level appointments are called for at both institutions. A shortage of students is noted. The publication records of both faculties were criticized; the University of Montana's was criticized a bit more severely. Neither campus was commended for attracting outside money.

RECOMMENDATIONS

1. Life Sciences

a. Microbiology. It is a pleasure to write about Montana's two fine Microbiology programs. The faculty at both institutions is active in publication and securing outside funding. The programs serve other Ph.D. programs, as well as the state and region. As you have read in part B, prestigious national reviewers recommend retention of both programs. No other programs were praised more highly.

The obvious question is whether there is a need for two programs, especially when relatively few doctoral candidates (about two a year in each program) are produced. (See attachment 11 which lists Ph.D. production in all of the programs.) There are justifications for maintaining both programs, even beyond the reviewers' statement that the programs complement -- not duplicate -- each other.

Turning first to the criterion of quality, Montana State University's program has developed overall strength and an international reputation in several areas of immunology. By itself, this is an important accomplishment. When it is remembered that Montana State University is the unit primarily responsible for medically related academic programs, this specialization takes on additional importance. Indeed, the department is inextricably involved in the WAMI medical program and interacts with Nursing, Veterinary Science, and the Genetic Institute. The Montana State University Microbiology Ph.D. program also serves graduate students in nonmedical academic programs, including Agriculture, Biology, Chemistry, Engineering,

and Plant Pathology. It provides Montana with prestigious linkage with out-of-state programs. An individual, but illustrative, example occured when a Harvard Ph.D. candidate in Geochemistry did his field research with an environmental Microbiology team at Montana State University.

The Microbiology Ph.D. program has served the state in many ways. These include industrial consulting, a project which resulted in the opening of a watershed which has been closed to public entry for about fifty years, sanitation studies, water quality research, and many other types of activity.

As in the case with the elimination of any doctoral program, the truly first-rate faculty would be strongly tempted to leave, outside funding would suffer, as well as other detrimental effects eloquently described in general terms by a reviewer of another program (see p.33 of this report).

There is a special reason for continuing the Ph.D. program in Microbiology at both universities. Microbiology faculty have been campus leaders in (1) bringing many types of research projects to the institutions, (2) publishing extensively, and (3) receiving national honors. In short, both departments provide a model for other departments at each institution to follow and Microbiology faculty members stimulate colleagues in other departments.

The two departments have organized the Montana Institute for Immunology and cooperate by exchanging professors, engaging in joint research, sharing facilities at the Rocky Mountain Laboratory, serving on thesis committees from the other campus, and in other ways. The University of Montana Microbiology department also interacts

importantly with other departments. The strongest ties are with Biochemistry, but it associates closely with Botany, Zoology, Environmental Sciences and Microbiology. Faculty members serve on graduate committees in still other departments at the University of Montana. Installation of a new electron microscope will increase interaction and exchange of ideas.

The University of Montana's program serves the state in the allied health disciplines and has made a contribution of national importance in the understanding and treatment of venereal disease.

Both universities have had no trouble placing their graduates. There is a genuine national need for Ph.D. Microbiologists.

To repeat, the idea of eliminating either program is unthinkable if we are to encourage quality higher education in Montana. The following citations are from the reviewers' report (see attachment 2, pp. 4-5, 8).

> There is a well defined need for the doctoral program at the Montana State University. . . termination. . . would:
>
> (1) Reduce the base of retaining competent faculty members [illegible]e WAMI and undergraduate programs.
> (2) Reduce the inflow of research dollars to the State of Montana. . .
> (3) Terminate a strong basic and research oriented immunobiology program capable of service to the state, region, and nation.

The reviewers also defend vigorously the University of Montana Microbiology program:

> The graduate program in Microbiology plays a very important role to the University community and to participating departments. Cooperation with the Biochemistry faculty has been productive both from an academic concept and in the

> competition for research dollars. The student demand is good and the quality of students indicates the overall strength. . . .
>
> The Department does provide some services to the state and region. Research studies in the livestock industry, as well as health related activities through the Infectious Disease Center and the Rocky Mountain Laboratory, provide for a good background of experience.

In closing, the existing Microbiology programs are necessary at both universities due to their high quality, the example they set for other departments, and the service they provide to the university, state and region. The state should take great pride in having two such programs and see to it that they are funded adequately. It should be remembered that the reviewers recommended elimination of a Microbiology program in Louisiana, but they argued vigorously for the retention of both programs in Montana.

b. Botany. As discussed earlier in this report, the Botany reviewers believed the Montana State University program to be of lesser quality than the University of Montana program in Botany. It should be emphasized that they were reviewing the Ph.D. program, as opposed to the undergraduate program, and that their comments do not extend beyond the training of doctoral candidates.

The reviewers argue, nonetheless, for a strong Botany program at the Bozeman campus. In addition to citing the capability of some faculty members to attract outside funding and supporting the general idea of a doctoral program as a stimulus for research and teaching, the reviewers make the following statement, which endorses strongly the idea of a Ph.D. Botany program at Montana State University (attachment 3, pp. 1-2).

> Because the Agricultural Experiment Station is located at Bozeman, the Botany Section of the Biology Department has the inescapable responsibility of providing outstanding basic course in Botany for graduate students in such fields as agronomy, horticulture, soils (combined in the Department of Plant and Soil Science), range science, etc. The botanists must provide an array of courses in plant anatomy and morphology, plant physiology, plant taxonomy, and plant ecology to meet the needs of these departments, as well as for botany graduate students. Without quality course offerings in each of these botanical areas, the entire program of advanced work in agriculture is jeopardized. One of the strongest points that we can make is that we see no way that the State of Montana can benefit from having a weak program in Botany at Bozeman.

The Biology department at Montana State University also supports the idea of maintaining a Ph.D. program. Its report argues that:

> Elimination of the Ph.D. would have a significant impact on the undergraduate program. . . and would also reduce support for graduate programs in several departments. . . .These negative effects would result primarily from reduced faculty morale and greater difficulty in obtaining outside research support. The only way to overcome these negative effects would be to provide for more faculty research time on state funds, more technical assistance on state funds and more equipment purchases on state funds.

The Biology department at Montana State University also points out that elimination of the Ph.D. program would make it much more difficult to obtain good faculty and outside research funds for student stipends and for equipment used in both and undergraduate teaching labs, as well as research labs. This, in turn, would reduce MSU's attraction for other research facilities.

In responding to the Ph.D. review, the Biology Department (in which the Botany program is housed) points out that Botany is only one of three Ph.D.s offered in the botanical sciences at Montana State University. The others are Plant Pathology and Crop and Soil Science. No less than twenty-three currently enrolled

Biology graduate students are taking courses in these two degree programs.

The reviewers note little duplication between the University of Montana's Botany program and the smaller one at Montana State University, which, in their words, "is restricted to specialization in terrestrial and aquatic ecology"(attachment 3, p. 2).

Questions of need begin with whether or not a Ph.D. in Botany is required for a land grant institution to provide required services and, if so, what kind of a Ph.D. should Montana State University offer to perform its special service mission. Agriculture is one of Montana State University's most important programs, and a strong Botany program should support it. The strongest Botany faculty members, however, (and most successful grant obtainers) are ecologists. Although ecology is important to agriculture, additional strengths are needed. Perhaps they exist in the other departments in Botanical Sciences in the College of Agriculture. If so, a reorganization might possibly be in order. In this context, it is important to note that the agricultural programs will be reviewed in the near future.

In short, if we accept the reviewers' recommendations and their views about need, service, and Montana State University's mission, we should commit resources for this purpose and, in addition, permit Montana State University to reorganize (if necessary) to strengthen Botany. One possibility would be to continue the Ph.D. program in Botany at Montana State University on probation until the Board of Regents is presented with a convincing plan for steering the program in the correct direction.

The University of Montana's Botany program is of high quality, in the opinion of two reviewers from the University of Wisconsin. Its elimination would have, moreover, far-reaching effects on the surviving master's program in Botany, the master's program in Environmental Studies, the master's program for teachers of Biology, the master's program in Wildlife Biology, as well as the undergraduate programs, not only in Botany but also in Biology and Wildlife Biology. Students in other doctoral programs such as Forestry and Zoology might well be unable to take the courses they need to finish their Ph.D.s should the Botany Ph.D. program be eliminated. In addition, one could add that faculty quality would be lost and offer other reasons why a program should be maintained, not the least of which is service to the university, state and region and the attraction of outside funding to the University of Montana.

The same arguments could be applied also to the programs at Montana State University, but the point is that the University of Montana already has a quality program in Botany although some expansion of support is needed (such as a new greenhouse and additional equipment funds). High quality faculty members are there already and no radical upgrading is needed to continue the program at the level of a regionally competitive Ph.D. Clearly, the Botany program at the University of Montana can stand by itself as a quality program and also serve other programs, as well as the state and region. For example, the department reports a number of projects in which its faculty and students are actively participating. These include the effects of fire on state and national forests, mineral nutrition of forest trees, physiology of

plant virus diseases, and many others.

The reviewers noted a lack of rapport between the schools of Forestry and the Botany Department. The University of Montana is, however, putting this question under administrative review at the highest level. Logic would dictate the School of Forestry and the state's strongest program be located at the land grant university, which in Montana would be, of course, Montana State University. For historical reasons, this has not evolved in our state. In this instance, I would recommend that we live with the inconsistencies and continue a Ph.D. at the University of Montana as well as build an appropriate one at Montana State University.

The Botany review team made the following statement about continuation of the Ph.D. programs at the two institutions (attachment 3, pp.7-8).

> Because of the presence of an already strong Botany program at the University of Montana and the necessity of a strong one at Montana State University it is desirable that both Ph.D. programs in Botany be continued. Actually, there is little duplication in the two Ph.D. programs. The Ph.D. in Botany at Montana State University is restricted to students specializing in aquatic ecology and terrestrial plant ecology, areas not as strongly represented at the University of Montana. Conversely, the areas represented by the Ph.D program at the University of Montana are not duplicated at Montana State University.
>
> The presence of the Ph.D programs at both universities has made it possible for active faculty members to obtain very substantial research grants. Funds from these grants have made possible purchase of equipment and supplies.

And, in conclusion, they write that "the Ph.D program can serve as a stimulus for both teaching and research, and is especially valuable on the Montana State University and the University of Montana campuses, which are so isolated from other comparable

institutions of higher learning."

At the risk of being redundant, it seems that the future of the Montana University System would best be served by specialization at both the major universities. Without a doubt Montana State University should continue its historic and defined mission in the area of agriculture. To do this, a separate Ph.D program in Botany may or may not be necessary. Botanical research and program activity, whether focused on the question of ecology or not, might become a question which would be more closely related to the Agricultural Sciences. This is an organizational matter for Montana State University to address. All I can say at this point is that in comparing two Botany Ph.D programs, the program at the University of Montana is of higher quality, has more faculty, produces more students and appears to be of service in its own right. As a non-agriculturally oriented Botany program, it fits in well with the University of Montana's Microbiology and Zoology programs. Indeed, one review team recommended a reorganization of the three programs into a Ph.D in Biology with three options (see pp.33-34 of my report for further discussion).

In closing, the historical evolution of the universities in Montana has not been entirely based on logic and reason. This is one reason why a strong central office is needed. But aside from all that, the question which faces you, as Commissioner, and the Board of Regents is whether or not to start from the beginning, which I would find impractical, or to recognize what we have now. This means simply that the University of Montana's Botany program clearly deserves to be maintained. Montana State University's Botany program may require upgrading to exist by itself. If reorganization is called for, the matter deserves

study on the campus. Imposed reorganizations will not lead to the greatest benefits; those regarded as sensible by the faculty and the administration of a given unit within the system can lead to improvements. On the other hand, speaking generally in terms of role and scope, it is reasonable that the Montana State University Botany program be oriented more towards agriculture and less towards duplication of the life sciences Ph.D activity at the University of Montana.

c. Zoology

Earlier in this report, the reviewers compared Montana State University's Zoology faculty unfavorably with the University of Montana's on the basis of publications. In responding to this comparison, Professor James Pickett, Chairman of Montana State University's Biology department concurs but makes the point that his faculty is required to do more undergraduate teaching (see attachment 12, response iv). He believes that, given this situation, two refereed papers over a five-year period would be a fairer measure of scholarly productivity than the one-per-average suggested by the Zoology reviewers for Biologists in Ph.D. departments. When this measure is applied to his department, nine faculty members qualify, but only one with a primary research orientation in Zoology. (Five claim Zoology as a second field).

The Montana State University Biology department's response to the review of its Zoology program also points out that it is incorrect to say that WAMI faculty in Biology do not participate in graduate education. To the contrary, most WAMI courses are open to a limited number of graduate students. In another rebuttal, referred to in Part B but repeated here, the response of Montana State University shows clearly that there are substantial course offerings in the areas of Genetics, Animal Physiology, and Limnology. This appears to be an error on the part of the reviewers who suggested that offerings in these areas were weak.

In conclusion, the Montana State University Zoology response urges continuation of access for the Zoologists to a Ph.D. program. The Biology department should, "offer a Ph.D. in Biology" with

certain options. These options would include Botany, Fish and Wildlife Management, Genetics and Zoology. This recommendation is in line with the recommendation of the Zoology review team. The departmental response goes on to say that Ph.D. students should work only under faculty members who have had refereed publications in their recent history, who have directed at least one thesis, and who have financial support for the Ph.D. research project. Another recommendation by the Biology department suggests that the department should continue its research efforts in Ph.D. programs in Terrestrial and Aquatic Ecology (its area of strength in both Botany and Zoology) but also concentrate on agricultural and resource management problems. The departmental response concludes with suggestions on how to fill forthcoming positions.

This approach would permit Montana State University to maintain its strength in the restricted areas where it currently possesses clearly adequate quality for offering Ph.D. work. At the same time, applied Ph.D. work and research management and agriculture would be developed. I think that this is a commendable beginning to some long-range planning. As is the case with Botany, Montana State University should develop a systematic and clearly defined plan for staffing, reorganization, and improvement of program quality in Zoology. This plan should be in accordance with the University's role and scope. With regard to Zoology, resource management may indeed be a logical emphasis. The other two areas in Biology, not addressed by this review, are Genetics and Fish and Wildlife. (Professor Pickett does not support entrance of graduate students into the Entomology Ph.D. program -- also housed

in the Biology department -- at this time.) Genetics certainly relates to the medically related sciences which fall within Montana State University's role and scope. Some Zoologists also are oriented in this direction. In short, the Biology department's response to the Ph.D. reviews in Botany and Zoology stands as the initial piece of work in a lengthy process of redefining, reorganizing, and upgrading the Ph.D. programs in Botany and Zoology in accordance with the role and mission of Montana State University and with the hope of avoiding specialized duplication with the University of Montana. I think the most logical path to follow would be to require Montana State University to come up with a fully developed plan for submission to the Commissioner of Higher Education and to the Board of Regents for all of its programs in Biology during the 1976-77 academic year when all of the department's Ph.D. options will be under review. Until such a plan is developed, approved, and evidence is given of financial support by Montana State University and the Board of Regents, I would recommend that admissions into the Botany and Zoology Ph.D. programs be maintained but on a probationary status pending regential approval of the aforementioned plan.

The University of Montana's Zoology program received less substantial criticism with regard to the publication performance of the faculty than did the program at Montana State University. The reviewers regarded the publication record of the University of Montana's department as "fair" and when the curriculum vitae of the faculty of the Zoology department at the University of Montana is compared with the Missoula campus's other departments under review,

the record looks, by comparison, adequate. Nonetheless, the University of Montana (see attachment 12, response v, page 2) has outlined a series of steps to increase productivity in attracting outside funds (for which it was criticized) and increasing duplication. These include: (1) equalization of teaching loads, (2) budgetary support of grant application projects, (3) manipulation of teaching assignments to increase opportunities for preparation of grant proposals and publications, (4) replacement of senior faculty soon to retire with research oriented faculty, and (5) increased service to the community and to the state through extension offerings. Again, however, more than half of the faculty are active in research, especially those hired since the Zoology Ph.D. program was started at the University of Montana. There is every indication that this hiring pattern will continue, and the program as it stands now appears, as indicated earlier, to be of comparable (or greater) strength when matched against the other nine programs in the critical area of faculty publications and research.

The reviewers recommend that Zoology, Microbiology and Botany be organized in one school or division of life sciences at the University of Montana. (For their reasoning see Part B, p. 6.) The Zoology department at the University of Montana supports such a recommendation. The Microbiology department was silent on the matter. The Botany department opposes the idea, and their opposition was shared orally by the Botany reviewers, according to University of Montana officials. A reorganization such as this may be in order, but it should be the product of faculty study and analysis and local campus administrative decision-making. I would recommend

that the University of Montana examine the idea carefully, but a sudden, forced reorganization of this magnitude would be risky. Administrators at the University of Montana would prefer, moreover, to await the construction of a new sciences building which would unite the departments in terms of physical space.

The reviewers argue with eloquence that both the University of Montana and Montana State University should be permitted to offer access to Ph.D. programs to their Zoologists, whether as options of Biology programs or not. Rather than try to paraphrase their words let me present them directly:

> In general, the need for Ph.D. programs in biology can be summed up for both institutions as absolutely essential and the effects of elimination as devastating. The presence of the Ph.D. program is so essential and has so many ramifications to other programs and to the university community. . . .
>
> Importantly, the general misconception that exists at supra-university administrative policy and funding levels that elimination of Ph.D. programs will constitute financial saving is so naive that it could only be perpetuated by those totally unfamiliar with institutions of higher education. Especially in small to moderate sized universities, such as MSU or UM, the Ph.D. program is a labor of love, constituting the basis for an intellectual climate which provides the optimum setting for the educational experience at all levels, undergraduate and post-graduate. At both UM and MSU there is extensive use of graduate students in undergraduate teaching. Although on occasion this process has been maligned, it is usually the best way to provide a greater quality and a more individualized instruction within the economic constraints that always exist. Elimination of graduate programs with the intent of improving the quality of undergraduate education would be highly counterproductive. The quality of the faculty would certainly decline. Faculty teaching loads would increase and the usual methods of dealing with such situations, e.g.

> programmed teaching or undergraduate assistants, have had their best success in the presence of Ph.D. programs, not in their absence. The excellence of the master's programs is highly dependent upon the capability to offer the Ph.D.

The Montana State University Biology department adds to this that elimination of the Ph.D. would have significant impact on the undergraduate program and would reduce support for graduate programs in several programs. These negative effects would result primarily from reduced faculty morale and greater difficulty in obtaining outside research support. The only way to overcome these negative effects, the report continues, would be to provide for more faculty research time on state funds, more technical assistance on state funds and more equipment purchases on state funds. It would be harder for Montana State to maintain and attract faculty and outside research funds for student stipends and for equipment in both graduate and undergraduate teaching laboratories. This in turn would make Montana State University less attractive for other research activities.

The University of Montana's Zoology department makes the following points about the effects of program elimination: First of all, elimination of the doctoral program would harm the surviving master's program. The Zoology department fears a decline in the quality of students entering the master's program if the Ph.D. program were terminated. They also point to a loss of experienced teaching assistants to the undergraduate program, grant-purchased equipment losses, problems in recruiting and retaining quality faculty, and a loss of productive interrelationships with other parts of the university. As measured by service on theses

committees and course enrollment, the Zoology department interacts most closely with Wildlife Biology, Environmental Studies, Microbiology, Geology, Forestry, Education, Botany, Pharmacy, Anthropology — although these do not exhaust the list.

Similarly, at Montana State University, the Biology department which now houses Entomology, Fish and Wildlife Management, Genetics, and Zoology shares graduate committee memberships with faculty from Animal and Range Science, Chemistry, Microbiology, Plant and Soil Science, Plant Pathology, and Statistics and Veterinary Science. Five Zoology faculty members have split appointments with the WAMI medical program and a number of zoologists have been involved in joint research projects with other departments.

In closing, therefore, it should be obvious that Zoology programs, like the others under review, impact upon other programs and this consideration should be kept in mind in deciding whether to retain or eliminate Ph.D. programs. On the other hand, this interaction does not necessarily mean that constructive upgrading and reorganizational plans might not be in order.

2. Chemistry

The highly favorable Chemistry reviews have been summarized in Part B of this report. Retention of both programs is clearly essential due to the high quality of the programs and their importance to other university programs, the state, and region.

Questions of quality were not raised by the reviewers, and my own reading of the curriculum vitae of chemists show the great majority on both campuses to be active in research and publication. Montana State University has a larger department, but the University of Montana has more than enough active research chemists to maintain a Ph.D. program.

The existence of two Microbiology Ph.D. programs was justified, not only for reasons of quality, but because of the special importance of the program at both campuses. The same points support the existence of two Chemistry programs.*

At Montana State University, Chemical Engineering is a Ph.D. offering department highly dependent upon Chemistry, as is the Institute of Genetics, which also supervises a doctorate. Chemistry students take course work in Mathematics, Physics, Biology, and Microbiology. Similarly there is a large non-chemistry graduate student enrollment in Chemistry classes (101 in 1974-75). Disciplines represented by these enrollments include Microbiology, Biology, Chemical Engineering, and several of the agricultural sciences.

The Montana State University Chemistry department also plays a

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* If my arguments are not convincing on this point, see attachment 12, which was prepared jointly by the two Chemistry departments.

strong role in special programs and projects. Major examples include, first of all, the Agricultural Experiment Station where about half the faculty have joint appointments and participate in projects designed to help Montana's agriculture. Currently, fifty to sixty Montana State University faculty from several fields and students are working on ten different MHD projects with a sixteen-month budget of $1.1 million. Chemists are among this group. One of the courses taken by the first-year medical students in the WAMI porgram at Montana State is medical biochemistry, which is currently being taught by several members of the Chemistry department.

The University of Montana also reports strong interaction between its Chemistry department and other Ph.D. granting departments. This inter-departmental support/dependence includes consultation and interaction, availability of instrumentation, and use of courses by students. The University of Montana provides examples of research projects which involve analytical, organic, and inorganic chemists and biochemists in the Chemistry department working with microbiologists, zoologists, geologists and pharmacists. The same report describes how other graduate departments at the University make regular use of the department's instrumentation and how many graduate students in cognate departments take graduate and upper division undergraduate courses in Chemistry. It points out that virtually every Biochemistry course is taken by Ph.D. students in Microbiology. Graduate students in the life sciences use Biochemistry and Physical Chemistry courses, those in Geology take Physical Chemistry, and those in Environmental Studies use the

Analytical and Environmental Chemistry courses. A further example of this interaction refers to a Molecular Biology seminar which is cross listed as a course in Botany, Microbiology and Zoology as well as in Chemistry. As an additional example of the close interaction between Chemistry and other programs, three Ph.D. awardees in Forestry did their work under the supervision of a professor who specializes in Wood Chemistry.

The University of Montana also provides expertise for the state. Reported examples include research and consulting on topics ranging from poisonous metals in game fish to forest fire detection methods.

The national demand for Ph.D. chemists is picking up after a decline in the late 1960's. Both departments offer supporting statistics, and the placement records of graduates from both programs indicate a demand.

The reviewers strongly support retention of both programs. Professor Peter Freeman, of Oregon State University, who had not intended to recommend on program retention or elimination, changed his mind after the review. After pointing out that good faculty would leave, morale would suffer, the quality of teaching would decline, grant funding would decrease, and the learning environment would suffer, he points out that loss of research quality and competence in Chemistry would cause a ripple effect across the campus in both cases, due to the fact that Chemistry interacts strongly with other departments such as Zoology, Geology, and Microbiology at Missoula and with Chemical Engineering, Physics, Plant and Soil Science, Animal and Range Science,

Microbiology, Genetics and the MHD program in Bozeman. He finds the degree of collaboration with other departments to be particularly strong for both Chemistry departments. Buttressing his point, he adds that this interaction is much more than an exchange of members on doctoral committees; collaborative efforts on research are underway so that scholarly efforts in other departments would be placed in jeopardy by eliminating the Ph.D. program in Chemistry. He adds that the WAMI program, which is, in his view, off to such an excellent start, might very well be hurt.

It is difficult to imagine how a comprehensive university could survive without a quality Ph.D. Chemistry program. The University of Montana has programs of proven quality in Zoology and Botany. Like Montana State University it has a quality doctoral program in Microbiology. Quality programs in the life sciences should be supported by a doctoral program in Chemistry. The interaction is obvious and necessary. Montana State University has a Chemical Engineering program, a Physics program, programs in Agriculture such as (Plant Pathology and Crop and Soil Science) and Biology as well as activity in the medically related sciences. In short, if Montana State University is to be the center of studies in Engineering, Agriculture, the medically related sciences and the University of Montana a campus on which programs in the life sciences are offered, Chemistry Ph.D. programs are needed at both institutions. To repeat, there are no questions about the quality of the faculty as it presently exists. There are no major improvements called for by the reviewers. In short, the Chemistry programs stand on their own merits, as well as serve other programs and attract adequate outside funding to the State of Montana.

3. Mathematics

The State of Montana has two quite different Ph.D. programs in Mathematics. Each institution should continue to offer the Ph.D., but each needs support from its own institution, the Board of Regents, and the State of Montana if it is to reach a quality level comparable with most other programs under review.

Both programs received reviews that were often critical in tone (see pp. 12-18 of this report), but it is important to remember several factors about the nature of Mathematics departments in general.

(1) They provide more service to other departments. This is reflected, not only in heavy undergraduate teaching loads, (most disciplines require some mathematics) but also in consulting services for other faculty members who need mathematical assistance in their work. Statisticians are in especially heavy demand.

(2) In this report Mathematicians are compared with people from departments in four disciplines with access to laboratories. The laboratory scholar, if not overburdened with undergraduates, should produce publications on his experiments. For this reason, too, a lower publication rate could be expected from Mathematicians.

On the criterion of publications both programs were criticized — the University of Montana more so than Montana State University. In each department, however, young, recently hired scholars are leading the way. All new hires should be research-oriented. The market is such that this type of person is available.

Montana State University's program emphasizes the Statistics option, which the reviewers regarded highly. The program also offers applied analysis and thus trains students for industry and government, as well as for traditional academic employment.

(For this information and that included about Montana State University in the following paragraphs, see the department's response to reviewers' report, attachment 10, response ix.)

Returning to the question of a publishing faculty and its importance for a Ph.D. program, Montana State University's recent improvement was noted by two reviewers. One remarked that two Mathematicians with good research records have joined the department and "a high research producer already in the department has started directing theses" (attachment 9, p. 13). Another described the Statistics faculty (the reviewer's area of specialization) as "sufficiently active in publication to enable them to direct theses" (attachment 7, p. 2). Also, eleven Montana State University mathematicians have had twenty-eight articles published or accepted in major mathematics journals in the 1974-76 period. The Mathematics department also has a plan for developing further capabilities in this important regard and administrative support for implementing it.

A second major criticism of Montana State University's program was low enrollment. In point of fact, however, Montana State University's Mathematics Ph.D. counts thirty-two graduate students at the present time, a substantial number when compared with other Ph.D. programs under review.

A third criticism of Montana State University's Mathematics Ph.D. specified problems in attracting outside funding. The department claims it has attracted $75,000 in funding since the reviewers' visit (in May) in addition to previously reported grants.

As stated at the outset of this discussion and by the reviewers, both programs could benefit from improvements. Additional staffing was cited as one need. Given the financial constraints of the Montana University System, a more appropriate approach (for both institutions) would be to combine hiring of research-oriented people to replace retirees with a faculty development program in which non-productive professors are revitalized or given undergraduate teaching assignments. In its response to the review, Montana State University sets forth such objectives.

The Mathematics doctorate at Montana State University merits continuation on the basis of service and need. This can be measured both inside and outside of the institution.

The School of Engineering and the Chemistry department both offer Ph.D.'s and draw heavily upon the services of the Mathematics Ph.D. program. Letters attached to the Mathematics department's response verify this obvious point. In addition, the statistician reviewer writes that statisticians "should be active in research and consulting with. . .scientific departments on campus where research is done. . . . Montana State University has done very well. . . and should be complimented" (attachment 7, p. 1). Second the department provides services to state agencies. Finally, it provides a regional opportunity for Ph.D. education. Over half of its students are from Montana or our surrounding states.

In closing, one reviewer commented on the adverse effects of eliminating the program (attachment 9, p. 17):

(i) Loss of a useful training program for Ph.D.'s in Mathematics, one of the very few in a rather large geographic area.

(ii) Weakening of the department, with the probable loss of several staff members. . . .

(iii) Weakened support for other departments.

It will be seen later that he applies the points to the University of Montana, though at Montana State University the existence of Ph.D. programs in Engineering and Physics make point (iii) especially important.

The University of Montana offers a Ph.D. in Mathematics which, in the words of one reviewer, "might be described as a college teacher training program with applied overtones." Later discussion will show that this is not a criticism. Indeed, the reviewer goes on to say the department is "doing about as good a job as possible, assuming certain constraints which exist at present" (quotes from attachment 8, page 4), and the reviewers approve of the movement away from traditional Mathematics.

There are, in a formal sense, two options -- the traditional Ph.D. and the Mathematical Sciences option. In point of fact, the latter option now constitutes the entire program, or nearly so. In this option, students are trained broadly in Mathematics with the idea in mind of (1) serving small academic institutions where Mathematicians must be able to instruct in a wide range of courses; (2) training graduates who can apply Mathematics to problem-solving in other sciences. The first three graduates of the program are currently teaching; two students who have completed all requirements but their dissertations plan to work outside of academe.

Even more than that was the case with Montana State University's

department of Mathematics, .the publication record of the department was questioned by the review team. Two points should be made to place matters in perspective. First, my reading of the curriculum vitae indicates a good deal of the publication concerns the education of Mathematicians -- a subject perhaps germane to this kind of Ph.D., but possibly not considered as appropriate by some Mathematicians. Second, as is the case with Montana State University, the more recently hired faculty are publishing. Also, the department plans further encouragement of research and,as openings permit, plan to hire research-oriented faculty.

Second, the program was criticized for not having enough students. Although it has fewer students than the Montana State University program, the number of enrollees is comparable with most other Ph.D. programs. Also, the departmental response to the review (attachment 10, response viii, p. 1), projects an expansion to 30 students.

A third point on which both departments were criticized was the lack of outside funding. Although the large National Science Foundation grant which launched the Mathematical Sciences option of the program has expired, the department has brought in at least $50,000 in 1976. The charge is rebutted further in the departmental response.

In discussing the adverse effects of eliminating chemistry Ph.D. programs, I quoted a reviewer who described a ripple effect on dependent programs. The Mathematics department believes elimination of its program would create a "tidal wave," (even though the University of Montana does not have Engineering or Physics Ph.D.

programs). Statistics and Operations Research courses are offered to graduate and undergraduate students and they likely would not exist without the Ph.D. program. The department reiterates the belief of some reviewers that elimination of a Ph.D. program would hurt undergraduate education because the load carried by teaching assistants would have to be borne by the regular faculty. The Mathematics department also provides statistical consulting services.

A reviewer points out that elimination of the program would lead students to:

(i) Complete a similar program at one of a small number of places where such are offered, or

(ii) Not complete a Ph.D. program at all.

With (i) he emphasizes the fact that there are only a few universities with this type of a doctoral program. Usually, a program which emphasizes preparing teachers for small colleges is called a doctorate of arts. No reviewer applied this label to the University of Montana's program. Even though the theses may be surveys or syntheses (as opposed to original research), the reviewers regarded those they saw as doctoral-level work in Mathematics. (See also the memorandum from Professor McKelvey in attachment X, response viii.)

In summary, we have two quite different programs in nature, both of which drew a large number of major suggestions for improvement (except for the Statistics option at Montana State University). Yet their graduates are finding employment due, perhaps, to the applied nature of the programs. The programs seem to be headed in the right direction in terms of improving quality. The Montana State University

program is larger and provides a crucial service to Physics and Engineering, as well as to the other departments and region. The University of Montana's program provides service and trains Mathematicians in a non-traditional broad fashion. Were the programs truly duplicative, resources should be concentrated on just one campus -- in my view, Montana State University because of its successful statistics option and better publication record (in the opinion of the reviewers), and also due to its larger size and importance to doctoral programs in Engineering and Physics. But, as elaborated above, the University of Montana's program does not duplicate. It should be retained if the University of Montana is willing to add faculty who publish in Mathematics. If the legislature provides a generous appropriation, the Board of Regents should help. Given the uncertainties of this the University of Montana should specify a plan based on its own budget. Also, all theses should be based on primary research or a request be made to change the title of the program.

4. Summary and Conditions on Recommendations

In supporting the ten programs reviewed, I do so with varying degrees of enthusiasm and, in some cases, with conditions.

First, let me comment on the seven programs which I believe imperative to maintain. I recommend them unconditionally. Six were found to be of unquestionably high quality and to provide essential services to their university, state, and region. These are the doctoral programs in Microbiology and Chemistry at both campuses, and Botany and Zoology at the University of Montana. The seventh essential program is Montana State University's Mathematics program. Reviewers made suggestions for quality improvement, particularly in the area of faculty publications (though the reviewers rated Montana State University higher than the University of Montana's program on this count). In my view, the current faculty has recently began to publish at a rate (see p. 41 of this report) sufficiently high to avoid hiring expensive new faculty members. As discussed earlier, a Ph.D. in Mathematics is necessary to support the several Ph.D. programs in Engineering, the Physics Ph.D. and provides recognized state and regional service. The Statistics option, which is the major part of the program, drew praise from the reviewers.

The remaining three programs attracted substantial suggestions for improvement and my recommendations for continuation are conditional. These include, first of all, Montana State University's Botany and Zoology programs. Montana State University is a land grant institution and logically should have Botany and Zoology doctorates to complement research in Agriculture. The Zoology doctorate or

a Biology Ph.D. of some type should support the WAMI program. The existing Botany and Zoology programs are ecologically-oriented and narrowly so (terrestrial and aquatic ecology). The Biology department at Montana State University proposes offering a Ph.D. in Biology with options in Botany, Zoology, Fish and Wildlife Management, and Genetics (rather than individual doctorates in each of these areas as now is the case). The Biology department would no longer accept Entomology students into a Ph.D. program.

In my view, Montana State University should devote even more attention to priorities, reorganization, and moving toward a role and scope in the Life Sciences even further differentiated from the University of Montana's traditionally oriented Life Sciences doctorates.

In addition to the Biology doctorates not reviewed this year but mentioned above, Montana State University's College of Agriculture offers doctorates in Plant Pathology and Crop and Soil Science. All of these interrelated degrees are scheduled for review in 1976-77 as are medically related programs. Montana State University thus has a splendid chance to develop a plan for upgrading its Zoology and Botany programs, study reorganizational possibilities, and consider tying Botany more closely to agriculture and Zoology to agriculture and the medically related disciplines. When that plan is developed, submitted, and evaluated in terms of funding realities and academic factors, the Botany and Zoology Ph.D.'s (or options) will be reassessed. In the interim the programs could continue with the knowledge that changes are required. An alternative would be to suspend them, but I believe this is unnecessary.

The final program is the University of Montana's Mathematics Ph.D. which I also recommend conditionally. This program is labelled a Ph.D. Another degree in graduate education is the Doctorate of Arts. The latter degree reflects a training program which emphasizes preparation of small college teachers and does not require primary research — a hallmark of Ph.D. programs. At first glance, it appeared to at least one reviewer (before he visited the campus) and to me that the University of Montana is offering a Doctorate of Arts in Mathematics.

The program is, however, something more than a Doctorate of Arts. No reviewer described it as a Doctorate of Arts. It also trains people for work in applied Mathematics. Comprehensive examinations are difficult and of Ph.D. quality. But it is still possible to write non-standard theses. In my view, the program should have a primary research requirement for all theses or request permission for a change in title. (For a dissenting view see Professor McKelvey's memorandum in attachment 10, response viii.) It is difficult to survey or synthesize intelligently at the doctoral student level, even if a person has teaching experience. Doctorates in all fields traditionally require primary research.

A small program, which like Montana State University's provides the university with money-saving teaching assistants, it can be upgraded and developed with just a few additions to the existing faculty. The publication record of the faculty was considered by the reviewers to be less than that of Montana State University's. I was not provided with evidence of a recent spurt of publishing activity in refereed Mathematics journals. Some new blood is needed,

though not as much as the reviewers suggest.

The products of this program do differ from the standard Mathematics Ph.D. program and according to the reviewers applied mathematicians will have an easier time of it finding jobs than pure mathematicians. For one thing, more non-academic employment is available. As explained in pp. 44-45 of this report, the program, by itself, meets review criteria of service to the campus and state. If the University of Montana chooses to commit greater resources to this experiment in graduate education at the expense of other programs, it should be maintained. But my recommendation is dependent on a clear cut commitment that this be done and a detailed explanation of where the money is coming from. Extra money should not be pumped into the University of Montana for this purpose unless the Board of Regents can receive a higher amount of money from the state. As stated earlier, we all should be working toward this end, but it would not be realistic to count upon it at this time.

ATTACHMENT # 1

REVIEW AND EVALUATION OF DUPLICATING Ph.D. PROGRAMS
IN THE MONTANA UNIVERSITY SYSTEM BY OUTSIDE REVIEWERS

I. General Questions as to Purposes of the Review

A. Content, purpose, goals and limitations of the program

B. Need for the program and results if eliminated

1. Student demand
   Market for graduates
   Enrollment data
2. Service to state, region and institution

C. Quality of Program

1. Faculty

2. Students
   Quality of incoming student
   Quality of post-graduate school careers

3. Facilities, equipment and library holdings

D. Program Comparison between the Two Schools

1. Content and extent of duplication

2. Quality

E. Record of the Department Program in Attracting Additional Resources to the University and the State

1. Grants and Contracts

2. Facilities

I. Possible Outcomes

A. Both programs continue

B. Redirection or change in a program, including possibility of increased funding

C. Increased collaboration between programs at University of Montana and Montana State University - to whatever extent is actually feasible and beneficial

D. Elimination of one or both programs

E. Secondary outcomes
   The effects of any action on other programs in the institutions and state agencies and programs

III. Procedures for Review and Evaluation Process

A. Preparation of standardized information in a report presented by each department by Jan. 30, 1976, fifteen (15) copies sent to Helena, plus institutional needs

B. Selection of outside review team members (2 for each discipline)

C. Outside reviewers receive reports for review by mail approximately one month prior to visit and names of institutions in region offering Ph.D's in same fields. They may request additional information from the two schools prior to visit.

D. Reviewers visit both campuses, up to two days on each campus with appropriate rest and remain in the state for one day after both visits, to confer on their findings and outline their reports. Visits will be preceded by an entrance interview by the Deputy Commissioner for Academic Affairs and representative from each campus.

E. Each reviewer submits report to the Commissioner's Office who will forward it to the universities

F. Departments respond to report through campus channels to the Commissioner's Office

G. Deputy Commissioner for Academic Affairs and the Commissioner for Higher Education prepare a report and recommendations to the Board of Regents

IV. Reviewers' Responsibilities

A. Each reviewer prepares own report on each school's program

B. Assessments of quality and recommendations are made related to the general questions in I above and in a stated frame of reference with regard to comparable institutions

C. Comparison of the programs at the two schools again related to the general questions in I.

D. Reviewers are encouraged to make suggestions about possible outcomes or changes, though they are not required to make definitive recommendations regarding retention or elimination

V. Format for Report Prepared by Department

A. The Program

1. Brief narrative defining objectives, specializations or limitations of the program. Does it train research specialists, teachers, or practitioners?

2. Describe how the role and scope of the program as defined in (1) fit those of the institution.

3. Requirements for the degree, including options available.

   (a) Quality controls should be listed as special section

4. Relationship to other graduate programs in the university - evidence of interdepartmental exchange and support.

5. Evidence of need for the program in terms of potential market for the graduate, student demand, state, regional and institutional needs.

6. Special features which could be ascribed to relevance to problems of the state, society or the region, geographical considerations, special expertise of faculty members, etc.

7. Relationship of the graduate program to the undergraduate program in this field. Are they complementary and, if so, how?

8. What would be the effects of elimination of the program?

9. List each graduate course taught and enrollment starting Autumn 1970.

B. The Faculty

1. Numbers and diversity of interests and competence for the program options offered

answer 2-6 for each faculty member:

2. Complete vitae - including all publications to date-(according to format of Governor's Commission on Higher Education Report)

3. Faculty teaching loads and other professional or scholarly activities

4. a. Number of Ph.D. degree program committees presently serving on and number of current chairmanships

   b. Number of Ph.D. theses directed at the institution (student, title and year completed)

   c. Ph.D. theses in progress (being directed)

5. Total faculty research grants and other awards naming institution (sources and amounts)

6. Current research in progress

C. Students

1. Number of degree students in the graduate program (Master's and Ph.D. levels combined) for each year starting Fall 1970

2. Number of Ph.D. graduates from the program for each year starting Fall 1965

3. Criteria for acceptance of a student into the graduate program. If possible, list number of acceptances vs. rejections for the last five years starting Fall 1970.

   a. Criteria for acceptance into Ph.D. program

   b. Undergraduate g.p.a, baccalaurate school and GRE scores for Ph.D. enrollees. (Enrollees to be defined by the department from the time at which the department agrees to accept the student to work toward a Ph.D. degree). For the information of the reviewers it should be noted that the enrollment data from the two schools may not be comparable.

4. Record of subsequent career (employment, research, etc.) of the Ph.D. graduates

5. Financial support data for the graduate students (how many T.A.'s, R.A.'s, Fellows, Trainees, etc. - with sources of funding) - current year only

D. Facilities and Other Resources Available

1. Itemize specialized laboratories

2. Specialized instrumentation, research equipment, etc.

   a. Within department

   b. In other departments but used in program

   c. Computer facilities

3. Support staff (secretarial, technical, etc.)

4. Library holdings (data provided by serials list in Library - not required in report)

5. a. Annual expenditures of outside support funds for last five years (fiscal years)-(Audited Foundation reports)

   b. Other resources attracted to institution as result of program (visiting fellows, state and federal laboratories or programs)-(current year)

ATTACHMENT # 2

REPORT TO THE
BOARD OF REGENTS OF THE
UNIVERSITY OF MONTANA
April 15, 1976

THE PH.D. PROGRAMS IN MICROBIOLOGY

Advisory Committee of the
American Academy of Microbiology

Norman Durham
Dean of Graduate School and
Professor of Microbiology
Oklahoma State University
Stillwater, Oklahoma

Orville Wyss - Chairman
Orville Wyss
Prof. and Chairman of Microbiology
The University of Texas at Austin

INTRODUCTORY COMMENTS

This program evaluation is submitted to educational leaders in the State of Montana to serve as a resource document during consideration of (1) the quality of graduate programs desired and (2) the economic investments that accompany such decisions. It is the understanding of this team that several programs will be evaluated. Regardless of the various committee recommendations, it is imperative that the decision makers in education fully understand their mission, goals and objectives. A dedication to developing quality, scholarly programs to which the young men and women and the adults of Montana are entitled requires maximum use of available resources. Maximization of resources requires establishment of priorities and the development of quality programs.

Quality programs can not be developed using a formula base for appropriations. Quality can not be measured in terms of the number of graduates or the number of student credit hours produced within a given academic unit. Quality dictates the need for economic investment to provide an opportunity for faculty and students to work together in satisfactory teacher-student ratios in an environment which encourages scholarly and creative activities. It is essential that priorities be established and confirmed and that the dedication of faculty and administrators be evident if programs are to achieve some degree of recognition. Such action requires maximum use of available resources as well as the exploration of all available avenues to expand the revenue potential.

Since the final and most important step of the Ph.D. program involves the establishment of an apprentice-master relationship between the student and his major professor, the success of a Ph.D. program is possible only where the major professor has an exciting research program. Good research programs do require funds and where they exist in educational institutions they should be made to serve the additional purpose of graduate training.

The discipline of microbiology, fortunately, is located at the "cutting edge" of science as evidenced by Nobel laureate awards and related recognition programs. While much has been published about employment opportunities, it is cognizant that microbiologists are enjoying a rather good marketplace. Suffice it to say that students originating from quality programs are often able to choose from several opportunities. The important factor is that quality is a significant determinant and thus this is the time to emphasize qualitative rather than quantitative characteristics.

Our visit to Montana State University and the University of Montana revealed the following general characteristics about the Doctor of Philosophy program in Microbiology in the State of Montana. (1) Both Universities have relatively strong microbiology programs at the graduate level. (2) The graduate programs and research activities at both Universities complement each other and we found very little unnecessary duplication in the specialized research areas. (3) The faculty are competing for a very significant portion of outside research dollars. This is to be commended since these federal dollars now return to the

State rather than being expended in other States. (4) The spin-off of the research activities connected with the Ph.D. programs greatly enhance the teaching programs at both the masters and bachelor's level.

There is cooperation between the research groups, which is highly desirable. The most active research effort is in immunobiology and immunochemistry. The expertise of faculty from the two Universities in this endeavor provides a strong base for recognition of the Montana Universities. Other subdisciplines of microbiology which are gaining recognition and can be expected to add prestige to the University are those in environmental microbiology and the molecular approach to life processes and to pathogenesis in microbes.

The faculty, students and administration were most courteous during our visit and we greatly appreciate their willingness, frankness, and desire to be a part of an on-going evaluation effort. Individual comments will be provided for each of the Universities and will be presented in the sequence in which the team visited the campuses.

MONTANA STATE UNIVERSITY

1. Content, Purpose, Goals and Limitations of the Program.

The academic composition of the doctoral level program was good. As would be expected with a strong graduate program, the undergraduate offerings showed many areas of strength. The faculty are dedicated to the process of producing strongly oriented microbiologists with good basic preparation. The morale of faculty and students is very good which speaks well for the overall program.

2. Need for the Program and Result if Eliminated.

There is a well defined need for the doctoral program at the Montana State University. The enrollment at the graduate level is very satisfactory, graduates have little difficulty in locating positions, and the student demand for the program at the graduate level is very high. The undergraduate microbiology and medical technology enrollment likewise reflect this strength. The doctoral program and the ability of faculty to maintain creative and scholarly programs greatly contributes to the success of the undergraduate effort. In addition, the strong graduate program provides crucial support for the WAMI program established with the University of Washington which deals with medical education. Thus, termination of the doctoral program at the Montana State University would:

(1) Reduce the base for retaining competent faculty members for the WAMI and undergraduate programs.

(2) Reduce the inflow of research dollars to the State of Montana. These funds are used for support of students, purchase of equipment and other program needs.

(3) Terminate a strong basic and research oriented

immunobiology program capable of providing service to the State, region and Nation.

The Department does provide service to the people of the State in a number of areas. Research efforts are being conducted under the auspices of the Environmental Protection Agency and selected faculty are participating in programs sponsored through the Agricultural Experiment Station. It is possible that the application of microbiological concepts to other problems associated with the State, its peoples and industries could and should be carefully explored. This might be appropriate for faculty members that are not presently competing satisfactorily in Federal granting programs.

It is our understanding that a program in Veterinary Medicine similar to the WAMI program is being considered. It is essential to medical and veterinary medicine programs that a strong public health research oriented microbiology curriculum be available to the young men and women matriculating through this academic effort. The basic and applied aspects of this departmental research program contribute to this base very nicely.

3. Quality of Program.

The quality of faculty and students was very adequate. Interviews with students revealed a very capable group of young scientists interested and dedicated to science. The facilities, equipment and library holdings are adequate for the program, but not overly impressive. Present funding levels reveal the source of many of these problems.

4. Program Comparison.

The primary strengths in research at Montana State University are immunobiology, water resources and environmental sciences. The research is concentrated in rather well defined specific areas which permits the faculty to achieve some level of regional and/or national recognition. Programs where departmental research is diffused across several broad areas never achieved this acclaim. It is important to note that the immunobiology program differs considerably from the immunochemistry oriented program associated with the University of Montana. The specific areas and specialities of research do complement each other very nicely and, overall, provide a very strong program for the State.

5. Record of Outside Resources.

The record of the faculty at Montana State University for attracting outside funds is very good. The faculty are to be commended for receiving financial support. The Committee wishes to voice a word of caution in that Dr. John Jutila has recently moved into administration and is serving as Dean. Dr. Jutila is a recognized immunologist and it would be highly desirable if the University would seek to fill a research position in this area to maintain the status and level of the immunology program. Dr. Jutila will spend much time in administration and it would be indeed unfortunate if the University were to let a recognized program deteriorate on this base. Dr. Norman Reed, a Research Career Development Awardee, likewise assumes an extremely heavy load in the department. While his willingness to serve in many capacities within the department is indeed commendable, it is not the intent of the Research Career Award Program for the faculty member to devote significant time to activities other

than scholarship and creative components.

THE UNIVERSITY OF MONTANA

1. Content, Purpose, Goals and Limitations of the Program.

The course work and content of the doctoral program in the Department of Microbiology at the University of Montana are adequate in breadth and strong in specialities. The faculty and students are committed to a strong microbiology program. The morale is good.

2. Need for the Program and Result if Eliminated.

The graduate program in Microbiology plays a very important role to the University community and to participating departments. Cooperation with the Biochemistry Faculty in the Department of Chemistry has been productive both from an academic concept and in the competition for research dollars. The student demand is good and the quality of students indicates the overall strength of the research and scholarly effort. The students have little difficulty in finding jobs since they are well prepared.

The Department does provide some services to the State and region. Research studies in the livestock industry as well as health related activities through the Infectious Disease Center and the Rocky Mountain Laboratory provide for a good background of experience. Faculty not actively involved in research projects funded by outside agencies could participate in service oriented activities that would be beneficial to the people of Montana.

3. Quality of programs.

The Faculty and students are well prepared and interested in a quality academic program. The physical facilities are adequate although the supplies and expenses budget is exceptionally small and investment in library holdings could profit from additional resources.

4. Program Comparison.

The principal research specialities at the University of

Montana are in immunochemistry (structure of antigens), parasitology and related public health oriented studies. These specialities do not overlap the Montana State University program but do permit an opportunity for faculty to interact and coordinate their efforts so that each may benefit from the expertise of complementing areas. The research program is visibly strong as evidenced by the productivity and publications of the faculty and the outside grant support. Similar to Montana State, the graduate students are primarily associated with faculty handling research grants.

5. Record of Outside Resources.

The attraction of additional resources has been very good by faculty in the Department. This speaks quite highly of the overall program, and it would appear that research has basically been the source of support for the departmental program both at the undergraduate and graduate level. We were pleased to learn the 1975-76 Microbiology expenditures of non-state funds (page 96 of the Ph.D. report) will bounce back to a record value. In spite of the general cutback in research funds the Department has in hand committed research grants for this year of the order of $100,000; this is in addition to Stella Duncan Institute funds and it demonstrates that the low value of $47,812 reported for 1974-75 was a temporary setback of the program.

7. Funds for supplies and expenses, travel, equipment and the library were inadequate. Unfortunately, scientific costs involved with maintenance and repair of equipment have become a prime factor in support of scientific areas. In addition, travel to scientific meetings to convey scientific data and results and to remain at the forefront of the problem areas needs to be improved

within the University structure. The Library facilities were the subject of some disappointment at the University of Montana.

8. The Montana State University allocated four FTE teaching assistantship positions to the Department while the University of Montana had exactly twice that number with eight FTE teaching positions. The stipends at both Universities are relatively low. It is entirely possible that both Universities might wish to raise the stipend level to insure recruitment of outstanding graduate students. The better well-prepared student will provide improved services in the courses in which they participate and the University is, therefore, greatly reimbursed for its investment.

SUMMATION

The State of Montana is fortunate to have strong doctoral programs in Microbiology in each of its two major Universities. It is interesting to note that these two programs do not duplicate the scholarly and creative areas, but rather complement each other. As a result, a very strong research and academic base in immunology (immunology and immunochemistry) has been achieved and the faculty and programs are recognized regionally and nationally in their respective areas of expertise. The programs are tied with important programs such as the WAMI and perhaps the future Veterinary Medicine program at the Montana State University and the Infectious Disease Center and Rocky Mountain Laboratory for the University of Montana. There is good cooperation between these programs in the area of immunobiology and immunochemistry. Other good programs are in the health related areas.

There is no doubt that the expertise associated with these quality programs brings thousands of dollars into the State of Montana as research and academic support. Therefore, dollars are returned to the State which would normally be expended in other States. In addition, termination of one or the other program would in reality cost the State more dollars since research and support dollars are playing a very significant role in the overall financial base of both departments as well as the University.

The Committee was very pleased with the reception provided by administrators in the terminal session at the University. At the Montana State University, Dr. Irvin Dayton, Dr. Roy Huffman, Dr. John Jutila, Dr. Henry Parsons and Dr. William Walter were

present during the debriefing session. The Committee was pleased to meet with Dr. John Stewart, Dean of the Graduate College at the University of Montana. We greatly appreciate the frankness and openness of the administrators in discussing the quality of instructional programs. Dr. Freeman Wright, Deputy Commissioner, Office of the Commission of Higher Education joined us during the Montana State University visit.

RECOMMENDATIONS

1. The Committee encourages both Departments to capitalize on the availability of elder statesmen from the discipline of Microbiology in their academic program. Exposure of graduate students, as well as faculty, to the philosophies of science as noted by these individuals could contribute to a broader background and appreciation for research and scholarly activities.

2. While there is a great deal of cooperation between selected members of the Departments, the Committee would encourage further exploration of faculty interaction. In addition, faculty within a department may wish to consider adjunct faculty from other areas. For example, at Montana State University, Dr. Scarr is active in the area of genetics and could play a very important role in providing a sound scientific base.

3. Common characteristics between the two Universities would indicate that additional investments in support personnel could be beneficial to faculty and graduate students in delivering a quality program. Adequate secretarial help for preparing manuscripts for publications and/or proposals for research grants competition is very important.

4. The academic year salaries are obviously on the low side for salary levels in regional and national surveys. The beautiful scenery, relaxing atmosphere and congenial people provide an environment which permits the Universities to retain competent faculty at relatively low salary levels. Certainly it would be

advantageous if faculty could receive appropriate reimbursement for their productivity. A faculty reward system to reward productive faculty was not readily apparent.

5. Continued investment in research by both Universities could be meaningful and important. Research investment in the Departments of Microbiology could provide a positive incentive for faculty. The utilization of postdoctoral fellows will greatly enhance the scholarly and creative capabilities of a laboratory and provide a broader and stronger base on which to seek outside funds. In some instances there appears to be a very excellent example of negative incentive in which if funds were brought to campus from outside agencies, local monies presented to the Department were cut. The philosophy seems to indicate that the Department needed less State money, if outside monies were secured. The second mechanism that could serve as a positive incentive is a definite program to return a majority of the overhead back to the generating department. The Committee was aware that in some instances a small percentage of the overhead did come back to the Department but the Universities might wish to review the overhead policy from the positive incentive.

6. Research investments in terms of technicians can be extremely meaningful to new incoming professors since it is important that these young scientists have a technician or laboratory help to initiate and develop their research program. The competition facing a young scientist starting a research program in a new environment becomes more intense every year. Many Universities have found it to be sound business practice to furnish, during the first year, a half or a full-time technician to a new faculty

member in whom they comtemplate investing almost a million dollars in life-time salary and support.

ATTACHMENT # 3

Review of Ph.D. Programs in Botany at
Montana State University and University of Montana
June 7-10, 1976

This report was made after reviewing documents provided by each department, conferences with each available staff member in botany, conferences with deans and vice-presidents, conferences with all available heads and several faculty members of departments whose graduate students depend on graduate training in botany, and examination of all Ph.D. theses in botany produced by both institutions during the period 1970 to 1975. The Ph.D. programs will be evaluated in terms of quality and the mission of the Botany program in each university. It is essential to recognize at the outset that, in both universities, Botany has very important service functions that have a tremendous impact on the economy of Montana.

MONTANA STATE UNIVERSITY

The botany program is conducted within the Biology Department which offers B.S. degrees in Fish and Wildlife Management, Premedicine, Zoology and Botany. M.S. degrees are offered in Botany, Entomology, Zoology, and Fish and Wildlife Management. The Ph.D. degree is offered in Botany, Entomology, Zoology and Fish and Wildlife Management.

Because the Agricultural Experiment Station is located at Bozeman, the Botany Section of the Biology Department has the inescapable responsibility of providing outstanding basic courses in botany for graduate students in such fields as agronomy, horticulture, soils (combined in the Department of Plant and Soil Science), range science, etc. The botanists must provide an array of courses in plant anatomy and morphology, plant physiology, plant taxonomy, and plant ecology to meet the needs of these departments, as well as for botany graduate students. Without quality course offerings in each of these botanical

areas, the entire program of advanced work in agriculture is jeopardized. One of the strongest points that we can make is that we see no way that the State of Montana can benefit from having a weak program in botany at Bozeman.

The Ph.D. program is a small one and is restricted to specialization in terrestrial and aquatic ecology. Since 1973, two Ph.D. degrees were awarded in Botany; a total of 15 were awarded between 1966 and 1975. Two students are presently enrolled. Graduates are oriented toward applied or resource management, research in academic, governmental, or industrial organizations. Ph.D. degrees have not been granted in recent years in plant physiology, taxonomy, or plant anatomy.

Strengths of Ph.D. Program

(1) Course offering: In general graduate course offerings in plant physiology and ecology are very good. There is a devotion to teaching in these areas. Course offerings in other areas are not adequate. This will be referred to later.

(2) Excellent Leadership in Terrestrial and Aquatic Ecology: Both Dr. Wright and Dr. Weaver are competent, scholarly, and professionally oriented. The Ph.D. programs they lead is of high caliber. Both are actively engaged in research and publishing and both have been very successful in attracting research grants.

(3) External Funding: The ability of the Botany section-or at least certain members of the group-to obtain outside research support is phenomenal. Within the 11-year period, 1965-1976, Dr. Wright alone received $1,008,995 in grants. Between 1970 and 1976, the Botany section received approximately $775,636 in grants. The overhead, or indirect costs, to the University undoubtedly exceeded the cost to the State for the Ph.D. program during the same period.

(4) Facilities: The space, equipment, and library holdings are quite

(5) Excellent Administrative Leadership: Despite serious problems, which we consider to be historical, the present administrative leadership is excellent. We consider Dr. Pickett, Head of the Biology Department, to be highly competent, fair, professionally oriented, and highly respected by his colleagues. In addition both Dean Juttila and Vice-President Dayton are providing outstanding leadership, with a view toward maintaining high standards for upgrading staff and programs in botany. The reviewers appreciated the fine cooperation of these administrators.

Weaknesses of Ph.D. Program

(1) Lack of Faculty Involvement: A disproportionally high percentage of the botany staff (at least half) is not seriously involved in leading and doing research, publishing research results in reputable journals, or serving as major professors for Ph.D. students. We consider this lack of professional orientation to be a very serious deterrent to a balanced and high quality Ph.D. program. The reasons given for this situation by various staff members are the demands of unreasonably heavy teaching and committee responsibilities, etc. Although the reviewers recognize that such activities are very important and do release other staff members for leading research and Ph.D. programs they also are aware of the serious problem of abdication of responsibility for the Ph.D. program, thereby thrusting that responsibility on a very small minority of the botany staff.

(2) Small Staff and Lack of Balance: The program has a very narrow base. Five of the eight faculty members are ecologists. Ph.D. programs in botany with research specialization in such important areas as plant physiology, plant taxonomy, and plant anatomy have not been given for lack of leadership. Two of the eight staff members lack Ph.D. degrees.

Two botanical disciplines, plant anatomy and taxonomy, are in critical need of competent representation, not only for the Ph.D. program but also for the

necessary supportive and service roles for the other departments or groups associated with the Agricultural Experiment Station. The loss of competent representation in plant anatomy and taxonomy appears to us to be the result of poor administrative judgement and possibly inertia prior to creation of the Biology Department. A research-oriented plant anatomist and research-oriented taxonomist should be hired as early as possible, if necessary by resetting priorities at Montana State University. Not only should these people be competent in their respective fields, but they should cooperate with researchers in other departments of the Agricultural Experiment Station.

(3) Lack of Research Orientation: Some members of the botany staff have had very large research grants that provide splendid opportunities for executing and publishing research, and for leading Ph.D. programs. Regrettably, however, very few quality research papers have been or are being published in refereed journals by much too high a proportion of the botany staff. Much of the work done with very large grants is professionally undistinguished. A notable exception is the work of Professor Wright who has obtained large grants, built a quality Ph.D. program, published regularly, and turned out good students. Professor Weaver is also highly motivated and oriented toward research. We believe he is making excellent progress.

(4) Salaries: The relatively low salaries at Montana State University must make it difficult to recruit and retain top-flight faculty members in many instances.

(5) Technical help is seriously needed to relieve faculty members of mundane chores.

UNIVERSITY OF MONTANA

The Botany program is conducted by a faculty of 11 in the Department of Botany. The Ph.D. program provides concentrations in ecology, environmental studies, physiology, paleobotany, morphology, taxonomy, and systematics.

A total of 17 Ph.D. degrees were awarded in Botany between 1966 and 1975. In 1975 six students were enrolled in the program. The program is designed to produce teachers for universities and colleagues and researchers for universities, as well as state federal and private agencies. It also provides a center of expertise in botany and environmental studies. The program is highly respected nationally for its significant contributions to effects of pollution on the environment.

Strengths of Ph.D. Program

(1) High Quality and Excellent Balance: The quality of the faculty is generally high. Recruiting has been responsibly accomplished to create a highly competent faculty that is well oriented to its overall professional responsibility of both teaching and research. The age spread among faculty members provides for stability within the Department now and in the future.

Within the Department of Botany there are several areas of excellence that have greatly benefitted the State of Montana. There is unusual strength in ecology, with particular expertise in environmental maintenance and in forest fire ecology (Gordon, Chessin, Sheridon, Behan). Dr. Gordon is widely recognized as an international authority on effects of pollution on the environment. His activities and leadership have been of tremendous service to the State of Montana and the nation. Dr. Habeck's studies on fire ecology also are well known both in Montana and elsewhere. Other centers of excellence are in taxonomy and systematics (Preece, Harvey, Watson), morphology (Prescott, Miller, Bilderback), and paleobotany (Miller). A very important asset to Ph.D. research is the Yellow Bay Biological Station at Flathead Lake.

(2) Strong Interaction with Other Departments and Federal Agencies: The Botany Department has earned the respect of a large number of University departments and other units with which it cooperates and interacts. For example, the partment interacts well and has the staunch support of the Departments of

Biochemistry, Geology, Zoology, Chemistry, Mathematics, Microbiology, and Pharmacy. Chairmen and other representatives of these Departments met with the reviewers and provided many details of splendid cooperation and interaction with botanists. The point was emphatically made by the indisciplinary groups that the standards in Botany are among the highest in the University and that important research in the cooperating departments depends to a large degree on expertise and input from the Botany Department. Representatives of the U.S. Forest Service also provided details of the high quality of work done in the Botany Department and cooperations by botanists on problems of mutual interest. The reviewers were particularly impressed by the large turnout of interdisciplinary faculty (as many as 3 representatives from certain departments) and the genuine expression of concern about the questioning of the Botany Ph.D. program.

(3) Capacity for Obtaining External Support: The Department of Botany has been phenomenally successful in obtaining external funds for research and teaching. The Botany faculty has generated more than 1.4 million dollars over the years for research and, in addition, more than 786 thousand dollars from the National Science Foundation for conducting Summer Institutes for Biology teachers for the years of 1961 to 1971 inclusive. Dr. Gordan alone has obtained about 0.75 million dollars in assorted research grants.

(4) Facilities: The equipment and library holdings are quite adequate.

(5) Strong Leadership at the Department Head Level and Above: Dr. Preece is a highly respected professional botanist who is heading up a splendid organization. In addition the very high academic standards are being adhered to by Deans Solberg and Stewart and Vice-President Talbot. The viewers appreciated the fine cooperation of these administrators.

Weaknesses of Ph.D. Program

(1) Inadequate Space: The Botany Department has considerable equipment obtained largely through faculty grants from external sources) but space for

the program is inadequate. The laboratories are too few and too small. For example, the total laboratory space available for research of one staff member amounts to only 144 sq. ft. The greenhouse situation is deplorable. One tiny greenhouse is available for all teaching and research. For a balanced program of teaching and research completely new greenhouse facilities are needed immediately to grow plants for classroom and laboratory instruction, for student experiments in several courses, and for graduate student and faculty research. Something of the order of 10 times the presently available greenhouse space is urgently needed.

(2) Lack of Rapport Between the School of Forestry and Department of Botany: Ideally there should be strong interaction and cooperation between the biological staff in the School of Forestry and the Botany Department. Training of forest biologists depends heavily on courses in general botany, plant physiology, ecology, taxonomy, etc. Forest biologists and botanists also have common and overlapping research interests. The reviewers agree that cooperation between forestry and botany is generally lacking. However, there are exceptions and some individuals from both units are cooperating in research and interacting well. A major problem area involves lack of agreement on prerequisites for advanced botany courses. The Dean of the School of Forestry believes the prerequisites are too rigorous for forestry students. The Botany Department disagrees. Administrative review of this question may be in order for the best interests of the University.

GENERAL CONCLUSIONS

Because of the presence of an already strong Botany program at the University of Montana and the necessity of a strong one at Montana State University it is highly desirable that both Ph.D. programs in Botany be continued. Actually, there is little duplication in the two Ph.D. programs. The Ph.D. in Botany at Montana State University is restricted to students specializing in

aquatic ecology and terrestrial plant ecology, areas not as strongly represented at Montana University. Conversely, the areas represented by the Ph.D. program at Montana University are not duplicated at Montana State University.

The presence of the Ph.D. programs at both universities has in large part made it possible for active faculty members to obtain very substantial research grants. Funds from these grants have made possible purchase of equipment and supplies eventually used for both graduate and undergraduate research and instruction. With the loss of one or both Ph.D. programs, and possibly of future research support, the effectiveness of both graduate (the remaining M.S. program) and undergraduate instruction undoubtedly would suffer. There would be no financial savings, but rather a loss, to the State of Montana.

Undergraduate instruction would suffer in another way with the loss of a Ph.D. program. The most experienced and competent teaching assistants are doctoral students. Without the Ph.D. program teaching assistants would have to be selected entirely from M.S. students.

Increased collaboration between programs at University of Montana and Montana State University seems impractical. The two institutions are simply too far apart. Interaction between these departments and others on the respective campuses is far more practical. Such interaction is already a reality and should be encouraged. The stronger the Botany programs on each campus, the stronger will be other programs relying on Botany for both basic courses and research advice and collaboration.

The loss of the Ph.D. program at either campus would undoubtedly result in an erosion of the quality of research conducted in the affected department, and possibly in standards of instruction in that department as well. The professional attitude of the Botany faculty at the University of Montana is a reflection of its successful Ph.D. program and of the excitement generated in a department with strong research commitments. The Ph.D. program can serve as a stimulus for both teaching and research, and is especially valuable on the Montana State University

and Montana University campuses, which are so isolated from other comparable institutions of higher learning.

We concur in the above report,

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ATTACHMENT # 4

Review of the Ph.D. Programs in Zoology at Montana State University (MSU) and the University of Montana (U. of M.)

By

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I. Content, Purpose, Goals, Limitations

In addition to the dissemination of knowledge, a principal function of a university is the creation of knowledge. The vehicle for this creativity at most universities is the graduate program; thus, the establishment of a strong graduate program in a specific discipline is a major prerequisite for creativity in that discipline. Such creativity is valuable not only for its own sake, but because it may form the basis for the continued acquisition of knowledge and it may have direct application to problems that face man. Moreover, a creative faculty is one that has both talent and enthusiasm and these are both features that are important to good teaching. It was obvious during our review that an understanding of these premises is in operation in the development and maintenance of Ph.D. programs in Zoology at both Montana State University and the University of Montana. However, there are some differences in the two programs with respect to content, purpose, goals, and limitations at the two universities.

A. Montana State University

1. Content. The content of the Ph.D. program at MSU is extremely broad in its coverage including programs and interests in fish and wildlife management, terrestrial and aquatic ecology, entomology, and health care education. In general, the Ph.D. program has an applied orientation, however, attention to theoretical aspects frequently emerges. It should be emphasized that the content of the Ph.D. program is greatly influenced by the purposes and goals of the program which are definitely oriented toward environmental problems. This is reflected in both the nature of thesis topics and in course offerings.

   a. Courses and requirements. While an array of courses is available there are notable weaknesses in offerings in genetics, physiology and limnology. In large measure this is a reflection of the disciplines represented by the faculty. However, it should be emphasized that some faculty who could offer courses at the

graduate level do not because their time is already over committed to undergraduate training. This is especially true of the WAMI faculty.

The requirements for the Ph.D., including courses, examinations and thesis quality, are like those of comparable Ph.D. programs in Zoology throughout the country.

2. Purpose. The principal stated purpose of the Ph.D. program is to produce sophisticated scientists capable of performing high level research and teaching in order to fill needs at both colleges and universities and at various research agencies. Because of the increasing need to train scientists who are competent to deal with problems related to the environment, special emphasis is placed on training Ph.D.'s whose interests are related to ecology and resource management.

3. Goals. While is is sometimes difficult to distinguish between "goals" and "purpose", it is obvious that research goals are achieved during the training of Ph.D. students. There is no doubt that the MSU faculty feels that they interact strongly with their Ph.D. graduate students during their training. This has positive effects on both thesis advisor and advisee. They support one another's research activities and this leads to better research productivity from each with more meaningful knowledge produced. It should be emphasized that faculty members who are training Ph.D. students enjoy a greater morale, are more abreast of the literature, and become more effective and stimulating teachers. The ramifications of these benefits are of course a special blessing to the undergraduate and masters programs.

4. Limitations and Advantages. The Ph.D. program is obviously influenced by the quality and quantity of both faculty and students. It is also drastically affected by the physical and financial resources. Some of these factors are dealt with in greater detail later in the report. In general it can be concluded that there are and have been relatively few Ph.D. students in the Zoology program. Fortunately, the students seem to be of a relatively high quality, probably a result of good selection procedures. The quality of the faculty is variable - some are quite good and others are not. This point is taken up later. There are limitations in the number of faculty and in view of the breadth of the Ph.D. program this has a strong effect on the nature of graduate training. Some important subject areas are either not treated or not treated adequately because there are no faculty to cover them.

While the physical plant seems more or less adequate, some facilities are inadequate, although the students themselves do not feel deprived of equipment. (Perhaps they don't know what they are missing). One of the limitations to the program is the lack of adequate stipends which are just not competitive with other institutions. This affects both the quality of the students and their morale.

Limitations in faculty size and in facilities may work to the advantage of a program and such surely seems to be the case at MSU. Faculty and students seem to enjoy a much greater deal of interaction both between themselves and with faculty and students of other departments. This is quite unusual and perhaps results from an overall lack of facilities at the university. By necessity, departments must borrow from one another. Whatever the cause, there seems to be an unusual degree of cooperation and good will between departments (and even colleges).

A decided limitation is that the university is remotely located in reference to populated areas and as result there are many fewer visiting scientists available for interaction. First of all it is expensive to bring them in and secondly it is out of their way to stop in transit to the east or west coast.

B. University of Montana

1. Content. The U. of M. Ph.D. program in Zoology is considerably less diverse due to the fact that it derives from a single department. Moreover, although wildlife management is involved in the department and provides students to the Ph.D. program, much less emphasis is placed on applied aspects of Ph.D. training. In general the department is of the older classical type although the majority of graduate emphasis is directed toward ecological and environmental problems.

   a. Courses. The strength of the course offerings are in invertebrate zoology, ethology and ecology but a definite weakness exists in physiology. The lack of courses in environmental or comparative physiology is especially obvious. Genetics also seems to be weak and replacement of a limnologist is required.

   The requirements for the Ph.D. program are like those of comparable Ph.D. programs throughout the country.

2. Purpose. The purpose of the program is very much like that stated for MSU in the previous section even to the extent that it is important to produce some Ph.D.'s whose training will allow them to pursue work in ecology and management. The wildlife component of the department, which is interdisciplinary, produces Ph.D.'s to fill a niche in wildlife programs at the national level.

3. Goals. The goals of the Ph.D. program at the U. of M. are essentially like those that we have indicated for MSU.

4. Limitations and advantages. Essentially the same general limitations and advantages that were indicated for MSU apply to the Ph.D. program at the U. of M. An additional advantage of the Ph.D. program at the U. of M. is the availability of the Biological Station on Flathead Lake.

II. Need for the Ph.D. Program and Results if Eliminated

In general, the need for Ph.D. programs in biology can be summed up for both institutions as absolutely essential and the effects of elimination as devastating. The presence of the Ph.D. program is so essential and has so many ramifications to other programs and to the university community as a whole, that termination at either institution is unthinkable. However, it seems advisable that the existing Ph.D. programs in zoology should be a part of a broader context such as the existing Department of Biology at MSU or a new organizational unit such as a Division of Biological Sciences at the U. of M. The critical point is that staff members in life science continue to have access to a Ph.D. program. Whether the Ph.D. degree program is called Zoology or Biology is not as significant - in fact, since modern biology is functionally oriented and highly interdisciplinary, there are both philosophical and practical advantages to a broader context within which to offer the Ph.D. degree.

Importantly, the general misconception that exists at supra-university administrative policy and funding levels that elimination of Ph.D. programs will constitute financial saving is so naive that it could only be perpetuated by those totally unfamiliar with institutions of higher education. Especially in small to moderate sized universities, such as MSU or UM, the Ph.D. program is a labor of love, constituting the basis for an intellectual climate which provides the optimum setting for the educational experience at all levels, undergraduate and postgraduate. At both UM and MSU there is extensive use of graduate students in undergraduate teaching. Although on occasion this process has been maligned, it is usually the best way to provide a greater quality and a more individualized instruction within the economic constraints that always exist. Elimination of graduate programs with the intent of improving the quality of undergraduate education would be highly counterproductive. The quality of the faculty would certainly decline. Faculty teaching loads would increase and the usual methods of dealing with such situations, e.g. programmed teaching or undergraduate assistants, have had their best success in the presence of Ph.D. programs, not in their absence. The excellence of the masters' programs is highly dependent upon the capability to offer the Ph.D.

Therefore, at both U. of M. and MSU the loss of access by the zoology faculty to a Ph.D. program would have the most fundamental negative effect on all phases of the education-research process.

A. Montana State University

1. Student Demand, Quality and Placement. MSU has more than adequate student demand for the Ph.D. program and has had a high level of success in placement of graduates. MSU places most of the doctorates

in applied areas, e.g. state and federal resource related agencies. The size of the Ph.D program at MSU is fairly consistent with the ability of the faculty to provide adequate personalized training. However, the present limitation in the size of the Ph.D. program tends to be financial support rather than space or faculty graduate loads. At MSU one quarter of the graduate students (i.e. both MS and Ph.D.) are supported on teaching assistantships. As stated above, graduate student stipends (including allowances for tuition and other benefits) are not competitive with most other institutions. At MSU the Ph.D. has often served to provide additional training for outstanding students identified in the masters programs.

2. Service to State, Region and Institution. The zoology faculty at MSU has had the foresight to orient many research projects around the "natural laboratory", i.e. the quality environment, that exists in Montana generally and in close proximity to MSU.

Accordingly, the service functions to the state and region are environmentally oriented. MSU has placed many Ph.D.'s in resource related agencies. Staff and graduate students are becoming involved in environmental impact assessment work to an increasing degree. This service function will undoubtedly gain even greater significance as Montana wrestles with the difficult problem of accelerated resource development and the maintenance of environmental quality. Because of the complex nature of environmental problems, the interdisciplinary approach is essential to both the underlying basic research and the applied studies. Strong Ph.D. programs involving zoologists will be instrumental in fostering such interdisciplinary efforts. The Ph.D. program will be important to interactions at a comparable level with other Ph.D. units. Also, the Ph.D. program provides the appropriate research-education atmosphere and allows for the direction of doctoral theses relevant to the environmental problems which would not otherwise be possible.

The impact of the MSU doctoral program through the Extension Service has been, and will continue to be, extremely important. Staff and doctoral candidates and their research efforts constitute a vital resource of the extension work in Montana, which has long been recognized to be fundamental to agricultural and wildlife related activities.

Continued success of the WAMI medical program depends upon a strong Ph.D. program involving zoologists in order to ensure the participation of high quality staff with access to graduate research. We believe that without such a Ph.D. program MSU would lose the WAMI program. Undoubtedly many of the individuals studying in the program, which is designed to give Montanans access to training in the health professions, will pursue professional careers in the State.

B. University of Montana

1. Student Demand, Quality and Placement. If the Ph.D. program in Zoology and Botany are taken together the effort is similar in size to the Biology program at MSU. As indicated above, a combination of the life sciences at U. of M. would be desirable. The Ph.D. program in Zoology at U. of M. is also fairly consistent with the ability of the faculty to provide adequate staff-graduate student interaction. Student demand is high, resulting in predoctoral candidates of very high quality - accomplished and well motivated. However, financial support is presently a greater constraint than faculty loads or space. At U. of M., one half of the graduate students (both MS and Ph.D.) are supported on teaching assistantships having substandard stipends.

   Because of a more traditional orientation, U. of M. has tended to place the doctoral products of the zoology program in academic institutions rather than resource related agencies. Ph.D. training has been primarily of individuals whose purpose has been attainment of the higher degree from the inception of their graduate training. Ph.D. graduates in Zoology from U. of M. have had no problem in obtaining employment both in the state and the nation.

2. Service to State, Region and Institution. As in the case of MSU, a considerable portion of the Ph.D. program at U. of M. is oriented toward environmentally related problems. Again, the zoology staff at U. of M. has taken advantage of the magnificent natural laboratory that exists all around them. Although U. of M. has traditionally played less of a role than MSU in applied areas, with the wildlife program being centered in the School of Forestry, the increased use of the Flathead Lake Biological Station as an interface with the public and applied problems is evident. Expansion of this function at the Flathead Station is presently underway and federal funding has been sought.

   The situation with regard to an increased contribution to the solution of environmental problems in Montana, such as those related to coal removal, is similar to MSU. Some of the zoology staff and graduate students at U. of M. are presently involved in applied environmental research and such involvement will undoubtedly increase in the future.

III. Quality of Program

1. Faculty. Since the Ph.D. degree is one that is research oriented it follows that the faculty that serve as thesis and dissertation directors be active in research. It has been often said that an active biologist associated with a university should probably publish an average of about one sound scientific article (in a reputable refereed journal) each year. We have used this criterion as at least one parameter in assessing the quality of the Ph.D. programs at both MSU and the U. of M.

Unfortunately, the publication record of the faculty is very poor. At most, one or two faculty members approach the "one paper a year" criterion. We realize, of course, that this is in part affected by the fact that the wildlife faculty policy is to not co-author the papers of their graduate students. Also, we realize that the older traditions of the university did not involve an active publication policy especially because teaching loads were higher. It is also noteworthy that the WAMI faculty has not had the opportunity to be overly active in research because their teaching responsibilities, at the onset of the program, are so heavy.

It should be emphasized that despite the poor publication record of the faculty we feel that the papers they have published are sound and we feel that the faculty is capable of guiding Ph.D. research. We were particularly impressed with the genetics group and we feel that their rapport with one another is particularly good. It is unfortunate that at least one of them who had been particularly active suddenly stopped research publication in his area.

A. University of Montana

The publication record of the faculty is fair. More than half of the faculty meet the "one paper a year" criterion and fortunately the younger members of the faculty are active. This holds promise for the future. We feel that some of the younger faculty are particularly good and enthusiastic and are successful in obtaining grants. They rank well with faculty at comparable universities with comparable orientation. Those faculty members involved in ecology and ethology are particularly active and successful in the Ph.D. program and the same can be said for the two younger physiologists.

1. Students

A. Montana State University

We were much impressed both by the enthusiasm of the graduate students and by their apparent high quality. That quality students (as judged by GRE scores) who enroll at MSU is surprising in view of the stipends available. They seem to be doing good research and relate to other students both within their department and in other departments. The fact that they have their own well-organized and well-attended seminar groups is a reflection of their interest.

B. University of Montana

The Ph.D. students at the University of Montana definitely are of a high quality. They were attracted to the university not only because of the environmental advantages of the state, but because they were impressed by the research record of specific faculty members. Dr. Jenni was especially notable in this regard. We would compare the incoming students very favorably with most major Zoology programs at the national level.

2. Facilities, Equipment and Library Holdings

A. Montana State University

Facilities seem adequate especially with respect to the physical plant. Equipment while not abundant is adequate for carrying out Ph.D. research. The graduate students indicate that they are not hampered by lack of equipment and seem to make do through borrowing and ingenuity. The computer facilities are excellent and of a great help to the Ph.D. program. The students are proud of their library and can easily obtain materials not available on campus through inter-library loan.

B. University of Montana

Facilities and physical plant are adequate, although the separation of the graduate students into an annex may not be conducive to the best interests of the program. Equipment is available in much the same way as at MSU. The computer facilities are good and library is adequate, but perhaps not as good as those at MSU.

IV. Program Comparison Between MSU and UM

A. Content and Extent of Duplication

An essential feature, producing maximum benefit to Montana from life science education and research, should be cooperative programs between the two institutions. Since such cooperation can be viable only if areas of mutual interest are identified, some general overlap between the two programs is required. Such overlapping (actually complementary) areas of research do exist in the doctoral programs involving zoologists and cooperative effort is hindered by physical separation - that is, the lack of financial support to counteract the physical separation. It appears that the higher administration of both MSU and UM, the Commissioner's Office and the Legislature have all been less than helpful in fostering cooperative exchanges between participants in the two Ph.D. programs.

As stated previously, the two Ph.D. programs are generally different; MSU provides a more applied aspect and UM a more academic one. Even if the overlap of the two Ph.D. programs was exact, which it definitely is not, the differences in the university programs related to the zoology Ph.D. are so divergent that the products represent a healthy diversity of approach. In other words, the programs at UM and MSU are much more accurately characterized as complementary than overlapping. Since areas of Ph.D. research and training in zoology have little direct overlap, cooperation between the two institutions should be mutually profitable. The UM Biological Station could provide a useful vehicle for increased cooperation in environmentally related areas.

B. Quality - It is difficult to make a qualitative analysis of the two Ph.D. programs, because while there are certain similarities the basic programs are different. At MSU several Ph.D. programs are offered by a department of biological sciences and the Zoology Ph.D. program has as a result, input from a variety of disciplines in the same department. At the University of Montana there is only one Ph.D. program in the one department of Zoology. On the basis of productivity of individual faculty members, it is probably true that the quality of the Ph.D. program at the University of Montana is relatively better than that at MSU. However, this criterion alone is difficult to use in the total qualitative analysis of the program.

One obvious difference in the programs is the relative strength of invertebrate zoology at MSU and of vertebrate zoology at the U. of M. Perhaps there is more potential at the U. of M. in that some of their most active faculty members are young. Moreover, they expect to add five new people during the next five years due to openings created by retirement. A source of potential at MSU may be the WAMI program. If these young people can really develop their research programs in the face of heavy teaching responsibilities, the Ph.D. program in Zoology will be enhanced.

One problem at MSU is the status of entomology. Most members of the "entomology group" seem to be willing to operate through the Zoology Ph.D. program, however, one other member is a persistent supporter of entomology. Perhaps this accounts for the unusual situation at MSU wherein a Ph.D. program in Entomology exists in the absence of definitive courses in that discipline.

Some vertebrate zoology at the U. of M. is perhaps a little "old fashioned." However, this characteristic seems to be changing and probably will be resolved through the addition of new faculty.

At present it appears that the quality of the whole Ph.D. programs, including faculty and students, at the two universities is perhaps less than that of other universities on a national basis, however, the programs are young and are in a state of maturation. Both Zoology Ph.D. programs are to be complimented for their emphasis on environmental problems - a proper emphasis in a state that has "environment." The development of interests in molecular biology is a luxury that neither Ph.D. program needs nor could afford.

V. Records of the Department Programs in Attracting Additional Resources

A. Grants and Contracts

There is a definite need at both institutions to increase the level of outside support for graudate level research. The more applied aspect evident at MSU has been reflected in the support from Montana and federal fish and wildlife and agricultural agencies. UM has obtained some support from other agencies (NSF, NIH) and a few zoologists at both institutions have been supported by contract work related to environmental problems. Additional support should be

actively sought, particularly in the area of environmental problems from agencies such as EPA, ERDA and basic research from NSF. If given time, the WAMI faculty at MSU should be able to obtain NIH support.

B. Facilities. The outstanding example of outside facility support is the U. of M. Flathead Lake Biological Station which has received both NSF and EPA funding for phsical plant expansion. However, the area of facility improvement and expansion is primarily a University function. If MSU or U. of M. take the position that this constitutes an additional responsibility of the staff, one could well ask what useful role the administration serves.

VI Recommendations

A. Ph.D. programs at both institutions should definitely be retained.

B. Offering of a single Ph.D. in Biology, with area of emphasis such as Entomology or Wildlife indicated parenthetically, at MSU.

C. Combination of Zoology, Botany and Microbiology in a Division of Life Science and offering of a Ph.D. in Biology (with area of emphasis indicated) at U. of M.

D. Increased interaction between staff and graduate students at the two institutions. In the environmental areas, a logical vehicle for this would be the U. of M. Flathead Lake Biological Station. Regular bus service (already under study by U. of M.) between the two campuses should be implemented as soon as possible.

E. More emphasis at both institutions on outside research support and publication in national and international refereed journals. Staff members should be encouraged in such endeavors by more release time and improved, university generated, facilities. The equalization of teaching loads evident at U. of M. is certainly a positive step.

F. Re-evaluation of the paramedical programs at both institutions. It seems foolish that WAMI should be located at MSU while Pharmacy and Medical Technology, etc. are at U of M. Since it seems obvious that a medical school will not exist in Montana in the foreseeable future, consolidation of the paramedical interests seems advisable. However, neither the life science unit at MSU nor at U of M should be paramedically oriented, but rather should continue to develop with major emphasis on environmental biology.

ATTACHMENT # 5

An Evaluation of the Doctoral Programs in Chemistry at the University of Montana and Montana State University

by

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A. Faculty

(1) Biochemistry

The biochemistry group, consisting of Professors H. R. Favold, W. E. Hill, G. P. Mell, and K. E. Watson represents the most vigorous division in the Department of Chemistry as a consequence of successful fund raising and a reasonable rate of publication. The biochemists have attracted, partly as a result of their own efforts and partly as a consequence of the present inclinations of graduate students who have chosen the department for their graduate studies, the lion's share of the graduate students (ca. 75%). Clearly, biochemistry is a major theme of the chemistry department and biochemistry faculty members interact strongly with other departments on the campus such as Zoology and Microbiology.

undergraduates. He does not have major federal grant support, but efforts are continuing. Although his publication record is good up until 1973, he has not published in the last few years. One senses that this is not a problem and that publications will be forthcoming in the near future.

Dr. H. R. Fevold has strong grant support, an active research program and a reasonable publication list. With this strong funding, including support 1965-1970 on an NIH Research Career Development Award, one can look forward with confidence to regular contributions to the literature in the future by Dr. Frevold.

Dr. W. E. Hill has strong federal grant support, including an NIH Research Career Development Award, a research group of one undergraduate, two graduate students and a technician and a good publication rate. I am impressed with the vigor of his research program.

Dr. K. F. Watson is certainly off to a good start with a choice of two different career development grants on the horizon, strong federal grant support and a research group of five graduate students (one shared with the Microbiology Department) and a postdoctoral fellow to arrive in the near future. His contributions to the literature already look good and one can anticipate a bright future.

(2) Inorganic Chemistry

The inorganic chemistry research area includes Professors R. K. Osterheld, F. D. Thomas and W. P. Van Meter. With Dr. Thomas's emphasis on undergraduate teaching and interaction with the high schools, Dr. Osterheld's role as department chairman and Dr. Van Meter's interests in environmental chemistry, the inorganic group contributes to the doctoral program principally in a

supportive role. Dr. Osterheld has directed one Ph.D. thesis at the University of Montana, but otherwise the inorganic chemists have played a secondary role. Dr. Van Meter has recently obtained a major grant from ERDA (in collaboration with Dr. Erickson), which should be a stimulus to scholarship. However, he views the project as unsuitable for the participation of doctoral candidates and anticipates the use of technicians and perhaps M.S. candidates as the major source of assistance.

(3) Organic Chemistry

The chemists in the area of organic chemistry, R. J. Fessenden, R. E. Juday, R. E. Erickson (on sabbatical this year), A. A. Kamego, F. Shafizadeh and W. L. Waters, represent the largest divisional grouping.

Professor Fessenden served as chairman of the department for a six year period ending in 1973 and is active as an author of undergraduate textbooks. His research interests focus on synthetic methods for the synthesis of heterocyclic silicon compounds and he has been active over the last few years, although his publication rate is not high, which is understandable in view of his other commitments. Presently he has no outside funding.

Professor Juday's research interests are turning from the synthesis of steroid analogs to an analysis of trace components of lakes, although he has a collaborative project with Professor Waters on the stereochemistry of cathodic reduction of organic substrates. He has directed one Ph.D. thesis and has been active in research, but not at a high rate of publication.

Professor Erickson is on sabbatical leave this year, so we didn't have a chance to talk to him. His research interests have been concentrated on the mechanism of ozonation reactions and electroreductions, and he has achieved good funding for these studies, which have resulted in a very nice series of publications. Recently, however, Erickson's interests have turned to

environmental chemistry and public policy as it pertains to environmental considerations; according to Dr. Osterheld and others he is no longer interested in teaching graduate level organic chemistry. Presently he has funding from ERDA, in collaboration with Dr. Van Meter, for an environmental study on waste products from coal gasification.

Since Dr. Kamego is on a one year appointment, replacing Dr. Erickson, we did not interview him.

Professor Shafizadeh is Professor of Chemistry and Director of the Wood Chemistry Laboratory. He is a department all by himself and has been highly successful in fund raising and publishing in his fields of cellulose chemistry and natural products of sagebrush. His direct participation in the doctoral program in chemistry (two Ph.D. dissertations directed in chemistry and three in forestry) is not as great as one might expect based on his publication rate and extensive funding. He has used his research funds to a large degree to support postdoctoral fellows and research assistants (non-degree candidates).

Professor Waters has made a strong contribution to the doctoral program in chemistry at Montana. His studies, principally in the area of physical organic chemistry, have resulted in regular contributions to the literature. He does not have extensive funding at the present time, but his vigorous approach to research suggests that he will continue to contribute high quality papers on a regular basis.

(4) Physical Chemistry

The physical chemistry group at Montana consists of Professors R. J. Field, G. W. Woodbury, Jr., and L. M. Yates.

Professor Yates is not directly involved in the doctoral program, but does support the Ph.D. program as desirable.

Professor Field is new this year and certainly represents an outstanding

addition to the staff. He is already rather nicely established in his area of interest, oscillatory chemical reactions, as illustrated by an extensive list of papers with R. M. Noyes (University of Oregon). Dr. Field has all the personality and talent that one could hope for and it seems highly probable that if the Ph.D. program is maintained at Montana that he will develop a national reputation.

Professor Woodbury is also a source of strength in physical chemistry and in the department. He has contributed to the literature on a regular basis and has maintained nearly continuous funding from the National Science Foundation, (not an easy feat in these days of extremely keen competition).

B. The Doctoral Program

The faculty, grant funds and facilities all seem satisfactory for the modest Ph.D. program underway. The size of the graduate program is small with only 20 graduate students and the emphasis that has developed is on biochemical research. Dr. Shafizadeh's carbohydrate and natural product research also prospers, but this does not at present make a large impact on the doctoral program. Perhaps both the size and the emphasis are right for the times. The number of graduate students is smaller than most chemists would consider to be ideal for a doctoral program and this will most likely continue to be a problem in the future, although some partial answers may be available (see below). The quality of the graduate student attracted to this program is presently varied and this will most likely also continue to be a problem (as it is a national problem).

C. Conclusions and Recommendations Specific to the University of Montana

Biochemistry represents the major emphasis of the graduate program in chemistry and perhaps the major factor in any decision on the future of the department. If the biochemistry group is moved to Pharmacy and Allied Health Sciences in order to interact more strongly with Microbiology, the Micro

department having jsut voted to move to Pharmacy, the heart of the chemistry program will be lost. I doubt that the doctoral program in chemistry could survive such a blow. My recommendation is that Biochemistry remain in the Chemistry Department and that interactions with Microbiology (already extensively developed) be encouraged by other means. Perhaps joint seminar programs, areas of concentration and closer siting of laboratory operations are reasonable routes for enhanced interaction.

If Biochemistry remains with Chemistry, the doctoral program can be improved by building on the strength in Biochemistry and improving the participation by staff members in the remaining divisional areas, especially organic and physical, where there is residual strength. In organic chemistry a quantum leap forward is possible. Dr. Shafizadeh supports three to seven postdoctoral fellows and two research assistants, none of whom are directly involved in the doctoral program. My view is that he should use approximately 50% of his salary funds (presently postdocs and research assistants) on pre-doctoral students. He could add to the department total of 20, approximately four to nine pre-doctoral students. Dr. Erickson's apparent loss of interest in doctoral level research is a disappointment after his impressive accomplishments initially. If he can be encouraged to use his talents and interests in environmental chemistry to direct research in environmental chemistry at the doctoral level, then he would be making the kind of contribution that would enhance the Ph.D. program. If this is not possible, then the appointment of Dr. Erickson to head up the interdisciplinary environmental program, presently in the planning stages, is a logical one, as it would allow the department to replace him with a young research active organic chemist. Changes along these lines would undoubtedly increase the morale of Dr. Waters who presently is providing the most enthusiastic support of the Ph.D. program

in organic chemistry.

Research in Physical Chemistry looks very promising with Woodbury and Field, but another research active staff member is needed. This might be accomplished best at the next retirement opportunity. Inorganic chemistry represents perhaps the weakest area where doctoral research is planned. Dr. Osterheld is perhaps making his contribution to the Ph.D. program by providing able administration as chairman. Dr. Van Meter's contribution to the graduate program could be enhanced through the use of some of his ERDA funds to support M.S. candidates.

II. Department of Chemistry, Montana State University

A. Faculty

(1) Biochemistry

The biochemistry faculty group at Montana State consists of Professors M. T. Arnold, K. J. Goering, K. D. Hapner, L. L. Jackson, G. R. Julian (on leave this year), J. E. Robbins, S. J. Rogers, R. V. Thurston and G. R. Warren. The large size is made possible by salary support from the Agricultural Experiment Station and WHAMI. The doctoral program presently is being carried by Jackson, Julian and Rogers with support from Hapner and Robbins. All are research active, with Jackson the most prolific publisher in this group of five. It would appear that Ph.D. candidates have a suitable range of projects from which to choose in the area of biochemistry. Outside support in the form of grants from federal agencies such as NIH and NSF is not large, but this lack appears to be made up by Agricultural Experiment Station support. Professor R. V. Thurston, Director of the Fisheries Bioassay Laboratory does have considerable support from the EPA and NSF. This certainly adds to the strength of the scientific community,

but it does not impinge directly on the Ph.D. program in chemistry.

(2) Inorganic - Analytical Chemistry

Inorganic and analytical chemistry at MSU comprises Professors J. R. Amend, K. Emerson, E. P. Grimsrud, R. A. Olsen, G. K. Pagenhopf and R. A. Woodriff. The thrust of the doctoral program in this grouping is carried by Emerson, Pagenhopf and Woodriff, with Woodriff's program impressively active although he is at retirement age. Although Dr. Emerson has directed no doctoral students since 1972, his past accomplishments and present research program add strength to the graduate research program. Dr. Pagenhopf has a vigorous research program with good grant support and a strong publication record. Dr. Grimsrud is new on the faculty but is in an interesting and currently important research area. His support by the ACS-PRF and a good start on contributing to the literature augurs well for the future. Dr. Olsen is a soil scientist with an active research program, which supports the doctoral program, although he has not played a large role in directing doctoral work. Dr. Amend's accomplishments in science education are impressive but are not tied intimately to the doctoral program.

(3) Organic Chemistry

Faculty with interests in organic chemistry are Professors A. C. Craig, R. E. R. Craig, R. D. Geer, H. E. Gerry, P. W. Jennings and B. P. Mundy. The doctoral program is carried in organic chemistry by A. C. Craig, Jennings, and Mundy, with support by Geer. Professor Jennings has been particularly active in the Ph.D. program, turning out six Ph.D. students in a 10 year period, raising funds for his own program and coordinating successful proposals to obtain instrumentation vital to the Ph.D. program. The efforts of A. C. Craig and B. P. Mundy also add significant strength, with Mundy's publication rate particularly strong. Professor Geer is active in the

doctoral program, directing the work of two successful Ph.D. candidates and contributing to the literature on a regular basis.

(4) Physical Chemistry

Faculty members with interests in physical chemistry include E. W. Anacker, P. R. Callis, C. N. Caughlan, R. A. Howald and R. G. Stebbins. Professor Caughlan has been a source of great strength for the department through the years, serving as department chairman, directing ten Ph.D. theses and collaborating with colleagues at other institutions and at Montana State. His contributions to the literature are numerous. Professor Caughlan's activities have not carried the doctoral program alone in physical chemistry. Complementary strength has been provided by Professors Anacker, Callis, and Howald, all of whom have been active in directing doctoral disertations, raising funds and contributing to the literature on a regular basis. The physical chemistry group has strength throughout and there are, therefore, a good variety of projects for doctoral candidates. Professor Stebbins is new this year and has not had an opportunity to become heavily involved in the Ph.D. program.

B. The Doctoral Program

There is strength exhibited in all the traditional areas of chemistry at Montana State. If one considers the resources expended in terms of state support, quality of graduate students, salary levels of faculty, teaching assistant stipends and teaching loads, the accomplishments of the doctoral program are impressive. A new area of emphasis is clearly developing in environmental chemistry and Montana State is certainly a logical place for such a trend. There is, however, one aspect of this which may develop into a problem. A fairly substantial fraction of the faculty is now moving to greater involvement in chemistry applied to environmental concerns. Some

faculty members may be spread across too many different aspects of chemistry and the competence of staff in the traditional academic areas may decrease to a point where the quality of graduate instruction in traditional academic areas is reduced. I believe that the present faculty are not unaware of this problem, but it appears to me to be an important consideration in future planning.

The facilities for a doctoral program in terms of space and equipment appear to be excellent. There would be no apparent problem in expanding the program to 40 or so graduate students in terms of limitations imposed by the availability of physical facilities.

As in the case of the program at the University of Montana, the doctoral program at Montana State is small. The present 24 graduate students are too few for the staff and for optimum interaction in classes, seminars and informal discussions of research. I do not view this as a fatal flaw and there are always some compensations in a smaller program.

C. Conclusions and Recommendations Specific to Montana State University

The quality of the program in Chemistry at MSU is good with good balance achieved in the traditional sub groupings of chemistry. My only specific recommendation would be that continuing efforts to maintain research in some of the traditional areas of chemistry be maintained so that the department does not become a department of environmental chemistry. I see nothing wrong, however, in environmental chemistry being a major theme of the department.

III. Recommendations

An assessment of the desirability of eliminating the doctoral program in chemistry at either the University of Montana or Montana State University can be brought into focus by considering the effects of such a change. The

effects of termination would be quite similar in either department and so they are considered together.

(1) Many of the staff of either department would attempt to leave (Fevold, Hill, Watson, Waters, Field, Woodbury and perhaps others at Missoula and Jackson, Jennings, Mundy, Rogers and others at Bozeman). The academic job market is tight and perhaps of all of those that attempt to leave only two or three would actually leave. The odds are that those that leave will represent the major contributors to quality graduate as well as undergraduate instruction.

(2) As a consequence of the attempts at mass exodus and the reduced scholarly opportunities, the morale of either or both departments would be extremely low during a fairly extended period of time. The quality of instruction at all levels would certainly suffer.

(3) Without a Ph.D. program the quality of the average teaching assistant attracted to the program would be reduced with the only option to counteract this being the employment of instructors, which would be, on balance, an added expense.

(4) Grant funds from federal agencies would decline, with loss of funds for instruments. If the quality of the undergraduate program is to be maintained, state funds would have to meet this need.

(5) Undergraduates who are bright and eager and wish to pursue research projects in their junior and senior years would often have a less stimulating environment without the opportunity to work in a reasonably vigorous research group with advanced graduate students.

(6) A loss of research quality and competence in chemistry would cause a ripple effect across the campus in both cases due to the fact that chemistry interacts strongly with other departments such as Zoology, Geology

and Microbiology at Missoula and with Chemical Engineering, Physics, Plant and Soil Science, Animal and Range Science, Microbiology, Genetics and the MHD program at Bozeman. The collaboration with other departments appears to be particularly strong for both chemistry departments. This interaction is much more than an exchange of members on doctoral committees; collaborative efforts on research are underway so that scholarly efforts in other departments would be placed in jeopardy by eliminating the Ph.D. program in chemistry. The WHAMI program, which is off to such an excellent start might very well be hurt; loss of the program is a definite possibility if staff competence in biochemistry is reduced, as seems likely.

(7) Savings undoubtedly could be achieved by a discontinuation of the Ph.D. in chemistry, if one is willing to make a compromise in the quality of the undergraduate program. Assuming that quality is to be maintained in the undergraduate program, the picture is not clear. Less graduate course offerings might be possible, and individual teaching loads probably could be increased to some degree. There would be some savings in staff time spent on committees primarily involved with doctoral program considerations. It appears, however, that the state does not support the Ph.D. programs directly to a very large degree; most of the direct support is derived from federal grant funds. Therefore, the potential savings to be made are rather limited at the start. Whatever savings might be achieved in professorial FTE would be offset, probably to an important degree, by the necessity of purchasing modern chemical instrumentation without as much federal assistance, and replacing teaching assistants with instructors.

Originally, when I agreed to take up the assignment of reviewing the doctoral programs in Montana I felt I would not be able to reach a conclusion as to the most desirable course of action, but would only be able to outline

alternatives and their consequences. However, the opportunity to visit both departments, view the programs in action and study the accomplishments of each department has convinced me that it would clearly be a mistake to discontinue either doctoral program.

One must take into consideration the fact that University chemistry departments have produced too many Ph.D. chemists in the recent past. All departments have the obligation to keep market place economics in mind. The answer for the Montana departments (Oregon State also) is to maintain or perhaps raise the quality of their doctoral product. If this results in a somewhat smaller number of Ph.D. chemists produced per year, that may, in fact, be a desirable result. I wish to stress that the benefits in overall quality in chemistry and all the other disciplines which it touches can not be measured by the number of doctoral theses turned out per year.

The presence of the doctoral program in chemistry might be considered to be a fringe benefit to be added to the opportunity to live in a beautiful part of the world. The salary levels of professorial staff and teaching assistants in both departments indicate that the state is already taking advantage of these fringe benefits. The geographical benefits will remain, but if the Ph.D. programs and the opportunity for scholarship that goes with them are discontinued, the salary levels for remaining staff will have to be adjusted sharply upward to maintain the present level of quality for the remaining instructional programs.

In concluding this report, I emphasize that an analysis of the savings to be made by discontinuing either Ph.D. program is difficult to estimate, but I am confident that the savings would be small, if any, and the damage done would be great. The best route to follow, I believe, is to continue

both programs, monitoring the quality of the doctoral candidates carefully and responding in a sensitive manner to the national need for doctorates in chemistry.

SUBJECT: Program Comparison - Departments of Chemistry at University of Montana and Montana State University

REVIEWER: Jean'ne M. Shreeve, Head, Chemistry, University of Idaho

DATE: June 9, 1976

Both institutions have quality, dedicated faculties. Both departments are engaged in a variety of interesting and worthwhile basic and applied research efforts. Each department does very well in its individual undertakings. Montana State with its larger faculty, longer established Ph.D. program and built-in benefits from the Agricultural Experiment Station and the WAMI program is involved in a greater variety and larger number of activities. The research at Montana State leans slightly more to the applied than that at Montana as is to be expected from its land-grant mandate.

Each department does a creditable job preparing Ph.D. chemists to assume a variety of jobs in meeting the needs of American industry, government and academic institutions for well trained personnel who can adjust to searching for solutions to new and complex problems as they arise. There is duplication in the sense that each department grants Ph.D. degrees in biochemistry, in physical, organic and inorganic chemistry while MSU only offers the Ph.D. in analytical chemistry. However, the research problems which are solved by the Ph.D. candidates are quite different. There is duplication in much of the instrumentation which the Ph.D. programs have brought to each campus and which have given real strength and a modern approach to the undergraduate offerings. However, there is some sharing and loaning of research gear between departments.

The University of Montana program has fewer Ph.D. candidates than does Montana State University, but probably not fewer than MSU had after its first 10 years as a Ph.D. granting department. MSU is fortunate to have been a Ph.D. granting department during the late 50's and the 60's when science was in its heyday whereas UM did not commence granting the degree until 1965 with the first

candidate being graduated in 1969. Both institutions compete very successfully with other Ph.D. granting institutions across the nation for research and instrument funds and the faculties are to be commended for this fine showing. There are, I believe, two ready measures of the success of a chemistry Ph.D. program--1) the success of its products and 2) the extent and continuity of outside funding. The state should well take pride in both programs on both points.

Each department plays important roles in the success of programs in several other departments. This is not surprising. Chemistry is the central science! MSU and UM chemists with their research expertise and research programs do much to enhance quality science at all levels on each campus.

More extensive collaboration, which could enhance and enrich both programs, should be pursued. Both institutions and programs suffer from the extreme isolation and rather poor accessibility of the two towns in which they are located. Although state-originated travel funds are limited, faculty members do attend national chemical meetings frequently and take advantage of study leaves. Sharing of available funds for joint visiting well-established lecturers throughout the year would combat the geographical situation, particularly for the graduate student. With a rather small commitment of state funds it should be possible to exchange expertise on one campus with that on the other through professors giving lectures one day/week at the sister campus--this would be very useful to graduate students whose chemical world could be broadened markedly. Better use of the respective expertise could be made by a more extensive use of joint Ph.D. committees. Students should be apprised of course offerings on research techniques on each campus which might encourage enrollment on the sister campus for a quarter. The idea of an intercampus shuttle, preferably via aircraft, two or three times per week should be considered seriously. The institution of a state-wide television network would increase the ease of cross-fertilization and broadening of the training of Ph.D. students.

SUBJECT: Department of Chemistry, University of Montana June 9, 1976

REVIEWER: Jean'ne M. Shreeve, Head, Chemistry, University of Idaho

The evaluation team of Dr. Peter K. Freeman, Professor of Chemistry, Oregon State University and Dr. Jean'ne M. Shreeve, Professor and Head of Chemistry, University of Idaho, was met in Missoula by Dr. Freeman Wright of the Office of Higher Education, on Tuesday, May 25, 1976, at 6:30 P.M. A discussion of the responsibilities of the evaluations and the philosophy of the reviewing procedure ensued.

The team was picked up at 7:50 A.M. (May 26, 1976) to commence a well organized, well-run busy day of interviews with students, faculty, cognate faculty and administrators and of a tour of the physical plant. Each interviewee was given the opportunity to respond to several common questions as well as any other points which arose during the half-hour meeting. The team encountered in every case a strong willingness, even an eagerness, on the part of the interviewees to cooperate in every possible way, e.g., an openness in replying to queries, volunteering other pertinent information, and, in general, being perfectly candid.

The Chemistry Department at the University of Montana is housed in one rather old (by science standards) and one very new building situated close at hand. The laboratories available for graduate work range from good to excellent--well-lighted both naturally and artificially and of sufficient size to allow a fair sized group of students to be actively producing good research simultaneously in each laboratory. One complaint shared by the biochemistry faculty was the lack of close proximity to the Department of Microbiology with whom they interact very strongly. It was felt that sufficient geographical closeness should be realized to allow informal interaction between colleagues, precluding the necessity of spanning the distance and wasting the time now required--i.e., interaction with minimum effort, which is a valid point.

The department has most of the standard instrumentation associated with chemistry departments with viable undergraduate and graduate programs. However, much of the gear, particularly that not specifically utilized by biochemists, is aging rapidly and will need to be replaced gradually over the next few years. It must be noted that a huge majority of the gear owned solely by chemistry or shared by chemistry with other departments, such as Geology, Microbiology, and Zoology, was purchased by funding from outside sources, either Federal government or private industry, and essentially none was acquired through the utilization of funding provided by the State of Montana. Without instrumentation of this quality and quantity it is impossible to provide a quality program at any level (B.S., M.S. or Ph.D.). The department has the admirable philosophy that all students, after suitable instruction, should have hands-on access to instrumentation. Thus, their student products are better prepared to accept and be of use in a greater variety of jobs than students trained in wealthier institutions where only technicians are allowed to operate the instruments. Montana is fortunate in having a gifted electronics person who has the know-how and the dedication to keep these "black boxes" operational without the added major expense of bringing company-employed technicians to Missoula from far-flung cities in the United States.

However, the area of scientific instrumentation is one which is constantly growing in range and undergoing improvement. All chemistry departments are faced not only with the problem of replacing obsolete gear with modern analogs which are more versatile and more sensitive, but also with acquiring new additions to the chemists armory of instruments which make solution to problems that were insolvable five years ago now almost routine and which are necessary if the undergraduate or graduate student is to be trained to compete successfully in the job market.

The report prepared by the University of Montana Department of Chemistry is well done--it points out clearly that some areas within the department are staffed by people who have a stronger orientation toward research than others. It is clear that all of the sub-areas are peopled by dedicated and willing teachers. The Ph.D. is not awarded in the area of analytical chemistry--this is as it should be with the current research interests of the faculty, However, the faculty who are involved with the teaching of analytical chemistry at the undergraduate or graduate level use this expertise to help in solution of research problems not only in the department but in other campus departments and in the private sector, e.g., a very applied study concerned with ground water from by-products of coal gasification processes.

The research throughout the department seems to be of uniformly high quality. Biochemistry is the strongest of the sub-areas within Chemistry in which the Ph.D. may be pursued. This is where the majority of graduate students, the greatest outside support (with the exception of wood chemistry) and the largest number of research-active faculty are concentrated. It should be noted here that three of the four faculty biochemists was, is, or is about to become an NIH Career Development Awardee - a real tribute to these people and the department. The research facilities in this area are particularly impressive. The ties between Biochemistry and Microbiology are strong and mutually beneficial at all levels, e.g., graduate courses, seminars, research interaction, active participation of faculties on joint Ph.D. committees, sharing and joint ownership of research gear, consultants, and cross-fertilization of good research ideas. The two programs are highly interdependent. In addition, this interdependence and concomitant enhancement of graduate programs exists between all of the chemistry program and such other departments as Geology and Zoology. The addition of a second research-active physical chemist in Fall 1975 has done much to broaden the offerings and to give

that area greater viability for graduate students as well as for inter-faculty stimulation. Organic chemistry, very often the largest research area in Ph.D. programs since industry utilizes greater numbers of organic chemists, has been markedly changed due to faculty members devoting their time to other scholarly pursuits, such as writing textbooks, applied research or research in a different area. Organic chemistry is still a very important one for the research being done as well as for being the main support area for biochemistry and microbiology. Inorganic continues to be productive and to have particularly important interactions with the geology program.

The wood chemistry program which admirably bridges and enhances chemistry and forestry is powerful. The quantity of funds from outside agencies is very impressive, and the quality and practicality of the work performed is high. The Ph.D. students involved in this area of course are dependent on courses in the other areas of chemistry. Large amounts of research and teaching gear have come to the department, purchased solely by wood chemistry funds or from outside funds generated by wood chemistry and other chemistry areas.

The morale of the faculty, cognate faculty and the graduate students seems to be high almost without exception. In spite of the small numbers of students in the graduate program, the students feel they receive good training and have a good research experience due largely to the very extensive and intensive faculty-student interactions. The students appreciate the quality and dedication of the chemistry faculty. Montana Ph.D. degree holders have been very successful in obtaining good jobs even in this period of a tight job market. The faculties of cognate departments were most enthusiastic in their praise of the chemistry faculty and the Ph.D. program and adamant about the extreme importance of that program to their own.

Particularly impressive is the number of research dollars generated from federal funding agencies by this small faculty of dedicated researchers. During the period 1971-75, the department (excluding wood chemistry) was awarded $767,936 and when wood chemistry is included the amount obtained for that period soars to $1,314,716. These dollars not only enhance the local economy but make possible a level of quality research that the state is probably neither willing nor able to support. The money comes primarily to support research and the accompanying gear at the Ph.D. level, but the concomitant benefits to the undergraduate program are also marked. Abolishing the Ph.D. granting capability in chemistry would preclude funding from many of the granting agencies now involved since most are unwilling to support departments where only M.S. level research is underway because the caliber of the average M.S. candidate is lower and his lifetime, and thus productive period, is much shorter. In addition to funds given to solve basic or more widely applicable problems, faculty members have taken advantage of federal funds available in an attempt to answer many of the environmental and energy problems faced by the people of Montana, e.g., ERDA, EPA, USDA.

Loss of the Ph.D. program would reduce the graduate enrollment to a small number of M.S. candidates and would increase the undergraduate teaching responsibilities of the faculty with additional faculty (Ph.D.) having to be hired to handle the load. While the salary of a very junior faculty member is equivalent to that of about 4-4.5 teaching assistants, there is no way that the faculty member could be expected to assume all of the teaching and laboratory responsibilities of that number of teaching assistants. In addition, the few graduate students would on the average be of lower quality since in chemistry most often the best students go directly from the B.S. to the Ph.D. This would be reflected in poorer instruction for the undergraduates and a marked decrease in research quality.

Loss of the Ph.D. program would markedly weaken graduate and undergraduate

programs in other departments on campus, e.g., Microbiology, Zoology, Geology, and Forestry, as well as the undergraduate program in Chemistry (quality of instruction and facilities). The complexion of the faculty would change abruptly as the younger research-active members attempted to leave for universities with Ph.D. programs followed then by a gradual transition to a department of teachers which rarely does the quality job of training undergraduates that is possible when the lifeblood of chemistry, good research opportunities, is available.

Maintenance of the undergraduate program at its present level without the benefits of the Ph.D. program would require an increase of funding by the state by at least an order of magnitude. The State of Montana gets amazingly good value for the few dollars invested in chemistry. The annual support budget of UM's Chemistry Department is considerably lower than that of the University of Idaho--a school which competes for graduate students from the same pool and with a comparable faculty. The chemistry faculty salaries and teaching assistant stipends are higher at the University of Idaho.

The library holdings are very modest and are viable only because of interlibrary loans or phone calls to friends who will send Xeroxed copies of journal articles by return mail.

Suggestions for Constructive Changes

1. Greater interaction with Montana State (discussed under program comparison section).
2. Replacement of forthcoming retirees with research-active personnel.
3. Reassignment of personnel to enhance research activity, particularly in the area of organic chemistry.
4. Encourage faculty with large amounts of outside funding to utilize a larger portion of salary money for support of Ph.D. students as research assistants and a smaller portion for postdoctoral fellows, if possible.

SUBJECT: Department of Chemistry, Montana State University June 9, 1976

Reviewer: Jean'ne M. Shreeve, Head, Chemistry, University of Idaho

The evaluation team of Dr. Peter K. Freeman, Professor of Chemistry, Oregon State University and Dr. Jean'ne M. Shreeve, Professor and Head of Chemistry, University of Idaho, were met in Bozeman by Dr. Ed Anacker, Head of Montana State's Chemistry Department on Thursday morning, May 27. Commencing with a working lunch attended by several chemistry faculty members, the remainder of Thursday and Friday until 4:00 P.M. were utilized in discussions with chemistry faculty, cognate faculty, graduate students, and administrators and a tour of the physical plant. Each chemistry faculty member was interviewed for one-half hour or in a small group during a meal. In general, several common queries were made of each interviewee in addition to discussion of any other points which arose during the ensuing discussion. All of the Montana State faculty and students were most cooperative and helpful to the team, being completely forthright and candid.

The Chemistry Department at Montana State University is housed in a modern building with excellent facilities for graduate research. In the near future the biochemistry area is scheduled to move to a new laboratory building which will allow the remainder of chemistry plenty of room for expansion. The rationale behind this move is to house the biochemists in close proximity with the microbiologists with whom there are very strong research interactions. The department has most of the standard laboratory gear necessary for viable undergraduate and graduate education. This department, like all others who want to do the best possible job in research and training of students, is confronted constantly with the problem that research gear too rapidly becomes obsolete and needs to be replaced with new models which do all the old jobs better and solve some new problems as well. In addition, new types of instrumentation are being developed and must be added to the department's instrument repertoire to continue to do competitive research and to

train students (at all levels, B.S., M.S., and Ph.D.) for today's job market. A good deal of the present instrumentation, much of which is shared with other departments, was acquired with funds not supplied by the State of Montana. Thus, at little or no expense to the state the chemistry program at all levels is better for the presence of a viable graduate (Ph.D.) program which can attract funding for expensive modern gear.

The report prepared by the Montana State University Department of Chemistry is excellent. It points out clearly that some people in the department have a stronger orientation toward research than others. All areas in the department are staffed by dedicated and enthusiastic teachers. The split appointments between chemistry and the Agricultural Experiment Station, and now the WAMI program, does much to strengthen the chemistry program at MSU--this organization not only allows for a larger faculty with greater range of expertise but also a wider choice of research topics for Ph.D. candidates and a greater opportunity for solving pertinent problems of interest to the state and nation. The existence of the Ph.D. program has certainly influenced in a positive way the caliber of faculty available for these appointments.

Faculty and graduate student enthusiasm for the graduate program is very high. The students appreciate and realize the good fortune of having a great deal of interaction with a large number of interested faculty members. The quality of the basic and applied research completed in this department as reported via publication in good journals is very good. The faculty is obviously very competent and is able to mold the available students into well trained, thinking, producing scientists.

Members of other departments who work closely with the chemistry department strongly praise the value of the high caliber faculty and Ph.D. program to their own disciplines, e.g., Microbiology, Plant and Soil Science, Physics, Chemical Engineering, etc. There is continuing active interaction on Ph.D. committees, research problems, sharing of gear, cross-fertilization, consultation, and in graduate

courses. It is felt that changing the professional expectations of the chemistry department by phasing out the Ph.D. program would drastically affect other departments to the point of losing good faculty in addition to losing productive chemistry faculty.

Nearly one-half of the graduate students are doing research in biochemistry and this sub-area has got to be the strongest as well as the largest, faculty-wise, in the department. The sub-areas of physical and organic chemistry, although with fewer staff members, also are very productive. Inorganic and analytical chemistry sub-areas have active programs but the staff is very small (including one member who is officially retired but who maintains a very strong program). The addition in Fall 1975 of a young analytical chemist at the assistant professor level will be most beneficial to the entire chemistry program, particularly in these days when great importance is placed on quantities as well as kinds of substances turning up in the environment.

Nearly all of the surviving Ph.D. awardees are employed in positions which cover a wide range of industries and academic roles and which would be typical of such degree holders from any Ph.D. granting department. This suggests that the products of this program are employable and can successfully compete for the jobs even during this tight economic period.

There is a considerable amount of exciting research being pursued by MSU chemists and their research students. In spite of the funding available through the Agricultural Experiment Station, faculty members have a commendable record of obtaining funding from Federal and private sources. They have equipped the department with modern research gear primarily from non-state funds. During the period 1971-75, exclusive of AES funds, they have added $847,344 to the economy of the state and to the general welfare of chemistry and chemical research and related departments (at all levels). The quality of the undergraduate, as well as the

graduate, program has got to be higher as a result of this supplemental funding which the state has not been able to provide. Faculty members have eagerly seized the opportunity to help solve cooperative environmental and energy problems by utilizing funding from ERDA (MHD) and EPA--problems which Montana must solve. Abolishing the Ph.D. granting capability in chemistry would preclude funding from many of the granting agencies now involved since many are unwilling to support departments where only M.S. level research is underway because the caliber of the average M.S. candidate is lower and his lifetime, and thus productive period, is much shorter.

Loss of the Ph.D. program would reduce the graduate enrollment to a small number of M.S. candidates and would increase the undergraduate teaching responsibilities of the faculty with additional faculty (Ph.D.) having to be hired to handle the load. While the salary of a very junior faculty member is equivalent to that of about 4-4.5 teaching assistants, there is no way that the faculty member could be expected to assume all of the teaching and laboratory responsibilities of that number of teaching assistants. In addition, the few graduate students would on the average be of lower quality since in chemistry most often the best students go directly from the B.S. to the Ph.D. This would be reflected in poorer instruction for the undergraduates and a marked decrease in research quality.

Loss of the Ph.D. program would markedly weaken graduate and undergraduate programs in other departments on campus, e.g., Microbiology, Plant and Soil Science, WAMI, Genetics, as well as the quality of instruction and facilities in the undergraduate program in chemistry. The complexion of the faculty would change abruptly as the younger research-active members attempted to leave for universities with Ph.D. programs, followed then by a gradual transition to a department of teachers which rarely does the quality job of training undergraduates that is possible when the lifeblood of chemistry, good research opportunities, is available!

Maintenance of the undergraduate program at its present level without the benefits of the Ph.D. program would require an increase of state funding by at least an order of magnitude. The State of Montana gets amazingly good value for the few dollars invested in chemistry. The annual support budget of Montana State's (including that from the Agricultural Experiment Station) Chemistry Department is about the same as that of the land grant institution at Idaho--a school which competes for graduate students from the same pool and with a comparable faculty. Chemistry faculty salaries and teaching assistant stipends are higher at the University of Idaho. The MSU library holdings are modestly adequate. Inflation is particularly treacherous in this area.

Suggestions for constructive changes -

1. Greater interaction with the University of Montana (discussed under program comparison section).
2. Modify Graduate Record Examination requirement to enhance graduate student recruiting.
3. Encourage faculty with large amounts of outside funding to support a greater number of Ph.D. candidates as research students rather than personnel at M.S., postdoctoral or technician level.
4. Utilize graduate teaching assistantships to support only students who are pursuing a research degree.

Reviewer's report on the Mathematics Ph.D. programs at University of Montana and Montana State University

Reviewer: Paul C. Fife, University of Arizona

Let me begin the report with a statement about the condition of Mathematics Ph.D. programs in the nation as a whole. It's a pretty well known fact that graduate education in most fields, mathematics included, is in a period of crisis. Academic employment for Ph.D.'s has been much harder to come by in the last several years than it has been in the past, due to a slowing and leveling of the growth of universities, and to financial stringency measures in practically all funding sources. Non-academic employment for Ph.D. mathematicians has also been harder to obtain, despite the facts that many facets of our society are becoming more mathematized, and that more than ever before we have tough problems which need to be tackled by mathematical scientists.

Mathematics departments in the United States are responding to this crisis in many different ways. There has generally been more talk than action. A lot of the talk has been about offering students more options in applied mathematics and in interdisciplinary studies*. There is also a fairly general feeling that graduate programs should be restructured to provide broader and/or more flexible training. I personally feel this is definitely the way to go. The nature of our nation's most serious technological problems changes rapidly, but always what seems to be needed most are scientists or teams of scientists whose expertise spans several fields, and who are able to adapt quickly to new

*See discussions about this, and in general about the employment situation in mathematics, in the Notices of the American Mathematical Society, Vol. 22, Nos. 2 and 7 (1975), and Vol. 23, Nos. 2 and 3 (1976).

problem areas. World War II was a crisis to which a lot of creative scientists, including mathematicians, gave their energies, and in so doing, really forced themselves to think in new ways and work in new directions. Today's crises are almost as unsettling, and certainly as never before require mathematicians which are creative, broad, and flexible.

Most projections indicate that in the future a greater percentage of Mathematics Ph.D.'s will be taking nonacademic employment. But in any case, what is needed by future scientists in the way of graduate education is equally needed by future teachers, because as the needs and uses for mathematics change, the relevance of the various types of mathematics taught also changes. A teacher will need to know lots of fields, in and out of mathematics proper, will need to be able to relate the mathematics being taught to its potential fields of applications, and will need to keep abreast of the changing times.

All this is why I believe that far more broadly based and innovative graduate training is going to have to be the thing of the future in mathematics departments, and other departments as well, for that matter. But it is not an easy thing to convince mathematics faculties that more than token changes must be made.

After this preliminary excursion into generalities, let us look to the problem at hand. The mathematics departments in the two universities in Montana have shown a willingness to move in directions suited to the current situation, and in fact are already to a certain extent meeting challenges in graduate education as I have outlined them, each in its own way. The department at Missoula has its Mathematical Sciences Option----actually more of a requirement than an option----which emphasizes education in a broad range of mathematical subjects and applications, and in teacher training. In Bozeman, there is the Statistics Laboratory,

which affects the lives of regular mathematics students as well as of statistics students. All students take statistics courses, and the statistics program is very applied and service oriented. Statistics students are given a good deal of training in actual projects arising on and off campus. In this way, they are probably afforded more contact with mathematics users than students in math departments at other universities. Mathematics students at both universities are encouraged to minor outside the department. Statistics students at Bozeman are not so encouraged, but they have a lot of contact with other departments through the Stat Lab, as I mentioned.

So the two departments are offering something "special" to their students, and at least to that extent have been innovative in a world where inspired innovation is sorely needed. The programs at the two institutions should be retained, and encouraged to develop further in the directions they have chosen. Further development is very desirable, in view of the fact that other universities are also recognizing that new directions are needed. As new types of Mathematics Ph.D. programs emerge throughout the country, those in Montana will be less exceptional. They have started in right direction, but need to keep moving to keep pace with the rest of the world.

I believe the two departments are meeting the needs of their students, in large part because of their special programs, and also because the programs are evidently being well effectuated. The students are satisfied; they are getting jobs despite the bleak market; and they are recommending the departments to other prospective students. In both places, the supply of applicants for teaching assistantships (practically the only means of supporting the students) has been fairly constant in recent years.

The departments are also meeting needs of the rest of their respective universities and of the state. In this respect mathematics is

somewhat unique among the sciences, in that it is a common tool for so many of them. As a result, the potential service role of mathematics departments is great. So many departments ignore this potential, but the ones at Missoula and Bozeman take it seriously. This role consists both in teaching undergraduate mathematics courses to students of other departments, and also in providing consultation and collaboration to users of mathematics. According to many testimonials by users on both campuses, the departments are very cooperative in both respects. At Missoula, around half of the teaching assistants have masters degrees and teaching experience in small colleges. And we can surmise that most of the other teaching assistants have more than the usual interest in teaching, by virtue of the fact that they have chosen this particular program. Of course, they also get special teacher training in seminars and internships. From all indications, they are doing a better job at teaching service courses than T. A.'s at most other schools. As regards consultation, professors from Forestry, Chemistry, Psychology, Zoology, and Business have told us of their delight with the cooperation and help they have received. Students often take part in this. Also clearly the existence of a Ph.D. program draws faculty competent in consulting.

Strong testimonials of this type were also given in Bozeman, though from people in different fields from those in Missoula: engineering, entomology, microbiology, etc. The Statistics Lab is evidently prospering and performing a very useful function on campus. The Dean of Engineering told us of his pleasure in the degree of cooperation he now gets from the Math Department in the matter of teaching service courses to engineers. Again, Ph.D. students are used extensively and form an important part of the consulting services.

All of the above comments about the departments have been rather

positive. Now let me dwell on some deficiences. I shall frame my remarks mostly in terms of how improvements could be made. In each department there is an active group which provides the impetus for the Ph.D. program, and the rest take on a secondary role. In fact, a good part of each department is relatively unproductive. The fact is that a broader based leadership is needed. One to three senior level mathematicians should be hired in each department. In addition, some two-or three-year terminal rotating junior level positions should be created. These new people should be individuals with strong research records in areas that will fit well with the existing programs in the departments. The particular areas of expertise would be best determined by the departments themselves, but in each case I would strongly recommend people currently active and knowledgable in applications of mathematics as well as being good mathematicians themselves. In Missoula this would obviously strengthen the Math Sciences option, one of whose stated objectives is to produce well-rounded students knowledgable in current important applications. As I said before, this is a direction schools all over the country will be taking, to revive their graduate programs in mathematics. In Bozeman, these people should, at least in part, represent areas in applied analysis, in order to complement and support the statisticians in their outward-directed activities, both in service to other departments and in training graduate students. The department should then advertise to prospective students that it specializes in applied mathematics, statistics, and analysis.

Even if budget considerations would allow it, these positions should not be filled hastily, but rather over a period of five years or so. Long, painstaking efforts to find the right people always pay off. There is no question that excellent junior level people are available. As

regards the senior people, I definitely think they can also be found, but it will require a great deal of effort----lots of inquiries, letters, and perhaps visits.

Along with the creation of new temporary positions, at Bozeman the high teaching loads offered advanced graduate students should be eliminated. It makes more sense to hire new Ph.D.'s to do this teaching. Furthermore the teaching loads of faculty members engaged in research should be strictly limited to two courses (see the attached statement by the Council of the American Mathematical Society).

In each department, one of the new senior people should, if possible, be hired as department head. In my opinion, a developing department needs a well-qualified knowledgable research mathematician as head, to provide strong leadership. In the absence of such heads, formal executive committees, with specific written functions, should be formed in place of the informal ones.

Along the lines of improving the faculty, some other things should be done as well. In recent years, tenure and promotion have been granted too readily. Both universities should immediately tighten their requirements. New policies in this regard have been recently formulated, I know. But the actual interpretation of the policies is in danger of being too lax, on both the university and department levels. I gather this from talking with both administrators and department members, particularly at Missoula. Being hard-nosed in this regard, together with creating temporary positions as indicated above, are necessary to insure turn-over with its concomitant influx of new ideas.

Also as regards merit increases for tenured faculty, Missoula does not seem to reward people enough for real scholarly effort. Their system for providing salary increases is too rigid, and I'm not convinced the

department makes merit increase recommendations for substantial enough reasons----though this, of course, is subject to dispute.

The granting of tenure and promotions is but one area in which well codified procedures and rules need to be set up, particularly at Bozeman. On the university level, the procedures for granting tenure, promotion, and firing for cause need to b well systematized. On the department level, the whole operation of the department needs to be codified (it is not now, except for a listing of the committees). This document should include the functions of committees, the method of selection of their members. and hiring, tenure, promotion, and firing procedures. This should make for a smoother functioning department with each member better able to see his or her own role as part of the whole.

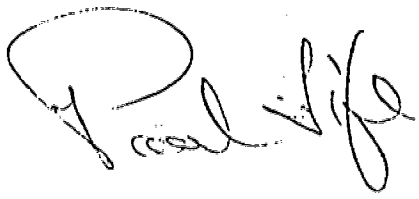
There should be more checks on the quality of teaching, with student evaluation required in all courses, the results being available to the department head. I am not implying that such evaluations will be accurate, but in extreme cases (either way) they will be, and they would provide the teacher with further incentive to improve.

The students don't seem to be too well informed about the value to them of writing a thesis. The latter should be a significant contribution (as most of them seem to be), including the nonstandard theses written at Missoula. They should be written under the direction of someone who has already published recently in the area. (This is my opinion; there is some disagreement on this point.) More experimentation should be made with interdisciplinary theses, codirected with someone from another department, who, again, has himself done research (though not necessarily mathematical) in the area. In this way the math department codirector would not have to be quite as expert in the area. This approach would fit in with the "area degree" envisioned in the "role and scope" statement of Missoula.

At Missoula there is some talk of merging the Mathematics and Computer Science Departments. This would strengthen both departments and eliminate much cross-effort.

Finally, a comment on outside grants and contracts. Except for the Stat Lab, the record is poor in this regard. This statement should be tempered, however, with the following facts. In mathematics, by far most of the federal research funding comes from the National Science Foundation, which of course has been cutting back in recent years. They have always funded proportionately fewer mathematicians than, say, chemists and physicists. And since mathematical research does not need capital expenditures or assistants, the dollar level of funding is always far below those other fields. Furthermore other scientists can get funding more readily from other federal agencies. So in a top-ranking university, typically 90% of the chemists might be funded for research, but only perhaps 60% of the mathematicians. If senior people are hired as in my recommendation, they would bring in federal funds.

I would be most happy to elaborate on any part of the report, if the need arises.



STATEMENT ON TEACHING LOADS AND CLASS SIZE
Adopted by the Council of April 11, 1975

1. In response to economic difficulties, some colleges and universities have created faculty positions with unusually heavy teaching loads. The American Mathematical Society is apprehensive over the long-term effect of such measures, and it believes that educational institutions should not solve their financial problems by depressing pedagogical standards and diminishing scientific activities.

First-class performance in the classroom requires careful preparation based on frequent evaluation of the students' reactions. For a teacher working under perpetual pressure, adequate preparation is impossible. Moreover, the overworked teacher is forced to abandon his own professional development, and sooner or later his students must suffer from the inadequacies he has developed in service.

Some students regard their teachers entirely as technicians who can provide expert instruction. Others look to their teachers also for intellectual or moral leadership; without time for thought and reflection, teachers can not discharge the important obligation thus imposed on them. Before administrators increase teachers' work loads by enlarging classes, by increasing the number of courses or the number of weekly hours, or by diminishing the supportive service of graders, they should consider the possible effects of such economy measures on performance in the classroom and in informal contacts with students. There is in many institutions a tradition of teaching elementary mathematics in small classes. A change from small sections to large lectures tends to be an irreversible step. Before supplementing the approach of teaching in small sections by lecture-discussion sections, administrators are urged to weigh carefully the educational merits of the two methods of instruction, as they apply to their own institution.

2. The Society recommends that for mathematics teachers who are expected to engage in research or to render more than trivial administrative service, teaching loads be limited to two courses per term. For mathematics teachers whose duties involve neither research nor administration, teaching loads should not exceed three courses per term.

3. The Society recommends that when an institution creates a special faculty position, the teaching load associated with that position should not exceed the normal load for assistant professors at that institution. The Society urges its members to reinforce this recommendation by refusing to accept any appointment at an institution that does not operate within the spirit of this recommendation.

4. The Council is establishing a standing committee to whom mathematicians may report cases of excessive teaching loads and class sizes. The Society hopes that by tactful consultation, the committee can convince administrators of the inadvisability of heavy teaching loads. The Society also recommends that the committee establish a program to monitor teaching loads, and that it publish regular reports.

EDITOR'S NOTE: The members of the standing committee have been appointed, and are listed on page in the News Items of this issue of the *Notices*.

REVIEW AND EVALUATION OF THE PH.D. PROGRAMS IN MATHEMATICS IN THE MONTANA UNIVERSITY SYSTEM

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0. Introduction.

At the request of Dr. Freeman J. Wright, Deputy Commissioner for Academic Affairs, The Montana University System, a team consisting of Professor Paul Fife, University of Arizona, Professor Franklin Graybill, Colorado State University, and Professor William Scott, University of Utah, reviewed the Ph.D. programs in Mathematics at the University of Montana and Montana State University during the week of May 10-14. The equivalent of two full days was spent on each campus. The reviewers are submitting separate reports on their visit.

This report is divided into three parts. The first part contains general information about the job market for Ph.D.'s in various areas of mathematics and statistics, as well as salary information, both nationally and in the Montana University system. The second part deals with the situation at the University of Montana; the third part treats Montana State University. Each of the latter two parts includes its own set of conclusions.

It should be mentioned first that there is little overlap between the Ph.D. programs at the two Universities. The University of Montana's program is now almost entirely devoted to a training program for college teachers, while Montana State has two separate programs, one in statistics and the other in mathematics, the latter usually with a minor in some applied area. Although the programs are different, it will become apparent

that some of their problems are similar.

1. General information.

In the decade from 1965 to 1975, a large number of Ph.D.'s in mathematics were produced, mostly in pure mathematics. Over the years, these people have been accepting positions at smaller and smaller schools. The result is that the demand is low for those in the purer parts of mathematics (such as algebra and topology), not good, but better, for areas such as analysis and differential equations, and still good in numerical analysis, applied mathematics, and applied statistics. Such predictions as exist[1] say that this trend will continue and worsen for the next fifteen years.

The situation described affects the departments of mathematics at both institutions in two ways. Firstly, the market for pure mathematics Ph.D.'s is down and will probably get worse, while that in applied areas is good (with a possible worsening trend in the 1980's). Secondly, this is an ideal time to fill open positions with good applicants in pure areas; but more difficult and/or costly in more applied areas.

The American Mathematical Society conducts an annual salary survey. The results for the academic year 1975-76 are published in the Notices of the American Mathematical Society, Oct. 1975, p. 303 ff. The relevant figures together with those for University of Montana and Montana State are

Median Salaries for Faculty with Doctorate

	Ass't. Prof.	Assoc. Prof.	Prof.
AMS Survey, Group III	137-153	172-189	224-265

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1 See Wendell H. Fleming "Future job prospects for Ph.D.'s in the mathematical sciences", Notices of the Amer. Math. Soc., Dec. 1975, 377-380.

University of Montana	125	160	184
Montana State	151	178 (approx.)	203

Salaries are in hundreds of dollars. Group III to which both universities belong are those universities in the United States which grant the Ph.D. in Mathematics, but which are not listed in the top 65 by Roose and Anderson "A rating of graduate programs" Amer. Counc. of Educ., Wash.D.C., 1969. At each professorial rank, the smaller figure in the AMS survey represents the twenty-fifth percentile figure (among the universities reporting), while the higher figure is the seventy-fifth percentile number, and in all cases, these are median salaries for the rank. The Associate Professor value at Montana State is in doubt by a small amount because of a typographical error in the data furnished to us. Although special factors may influence an individual entry in this table, it is clear that the salary scale at the University of Montana is low at all ranks, while that at Montana State is good at the Assistant Professor rank, and low for full Professors (but is consistently well above that at the University of Montana).

2. University of Montana.

The University of Montana began its (regular) Ph.D. program in mathematics in 1965, with the first degree being awarded in 1971, and three more since then. A second Ph.D. program, the Mathematical Sciences option, was started in 1971 with a development grant from the National Science Foundation (approximately $300,000 total). The first two graduates of this program completed their degrees in 1975, and two more are expected to finish this summer.

Over the years, some changes have occurred in these programs. First, the Mathematical Sciences option has experimented with several types of

seminars, etc., retaining those things which seem to work best. Our description of the program will be what we understand it to be now. Second, the two programs have gradually merged, so that it is about 90 percent correct to say that there is just one program at the University of Montana, the Mathematical Sciences option. In any case, the second program does not cost additional dollars.

Because of the existence of the regular option, I will review its status briefly. All of its graduates have obtained suitable academic positions, but it is too early to tell whether all will obtain tenured positions. The research record of the department as a whole is not strong, particularly compared with other Ph.D. producing departments. Moreover, one of the two men with the strongest research records in the department has not directed and is not now directing any theses (the other one is directing three). It should also be mentioned that the department lost a strong, young, research man, Professor Fisher, who died several years ago. He was directing a thesis at the time of his death. Finally, it is only fair to state that sometimes people with mediocre publication records are gifted at getting students to produce research theses, and that this seems to be the case here. Nonetheless, the regular Ph.D. program must be rated as minimal. [See other comments below.]

The Mathematical Sciences option, which might be described as a college teacher training program with applied overtones, appears to be doing about as good a job as is possible, assuming certain constraints which exist at present. From now on, in this section, I will speak as

though there were just one program, the Mathematical Sciences option. This program includes the following items:

(1) A somewhat greater breadth, i.e., concentration on first year graduate courses with fewer second year courses than usual.

(2) A one-quater teaching seminar.

(3) A teaching internship. The graduate student teaches a substantial part of an advanced undergraduate course under the direct supervision of a regular staff member.

(4) A history of mathematics seminar.

(5) A current topics seminar. This involves the application of mathematics to a topic chosen from an area outside mathematics in consultation with a faculty member in that area.

(6) A minor, usually outside of mathematics (about 9 quarter hours).

(7) The usual written comprehensive examinations.

(8) A thesis which may be partly or wholly expository, but which is mathematical (not historical, for example).

Also, as an observed fact, all of the students have taken a year of statistics. This will be of value to those who will teach in small colleges, for example.

Several of the items in this program bear directly on teaching. When we talked to the faculty and students (separately), I was impressed by the strong commitment to good teaching and to improving teaching on everyone's part. It seemed to me that this is the strongest part of this program, as it probably should be.

Copies of some of the comprehensive examinations were furnished to the committee. The examinations were as hard as, and longer than, the ones I am familiar with. Moreover, comments from one of the faculty have convinced me that the grading is such that the standards of the department are high. This has kept the Ph.D. production down, but insured the quality of the product.

I examined the Ph.D. theses in as much detail as time permitted. All but one were well written, and all of them involved mathematics on the Ph.D. level. Several were wholly or partly expository. As best we could determine, only one published paper will result directly from any of the theses already completed. For the standard type thesis, the usual expectation is that at least one paper per thesis will result. For expository material, on the other hand, there are only a few outlets, and one should probably not expect publication.

The comments of the students on the program were uniformly favorable. Morale was high, and the only real complaint we heard involved another department (Computer Science; see below).

Most, but not all, of the graduate students at the University of Montana came because of the Mathematical Sciences program. Many were already teaching in colleges, usually small ones, and nearly all intend to teach in colleges after obtaining their Ph.D. The quality of the students in the Mathematical Sciences option was poor at first, but has been improving as the program became better known, and the department more adept at screening applicants. For next year, there were 20 applicants for 8 positions.

The principal problem of the program is the small number of graduate students [25, according to the written information furnished to us, 23 according to oral information] . This number is limited by the amount of financial support available, although two students are self-supporting. In the past few years, the NSF grant has provided some support for students, but this money is (nearly) gone. Since the University does not have an Engineering School, the demand for undergraduate mathematics is not as great as at Montana State, hence the number of graduate assistants required is smaller. With no Federal support in the form of Fellowships in sight, it is apparent that the graduate mathematics program cannot grow very rapidly at the University of Montana. On the other hand, there is no doubt that the program could be run more efficiently if the student body size were increased by 50% (say). The reason is that the class size of graduate classes is small. The first year graduate classes are in reasonably good shape. However, second year courses, which are necessary to lay a foundation for thesis work, are almost always run as seminars. These have been nearly always taught by the instructor as an overload, with some corresponding unhappiness. It is to the department's great credit that this has been done, but some system of relief, or at least partial relief, must be found.

In addition to problems created by the small size of the graduate program, the department has several other major problems. The low salaries and the generally poor research record have already been commented upon. Until recently, the promotion and tenure requirements

were quite low, and, I believe, are still well below the standards of better Universities in this region. In any case, past mistakes should not be repeated, and steps should be taken to raise these requirements still further. Not many openings will occur within the department soon, but some will. The real need of the department staffwise is a senior level appointment, but unfortunately, the administration, as an economy measure, has established the (almost firm) policy of making all new appointments of new Ph.D.'s only. As was pointed out in the introduction, there are a lot of good young Ph.D.'s available at this time, and the department should take advantage of this fact as openings arise. The committee could detect no realization within the department of the urgency for doing this. [No member of the department mentioned it at all until we brought it up late in our visit.]

Library facilities were visited and appeared adequate for a Ph.D. program.

Grants and contracts within the department are few, now that the NSF development grant has been used up.

With one major exception, relations with other departments are good. In fact, the Mathematics Department appears to make strong attempts to use mathematics in other areas, and to help students and faculty from other areas with their mathematical and statistical problems. Several members of the department, and some students, are or have been involved in applying mathematics (often jointly with members of other departments) in ecological areas. We met with some "users of mathematics" from other

departments. The statisticians in the department were particularly appreciated, both for courses taught, and for some consulting. The consulting is not yet on a paid formal basis, however. Mention should also be made of good use of the computer in certain courses taught in the mathematics department.

There was one area, computer science, where cooperation appeared to be lacking. Computer science would be a useful minor for a college teacher of mathematics to have, yet, through no fault of the mathematics department, it appears to be virtually impossible for a graduate student to obtain such a minor. [Strangely enough, the situation at Montana State is somewhat similar. Perhaps this points out the value of a strong graduate program in keeping a service department useful.]

The Mathematical Sciences option is the brainchild of Professor Robert McKelvey. He has been remarkably successful (90?) in instituting the program and in obtaining the necessary departmental enthusiasm for it. The dependence of the program on Professor McKelvey's continued presence is less than formerly,but it is still a consideration. Also, there was quite a bit of dragging of the feet by the administration of the University in picking up of financial commitments as the NSF grant expired (this continued over more than one year), but that crisis is now over.

Graduates of the program have all obtained suitable positions, and demand for the program is currently reasonably good. It is not at all clear whether, and how long, the market for graduates from programs of this type will remain good. Four-year colleges with no graduate programs

do not attract, and usually do not want, the standard Ph.D. in mathematics. Such colleges would prefer graduates of this and similar programs. In addition, there is some possibility that the good two-year college will provide a market for these graduates in the future. (A few states have good Junior Colleges, most do not.) In the Fleming article referred to above, it is stated that only about 10 percent of the two-year college mathematics faculty have the Ph.D. whereas, a much higher percentage of the Biology faculty do. At present, there are few such teacher-training programs in the United States, perhaps five or so. However, these programs may be expected to increase in number and in quality, so that the Montana program must continue to improve to compete.

Conclusions.

1. The Mathematical Sciences option program fills a need in American education, and is doing it successfully. If it were not for this program, most of its students would either
   (i) Complete a similar program at one of the small number of places where such are offered, or
   (ii) Not complete a Ph.D. degree program at all.

2. The regular option, although technically still available, is rather blurred with the Mathematical Sciences option. There is hardly any financial or educational point in formally removing it.

3. There is essentially no duplication with any program at Montana

State. Formally, the regular option at Montana overlaps with the mathematics option at Montana State, but see earlier remarks.

4. The program is gradually improving in student quality.

5. The number of students is small and remains the principal problem of the program.

6. The teaching overload resulting from number five should be relieved, starting with relief for those directing theses.

7. The research output of the staff is not large. Any new appointments (Preferably at the Associate Professor or Professor level) must be of people with research talent as well as dedication to the department's program.

8. Strong efforts must be made to bring the salary scale in line with (at least) the twenty-fifth percentile of Group III Universities (see earlier table).

9. The Mathematics Department has good relations with most of its users on the campus. They also have a good percentage of faculty members who are actively applying or seeking to apply mathematics in other areas.

10. Removal of the program would result in

    (i) Loss of a useful part of American educational program for which the University of Montana is gradually becoming well known;

    (ii) Weakening of the department, with probably loss of several staff

members over the next few years.

(iii) Weakened support for other departments. It is hard to predict in advance exactly all of the consequences, but the example of the Computer Science Department is instructive.

3. Montana State University.

There are three Ph.D. programs in mathematics at Montana State University, pure mathematics, applied mathematics, and statistics. In effect, this is more nearly two programs, mathematics and statistics, and I will treat them from this point of view.

The statistics program is under the charge of Professor Tiahrt. It is nearly, but not quite, disjoint from the mathematics program, although both are under the same departmental roof. Since Professor Graybill is the statistician on the reviewing team, I will leave detailed comments on this program to him and content myself with some general impressions. The program is primarily one in consulting statistics (or applied statistics), and not theoretical statistics. As such it is successful, and its graduates have no difficulty obtaining suitable positions. Student morale is good. Consulting is done on a formal basis, and the users that we talked to were uniformly satisfied with the results. The consulting performed by the staff covered a surprisingly wide range of topics, and served a number of departments and agencies within and outside the University. It is clear that this entire program and its staff perform quite a useful function to the University and the State of Montana. We detected no friction between the statistics program and the mathematics program. A recent change in the catalogue specifically labelling statistics courses

as such and having a separate section for these courses should prove useful. The only two criticisms I have are relatively minor:

(i) One member of the statistics group appears to be rather inactive, and it is not clear what contribution he makes to the program. In a large program this would not be serious, but the statistics staff is small at Montana State.

(ii) The degree conferred is called Ph.D. in Mathematics. This is a serious misstatement of the situation. Absolutely no money (but some administrative effort) would be required to make the change to Ph.D. in Statistics.

The mathematics Ph.D. program is reasonably standard, but, in practice, is rather lacking in advanced courses. It usually includes a minor outside of mathematics. It has produced, I believe, 23 or 24 Ph.D.'s, with the first degree being granted in 1966 (or 1963). The degree recipients for whom the location is known (all but one or two) have academic positions with one exception, the exception being with the Aerospace Corporation. The program has thus been performing a useful service to the country.

The problem of low research output of the department as a whole exists here also, although not quite to the same degree as at the University of Montana. In the last few years the situation has improved in two ways:

(i) Two mathematicians with good research records have joined the department;

(ii) A high research producer already in the department has started directing theses.

In spite of these improvements and the fairly large number of Ph.D.'s produced, the program must be regarded as of minimal quality.

Along with the problem of the low total research output of the department is the fact that a large percentage of the faculty have tenure. This makes it all the more important that action be taken now to insure that tenure and promotion requirements are raised. When there are openings, good people must be hired to fill them. In my opinion, the next appointment or two should be made at the Professor or Associate Professor level. This may well involve going above the present maximum salary at the rank in question.

The situation as to student numbers is slightly worse than at the University of Montana, and the consequences are quite similar. Very few (at most one or two) advanced graduate courses have been taught within the last five years. Again this puts the burden of advanced training on seminars, reading courses, etc., usually resulting in a teaching overload of the instructor.

It appears to me that the student shortage is such that the first financial priority is that of hiring more graduate assistants. Montana State is in a more fortunate situation in this respect than the University of Montana since enrollments in the Engineering School are increasing at a good rate, with the result that undergraduate mathematics enrollments are also increasing.

There is some dissension within the Mathematics Department. The

basic causes of this seem to be rather varied, and our committee had insufficient time to fully explore all claims and counterclaims. While I believe that it is impossible to prevent all of this wrangling, some of the difficulty could have been prevented by having written rules and procedures for the department. Moreover, it seems clear that democracy must be increased. The members of the department must be given a reasonable amount of control over their own affairs, and must themselves, in turn, exercise this control responsibly. A certain amount of decentralization within the department might also be helpful.

In view of the various problems mentioned or alluded to above, it seems to me to be essential that the department agree formally (by majority vote) on the goals and details of their graduate program for, say, the next five years. The reviewers were furnished with copies of a proposal for such a program by one department member. Its main suggestion was that the Ph.D. program concentrate on applied analysis. While it would be inappropriate for me to endorse a specific proposal, it seems to me that only by agreeing on some program rather near to this can the Ph.D. program continue to succeed. Concentration of the advanced work in a relatively small area of mathematics is virtually forced by the small number of students. Moreover, in view of the employment situation for Ph.D.'s, it will become increasingly difficult for Montana State to place its graduates unless the program emphasizes the applied area. Finally, I wish to re-emphasize the very high priority which should be given to recruitment of good graduate students and to increasing the number of positions open to them. If it is financially necessary, the increased staff can wait, but not the increased student body.

[It might be asked why a similar shortage of students does not adversely affect the statistics program. The answer seems to be:

(i) The course work in this program is tightly scheduled;

(ii) To a large extent, consulting experience takes the place of second level graduate courses.]

Finally, we mention several important but unrelated items.

(a) I examined several written Ph.D. examinations and found the questions to be of standard type and difficulty.

(b) I examined two theses and found them to be well written and on a Ph.D. level, but one of them involved somewhat "old-fashioned" mathematics.

(c) Only about half of the theses lead directly to a published paper. As we pointed out earlier, this percentage is rather low.

(d) There are very few grants and contracts within the department (outside of statistics).

(e) The library holdings are more than sufficient for a Ph.D. program.

(f) Relations with other departments and Colleges appeared to be good with the possible exception of Computer Science. [This remark does not apply to the Computing Center. My impression is that, though probably underfunded, it is doing an excellent job.]

(g) Several members of the department are, or have been actively involved in various applications of mathematics. This has included consulting as well as research.

(h) The administration appeared to be actively concerned with improving the department and its program.

Conclusions and recommendations.

1. The Statistics program is small, but in good shape, and renders a service, both in its counsulting program and in its teaching program.

2. The title of the degree conferred in the Statistics program should be changed from Ph.D. in Mathematics to Ph.D. in Statistics.

3. The Mathematics program has successfully produced Ph.D.'s in the past, but needs urgent attention to insure its continued success. It should be saved and improved.

4. There is essentially no duplication with any program at the University of Montana.

5. Removal of the program would result in

   (i) Loss of a useful training program for Ph.D.'s in mathematics, one of very few in a rather large geographic area.

   (ii) Weakening of the department, with probably loss of several staff members over the next few years.

   (iii) Weakened support for other departments. As at the University of Montana, the lack of a strong graduate program in Computer Science has led to weakened relations with other departments. Undoubtedly the same thing would occur in Mathematics were its Ph.D. program to be dropped.

6. The number of students is small and is one of the main problems of the program. Correcting it should have the highest priority.

7. The teaching overload resulting from this shortage of students should

be relieved, beginning with thesis directors.

8. Students completing a Ph.D. thesis should be strongly encouraged to submit a paper containing the results of this thesis for publication before obtaining their degree. [This suggestion applies to the Statistics program as well as the Mathematics program.]

9. The research output of the staff as a whole is below standard, but there are several bright spots.

10. Increased standards for promotion and tenure should be adopted.

11. After an increase in the number and quality of graduate students is effected, a new appointment or two at the senior level will be required. New appointments at the rank of Professor will likely require an increase in the maximum salary within the department.

12. The Mathematics Department has good relations with most of its users on the campus. The statistics group has excellent relations with the users of its consulting program.

13. Because of the shortage of students, it is imperative that the Ph.D. program become more narrow (mathematically) but also more intense. Because of the employment situation, it is highly desirable that applications be part of this program.

14. Codification of rules and procedures, both for intradepartmental affairs and for relations between the department and the administration should be accomplished. The situations that this would correct vary

from year to year, but several have occurred recently enough that it is clear that this should be done as soon as possible.

15. Democracy should be increased within the department.

16. The adminstration is strong and more than willing to assist the department improve its Ph.D. program.

Wm. Scott

William R. Scott

WRS:rr
6.9.76

Ph.D. Review of Department of Mathematics, University of Montana, May 1976

General Comments

My major field of experience and training is statistics, so my remarks will be directed mainly to the statistics program and how it contributes to the university and to the Ph.D. program in mathematics. The other members of the team, Drs. Fife and Scott, who are mathematicians, will give you direct information concerning the mathematics program.

The purpose of the Ph.D. program in mathematics is principally to train students in the mathematical sciences to enable them to obtain teaching jobs in four-year colleges and small universities. It appears to me that they have their goals well set and are working very well as a team towards them. There is undoubtedly a market for graduates from this program and many of the students who are now in training have had teaching experience in four-year colleges and plan to return when they receive their degrees (they may not return to the same college from which they came). In this regard, the students are mature and their desire for a particular program has been well thought-out. Hence, they bring to the program some degree of understanding of the problems they will encounter as teachers in small colleges. These problems are discussed among the students and this further improves their education.

There are many students in the U.S. who want to teach in smaller colleges (I am not aware of any hard figures) and there is demand for graduates from this program. It is a unique program and I believe (the two mathematicians on the committee can speak better to this) that there are only a few universities that offer this particular degree. I cannot speak directly to the quality of the program in mathematics but I can speak to the quality of the statistics program which is an integral part of their undertaking.

There are four faculty whose principal training and work is in statistics and they make a significant contribution to the goals and objectives of the Ph.D. program in mathematics at the University of Montana. Students can take a significant number of courses in statistics and this, of course, greatly enhances their chances of getting a job teaching in a small college. The content of the statistics courses is a good balance between theory and application and will be very suitable to the type of work the student can expect to be asked to perform if he obtains a teaching job in a small college. If, however, upon graduation the student decides to work in industry or in Federal or State government, the statistics courses will also be of significant help in obtaining employment there. The number of courses required for the option in statistics is slightly less than what would be expected for a masters degree in a major university that has a department of statistics; however, the purpose is not to give a masters degree in statistics but a "teaching minor".

One of the strengths of the statistics group at the University of Montana is their consulting. We interviewed several faculty members from various departments on campus and they were very complimentary about the teaching as well as the consulting assistance on research problems that had been given to them by the statistics faculty. This is the modern approach for a group of statisticians in a university and it is my opinion that they are doing extremely well in this area.

The library, equipment, and facilities for training students in statistics are adequate for this program but they must be continually improved. The statistics courses are taught from modern textbooks and there seems to be high morale among students as well as faculty. In most of the universities in the United States in which there is a separate statistics department that offers masters and Ph.D. degrees in statistics, the department was started in the

department of mathematics and separated as soon as the statistics group got sufficiently large. I would advise against separation of mathematics and statistics at the University of Montana, at least in the foreseeable future. There are not sufficient statistics faculty for a separate department to be viable and efficient. However, the statisticians make a significant contribution to the goals and objectives of the mathematics department, and the mathematics department greatly complements and supplements the statistics program. In discussions with the faculty, it appears that they get along very well and that there is no plan for separation. On the other hand, the department of computer science is an extremely small department and may be able to better serve the university by being a part of the department of mathematics. The computer scientists could play a role in the department of mathematics similar to what statistics plays. My recommendation is that the computer science department be abolished and made a part of the department of mathematics. Thus, a student who receives a Ph.D. degree in mathematics could have a "minor" in several areas of mathematics or in statistics or in computer science. This would greatly enhance his ability to get a job in a small university or a four-year college since he would be prepared to teach any of the three subjects -- mathematics, statistics, or computing science. I realize that organizing computer science within mathematics will be a difficult maneuver.

The starting salary in the department of mathematics, especially for the statistics faculty, seems to be somewhat low and hiring and keeping good faculty may become a problem unless the salary structure is given some attention.

The internship program is an excellent undertaking and seems to be working well.

In summary, I believe that the program is a unique one, it is needed, and is progressing well. It, of course, needs to have constant attention and needs constant improvement and change as opportunities become available. I believe the group knows what its goals are and are working hard to achieve them.

Summary and Recommendations

The statistics group at the University of Montana is playing an integral part in the program in the department of mathematics. The program in mathematics is not a conventional one, but I believe is useful and important. The statistics group, however, makes a contribution beyond the Ph.D. program in mathematics through consulting with faculty in various departments on campus who are doing research. They have an adequate staff to do this, their training is good and their desire to do a good job seems evident. I recommend that they not separate into a department of statistics but remain with the department of mathematics and continue to work towards the goals that they have set for themselves.

I. General Questions as to Purposes of the Review

A. Content, purpose, goals and limitations of the program

Goals are well defined and are being implemented. The Ph.D. program is unique and will perhaps require a less research oriented faculty. (Also see my General Comments.)

B. Need for the program and results if eliminated

1. Student demand, Market for graduates, Enrollment data

The two mathematicians on the review team will have to speak to the subjects -- student demand, market for graduates -- in mathematics. The "minor" in statistics in the program will help the student get employment in four-year colleges and small universities.

2. Service to state, region and institution

The statistics group is serving the University through teaching, service courses and consulting. The consulting is also useful to the state and region. Every major university must have well-trained statisticians to aid in research where data collection (and interpretation) is required.

C. Quality of Program

1. Faculty

The statistics faculty is heavily loaded with teaching and consulting duties. They have little time for research. This will be detrimental to them and to the program in the long run. They should arrange their activities so that they can publish research in mainline statistical journals as well as joint papers with investigators in non-statistical journals.

2. Students

Quality of incoming student. The incoming students are of sufficiently high quality for the work they do in statistics if they choose that option. They can compete for jobs in industry and government when they finish the program.

3. Facilities, equipment and library holdings.

These are minimally adequate but they must be constantly improved. The main deficiency is the arrangement with the computer science faculty (see my General Comments).

D. Program Comparison between the Two Schools

1. Content and extent of duplication

In a real sense there is very little duplication between the two programs in statistics although on paper it may appear so. The consulting activities could not possibly be carried on in the university in which the statistics group was eliminated.

2. Quality

The quality of the program at the two schools is comparable. However, they differ somewhat because the objectives are not the same but the quality is adequate at each school.

E. Record of the Department Program in Attracting Additional Resources to the University and the State

The statistics faculty has not been very successful in this regard. They should take appropriate steps to improve this significantly. This will require more research, more publication, and/or more

consulting where the statistician is a resource member on proposals. This is an area where they are very weak.

2. Facilities.

The facilities are adequate (see General Comments).

Franklin A. Graybill

Franklin A. Graybill
Colorado State University

Ph.D. Review of Department of Mathematics, Montana State University, May 1976

General Comments

My major field of experience and training is statistics so my remarks will be directed mainly to the statistics program and how it contributes to the Ph.D. program in mathematics. The program in the mathematics department at Montana State University is in many ways a conventional Ph.D. program and the main strength, in addition to mathematics, is the option in statistics. The statistics group at Montana State University, though small, is of good quality in training and energy. A student who enters the program in the department of mathematics can receive a masters and/or a Ph.D. degree with an option in statistics. This is the way that many statistics groups have operated in the past and some operate that way at the present time. Historically it has turned out to be a good method of operation and has worked very satisfactorily for many universities until the statistics group got large enough to offer stand-alone degrees. It must be pointed out that in a major university such as Montana State University, the statisticians should not only be involved in teaching courses in statistics but should be active in research and consulting with experimenters from most scientific departments on campus where research is being done. The statistics faculty at Montana State University has done very well in this regard and should be complimented. To indicate the breadth of their contributions in consulting, I have attached a list of some of the projects with which they have been involved (see Appendix). I cannot speak about the quality of the program in mathematics (Drs. Fife and Scott will do this) but it does contribute significantly to the program in statistics and the program in statistics also gives additional opportunity to the mathematics student. This will undoubtedly help him obtain employment,

and there are ample positions for students who receive masters and Ph.D.'s with options in statistics from Montana State University.

The goals of the faculty seem to be well thought-out and they appear to be working as a team to attain the goals. The administration is aware of the contributions made by the statistics group and are supportive of them.

The visiting team met with several research faculty from different departments to find out how the statistics faculty is aiding in this research through consulting activities. The contributions of the statistics faculty seem to be high quality and the research faculty in the departments interviewed were very complimentary of this assistance. A modern university doing research in the empirical sciences must have statistical help, and I foresee that in the near future more statistics faculty will be needed due to the fact that the consulting activities may increase rapidly. Some of the monies for this increased faculty can come from contracts and grants if a statistics member is listed as a resource person on proposals submitted to funding agencies. Most funding agencies are not only willing, but are somewhat enthusiastic about a statistician being a member of a group who works on a research project. The statistics faculty already has some monies from this source and if they can get additional faculty they can undoubtedly increase these funds.

We interviewed many staff members at Montana State University and several members of the administration. Everyone interviewed seemed to be well aware of and satisfied with the progress of the statistics group and the relationship between the statistics group and the faculty in other departments. The statistics faculty is using modern statistical techniques in their consulting and are sufficiently active in publication to enable them to direct students who are working on theses. However, they are extremely busy because of the diversity of their activities.

The students working in statistics appear to be well satisfied with their program and with the instructors who teach the statistics courses. Those students who are assisting in consulting also feel that they are getting practical experience that will be of tremendous help in obtaining a job. The statistics group is making a significant contribution to the state, to the university and to the local area. They have their goals quite well established, they believe in them as a group, and they have a good chance of realizing them if given sufficient resources by the administration and the state.

Summary and Recommendations

As one can see from what I have written above, I believe that the statistics program within the department of mathematics is making a real contribution to the advanced program in the department. The statistics group is also making a valuable contribution to many research projects and subject matter areas across campus. Their faculty also has the training and the desire to direct masters and Ph.D. dissertations. Their teaching and interest in students is satisfactory. I find the program to be an applied statistics program which is in line with their goals and objectives, and the students who graduate from the program will be well-trained and be able to obtain employment.

I recommend against separation of the statistics group from the department of mathematics since I believe the size is such that it would be more efficient and beneficial for them to remain together so they can complement and supplement each other's programs. I think it would be a distinct advantage if there would be an increase in the number of undergraduate students.

I also recommend that the statistics faculty try to obtain contract and grant monies by having their names listed on proposals as a resource personnel. This would help them with summer employment and could free some resident instruction money that would be available for additional faculty. To increase their program, as they are going to be required due to the demand for consulting, it seems quite clear that within the next year or two one or two additional faculty in statistics should be hired. While the program in statistics is a conventional one, it is similar to most statistics programs in the United States today. Their plans for the future seem to be well in line with the major trends. I think they have good promise, they are doing a commendable job and have a bright future.

I. General Questions as to Purposes of the Review (Montana State University)

A. Content, purpose, goals and limitations of the program. The statistics program is satisfactory in content, purpose and goals but will be limited by the number of faculty in statistics. As the consulting activities increase the staff will undoubtedly need to be increased. Further information on this is referred to in the General Comments of my report.

B. Need for the program and results if eliminated.

1. Student demand, market for graduates, enrollment data. There is no shortage of jobs for masters and Ph.D. students in statistics. Those in the program who declare an option in statistics will be employable.

2. Service to state, region and institution. The service to the institution is explained in my General Comments and examples of the service to the state and region is described in the Appendix.

C. Quality of Program

1. Faculty. The quality of the faculty is adequate but their responsibilities in teaching, consulting, and directing graduate students is important for a quality program. This will require additional faculty.

2. Students. Quality of incoming student; quality of post-graduate school careers. The quality of the student seems to be adequate and those who take an option in statistics are sufficiently trained to obtain and perform in a job in industry, federal or state governments.

3. Facilities, equipment and library holdings. These are adequate but they need to be constantly monitored and increased as the demand warrants.

D. Program Comparison between the Two Schools.

1. Content and extent of duplication. In a real sense there is very little duplication between the two programs in statistics although on paper it may appear so. The consulting activities could not possibly be carried on in the university in which the statistics group was eliminated.

2. Quality. The quality of the program at the two schools is comparable. However, they differ somewhat because the objectives are not the same but the quality is adequate at each school.

E. Record of the Department Program in Attracting Additional Resources to the University and the State.

1. Grants and Contracts. The statistics group has been successful in obtaining some contract and grant monies but this could be significantly improved if they would make a concerted effort to be resource faculty on many of the proposals that are submitted to granting agencies where a statistician is required to help conduct the research. This is explained in more detail in the General Comments of my report.

2. Facilities. The only facilities required are faculty, graduate students, and computing time. These appear to be adequate.

Appendix

1. Development of an index number system to measure human attitudes toward recreation activities and major recreation development.

2. Determination of feasibility of controling grasshopper infestations through natural disease applications.

3. Simulation model for air polution sources in West Fork Basin of Gallatin Canyon Montana.

4. Relationship between climatic conditions and magpie distribution in Montana.

5. A comprehensive data bank for soils classification data for the state of Montana to be used in predicting fertilizer and moisture needs for successful cropping.

6. Prediction of population of Gallatin County Montana by age, sex and occupation.

7. Development of a predictive model for watershed runoff for the state of Montana for planning bridge and culvert construction.

8. Model of relationship between roughness of land topography and miles of waterway per section.

9. Vehicle traffic survey for Gallatin Canyon Montana.

10. Gallatin Field - Bozeman air traffic survey.

11. Sikorski Ranch (Montana) land use management plan.

12. Homing instincts of Canadian geese.

13. Projections of air traffic for state of Montana.

14. Assist Dept. of Ag. Education with a statewide survey and data analysis to determine job requirements and employee competencies in agriculture and agri-business areas.

15. Assist a Ph.D. student from the University of Montana with an evaluation of environmental education teaching methods.

16. Survey of drivers in Montana to determine attitudes towards safe driving and law enforcement, for Montana Safety Office and Highway Patrol.

17. Consultant to Montana Dept. of Public Instruction regarding public survey and data analysis to determine K through 12 quality of education in a study requested by the State Legislature.

18. Determination of expectedvehicle accident rates on US 191 in the Gallatin Canyon area upon completion of the Big Sky Recreation Development.

19. Consultant to Montana Post Secondary Commission to survey high school seniors regarding post secondary educational desires and intents and related financial needs.

20. Consultant to Montana Board of Crime Control to design, develop and implement a statewide survey to determine levels of unreported crime, public awareness of crime prevention activities, and public priorities and attitudes towards low enforcement methods and optional penalties.

21. Consultant to Montana Bureau of Maternal and Child Health Care in conducting a statewide survey to determine public awareness and priorities regarding health care programs and availability of these services.

22. Assist a Fish and Wildlife student with a thesis study using multivariate discriminate analysis to determine suitable eagle nesting sites in the Madison and Yellowstone river drainages.

23. Assist Biologists from Targhee National Forest with statistical analysis of data from gopher reduction study.

24. Assist a Fish and Wildlife student with analysis of paddlefish catch and population study data.

25. Study for MSU Equal Employment Opportunity Office to determine a method of examining faculty salaries which discovers inequities (particular emphasis related to examining the presence or absence of differences related to sex). This project involved serving as an expert court witness for MSU in the Jane Doe discrimination suit, 1975.

26. Consultant to the Montana Fish and Game, Fisheries Division to develop and implement a statewide fisherman mail survey to determine fishing pressure (fisherman days of use) on all fishable waters in the state.

27. Consultant to the Deer Lodge County and City of Anaconda Government Study Commissions on development of a questionnaire to determine public opinion on local issues.

28. Consultant to the Powell County and City of Deer Lodge Government Study Commissions to determine sample size and method for an interview survey to gather public input on local government options.

29. Assisted a Ph.D. student in Plant and Soil Science in clustering international barley growing regions so that specific strains developed for one region can be easily transferred to suitable growing areas.

30. Consultant to the Montana Fish and Game, Fisheries Division to design a sample frame for improving the fisheries creel surveys, to design data collection forms and to complete a computer program for analysis of creel census data. This has been used for studies on the Yellowstone, Flathead, and Madison rivers and on Hyalite and Georgetown lakes, and will become the "standard" statewide procedure.

31. Consultant to the Montana Highway Traffic Safety Office to design a demonstration motor vehicle inspection sampling program. The results of this inspection program will help determine whether Montana vehicles will be required to have annual inspection. If not, the results will be given to the Federal government as evidence for exemption; if so, they will be given to the State Legislature to support enabling legislation.

Franklin A. Graybill

Franklin A. Graybill
Colorado State University

DEPARTMENT OF MICROBIOLOGY
University of Montana
Missoula, Montana 59801
(406) 243-0211

File
Pett:
Ferri
Hjort
Lanna
Mattou
Noble
Swift
Wright
Burke
McKay
McMillan
Waite

July 15, 1976

Dr. Freeman Wright
Deputy Commissioner of Academic Affairs
Office of the Commissioner of Higher Education
1231 11th Ave.
Helena, MT 59601

Dear Dr. Wright:

The Ph.D. graduate program in microbiology at the University of Montana provides training in the general areas of microbiology and thus enables the graduates to enter any of the many areas available from the academics to clinical or research laboratories. The training also includes specialized areas as required by the nature of the degree. As indicated in the evaluation report, the programs at MSU and U of M complement each other with very little duplication in the specialized research areas.

The undergraduate education is one of the most profound beneficiary of the graduate programs. Professors engaged in active graduate research and constantly stimulated by the challenge of Ph.D. candidates cannot help but remain enthusiastic and impart current and updated informations and advancements in their teaching. The people of Montana have also benefited enumerably by the expertise thus developed. For example, physicians and veterinareans and even ranchers throughout the state have received valuable assistance and advice in the care and even treatment of patients or animals.

Although both institutions have several professors with similar background training, there are still very little overlapping or duplication. Graduate students obtaining their training at one of the institutions can easily spend at least another year at the other and obtain further training and education. The diversity and complexity of the disciplines in microbiology account for our differences. The areas of physiology, immunology, mycology and virology are similar only where the fundamentals of facts and concepts are concerned, but the research areas and training obtained at the graduate level are quite different.

The distance between the two institutions has been a deterrent for the limited cooperative participation. However, where possible, on numerous occasion faculty members from one institution have been invited to the other campus as guest lecturer. The graduate students from one department have frequently utilized the expertise of a faculty in the other institution through the "hot line" to clarify and obtain recommendations in complex research projects. Perhaps with more travel support through the state and eventual development

of direct television communication system, the strengths of the two departments can be put to more effective use benefitting the entire state.

Collaboration between departments within the institution is most evident by the presence of a faculty member from one department on graduate student committees of another. These can readily be verified through the files of the graduate dean. On many occasions faculty from the department of microbiology have presented lectures in the graduate courses of another department and the reverse has also been true. Exchange of major pieces of equipment has existed on this campus for many years. The achievements between departments in microbiology were no doubt influenced partly by the expertise of faculty members from other departments and again the reverse has definitely been the case as well. It is our hope that this continued exchange of ideas and cooperation between the other departments continue.

Sincerely,

Richard N. Ushijima, Ph.D.
Professor & Chairman
Department of Microbiology

RNU:dk

ATTACHMENT # 10
Response - ii

MSU DEPARTMENT OF MICROBIOLOGY

COLLEGE OF LETTERS & SCIENCE MONTANA STATE UNIVERSITY, BOZEMAN 59715

Pettit
Ferrar
Hjorth
Lauer
McIntyre
Redfield
Smith
Wright
Burke
McKay
McMillon
Waite

July 20, 1976

Dr. Freeman Wright
Deputy Commissioner of Academic Affairs
Office of the Commissioner of Higher Education
1231 11th Avenue
Helena, MT 59601

Dear Freeman:

The Microbiology Staff at MSU was pleased with the report submitted by Dr. Orville Wyss and Dean Norman Durham. This review team documented impressions that we have had regarding our program, but it is always encouraging to have confirmation from the outside.

We are anxious that several of the recommendations of the reviewers receive consideration by you and Commissioner Pettit, viz:

(1) "Additional investments in support personnel could be beneficial to faculty and graduate students in delivering a quality program." This is particularly true in the case of animal care and other routine laboratory activities.

(2) "The academic year salaries are obviously on the low side for salary levels in regional and national surveys." The reviewers mentioned the value of some merit system for productivity and we heartily agree.

(3) "Research investment in the Department of Microbiology could provide a positive incentive for faculty. The utilization of post-doctoral fellows will greatly enhance the scholarly and creative capabilities of a laboratory and provide a broader and stronger base on which to seek outside funds." The reviewers mentioned "negative incentive" and sometimes our staff feels in this position when they work hard to get grants and then have difficulty in getting University support to complement their programs.

(4) "Many Universities have found it to be sound business practice to furnish, during the first year, a half or full-time technician to a new faculty member in whom they contemplate investing almost a million dollars in life-time salary and support." This will be important to us as we recruit for two new staff members whom we expect to conduct an active research program as well as carry a heavier teaching load than they might at many other schools.

TELEPHONE (406) 994-2903

We have no disagreements with this complimentary report but hope that the Commissioner and members of the Board of Regents appreciate the major efforts that over the years have gone into achieving this level of excellence. We need more understanding and support in order to maintain such a program in the face of competition and tightening federal funding.

Sincerely,

William G. Walter
Professor and Head

WGW/jvb

cc Vice President Dayton
Dean Jutila

University of Montana
Missoula, Montana 59801
(406) 243-0211

RESPONSE TO PH.D. BOTANY PROGRAM REVIEW

by

BOTANY DEPARTMENT
UNIVERSITY OF MONTANA

The opportunity to have our program reviewed by such outstanding professionals as Dr. Kozlowski and Dr. Evert was greatly appreciated and has already been of great benefit to us in planning and reflection. The review has been thorough and the report contains material with which we have no substantial disagreement. However, there are a few points which should be emphasized or reinforced and a few omissions which warrant comment.

The reviewers of the Botany program as well as other reviewers, especially for Zoology, make pointed statements about costs associated with retention or elimination of doctoral programs. Some of these points should be reinforced. For example they write that the Department of Botany at the U of M has been phenomenally successful in obtaining external funds for research and teaching. They also state that we have considerable equipment obtained largely through faculty grants from external sources. They further state that the presence of Ph.D. programs has in large part made it possible for active faculty members to obtain very substantial research grants. The related benefits of the research funds to faculty, graduate and undergraduate research as well as instruction is outlined clearly as is the erosion of quality expected should the program be eliminated. The relationship of a strong advanced program in Botany to the well-being of the University and the State of Montana should not be underestimated.

The reviewers' report makes an important point of our inadequate space and deplorable greenhouse conditions and this cannot be emphasized enough. The long range building program could help remedy this situation but it is also hoped that some more immediate relief would be made a reality by finding new quarters for Science Education outside of our Natural Science Building and building some greenhouse facility in cooperation with the Physical Plant to serve until a new building with rooftop greenhouses is possible.

Although the reviewers met with and made favorable remarks about our graduate students, none of this found its way into their written report. It should be emphasized that the report prepared earlier by the Botany Department does have a section on the students which includes information about high quality, achievement and successful placement of these graduate students.

The statement in the reviewers' report that the equipment and library holdings are quite adequate might be an overstatement of the facts. For example the library holdings are minimally adequate but only because outside funding resulting from research grants has been added to the Botany library budget to the tune of $1,000 to $2,000 per year. Also, while we do have considerable equipment, obtained largely through faculty grants, we lack certain items of modern equipment, such as scanning electron microscope, which have now become almost routine in modern scientific laboratories and would add a worthwhile dimension to our program.

The reviewers refer to our doctoral program as "successful" and our department as a "splendid organization." They also refer to the department as having "several areas of excellence." Such statements indicate to us that this quality program should be left intact in order to continue performing for the University and State in a productive manner. To divide, separate or amalgamate the Botany program would be counter productive and disastrous to our present worthwhile effort.

ATTACHMENT # 10
Response - iv

MSU

DEPARTMENT OF BIOLOGY

COLLEGE OF LETTERS & SCIENCE MONTANA STATE UNIVERSITY, BOZEMAN 59715

July 14, 1976

To: Dr. Freeman Wright, Deputy Commissioner for Academic Affairs

Fr: Dr. Jim Pickett, Head, Biology Dept., MSU J. M. Pickett

Re: Comments upon the Ph.D. reviews in Botany and Zoology at MSU

I. Botany:

A. Anatomy, Morphology and Taxonomy: The Department of Biology offers the following upper division courses in plant anatomy, morphology and taxonomy:

Course	Title	Instructor	Enrollment Total	Ag
Biol 315	Agrostology	Rumely	26	13
316	Plant Anatomy	Hahn	12	2
410	Cytology	Carroll	15	5
421	Adv. Plant Taxonomy	Rumely	9	3

The faculty in Biology and in the College of Agriculture would prefer that a professional anatomist-morphologist teach Biol 316 and that Biol 315 and 421 be oriented more toward agriculturally and ecologically important plants. I doubt that there would be sufficient demand to support graduate courses in these areas. It might be possible to hire one professional who could fill this need for better coverage of anatomy and applied taxonomy either now or when Mr. Hahn retires (by 1980). It should be noted that there have been four retirements in Biology (Booth, Hastings, Scharff and Quimby) since 1973 without any replacements so far.

B. Plant Ecology and Agriculture: Ecology, the study of relationships between living systems (organisms, populations, and communities) and their environments, is pursued and applied by both botanists and students of agriculture. 1) Knowledge about the relationship of a plant or a population of plants to its environment (aut-ecology) is useful in managing native and crop plants. Crop science and range management students comprise about half of our Autecology class while Biology students turn to agriculture for other

autecology courses in bioclimatology, crop physiology, plant nutrition, etc. Much of the research in autecology is directly applicable to agriculture. For example, we have studied effects of increased precipitation on yields, effects of possible toxins associated with cloud seeding on crops, effects of trampling on plant survival, etc. 2) European ecologists and US Forest Service ecologists have demonstrated that the relationships of biotic communities to their environments (syn-ecology) can be used to predict what 'crops' will perform best on a given site. Current studies will estimate the indicator values of natural vegetation of Montana. Courses in Biology and Range Science complement each other in this area and attract students in both disciplines.

The ecological and physiological relationships of agricultural plants are becoming increasingly important to identify which environmental variables significantly alter plant growth and development. The interest of agricultural students in plant ecology and plant physiology is indicated below:

Course	Title	Instructor	Enrollment Total	Ag
Biol 510	Adv. Plant Physiology	Mills	9	6
511	" " "	"	7	4
512	" " "	"	6	5
529	Plant Geography	Collins	9	4
534	Plant Autecology	Weaver	10	5
536	Plant Synecology	Weaver	15	5

C. Interaction Between the Ph.D. in Botany and the Ph.D.'s in Plant Pathology and Crop and Soil Science:

There are actually three Ph.D. programs in the botanical sciences at MSU; i.e., Botany, Plant Pathology and Crop and Soil Science. These programs all interact as is indicated by the number of currently enrolled Biology graduate students taking courses taught by faculty in Plant Pathology and Plant and Soil Science:

Plant Pathology Courses

Course	Title	Instructor	Number of Biology Graduates
301	Plant Pathology	Mathre	3
550	Plant Biochemistry	Strobel	3
402, 530, 531			4
		Total	10

Plant and Soil Science Courses

426	Agricultural Climatology	Caprio	2
480	Photo Interpretation	Nielsen	3
305, 319, 406, 410, 412, 420, 505, 525			8
		Total	13

In addition to these courses, Dr. Carroll (Plant Pathology) has a 0.30 FTE appointment in Biology and teaches Biol 410-Cytology. Lists of recent publications of Drs. Caprio, Carroll, Mathre, Nielsen and Strobel, who have the most contact with Biology graduate students, are attached. It is quite evident that the Ph.D. in Botany at MSU does not function as an isolated program, but is only one of three Ph.D. programs in the botanical sciences at MSU.

II. Zoology:

A. Upper Division and Graduate offerings in Genetics, Physiology and Limnology: In view of the following lists, I do not understand the reviewers' comment (page 1) "...there are notable weaknesses in offerings in genetics, physiology and limnology."

Area	Biology Course	Title	Instructor	Last Enrol.
Genetics	324	Principles of Genetics	Staff	85
	411	Genetics Lab	Vyse	8
	412	Genetics Lab	Skaar	16
	413	Physiological Genetics	Skaar	13
	415	Human Genetics	D. Cameron	6
	443	Genetics of Development	Vyse	8
	450	Evolution	Skaar	42
	519	Adv. Physiological Gen.	Skaar	2
	533	Population Genetics	D. Cameron	4
Animal Physiology	405	Animal Physiology	Picton	80
	431	Insect Physiology	Roemhild	5
	444	Comparative An. Physiol.	Picton	15
	446	Functional Biology of Fishes	Kaya	20
	505	Cellular Physiology	Vyse	18
	531	Adv. Animal Physiology	McMillan	7
	532	" " "	"	4
	540	Environmental Physiol.	Picton	7
Limnology	414	Limnology	Kaya	32
	417	Fresh Water Algae	Wright	41
	446	Functional Biology of Fishes	Kaya	20
	513	Fisheries Management	Gregory	7
	518	Algal Physiology	Pickett	4
	538	Fresh-water Invertebrates	Roemhild	7
	541	Population Dynamics	Wright	17
	542	Chem. & Physical Limn.	Wright	11
	543	Aquatic Community Ecol.	Wright	14
	553	Biology of Water Pollution	Kaya	13

B. WAMI and Graduate Education: It is incorrect to say that WAMI faculty in Biology do not participate in graduate education. Most WAMI courses are open to a limited number of graduate students as the following table indicates:

			Graduate Students Enrolled (75-76)
MedS	500	Nutrition	1
	511	Anatomy	2
	512	Mech. in Physiol. & Pharm.	1
	515	Ages of Man	0
	531	Head, Neck Ear, Nose and Throat	0
	532	Nervous System	0
	534	Endocrine System	1
		Total	5

Also, Dr. McMillan teaches Biol 531-532--Adv. Animal Physiology and has a student working on a master's thesis in Zoology. Overall, the teaching loads of WAMI faculty are about average for the Biology Dept.

III. Publication Record:

Both the faculties in Botany and Zoology (including Entomology, F&WL and Genetics) at MSU are criticized for a rather poor publication record. I must concur in the reviewers' conclusion. However, the primary function of the Biology faculty at MSU is to teach undergraduate students. Based on information provided by the departments and the Commissioner's office we teach about 12% more credits per instructional FTE (15.5 vs. 13.9) and about 30% more student credit hours per FTE (1051 vs. 809) than the combined Botany and Zoology faculties at UM. Also, ecological experiments often require two or more years' data for comparisons. Consequently, I can accept a publication rate of two or three refereed publications in national journals during the last five years as an acceptable indicator of productive research. Nine Biology faculty (D. Cameron, H. Cameron, Eng, Kaya, McMillan, Phillips, Pickett, Weaver and Wright) have published two or more papers in refereed national journals in the last five years. Five faculty (Eng, Kaya, Pickett, Weaver and Wright) have published three or more such papers in the last five years.

IV. Conclusions and Recommendations:

A. The Biology Dept. at MSU should offer a Ph.D. in Biology (not Environmental Science as mentioned July 7) with options in Botany, Entomology, Fish and Wildlife Management, Genetics and Zoology. However, because of the limited course offerings due to low enrollment and the poor publication record in Entomology during the past five years, I cannot support the acceptance of Ph.D. students in Entomology at the present time. The composition of such a program is indicated below:

Enrollment in the M.S. and Ph.D. Programs

	1973-74		1974-75		1975-76	
	M.S.	Ph.D.	M.S.	Ph.D.	M.S.	Ph.D.
Botany	9	2	6	2	6	2
Entomology	0	1	1	0	2	1
F&WL	20	1	22	1	18	1
Genetics	-	5	-	6	-	3
Zoology	9	1	9	2	10	2
Total	38	10	38	11	36	9

B. Any faculty member accepting a qualified Ph.D. student should have at least two refereed publications during the last five years in national journals relevant to the option of the Ph.D. The faculty member should also have demonstrated competent supervision of at least one prior thesis and should have financial support for the Ph.D. research project. It is also necessary that a sufficient number and variety of courses be available to construct a Ph.D. program for the student.

C. The Biology Dept. should continue to concentrate its research efforts and Ph.D. programs in terrestrial and aquatic ecology especially as related to agricultural and resource management problems.

D. The current vacant position in F&WL should be filled with a research-oriented big-game ecologist to maintain one of our strongest undergraduate and graduate programs.

E. A competent plant anatomist and agriculturally-oriented taxonomist should be hired now or when Mr. Hahn retires (by 1980). This person's primary responsibility would be to teach undergraduate plant anatomy and taxonomy to students in Biology, Plant Pathology and Plant and Soil Science. We should not try to develop graduate courses or Ph.D. programs in plant anatomy, morphology or taxonomy.

JMP:dml

Encl. Publication lists

cc: Vice President Dayton
Dean Jutila
Biology faculty

July 9, 1976

To: Biology faculty

Fr: Jim Pickett

Re: Information for F. Wright needed by Wed., July 14.

1. Please list all refereed publications since 1970 based on theses under your direction for which you are not listed as a coauthor. Provide: authors, year, title, journal, volume and pages.

2. If you teach a WAMI course, please list the number of graduate students enrolled during each offering of each course.

3. Do you favor a Ph.D. in Biology? Please qualify your answer if you wish.

yes 10 if option is listed on transcript
no 3 and diploma.

To: Jim Pickett

Fr: Dick Mackie

Re: List of publications based on thesis research under my direction since 1970 on which I am not listed as co-author.

Kohn, B. E. and J. J. Mooty. 1971. Summer habitat of white-tailed deer in northcentral Minnesota. J. Wildl. Manage. 35(3): 476-487.

Van Ballenberghe, V. and J. M. Peek. 1971. Movements and habitat use of radio-marked moose in northeastern Minnesota. J. Wildl. Manage. 35(1): 63-71.

Peek, J. M. 1970. 1970. Wilderness moose. Naturalist. 21(4) 38-41.

_____. 1971. Canopy and volume relationships to production of three woody species. Ecology 51(6): 1098-1101.

_____, L. W. Krefting, and J. W. Tappeiner, III. 1971. Variation in twig diameter-weight relationships in northeastern Minnesota. J. Wildl. Management 35(3): 501-507.

_____, 1971. Moose-snow relationships in northeastern Minnesota. Proc. Snow and Ice Symp. in Relation to Wildlife and Recreation. Iowa State Univ., Ames., pages 39-50.

_____, 1972. White-tails in winter. Symp. on the White-tail Deer in Minnesota, St. Paul. The Wildlife Society, pages 23-26.

_____, 1973. Adaptations to the burn: moose and deer studies. Naturalist 23(3-4): 8-14.

_____, R. E. LeResche and D. R. Stevens. 1974. Dynamics of moose aggregations in Alaska, Minnesota and Montana. J. Mammal. 55(1): 126-137.

_____. 1974. A review of moose food habit studies in North America. Le Naturaliste Canadien 101: 195-215.

_____. 1974. On the nature of winter habitats of Shiras moose. Le Naturaliste Canadien 101: 131-141.

_____. 1974. Initial response of moose to a forest fire in northeastern Minnesota. Am. Midl. Nat. 91(2): 435-438.

C. W. Neu, C. R. Byers and _____. 1974. A technique for analysis of utilization-availability data. J. Wildl. Management 38(3): 541-545.

_____, L. W. Krefting and J. C. Tappeiner, III. 1974. Twig diameter and weight relationships for important browse species in northern Minnesota. Minnesota For. Res. Note 248. 4 pages.

Ohmann, Lewis F., Charles T. Cushwa, Roger E. Lake, James R. Beer and Robert B. Brander. 1973. Wilderness ecology: the upland plant communities, woody browse production, and small mammals of two adjacent 33-year-old wildfire areas of northeastern Minnesota. North Cent. For. Exp. Stn., St. Paul, Minn. 30 pages, illus. (USDA For. Serv. Gen. Tech. Rep. NC-7).

Wetzel, J. F., J. R. Wambaugh, and J. M. Peck. 1975. Appraisal of white-tailed deer winter habitats in northeastern Minnesota. J. Wildl. Manage. 39(1): 59-66.

Publications 1971-76

Dr. Thomas W. Carroll
Professor of Plant Pathology

Carroll, Thomas W. 1972. Seed transmissibility of two strains of barley stripe mosaic virus. Virology 48:323-336.

Carroll, T. W. and Mayhew, D. E. 1976. Anther and Pollen Infection in relation to the pollen and seed transmissibility of two strains of barley stripe mosaic virus in barley. Can. J. Bot. (In Press).

Carroll, T. W. and Mayhew, D.C. 1976. Ovule and embryo sac infection in relation to seed transmissibility of barley stripe mosaic virus in barley. Can. J. Pot. (In Press).

Darlington, L. C., Carroll, T. W., and Mathre, D. E. 1976. Enhanced susceptibility of barley to ergot as influenced by barley stripe mosaic virus infection. Plant Dis. Reptr. (In Press).

McNeal, F. H., Berg, M.A., and Carroll, T. W. 1976. Agronomic and Barley stripe mosaic virus data from six infected spring wheat cultivars seeded after 14 and 19 years of storage. Plant Dis. Reptr. (Ms. submitted).

Publications 1971-76

Dr. Donald E. Mathre
Professor of Plant Pathology

Mathre, D. C. 1971 Mode of action of oxathiin systemic fungicides. II. Structure-activity relationships. J. Ag. & Food Chem. 19:872-874.

Mathre, D. E. 1971. Mode of action of oxathiin systemic fungicides. III. Effect on mitochondrial activities. Pesticide Biochem. & Physiol. 1:216-224.

Shively, O. D., and D. E. Mathre. 1971. Mode of action of oxathiin systemic fungicides. IV. Effect of carboxin on solute leakage from hyphae of Rhizoctonia solani. Can. J. Microbiol. 17:1465-1470.

Furanik, S. B., and D. E. Mathre. 1971. Biology and control of ergot on male sterile wheat and barley. Phytopathology 61:1075-1080.

Ulrich, J. T., and D. E. Mathre. 1972. Mode of action of oxathiin systemic fungicides. V. Effect on electron transport system of Ustilago maydis and Saccharomyces cerevisiae. J. Bact. 110:628-632.

Mathre, D. E. 1972. Effects of oxathiin systemic fungicides on various biological systems. Bull. Environmental Contam. of Tox. 8:311-316.

Johnston, R. H., and D. E. Mathre, 1972. Effect of infection by Cephalosporium gramineum of winter wheat. Crop Sci. 12:817-819.

Cunfer, B., D. E. Mathre, and E. A. Hockett. 1974. Factors influencing the susceptibility of male-sterile barley to ergot. Crop Sci. 15:194-196.

Mathre, D.E., V. R. Stewart, R. H. Johnston, and D. E. Baldridge. 1974. Fungicide treatment of wheat seed: Is it necessary? J. Environ. Qual. 4:117-120.

Mathre, D. E., and R. H. Johnston. 1975. Cephalosporium stripe of winter wheat: Procedures for determining host response. Crop Sci. 15:591-594.

Mathre, D. E., and R. H. Johnston. 1975. Cephalosporium stripe of winter wheat: Infection processes and host response. Phytopathology 65:1244-1249.

Mathre, D. E., and R. H. Johnston. 1976. Presence of dwarf and common smut in Montana wheat. Plant Dis. Reptr. In Press.

Darlington, L. C., and D. E. Mathre. 1976. Resistance of male sterile wheat to ergot as related to pollination and host genotype. Crop Science: In Press.

Darlington, L. C., T. W. Carroll, and D. E. Mathre. 1976. Enhanced susceptibility of barley to ergot as influenced by barley stripe mosaic virus infection. Plant Dis. Reptr. In Press.

Publications 1971-76

Dr. Gerald A. Nielsen
Professor of Soil Science

Soil Interpretations for Land Use Planning and Development in the Gallatin Valley Area with SCS and Exp. Station Staff. Mont. Agric. Exp. Sta. 1971.

Soil Crust Studies. R. A. Moe, G. A. Nielsen and R. T. Choriki. Mont. Agric. Exp. Sta. 1971.

Soil Interpretations for Land Use Planning and Development in the Gallatin Canyon Area, Montana. J. A. Olsen, B. F. Leeson and G. A. Nielsen. Mont. Agric. Exp. Sta. 1971.

Impact of Large Recreational Developments Upon Semi-Primitive Environments. The Gallatin Canyon Case Study. Gallatin Canyon Study Team. Research Report #66. Center for Interdisciplinary Studies and Montana Ag. Exp. Sta., Montana State Univ., Bozeman, June 1974.

The Gallatin Area, A Summary Report. Gallatin Canyon Study Team. Bulletin 344, Cooperative Extension Service, Montana State University, Bozeman, February 1974.

Problems of Interdisciplinary Applied Research in a University Setting. A. S. Williams, G. A. Nielsen, J. W. Reuss, D. G. Stuart and H. F. Shovic. Montana State University, Bozeman 1974.

Computer Codes Montana Soil Data. Soil Conservation. Vol. 40, No. 4, USDA, SCS. 1974.

Inventorying Montana Soils with Computers. G. A. Nielsen. Now. Montana State University. Bozeman, Vol. 10:6. 1974.

Environmental Impact Assessment: The Gallatin Canyon - Big Sky Study. G. A. Nielsen et al. Journal of Soil and Water Conservation. 28(5) 208-210. 1974.

The Montana Automated Data Processing System for Soil Inventories. G. L. Decker, G. A. Nielsen and J. W. Rogers. Mont. Agric. Exp. Sta. Research Report #89, 1975.

Soils of the Coram Experimental Forest. M. G. Klages, R. C. McConnell and G. A. Nielsen. Mont. Agric. Exp. Sta. Research Report #91, 1976.

Publications 1971-76

Dr. Gary Allan Strobel
Professor of Plant Pathology

Steiner, G. W., and Gary A. Strobel. 1971. Helminthosporoside, a host-specific toxin from Helminthosporium sacchari. J. Biol. Chem. 246: 4350-4357.

Quinn, R., and Gary A. Strobel. 1971. α-ketobutyrate decarboxylase activity in Rhizoctonia solani. Can. J. Bot. 49: 1059-1065.

Ries, S. M., and Gary A. Strobel. 1972. A phytotoxic glycopeptide from cultures of Corynebacterium insidiosum. Plant Phys. 49: 676-684.

Strobel, Gary A. 1972. Phytotoxic Glycopeptides of Corynebacterium in Phytotoxins in Plant Diseases. Academic Press, London. 536 pp.

Strobel, Gary A. 1972. Comparative biochemistry of some toxic glycopeptides produced by plant pathogenic corynebacteria. Proc. 3rd International Conference on Plant Pathogenic Bacteria, Wageningen, Netherlands, 357-365.

Strobel, Gary A., W. M. Hess, and G. W. Steiner. 1972. Ultrastructure of cells in toxin treated and Helminthosporium sacchari infected sugarcane leaves. Phytopathology 62: 339-345.

Strobel, Gary A., K. Talmadge, and P. Albersheim. 1972. Observations on the structure of the phytotoxic glycopeptide of Corynebacterium sepedonicum. Biochem, Biophys, Acta. 261: 365-274.

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Ries, S. M., and Gary A. Strobel. 1972. Biological properties and pathological role of a phytotoxic glycopeptide from Corynebacterium insidiosum. Physiol. Plant Path. 2: 133-142.

Strobel, Gary A., and Gary Steiner. 1972. Runner formation in relation to helminthosporoside in sugarcane infected by Helminthosporium sacchari. Physiol. Plant Path. 2: 129-132.

Strobel, Gary A. 1973. The helminthosporoside binding protein of sugarcane. Its properties and relationship to susceptibility to the eye spot disease. J. Biol. Chem. 248: 1321-1328.

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Mundy, B. P., F. Lin, and Gary A. Strobel. 1973. α-aminobutyronitrile as an intermediate-cyanide fixation by Rhizoctonia solani. Can. J. Biochem. 51:1440-141

Straley, C., Mary Straley, and Gary A. Strobel. 1974. The use of a phytotoxic glycopeptide as a rapid screening technique for bacterial wilt resistance in alfalfa. Phytopathology 64: 194-196.

Karr, A., D. Karr, and Gary Strobel. 1974. Isolation and partial characterization of four host-specific toxins of H. maydis. (Race T). Plant Physiol. 53: 250-257.

Kent, S., F. Pinkerton, and Gary A. Strobel. 1974. Photosynthesis in the higher plant, Vicia faba III. Serine, a key intermediate of the formate pathway and a precursor of the TCA cycle. Plant Physiol. 53: 491-495.

Strobel, Gary A., and W. M. Hess. 1974. Evidence for the presence of toxin binding protein on the plasma membrane of sugarcane cells. Proc. Nat. Aca. Sci. (USA) 71: 1413-1417.

Strobel, Gary A. 1974. Phytotoxins from plant parasites. Ann. Rev. of Plant Physiol. 25: 541-566.

Strobel, Gary A. 1974. The toxin binding protein of sugarcane. Its role in the plant and in disease development. Proc. Nat. Aca. Sci. 71: 4231-4236.

Strobel, Gary A. 1975. A Mechanism for Disease Resistance in Plants. Scientific American 80-88.

Karr, Dale, A. Karr, and Gary Strobel. 1975. Toxins of H. maydis Race T - a colorimetric determination of the toxins, their appearance in culture, and infected plants. Plant Physiol. 55: 727-730.

Barash, I., A. Karr, and Gary Strobel. 1975. Isolation and characterization of stemphylin, a chromone glucoside from Stemphylium botryosum. Plant Physiol. 55: 646-651.

Strobel, Gary A., and K. Hapner. 1975. Transfer of toxin susceptibility to plant protoplasts via the helminthosporoside binding protein of sugarcane. Biochem. and Biophys. Res. Commun. 63: 1151-1156.

Strobel, Gary A., Gary Steiner, and R. Byther. 1975. Deficiency of Toxin Binding Protein Activity in Mutants of Sugarcane Clone H54-775 as it Relates to Disease Resistance. Biochemical Genetics 13: 557-565.

Strobel, Gary A. 1976. Toxins of Plant Pathogenic Bacteria and Fungi. Plant Biochemistry Series, Phytochemical Society. Academic Press (in press).

Sinnasky, M. and Gary Strobel. 1976. The chemical nature of a fraction of sugarcane enriched in plasma membrane. Plant Sci Lettres 6: 209-214.

Currier, W., and Gary Strobel. 1976. Chemotaxis of rhizobium spp. to plant root exudates. Pl. Phys. 57: 820-823.

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Pinkerton, F., and Gary A. Strobel. 1976. Serinol as an activator of toxin production in attenuated cultures of H. sacchari. P.N.A.S. (USA) (in press).

Strobel, Gary A. 1976. Phytotoxins as tools in studying plant disease resistance. Trends in Biochemical Sciences (in press).

Strobel, Gary A. 1976. Biochemical observations on heat-induced plant disease resistance. Plant Physiol. (in press).

Currier, W., and Gary A. Strobel. 1976. Chemotaxis of Rhizobia spp. to a glycoprotein produced by birdsfoot trefoil. Science (submitted).

ATTACHMENT # ..
Response - v

30 June 1976

TO: Dr. Freeman J. Wright, Deputy Commissioner for Academic Affairs

FROM: Lee H. Metzgar, Chairman, Department of Zoology, U of M

RE: University of Montana Department of Zoology Doctoral Program Review

On behalf of the U of M Department of Zoology, I wish to express appreciation for the opportunity to thoroughly review our Ph.D. program. The outside reviewers' report (as well as other aspects of this process) increased our confidence in the high quality of our program, its even greater potential, and its very real contributions to the university, the state, and the nation. The review has helped sharpen our focus on the strengths of our program. It has also given us confidence that we are working effectively to strengthen certain portions of our activities. Because of this review, we will approach these tasks with increased direction, confidence, and enthusiasm.

We were pleased that Dr's. Cummins and Bagnara characterized the Zoology Ph.D. programs at U of M and MSU as "complementary" rather than "overlapping". Indeed, the review has increased our appreciation for the unique direction and content of each program. We agree with the reviewers that we can use this complementarity to good advantage by increasing the contact between faculty and students of the two institutions. We look forward to developing such activities.

Throughout their report, the reviewers argued effectively that the Zoology Ph.D. programs must be retained and strengthened. In both programs, the primary limitations were not facilities, faculty quality, student quality, job availability, or any number of other factors investigated. Rather, the programs' primary restraints were judged to be financial. Clearly the reviewers felt we do not need program elimination. We do need greater awareness of and support for these existing programs of demonstrated quality and contributions. We are pleased that the reviewers saw both programs "... as absolutely essential and the effects of elimination as devastating." They expressed the need for greater appreciation and support when they stated, "Importantly, the general misconception that ... elimination of Ph.D. programs will constitute financial saving is so naive that it could only be perpetuated by those totally unfamiliar with institutions of higher education."

Many faculty and administrators on the U of M campus have long recognized that, in the words of the reviewers "... modern biology is functionally oriented and highly interdisciplinary ... (and that) Ph.D. programs in zoology should be part of a broader context such as ... a Division of Biological Sciences...." The Zoology Department has and will continue to pursue a more efficient and more broadly-based organization of the life science faculties at the University of Montana. Many of us have recognized for years that the life sciences could be reorganized to increase the efficiency and strength of our undergraduate and graduate education. We hope that the reviewers' recommendation will help achieve this goal.

The reviewers accurately noted that this faculty's productivity (when measured be grants and publications) is "fair" and is not evenly distributed among the members of the department. They did commend the excellence of over half of this faculty and, of course, the overall contributions of all our faculty members

(considering a wider variety of criteria) was demonstrated in the faculty vitae supplied earlier. None-the-less, we have recognized the need for increased outside funding for our research activities. During the reviewers visit, we discussed several steps that have been initiated or planned that will increase our productivity in these critical areas. In all cases, they felt we had accurately assessed our needs and begun to move effectively to satisfy them. These actions and policies include the following:

1) Equalization of teaching loads. To a large extent, this has been accomplished during the 75-76 school year, and was favorably noted by the reviewers (pg 10). Certain faculty members' teaching loads will now permit more aggressive pursuit of grant support and publications.

2) Certain budget categories (eg. Capital Equipment) will be used exclusively to initiate projects that will lead to preparation of grant applications. This policy became effective in 75-76.

3) Certain teaching assignments will be transferred between faculty members and between quarters to increase faculty opportunities to prepare grant proposals and publications.

4) The nature of the departmental personnel will change greatly in the coming years. Several senior faculty members who will soon retire provide services based on decades of unique experience in this university system. This department gains a great deal of strength from such experience. However, such expertise cannot be replaced and we anticipate that such replacements will be "functionally" trained and oriented biologists who will participate heavily in the research and graduate programs of this department.

5) We also point out that this department will provide increased service to the community and to the state through increased extension offerings. This policy was pursued aggressively during 75-76 when we presented eight different offerings to the people of Western Montana. This zoology extension program included courses for teachers, outdoor recreation education for sportsmen, a course for prison inmates, an important workshop for wildlife agency personnel, and other offerings. In all cases, the responses have been gratifying and we presently plan to expand our extension activities in 76-77.

The reviewers noted that the Ph.D. "... programs are young and in a state of maturation." Indeed a large proportion of our faculty was hired before the Ph.D. program was even planned. They repeatedly noted the outstanding scholarship and productivity of the majority of this faculty and drew attention to the high potential of the program. We believe they are correct and we are confident that we will realize that potential.

cc: John M. Stewart, Graduate Dean
Arnold Bolle, Acting Academic Vice President

Intra-campus MEMORANDUM

ATTACHMENT
Response - VI

File
Pettit
Ferrant
Hjort
Mullen

UNIVERSITY OF MONTANA

DATE: June 28, 1976

TO: Dr. Freeman J. Wright, Deputy Commissioner for Academic Affairs

FROM: R. Keith Osterheld, Chairman, Department of Chemistry

RE: Doctoral Program Review, Department of Chemistry, University of Montana

McMillen
Waite

We were pleased with the reviewers' reports on our doctoral program. We particularly liked the reviewers' recognition that:

1. Doctoral programs are a necessary part of major institutions, particularly in the sciences, as a guarantee of the research activity that guards against obsolescence in faculty, in instrumentation and in program emphases.
2. The faculty, grant funds, and facilities all seem satisfactory for the modest Ph.D. program underway.
3. Our undergraduate program is greatly enhanced by the quality of faculty, of instrumentation, of teaching assistants, and of research activity that result from our doctoral program.
4. Economies cannot be expected from the elimination of this doctoral program.

We appreciated Dr. Shreeve's observation that each department does a creditable job preparing Ph.D. chemists and that the state should take pride in both programs for the success of their products and the extent and continuity of outside funding. Dr. Freeman's cogent conclusions that "it would clearly be a mistake to discontinue either doctoral program," and that "the savings would be small, if any, and the damage done would be great," are particularly telling in view of his statement that when he took the assignment, he did not expect to be able to reach a conclusion.

Because the impetus for the proposed elimination of doctoral programs appears to have been the assumption that economies would result, we have subsequently looked in some detail at the direct economic value to the state of the University of Montana Ph.D. program in chemistry. The two examples that follow illustrate the magnitude of this value.

1. Instrumentation needs

We estimate that without the doctoral program, the state would have to furnish at least $15,000 per year

(in place of the current $1,000-1,500) to keep our instrumentation sufficiently current for undergraduate instruction. Of our present $561,000 inventory of major equipment, only about $20,000 was purchased with state funds.

2. Direct contribution to state economy

In 1975-76, of the $375,000 of non-state funds obtained by Chemistry Department faculty for the department's research programs, over $205,000 was spent on salaries and wages. Using the economists' estimate that salary dollars paid in Montana pass through a total of 2.7 hands within the state, one can estimate a total wage benefit to Montana from our research grants of over $550,000. In addition, we estimate that $45,000 of the non-salary grant funds are expended within the state. In our judgment, at least 80% of our grant-getting ability would be destroyed by loss of the doctoral program.

Reviewers' recommendations

The reviewers' recommendations will be implemented as fully as possible. Comments on several follow:

1. Professor Shafizadeh will take steps to attract graduate student research assistants to partially replace his present research staff with pre-doctoral students.
2. In conjunction with Professor Erickson, the department is working for his reassignment to the environmental studies program, which would allow his replacement in chemistry with a research-active physical organic chemist.
3. This year, two visiting lecturers were jointly supported with the MSU Department of Chemistry. Programs of this sort will be expanded.
4. During the past year, three staff members from each chemistry department visited the other, giving lectures and consulting with students and staff. Interactions of this type would be facilitated by an intercampus shuttle, as suggested by Dr. Shreeve. Ideally, there should be system funding for travel and housing, so that cost is not a deterrent.
5. Because Dr. Freeman raised the issue in his review, we should like to make it clear that although our biochemists desire to keep their present strong ties with the life sciences--microbiology, zoology and botany--they regard themselves as chemists and wish to remain in the Department of Chemistry. The University building program now under development is being designed to provide the proximity among the sciences that is the real key to useful interaction.

Consequences of program loss

Finally, one must not overlook the adverse consequences of elimination of either doctoral program in chemistry, which have been stated by the reviewers to include:

1. Loss of the currency and vitality of the program, which is dependent on research activity.
2. Loss of the best faculty.
3. Loss of outside funding for instrumentation.
4. Major decrease in the quality of undergraduate instruction as a result of the above factors.
5. A serious cutback in research programs now serving the state in wood chemistry, limnology, allelopathy, and coal waste problems.
6. Loss of financial support for students.
7. Damage to other science programs on the campus--at both the undergraduate and graduate levels.

The decision on the future of this program must not be taken lightly; it has taken 10 years and much effort to build the present program.

cc: Dean John M. Stewart

MSU

DEPARTMENT OF CHEMISTRY

COLLEGE OF LETTERS & SCIENCE MONTANA STATE UNIVERSITY, BOZEMAN 59715

July 15, 1976

Dr. Freeman J. Wright, Deputy Commissioner of
Academic Affairs
The Montana University System
Twelve Thirty-One Eleventh Ave.
Helena, Montana 59601

Dear Dr. Wright:

I have received the reviews of Drs. Peter Freeman and Jeanine Shreeve and have passed them on to the staff. We see the reviews as discerning, thoughtful, and complimentary of our doctoral program. There is not much in them with which we can quarrel. Both reviewers urge the continuance of the chemistry doctoral programs at MSU and the U of M and present strong arguments for this recommendation. We are, of course, in complete agreement.

Dr. Osterheld of the University of Montana has accurately summarized the major observations of the review team applicable to both chemistry departments and I shall not repeat them. We are naturally pleased with the following comments, which were made specifically about our department:

Faculty: "There is strength exhibited in all the traditional areas of chemistry at Montana State." Freeman, page 9.

"All areas in the department are staffed by dedicated and enthusiastic teachers....The faculty is obviously very competent and is able to mold the available students into well trained, thinking, producing scientists. Members of other departments who work closely with the chemistry department strongly praise the value of the high caliber faculty and Ph.D. program to their own disciplines, e.g., Microbiology, Plant and Soil Science, Physics, Chemical Engineering, etc." Shreeve, page 2.

Facilities: "The facilities for a doctoral program in terms of space and equipment appear to be excellent. There would be no apparent problem in expanding the program to 40 or so graduate students in terms of limitations imposed by the availability of physical facilities." Freeman, page 10.

"The Chemistry Department at Montana State University is housed in a modern building with excellent facilities for graduate research." Shreeve, page 1.

Program: "If one considers the resources expended in terms of state support, quality of graduate students, salary levels of faculty, teaching assistant stipends and teaching loads, the accomplishments of the doctoral program are impressive." Freeman, page 9.

"Faculty and graduate student enthusiasm for the graduate program is very high. The students appreciate and realize the good fortune of having a great deal of interaction with a large number of interested faculty members. The quality of basic and applied research completed in this department as reported via publication in good journals is very good." Shreeve, page 2.

"Nearly all of the surviving Ph.D. awardees are employed in positions which cover a wide range of industries and academic roles and which would be typical of such degree holders from any Ph.D. granting department. This suggests that the products of this program are employable and can successfully compete for the jobs even during this tight economic period." Shreeve, page 3.

Dr. Freeman made but one specific recommendation, namely, "continuing efforts to maintain research in some of the traditional areas of chemistry be maintained so that the department does not become a department of environmental chemistry." It is our intention to do this. Recognition by the federal and state governments of the importance of basic research would substantially assist us in this effort.

Dr. Shreeve suggests greater interaction with the University of Montana, modification of the Graduate Record Examination requirement to enhance graduate student recruiting, the use of outside funding to support a greater number of Ph.D. candidates as research students, and the utilization of graduate teaching assistantships to support only students who are pursuing a research degree. We are in agreement with these suggestions and will implement them as quickly as administrative cooperation and the availability of quality graduate students permit.

Sincerely,

E. W. Anacker
Professor and Head

EWA:fl
cc: President Carl McIntosh
Vice President Irving Dayton
Vice President Roy Huffman
Dean John Jutila

ATTACHMENT # 10
Response -viii

University of Montana
Missoula, Montana 59801
(406) 243-0211

MATHEMATICS DEPARTMENT

June 28, 1976

Freeman Wright
Deputy Commissioner for Academic Affairs
1231 Eleventh Ave.
Helena, Montana 59601

Dear Dr. Wright:

Attached you will find this department's response to the report of the reviewers of our Ph.D. program, which will, we trust, be useful to you.

We are looking forward to seeing you next week.

Sincerely yours,

William R. Ballard
Chairman
Mathematics Department

vs

Response from the UM Mathematics Department, to Reviewers' Report

We deeply appreciate the reviewers' thoughtful appraisal of the strengths and weaknesses of our graduate program. Since our major effort in graduate education has been in developing a Ph.D. program that departs from the traditional program in Mathematics, we were particularly pleased that the reviewers - all respected scientists involved in traditional programs - found our program nationally unique and valuable.

We have felt, and argued locally, that the Ph.D. program with its emphasis on college teaching improves the teaching of undergraduate mathematics at the University of Montana. The reviewers perceived that this is the case. (It is our feeling that cooperation between mathematics and other disciplines has improved since the initiation of the Ph.D. degree in mathematics. It is a matter of record that enrollment in service courses in mathematics has increased at a much greater rate than has university enrollment in general.)

Quality control is sometimes difficult to maintain at a school such as the University of Montana. It is thus helpful to us to be told by external reviewers that our comprehensive examinations are sufficiently difficult and that our students' dissertations are worthwhile scholarly works.

While the reviewers' comments were generally favorable and strongly support the retention of the program, they did offer some specific suggestions for improvement of the department. We agree with virtually all of these suggestions; in fact, we have made most of them ourselves, and specifically urge that the following actions be given high priority:

1. That discussions begin on ways of effecting closer ties and the possible merger of the departments of mathematics and computer science.

2. That graduate enrollment in mathematics be expanded gradually over several years to a total of 70 students. This requires at the minimum that the University commit itself to take over the support of the teaching assistantships which have been funded up to now through the NSF Graduate Education Grant. As emphasized by the reviewers, this mild expansion of enrollment would enhance both the quality and efficiency of the graduate program, by providing a "critical mass" of enrollment in second year graduate courses and seminars. It would also help relieve the pressure at the lower division teaching level, where classes are constantly oversubscribed and students have to be turned away. Adding graduate students is a very inexpensive way to meet increasing teaching demands in the department.

3. That research and public service activities be given the same high priority as classroom teaching. High standards of research or public service performance as well as a high level of teaching should be demanded as a precondition to tenure and promotion. (These standards are spelled out in the new Departmental Promotion and Tenure document.) Achievement in research and public service should be rewarded by more meaningful merit salary increments, and teaching loads should be adjusted so that those individuals most heavily involved in research and public service be able to devote more time to these activities, in line with nationally recognized professional standards.

4. That the salary levels in mathematics at this University be made more competitive - at least moved to parity with those at Bozeman.

5. That there be created in the department several new faculty positions at the assistant professor level, these positions to be filled by individuals whose main interest is in graduate education and research. The department is very much aware of the availability of talented young mathematicians to fill such positions; indeed, we believe that the few appointments we have been able to make in recent years are first-rate. We note that campus-wide this university has been attracting able young faculty members, but that the best of these often leave when they begin to acquire a national reputation. This circumstance underlines the importance of the reforms mentioned in items 3 and 4.

6. That, as soon as the University's resources permit, a high level full professorship be created, to be filled by an experienced senior mathematician whose major focus will be on the graduate program and on providing leadership in research. In view of the highly competitive market for established research mathematicians, we feel that this position must be funded at least at the $30-35 thousand level. (As a fall-back, one might seek instead an associate professor, with salary in the upper twenties.)

7. That a permanent Review Panel be constituted, which periodically will re-examine the progress of graduate mathematics at this institution.

We are confident that we can continue to have a small graduate program of high quality and national importance, and that the presence of this program will continue to have positive impact on undergraduate programs and on service to other parts of the university and to the state. However, the department will not be able to perform all of its functions at a desirable level without additional staffing. (We have argued in other documents that the elimination of the Ph.D. program would result in <u>increased costs</u> and <u>decreased quality</u>.)

The two appendices which follow provide 1) a clarification of a reviewers' comment with regard to the departments record of obtaining outside grants and 2) a list of consulting activities of the departments' statisticians analogous to the list of MSU's statisticians' projects included in Professor Graybill's report.

Appendix 1

In the recent review of the Ph.D. program in Mathematics at the University of Montana, two of the reviewers commented that our record in obtaining outside grants and contracts was poor. Dr. Fife added that in a top-ranked university "perhaps 60 percent of the mathematicians" would have such grant support. We shall show that this criticism is unjustifiable and that the standard mentioned by Dr. Fife is one which extremely few universities meet.

(i) The reviewers' own universities do not measure up to Dr. Fife's standard. The following information was obtained in telephone conversations with members and chairmen of the reviewers' departments.

University	No. of Faculty Members	Faculty Currently on Grants	Percentage
Colorado State*	35	5	14 o/o
Arizona	44	14	32 o/o
Utah	45-50+	15	30-33 o/o

Clearly, Dr. Fife must be referring in his statement to the very best departments of mathematics in the country. It is unreasonable to compare our department with that of universities with the resources and prestige to attract the top international scholars in our profession.

(ii) The Mathematics Department has not been lax in its pursuit of grants and fellowships. The attached list of awards shows that in the last 5 years over half of our faculty has been successful in obtaining such funding. Eight awards have been obtained this year alone. Less than half of the $560,166 awarded to the

* Department of Mathematics
\+ Some faculty members are temporary

Department has been used for faculty salaries. The rest has benefited the University through the acquisition of equipment, library books, overhead funds, and the tuition generated by the teaching performed by the Teaching Assistants which were supported by the Ph.D. Development Grant. We believe this is a creditable performance by a 19 member department and totally disagree with the reviewers' assessment.

Federally Funded

GRANTS AND FELLOWSHIPS

Name	Grant and Year	Grant Agency	Salaries	Total
Ballard, W.R.	1971 Summer Institute in Mathematics	NSF	23,064	85,496
	1973 Summer Institute in Mathematics	NSF	8,400	16,130
	1974 Summer Institute in Mathematics	NSF	14,723	50,672
	1976 Title VI Equipment Program	HEW	-	500
Billstein, R.N.	1974 New Educational Horizons for Montanans	HEW	1,000	1,000
	1976 Title VI Equipment Program	HEW	-	1,000
	1976 Site Director Idaho, Montana, Utah, Wyoming Metric Consortium	HEW	2,600	5,990
Derrick, W.R.	1975 Fulbright Fellowship	DOS±	NA	NA
	1976 Elementary Mathematical Models (with R. Gideon and G. McRae)	NSF	13,635	20,000
	1976 Faculty Science Fellowship	NSF	NA	NA
Fisher M.J.	1970-72 Fractional Power of Operators	NSF	6,848	11,000
	1972 Regional Research Conference	NSF	NA	NA
	1973 Algebras of Multipliers	NSF	3,835	6,100
Gideon, R.	1971 Distribution Functions	*	300	300
Grossman, S.I.	1973 Volterra Integras Systems	NSF	3,573	5,700
	1974 Fulbright Fellowship	DOS±	NA	NA
	1974 Volterra Integro-differential Systems	*	1,000	1,000
	1976 National Academy of Science Fellowship	NAS	NA	NA
Hewitt, G.C.	1973 Summer Institute for teachers in Developing Colleges	HEW	10,035	36,500

* locally administered Federal Funds

± Department of State

Continued

Name	Grant and Year	Grant Agency	Salaries	Total
Loftsgaarden D.O.	1973 Statistical Analysis of Home Range Models	*	450	550
McKelvey, R.	1971-76 Ph.D. Development Grant	NSF	66,040	159,929
	1976 Turning Point Problems	NSF	7,069	11,200
	1974 Missoula Mass Transit Study	*+	6,370	8,600
Myers W.M.	1972 Summer Institute in Mathematics	NSF	17,938	60,715
Reinhardt, H.E.	1971 Summer Institute for teachers in Developing Colleges	HEW	10,648	40,584
	1972 Summer Institute for teachers In Developing Colleges	HEW	8,997	33,600
	1976 Instructional Scientific Equipment Grant	NSF	-	3,600
			206,525	560,166

* locally administered Federal Funds
\+ Includes Missoula City and County contributed funds

Appendix 2. Partial list of Statistical Consulting Assistance provided by Statisticians in the Mathematics Department at the University of Montana. Fall, 1974 - Spring, 1976.

1. A complex forestry experiment designed by faculty members in Forestry involving the analysis of the growth of seedlings was examined. The proper statistical model for this experiment was devised in order to analyze the data correctly. The model was a complex mixed and nested one.

2. The Missoula County Health officer was given statistical help in evaluating the effects of air pollution on health in smelter towns.

3. The Missoula City-County Planning Board was given help in drawing a random sample of households in Missoula for a housing survey.

4. The University of Montana Student Environmental Research Center was given statistical help in analyzing the data from a summer pollution study in Missoula.

5. A statistical analysis was performed for the Missoula County Health Department to determine the reliability of a new technique in transporting gonorrhea specimens.

6. A graduate student in Zoology was given help with some non-parametric statistical tests he was carrying out.

7. A graduate student in speech communication and disorders was given advice on the analysis of data gathered in her thesis research work.

8. Statistical assistance was given to an interdisciplinary study involving the Missoula County Health Department, several Missoula physicians and the Student Environmental Research Center. The study investigated the conjunctivitis rate of Missoulian's eyes as compared to other less polluted cities.

9. The Missoula County Health Department was assisted in a rather lengthy investigation of the feasibility of conducting a study on the effect of pollution in Missoula on the occurence rates of certain diseases compared to less polluted areas.

10. A faculty member in Interpersonal Communications was assisted with a measure of association once significance has been determined by the F test in an analysis of covariance.

11. Hundreds of hours were spent in designing and supervising the data gathering for a mass transit feasibility study and opinion poll for Missoula County. The final outcome has been the setting up of a Mass Transit District in Missoula County.

12. A graduate student in Forestry was assisted with an analysis of variance problem in a plant physiology experiment.

13. A faculty member in Forestry was assisted in formulating a regression model for the annual spring runoff in a certain watershed.

14. A member of the Computer Center was assisted with several statistical programs in a statistical package.

15. A graduate student in Zoology was assisted with a two-way analysis of variance.

16. A graduate student in Zoology was assisted in using contrasts in the analysis of his data.

17. A graduate student in Geology was helped to evolve a discriminate problem on aging garnets and the basics of crystalline structure.

18. Assist a Ph.D. student in Forestry Develop a sampling technique for use on his Ph.D. thesis Elk study.

19. Assist a faculty member in Economics with a Monte Carlo technique for determining the distribution of a parameter in a non-linear regression problem.

20. Assist a faculty member in Computer Science in gathering information on Stochastic Differential equations.

21. Design and carry out a collective Bargaining Survey for the Faculty Senate.

22. Assist a Ph.D. student in Geology with a discrimination problem related to his dissertation work in determining the makeup of certain rocks.

23. Assist a faculty member in Health, Physical Education and Recreation with correlation analysis related to data in a survey he made.

24. Assist a faculty member in Speech Communication with an experimental design problem.

25. Assist a graduate student in Forestry with data analysis problems in an experiment where experimental burns were being made.

26. Assist a researcher in the Crime Prevention Bureau of the Sheriff's office with a statistical problem.

27. Assist a graduate student in Forestry with the design of a questionnaire and analysis of the data in a survey conducted for her thesis. The research dealt with Daubenmire classification procedures.

28. Assist a student from the Law School with a probability question.

29. Assist a faculty member in the School of Forestry with an experimental design question related to sampling rainfall in various parts of the Lubrecht forest and comparing the rainfall gathered there with that gathered at the airport in Missoula.

30. Assist a student in Forestry with a survey of people in Missoula concerning their feelings on Colstrip 3 and 4.

31. Assist a graduate student in Forestry with the design of his experiment for his M.A. thesis research.

32. Assist a Ph.D. student in Zoology with the analysis of her data for a bird study.

33. Assist a graduate student in Forestry with the design of sampling techniques for a grouse study for his M.A. thesis research work.

34. Assist a forester from the U.S. Forest Service at Fort Missoula with a timber estimation problem.

35. Provided statistical help for the Montana Fish and Game Department on their Georgetown Lake fish surveys.

36. Helped Computer Center prepare a non-linear regression program for general useage.

37. Helped a graduate student in Psychology interpret a Multivariate Discriminant Analysis Computer output.

38. Helped a forestry student to relate multiple regression techniques to stream flow data.

39. Helped two wildlife biology students in a statistical analysis of the protein in bud stems on winter goat ranges.

40. Helped a Zoology student relate multiple comparisons of measurements of snails to geographical data.

41. Helped a graduate student in Geology by suggesting using a censored data techniques in low level nickel determination in plants and soils.

42. Helped a student with a difficult correlation problem involving mineral content of river bottom samples.

43. Helped a Botany graduate student make up experimental design to analyze a beetle population.

44. Helped a student from wildlife biology run X^2 tests to study coyote food habits.

45. Assist a graduate student from Forestry with the study of the spatial distribution of trees in a forest before it was disturbed by man.

46. Assist a doctoral student in Education with his survey data.

47. Assist a faculty member in Wildlife Biology with data analysis on a Grizzly Bear study.

48. Assist a faculty member in Microbiology with analysis of some of his experimental data.

49. Assist a graduate student in Zoology with the experimental design work for her Ph.D. thesis.

50. Assist a heart specialist at Western Montana Clinic with gathering information on setting up a new diagnostic procedure in Missoula.

51. Assist a graduate student in Environmental Studies with a regression analysis problem related to the effect of pollution on trees.

52. Assist a Ph.D. student in Zoology with the analysis of her data for her Ph.D. thesis. This was a study of gulls in Montana.

53. Assist a Ph.D. student in Zoology with the analysis of her data from a bird study.

54. Assist a graduate student in Wildlife Biology with the analysis of data on her study related to the social behavior of does.

55. Assist a graduate student in Forestry with the analysis of her data.

56. Assist a graduate student in Wildlife Biology with the analysis of his data from a water quality study using diversity indices for number of species of insects found in samples from a stream.

57. Assist a graduate student in Forestry with the experimental design for his Masters research work.

58. Estimated the number of valid signatures on petitions to put a Mass Transit issue on the ballot in Missoula.

59. Assist a doctoral student in Education with the analysis of his survey data. Many chi-square tests and similar type of analyses.

60. Assist a Missoula teacher with the analysis of data gathered in an experiment to test a new teaching technique.

61. Derive a Scheffe multiple comparison procedure for a messy design for a graduate student in Geography.

62. Assist a professor in Forestry with a statistical problem related to the spatial distribution of trees in a forest.

63. Assist a mathematics graduate student who is working on a survey data analysis for a faculty member in Social Welfare.

64. Assist a graduate student in Forestry with a multivariate analysis and the related programs.

65. Assist a graduate student in Business Administration in setting up and running a Linear Programming program.

66. Assist a graduate student in Zoology with a problem involving testing for equality of the slopes in regression lines.

67. Assist a faculty member in Zoology with the derivation and analysis for a messy experimental design in a bird study.

68. Assist a Ph.D. student in Zoology with the analysis of his thesis data for a study of Bat Flies.

69. Fitting segmented regression curves to physiological data. (with Zoology faculty member)

70. Statistical analysis of Chemical measurements on urine of black-tailed prairie dogs (with Zoology student).

71. Multivariate analysis to determine cultural simularities (with Anthropology faculty member).

72. Analysis of performance of two kinds of parachute for U.S. Forest Service.

73. Statistical analysis of feeding habits of aquatic insects (with Zoology graduate student).

74. Statistical analysis (with USFS) of controlled burn data.

MATHEMATICS DEPARTMENT

University of Montana
Missoula, Montana 59801
(406) 243-0211

July 21, 1976

Dr. Freeman J. Wright
Deputy Commissioner of Academic Affairs
Montana University System

Dear Dr. Wright,

I wish to comment on one issue raised in the mathematics Ph.D. review. It has been suggested that the dissertation in the UM Mathematical Sciences doctoral program, the so-called "expository survey", is not genuine research and that therefore the degree is not a genuine Ph.D. I believe I can demonstrate that this allegation is utterly false. My response is in three parts.

I. First of all, only relatively few of the dissertations in this program are turning out to be surveys: of the first 8 Math Science option theses completed or well along, five are entirely of the traditional type (so-called "primary research") and the other three are a mixture of survey and primary research. There is strong evidence that every one of these theses is potentially publishable:

1. The first two Math Science options were awarded last summer, to Terry and Susan Lenker. Susan Lenker's thesis is outstanding. (Reviewer Bill Scott was much impressed by it). It will be the basis for three separate articles, to be submitted to primary research journals. Terry Lenker's thesis is marginal, but contains one major result, a generalization of a theorem by the prominent mathematician S. Eilenberg, which in my opinion will be published.

2. The third math science degree was awarded to Dick Wood, of Seattle Lutheran College, last December. Dick has presented his results at the American Mathematical Society's national meeting and is now preparing a paper for publication. Wood is the third Ph.D. student of Charles Bryan, the first two having finished in 1971 in the old (traditional) Ph.D. program. All three theses are primary research and according to Bryan of roughly equal

calibre. One thesis (Schelin's) has been published, in the SIAM Journal of Numerical Analysis. The second thesis (Hansen's) has not, but then Hansen has never submitted it to any journal, despite Bryan's urgings. Based on this comparison and my own appraisal of Wood's thesis I predict that it will be published too.

3. The next Math Science option student to finish will be Bob Bohac who has been teaching at Algoma University College in Canada, and who is my own student. This summer Bob is in the final process of writing up his results. Some of the results in the thesis are included in a joint paper of ours, presently in galley proofs, which will appear in the Rocky Mountain Journal of Mathematics this fall. (Bill Scott is managing editor of this journal). Bob's thesis is entirely primary research.

4. Finishing soon, perhaps in the fall, is Paul Smith, a faculty member at the University of Victoria, B.C. Paul's adviser is Howard Reinhardt. According to Reinhardt, Paul's thesis is partly primary research, partly survey. Part of the thesis has already been accepted for publication by Discrete Mathematics, a primary research journal. Reinhardt believes that the entire thesis might appear as a survey monograph. I personally believe that Smith, who is an outstanding expositor, will provide our first example of the kind of high quality survey writing that we have been trying to demonstrate.

5. A bit further down the road, but still expected to finish during academic 1976-77 are Vilas Deane, Kathy Yerion, and Champak Panchal. The latter two are students of Bill Derrick who describes both of their theses as primary research. Bill says both students already have some publishable results. He appraises these students as superior to two of his Ph.D. students at the University of Utah, whose thesis results have appeared in print. The third of our 1976-77 finishers is Vi Deane, a student of George McRae (who was also the advisor of our first graduate in the program, Susie Lenker). Vi Deane's thesis is partly expository and partly survey in nature. McRae (whose sound judgement is confirmed by Scott's appraisal of Susie Lenker's thesis) says that Vi already has some publishable results.

II. The distinction between the traditional thesis and the expository survey is this: A "primary research" paper states and proves new mathematical theorems. Most such papers are highly specialized and often technical in character. Survey writing is closely parallel to the "critical scholarly writing" which is common in the humanities; it requires a synthesis of knowledge and a re-thinking and restructuring of a body of fact (in this case, a collection of theorems). At its best it calls for imagination and originality of the highest order. Survey writing can be published; there are journals devoted exclusively or in part

to this kind of writing. Alternatively it may appear in monographs. One difficulty is that a typical primary research paper, formulated in terse style, will run 15 journal pages, while a survey might run 75. So there is a greater financial subsidy involved in survey publication. Because of recognition of the importance of survey writing to the advancement of mathematical science, efforts have been made in recent years to overcome the financial problem and to encourage mathematicians to undertake the major labor involved in such an ambitious scholarly project. Thus the number and variety of outlets for survey writing has significantly expanded over the past 10 years.

We did not incorporate survey writing into our Math Science degree program in order to cheapen the degree - it obviously does not - but because we deemed this a most appropriate kind of activity for a college teacher to pursue throughout his career. The small number of expository surveys among our theses simply indicates the difficulty in writing this form of thesis compared with the usual, and the reluctance of thesis advisors and students alike to risk departing from the norm.

III. A word about the 6 dissertations discussed by Professor Scott. These are not really representative of our present program, since of the 6 only the recent two Lenker theses are Math Science option theses. None of the 6 was directed by the new faculty members, brought in since 1970 to develop the new degree program.

Still I think that Professor Scott's understanding that only one paper would result from the 6 theses is too conservative. My own estimate is that 3 or 4 of these theses clearly have "publication potential" and that, besides Schelin's already published 1971 thesis, both of the new Math Science option theses are likely to be published.

It would be helpful to be able to cite figures on the fraction of math theses nationally that are published. At schools I know about (like Colorado and Utah) I believe it is under 50 o/o. Many new Ph.D.'s who go into industry, government or small colleges (like our Hansen at NE Oklahoma State in Talleguah) are really under no pressure to publish anything, so don't even bother to try. Surveys show that less than 25 o/o of math Ph.D. holders ever publish anything beyond their thesis!

These figures suggest that there is something wrong with the traditional primary research thesis as an entre into a scholarly career. In fact there has been much criticism within the Mathematics community about the traditional Ph.D. program and traditional dissertation, and prominent mathematicians have called for reform. Our Mathematical Sciences program was created in an

attempt to respond to the criticisms. It was underwritten by the National Science Foundation in the expectation that it might have a national impact on graduate education in mathematics. That remains our goal.

Sincerely,

Robert McKelvey

Robert McKelvey
Professor of Mathematics

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Attachment: Two of the influential early proposals for reform:

I. N. Herstein — On the Ph.D. in Mathematics

W. L. Duren — Are there too many Ph.D.'s in Mathematics?

Both articles appeared in the American Mathematical Monthly, published by the Mathematical Association of America.

University of Montana
Missoula, Montana 59801
(406) 243-0211

MATHEMATICS DEPARTMENT

July 23, 1976

Dr. Freeman J. Wright
Deputy Commissioner of Academic Affairs
Montana University System
1231 Eleventh Avenue
Helena, Montana 59601

Dear Dr. Wright:

The mathematics review team in your Ph.D. program review has made concrete proposals for new faculty positions and teaching assistantships at Missoula. I would like to provide some perspective on these recommendations.

1. The proposal for faculty additions is for several assistant professors and one or more senior faculty, all of these people to be active in research and graduate education. This is a natural proposal for the reviewers to make: they are asking that we do on a small scale what their own institutions have been doing on a much larger scale.

The most remarkable example of this in the Rocky Mountain region is the University of Utah. In the past five years Utah has pumped massive sums of money into its graduate math program, paying high salaries in an attempt to attract nationally prominent research mathematicians. According to my information there are "about a half dozen" Utah math faculty whose academic year salaries are "between $35,000 and $40,000". In addition to this, in order to capitalize on the buyers' market in young faculty, Utah has converted fully one-third of its faculty positions (15 out of about 45) to non-tenure-track instructorships, paying $12,000 to $13,000. Most of these young Ph.D.'s will not be retained after their 3 year contract expires, for there are no permanent positions at Utah for them.

A similar process of "faculty building" occurred at the University of Arizona and the University of Colorado in the late '60's and beyond, aided by NSF "Centers of Excellence" grants. Though these schools are not as affluent as Utah, top salaries there are probably in the lower or middle 30's.

Another technique for acquiring prestigious researchers, a method accessible to poorer institutions, is to hire eminent retired mathematicians. Thus in the late 50's and 60's, Arizona had the well-known British hydrodynamicist Milne-Thompson, New Mexico had the eminent Yale University mathematician Einer Hille, and Colorado had the British geophysicist Sidney Chapman. I judge that Colorado State has now reached this particular stage in its development.

It must be obvious to everyone that there is no mood or money in Montana to engage in the kind of high-pressure competition that I have been

describing. This has always been a constraint we have faced in our efforts to build up mathematics at the University of Montana. The solution we chose, six years ago, was to design our graduate program along special lines which would keep us out of direct competition with the more affluent universities. We have followed through on this plan, and our reviewers say that we are carrying out our special task "about as well as it can be done".

2. Now, returning to the proposal that the University of Montana add several additional graduate faculty: obviously the present faculty would like to see such an expansion. It is always stimulating to be part of a cadre of dedicated, enthusiastic workers, and the more the better. Furthermore, making these appointments would certainly speed up the transformation of the department from one which once had almost exclusive emphasis on undergraduate liberal arts and service teaching, to one in which the graduate program is dominant.

But I do not believe that these appointments are essential. Based on the distribution of the department's teaching responsibilities, the real need in staffing is at the lower division undergraduate level! That is where staffing is tight, where classes are oversubscribed and oversized, and where students are being turned away. On the other hand, the level of demand simply does not justify expanding the number of advanced courses that we offer. Even at the present faculty size, research oriented faculty must be devoted to elementary teaching. For example, when I was a faculty member at the University of Colorado, I taught exclusively upper division and graduate courses; here one half of my teaching is lower division. This is typical, and would be exaggerated by any expansion of faculty size.

Thus my advice on adding faculty is to cool it. In the normal course of events there will be turn-over. Senior people will retire early, faculty members will move elsewhere. Positions will become available and can be filled advantageously.

3. The recommendation for more teaching assistants is something else again. I very much endorse this recommendation, indeed have been urging it for some time. The primary justification for these positions is the need for more man power at the lower division undergraduate level. Teaching assistants in mathematics independently handle small classes, and provide by far the cheapest way of staffing those lower division classes. At Missoula the teaching they do is exceptionally competent, since most come from full time regular teaching positions in small colleges (where their pay scale is comparable to ours). They are willing to accept a few years of grossly underpaid labor only because we are providing them with the graduate training that they seek for themselves.

Thus there is a natural symbiosis between the undergraduate and graduate programs. As it happens, our graduate program presently has an unfilled capacity, i.e. the enrollment could be increased by about half (say up to a total of 30) without costing the university a cent. This is because enrollment in graduate classes is small, so no new sections would have to be created, and also because the present faculty is large enough to handle the additional dissertations (some qualified faculty at present

have no dissertation students.) According to reviewer Bill Scott (phone conversation), adding these new graduate students "would cure most of what is wrong with the graduate program at Missoula".

Should assistantships be authorized, we would have no trouble in filling them with able, competent graduate students: more good ones apply than we presently can accomodate.

It would be unfair to attribute the cost of these assistantships to the graduate program. Rather, their low cost should be regarded as a subsidy by the graduate program of the undergraduate program. And the undergraduate program has a demonstrable need.

Sincerely,

Robert McKelvey

Robert McKelvey
Professor of Mathematics

vs

MSU
DEPARTMENT OF MATHEMATICS
COLLEGE OF LETTERS & SCIENCE MONTANA STATE UNIVERSITY, BOZEMAN 59715

M E M O R A N D U M

July 26, 1976

TO: Freeman Wright, Deputy Commissioner of Higher Education

FR: Dr. Robert D. Engle, Head, Department of Mathematics

RE: Response to Ph. D. Review in Mathematics

I. General Comments

The report that follows utilizes statements from the reports of Professors Fife, Graybill, and Scott, who have recently completed a comprehensive review of the mathematics Ph. D. programs at Montana State University and the University of Montana. If, for example, a statement from page three of Professor Fife's report is quoted, this will be indicated by Fife (p. 3) says ". . .". Other facts quoted below are taken from the report prepared for Reviewers Fife, Graybill, and Scott by the Montana State University Mathematics Department. All of the reports referred to above are on file in the Office of the Commissioner of Higher Education.

II. Role, Scope, and Need

The Ph. D. program at Montana State University is a traditional Ph. D. program and now emphasizes applied analysis and statistics. These directions are entirely consistent with the role and scope of Montana State University. Because of this emphasis, the Montana State University Mathematics Department is able to train students for industry and government as well as for traditional academic employment. Furthermore, this emphasis enables the Mathematics Department to be involved in cooperative research

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and to provide service, teaching, and consulting to the various graduate programs in the College of Engineering, College of Agriculture, and departments in the College of Letters and Science such as Physics and Chemistry, and to many governmental agencies in the State of Montana. The program at Montana State University services the entire nation, but primarily services the five-state region composed of Montana, Idaho, Wyoming, North Dakota, and South Dakota. According to the roster of graduate students contained in the Department's report, over half (20 out of 39) of the Ph. D. students at Montana State University come from the region mentioned above, and eleven were from Montana. This clearly indicates that Montana State University is serving the needs of persons in our geographic region, as well as other areas.

Since the Ph. D. program at Montana State University now stresses applied analysis and statistics, Montana State University graduates (M. S. and Ph. D.) have employment opportunities in industry and government, as well as the traditional academic opportunities. The focus of the Montana State University Mathematics program is significant in that most projections by experts in the mathematical community indicate the number of academic positions available to Ph. D. recipients in mathematics will decline. Fife (p. 2) states, *"Most projections indicate that in the future, a greater percentage of math Ph. D.'s will be taking non-academic employment."* In this regard, it should be noted that several Montana State University statistics graduates are employed by Montana State Government, and at least five of the Montana State University Ph. D. recipients are now employed in industry.

The Mathematics Department at Montana State University provides valuable services to the entire University. The primary reason for this is because traditional users of graduate level mathematics (Ph. D. candidates in Physics and various engineering departments) also have strong graduate programs at Montana State University. The continued demands of these expanding areas will increase the number of graduate assistants needed to teach service courses. In regard to enrollment, Scott (p. 14) says, "*Montana State is in a . . . fortunate situation in this respect . . . since enrollments in the Engineering School are increasing at a good rate, with the result that undergraduate mathematics enrollments are also increasing.*" As a consequence, the mathematics Ph. D. program at Montana State University will necessarily expand and increase in viability without substantial outside funding.

III. Quality

Fundamental to any Ph. D. program regardless of emphasis is the continuing quality of the mathematical research activities of the staff. The mathematics community recognizes that a primary indicator of the research activities of a mathematics staff is the number of recent publications produced by said staff that appear in mainline, scholarly, refereed journals with an international audience. The following analysis of the publication activities of the Montana State University Mathematics Department is based on the years 1974 - present. Included in the analysis are all refereed research articles accepted for publication in either mainline, scientific journals or in the proceedings of international conferences.

The Montana State University Mathematics Department has had twenty-eight articles published or accepted in mainline refereed journals during the 1974-76 time period. The articles are distributed among eleven Department members. None of the articles alluded to above are mathematics education articles. The latter type are generally not considered as mathematics publications, but rather as education publications. In addition, the publications referred to above do not include technical reports, abstracts, or textbooks.

These facts demonstrate that the Montana State University Mathematics Department is presently professionally active. This conclusion is reinforced by the following quotes of the Ph. D. review team. Scott (p. 13) says, "*In the last few years, the situation (regarding research at Montana State University) has improved in two ways: (i) Two mathematicians with good research records have joined the department; (ii) A high research producer already in the department has started directing theses.*" Graybill (p. 2) remarks, "*The statistics faculty (Montana State University) . . . are sufficiently active in publication to enable them to direct students who are working on theses.*" These quotes are a clear indication that the Montana State University Mathematics Department is an improving department in spite of the rather severe financial restraints of the past several years.

Another essential aspect of a Ph. D. program is the directing of Ph. D. dissertations by qualified staff. Every Montana State University staff member who has recently directed a Ph. D. dissertation has also published in a scholarly journal during the 1974-76 period. During the last ten years, at least half of the twenty-three Montana State University

Ph. D. dissertations have been published in mainline journals. Publishing said dissertations is the accepted way of determining the quality of the dissertation. In this regard, the following quotes are relevant. Scott (p. 16) remarks, ". . . *about half of the theses (Montana State University) lead directly to a published paper.*" Although Professor Scott feels this percentage is not high enough, we believe this percentage does not deviate significantly from the national average.

Consulting services to various state agencies as well as to research projects at Montana State University are an important part of the Montana State University Mathematics Department's activities. The success of Montana State University in this regard can be well documented. In fact, Graybill (p. 1) says, "*It must be pointed out that in a major university such as Montana State University, the statisticians should not only be involved in teaching courses in statistics, but should be active in research and consulting with experimentors from most scientific departments on campus where research is being done. The statistics faculty at Montana State University has done very well in this regard and should be complimented.*" Moreover, Graybill (p. 2) continues, "*The statistics faculty is using modern statistical techniques in their consulting . . .*".

Fundamental to quality Ph. D. programs are library facilities and administrative support. Scott (p. 16) says, of the Montana State University library, "*The library holdings are more than sufficient for a Ph. D. program.*" The Montana State University administration has supported the Montana State University program in spite of severe fiscal restraints imposed on the University as a whole. Scott (p. 16) notes, "*The adminis-*

tration appeared to be actively concerned with improving the department and its program.'

IV. Montana State University's Plan for Continuing Development

The collective opinion of the reviewers of the mathematics Ph. D. program is that the Montana State University Ph. D. program has successfully produced Ph. D.'s in the past and is presently providing a valuable service to the University, the State of Montana, and the Nation. All of the reviewers strongly recommend that the Montana State University program be retained and strengthened.

A number of deficiencies in the present program are alluded to by the reviewers. It is the purpose of this section to identify these deficiencies and to propose actions to correct them.

Perhaps the fundamental problems of the Montana State University Mathematics Department are the low research productivity of some of the staff and the need for additional staff. The Department has already taken steps to increase the research productivity. In particular, all recent hirings by the Department have resulted in productive staff (see Scott, p. 13). In addition, faculty responsibilities will be redistributed to insure that members of the Department engaged in research will have ample time to continue their scholarly pursuits.

Future replacements will result in additional research staff in applied analysis and statistics. Identification and hiring of such qualified replacements and additions is a matter to which the Department of Mathematics and the Dean of the College of Letters and Science are deeply committed. In a university such as Montana State University, it is

expected that one or more of these positions will be supported by outside funds (presently, AY 1975-1976 and AY 1976-1977, two-thirds of an FTE in Statistics is supported by such funding).

A second objective of the Montana State University Mathematics Department is to increase the number of graduate students and to sharpen the focus of the Ph. D. program. Presently, thirty-two graduate students are enrolled in the Montana State University program. Since the scope of the program now emphasizes only applied analysis and statistics, a moderate increase in the number of graduate students will insure the continuation of a viable program.

A number of other minor problems are identified in the reviewers' reports. Steps have been or are being taken to correct all of these problems.

For example, Scott suggests that a higher percentage of Ph. D. theses should be published. In this regard, several theses directors have been requiring students to submit papers based on their theses for publication prior to graduation. This is now a departmental policy. In addition, the Department endorses the concept that theses directors should have recently published scholarly research.

The reviewers also note that the Montana State University Mathematics Department needs more outside funding. Since the reviewers' visit to Montana State University, the Department has been awarded over $75,000 in Grants and Contracts. This support has originated from both federal and state agencies.

During the last two years, the Department and the University

have taken steps to strengthen promotion and tenure requirements, and the Department is in the process of codifying these requirements.

In conclusion, as suggested by the reviewers, the Department of Mathematics at Montana State University intends to establish an executive committee to assist in the continuing development outlined above.

RDE/kss

MSU

DEPARTMENT OF PHYSICS

COLLEGE OF LETTERS & SCIENCE MONTANA STATE UNIVERSITY BOZEMAN 59715

January 14, 1976

Dr. Freeman J. Wright
Deputy Commissioner for
Academic Affairs
1231 11th Avenue
Helena, MT 59601

Dear Freeman:

In several recent meetings, discussions have turned to the ongoing review of duplicate Ph.D. programs. Not having a duplicate Ph.D. program, physics is not directly involved at this time. However, I would like to take this opportunity to express to you some concern and feelings on our part, in particular with respect to mathematics.

Being the educational institution of the highest level, a university has a double role. First, it must strive for a constantly improved understanding of the nature of man, of society, and of the universe. Second, it must communicate this understanding and the ways of achieving it. This double role implies two major functions for a department or college, namely, to carry on research and to teach. Involvement in service functions should be a natural evolution of and be compatible with these two major roles.

In analyzing a given department's ability to carry out these roles and also the desirability of the same, it is important to realize that there is a close interaction and coupling among what we traditionally call departments. In the case in point, we are concerned that a proper understanding exists or develops of the importance of a graduate degree program in mathematics at MSU to the research and teaching function of the Physics Department as well as, I am sure, of the rest of the sciences, agriculture, and engineering.

A few minutes before I began writing this letter, I came across an abstract, the title of which is, "Non-Linear Evolution Equations Solvable by the Inverse Spectral Transform." The abstract reads "The importance of the Fourier Transform in physics originates essentially from the fact that this mathematical technique is the basic one for solving linear partial differential equations with constant coefficients. Recently, an analagous technique has been invented so that non-linear equations can be solved. Because so many physical phenomena are described by non-linear evolution equations, this mathematical development is likely to have a substantial impact on many branches of physics." As a result of this, I will contact appropriate faculty in the Mathematics Department in order to find out more about this new technique developed in mathematics which could have a substantial impact since many of the present problems in

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engineering and the sciences turn out to be described by non-linear equations. Without a competent research faculty in the Mathematics Department, it would not be possible to get this kind of information on this campus. There are other recent examples where I have gone to the Mathematics Department when we have had questions in the areas of functional analysis, partial differential equations, non-standard analysis, catastrophy theory, and so on, which have been able to be addressed by staff members in mathematics.

A requirement of all Ph.D. programs at Montana State University is a minor in another field of study. Ninety percent of the graduate students in physics choose mathematics for their minor field. Therefore, in order for our students to satisfy the requirements for the Ph.D. degree in physics, it is extremely important to have available the appropriate faculty and graduate courses in mathematics to put together minor programs.

Another important area where the Mathematics Department must play a role is in its supporting activities with respect to many of the other disciplines on campus. Partly, as a result of the success physics has had with the construction and analysis of mathematical models to describe physical reality, the other disciplines in the sciences, both natural and social, are becoming more quantitative and less qualitative. Over the next quarter of a century we will see in these areas an increase in this trend toward quantitative analysis, prediction and understanding. As this evolution continues, more and more demands will be placed on the mathematics faculty to aid research and instruction going on in other disciplines as well as to provide the appropriate course work for students in or preparing for graduate work in these disciplines. It seems to me a major role of the faculty and graduate program in mathematics is to provide leadership in and support for the introduction of quantitative methods and mathematical model making in some of the more qualitative disciplines presently on campus. A reduction in the level of the mathematics offerings at Montana State University would in my opinion impede this important trend toward quantification.

Thank you for your attention. I would be pleased to cooperate in any way in which you feel I would be useful.

Sincerely yours,

Robert J. Swenson, Chairman
Department of Physics

RJS:dm

cc: Dr. Robert Engle
Dean John Jutila

MSU

SCHOOL OF ARCHITECTURE

THE COLLEGE OF ARTS AND ARCHITECTURE MONTANA STATE UNIVERSITY BOZEMAN 59715

July 12, 1976

TO: Dr. Robert Engle
Head and Professor of Mathematics
Montana State University

FR: Ilmar Reinvald, Director
School of Architecture

RE: Ph.D Program in Mathematics Department at MSU

This memorandum is to express the support of the School of Architecture for the continuation of the Ph.D program in the Department of Mathematics. The quality of the program in this School is heavily dependent on the quality of program and instruction in your department, both as a science and as an art. As a science, mathematics is responsible for a foundation in all our technical courses such as the structure design sequence and the environmental controls sequence. This part of our program helps architects design technically sound buildings and environments. As an art, mathematics and its concern for the search of beauty in abstract patterns is directly applicable to complex urban and environmental design problems, where the discipline of topology might be applied directly in the search for both continuity and contiguity. Ultimately, mathematics helps our students to think clearly and productively. I am very pleased with the high quality of instruction from which our students presently benefit in the Department of Mathematics. Should your ph.D program be eliminated, we should suffer greatly through the imminent decrease of quality of instruction in your Department. I sincerely hope this wll not be the case.

IR/nb

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Montana State University
Bozeman, Montana 59715 Tel. 406-587-3121

College of Engineering
Office of the Dean

July 7, 1976

Dr. Freeman J. Wright
Deputy Commissioner for Academic Affairs
Office of the Commissioner of Higher Education
1231 Eleventh Avenue
Helena, Montana 59601

Dear Dr. Wright:

When I was pursuing my program of study at Stanford University, one portion of my doctoral dissertation proved particularly difficult. After much work the problem was formulated in terms of then unsolved non-linear equations. A closed solution was desired.

A check with most of the Mathematics professors at Stanford yielded a few suggestions but no concrete results. Finally I sought the counsel of Dr. Polya. He was immediately interested in a problem of such challenge. Within weeks he had not only solved the problem for me but had generalized the procedures and written a paper for the most prestigious French Mathematics journal.

This same story is repeated with variations wherever good graduate programs exist in a University. In particular the interaction between Mathematics and Engineering is vital. The PhD program in Engineering is enhanced immeasurably by excellent staff in Mathematics. Conversely, I believe that the productivity of our Mathematics staff is increased through interaction with Engineering students and faculty.

In order to maintain top quality staff in Mathematics, I believe that a Mathematics PhD program is essential. Polya would not have been at Stanford if Stanford had not been a center of excellence in Mathematics - undergraduate through PhD.

I hope these remarks will prove helpful to you as you make your decision.

Sincerely yours,

Byron J. Bennett
Dean

BJB/bmh

NUMBER OF GRADUATES

FROM

Ph. D. PROGRAMS WHICH EXIST ON MORE THAN ONE CAMPUS

OF THE MONTANA UNIVERSITY SYSTEM, 1966-75

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	Average past 5 yrs.
Microbiology - MSU	2	1	2	1	1	2	2	1	6	1	2.4
Microbiology - UM	-	1	1	0	2	2	2	2	3	1	2.0
Zoology - MSU	3	4	2	1	6	2	1	3	1	1	1.6
Zoology - UM	2	2	4	2	2	2	2	3	1	1	1.8
Botany - MSU	1	4	0	0	2	2	0	0	1	1	0.8
Botany - UM	1	0	0	1	2	0	6	0	3	6	3.0
Chemistry - MSU	*	2	1	4	4	3	7	5	7	6	5.6
Chemistry - UM	-	-	-	1	1	4	0	0	2	2	1.6
Mathematics - MSU	3	4	2	1	0	6	0	2	5	3	3.2
Mathematics - UM	-	-	-	-	-	-	2	1	1	2	**1.5

* Program in operation, no figure reported.

** Counted over the past four years, due to newness of the program.

ATTACHMENT # 12

Pettit
Ferrant
Hjort
Lannan
Matteucci
Noble
Smith
Wright FJW
Burke
McKay EM
McMillon
Waite

July 22, 1976

Dr. Freeman J. Wright, Deputy Commissioner of
Academic Affairs
The Montana University System
Twelve Thirty-One Eleventh Ave.
Helena, Montana 59601

Dear Dr. Wright:

Enclosed is a joint response to your recent request for amplification of the relationships between our two departments of chemistry and between the respective departments and the programs with which each interacts. If we can be of further help please let us know.

Sincerely,

R Keith Osterheld

R. Keith Osterheld
Chairman and Professor
Department of Chemistry
University of Montana

E. W. Anacker

E. W. Anacker
Professor and Head
Department of Chemistry
Montana State University

A. Importance of the chemistry doctoral programs to other disciplines

To a surprising degree, many processes of importance in disciplines other than chemistry are in fact chemical processes and require a knowledge of chemistry for true understanding. The rates of these processes are subject to the principles of chemical kinetics. Whether a given process (any conceivable process, in any living or non-living system) can occur is predictable, in principle, from the laws of chemical thermodynamics. Kinetics and thermodynamics are major parts of physical chemistry.

The fields of biochemistry, organic chemistry and inorganic chemistry build on the principles of physical chemistry to give one an understanding of the properties and structures of materials and of the changes that occur during chemical reactions for living systems (biochemistry), systems involving compounds of carbon (organic chemistry) and systems dealing primarily with elements other than carbon (inorganic chemistry). Analytical chemistry provides the techniques for studying the content of samples, identifying the elements and compounds present and determining the percentage of each in the sample.

Not only is a background in chemistry needed for an understanding of any field concerned with chemical processes, but also the methods and techniques of chemistry must be employed in studies in such a field. Graduate programs other than in chemistry make use of spectrophotometers, spectrofluorometers, mass spectrometers, liquid scintillation counters, gas chromatographs, major centrifuges, x-ray equipment and epr spectrometers belonging to the UM and MSU departments of chemistry. Little of this equipment would be available without the doctoral programs.

We have listed below some examples of the interrelation of the chemistry and the cognate programs at UM and MSU. For each cognate area we have briefly characterized the ways in which chemistry arises in the area and have then given examples of specific studies done cooperatively or with the use of consulting or instrumentation from chemistry. The expertise and facilities for the necessary level of support of the cognate area would be likely to be unavailable in the absence of the doctoral programs in chemistry.

BOTANY:

Relation to chemistry. Not only is the growth of plant material a chemical reaction, but almost all herbicides,

insecticides, and plant growth regulators act through chemical processes. Chemical analytical techniques, often highly advanced, are employed in evaluation of nutrient materials, of plant composition and of environmental conditions affecting plant growth.

Support from chemistry at UM. Cooperative studies have been carried out on the ability of certain plants, including sagebrush, to prevent the development of other plants in the soil nearby; on plant enzymes capable of breaking proteins into simpler substances; on the use of the chemical composition of plants in identifying and differentiating plants of very similar appearances; and on the isolation and characterization of the DNA of various species of ponderosa pine seedlings (DNA means deoxyribonucleic acid, the material carrying the hereditary information of an organism).

BIOLOGY (Microbiology, Zoology, Entomology, etc.):

Relation to chemistry. The life and sensory processes of all animals and microorganisms employ chemical reactions. These chemical reactions are governed by the same principles that govern all chemical reactions. Consequently, many studies in these fields require the application of chemistry, particularly those dealing with bodily function and dysfunction, with nutrition, with the effect of drugs and medicines, and with environmental effects.

Support from chemistry at UM. Cooperative studies have been carried out on factors affecting the production of enzymes and hormones in various animals and birds, which could lead to an understanding of population density fluctuations of animals in nature and of glandular disorders in humans; on the development of a skin test for gonorrhea; on the role of ribosomes in immunization for tuberculosis; on enzyme activity in placental tissues; and on RNA tumor viruses.

Support from chemistry at MSU. To learn more about the embryology of grasshoppers and to eventually control their populations, trace element studies on grasshopper eggs have been made. Cyanine dyes have the potential for eliminating certain parasites from man and domestic animals; their anthelminthic properties are currently being investigated.

AGRICULTURE:

Relation to chemistry. Concerned with plant and animal utilization, agriculture involves chemistry in all of the ways inherent in botany and biology.

Support from chemistry at MSU. Chemistry is one of ten research departments at MSU which is linked to the Agricultural Experiment Station. Current Chemistry Station projects include the evaluation and characterization of starches from a variety of barleys; a study of the factors involved in the degradation, deposition and persistence of selected pesticides and related chemicals; the development of detailed information on the composition and biochemistry of cuticular waxes of plants and insects; isolation and characterization of the heat stable enterotoxin of E. coli responsible at least in part for calf scours in Montana; increasing longevity and nodulating characteristics of sainfoin (an increasingly important crop for forage and hay); the development of efficient methods of producing ammonia from animal wastes; devising a suitable technique for screening wheat varieties for winter hardiness; and a study of the genetic toxicology of a variety of air and water pollutants. Some of these projects are interdisciplinary and involve cooperation with faculty from Plant Pathology, Plant and Soil Science, and Biology.

GEOLOGY AND EARTH SCIENCES:

Relation to chemistry. Much of the mineral and rock material studied by geologists formed or deposited by chemical processes. The movement of mineral material through the earth by solution and diffusion processes follows chemical principles. The methods of analytical chemistry are needed to identify and quantify the chemical species present in geological samples.

Support from chemistry at UM. Help has been given in the application of analytical methods to many geological problems, in the development of a relationship systematizing bond strengths in a class of mineral materials, in designing a system that would serve as a model of the deposition of minerals in tidewater pools, and in assessing the diffusion rates in molten rocks.

Support from chemistry at MSU. The Chemistry and Earth Sciences Departments have cooperated in determining the presence and amounts of trace elements in coal and the fallout and distribution of silver from cloud seeding. The two departments are currently studying the air pollution potential for future strip mining operations at Sarpy Creek in Eastern Montana.

PHARMACY:

Relation to chemistry. As the science concerned with medicinal substances, pharmacy deals with the preparation, properties and biological action of chemical substances. In general, the mode of action is through chemical processes.

Support from chemistry at UM. A cooperative study with pharmacy has dealt with the recovery from plant tissue cultures of enzymes of medicinal and industrial value. The expertise and equipment of our organic chemists is often contributed to studies in which new organic chemicals are being prepared for evaluation for possible medical applications.

MHD RESEARCH:

Relation to chemistry. Electrical energy can be produced by burning coal in a magnetohydrodynamic generator. Because such a plant is theoretically much more efficient than a conventional coal-fired plant, MHD may provide a workable solution to our current energy problem. Coal combustion is a chemical process in which a large number of chemical compounds--mostly organic--are converted into others, along with heat.

Support from chemistry at MSU. Before MHD power plants can be practical, a number of chemical problems must be solved. Chemistry faculty are developing techniques and instrumentation to analyze the gases and slag produced in a MHD generator and the interactions between the two.

WAMI:

Relation to chemistry. The successful practice of medicine requires an extensive knowledge of chemistry. Life processes are almost entirely biochemical in nature. The treatment and prevention of disease invariably involves the administration or restriction of chemicals in one form or another. Training in all fields of chemistry, but especially in biochemistry, is essential to the modern physician.

Support from chemistry at MSU. Montana State is one of five universities participating in the WAMI (Washington, Alaska, Montana, Idaho) medical education program. The program is sponsored by the University of Washington School of Medicine at Seattle and leads to the M.D. degree from that school. It is designed to increase the number of physicians in rural areas of Alaska, Montana and Idaho.

Montana WAMI students spend the first year of their training at MSU. One of the courses they take is medical biochemistry which is taught by Drs. Armold, Hapner, Jackson, Robbins, Rogers and Warren of the Chemistry Department.

ENGINEERING:

Relation to chemistry. Engineering is the art and science by which the properties of matter and the sources of power are made useful to man in structures, machines, and manufactured products. The principles of chemistry govern the development of materials with desirable properties and the transformation of one form of energy into another.

Support from chemistry at MSU. Faculty members from Chemistry, Earth Sciences, Civil Engineering and Plant and Soil Science, as well as faculty from North Dakota State University and the University of Wyoming, are evaluating surface and groundwater problems associated with potential strip mine sites. Recently the Chemistry Department and Chemical Engineering Departments cooperated on a utilization study of delta-3-carene, a byproduct of the paper industry. The department has also been involved with the Civil Engineering Department in projects concerned with trace elements in sewage and the clarification of waste fluids from paper production.

B. Complementary character of the UM and MSU programs

The field of chemistry can be subdivided conveniently into five areas, for each of which the UM and MSU programs are compared below. For each campus we have listed the faculty involved in each area. Several faculty have been listed for more than one area, in accord with their interests and activities. Faculty specializations are also the specializations in which doctoral candidates can be prepared in each department.

Consistent with the land-grant character of Montana State University and the presence there of the Agricultural Experiment Station and the engineering programs, the chemistry department at MSU properly has more of an orientation to the applied side of chemistry than has the one at UM.

1. Analytical, instrumental and environmental chemistry.

MSU faculty: Amend, Grimsrud, Pagenkopf, Thurston, Woodriff, Geer, Emerson

UM faculty: Erickson, Juday, Van Meter, Waters

Doctoral preparation in analytical chemistry is offered at MSU, but not at UM. Consistent with this, the research at MSU on the development of instrumental methods of chemical analysis is not duplicated at UM. Environmental chemistry, which uses the methods of analytical chemistry to study environmental effects, is prominent in the programs of both department, although neither offers a Ph.D. in environmental chemistry. At MSU, environmental chemistry studies have been directed largely towards problems pertinent to development of the south-eastern Montana coal and oil shale deposits, the MHD process, and atmospheric ozone levels. At UM, studies have concentrated on water quality, including yearround testing of western Montana lakes and streams, water quality threats from coal gasification processes, and the use of ozone in water purification; on pesticide and heavy metal levels in fish and migrating birds.

2. Biochemistry.

MSU faculty: Armold, Callis, Goering, Hapner, Jackson, Julian, Rogers, Warren

UM faculty: Fevold, Hill, Mell, Watson

Bicchemistry is, in a sense, an applied field, the principles of chemistry being applied to explain biological phenomena. In the programs at UM and MSU, the practical values sought tend to be longerterm at UM and more immediate at MSU. This general pattern derives from the involve-

ment of many of the MSU biochemists with the Agricultural Experiment Station. The UM program empnasizes medical biochemistry, whereas that at MSU emphasizes agricultural biochemistry, although neither emphasis is exclusive.

Unique at UM are research programs in nucleic acid biochemistry; in vertebrate hormone biochemistry, in general, and in steroid hormone biochemistry, in particular; in physical studies of large biochemically important molecules; and in the field of tumor viruses. Research programs unique at MSU are on protein synthesis, on utilization of starches, on the surface lipids (fats) of insects, and on analysis of ergot alkaloids.

Although ribosomes are studied in both departments, their structures are studied at UM and their function at MSU. Whereas studies on enzymes at UM are concerned with the relation between protein structure and enzyme activity and with the breakdown of proteins by enzymes, those at MSU are more physically oriented. There is, in fact, no duplication in the areas of specialization in biochemistry, in spite of this being a principal field of activity for both departments.

3. Inorganic chemistry.

MSU faculty: Emerson, Pagenkopf, Howald

UM faculty: Osterheld, Thomas, Van Meter

Unique to UM is research on the rates and mechanism of the decomposition of solids and of polyphosphates in solution. Unique at MSU are studies of inorganic aspects of soil chemistry and of ion transport through membranes.

Research is carried on in both departments on coordination compounds (ones containing metal ion complexes). At MSU the interest is directed toward determining the structures and physical properties of the compounds and rates of their reactions, whereas at UM it is directed toward the preparation of novel complexing agents for forming the compounds. The environmental chemistry interests of the inorganic faculty are compared in an earlier section.

4. Organic chemistry.

MSU faculty: A.C. Craig, R.E.R. Craig, Geer, Gerry, Jennings, Mundy

UM faculty: Erickson, Fessenden, Juday, Shafizadeh, Waters

Unique at MSU is research in organic electrochemistry, on rates of degradation of pesticides in the environment, and preparation of naturally occurring insect attractants. Unique at UM are studies on the reaction of ozone with organic compounds, on organic compounds containing mercury, on silicon-containing analogs of medicinally important compounds, and the programs of the Wood Chemistry Laboratory. The latter programs include the conversion of waste forest products to useful chemicals, the use of waste forest products for fuel, the control of fires in cellulosic materials (including forest materials), and studies to improve the utilization of sagebrush covered lands.

The major area of commonality is in the development of methods of preparation of organic compounds. The classes of compounds prepared are totally different, however.

5. Physical chemistry.

MSU faculty: Anacker, Callis, Caughlan, Howald, Olsen

UM faculty: Field, Woodbury, Yates

Purely theoretical studies of liquid and surface structures are unique to UM. Areas of physical chemistry studied only at MSU include the x-ray crystallographic determination of the structures of molecules and crystals, the determination of the structure and properties of surfactant (soap and detergent) solutions, studies of the electronic structure of molecules (especially those of biological importance), the physical chemistry of soils, and equilibria in solutions and slags.

Work in chemical kinetics (chemical reaction rates) occurs in both departments, but the types of reactions studied and the emphases of the studies are notably different. At MSU, the studies emphasize applications, as in the problem of nitrogen oxides produced in the MHD process. At UM, the emphasis has been on complex chemical reactions, especially those exhibiting oscillations, not only studying the reactions experimentally, but developing the theoretical and numerical treatments necessary to their understanding.

C. Examples of Collaboration between Departments of Chemistry at Montana State University and University of Montana

1. Seminars

Each department has provided the other with seminar speakers. In recent years Erickson, Fessenden, Fevold, Field, Hill, Kelsey, Magar, Van Meter, Waters and Watson from the University of Montana have spoken at Bozeman. Craig, Emerson, Jennings, Mundy and Pagenkopf from Montana State have lectured at Missoula. Anacker of Montana State provided a telelecture for a UM chemistry seminar last year.

On a number of occasions, the two departments have jointly sponsored prominent outside speakers and thus reduced the expense to each. The most recent examples are Henry Eyring of the University of Utah and Charles Wilcox of Cornell University, during 1976-76.

2. Graduate Committee Exchanges

a. Ken Emerson (MSU) participated in the administration of the final oral examination for Master's candidate Geoffrey Hughes at UM in Spring, 1972.

b. Brad Mundy (MSU) took part in the research proposal and final oral examination of UM doctoral student P.G. Marsh.

c. Bill Waters (UM) served on the committee examining the outside research proposal of Rod Otzenberger, a MSU doctoral student.

d. Arnold Craig (MSU) met with the Graduate Program Committee of the Chemistry Department at UM to exchange ideas on graduate program requirements.

e. The chairmen of the two departments confer on the telephone several times a year.

3. Instrumentation

a. Both departments have supplied lists of special instrumentation and invited the other to make use of unique items.

b. Before MSU acquired a versatile NMR spectometer, MSU doctoral students Lipkowitz, Pillsbury and Voecks used UM's instrument in some of their research.

c. Sam Rogers and Gordon Julian of MSU made several visits to Missoula for advice from Walter Hill of UM regarding the use of a zonal rotor of an ultracentrifuge to isolate ribosomal subunits and viral particles by the sucrose density gradient technique.

d. Richard Stebbins (MSU) used UM's EPR spectrometer this past year because the one on the MSU campus was out of order.

e. Wyn Jennings of MSU has run a number of samples from UM on the mass spectrometer at MSU.

f. Wyn Jennings' group at MSU is carrying out total organic carbon analyses for the water quality studies by Juday at UM.

4. Research

M.E. Magar (UM) and J.E. Robbins (MSU) collaborated on the following publication: "The Subunits of Porcine Heart TPN-Linked Isocitrate Dehydrogenase," Biochem. Biophys. Acta, 191, 173 (1969).