



Cornell  
University

ANNOUNCEMENTS

Graduate School  
*Biological Sciences*

1969-70

**CORNELL UNIVERSITY ANNOUNCEMENTS**

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## GRADUATE SCHOOL OF MEDICAL SCIENCES

1300 York Avenue  
New York, New York 10021

John E. Deitrick, M.D., Dean of the Graduate School of Medical Sciences

Julian R. Rachele, B.A., M.A., Ph.D., Assistant Dean of the Graduate School of Medical Sciences

## UNIVERSITY PROFESSORS-AT-LARGE

Professors-at-Large are distinguished nonresident members of the University Faculty. During short visits to the campus, of up to a month's duration, made at irregular intervals, they hold seminars, give public lectures, and consult informally with students and faculty.

Pierre Aigrain  
Raymond Aron  
Sir Eric Ashby  
Elliott Carter  
Daniel Cosío Villegas  
Manfred Eigen  
Gino Gorla

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Barbara McClintock  
Sir Peter Medawar  
Charles S. Singleton  
Georg Henrik von Wright  
Elizabeth Mary Wilkinson

The business office of the Graduate School and the office of the Dean are in Sage Graduate Center. Office hours are 8:30 A.M. to 4:30 P.M., Monday through Friday. The office is closed on Saturday.

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The courses and curricula described in this *Announcement*, the teaching personnel listed therein, and the dates shown in the Graduate School Calendar are subject to change at any time by official action of Cornell University.

# Cornell University

## GRADUATE EDUCATION AT CORNELL

Graduate education at Cornell is based on the principle that no objective of a university lies deeper in its tradition or springs higher in its aspiration than does the nurture of scholarship. The advancement of learning, the methods of learning, and the criticism of learning occupy the highest reaches of university life and work. Graduate education brings into fruitful contact the most distinguished scholars and the most advanced students, that learning may be shared and that wisdom may be at least glimpsed.

The Graduate School provides an environment within which scholarly capability is encouraged to emerge, thrive, and transmit itself. The School arranges a set of conditions congenial to the student who is prepared to profit from the availability of advanced courses of study; the opportunity for sustained reflection; the companionship of active, full-time fellow students; the most highly developed libraries, laboratories, and other facilities for research; the prospect of independent discovery or recovery, of evaluation or reevaluation; the daily presence of distinguished teachers; and the hope of attaining a firmly based structure of knowledge and a free and independent habit of judgment.

Freedom and independence are key qualities of scholarship, and graduate studies at Cornell are ordered so as to preserve them for both teacher and student. The Cornell principle is that scholars are begotten by other scholars, that judgments are formed by associating with the best judges, that learning lives in the unbroken succession of the learners and the learned, that genuine scholarship is always humane and rests ultimately on personal teaching and personal learning, that success in graduate studies must consist of satisfying the professor rather than a mute schedule of requirements. Graduate School standards are high, but they are maintained there not by the pronouncements of an office but rather by the men after whom such standards are themselves fashioned.

The Cornell graduate student selects not only the study he wishes to pursue, but also the scholar under whose tutelage he wishes to pursue it. The candidate himself, no one else, makes the choice. Some candidates when they apply for admission have in mind the man or men with

whom they wish to study. Those who do not are granted, under a temporary adviser, a semester in which to form an acquaintance and to come to a decision. The supervising professor is called the student's chairman. The chairman and his associate or associates, also chosen by the student, form the student's Special Committee. All such matters as the outlines of study, the observation of progress, the setting of general examinations, the conduct of the thesis, and other exercises leading to a graduate degree are determined within this small circle—the student and the professors he has selected to direct him. So successful is this arrangement and so strongly does Cornell believe in it, that the Special Committee enjoys extraordinary freedom and independence in conducting the student to his degree. The Graduate School sets no course requirement, no credit-hours requirement, no grade requirement. Within the broad agreements of the Graduate Faculty concerning residence, oral examinations, and thesis, the student will be recommended for his degree whenever his Special Committee judges him ready to receive it. When the Committee is satisfied, the requirements are.

The Cornell Graduate School has an enrollment of 3,300 students, and the Graduate Faculty consists of about 1,100 members. In contrast to many other graduate schools, approximately 98 percent of the students are full-time degree candidates, with the majority in programs leading to the Ph.D. degree.

*The University expects that all graduate students at Cornell University shall, at all times, act with a mature and morally responsible attitude, recognizing the basic rules of society and the common rights of others.*

## ADMISSION

### APPLICATIONS

To be considered for admission to the Graduate School an applicant must (1) hold a baccalaureate degree granted by a faculty or university of recognized standing or have completed studies equivalent to those required for a baccalaureate degree at Cornell, (2) have adequate preparation for graduate study in his chosen field of instruction, (3) have fluent command of the English language, and (4) present evidence of promise in advanced study and research. Students from United States colleges and universities should be in the top third of their graduating class.

Applications for admission should be requested from the Graduate School, Sage Graduate Center, Cornell University, Ithaca, N.Y. 14850. Two letters of recommendation should be sent from the applicant's major instructors. Official transcripts from all the institutions of higher learning attended, and, where required, the Graduate Record Examination or the Miller Analogies Test scores complete the application.

All applications from residents or citizens of the United States or Canada must be accompanied by a \$15.00 nonrefundable fee. Applicants from other countries who have been accepted for admission must pay this fee before registration.

Fellowship and admission applicants are urged to take the Graduate Record Examination (GRE) Aptitude (Verbal and Quantitative) Tests of the Educational Testing Service, and to have the scores sent to the Cornell Graduate School as part of their application materials. Information about the times and places of test administrations may be obtained directly from the Educational Testing Service, Princeton, New Jersey 08540. The Field listings, pages 53 ff., should be consulted for Fields requiring the scores of both the Aptitude Test and the pertinent Advanced Test.

Foreign applicants whose native language is not English and who have received their secondary or advanced education in the English language should submit to the Graduate School a statement to this effect signed by a responsible officer of a United States Embassy or Consulate or by an appropriate official of the educational institution involved. If English has not been the medium of instruction, applicants must take the Test of English as a Foreign Language by arrangement with Educational Testing Service, Princeton, New Jersey 08540. This testing program is available throughout the world. Information on times and places for administration of the test may be obtained directly from the address given above. The test score must be reported directly by the testing organization to the Graduate School as part of the essential application information. Since this test is diagnostic, no final action on applications will be taken until the scores have been received. Admission to those applicants whose scores indicate unsatisfactory command of English may be denied, or it may be made contingent upon evidence of improvement.

## CATEGORIES OF ADMISSION

### Degree Programs

It is expected that most applicants for admission intend to pursue a program for an advanced degree. Applicants may specify candidacy for the Master of Arts or Master of Science or one of the professional Master's degrees listed on pages 26-30. However, since Cornell has a strong commitment to doctoral work, most students are encouraged to enroll in a doctoral program. In some fields, students registered in a doctoral program may be required to seek a Master's degree as an initial step in the program.

Only under unusual circumstances will anyone who already holds an advanced degree be permitted to apply for the same degree.

## Provisional Candidacy

Under circumstances in which it is difficult to evaluate the academic background of qualified applicants, they may be admitted to *provisional* candidacy. Ordinarily only one semester of study in provisional candidacy is permitted, and the student who fails to qualify for candidacy at the end of that time may be requested to withdraw from the University.

## Noncandidacy

When staff and facilities are available, the Graduate School will admit some applicants who do not intend to work toward an advanced degree at Cornell but who have special objectives for formal study or scholarly work at the graduate level, provided they satisfy all the entrance requirements expected of degree candidates. Registration in noncandidacy is restricted to two semesters.

## CHANGE OF STATUS

A student who wishes to change his status from nondegree candidacy to regular candidacy or from one degree or Field to another, or who, after receiving the Master's degree, wishes to undertake candidacy for the doctorate, must submit a request in writing to the Dean of the Graduate School asking for transfer to the new status. Reasons for the change in status should be given. Provisional candidacy is automatically reviewed at the end of each semester; therefore, no letter is necessary.

## DEGREE REQUIREMENTS

### THE SPECIAL COMMITTEE

The general degree requirements of the Graduate School are kept at a minimum in order to give the student maximum flexibility in choosing a desirable program of studies. Since progress in graduate study depends so much on the individual student's situation, there are no course or grade requirements imposed by the Graduate School. The student's program is developed with the aid and direction of a Special Committee chosen by the student from the area of studies of interest and is designed to best fit the specific needs and desires of the individual student. Satisfactory progress toward the degree is judged solely by the Special Committee rather than by any arbitrary standards imposed by the Graduate School.

The Special Committee under which a Master of Arts or a Master of

Science candidate carries on his work is composed of a chairman who represents the major subject, and one representative of an appropriate minor subject. The Special Committee of a doctoral student is composed of a chairman, representing the major subject, and two other members representing other areas of interest. The chairman of the Special Committee directs the student's thesis research. Some Fields of study require two minor subjects for doctoral programs while others require only one, but all Ph.D. Special Committees have three members.

The selection of the Field and the major subject, as well as the chairman of the Special Committee, is made by the incoming student. It is the privilege of the graduate student to ask any member of the Graduate School Faculty who is in the Field of his major subject to serve as his chairman. The chairman in turn advises the student about minor subjects and faculty members who might be appropriate to represent them on his Special Committee. The choice of major and minor subjects and the formation of the Special Committee must be recorded in the Graduate School Office within two weeks of the beginning of the first term of residency. However, since the student may be uncertain of his aspirations at that time, he is encouraged to change the membership of his Special Committee as his aims become more definite.

In some of the larger Fields of the Graduate School the difficulty in making a wise selection of a Committee is so great that the Field Representative or other faculty member may serve temporarily as the chairman of the Special Committee while the student seeks a permanent chairman and committee to supervise his programs of study.

The members of the Special Committee decide upon the student's program of study and research and whether he is making satisfactory progress toward the degree. They conduct and report on oral examinations, and they approve the thesis. The Committee and the student constitute an independent working unit. All members of the Graduate School Faculty, however, are free to participate in the scheduled examinations and review the theses of candidates for degrees.

The organization of the Graduate School at Cornell is based on a concept of fields of study which is independent of colleges and departments. It is thus possible for a graduate student to take courses in any division of the University and to choose major and minor subjects without regard to organizational lines.

## RESIDENCE

The Graduate Faculty regards study in residence as essential. Although a person working off-campus may attain proficiency in a technique or even in a field of knowledge, he may fail in other ways to attain the breadth of knowledge necessary for scholarly work. In addition to contact with the libraries and physical facilities of the University, he needs the daily acquaintance, company, aid, and stimulus of others engaged in similar pursuits. He should form the habit of attending lectures, seminars, and meetings of groups in whose activities he takes interest.

Full-time study for one semester with satisfactory accomplishment

## 10 DEGREE REQUIREMENTS

constitutes one residence unit. The Graduate School Faculty requires that each candidate for a Master's degree earn two units of residence, and for the Ph.D. degree six units of residence. However, the time required to obtain the degree generally exceeds those minimum requirements.

A student must complete all the requirements for the Master's degree in four years and for a doctoral degree in seven years.

A student in a doctoral program may earn no more than two units for work done in Summer Research, Summer Session, and the Division of Extramural Courses. At least four of the six required units must be earned as a full-time student, earning three-quarters of a residence unit or more each term, and two of the last four units must be earned in successive terms of full-time study on the Cornell campus.

### Transfer of Residence

Candidates for the Master's degree may not count study in other graduate schools as part of their residence. Candidates for the doctorate may be permitted to count study for the Master's degree as equivalent to two residence units; those who have received training of an exceptional quality and amount may petition for more. No commitment regarding this may be made until after the student has entered into residence and his Special Committee has had further opportunity to judge his accomplishments. The residence transferred must not exceed that which would have been earned under similar circumstances at Cornell. Credits secured during study as an undergraduate or as a special student, even for work in courses designed primarily or wholly for graduate students, will not be allowed.

### Summer Session

To receive residence credit through registration in the Summer Session, the candidate must register in both the Summer Session and the Graduate School and must file a statement of courses satisfactory to his Special Committee. The completion of eight or more hours of credit in the eight-week session, or a minimum of six hours in the six-week session, will count as one-half or two-fifths of a residence unit respectively, if approved in advance and reported as acceptable by the candidate's Special Committee.

Requirements for Master's degrees may, upon approval of the appropriate graduate Field, be completed solely during the summer period if instruction in the chosen major and minor subjects is offered. Only two residence units for study in the Summer Session may be accepted in fulfillment of requirements for the doctorate. Upon recommendation by the Special Committee of a student and on approval by the Dean of the Graduate School, residence may be transferred for study done in one preceding Cornell Summer Session period if such study is attested to be an integral part of the graduate program subsequently undertaken.

## SUMMER RESEARCH

To encourage students to continue their studies during the summer period, no tuition or fees are charged for summer research if the student has been registered during the previous academic year. Substantial funds are also available for summer fellowship and research assistantship support. A special summer fellowship program is also available for those students who have held teaching fellowship appointments during the previous academic year. Students have access to the regular services of the University Clinic and Hospital during the summer without charge.

Under certain conditions, students may also accumulate residence credit in the summer term.

## Part-Time Studies

Essentially, all graduate students at Cornell are full-time students. In those cases where employment is necessary, students may hold positions requiring up to ten hours of work without reduction of residence credit. Teaching fellows and research assistants whose duties require up to twenty hours a week are able to obtain full residence credit.

The legislation with respect to eligibility of part-time employees for residence units is as follows.

EMPLOYMENT	RESIDENCE UNITS ALLOWABLE PER SEMESTER			
	<i>Total clock hrs. per week</i>	<i>Contributory in the major field of study and on campus</i>	<i>Noncontributory but on campus</i>	<i>Off campus</i>
0-10 hours	1 unit	1 unit	1 unit	
11-20 hours	1 unit	$\frac{3}{4}$ unit	$\frac{3}{4}$ unit	
21-30 hours	$\frac{3}{4}$ unit	$\frac{1}{2}$ unit		(See paragraph below)

If the employment is more than twenty clock-hours per week and is off campus, or if it is more than thirty clock-hours per week under any circumstances, a maximum of two-fifths of a residence unit per semester may be earned through registration in the Division of Extramural Courses, but this will be permitted only on the basis of petition approved prior to the time that the work is undertaken. For the degree of Master of Arts or Master of Science a maximum of one unit, and for the degree of Ph.D. a maximum of two units of residence may be earned in this way.

Therefore, under the circumstances described above, degree candidates may accumulate residence units for course work completed through the Division of Extramural Courses. Instruction is offered in certain fields

## 12 DEGREE REQUIREMENTS

of study both on and off the campus. Fifteen credit hours are the equivalent of one residence unit, and six credit hours the equivalent of two-fifths of a residence unit—the smallest fraction that will be recorded by the Graduate School toward fulfillment of residence requirements. Detailed information concerning extramural courses and registration procedures may be obtained from the Division of Extramural Courses, B-20 Ives Hall.

## EXAMINATIONS

The Special Committee conducts the examinations that are required for the degree. At the discretion of the Special Committee these examinations may be entirely oral or both oral and written. The following examinations are required:

For the Master's degree: a final examination, which under certain conditions may be combined with the Admission to (Ph.D.) Candidacy Examination.

For the doctoral degrees: (1) A comprehensive Admission to Candidacy Examination for formal admission to doctoral candidacy. This examination may not be taken until two units of residence credit have been accumulated and is normally taken in the second or third year. Two terms of residence must be credited after this examination. (2) A final examination, which is primarily concerned with the doctoral dissertation.

In Fields that so desire, the Special Committee may, after the Admission to Candidacy Examination has been taken, nominate the student for a Master's degree without the requirement of a thesis whether or not admission to candidacy has been approved. The degree would be awarded after the completion of four units of residence credit.

In some Fields a qualifying examination is given at an early date to determine the student's fitness for undertaking advanced study and to enable the Special Committee to plan a program which will make him familiar with the requisite knowledge and techniques of his chosen field of study.

When the candidate has completed the thesis, he presents it to the Special Committee at the final thesis examination. This examination is oral and covers subject matter related to the thesis topic.

## FOREIGN LANGUAGE REQUIREMENTS

Each Field of instruction has its own foreign language requirements which it considers most useful to the particular area of study. Any Special Committee may, at its discretion, require knowledge of foreign languages beyond the announced requirements.

Candidates required by Fields to demonstrate a reading ability in French, German, Russian, or Spanish must pass the Graduate School Foreign Language Test given by the Educational Testing Service, Princeton, N.J. 08540, and administered by the Graduate School. A

charge is made to cover the cost of administering each test. As an alternative, candidates may pass the reading part of the CEEB college language test with a score satisfactory to the Division of Modern Languages. Students who take examinations in languages other than French, German, Russian, or Spanish or in a speaking knowledge of any language, should arrange with the Graduate School Office for assignment to a suitable examiner. Arrangements to demonstrate a higher level of proficiency in a foreign language as required by some Fields may be made at the Graduate School Office.

A student may petition the Dean to transfer a language examination taken elsewhere to his record at Cornell.

Courses designed to aid graduate students in learning how to read French, German, Russian, and Spanish are given by the Division of Modern Languages in cooperation with the Graduate School Faculty.

## THESIS

Candidates for the degrees of Master of Arts or Master of Science are required to submit a thesis in fulfillment of the requirements for the degree. In some fields a thesis is also required for professional Master's degrees. Candidates for the doctoral degree must complete a thesis which constitutes an imaginative contribution to knowledge. The faculty requires publication of Ph.D. theses by abstract or microfilm.

## FINANCIAL SUPPORT

Extensive financial support is available to Cornell graduate students. Approximately 3,000 of the 3,300 graduate students have financial support in the form of fellowships, teaching fellowships, and research assistantships.

Since the demands of graduate study are so great, students are discouraged from trying to obtain financial support through employment outside their academic interests.

No special forms are available for financial aid. The applicant should check the type or types of appointment for which he wishes to be considered on the application for admission form.

## TEACHING FELLOWSHIPS

The duties of a teaching fellow normally involve classroom and laboratory instruction of undergraduates and, as such, play a major role in the educational process and the academic atmosphere of the University. Since a large majority of Cornell's graduate students eventually seek a career in teaching, the experience gained from these appointments is an invaluable part of the student's development. In most fields

## 14 FINANCIAL SUPPORT

of study students are encouraged to spend some time in teaching, and in a few fields the faculty believe the experience so important that they require it of all students in doctoral programs. An appointment as a teaching fellow is usually in the student's major field or in one that is closely related. The duties require from ten to twenty total clock-hours a week of the student's time, depending on the field. A teaching fellow whose duties are in his major field of interest and do not exceed twenty hours is eligible for full residence credit. The remuneration varies widely, but it is usually from \$1,900 to \$2,700 for an academic year and may be supplemented by a scholarship which covers tuition and general fees. A special summer fellowship program is also available for teaching fellows. Because of possible problems in communication with undergraduates, applicants from non-English-speaking countries are not normally appointed as teaching fellows in their first year at Cornell. Teaching appointments are made by department chairmen. Applications for these positions should be made to the Field Representative of the field offering the major subject of interest to the student.

## RESEARCH ASSISTANTS

The duties of a research assistant involve work on a research project. The work performed is frequently applicable to the student's thesis research and is under the direction of the chairman of his Special Committee. The student is required to spend twenty hours a week, but if the research is in the field of his major interest he is able to acquire full-time residence credit. In many fields of study such appointments are normally made after the student has completed at least one year of graduate study.

## FELLOWSHIPS

A fellowship ordinarily is awarded in open competition to a full-time student who is a candidate for a higher degree (usually a Ph.D.), primarily on the basis of scholastic ability and promise of achievement as a graduate student. However, if the combined anticipated income of the student and his spouse for the year of September 1, 1969, to September 1, 1970, exceeds \$8,000, the fellowship may be adjusted accordingly. The award is made as a tax-exempt gift, and it usually covers not only tuition and general fees but may also provide a substantial stipend for living expenses during tenure. A student who holds a fellowship is free to select his own research project, subject to the approval of his Special Committee, and his primary responsibility is to pursue his studies for his degree. The award of the fellowship does not obligate the holder to render services to the University, except that in certain fields some teaching is required of all graduate students for the sake of experience and training, nor is the holder of a fellowship committed in any way with respect to future employment. The holder of a fellow-

ship may accept no other appointment or employment without permission of the Fellowship Board; however, teaching responsibilities will usually be approved as a routine matter if they contribute to the student's graduate program and do not exceed ten clock-hours of work per week.

The number of academic-year fellowships awarded by the Graduate School is so extensive that it is impractical to present a listing. (See also Summer Fellowship Support, p. 16.) Many other fellowships are offered to students majoring in certain fields of study, and some of these are noted in the descriptions of the fields.

A new program has been initiated at Cornell for students in the humanities and in selected fields of the social sciences (Anthropology, Economics, Government, Linguistics, Psychology, and Sociology). Its aim is to reduce the time required for a Ph.D. degree. This is to be accomplished through a greatly enlarged program of support, without any sacrifice in the academic standards or requirements for the degree. Incoming students in the Fields covered by the program will be guaranteed support for four full years, including the summer following the first academic year. In most cases, there will be fellowship support for three of the years, with increasing stipends accompanied by full tuition and general fees. One year, or in a few cases up to two years, of teaching fellowship will provide both support and valuable experience and training. Dependency allowances will be available. About 90 per cent of those in the program will be given modest summer scholarships to enable them to continue their studies throughout the year.

Many private and federally supported fellowships are also administered by the Graduate School. National Science Foundation Traineeships, as well as National Defense Education Act (NDEA) Title IV Fellowships, are available to U.S. citizens. The application deadline for these is February 1 for the following academic year; candidates for these fellowships are nominated by the Field, having been chosen from among those students applying. NDEA Title IV Fellowships offer three years of support to doctoral students who intend to enter a teaching career. (Since completion of a Ph.D. program at Cornell normally requires four years, and because the program is aimed at prospective teachers, NDEA Fellows are normally expected to gain teaching experience and have support during one of the years as teaching fellows.)

The purpose of the NDEA Title VI (NDFL) Fellowship program is to provide encouragement to individuals taking advanced training in languages and in associated area studies designated as being of critical importance to the United States. For area studies, see pp. 32-42. Applicants who are interested in NDFL Fellowship support must so indicate when requesting their application materials for admission. National Institutes of Health Traineeships are available and are offered by fields which have been awarded such grants.

A space is provided on the admission application form in which the student may indicate the type of support for which he wishes to be considered. No special fellowship application form is required.

Prospective graduate students should also consider applying for

fellowships awarded on a national basis by the National Science Foundation, the Atomic Energy Commission, the Public Health Service, the Woodrow Wilson National Fellowship Foundation, and the Ford Foundation. These programs have deadlines for applications, some as early as December 1. Applicants should check on the date pertinent to the fellowship. In some cases it is possible for winners of NSF and AEC awards and for PHS Fellows to hold half-time appointments as teaching fellows for an additional stipend.

New York State provides several forms of financial support. The Herbert H. Lehman Fellowship program is open to applicants from all states whose interest is in social sciences or public or international affairs. These Fellowships are awarded on a competitive basis and may be used only in New York State institutions. Lehman Fellowships provide each recipient with \$4,000 for the first year of graduate study and \$5,000 for each subsequent year. New York State residents are eligible for Regents College Teaching Fellowships or Regents Fellowships for Doctoral Study in Arts, Science, and Engineering. Any of these must be applied for by December 1 on forms obtained from the Regents Examination and Scholarship Center, New York State Education Department, Albany, New York 12224.

As agreed upon by some of the members of the Council of Graduate Schools in the United States, the regular time for notification of award from Cornell of fellowships and scholarships for the succeeding academic years is April 1. *All fellowship and scholarship applications received by February 1 will be considered for April awards*, and every effort will be made to notify each applicant approved for award no later than April 6 as to whether he has a fellowship or is named as an alternate. It is hoped that the awardees will notify the Graduate School no later than April 15 of their acceptance or rejection of the award. Failure to do this by April 15 will be considered a declination. Applications received after February 1 will be considered only if vacancies occur.

## SUPPORT IN THE HUMANITIES

Recognizing that the availability of financial support for continuing graduate students in the area of the Humanities is less than in other areas, Cornell has made a particular effort to compensate for this inequity by a special Cornell-supported program. Students in doctoral programs in the Humanities area who enter with financial support from Cornell, or with nationally awarded fellowships, are guaranteed support in the form of an assistantship or a fellowship for a four-year period, provided they are making satisfactory progress toward the doctoral degree.

## SUMMER FELLOWSHIP SUPPORT

The Graduate School Faculty believes that graduate education, in contrast to undergraduate programs, should be on a year-round basis to

enable students to obtain their degrees in a reasonable period of time. The majority of Cornell Ph.D. students are, therefore, supported over the summer period through research assistantships and fellowships. Normally the summer period is devoted to informal study and research rather than to course work, and no tuition or fees are charged.

Two extensive summer fellowship programs based on financial need are noteworthy. One involves awards to those students who have been full-time teaching fellows. The other involves fellowship support to students who are in the final stages of their thesis preparation. It is expected that some 250 summer fellowships will be awarded for the summer of 1969 under these two programs. Another 1,300 students will be supported as research assistants, and 250 students will be on twelve-month fellowships.

## RESIDENCE HALL ASSISTANTSHIPS

Assistantships in University residence halls are available for men and women graduate students in any academic field. They are most appropriate for graduate students who desire experience in working with undergraduate students and University staff while contributing financially to their own study.

In the women's area eighteen assistantships are available, offering living expenses and a yearly stipend. Particulars and application forms may be obtained by writing to the Office of the Dean of Students, 133 Day Hall. Personal interview is desirable but not always required.

In the men's housing area two types of positions are available, the Head Residency and Resident Advisorship. There are Head Residencies for single and married men. A Head Resident receives his apartment, a stipend of \$700, payment of one-half tuition and fees, and board package which varies according to his marital status. Resident Advisorships are available to single men. A Resident Advisor receives his room, a \$500 stipend, payment of one half tuition and fees and twenty meals weekly in University facilities. There are eight Head Residencies and Resident Advisorships. These men work in counseling and guidance, programming and direct the activities of Undergraduate Residence Counselors.

Applications should be addressed to the Office of the Dean of Students, 133 Day Hall. The deadline for application for positions in men's dormitories is January 15. A personal interview is required for acceptance for a position.

## LOANS

Only graduate students duly registered in a degree-granting program are eligible for loans. This does not include provisional or noncandidate students.

Cornell utilizes university, state, and National Defense Loan programs. The total amount of loan recommended, regardless of source, is

based upon the financial need of the student as analyzed by the University Committee on Financial Aid.

Applications are available at the Office of Scholarships and Financial Aid, 105 Day Hall. State loan applications may also be obtained at this office.

## PART-TIME EMPLOYMENT

Additional opportunities for part-time work are often available in connection with departmental research projects or other activities. Applications for this type of work should be made directly to the department concerned. If a candidate is employed in research or other work closely allied to his academic interest, he may find such employment academically valuable.

Progress in candidacy is difficult when a student attempts to support himself wholly or partially by work unrelated to his studies. It usually is sounder economy to borrow from the Office of Scholarships and Financial Aid and keep employment to a minimum. However, the University maintains a part-time student employment service in that office.

## EMPLOYMENT OPPORTUNITIES FOR WIVES OF GRADUATE STUDENTS

Cornell University offers many nonacademic positions for working wives through the Personnel Division, B-12 Ives Hall. Types of work include secretarial and clerical work, work for technicians in the various laboratories, library work, limited nursing positions, and some administrative positions. Applications may be made through the Personnel Division upon arrival on campus. Applicants for academic positions should apply to the specific departments in which they are interested.

In addition to the University positions, the Ithaca area offers opportunities for similar positions in small industrial plants, Ithaca College, the local hospital, and various businesses, as well as for teaching positions in the public school system and some professional positions in service agencies. Applicants should go to the New York State Employment Office for further information regarding these opportunities.

## GENERAL INFORMATION

### ACTIVITIES FOR GRADUATE STUDENTS

Cornell is in a small academic town in central New York State. It has the advantages of a small-town atmosphere but at the same time has many cultural aspects that rival those of any large city. A significant concert program brings internationally famous artists to Ithaca. Dramatic programs, talks by visiting lecturers, and art exhibitions fill the

weekly calendar of the University and present such a wide choice of events that a student cannot possibly attend all in which he is interested.

There are places for graduate students in many extracurricular activities shared by undergraduates; among others are intramural sports, drama, Glee Club, Sage Chapel Choir, publications, music, and folk dancing. A Graduate Student Activities Committee is active in scheduling weekly social events. A Graduate Wives' Club has had a long tradition of activity for the wives of graduate students. Willard Straight Hall and the Sage Graduate Center provide facilities for graduate groups and aid in planning special functions for them.

Cornell United Religious Work (CURW) includes a range of activities for graduate students. Its offices are in Anabel Taylor Hall, which serves as a headquarters for chaplains who represent several denominations and who may be consulted by students.

Cornell's location in the Finger Lakes Region of New York State stimulates outdoor activity. Many swimming and boating facilities are available. In addition, Cornell operates a private eighteen-hole golf course; indoor and outdoor swimming facilities; indoor skating rink; tennis, handball, and squash courts; gymnasium; and riding stables all of which are open to graduate students. A variety of ski resorts also operate near by.

Almost all fields of study sponsor weekly seminars for their faculty and graduate students.

## COUNSELING

The University maintains a variety of counseling services available to graduate students. A student's primary academic counselors are the members of his Special Committee.

Other counselors who are able to help in matters of various kinds will be found in the Office of the Dean of Students, the Office of Scholarships and Financial Aid, the International Student Office, the Gannett Medical Clinic, and the Sage Graduate Center.

## INTERNATIONAL STUDENTS

Cornell has, since its founding, welcomed students from abroad. Currently 1,068 foreign students representing 86 countries are pursuing study in a variety of fields.

In addition, each year over one hundred faculty members spend some time abroad in study and research, often in close association with foreign universities. This creates within the University community opportunities for scholars from other countries to meet and exchange ideas with members of the Cornell faculty, who often have first-hand knowledge of several countries and understand and appreciate a variety of cultures.

Special study programs within the Graduate School permit study in depth of particular areas such as Africa, Asia, Southeast Asia, Latin

America, and the Near East. Students from those areas have an opportunity to contribute to such programs.

The Ithaca community is in a natural setting which allows for enjoyment of many recreational activities. In addition, varied cultural and intellectual activities are sponsored by the University. Tours of the community are conducted at the beginning of the fall semester. A group of Cornell faculty and Ithaca families maintain a Host Family Program, in which foreign students are invited to share in some aspects of American family life in the Ithaca community. With the University population a varied one, the community itself, although not large, tends to have a more cosmopolitan atmosphere than most other small cities, and the student can usually find an outlet for a wide variety of interests.

The University maintains an International Student Office at 142 Day Hall. Students from abroad are invited to consult the staff of that office on any questions they may have. The office works in close association with academic advisers and sponsors, and also with persons involved in a number of student and community programs in efforts to enrich the international and cultural life of Cornell. Students are asked to report to this office upon arriving in Ithaca.

## HEALTH REQUIREMENTS ON ENTRANCE

The following health requirements for entering graduate students have been adopted by the Board of Trustees of Cornell University. Failure to fulfill these requirements may result in loss of privilege of registering the following term. The responsibility for fulfilling these requirements rests upon the student.

**IMMUNIZATION.** A satisfactory certificate of immunization against smallpox, on the form supplied by the University, must be submitted before registration. It will be accepted as satisfactory only if it certifies that within the last three years a successful vaccination has been performed. If this requirement cannot be fulfilled by the student's home physician, opportunity for immunization will be offered by the Cornell medical staff during the student's first semester, with the cost to be borne by the student. If a student has been absent from the University for more than three years, immunity will be considered to have lapsed and a certificate of revaccination must be submitted.

It is strongly recommended by the University Health Services that all graduate students have immunization against tetanus before entering the University. All graduate students may, however, obtain initial and all booster tetanus toxoid immunizations at the Gannett Clinic for a nominal charge.

**HEALTH HISTORY.** Graduate students, when accepted, must submit *health histories* on forms supplied by the University. These should be returned promptly to the Gannett Medical Clinic. A University physician will review the material before it becomes part of the student's permanent health record. All information given is confidential. After

arrival at Cornell, if the medical history indicates a need, a student will be given an appointment to consult a physician at the Clinic. When a student has been away from the University for more than a year, he must, upon reentrance, submit an interim health history on a University form.

**X RAY.** Every student is required to have a chest x ray. Opportunity to satisfy this requirement is given during the student's first week on campus. The cost of the x-ray examination is included in the General Fee. When a student who has been away from the University for more than a year wishes to reenter, he must at his own expense, once more fulfill the chest x-ray requirement.

## HEALTH SERVICES AND MEDICAL CARE

Health services and medical care for students are centered in two Cornell facilities: The Gannett Medical Clinic (outpatient department), 10 Central Avenue, and the Sage Hospital.

Students are entitled to unlimited visits at the Clinic. Appointments with individual doctors at the Clinic may be made by calling or coming in person. (An acutely ill student will be seen promptly whether he has an appointment or not.) Students are also entitled to laboratory and x-ray examinations indicated for diagnosis and treatment, hospitalization in the Sage Hospital with medical care for a maximum of fourteen days each term, and emergency surgical care.

On a voluntary basis, insurance is available to supplement the services provided by the General Fee. For further details see the *Announcement of General Information*. If, in the opinion of the University authorities, the student's health makes it unwise for him to remain in the University, he may be required to withdraw.

If a student prefers to consult a private physician rather than go to the Clinic, or to have the services of a private doctor while a patient in Sage Hospital, he must bear the cost of these services.

## LIVING ARRANGEMENTS

**DORMITORY ACCOMMODATIONS.** The University has established Sage Hall as a graduate residential center. Its dormitory facilities accommodate approximately seventy-five men in the north side of the building and 115 women in the south side. The Graduate Center, which is available for use by graduate students and faculty, also contains a cafeteria seating 200, study rooms, and lounges. In addition, Cascadilla Hall has accommodations for approximately 160 single graduate men.

Applications for dormitory accommodations may be obtained any time after January 1 for the coming academic year by writing the Department of Housing and Dining Services, 223 Day Hall.

**FAMILY ACCOMMODATIONS.** The University, through the Department of Housing and Dining Services, has three apartment developments

for married students and their families. They are Cornell Quarters, Pleasant Grove Apartments, and Hasbrouck Apartments, with total housing for about 450 families. All apartments are unfurnished. For further information and application, write to the Department of Housing and Dining Services, Room 223, Day Hall.

**OFF-CAMPUS HOUSING.** Faculty legislation requires that all students live in Cornell-approved housing. The Department of Housing and Dining Services in Room 223, Edmund Ezra Day Hall, functions as a bureau of information and maintains files of voluntarily listed accommodations for use of students and staff members who call at the office. Because the list of available accommodations is constantly changing, it is not practical to mail listings, nor is it feasible to maintain a waiting list of persons seeking accommodations.

## MOTOR VEHICLES

The University does not encourage student use of motor vehicles but recognizes that in certain cases there may be important reasons why a student needs a motor vehicle. University regulations apply to all types of motor vehicles, including automobiles, motorcycles, motor bikes, and motor scooters.

Every student who owns, maintains, or for his own benefit operates a motor vehicle in Tompkins County, must register it with the Safety and Security Division, even though that vehicle may be also registered by faculty, officers, or employees. All students must register motor vehicles within the prescribed time for University registration at the beginning of the fall term (*exception*: students who are not then subject to this rule but later become subject to it must register vehicles within five days after becoming so subject). Nonregistered vehicles may not be parked on campus at any time. Students entering the University for the spring semester or reentering after a period of absence must register motor vehicles with the Safety and Security Division at the time of, or within the time for, general registration.

Every student who has a motor vehicle must comply with the following requirements: (1) the student must be legally qualified to operate a motor vehicle in New York State; (2) the vehicle must be registered in New York State or legally qualified to be operated on the highways of New York State; (3) the vehicle must be effectively insured against public liability for personal injury and property damage for the minimum of \$10,000—\$20,000—\$5,000, for the duration of such registration and while the vehicle is under the control of the registering student; (4) the registration fee covering the fall and spring terms, or any part thereof, is \$4.00 and is due and payable in the Treasurer's Office on the same date as tuition and other fees. In case of late registrants, the fee will be due within a week after such registration. A fine is levied if the vehicle is not registered within the specified time.

No student may park his motor vehicle on the campus from 8 A.M. to 5 P.M. Monday through Friday, or from 8 A.M. to 1 P.M. Saturdays.

Certain areas are restricted twenty-four hours a day; such areas include "no parking" zones, dormitory parking areas, and areas listed as limited at all times to holders of specific permits.

Special area parking permits are issued only after careful consideration by the Safety and Security Division Office. Extenuating circumstances (physical disabilities, etc.) are the basis for the issuance of these permits.

The student's registration in the University is held to constitute an agreement on his part that he will abide by all its rules and regulations with regard to traffic and parking or suffer the penalty prescribed for any violation of them.

Correspondence regarding motor vehicles should be addressed to the Board on Traffic Control, G-2 Barton Hall.

## CAREER, SUMMER PLANS, AND PLACEMENT CENTER

The Career, Summer Plans, and Placement Center at 14 East Avenue is a clearing house for jobs in business, industry, government, and teaching; as well as study programs leading to the professions. It serves as an information center for careers, teacher placement, fellowships, techniques of job hunting, and summer experiences (work, study, travel, service projects). More than a thousand recruiters visit the campus each year representing employers and graduate schools. Students and faculty may be kept up to date on the activities of the Center by registering to receive its *Newsletter*. Alumni may be served by either the *Job Bulletin* or the *Registrants Available Bulletin*. Through the support and cooperation of the Cornell Club of New York and the Cornell Society of Engineers, a placement office is maintained in New York City primarily for alumni living in that area.

## TUITION AND FEES

Tuition and fees<sup>1</sup> become due when the student registers. Any student who fails to pay his tuition, fees, and other indebtedness to the University at the Treasurer's Office within the prescribed period of grace will be dropped from the University unless the Treasurer has granted him an extension of time to complete payment. The Treasurer is permitted to grant such an extension when, in his judgment, the circumstances of a particular case warrant his doing so. For any such extension the student is charged a fee of \$5.00. A reinstatement fee of \$10.00 is assessed against any student who is permitted to continue or return to classes after being dropped from the University for default in payments. The assessment may be waived in any instance for reasons

<sup>1</sup> All statements in this section are prepared by the Treasurer, who alone is authorized to interpret them.

satisfactory to the Treasurer and the Registrar when such reasons are set forth in a written statement.

Students registering at any time during the last ten weeks of any term are required to pay tuition at the rate of 10 per cent of the regular tuition of the term for each week or fraction of a week between the day of registration and the last examination day of the term.

*Tuition or fees may be changed by the Trustees at any time without previous notice.*

## FEES PAYABLE BY GRADUATE STUDENTS

### Registration Deposit

A deposit of \$35.00 must be made by every applicant for admission after the applicant has received notice of acceptance, unless the candidate has previously matriculated as a student at Cornell University. This deposit is used at the time of first registration to pay the matriculation fee, chest x ray, and examination-book charge, and covers certain expenses incidental to graduation if the student receives a degree. The deposit will not be refunded to any candidate who withdraws his application after May 10 or after fifteen days of his admission approval. This fee is *not* covered by university fellowships, scholarships, or assistantships.

### Tuition

Tuition is \$200 a term for all students registered in the Graduate School whose major chairman is on the faculty of the statutory divisions<sup>2</sup> of the University. Those with major work in the School of Nutrition, the Field of Education, and the Division of Biological Sciences also pay \$200 a term. All students in other divisions must pay tuition of \$847.50 a term. Tuition is payable at the beginning of each term.

Upon recommendation by the appropriate college dean and by action of the Controller, for each appointment in a statutory school or college, waiver of tuition in the Graduate School may be made to a member of the teaching or scientific staff, whose major field of study is in a statutory school or college.

Assistants in statutory schools or colleges who are on twelve-month appointments and who are registered for Summer Research for credit in the Graduate School may be recommended for waiver of tuition during the summer period under the above limitations. This waiver of tuition does not apply if the student registers in the Summer Session or is not doing productive work for the department.

Any student who is to receive less than full residence credit because of his employment should apply for proration of tuition on forms procurable at the Graduate School Office. *Tuition is based on residence eligibility.* See pp. 9-11.

<sup>2</sup> The statutory divisions are the Veterinary College, the Colleges of Agriculture and Home Economics, and the School of Industrial and Labor Relations.

## General Fee

A fee of \$275.00, payable at the beginning of each term, is required of each student registered in the Graduate School whose major chairman is on the faculty of one of the statutory divisions,<sup>3</sup> the School of Nutrition, the Field of Education, or the Division of Biological Sciences. All others pay a fee of \$252.50. This General Fee contributes toward the services supplied by the libraries, Clinic and Hospital, and the student union in Willard Straight Hall, and pays a portion of the extra cost of laboratory courses and general administration.

A student who is regularly registered in the Graduate School for either one or both terms of the academic year and has paid the above fee is entitled to these services while in residence during the summer immediately following the academic year without payment of an additional General Fee. If such a student registers with the University during the summer, he is liable for payment of any tuition and other fees, and must present his ID card at the time of payment of these charges in order to claim exemption from payment of the General Fee.

A graduate student who returns to the University to present his thesis and to take the final examination for an advanced degree, all other work for that degree having been previously completed, must register as a "Candidate for Degree Only" and pay a fee of \$35.00.

## Other Fees

**THESIS FEE.** Each doctoral candidate must pay \$30.00 at the time of depositing the approved thesis and abstract in final form. This fee covers the cost of preparing a master microfilm of the entire thesis; of publishing the abstract in the bimonthly periodical, *Dissertation Abstracts*; of mailing the microfilm and abstract to the microfilm publisher; and of binding both copies of the thesis for deposit in the University Library.

**LIMITED REFUNDS.** Part of the tuition and General Fee will be refunded to students who officially withdraw or take a leave of absence during the first nine weeks of a term. A student arranges for a leave of absence or withdrawal at the Graduate School Office. Students who withdraw are charged tuition and the General Fee at the rate of 10 per cent for each week or fraction of a week from registration to the effective date of withdrawal. No charge is made if the student withdraws within six days of registration. No part of the registration or matriculation fee is refundable.

**SUMMER SESSION.** Graduate students who attend classes in the Summer Session must register both in the Graduate School and in the Summer Session; they must pay the tuition and fees listed in the *Announcement of the Summer Session*.

<sup>3</sup> The statutory divisions are the Veterinary College, the Colleges of Agriculture and Home Economics, and the School of Industrial and Labor Relations.

**SUMMER RESEARCH.** Students registered for Summer Research pay one half of the General Fee for a registration period of not more than eight weeks and the full fee for a registration period of over eight weeks unless they were regularly registered in the Graduate School during the previous academic year. For those students eligible for and desiring residence, a prorated tuition is charged in accordance with the fraction of a residence unit to be earned, based on the tuition in effect for the subsequent academic term.

**IN ABSENTIA.** A graduate student registered *in absentia* will pay a fee of \$35.00 each term.

## ADVANCED PROFESSIONAL DEGREES

Advanced professional degrees are designed as preparation and training for a special profession.<sup>4</sup> The admissions, requirements, and curricula for such degrees, as approved by the Graduate Faculty, are announced by the faculty of a professional school or college, which, for this purpose, acts as a Division of the Graduate Faculty. Degrees are awarded upon recommendation of the Division to the Graduate Faculty. Detailed information regarding admission or academic requirements for any professional degree is included in the *Announcement* of the separate school or college in which the degree is offered. Inquiries addressed to the Graduate School will be forwarded to the proper official. The professional degrees listed below are approved by the Graduate Faculty.

### ARCHITECTURE, FINE ARTS, CITY AND REGIONAL PLANNING

The following three degrees are administered by the Division of Architecture, Fine Arts, and Planning of the Graduate School. Inquiries should be addressed to the listed professor.

For more detailed information on these degrees, as well as those in architectural structures, architectural history, and art, see also the *Announcement of the Graduate School: Humanities*.

**MASTER OF ARCHITECTURE (M.Arch.).** Training in urban design. Only graduates of a five-year professional program in architecture or

<sup>4</sup> The following are advanced degrees which are also first degrees of a school or college and therefore are not subject to the jurisdiction of the Graduate Faculty. For information regarding them, address the school or college indicated.

Master of Engineering (Aerospace) . . . . .	Graduate School of Aerospace Engineering
Master of Business Administration } . . . . .	Graduate School of Business and Public Administration
Master of Public Administration } . . . . .	
Doctor of Law . . . . .	Law School
Doctor of Medicine . . . . .	Medical College, New York City
Doctor of Veterinary Medicine . . . . .	Veterinary College

graduates of a program in city planning or landscape architecture are admitted as candidates. (Professor Colin Rowe.)

**MASTER OF FINE ARTS (M.F.A.).** Advanced training in the practice of painting, sculpture, or graphic arts. (Professor Jason Seley.)

**MASTER OF REGIONAL PLANNING (M.R.P.).** Training for a professional career in the field of city planning or regional planning. (Professor Kermit C. Parsons.)

## EDUCATION

Two professional degrees are administered by the Field of Education of the Graduate School. The programs leading to each of the degrees include courses, seminars, projects, and investigations which will develop the student's ability to perform acceptably the professional duties required of the several types of educational specialization.

**MASTER OF ARTS IN TEACHING (M.A.T.).** This program is designed for and limited to those preparing for teaching in elementary and secondary schools. The student and his Special Committee will select those courses and seminars in his teaching specialty and in Education which are deemed most appropriate for developing competence as a teacher. The student will be required to demonstrate his or her teaching skill in a supervised field experience. Completion of a twelve-month program, or two and two-fifths residence units is required. Graduates of a teacher-training program are not eligible for this degree.

**DOCTOR OF EDUCATION (Ed.D.).** The program for this degree is designed to prepare the candidate within a broad cultural context for positions of professional leadership in education. The program of studies must include advanced work in each of the following: educational psychology, history or philosophy of education, educational measurement and statistics, and research in education. At least fifteen hours of credit must be earned in courses other than those in professional education. A minimum of sixty-five credit hours beyond the Bachelor's degree is required, of which thirty-five hours should be completed beyond the Master's degree or its equivalent. A candidate is required to complete a minimum of five residence units beyond the Bachelor's degree and a year of directed field experience.

## Professional Teaching

**MASTER OF SCIENCE FOR TEACHERS (M.S.T.).** This is a coordinated program of training in the biological and physical sciences for practicing teachers. Each degree candidate must satisfy a broad core program in mathematics and science and complete advanced work in his selected Field of study. This degree is administered by the Divi-

sion of Professional Teaching of the Graduate School. Detailed information may be obtained from the Graduate School Office, Sage Graduate Center.

## ENGINEERING

The degree of Master of Engineering is administered by the Engineering Division of the Graduate School. Specially oriented graduate programs of study are in the areas of agricultural, chemical, civil, electrical, industrial, materials, mechanical, and nuclear engineering, and in engineering physics. The following titles designate the professional Masters' degrees offered in engineering: Master of Engineering (Agricultural), Master of Engineering (Chemical), Master of Engineering (Civil), Master of Engineering (Electrical), Master of Engineering (Engineering Physics), Master of Engineering (Industrial), Master of Engineering (Materials), Master of Engineering (Mechanical), Master of Engineering (Nuclear). The Graduate School of Aerospace Engineering administers the Master of Engineering (Aerospace) degree program.

The general requirements for the degrees listed above are:

1. A minimum of thirty credit hours of advanced technical course work in the specific field or in related subjects.
2. A minimum of three credit hours (included in the above) of engineering design experience involving individual effort and formal report.
3. A minimum grade point average of 2.5 and a minimum final grade of C minus for all courses counting toward the degree.

There are no residence requirements, although all course work must, in general, be completed under Cornell University staff instruction. The degree requirements must normally be completed within a period of four calendar years.

Graduates of Cornell University who hold Bachelor of Engineering degrees may be granted up to fifteen hours credit for advanced courses taken during their fifth undergraduate year, provided they enter the Master of Engineering program not later than the fall term following the sixth anniversary of their receiving the Bachelor of Engineering degree.

The *Announcement of the College of Engineering* should be consulted for further details on the professional Masters' programs in the various fields.

## ENGLISH

**MASTER OF FINE ARTS (M.F.A.).** The degree of Master of Fine Arts in creative writing is designed to prepare candidates for careers in professional writing or in the teaching of creative writing. The program is administered by a specially appointed committee of the Department of English, acting as a Division of the Graduate School.

## INDUSTRIAL AND LABOR RELATIONS

**MASTER OF INDUSTRIAL AND LABOR RELATIONS (M.I.L.R.).** The four-semester program leading to this degree provides a basic course of graduate study for those with professional interests in industrial and labor relations and further provides limited opportunities for specialized professional study where broad competence has been established. This degree is administered by the Division of Industrial and Labor Relations of the Graduate School. More information may be obtained by writing to the Graduate Field Representative, School of Industrial and Labor Relations, Ives Hall.

## LAW

The following two degrees are administered by the Division of Law of the Graduate School. The *Announcement of the Law School* should be consulted for a complete description of the program and requirements.

**MASTER OF LAWS (LL.M.).** This degree is intended primarily for the student who desires to increase his knowledge of the law by working in a specialized field.

**DOCTOR OF THE SCIENCE OF LAWS (J.S.D.).** This degree is intended primarily for the student who desires to become a proficient scholar by original investigation into the functions, administration, history, and progress of law.

## MUSIC

**DOCTOR OF MUSICAL ARTS (A.Mus.D.).** This degree is appropriate for mature composers who seek further professional training as well as knowledge of the other arts and humanities, both to enrich their creative perspectives and to prepare them for the teaching of composition and theory at the university level. It is administered by the Department of Music, acting as a Division of the Graduate School for this purpose.

## NUTRITIONAL AND FOOD SCIENCE

The following two degrees are administered by the faculty of the Graduate School of Nutrition acting as a division of the Graduate School. More information may be obtained by writing to the Secretary, Graduate School of Nutrition, Savage Hall.

**MASTER OF NUTRITIONAL SCIENCE (M.N.S.).** This program emphasizes fundamental study in the basic biological sciences that can

lead to specialization in such areas as nutritional biochemistry, human and clinical nutrition, experimental or animal nutrition, and public health and international nutrition. The program is open to students who have had no previous course work in nutrition. For candidates interested in the biological sciences, the program serves as a valuable preliminary for graduate study for the Ph.D. degree in such areas as biochemistry and physiology, as well as human or animal nutrition.

**MASTER OF FOOD SCIENCE (M.F.S.).** The fundamental sciences, chemistry, biochemistry, and bacteriology, that are involved in food processing and utilization, are emphasized. Electives are available to meet individual needs in engineering, economics, marketing, business administration, and international programs. The specialized training serves as a preparation for technical work as related to the food industry or for more advanced graduate study.

The *Announcement of the Graduate School of Nutrition* should be consulted for further details on the professional Master's degree programs.

## THEATRE ARTS

**MASTER OF FINE ARTS (M.F.A.).** The degree of Master of Fine Arts in theatre arts is intended for students who wish to increase their professional competence as actors or directors through a studio-oriented program. It is administered by the Department of Theatre Arts, acting as a Division of the Graduate School for this purpose.

## VETERINARY MEDICINE

**DOCTOR OF SCIENCE IN VETERINARY MEDICINE (D.Sc. in V.M.).** This degree is characterized by a professional rather than a general research objective, and it is designed especially for experienced persons in the basic and clinical sciences who need more specific, advanced, scientific, and professional knowledge in order to equip themselves for careers in teaching and research. This degree is administered by the Division of Veterinary Medicine of the Graduate School.

## SPECIAL RESOURCES FOR RESEARCH AND ADVANCED STUDY

The descriptions below are limited to major general facilities at the service of graduate students in any of a variety of fields of instruction. In addition, substantial collections and facilities, in many instances unique, have been assembled for the use of graduate students. Although the facilities cannot be described adequately in this *Announcement*,

some of them are mentioned in the statements given under the Fields of Instruction on pp. 53 ff.

## CORNELL UNIVERSITY LIBRARIES

The libraries are among the principal facilities in the University's program of graduate studies. The total number of volumes at Cornell is now over 3,000,000 and that figure increases by about 175,000 each year. For the convenience of students and faculty, the holdings are organized into a controlled system of distinct libraries. Some of the libraries are large; some have limited holdings. Some are general; some selective. Each library, whether within one of the colleges or housed in a building of its own, is situated where its books and its facilities lie most easily available to those who use them most. The libraries, whatever their nature, have been developed over many years by scholarly librarians and professors with the view of achieving breadth and depth in the central libraries, utility and coherence in the specialized ones.

The University's libraries offer support for graduate studies at several levels. They provide basic readings in virtually all subjects, collateral studies for classroom and seminar instruction, and highly specialized materials for advanced students. An unusually rich collection of reference works, both modern and antiquarian, expedites both the daily study and dissertational research. Of journals and periodicals, about 35,000 titles are available, most of them in complete runs, some of them in multiple copies, all of them immediately available. Special departments are maintained for maps, microtexts, documents, newspapers and other such collections.

To most graduate students, Olin Library, designed primarily as a research library, becomes the most familiar. Olin Library, completed in 1961, offers every modern library facility for its readers. The building is completely air-conditioned, scientifically lighted, comfortably furnished, and organized for efficient operation. It provides easy access to the book stacks, convenient photocopying facilities, and a comfortable lounge area for graduate students. Congestion is eliminated not only because of architectural design but also because undergraduates have their own open-stack library in a separate building. A graduate student whose work has advanced to the writing stage may apply for use of a carrel adjoining the book stacks in order to facilitate completion of his dissertation. Olin Library is open in term time from 8 A.M. to 12 midnight weekdays, and from 1 P.M. to 12 midnight Sundays.

Within Olin are a number of special collections likely to be of particular interest to advanced students of the social sciences and the humanities. The Department of Rare Books houses several distinguished collections, among them books and manuscripts relating to Dante, Petrarch, Wordsworth, Joyce, Shaw, and other literary figures. The Noyes Collection is rich in American historical documents, especially those pertaining to Lincoln and the Civil War. Students in the social sciences will also find extraordinarily interesting manuscripts and books

in the collections of slavery and abolition, of witchcraft, of the French Revolution, and of the life and times of Lafayette. Long familiar to professional scholars are the Wason Collection on China and the Chinese, the Old Icelandic Collection, and collections on Japan and Southeast Asia. The History of Science collections include the Adelmann Library of Embryology and Anatomy, and the library of the French scientist, Lavoisier. The collection of Regional History and Cornell University archives is a manuscript depository with total holdings of more than 14,000,000 items. These manuscripts relate to all aspects of the economic, political, and social history of this region and the areas historically connected with it. Here, too, are the documents and manuscripts relevant to the founding and development of Cornell University. In addition to the collections in Olin Library, many of the college and department libraries also contain materials unique in their respective fields. Curators and reference librarians in all the libraries are available for counsel concerning the availability and use of research materials.

The University libraries in aggregate consist of Olin Library, as mentioned, Uris Library for Undergraduates, the Physical Sciences Library, the Mann Library of Agriculture and Home Economics, and the libraries of the following colleges and schools: Fine Arts, Business and Public Administration, Engineering, Hotel Administration, Industrial and Labor Relations, Law, Medicine (in New York City), and Veterinary Medicine. Added to these are the libraries of academic divisions and departments, together with those of the Agricultural Experiment Station at Geneva, New York.

## INTERNATIONAL STUDIES PROGRAMS

### Center for International Studies

The Center for International Studies has as its primary function the coordination and support of the international activities of Cornell University. In addition to its role as a link between the activities of the specialized programs, the Center endeavors to facilitate and encourage research and teaching dealing with international affairs and to serve as a focal point for their discussion. The Center brings to Cornell visiting faculty, postdoctoral research fellows, and distinguished academic and professional personnel in the area of international affairs who give interdisciplinary courses and seminars. Through the use of the permanent Cornell faculty, the Center is developing a teaching program at the undergraduate and graduate levels where it can usefully add to the regular offerings of separate schools and departments.

Students interested in foreign area studies or in international problems will find that the flexibility of both undergraduate and graduate requirements permits considerable latitude in selecting subjects. Appropriate courses of study can be selected from the regular offerings of various departments of the University. For example, in the College

of Arts and Sciences the Department of Government offers instruction in comparative government, international relations, and international law and organization; in the Department of Economics there are offerings in international economics, economic development, and international trade. The College of Agriculture offers courses in the economics of agricultural development, international agriculture, and rural sociology. The School of Business and Public Administration offers courses in international development and comparative administration. The School of Industrial and Labor Relations offers courses in international and comparative labor relations.

The graduate student seeking specialized foreign-area knowledge may arrange a minor in one of the interdisciplinary area programs: Asian Studies or Latin American Studies. It is also possible for the student to pursue an area interest in African Studies, European Studies, or Soviet Studies.

The continued growth of the international programs has been accompanied by the creation of an outstanding and comprehensive infrastructure of staff, library, language facilities, and other necessary resources.

The work of the Center and of associated programs and activities is more fully described in the Center's *Annual Report of International Studies at Cornell University* and the *Announcement of the Center for International Studies*. Further information may be obtained from the Center's office in 217 Rand Hall.

## African Studies

**ADVISORY FACULTY COMMITTEE ON AFRICAN STUDIES:** William H. Friedland, Chairman; Douglas Ashford, Harold Feldman, Milton Konvitz, Ian Macneil, Chandler Morse, Thomas Poleman, Kathleen Rhodes, Victor Turner.

Cornell University has substantial facilities for graduate study and research on Africa. Many members of the faculty in a variety of fields are qualified by research experience in Africa to provide instruction or guidance to students who wish to specialize in some aspect of African studies, who plan to work there, or who are interested in a general or comparative knowledge of the area. Instruction and training in general linguistics are available for students expecting to deal with tribal peoples, and special courses on particular African languages (e.g., Ibo, Yoruba) have been given in recent years. Courses are regularly offered on the cultures and social systems of Africa and on the problems of economic, political and social development of the area. The University libraries provide a good working collection of books, documents, maps, newspapers, and periodicals on Africa of sufficient scope to enable students and staff to carry on regional research. A representative group of African students is attracted to Cornell each year, most of whom are eager to discuss African life and problems with interested students from other areas.

Inquiries should be directed to Professor William H. Friedland, Chairman, Committee on African Studies, Ives Hall.

## China Program

**FACULTY:** Knight Biggerstaff, Nicholas C. Bodman, Nai-Ruenn Chen, Chuen-tang Chow, John C. H. Fei, Ta-Chung Liu, John McCoy, David Mazingo, Charles A. Peterson, Harold Shadick, Judith M. Treistman, Arthur P. Wolf, Martie W. Young.

The China Program provides comprehensive graduate-level training and sponsors a wide range of research. The faculty represent the following fields: anthropology, economics, government, history, history of art, linguistics and literature.

Graduate students in the program take a major in one of the fields listed above. They are expected at an early stage to attain sufficient mastery of the Chinese language to permit use of Chinese sources in their courses and seminars and in their research.

The focus of much of the research and teaching in the Program is the society, polity, economy, culture, and arts of modern and contemporary China. Students with this concentration are also expected to develop a general knowledge of traditional institutions and culture. Students majoring in history concentrate on medieval or modern China; no chronological limits apply to those in the history of art, linguistics, or literature.

The China Program supports three projects: Political Organization, Social Change, and Personality Development; Economic Development within a Chinese Cultural Setting; and Linguistic Studies in South-east China and in the Southwest Border Regions. Research Assistantships are available to advanced graduate students working in these areas, and occasionally in other fields as well. London-Cornell Studentships are open to advanced Ph.D. candidates in the social sciences and humanities who are in the China Program. They are tenable for study during an academic year at the London School of Economics and Political Science or at the School of Oriental and African Studies of the University of London. Stipends include air fares and tuition and fees.

London-Cornell Field Research Grants are open to Ph.D. candidates whose interests directly concern problems of social change in East Asia. Grantees may conduct dissertation research in any part of East Asia, and stipends for this purpose include travel and research expenses.

National Defense Foreign Language Fellowships and Foreign Area Training Fellowships are tenable in the Program. Graduate students may also apply for other assistantships, fellowships, and scholarships offered by the University and by its departments.

Additional information on the Program and the various fellowships and awards may be obtained by writing to the Director, China Program, 100-A Franklin Hall.

## Program on Comparative Economic Development

The Program on Comparative Economic Development at Cornell University was founded in 1966 by a group of economists in the Department of Economics, the Department of Agricultural Economics, and the School of Industrial and Labor Relations. Its primary purpose is theoretical and empirical research into the causes and forces of economic development, emphasis being placed on the multiplicity and diversity of forms of the development phenomenon.

Several secondary benefits derive, or are expected to derive, from the activities of the Program. One is the educational feedback in the form of seminars, guest lecturers, and the availability of research scholarships to graduate students in the Department of Economics. Further, arrangements are being made for the establishment of regional research and educational centers in selected focal development countries.

The Program is not restricted to economists. On the contrary, it is hoped that as time goes on cooperation will be obtained from other fields. In fact, the philosophy of a wider basis of development science, not restricted to economics, is intended to become the central strength of the Program.

Additional information may be obtained by writing to Professor Ta-Chung Liu, Director of the Program, Goldwin Smith Hall, Cornell University, Ithaca, New York 14850.

## International Agricultural Development Program

Cornell University provides unusual scope and facilities for graduate-level study and research concerning development of the critical agricultural sector of newly developing nations. An integrated program of research and graduate training is available in the various biological, physical, and social sciences fields which are relevant to agricultural development.

A student preparing for work in international agricultural development majors in a specific Field. In addition to basic preparation in that Field, he may minor in the Field of International Agricultural Development. The student may take courses which help him in applying his knowledge to the special conditions of newly developing nations, consult with experienced faculty members in regard to such application, and pursue a research project for his dissertation which is relevant to the special problems of newly developing countries. In much of this work the program in agriculture draws upon the strong international programs in other colleges of the University, including the area study programs and the varied offerings in modern languages.

Faculty experience in overseas work is continuously developed through work in College overseas programs and individual consulting assignments. Several faculty members, who devote themselves full time

to research and teaching in international agricultural development, have built special programs of research and continuing contact with particular geographic areas. The environment for the International Agricultural Development Program is further enhanced by more than 250 foreign graduate students majoring in the various fields of studies represented by the College of Agriculture.

Substantial expansion has recently taken place in the international program of several departments. Most departments have a number of assistantships and teaching fellowships designed to finance graduate students while they work closely with the teaching and research program in international agricultural development. Doctoral candidates in these departments, who are interested in international agricultural development, generally do field research in newly developing countries for their doctoral dissertations.

Additional information may be obtained by writing to Professor K. L. Turk, Director, International Agricultural Development Program, 102 Roberts Hall.

## International Legal Studies

The Cornell Law School offers a program of concentrated study in international legal subjects. The full program is ordinarily pursued by J.D. candidates in their second and third years of regular law study, but all the courses in the field are open to graduate students in law. Some of the courses are offered by visiting faculty members who come to the Law School under its program for distinguished foreign professors. A number of foreign scholars and students also come to Cornell for research and study in the comparative and international law fields. Other activities of the International Legal Studies Program have included faculty seminars in comparative law, summer conferences in public international law, and a program of speakers and seminars open to students. In addition, the Law School sponsors a small number of fellowships for foreign students to pursue graduate work in law.

For more detailed information, see the current *Announcement of the Law School*, the current *Annual Report of the Center for International Studies*, and the current *Announcement of the Center for International Studies*. Further information may be obtained by writing to Professor Robert A. Anthony, Chairman, Graduate Study Committee, the Cornell Law School, or to the Director, Center for International Studies, 217 Rand Hall.

## Latin American Program

**FACULTY:** Donald K. Freebairn, Director; Charles Ackerman, Frederick B. Agard, Solon Barraclough, Jerome S. Bernstein, Dalai Brenes, Frank Cancian, Tom E. Davis, Martin Dominguez, Matthew Drosdoff, Charles L. Eastlack, Rose K. Goldsen, Richard Graham, Eldon Kenworthy, Henry A. Landsberger, Thomas F. Lynch, Robert E. McDowell, James O. Morris, Thomas Poleman, Bernard Rosen, Donald F. Solá,

J. Mayone Stycos, Terence S. Turner, William W. Whyte, Frank W. Young.

The Latin American Studies Program enables the graduate student to develop specialized competence in the history, culture, social organization, and language of Latin American countries. The student majoring in a relevant discipline can minor in Latin American Studies.

Forty courses directly pertaining to Latin America are offered by the Departments of Agricultural Economics, Agronomy, Animal Science, Anthropology, Economics, Government, History, Housing and Design, Industrial and Labor Relations, Romance Studies, Rural Sociology, and Sociology. The courses constitute the basis for formulating programs leading to a graduate *minor* in Latin American Studies. Normally, five or six semester-long offerings satisfy the formal course requirements. In addition, the degree candidate minoring in Latin American Studies must exhibit proficiency in reading and speaking either Spanish or Portuguese.

Applications for scholarships, fellowships, or teaching fellowships should be made to the department in which the student is taking his major. Ford Foundation support for the Program enables the University to award approximately ten fellowships annually, each providing an academic-year stipend of \$2,250 to supplement an award of tuition and fees. The holders of the fellowships are designated Ford Foundation Fellows in Latin American Studies. Students minoring in Latin American Studies also qualify for Title VI N.D.E.A. Modern Language Fellowships. Application forms may be obtained from the Graduate School.

Summer research travel grants and support for on-campus course work during the summer are available to selected graduate students through the Latin American Studies Program. Although thesis research may be supported by the Program, support should first be sought from the Foreign Area Training Fellowship Program, the Social Science Research Council, Fulbright-Hays, the Doherty Foundation, and the Organization of American States.

Because of the considerable volume of research on Latin America currently being carried out by Cornell faculty members, students will normally be afforded the opportunity of participating in ongoing projects while in residence and will generally be expected to do field work in Latin America at some stage of their graduate training. Major research projects are under way in the fields of Andean community development, comparative economic development, fertility and population, descriptive linguistics, and urbanization.

Additional information may be obtained by writing to Donald K. Freebairn, Director, Latin American Program, Rand Hall.

## Near Eastern Studies

ADVISORY FACULTY COMMITTEE ON NEAR EASTERN STUDY: Isaac Rabinowitz, Chairman; A. Henry Detweiler, Alfred E. Kahn.

Students wishing to relate the work of their major or minor subjects to Near Eastern area or language studies should seek advice or information from the Faculty Committee on Near Eastern Studies. In a number of Fields, the University's resources for specialized graduate study and research on countries of the Near East are of considerable value. Members of the Committee can provide suggestions regarding relevant courses in various subjects, assistance in planning research on the Near East, and guidance in applying for area training or research fellowships. Inquiries should be addressed to Professor Isaac Rabinowitz, Chairman, Department of Semitic Languages and Literatures, 173 Goldwin Smith Hall.

## South Asia Program

(Bhutan, Ceylon, India, Nepal, Pakistan, Sikkim)

STAFF: Gerald Kelley, Director; Messrs. Douglas E. Ashford, Harold R. Capener, Arch T. Dotson, Gordon H. Fairbanks, Harold Feldman, James Gair, Leighton W. Hazlehurst, Michael Hugo-Brunt, Kenneth A. R. Kennedy, John W. Mellor, Stanley J. O'Connor, Morris E. Opler. The increasing importance of the peoples of the Indian subcontinent and of the role they play in world affairs enhances the need for providing opportunities in America for training and research in the field of Indic studies. The South Asia Program at Cornell, dealing primarily with India, Pakistan, Ceylon, and Nepal, is organized and equipped to help meet this need. Since 1948 it has sponsored a series of research projects on India and Ceylon, and it has trained a distinguished group of younger American and South Asian scholars in South Asian area and language studies. The Program faculty includes members from agricultural economics, anthropology, government, history of art, child development and family relationships, business and public administration, rural sociology, city and regional planning, and languages and linguistics. Sanskrit, Pali, Hindi, Urdu, Telugu, and Sinhalese are languages regularly offered at Cornell. Cornell participates in the interuniversity summer program which provides instruction in other South Asian languages and selected social sciences and humanities disciplines each summer on the campus of a member eastern university.

Qualified graduate students interested in specializing in the study of South Asia minor in Asian Studies with concentration on South Asia, in South Asian art history, or in South Asian linguistics. Advanced degree requirements for this minor are roughly comparable in terms given below. The doctoral candidate must have a readable knowledge of Hindi or, depending upon the subarea of his specialization, some other important language of South Asia.

## RESEARCH AND FIELD TRAINING

The doctoral dissertations of students in the South Asia Program are normally based on research done in India, Pakistan, Ceylon, or Nepal. Students' field research may benefit from advice and guidance in the

field by a program staff member. At least one member of the faculty of the South Asia Program has been in South Asia for each of the last several years. Cornell is a charter member of the American Institute of Indian Studies, which was organized to facilitate study and research in India by American advanced students and by faculty specializing in various aspects of Indian civilization and contemporary affairs. The University also maintains close links with a number of research agencies, programs, and institutions of higher learning, such as the Deccan College Postgraduate Research Centre, Delhi University, Osmania University (Hyderabad), and universities in Ceylon. Staff members of these institutions have provided valuable assistance to Cornell students working in India. There are opportunities for graduate students to become associated with Cornell-sponsored research in South Asia or to carry on independent research abroad. Every effort is made by the Program staff to aid qualified students to obtain financial support for a field training or research project in one of the countries of the area.

Research interests under the South Asia Program are focused largely on recent or contemporary developmental problems of the countries of the area—on changes taking place in the economic, political, social, religious, artistic, and intellectual life of the region. A long-term research project in progress in India is primarily concerned with the ramifying problems of introducing technological changes and the influence of such changes when adopted. For this research program, faculty and students in anthropology have carried on, since 1949, an extended and varied series of rural and urban community studies in several different regions of India from the Deccan into the Himalayan foothills. A major related project, the Cornell International Agricultural Development Program, which is supported by Ford Foundation funds, is concerned with the development of the entire agricultural sector of the Indian economy. With Ford Foundation support, Cornell is assisting Delhi University to become a major center in the field of linguistics. At the same time, other studies in urban renewal and regional planning, public administration, the role of government in cultural change, and recent movements in the arts and in religions and ideologies are in progress under faculty direction. Cornell is also making a special study of the Sinhalese language and of linguistic problems of Ceylon, a nation so far much neglected by American scholars. Research is also under way on Oriya and Telugu, important regional languages of India. The new nations of South Asia present so many problems for study that the areas of inquiry open to students and staff members are limited only by availability of research means.

## FELLOWSHIPS AND ASSISTANTSHIPS

Fellowship and assistantship awards are available to qualified graduate students minoring in Asian Studies with a concentration on South Asia. The South Asia Program fellowships are open to incoming graduate students with South Asia interests, and should be applied for by writing to the Director, South Asia Program, 221 Morrill Hall. These

fellowships are normally given to provide supplementary support for student research projects, at Cornell or in the field. Students in the South Asia Program are also eligible for assistantships in their major discipline departments, for fellowships and scholarships offered by the Cornell Graduate School, for National Defense Foreign Language Fellowships, and for Foreign Area Training Fellowships. Additional information on financial aid may be obtained by writing to the Director, at the address given above.

## Southeast Asia Program

**FACULTY:** John M. Allison, Benedict R. Anderson, Arch T. Dotson, John M. Echols, Frank H. Golay, Alexander B. Griswold, D. G. E. Hall, Robert B. Jones, Jr., George McT. Kahin, Stanley J. O'Connor, Robert A. Polson, Robert M. Quinn, Lauriston Sharp, James T. Siegel, John U. Wolff, O. W. Wolters.

The Southeast Asia Program possesses substantial facilities for study and research on the graduate level and provides exceptional opportunities for general or specialized work on all of Southeast Asia in various disciplines of the humanities, social sciences, and some natural sciences, as well as in interdisciplinary area seminars. Instruction in the major languages of the area is an integral part of the graduate training of the Southeast Asia Program. Much basic and pioneering research remains to be done in this area, and the Southeast Asia Program is organized and equipped to help meet such needs.

Special intensive instruction in Southeast Asian languages is available during summer sessions. Entering graduate students intending to study one of these languages are encouraged to begin such study during the summer preceding registration in the Graduate School. Inquiries should be made as early as possible to the Director of the Southeast Asia Program.

Southeast Asia Program Fellowships are available on a competitive basis to graduate students. They carry stipends of up to \$3,200 plus tuition and General Fee, and are available only to qualified candidates for advanced degrees at Cornell. Competition for these awards is open to citizens of the United States or Canada, nationals of Southeast Asian countries, and, in exceptional cases, nationals of other countries.

The fellowships are available to applicants who are able to demonstrate a serious scholarly interest in Southeast Asian studies; who show the greatest promise of becoming qualified regional experts with specialization in a relevant discipline of the humanities, social sciences, or certain natural sciences; and who are admitted to the Cornell Graduate School for advanced work in such a discipline. Previous experience in Southeast Asia or in the study of that area is not necessarily required. It is important that the applicant be able to show that advanced work in a major subject offered at Cornell, combined with work in the Southeast Asia Program, will make his future professional activities more effective; this requirement is particularly important for a student in the natural sciences.

Fellowships are normally awarded for one academic year. If the student's work during the first year has been of high caliber, reappointment is sometimes possible. In such cases, formal reapplication is expected from the student. The primary purpose of these awards is to encourage graduate students to acquire a substantial knowledge of Southeast Asia while majoring in one of the discipline fields of the Graduate School. Accordingly, they are usually offered only to students who take a minor in Asian Studies and participate fully in the Southeast Asia Program. The recipient of a fellowship may be asked to devote up to six hours a week under faculty supervision to work connected with the Program.

London-Cornell Studentships are available for advanced Ph.D. candidates in the social sciences and the humanities who have already had at least one year of resident study in the Southeast Asia Program. These fellowships are tenable for study during an academic year at the School of Economics and Political Science or the School of Oriental and African Studies in the University of London. Stipends range up to \$3,000 plus air fares and tuition and fees. London-Cornell Field Research Grants are open to Southeast Asia Program Ph.D. candidates in the social sciences and humanities after they have had appropriate training at Cornell, or at Cornell and London. They are tenable for up to twenty-two months for the purpose of dissertation research. Recipients of London-Cornell Field Research Grants may conduct research in any part of Southeast Asia. Stipends range up to \$12,000 for twenty-two months including travel and research expenses.

Cornell-Philippines Field Research Fellowships are available, under a grant from the Rockefeller Foundation, for advanced graduate students who plan to write dissertations in the social sciences or the humanities, based upon field research in the Philippines. Fellowship support is for ten to fifteen months in the Philippines and includes living costs, local transport, and roundtrip transportation from the United States for the graduate student and dependent wife or husband.

National Defense Foreign Language Fellowships, Title VI, are offered by the United States Office of Education for study during the academic year, the summer, or both. Application should be made to Sage Graduate Center, Cornell University. Information about Foreign Area Training Fellowships, administered by the Social Science Research Council, may be obtained by writing to the Foreign Area Fellowships Program, 444 Madison Avenue, New York, New York 10022. Graduate students may also apply for other fellowships, teaching fellowships, assistantships, and scholarships offered by the University and its departments.

Additional information on the Program and the various fellowships and awards may be obtained by writing to the Director, Southeast Asia Program, 108 Franklin Hall.

## Soviet Studies

COMMITTEE ON SOVIET STUDIES: George Gibian, Chairman; Urie Bronfenbrenner, M. Gardner Clark, Jack Fisher, Walter Galenson, Richard Leed, Walter Pintner, Myron Rush, George Staller.

**OTHER FACULTY MEMBERS IN SOVIET STUDIES:** Patricia Carden, Frederick Foos, Antonia Glasse, Boris Glasse, Martin Horwitz, Augusta Jaryc, Alla Novosilzova, Hugh Olmsted, Nicholas Troizkij, Marla Wykoff.

The University offers a number of courses and seminar on the Soviet Union as well as pre-1917 Russia. Instead of a separate area program, graduate students have a choice of majors and minors in the established Fields of the Graduate School. Some of the subjects focus on area specialization: Russian history, Russian literature, Slavic linguistics. Other subjects combine area specialization with a nonarea framework: comparative government, economic planning, regional planning, social psychology.

Graduate students pursuing Soviet Studies in any of these subjects are expected to attain proficiency in the Russian language either before entering the Graduate School or soon thereafter.

The University's academic activities related to Russia are coordinated by the Committee on Soviet Studies. The Committee also sponsors a colloquium for faculty members and graduate students in Soviet Studies. In the Soviet Studies Graduate Study in the John M. Olin Library, major reference works and key current periodicals from and about the U.S.S.R. are brought together.

The Committee on Soviet Studies selects a limited number of graduate students each year as research assistants. The Russian section of the Division of Modern Languages and the Department of Russian Literature also appoint several graduate students annually as teaching fellows in the Russian language. For other teaching fellowships, fellowships and scholarships, students apply directly to the Graduate School or to the department concerned. N.D.E.A. Title IV and Title VI fellowships are available in various subjects.

## FACULTY SPECIALIZATIONS

**ECONOMICS:** M. Gardner Clark, Walter Galenson, George J. Staller.

**HISTORY:** Walter M. Pintner.

**LANGUAGES AND LINGUISTICS:** Frederick Foos, Boris Glasse, Richard Leed, Mrs. Augusta Jaryc, Alla Novosilzova, Hugh Olmsted, Marla Wykoff.

**LITERATURE:** Miss Patricia Carden, George Gibian, Miss Antonia Glasse, Martin Horwitz, Hugh Olmsted.

**POLITICAL SCIENCE:** Myton Rush.

**PSYCHOLOGY:** Urie Bronfenbrenner.

**REGIONAL AND CITY PLANNING:** Jack C. Fisher.

Inquiries about fellowships and other aspects of Soviet Studies should be addressed to Professor George Gibian, Chairman, Committee on Soviet Studies, Goldwin Smith Hall.

## OTHER PROGRAMS AND CENTERS

### American Studies

COMMITTEE ON AMERICAN STUDIES: David B. Davis, Chairman; Archie R. Ammons, LeGrace G. Benson, Walter F. Berns, Jonathan P. Bishop, Stuart M. Brown, Jr., Douglas F. Dowd, Robert H. Elias, Robert T. Farrell, Heywood Fleisig, Paul W. Gates, Rose K. Goldsen, Andrew Hacker, Baxter L. Hathaway, Richard I. Hofferbert, Michael G. Kammen, Michael Kaufman, Walter LaFeber, Thomas W. Leavitt, John E. Martin, James H. Matlack, Dan E. McCall, James R. McConkey, Andrew J. Milnor, Arthur M. Mizener, Richard Polenberg, Albert S. Roe, Clinton Rossiter, Joel H. Silbey, Allan P. Sindler, Walter J. Slatoff, James M. Smith, Fred Somkin, Gordon F. Streib, S. Cushing Strout, Robin M. Williams, Jr.

Although there is no formal program leading to a degree in American Studies, candidates for the doctorate in English and history will find ample opportunity to do interdisciplinary work in conjunction with a major in American Studies within their field. There are members of the staff in both fields who are professionally trained and currently active in the study of the interrelationships of American intellectual, literary, and social history, so that a student concentrating in American literature or American history may take advantage of the freedom permitted by Graduate School regulations and, in collaboration with his special committee, readily build an individual doctoral program that systematically embraces more than a single discipline. Inquiries concerning opportunities in this area should be addressed to Professor David B. Davis, Chairman, American Studies Committee, West Sibley Hall.

### Brookhaven National Laboratory

Cornell is one of nine eastern universities participating in Associated Universities, Inc. (AUI). Operating under contract with the Atomic Energy Commission, this corporation has the responsibility for the management of Brookhaven National Laboratory. The laboratory provides unusual research facilities for studies in biology, chemistry, applied mathematics, medicine, physics, high-energy particle physics, and reactor and nuclear engineering.

Graduate students may participate in research at Brookhaven by association with Cornell staff members who are engaged in research at the laboratory. Members of a variety of science departments at Cornell are currently involved in programs at Brookhaven. The laboratory also offers temporary summer appointments to a limited number of selected graduate and undergraduate students in science or engineering.

## Center for Environmental Quality Management

The Center for Environmental Quality Management brings together the faculties of the Cornell Medical College in New York and the various colleges and schools in Ithaca to study the manifold questions of environmental health in both urban and rural settings.

Current approaches to the modification and control of the environment, in concentrating on limited objectives such as air quality control, disease control, water quality control, pest control, food sanitation, occupational health, etc., have had limited success since they have been unable to take into account the interdependence of environmental health problems. The character and the urgency of the total environmental quality problem facing us appears insoluble short of an overall approach that will enable decision makers to consider simultaneously the significant variables and relationships relevant to the management of environmental quality.

Scientific management through systems analysis has begun to make it possible to consider these multiple relationships within the framework of common objectives and subject to predetermined constraints. It provides mechanisms by which various innovations can be examined in terms of their short and long-term effects upon the environment. Such an approach provides rational bases for establishing environmental quality goals and for the allocation of scarce resources to achieve these goals.

The Center is frequently able to provide predoctoral and postdoctoral fellowships for students interested in pursuing research topics in environmental health. For information regarding specific programs, write to Professor Walter R. Lynn, Director, Center for Environmental Quality Management, 302 Hollister Hall.

## Center for Housing and Environmental Studies

The purposes of the Center for Housing and Environmental Studies are to aid and guide basic research in the field of man's shelter and environment, to facilitate graduate study, and to aid the flow of information among colleges and departments and between the University and sources of information off campus. A small central staff assists in the initiation and conduct of projects.

The facilities of the Center for Housing and Environmental Studies are available to faculty members and graduate students in all Fields. Through the Center, students who cut across traditional lines of research may draw upon the knowledge and experience of specialists in such various subject areas as design, materials, equipment, structural methods, environment, family living, economics and finance, government, and health. The Director of the Center is Professor Glenn H. Beyer, West Sibley Hall.

The Division of Urban Studies of the Center has a broad range of research projects, with concentration in the areas of regional development, planning and heuristic gaming; and also has several publication

series. The Division is under the direction of Professor Barclay G. Jones, Associate Director for Urban Studies.

## Center for Radiophysics and Space Research

The Center for Radiophysics and Space Research unites research and graduate education carried on by several academic departments in the space sciences. It furnishes administrative support and provides facilities for faculty members and graduate assistants who are engaged in space research activities, and it offers opportunity for graduate students to undertake thesis work leading to the degrees of Master of Science and Doctor of Philosophy. A student's major professor can be chosen from the following Fields in the Graduate School: Aerospace Engineering, Applied Physics, Astronomy and Space Sciences, Chemistry, Electrical Engineering, Physics.

Thesis research in the following areas is now possible:

(a) Astronomy and Astrophysics. Astronomical aspects of cosmic rays, gamma-radiation, x rays, neutrinos; cosmology; experimental studies and theory relating to the surface of the moon and the planets; processes in the interstellar gas; solar-system magnetohydrodynamics; stellar statistics; theory of stellar structure, stellar evolution, nuclear processes in stars.

(b) Atmospheric and Ionospheric Radio Investigations. Dynamics of the atmosphere; incoherent electron scattering; study of refraction, scattering, attenuation due to the inhomogeneous nature of the troposphere and ionosphere; theory and observation of propagation of radio waves in ionized media such as the ionosphere.

(c) Radar and Radio Astronomy. Distribution and classification of radio sources; radar investigations of the moon and planets; solar radio observations; studies of gaseous nebulae.

(d) Space Vehicle Instrumentation. Instrumentation relating to lunar exploration; magnetic field measurements; tenuous gas and particle flux measurements; infrared observations from rockets.

The facilities of the Center include the lunar surface and electronics laboratory on the Cornell campus, the radio astronomy and ionospheric laboratories close to Ithaca, and the Arecibo Ionospheric Observatory in Puerto Rico. At Arecibo an extremely sensitive radio telescope and an unusually powerful space radar are available for use by qualified graduate students. In addition, certain facilities of Sydney University, Australia, are available through the Cornell-Sydney University Astronomy Center (see below).

## Center for Research in Education

The Center for Research in Education provides an institutional focus within the University for the interests of faculty members from different disciplines in educational research and development. In addition, the

Center attempts to stimulate investigation of socially significant educational problems and to train students in educational research. At present, research projects in adult-child interaction and cognitive socialization, in language development and literacy, in science education, and in early school learning are under way. Research programs in mathematics education and in undergraduate education are being planned.

The Center provides predoctoral and postdoctoral training through research assistantships, training grants, and postdoctoral fellowships. For information write to Professor Alfred L. Baldwin, Director, Center for Research in Education, Rand Hall.

## Cornell-Sydney University Astronomy Center

The Center is an inter-University organization designed to create a larger pool of facilities and skills for research in astronomy and related fields than would be separately available to either university. Graduate students can be interchanged between the two institutions whenever appropriate for the research work in which they are engaged. Both universities recognize research supervision extended by the sister university, and the time spent by a student on thesis work in the sister university can be accepted toward residence requirements with the proviso that the approval of the home research supervisor is given and also that the home university bylaws are not contravened.

The facilities available through the Center, in addition to those of Cornell's Center for Radiophysics and Space Research, are the one-mile by one-mile Mills Cross situated at Hoskinstown, New South Wales; the stellar intensity interferometer situated at Narrabri, New South Wales; the Criss-Cross, the Shain Cross, and Mills Cross situated at Fleurs, New South Wales; the Wills Plasma Physics Department, the Basser Computing Department, the Falkner Nuclear Department, and the facilities of the cosmic ray group at the University of Sydney. The Center includes H. Messel, R. Hanbury Brown, W. N. Christiansen, C. B. A. McCusker, and B. Y. Mills from the University of Sydney faculty.

Further information can be obtained from Professor T. Gold, Joint Director, Cornell-Sydney University Astronomy Center, Space Science Building, Cornell University.

## Developmental Studies

Specialization in this area normally involves participation in a program jointly sponsored by the Fields of Child Development and Family Relationships, and Psychology. The program presently emphasizes cognitive development. Students interested in the program should apply to either the Field of Child Development and Family Relationships, or Psychology. Training in research skills in both Fields is recommended. Students admitted to the program fulfill the requirements of whichever Field they enter. Current research interests of the faculty

include development of language, perception, thinking, intellectual development in natural settings, conceptual and affective behavior in infancy, cognitive socialization, and biological maturation. For further information see the description of the Fields of Psychology, and Child Development and Family Relationships, or write to either Field Representative.

## Division of Biological Sciences

The Division of Biological Sciences was established in 1964 to bring together into a single administrative unit a number of investigators and teachers representing a broad spectrum of interests in basic biology. Its members hold appointments in one or more of four schools and colleges but serve the University as a whole through the Division. The Division is responsible for all the undergraduate teaching of biology, including the establishment of requirements for the major in its various branches. It also has the primary responsibility for the promotion of research in basic biology, and its members engage in graduate teaching through participation in appropriate Fields in the Graduate School Faculty. At present the following subject areas are represented by separate sections of the Division: biochemistry and molecular biology; ecology and systematics; genetics, development, and physiology; microbiology; and neurobiology and behavior. A number of graduate fellowships, teaching fellowships, research assistantships, and traineeships are available through the Division. For further information, contact Dr. Robert Morison, 201 Roberts Hall.

## Materials Science Center

The Materials Science Center (MSC) at Cornell is an interdisciplinary laboratory created to promote research and graduate student training in all phases of the science of materials. The subjects of study represented in the MSC program are applied physics, chemistry, electrical engineering, materials engineering, materials science, mechanics, metallurgy, and physics.

The extent of the benefits a graduate student may derive from the MSC program depends on the actual research he pursues. If the student chooses to follow the more conventional course of becoming a specialist in one specific area, the MSC program could help him by providing new equipment, financial assistance through research assistantships, or, in some cases, the help of a technician to carry out routine measurements.

If the student wishes to follow a program of considerably more breadth than usual in his research training, the MSC program provides an additional advantage. Several central facilities have been set up where more specialized apparatus such as crystal-growing furnaces, high-pressure equipment, x-ray and metallography equipment, electron microscopes, etc., are available to all MSC members and their students.

In addition to the equipment, expert advice on its use and the interpretation of the results will be available. In these central facilities, it is expected that the student will come in contact with students from other disciplines, resulting in a mutually profitable interaction.

The office of the Director of the Materials Science Center, Professor R. E. Hughes, is in Room 627, Clark Hall.

## Military Science, Naval Science, and Aerospace Studies

(ROTC, NROTC, and AFROTC)

The advanced course in military science (Army ROTC), naval science (Naval ROTC), and aerospace studies (Air Force ROTC) is open to graduate students who have satisfactorily completed a basic course in ROTC or who enroll in a two-year ROTC program. Successful completion of the two-year advanced ROTC course will qualify a graduate student for appointment as a Second Lieutenant in the U.S. Army, Air Force, or Marine Corps Reserve; or Ensign, U. S. Naval Reserve; or as Second Lieutenant in the Regular Army or Air Force. Interested graduate students should consult the *Announcement of Officer Education* and apply to the Professor of Military Science, the Professor of Naval Science, or the Professor of Aerospace Studies (ROTC), Barton Hall.

## Statistics Center

The methods of statistics find important applications in many diverse fields of research. It is therefore necessary that (1) subject matter specialists be able to obtain assistance in using or developing statistical theory, (2) students who intend to do research work in a particular field which makes extensive use of statistical methods receive adequate training in statistics, and (3) individuals be trained as statisticians.

The staff members of the various schools and colleges of Cornell University who are interested in the development and application of statistical methods are associated with the Cornell Statistics Center. A major responsibility of the Center is to provide a focal point to which individuals, projects, and departments may come to receive assistance and guidance with respect to the statistical aspects of research and training programs.

The Acting Director of the Center is Professor Philip J. McCarthy, Ives Hall.

## Center for Water Resources and Marine Sciences

The Center is an interdisciplinary organization serving the entire University at the graduate study and research level. Its purpose is to pro-

mote and coordinate a comprehensive program in water resources planning, development, and management in such areas as the sciences, engineering, agriculture, law, economics, government, regional planning, and public health.

Its responsibilities are to undertake water resources research in engineering, in the physical, biological, and social sciences, and in the humanities; to encourage and contribute to graduate studies in water resources; to coordinate research and training activities in water resources; to encourage new combinations of disciplines in research and training which can be brought to bear on water resource problems; to disseminate the results of research; and to develop and operate central facilities which may be needed to serve participants in research and training.

Correspondence concerning the Center should be directed to Professor L. B. Dworsky, Director, Center for Water Resources and Marine Sciences, Hollister Hall.

Correspondence related to graduate study in the Field of Water Resources should be directed to the Field Representative, Professor C. D. Gates, Hollister Hall.

## SPECIAL FACILITIES AND SERVICE ORGANIZATIONS

### New York State Agricultural Experiment Station at Geneva

The New York State Agricultural Experiment Station was established in 1880 to promote agriculture through scientific investigations and experimentation. It is located at Geneva, fifty miles from Ithaca, and has been under the administration of Cornell University since 1923.

Professors on the Geneva staff are eligible to serve as members of the Special Committees of graduate students along with professors on the Ithaca campus of the University. Normally the graduate training provided at Geneva consists of research experience and supervision of the student's work on a thesis problem. The formal course work part of the student's training program is given on the Ithaca campus. Students who plan to do part of their graduate work at Geneva should correspond with their major advisers or with the Dean of the Graduate School concerning regulations as to residence, Special Committees, etc.

The Station is equipped to care for graduate students in certain specific lines of research, viz., chemistry, economic entomology, food technology, microbiology, plant pathology, pomology, seed investigations, and vegetable crops. Ample facilities are available for graduate research under laboratory, greenhouse, pilot plant, insectary, orchard, and other field conditions.

Certain phases of the investigations now being conducted at the Station and other problems for which the facilities of the Station are suitable may be used as thesis problems by graduate students.

The Director is Professor D. W. Barton, who may be addressed at the New York State Agricultural Experiment Station, Geneva, N.Y. 14456.

## Office of Computer Services

The principal computing facility at Cornell is an IBM 360 Model 65 located at Langmuir Laboratory at the Cornell Research Park. The system is equipped for remote access of several kinds, and the operating system is designed so that very few users find it necessary to visit Langmuir. The primary terminals are high-speed reader-printers located in Upson, Clark, and Warren Halls. While these are remote job-entry and delivery devices rather than conversational terminals, they permit convenient access, job turnaround-time in terms of minutes, and the use of on-line files. Each of these terminals is the core of a small computing center, with auxiliary equipment, consulting assistance, reference material, and work space. In addition to these high-speed terminals, teletypewriter terminals are available to individual projects that require interactive capability.

Two IBM 1800 computers that control various real-time laboratory devices are also linked directly to the 360/65. These machines provide graphical input-output capability and an analog-digital interface.

This computing system is busy but not saturated, and use by graduate students is encouraged.

The Office of Computer Services is responsible for the operation of this system and for the provision of consulting and programming assistance. The Office cooperates with the Department of Computer Science in providing courses in programming and computing techniques. Both organizations employ a number of graduate students on assistantships and part-time appointments for this work.

For further information write to the Office of Computer Services, Langmuir Laboratory.

## University Press

Cornell University Press, founded by Andrew D. White in 1869, was the first university press in America and is among the leaders in number of volumes published annually. The Press publishes scholarly books on nearly every academic subject, serious nonfiction of general interest, and advanced or experimental textbooks for universities. The imprint of Comstock Publishing Associates, a division of the Press, is placed on certain books in the biological sciences. The Press also publishes a paperbound series, Cornell Paperbacks. More than 20 per cent of the books published by the Press in recent years were written by members of the Cornell University faculty. All printing for the Press is done under contract by various book manufacturing firms; the Press has no production facilities of its own.

## Visual Aids

The University owns and operates the Photo Science Studios, which create or cooperate in the creation of photographic studies and visual aids of all kinds.

The extension services of the New York State Colleges, which form integral parts of the University, disseminate knowledge through an intensive program of publication, photography, and recording supervised by professional staffs. Materials produced by graduate students may find outlets through these channels.

## Other Research Units

Some other research units allied with the University, either as wholly owned and operated divisions or as wholly or partially autonomous organizations with which the University has a working agreement, are the Sloan-Kettering Cancer Research Institute in New York City, through the Graduate School of Medical Sciences, and the Veterinary Virus Research Institute in Ithaca.

Cornell is also one of fourteen founding members of the University Corporation for Atmospheric Research which, under National Science Foundation support, operates the National Center for Atmospheric Research at Boulder, Colorado. In addition to Brookhaven National Laboratory, Cornell, as a member of Associated Universities, Inc., has access to the facilities of the National Radio Astronomy Observatory in Greenbank, West Virginia.

Further opportunities for formal study, field work, and independent research by Cornell graduate students are available in many institutions, laboratories, and libraries both in the United States and in other countries. For example, the Cornell-Harvard Archaeological Exploration at Sardis, Turkey, and the Museum of Northern Arizona at Flagstaff, Arizona, both provide opportunities for field research related to doctoral work of Cornell graduate students. Information on that kind of arrangement is available directly from the Field Representatives.

## GRADUATE SCHOOL OF MEDICAL SCIENCES

The opportunity for graduate work leading to advanced general degrees was first offered in the Medical College in 1912 in cooperation with the Graduate School of Cornell University. In June 1950, the trustees of Cornell University entered into an agreement with the Sloan-Kettering Institute for Cancer Research whereby a new division of the Medical College, namely, the Sloan-Kettering Division, was created for the purpose of offering additional opportunities for graduate study toward advanced degrees, thus extending the areas of the basic sciences.

That expansion of the New York City component of the Graduate School resulted in the establishment in January 1952, of the Graduate School of Medical Sciences which, with the approval of the faculty of

the Graduate School of Cornell University, was given the full responsibility for administrative matters related to the advanced general degrees granted for study in residence at the New York City campus of Cornell University.

**DEGREES.** The general degrees of Ph.D. and M.S. are awarded for advanced study and scholarly, independent research in the fields of anatomy, biochemistry, biomathematics, biophysics, biostatistics, cell biology, genetics, microbiology, neurobiology and behavior, pharmacology, and physiology.

**FACILITIES.** The facilities for graduate work at the Graduate School of Medical Sciences include those of the Medical College and of the Sloan-Kettering Division. The five buildings of the Medical College, extending along York Avenue from 68th to 70th Street in New York City, contain the lecture rooms, student laboratories, library, and research facilities for graduate and undergraduate work. The Sloan-Kettering Division is located in the Sloan-Kettering Institute and the Kettering Laboratory on East 68th Street in New York City, and in the Walker Laboratory in Rye, New York. The special facilities and experienced investigators of the Sloan-Kettering Division offer ample opportunity for advanced graduate work in the basic science aspects of research related to cancer and allied diseases.

**FINANCIAL ASSISTANCE.** Predoctoral fellowships are available to qualified applicants. The fellowships may be renewed yearly providing the academic performance of the fellowship holders is satisfactory. Teaching fellowships and research assistantships are available to qualified graduate students in some departments of the Medical College. In addition to a stipend, the costs of tuition and fees are defrayed for those students receiving financial assistance.

**FURTHER INFORMATION.** Information on financial assistance and the entire program of the Graduate School of Medical Sciences is provided in the *Announcement of the Graduate School of Medical Sciences*. Requests for that Announcement should be addressed to the Graduate School of Medical Sciences, Cornell University Medical College, 1300 York Avenue, New York 10021.

## FIELDS OF INSTRUCTION

**REPRESENTATIVES.** Since instruction in the Graduate School is primarily individual, those interested in becoming students are encouraged to communicate with individual members of the faculty with whom they may want to study. Personal interviews in advance of formal application for admission are especially encouraged. For the benefit of those who are not acquainted with appropriate members in the Field or Fields of their interest, each Field has selected a representative, as director of graduate studies, to whom inquiries may be addressed.

### AGRONOMY

**Faculty:** Martin Alexander, W. H. Allaway, Richard W. Arnold, David R. Bouldin, Nyle C. Brady, Marlin G. Cline, Jeffrey E. Dawson, Bernard E. Dethier, Matthew Drosdoff, William B. Duke, Reeshon Feuer, George R. Free, David L. Grunes, Joseph F. Hodgson, W. Keith Kennedy, Harry A. Kerr, Ralph E. Krenzin, Joe Kubota, Douglas J. Lathwell, Edgar R. Lemon, Dean L. Linscott, Robert F. Lucey, Harry A. MacDonald, Robert D. Miller, Hugh F. Mulligan, Robert B. Musgrave, Ralph L. Obendorf, Gerald W. Olson, Michael Peech, William S. Reid, Thomas W. Scott, Robert R. Seaney, Earl L. Stone, Jr., Madison J. Wright, Paul J. Zwerman.

**At Geneva:** Benjamin E. Clark, Willard F. Crosier, Anwar A. Khan, LeRoy W. Nittler, M. T. Vittum.

**Field Representative:** Douglas J. Lathwell, 803 Bradfield Hall.

#### MAJOR AND MINOR SUBJECTS

Field Crop Science	Seed Technology (M.S. only when
Meteorology	a major)
	Soil Science

**ADMISSION REQUIREMENTS.** Scholastic records of students applying for admission to graduate work in Agronomy are judged by the extent and quality of previous training in chemistry, biological sciences, physics, mathematics, and geology, emphasis depending on the intended major subject. The Graduate Record Examination is strongly recommended. A passing grade in a test of English proficiency is required of applicants whose native language or previous medium of instruction was not English.

Plant Breeding, which at many institutions is included in Agronomy, is a separate but closely related Field at Cornell. Students primarily interested in plant breeding can apply to that Field, or can choose it as a minor subject.

Ordinarily, students complete a Master's program before being accepted for a doctoral program, but direct admission to a doctoral program is permitted when students are exceptionally well prepared.

**LANGUAGE REQUIREMENTS.** There is no general language requirement for either the M.S. or the Ph.D. in the Field. A candidate's Special Committee may require language to be included in the student's program.

**EXAMINATION REQUIREMENTS.** The Graduate School requires all Ph.D. candidates to take an Admission to Candidacy and a Final Thesis Examination. These are described on p. 12 of this *Announcement*.

**OPPORTUNITIES FOR GRADUATE STUDY AND RESEARCH.** Since 1968, the Field has occupied one of the most modern and diversified agronomic research facilities in the world. An air-conditioned eleven-story research tower and adjoining wings incorporate fully-equipped laboratory, teaching, office, and supporting spaces for work in field crop science, soil science, meteorology, and seed technology. The Field of Plant Breeding and the Section of Genetics, Development, and Physiology of the Division of Biological Sciences occupy a part of the tower and wings.

Graduate students have access also to newly-constructed growth chambers and greenhouse facilities on the campus. The Agronomy Department operates three main field stations near Ithaca, representative of major agricultural regions of the state, to provide sites and equipment for field experimentation.

Seed technology studies are conducted also in new quarters at Geneva; students may arrange to work there while enrolled at Ithaca. Some members of the Field are staff members at the U.S. Plant, Soil, and Nutrition Laboratory (USDA) on the campus.

Minors may be elected from a large number of Fields. In addition to physical, biological, and agricultural social sciences, these include water resources, soil engineering, soil and water engineering, and international agricultural development.

A limited number of students can do most or all of their research overseas under provisions of special agreements between Cornell and certain other institutions.

## Special Interests of the Faculty

### FIELD CROP SCIENCE AND SEED TECHNOLOGY

Crop chemistry: Professors Duke, MacDonald, Obendorf.

Crop ecology: Professor Musgrave.

Crop physiology: Professors Duke, MacDonald, Musgrave, Obendorf, and Wright.

Crop preservation: Professors Musgrave and Wright.

Crop production: Professors Krenzin, Lucey, and Seaney.

Seed technology: Professors Clark, Crosier, Khan, MacDonald, and Nittler.

Weeds and herbicides: Professors Duke and Linscott.

### METEOROLOGY

General meteorology: Professor Dethier.

Climatology and microclimatology: Professor Dethier.

Agricultural micrometeorology: Professor Lemon.

### SOIL SCIENCE

Soil chemistry: Professors Dawson, Grunes, Hodgson, and Peech.

Soil fertility: Professors Allaway, Bouldin, Lathwell, Reid, Scott, and Vittum.

Soil microbiology: Professor Alexander.

Soil morphology, genesis, and cartography: Professors Arnold, Cline, Feuer, Kubota, and Olson.

Soil physics: Professors Lemon and Miller.

Soil and water conservation: Professors Free, Kerr, and Zwerman.

- Soil and water studies in aquatic environments: Professors Bouldin, Dawson, Lathwell, and Mulligan.  
 Soils of the tropics: Professor Drosdoff.  
 Forest soils: Professor Stone.  
 Organic soils: Professor Dawson.

## Courses

### 401. GEOGRAPHY AND APPRAISAL OF SOILS OF THE TROPICS

Spring term. Credit three hours. Professor Drosdoff.

Character, geographic distribution, production potential, and management requirements of soils of tropical rain forests, tropical savannahs, tropical deserts, and tropical highlands, including soils under paddy culture. Emphasis is on the identification of soil properties associated with the principal kinds of soil, bases for predicting their occurrence, and bases for their interpretation in terms of production potential and management requirements. Lectures are used to introduce principles whose applications are treated by problem-solving, discussion, and independent study of the literature. Individuals who have not had the equivalent of Agronomy 301 will be expected to become familiar with standard nomenclature of field properties of soil by self-study.

### 402. CHEMICAL METHODS OF SOIL ANALYSIS

Spring term. Credit three hours. Prerequisites: Agronomy 200 and Chemistry 236 or their equivalent. Professor Peech.

Lectures, laboratory exercises, and demonstrations designed to familiarize the student with different chemical techniques for studying soils.

### 403. ORGANIC SOILS

Fall term. Credit two hours. Offered in alternate years. Prerequisite: Agronomy 200. Professor Dawson.

Physical and chemical properties of organic soils used for crop production and soil conditioning. One all-day Saturday field trip.

### [404. FOREST SOILS]

Fall term. Credit two hours. Given in alternate years. Prerequisite: Agronomy 200. Professor Stone. Not offered in 1969-70.

Ecology of forest soil including relationship to soil development, forest land use, and hydrology. Occasional field trips to be arranged.

### [405. SOIL MINERALOGY]

Fall term. Credit three hours. Given in alternate years. Prerequisites: Agronomy 200 and one year each of college chemistry and physics, or consent of the instructor. Not offered in 1969-70.

A study of the minerals found in soils, their structures, properties, and weathering characteristics, and a study of some methods used in making mineralogical determinations.

### 408. SOIL PHYSICS, LABORATORY

Fall term. Credit one hour. Professor Miller.

Exercises in physical methods used in soil investigations.

### 422. TROPICAL AGRICULTURE

Spring term. Credit two to four hours, depending upon student preparation,

participation, and related courses taken. Prerequisites: a course covering elementary botany and permission of the instructor. Professor MacDonald.

Designed to provide some knowledge and understanding of the tropical environment and its agriculture. Topics covered include the agriculture, principal crops, and cropping problems of the tropics and subtropics. Particular stress is given to (a) agricultural ecology, (b) agricultural patterns, traditions, and problems, (c) economic crops, their botany, adaptation, cultural requirement, improvement, management, protection, production, and use, and (d) resources, limitations, and opportunities for tropical agricultural development and improvement. Independent study of the literature is encouraged and facilitated. Lectures supplemented by illustrations, demonstrations, and discussions.

#### 431. AQUATIC PLANT ECOLOGY AND MANAGEMENT

Fall term. Credit three hours. Prerequisites: Biological Sciences 101-102 or 103-104 or the equivalent, and permission of the instructor. Assistant Professor Mulligan.

Environmental factors affecting the growth and distribution of freshwater plants as a basis for their management. Includes taxonomy and life cycles of common emergent, submerged, and floating plants. Several field trips will be conducted during laboratory periods.

#### 450. SPECIAL TOPICS IN SOIL SCIENCE

Fall and spring terms. Credit one to six hours. Staff.

The topics to be treated will be arranged at the beginning of each term for individual self-study or for group discussions.

#### 451. SPECIAL TOPICS IN FIELD CROP SCIENCE

Fall and spring terms. Credit one to six hours. Staff.

The topic to be studied will be arranged at the beginning of each term for individual self-study or for group discussions.

#### 461. REGIONAL AGRONOMY STUDIES

Fall term. Credit four hours. Prerequisites: Agronomy 111 and 200 or permission of the instructor. Enrollment limited and must be approved by the instructor in charge during preregistration. A three weeks' field study trip will take place during the preceding August. Enrollment in consecutive years permitted. Crops and soils staff.

Study of crops, soils, agriculture, agricultural institutions, and agricultural industries of major agricultural regions of the United States. The purpose is to give breadth of understanding of the Field of Agronomy and perspective of its applications. Study tour covers different major regions of the United States in consecutive years. During the summer field study trip, each student is required to keep complete notes of basic subject matter for seminars, discussion, and assignments during the fall semester. A written report of the field trip is required of each student. Bus transportation is provided. Students must finance meals and lodging, costs of which will be held to a minimum.

#### 481. SPECIAL STUDIES IN SOILS OF THE TROPICS

Spring term. Credit three hours. Prerequisites: Agronomy 200 and 301 or equivalent and approval of the instructor. Enrollment limited. Professor Drosdoff.

An eight-day field trip to a tropical area will take place during the preceding January intersession. Preregistration is required by December 1. Consult the professor in charge regarding financial arrangements.

**501. SOIL CHEMISTRY**

Fall term. Credit three hours. Given every other year alternating with Agronomy 507. Prerequisites: Agronomy 200 and a one-year course in introductory physical chemistry, or consent of the instructor. Professor Peech.

Chemical and mineralogical composition and chemical properties of soils, with emphasis on ionic equilibria in soils.

**[503. MORPHOLOGY, GENESIS, AND CLASSIFICATION OF SOILS]**

Spring term. Credit three hours. Given every other year, alternating with Agronomy 524. Prerequisite: permission of the instructor. Associate Professor Arnold. Not offered in 1969-70.

Principles of soil classification, reactions and processes of soil genesis, and development and significance of major groups of soils of the world. One all-day field trip will take place on a date to be arranged.

**506. ADVANCED SOIL MICROBIOLOGY**

Fall term. Credit one hour. Prerequisite: Agronomy 306 or permission to register. Associate Professor Alexander.

Discussions of current topics in special areas of soil microbiology. Particular attention is given to biochemical problems in microbial ecology.

**[507. SOIL PHYSICS, LECTURES]**

Fall term. Credit three hours. Given every other year alternating with Agronomy 501. Prerequisites: Agronomy 200 and one year of college physics, or permission of the instructor. Professor Miller. Not offered in 1969-70.

A study of physical properties and processes of soil, with emphasis on basic principles.

**[513. CROP ECOLOGY]**

Spring term. Credit two hours. Given every other year. Prerequisites: Agronomy 200, 111, and Biological Sciences 240. Class meetings to be twice weekly for the first eight weeks of the semester for two hours per meeting. Professor Musgrave. Not offered in 1969-70.

An extension of Agronomy 313 and a study of special techniques used to obtain and analyze physiological data on crop plant responses to environmental conditions occurring in the field.

**514. GRASSLANDS AND GRASSLAND RESEARCH**

Fall term. Credit three hours. Offered in alternate years. Prerequisites: Agronomy 312, Plant Breeding 200, and Biological Sciences 240, or their equivalents, and permission to register. Professor MacDonald.

A study of ecological factors underlying the development, maintenance, and management of different grassland types for different uses, and the principles and practices of grassland and forage-crop investigations. Different grassland species, types, and associations will be discussed in relation to adaptation, production, and use. Emphasis will be on research.

**524. SOIL FERTILITY, ADVANCED COURSE**

Spring term. Credit three hours. Given every other year alternating with Agronomy 503. Prerequisite: a major or minor in agronomy or permission of the instructor. Associate Professor Bouldin.

A study of selected topics in soil-plant-fertilizer relationships with emphasis on concepts of soil fertility, interpretation of experimental data, and soil-fertilizer chemistry.

**560. RESEARCH IN SOIL SCIENCE**

Fall and spring terms. All members of the professional staff.

**561. RESEARCH IN FIELD-CROP PRODUCTION**

Fall, spring, and summer terms. All members of the professional staff.

**690. SEMINAR**

Fall and spring terms. Required of graduate students majoring or minoring in the Department.

**METEOROLOGY**

**411. INTRODUCTORY DYNAMIC METEOROLOGY**

Fall term. Credit three hours. Prerequisites: one year each of calculus and physics.

Properties of air, hydrostatic stability, and convection, radiation in the earth's weather system, and atmospheric circulations.

**412. INTERMEDIATE DYNAMIC METEOROLOGY**

Spring term. Credit three hours. Prerequisite: Agronomy 411 or permission of the instructor.

Consideration of the atmospheric part of the earth's weather system. Review of attempts to find the governing relations in useful form and to identify, measure, and compute the significant parameters.

**[413. MICROMETEOROLOGY]**

Fall term. Credit three hours. Given in even-numbered years. Prerequisites: one year each of calculus and physics. Not offered in 1969-70.

Weather and climate near the ground, considered from the local point of view. Interaction of plants and their local physical environment.

**415. HYDROMETEOROLOGY**

Spring term. Credit three hours. Given in odd-numbered years. Prerequisites: one year of calculus and physics. Professor Dethier.

Atmospheric part at the hydrologic cycle—evaporation, precipitation, and transport.

**550. SPECIAL TOPICS IN METEOROLOGY AND CLIMATOLOGY**

Fall or spring term. Credit one or more hours. Prerequisite: permission of the instructor. Staff.

Study of meteorological topics more advanced than or different from those in other courses. Subject matter depends on the background and desires of those enrolling.

**562. RESEARCH IN METEOROLOGY**

Fall and spring terms. Credit one or more hours. Thesis research. Staff.

**691. SEMINAR IN METEOROLOGY**

Not offered every semester. Prerequisite: permission of the professor in charge. Staff.

Subjects for the seminar will be announced well in advance.

## ANATOMY

(See pp. 51 and 102.)

## ANIMAL BREEDING

Faculty: Robert W. Bratton, J. H. Bruckner, Randall K. Cole, Robert H. Foote, Charles R. Henderson, Robert E. McDowell, Paul D. Miller, L. Dale Van Vleck.

Field Representative: C. R. Henderson, Morrison Hall.

### MAJOR AND MINOR SUBJECTS

Animal Breeding

Animal Genetics

Students entering a program of study in the areas of animal breeding and genetics are expected to have had good basic undergraduate training in biology, chemistry, and mathematics. Previous experience with large animals or with poultry is desirable but not absolutely essential.

There is no specific foreign language requirement in the Field, but individual faculty members of the Field may require one or more languages depending upon the student's area of specialization and previous training in languages.

The Admission to Candidacy and Final Thesis Examinations required by the Graduate School are described on p. 12 of this *Announcement*.

Special interests of the faculty are as follows:

Professors Henderson, Miller, and Van Vleck: research and teaching, statistical genetics, with particular emphasis on selection programs for improvement of large animals.

Professors Bratton and Foote: research and teaching in reproductive physiology and related areas, and the use of various techniques in the genetic improvement of populations.

Professor McDowell: research and teaching in livestock breeding in the tropics.

Professors Bruckner and Cole: research in the area of poultry genetics.

Superior facilities are available for graduate student training in each of these areas. Students are expected to participate actively in these research programs and generally are provided assistantships.

## Courses

ANIMAL SCIENCE 420. PROBLEMS IN GENETICS OF ANIMAL BREEDING

ANIMAL SCIENCE 520. EXPERIMENTAL METHODS IN QUANTITATIVE GENETICS AND ANIMAL BREEDING

POULTRY SCIENCE 420. POULTRY GENETICS

In addition, faculty members assist in two seminars: Animal Science 601 and Poultry Science 609.

## ANIMAL SCIENCE

Faculty: Warren F. Brannon, Robert W. Bratton, H. Wilmot Carter, Carl E. Coppock, J. Murray Elliot, Robert H. Foote, William Hansel, Charles R. Henderson, Harold F. Hintz, Douglas E. Hogue, John K. Loosli, Robert E. McDowell, Alexander M. Meek, William G. Merrill, John I. Miller, Paul D. Miller, Ellis A. Pierce, Wilson G. Pond, J. Thomas Reid, Glen H. Schmidt, Samuel T. Slack, Sedgwick E. Smith, Robert W. Spalding, James R. Stouffer, Hugh F. Travis, George W. Trimberger, Kenneth L. Turk, Peter J. Van Soest, L. Dale Van Vleck, Willard J. Visek, Richard G. Warner, George H. Wellington.

Field Representative: J. K. Loosli, 149 Morrison Hall.

### MAJOR AND MINOR SUBJECTS

Animal Breeding  
Animal Nutrition

Animal Science  
Dairy Husbandry

To be admitted into graduate study in the Field of Animal Science a student should have demonstrated a high order of scholarship at the undergraduate level, should have had a good selection of animal science courses, and as many physical science and biology courses as possible.

There is no Field requirement regarding foreign languages; the choice of a foreign language is left to the individual's Special Committee.

No particular examinations are required by the Field of Animal Science. The Admission to Candidacy and Final Thesis Examinations required by the Graduate School are described on p. 12 of this *Announcement*.

## Research and Study Opportunities

The Field of Animal Science is well staffed and equipped to offer research and study opportunities in the following areas of specialization:

Animal Breeding: Professors Bratton, Foote, Henderson, P. D. Miller, and Van Vleck.

Animal Nutrition: Professors Elliot, Hintz, Hogue, Loosli, Merrill, Pond, Reid, Smith, Visek, and Warner.

Animal Physiology: Professors Bratton, Foote, Hansel, McDowell, Schmidt, Travis, Van Soest, and Visek.

Beef Husbandry: Professor J. I. Miller.

Dairy Husbandry: Professors Carter, Coppock, Elliot, Meek, Merrill, Schmidt, Slack, Spalding, Trimberger, and Turk.

Meats: Professors Stouffer and Wellington.

Sheep Husbandry: Professors Brannon and Hogue.

Swine Husbandry: Professors Pierce and Pond.

### FINANCIAL AID

F. B. Morrison Fellowship in Livestock Feeding: \$2,000 plus tuition and general fees.

## Courses

### 400. LIVESTOCK PRODUCTION IN THE TROPICS

Spring term. Credit three hours. Prerequisite: Animal Science 100, 112, or 220, or permission of the instructor. Professor McDowell.

A discussion of the present and potential roles of domesticated animals as a source of food, power, and fiber in tropical areas of the world. The effects of climate on animal performance; the physiology of heat regulation in animals; problems of providing feed supplies in the tropics; systems of breeding; management practices as they affect reproductive performance; animal health and performance traits; the relative efficiency of livestock in the tropics; and economic consideration in the production of livestock products will be summarized.

#### 401. SPECIAL STUDIES IN LIVESTOCK OF THE TROPICS

Spring term. Credit three hours. Prerequisites: Animal Science 220, 400, 410 and Biological Sciences 413, or permission of the instructor. Enrollment limited. Professor McDowell.

Initial briefings will be at end of examination week of the fall term followed by an eight- or nine-day field study trip to a tropical area during January intersession. Pre-registration required by December 1. Consult professor in charge regarding financial arrangements for travel and other course requirements.

#### 410. PRINCIPLES OF ANIMAL NUTRITION

Fall term. Credit three or four hours. Prerequisites: a course in human or veterinary physiology, and a course in organic chemistry or biochemistry, or permission of the instructor. Professor Loosli, Associate Professor Nesheim, Assistant Professor Hintz.

The chemistry and physiology of nutrition and the comparative nutritive requirements for maintenance, growth, reproduction, egg production, and lactation.

#### BIOLOGICAL SCIENCES 414. MAMMALIAN PHYSIOLOGY

(Consult the course listing in the *Announcement of the College of Agriculture*.)

#### 420. QUANTITATIVE ANIMAL GENETICS

Fall term. Credit one, three, or four hours. Prerequisite: Animal Science 220, Biological Sciences 281, or permission of the instructor. S and U grades optional. Associate Professor Van Vleck.

A consideration of the problems involved in the improvement of animals, especially farm animals, through the application of the theory of quantitative genetics with emphasis on the selection index.

The purpose of the optional (arranged) hour is to give graduate students and qualified undergraduates an introduction to methods of research in quantitative genetics and animal breeding.

#### 427. FUNDAMENTALS OF ENDOCRINOLOGY

Fall term. Credit four hours. Prerequisite: a course in human or veterinary physiology or permission of the instructor. Professor Hansel.

A general course in the physiology of the endocrine glands and the roles played by each hormone in the regulation of normal body processes.

#### 451. PHYSIOLOGY AND BIOCHEMISTRY OF LACTATION

Spring term. Credit three hours. Given if ten or more students register. Prerequisite: a course in physiology or Animal Science 427. Associate Professor Schmidt.

An advanced course in the anatomy of the mammary gland, the physiological mechanisms of milk secretion, and the biochemical synthesis of milk constituents in laboratory and farm animals.

490. MEAT TECHNOLOGY

Spring term. Credit three hours. Prerequisite: Animal Science 290 or permission of the instructor. Professor Wellington.

The character of muscle as a food, muscle structure, meat product formulations and production, methods for meat product quality control, product testing and improved meat packaging. The basic principles of meat preservation, processing, and meat product development through laboratory demonstration and practice in the pilot meat plant in Morrison Hall.

500. RESEARCH

Fall and spring terms. Credit by arrangement. All members of Departmental staff.

ADVANCED NUTRITION SERIES

(Consult the course listing in this *Announcement* for the Field of Nutrition.)

NUTRITION 510. SPECIAL TOPICS IN ANIMAL NUTRITION

NUTRITION 511. LABORATORY WORK IN ANIMAL NUTRITION

520. EXPERIMENTAL METHODS IN QUANTITATIVE GENETICS AND ANIMAL BREEDING

Fall term. Credit three hours. Prerequisite: Plant Breeding 514 or a course in mathematical statistics. Professor Henderson.

Estimation of genetic and environmental parameters required to design efficient selection programs. Particular emphasis is given to interpretation of experimental and survey data with unequal subclass numbers and to prediction of genetic progress resulting from alternative selection methods.

601. SEMINAR IN ANIMAL SCIENCE

Fall and spring terms. Credit one hour. Required of all graduate students taking either a major or a minor subject in animal science. Staff.

610. SEMINAR IN ANIMAL REPRODUCTION AND ENDOCRINOLOGY

Spring term. No credit. Open to graduate students with majors or minors in animal physiology.

NUTRITION 619. SEMINAR IN ANIMAL NUTRITION

Fall term. Credit one hour. M 4:30.

## BIOCHEMISTRY

(See also the listing under Medical Sciences, p. 102 of this *Announcement*.)

Faculty: Joseph M. Calvo, Louise J. Daniel, Stuart Edelstein, June Fessenden-Raden, James L. Gaylor, Quentin H. Gibson, Richard J. Guillory, Gordon G. Hammes, Leon A. Heppel, George P. Hess, Robert W. Holley, André T. Jagendorf, Elizabeth B. Keller, Richard E. McCarty, Donald B. McCormick, A. Leslie Neal, Walter L. Nelson, Efraim Racker, Gottfried Schatz, Harold A. Scheraga, John F. Thompson, David C. Wharton, Harold H. Williams, David B. Wilson, John F. Wootton, Lemuel D. Wright, Ray Wu, Roger G. Young, Donald B. Zilversmit.

Field Representative: Ray Wu, G-15 Wing Hall.

### MAJOR AND MINOR SUBJECT

Biochemistry

**ADMISSION REQUIREMENTS.** Prior training in the physical sciences should include calculus, physics, and chemistry sequences through introductory physical chemistry; some knowledge of the basic principles of biology is desirable, but this can, if necessary, be acquired as part of the course of study to be prescribed.

**LANGUAGE REQUIREMENTS.** There is no language requirement for the Master's degree. For the Ph.D. degree, the requirement is proficiency in two languages (German, French, Russian, Japanese) or the substitution of a third minor subject for *one* of the two language requirements.

For foreign students whose native language is not English, only one of the above languages is required.

**MINOR SUBJECTS.** Appropriate minor subjects may be chosen from among those offered in biological sciences, chemistry, physics, and mathematics.

**EXAMINATIONS.** Ph.D. candidates are expected to schedule an oral qualifying examination shortly after selection of a permanent committee, the oral Admission to Candidacy Examination upon completion of the subject matter recommended by the Special Committee, and an oral examination on the thesis and related material.

## Research and Study Opportunities

A wide variety of research opportunities is provided in modern, well-equipped laboratories. The research specializations of the faculty are summarized as follows:

Joseph M. Calvo: control of metabolic pathways in bacteria; bacterial genetics.

Louise J. Daniel: biochemical functions of vitamins B<sub>12</sub> and folic acid, inter-relationship of vitamins and trace elements.

Stuart J. Edelstein: structure and function of polypeptides and proteins.

June Fessenden-Raden: enzymes in oxidative phosphorylation, immunological approaches to oxidative phosphorylation and membrane structure.

James L. Gaylor: biosynthesis of sterols and steroid hormones, control mechanisms of sterol biosynthesis.

Quentin H. Gibson: haemoproteins, flavoproteins, rapid reaction spectrophotometry, and physical methods in enzyme kinetics.

Richard J. Guillory: bioenergetics of muscle contraction.

Gordon G. Hammes: biophysical chemistry, especially enzyme kinetics and mechanisms.

Leon A. Heppel: structure and metabolism of nucleic acids, cell permeability in microorganisms.

George P. Hess: protein-mediated reactions, biological specificity and control mechanisms.

Robert W. Holley: biochemistry of nucleic acids.

André T. Jagendorf: electron transport and phosphorylation mechanisms in chloroplasts, synthesis of chloroplast proteins and their physiological controls.

Elizabeth B. Keller: enzymes, cofactors, and ribosomes in protein biosynthesis.

Richard E. McCarty: photosynthetic phosphorylation and electron transport.

Donald B. McCormick: enzymes concerned with transformation of vitamins and coenzymes.

A. Leslie Neal: metabolism of plant pathogenic organisms and malignant cells.

Walter L. Nelson: biochemical mechanisms associated with functional states of cells.

Efraim Racker: mechanism of enzyme action, control mechanism, structure and function in mitochondria and chloroplasts, mechanisms in bioenergetics.  
Gottfried Schatz: yeast mitochondria synthesis.

Harold A. Scheraga: physical chemistry of proteins.

John F. Thompson: nitrogen and sulphur metabolism of plants.

David C. Wharton: cytochrome oxidase, metalloenzymes, electron transport.

Harold H. Williams: biochemistry of proteins and amino acids, selenium metabolism in microorganisms.

David B. Wilson: biochemical genetics, physical chemistry of enzymes.

John F. Wootton: enzyme chemistry, relationships between structure and function.

Lemuel D. Wright: biosynthesis of biologically active compounds, mevalonic acid metabolism, biotin metabolism.

Ray Wu: nucleotide sequence of phage DNA, control of enzyme and DNA synthesis in mammalian cells.

Roger G. Young: mechanism of action of insecticides, fat and wax metabolism of insects.

Donald B. Zilversmit: mechanism of fat absorption, lipid transport, cell membranes.

Combined graduate programs may be arranged with the following members of the staff of the Geneva Experiment Station: D. B. Hand, F. A. Lee, L. M. Massey, Jr., L. R. Mattick, R. S. Shallenberger, J. P. VanBuren.

## Courses

All courses carry Biological Sciences numbers.

### 531-532. GENERAL BIOCHEMISTRY, LECTURES

Fall and spring terms. Credit four hours a term. Prerequisite: Chemistry 358 and Physical Chemistry, or permission of instructor. Lectures, M W F S 9:05.

An integrated treatment of the fundamentals of biochemistry. Fall semester: proteins, enzymes and the nature of enzymatic catalysis; carbohydrate metabolism; energetics. Assistant Professor Calvo and staff. Spring semester: nitrogen metabolism; lipid metabolism; biosynthesis of macromolecules. Associate Professor Guillory and staff.

### 533. GENERAL BIOCHEMISTRY, LABORATORY

Fall term. Credit three hours. Prerequisites: Chemistry 358 and 388 or 390. Must be taken with or following Course 531. Laboratory, T or Th 9:05-4:25. One discussion period to be arranged. Professor Nelson and Assistant Professors McCarty and Wharton.

Selected experiments on carbohydrates, lipids, proteins, amino acids, nucleic acids, and metabolism (cellular particulates, kinetics, general enzymology) will be given to illustrate basic biochemical principles. The course will emphasize the quantitative aspects rather than qualitative identifications.

### 536-A. ADVANCED BIOCHEMICAL METHODS, LABORATORY

Spring term. Credit two hours. Prerequisite: Course 533. Graduate majors in biochemistry only. Assistant Professor Keller and Associate Professor Wu.

Research techniques in biochemistry and molecular biology.

### 536-B. ADVANCED BIOCHEMICAL RESEARCH

Spring term. Credit two hours. Prerequisite: Course 536A. Graduate majors in biochemistry only. Professor Racker and Staff.

Research work in the laboratory of staff members on a rotating basis.

**537-538. ADVANCED BIOCHEMISTRY, LECTURES**

Fall and spring term. Credit one to three hours. Prerequisites: Courses 531 and 532, or permission of instructor. Students may take one or more sections of the course, as each section can be taken without attending a preceding section. T Th 9:05. Staff.

This course will be comprised of advanced lectures in three of the following subjects per term (different subjects will be selected for different years): carbohydrates and lipids, proteins and enzymes, biochemistry of membranes, mechanism of coenzyme function, mechanism of enzyme action, nucleic acids, protein synthesis, control mechanisms, bioenergetics, etc.

**631-632. RESEARCH SEMINAR IN BIOCHEMISTRY**

Fall and spring term. Credit one hour per term. M 8-9:30. P.M. Professor Racker.

Required of all graduate students except first-year students majoring in biochemistry. The course may be repeated for credit.

**633-634. GRADUATE SEMINAR IN BIOCHEMISTRY**

Fall and spring term. Credit one hour. Prerequisites: Courses 531 and 532. Hours to be arranged. Staff.

Original publications in the following areas of research will be assigned to students for reporting and discussion: mechanism of muscular contraction, photosynthesis, mechanism of enzyme action, regulatory mechanisms, intermediary metabolism, etc.

**639. BIOCHEMISTRY SEMINAR**

Fall and spring terms. No credit. F 4:15. Staff.

Lectures on current research in biochemistry presented by distinguished visitors and staff.

**BIOMATHEMATICS**

(See pp. 51, 102, and 103.)

**BIOPHYSICS**

(See pp. 51, 102, and 103.)

**BIOSTATISTICS**

(See pp. 51, 102, and 103.)

**BOTANY**

Faculty: Harlan P. Banks, David M. Bates, Robert T. Clausen, Roderick K. Clayton, William J. Dress, John W. Ingram, Jr., André T. Jagendorf, John M. Kingsbury, Richard P. Korf, Lee N. Miller, Harold E. Moore, Jr., Hugh F. Mulligan, Jim L. Ozbun, Loyd E. Powell, Jr., Roger M. Spanswick, Adrian M.

Srb, Frederick C. Steward, Harry T. Stinson, Jr., John F. Thompson, Harold B. Tukey, Jr., Charles H. Uhl.

At Geneva: John Einset.

Field Representative: David M. Bates, 467 Mann Library.

#### MAJOR AND MINOR SUBJECTS

Cytology	Plant Ecology
General Botany	Plant Morphology and Anatomy
Paleobotany	Plant Physiology
Phycology	Plant Taxonomy

It is recommended that applicants to the Field of Botany provide scores of the Graduate Record Examination. Except under unusual circumstances all candidates for the Ph.D. will take a qualifying examination to be administered by the student's Special Committee during the first semester of residence. The Graduate School requires all candidates to take the Admission to Candidacy and Final Thesis Examinations, which are described on p. 12 of this *Announcement*. The language requirement for the Master's degree: college entrance French and/or German or proficiency in one language other than the native language before completion of the second residence unit. For the Ph.D. degree: proficiency in two languages other than the native language. Proficiency is to be regarded as a reading comprehension which meets the standards set by the Graduate School Language Board, except that in cases where English is allowed as a language, a reading and speaking ability will be required.

## General Requirements for All Degrees

An adequate knowledge of the structure, functions, and classification of plants is required of all candidates with major subjects in the Field of Botany. Candidates also should have basic training in chemistry, physics, geology, and mathematics.

## Requirements for Major Subjects

Additional basic requirements for the major subjects are as follows:

**CYTOLOGY AND CYTOGENETICS.** An adequate knowledge of cytology and two of the following: genetics or plant breeding, plant morphology and anatomy, plant physiology, or plant taxonomy. A. M. Srb, H. T. Stinson, and C. H. Uhl.

**GENERAL BOTANY.** Additional requirements will be determined in each individual case. Not approved as a major for the Ph.D. degree.

**PALEOBOTANY.** Additional training in plant morphology and anatomy and adequate knowledge of paleobotany and general stratigraphic geology. H. P. Banks.

**PHYCOLOGY.** Individual programs stressing mycology, invertebrate zoology, oceanography, limnology, plant morphology, plant physiology, taxonomy, cytology, or genetics will be required as appropriate to each student's interests and purposes in studying the algae. J. M. Kingsbury and H. F. Mulligan.

**PLANT ECOLOGY.** Additional training in plant ecology and adequate knowledge of plant physiology, genetics, morphology, taxonomy, soil science, and statistics as appropriate to each student's career objectives. R. T. Clausen, L. N. Miller, and H. F. Mulligan.

**PLANT MORPHOLOGY AND ANATOMY.** Additional training in plant morphology and anatomy and plant taxonomy and adequate knowledge of cytology, genetics, or paleobotany. H. P. Banks.

**PLANT PHYSIOLOGY.** Additional training in plant physiology and adequate knowledge of chemistry, a general knowledge of mathematics and physics, and training in bacteriology, genetics, mycology, plant pathology, or soils. R. K. Clayton, A. T. Jagendorf, J. L. Ozbun, L. E. Powell, R. M. Spanswick, F. C. Steward, J. F. Thompson, and H. B. Tukey, Jr.

**PLANT TAXONOMY.** Additional training in plant taxonomy and ecology and an adequate knowledge of genetics and statistics. D. M. Bates, R. T. Clausen, W. J. Dress, J. W. Ingram, Jr., R. P. Korf, and H. E. Moore, Jr.

For summer research grants and assistantships in botany at the Museum of Northern Arizona, consult the Field Representative.

## Courses

### BIOLOGICAL SCIENCES COURSES AVAILABLE ONLY TO GRADUATE STUDENTS

#### 541-542. PLANT PHYSIOLOGY, ADVANCED LECTURE COURSES

Fall and spring terms. Credit three hours a term. Prerequisite: Biological Sciences 240 or its equivalent; Biological Sciences 541 is a desirable but not a required prerequisite for 542. M W F 10:10. Plant Science 143. Professor Steward.

Fall term: cells and cell physiology; properties of protoplasm, its membranes and organelles; relations of cells, tissues, and organs to water and solutes; water relations and stomatal behavior; inorganic plant nutrition; the essential nutrient elements.

Spring term: plant metabolism and organic nutrition (photosynthesis, respiration, nitrogen metabolism); translocation; physiology of growth and development.

#### 543. PLANT PHYSIOLOGY, ADVANCED LABORATORY

Fall term. Credit four hours. Primarily for graduate students doing work in plant physiology, but open to others if space permits. Prerequisites: organic chemistry, biochemistry, Biological Sciences 240, or the equivalent. Pre-registration recommended. Laboratory, T or W 8-5. Plant Science 241. Recitation, M 4:30-5:30. Staff.

An introduction to some modern methods in experimental plant biology.

#### 545. PHYSICAL APPROACHES TO PROBLEMS OF PHOTOSYNTHESIS

Fall term. Credit three hours. Given in alternate years. Prerequisites: Chemistry 104 or 108, Mathematics 112, Physics 208, or permission of the instructor. M 1:25, T Th 10:10. Plant Science 141. Professor Clayton.

Emphasis is on physical and photochemical mechanisms and physical experimental approaches. Photosynthetic organisms, their photochemical apparatus, metabolic pathways and mechanisms for energy conversion; descriptive

introduction to the physics of excited states in molecules and molecular aggregates; optical and photochemical properties of chlorophyll and of the living photosynthetic tissue; contemporary investigations of the photosynthetic mechanism. The level of the course can be judged by consulting *Molecular Physics in Photosynthesis*, R. K. Clayton, Blaisdell Publishing Co., Waltham, 1965.

#### 547. GENERAL PHOTOBIOLOGY

Fall term. Credit three hours. Given in alternate years. Prerequisites: same as for Biological Sciences 545. M 1:25, T Th 10:10. Plant Science 141. Professor Clayton.

A survey of systems of current interest in photobiology, including photosynthesis, bioluminescence, vision, photoperiodism, and the action of ultraviolet on nucleic acids. Physical concepts and methodologies are emphasized.

#### 548. PLANT PHYSIOLOGY: ASPECTS OF METABOLISM

Spring term. Credit three hours. Given in alternate years. Prerequisites: Biological Sciences 240 and 431, Chemistry 353, or the equivalent. M W F 9:05. Professor Jagendorf, Associate Professor Thompson, Assistant Professor McCarty and staff.

Selected areas of plant biochemistry will be reviewed in the context of the plant life cycle and responses to the environment. Probable topics include: metabolism and storage function of lipids, carbohydrates, organic acids; proteins and pigments; nitrogen and sulfur assimilation; hormone metabolism; respiration, photosynthesis, development and replication of mitochondria and chloroplasts; cell wall composition and properties. Emphasis will be on operation of control mechanisms.

#### 549. PLANT PHYSIOLOGY: TRANSPORT PHENOMENA

Fall term. Credit three hours. Given in alternate years. Prerequisite: Biological Sciences 240 or its equivalent. M W Th 11:15. Plant Science 141. Assistant Professor Spanswick.

An advanced course dealing with the transport of ions, water and organic materials in plants. Mechanisms of ion transport. Relationships between ion transport and metabolism. Ion uptake and transport in higher plants. Phloem transport. Water relations of single cells and whole plants. Water relations of crops and natural communities.

#### 563. ADVANCED PLANT ECOLOGY

Spring term. Credit four hours. Prerequisite: consent of the instructor. One course each in ecology, plant physiology, and soils is strongly recommended. M W F 10:10. Assistant Professor Miller.

Lectures and seminars dealing with the physiological mechanisms and the physical, chemical, and biological processes which underlie ecosystem structure and function. Some major topics included will be responses to the environment by individual plants, populations, and species and the cycling of energy, nutrients, and water in ecosystems.

#### 587. PERSPECTIVES IN PLANT PHYSIOLOGY: ADVANCED LECTURE SERIES

Fall term. Credit two hours, or may be taken without credit. M W F 10:10. Plant Science 143. Professor Steward.

This lecture course is an alternative, wholly or in part, to the sequence 541 and 542. Normally it will not be offered when the more complete sequence is given. The course will review salient topics in plant physiology, their present status, historical development, and the problems they still present.

Topics considered will change somewhat from year to year but will normally include some treatment of cell physiology, organic and inorganic nutrition, metabolism, growth, and development.

PLANT PATHOLOGY 569, 579, 589. ADVANCED MYCOLOGY

641. SEMINAR IN TAXONOMY AND ECOLOGY OF VASCULAR PLANTS

Fall term. Credit one hour. Prerequisite: Biological Sciences 442 or permission to register. M 11:15. Plant Science 143. Professor Clausen.

An examination of primary problems concerned with the classification and environmental relationships of vascular plants.

643. SEMINAR IN PLANT PHYSIOLOGY

Fall and spring terms. Credit one hour if requested. Required of graduate students taking work in plant physiology and open to all who are interested. F 11:15. Plant Science Seminar Room. Staff.

Reports on current research in plant physiology by visitors, staff, or advanced graduate students.

645. CURRENT TOPICS IN PLANT PHYSIOLOGY

Fall and spring terms. Credit two hours per term. Course may be repeated for credit. Staff.

Seminar reports by graduate students on current literature in experimental plant physiology or related areas.

647. SPECIAL TOPICS IN PLANT TAXONOMY

Fall and spring terms. Credit one hour per term. Prerequisite: permission to register. Lecture and discussion. Mann Library 471. Professors Moore and Dress, Associate Professor Ingram, and Assistant Professor Bates.

A series of four topics, one presented each term, designed to provide professional background in biosystematics, literature of taxonomic botany, nomenclature, and tropical families of phanerogams.

A. *Families of Tropical Phanerogams*. Fall term, 1969. The families of flowering plants encountered solely or chiefly in tropical regions will be considered in lectures, discussions, and demonstrations with the aim of providing basic points of recognition for and an understanding of diversity and relationships in these families for the student venturing into the tropics. Professor Moore.

B. *Literature of Taxonomic Botany*. Spring term, 1970. A survey of the basic reference works in taxonomy from the pre-Linnaean literature drawn on by Linnaeus to contemporary publications with comments on the peculiarities of the books (when appropriate), on publication dates, typographic devices, and intricacies of bibliographic citation. Lectures, demonstrations, discussions, and problems. Associate Professor Ingram.

C. *Nomenclature*. Fall term, 1970. An analysis of the International Code of Botanical Nomenclature and its application to various plant groups. Lectures, problems, discussion. Professor Dress.

D. *Biosystematics*. Spring term, 1971. A consideration of biosystematic approaches to taxonomy, including chemical, numerical, cytological and statistical methodologies as well as a review of classic studies. Assistant Professor Bates.

PLANT PATHOLOGY 649. CURRENT TOPICS IN MYCOLOGY

**BIOLOGICAL SCIENCES COURSES AVAILABLE TO JUNIORS, SENIORS, AND GRADUATE STUDENTS**

**341. TAXONOMY OF VASCULAR PLANTS**

Fall term. Credit four hours. Professor Clausen.

**344. BIOLOGY OF THE ALGAE**

Spring term. Credit four hours. Associate Professor Kingsbury.

**345. PLANT ANATOMY**

Fall term. Credit four hours. (Appointment to be announced.)

**347. CYTOLOGY**

Fall term. Credit four hours. Associate Professor Uhl.

**349. PLANTS AND MAN**

Fall term. Credit three hours. Assistant Professor Bates.

**PLANT PATHOLOGY 309. COMPARATIVE MORPHOLOGY OF FUNGI**

Fall term. Credit four hours. Professor Korf and Associate Professor Lorbeer.

**440. CYTOGENETICS**

Spring term. Credit three hours. Associate Professor Uhl.

**442. TAXONOMY AND ECOLOGY OF VASCULAR PLANTS**

Spring term. Credit four hours. Professor Clausen.

**444. MORPHOLOGY OF LOWER VASCULAR PLANTS**

Spring term. Credit four hours. (Appointment to be announced.)

**446. MORPHOLOGY OF HIGHER VASCULAR PLANTS**

Spring term. Credit four hours. (Appointment to be announced.)

**448. PALEOBOTANY**

Spring term. Professor Banks.

**463. PLANT ECOLOGY**

Fall term. Credit four hours. Assistant Professor Miller.

**CELL BIOLOGY**

(See pp. 51, 102, and 103.)

**CONSERVATION**

Faculty: Clarence A. Carlson, W. Robert Eadie, Alfred W. Eipper, John L. Forney, Lawrence S. Hamilton, Oliver H. Hewitt, Richard J. McNeil, Aaron N. Moen, Robert R. Morrow, Arthur M. Phillips, Jr., Edward C. Raney, Daniel Q. Thompson, Dwight A. Webster, Bruce T. Wilkins.

Field Representative: W. R. Eadie, 206 Fernow Hall.

**MAJOR SUBJECTS**

Fishery Science  
 Natural Resources Conservation  
 Wildlife Science

**MINOR SUBJECTS**

Fishery Science  
 Forest Conservation  
 Natural Resources Conservation  
 Wildlife Science

**ADMISSION.** To undertake study in the biological subjects the student should be well prepared in biological sciences and should have or must acquire a foundation in the specialized area of study which he intends to pursue. A strong background in the other biological and physical sciences is highly desirable, and a working knowledge of statistical methods is important in all fields. To major in Natural Resources Conservation, the student should come with training in some scientific discipline which he proposes to use in an integrative way to focus on natural resource problems, and he should preferably have professional job experience.

Applicants for graduate study in the Field of Conservation are requested to submit the results of the Graduate Record Examinations (Aptitude Test, and Advanced Test in Biology if appropriate).

**LANGUAGE REQUIREMENT.** For the Ph.D. degree, the language requirement will be determined by the student's Special Committee.

**EXAMINATIONS.** An oral qualifying examination is given to Ph.D. candidates early in residence to explore possible deficiencies in educational background. This is followed by the comprehensive Admission to Candidacy Examination which is taken after most of the course work has been completed. There is a final examination on the thesis subject. For the Master's degree, there is a final examination on subject matter and thesis.

## Special Interests of the Faculty

- Anadromous and marine fisheries management: Professor Rancey.
- Forest conservation: Professors Hamilton and Morrow.
- Fishery science: Professors Carlson, Eipper, Forney, and Webster.
- Natural resources conservation: Professors Hamilton, McNeil, and Wilkins.
- Nutrition and physiology of fishes: Professor Phillips.
- Outdoor recreation: Professor Wilkins.
- Wildlife science: Professors Eadie, Hewitt, McNeil, Moen, and Thompson.

## Courses

### NATURAL RESOURCES CONSERVATION

#### 510. PERSPECTIVES ON CONSERVATION

Fall term. Credit two hours. Professor Wilkins.

A seminar based upon extensive readings of articles highlighting varying philosophical approaches to the conservation of natural resources. Views espoused by developmentalists, preservationists, naturalists, economists, welfare economists, and urban planners will be considered.

#### 511. INTERNATIONAL NATURE CONSERVANCY

Fall term. Credit two hours. Professors Hamilton and McNeil.

A seminar devoted to exploring international programs of nature conservancy, extinct and endangered species, floral and faunal protection in various countries, natural park systems, protection vs. management, the relevance of United States experience, and the role of nature conservancy in resource development of emerging nations.

#### 602. SEMINAR IN NATURAL RESOURCES PLANNING AND DEVELOPMENT

Spring term. Credit two hours. Professor Hamilton.

An interdisciplinary graduate student seminar. Seminar theme varies from year to year to include such topics as: small watershed planning, multiple use management, urban fringe problems, outdoor recreation, land use planning methods, and river basin development. Field trips and invited resource specialists.

#### FISHERY SCIENCE

##### 439. FISH ECOLOGY

Fall term. Credit three hours. Prerequisite: Biological Sciences 270 or permission of the instructor. Professor Carlson.

Interactions between fishes and their living and non-living environment and applications of ecological principles to fish population research and management; competition, predation, parasitism, commensalism, and other biotic interactions involving fishes; adaptations, behavior, distribution, and life histories of major taxonomic groups. The ecology of young fishes is stressed, and the student is introduced to the literature of fishery biology.

##### 440. FISHERY SCIENCE

Fall term. Credit three hours. Students other than majors in the Department of Conservation must have permission of the instructor to register. Professor Webster.

Principles and theories involved in dynamics of fish populations. Methods of obtaining and evaluating statistics of growth, population size, mortality, yield, and production as well as investigational aspects of fishery biology are included.

##### 441. FISHERY RESOURCE MANAGEMENT

Spring term. Credit three hours. Prerequisite: Conservation 439 and 440 or permission of the instructor. Professor Eipper.

Principles and problems in the management of freshwater and marine fishery resources, considered in relation to problems of human population and management of other natural resources; multiple use, evaluation, and allocation of water resources, with particular reference to fisheries; characteristics of fishery resources and their exploitation; applications of fishery science to the management of fish stocks through maintenance and improvement of habitat, fish population manipulation, and regulation of fishing.

##### 442. BASIC PRINCIPLES OF FISH CULTURE

Spring term. Credit two hours. Prerequisites: general zoology and a course in chemistry. A course in biochemistry or physiology is desirable. Professor Phillips.

A study of the nutrition, metabolism, and physiology of hatchery fish and principles of hatchery management.

**600. SEMINAR: MAJOR FISHERY INVESTIGATIONS**

Spring term. Credit one hour. Given in alternate years. Prerequisite: permission of the instructor. Staff.

A comparative review of major fishery investigations of the world constitutes the primary content of this seminar. A study of pertinent literature and special topics will be assigned.

**601. SEMINAR ON SELECTED TOPICS IN FISHERY BIOLOGY**

Fall or spring term. Credit one hour. Staff.

**WILDLIFE SCIENCE**

**304. WILDLIFE ECOLOGY**

Fall term. Credit three hours. Prerequisite: Biological Sciences 270. Professor Moen.

Consideration of the basic interspecific, intraspecific, and physical relationships between the organism and its environment. Laboratories and field trips provide opportunities for student participation in environmental analysis.

**413. WILDLIFE MANAGEMENT**

Spring term. Credit three hours. Prerequisite: Conservation 304. Professor Hewitt.

Practical application of methods and techniques in the management of game species. Intended for students interested in professional wildlife management. Includes several all day field trips.

**414. ECONOMIC VERTEBRATE ZOOLOGY**

Spring term. Credit two hours. Prerequisite: Biological Sciences 270. Professor Eadie.

Economics of amphibians, reptiles, birds, and mammals. Economic status, habits, and control of injurious species.

**603. SEMINAR IN SELECTED TOPICS IN WILDLIFE SCIENCE**

Fall or spring term. Credit one hour. Staff.

**RESEARCH**

Either term. Credit to be arranged. Problems are undertaken in any of the areas of study in the Department, but adequate preparation in the specialized area and permission of the instructor are prerequisites.

**492. MAMMALOLOGY**

Professor Eadie.

**494. FISHERY SCIENCE**

Professors Carlson, Eipper, Forney, Phillips, and Webster.

**495. WILDLIFE SCIENCE**

Professors Eadie, Hewitt, McNeil, Moen, and Thompson.

**496. FORESTRY**

Professors Hamilton and Morrow.

498. NATURAL RESOURCES

Professors Hamilton, McNeil, and Wilkins.

DEPARTMENTAL SEMINAR

610. CONSERVATION SEMINAR

Fall and spring terms. Without credit. Staff.

Discussions of literature and current research in the broad field of conservation.

DAIRY SCIENCE

Faculty: Norman C. Dondero, Robert F. Holland, William K. Jordan, John E. Kinsella, Frank V. Kosikowski, Richard A. Ledford, Richard P. March, H. Brooks Naylor, Neil L. Norcross, Norman N. Potter, John W. Sherbon, W. Frank Shipe, Jr., James C. White.

Field Representative: William K. Jordan, 106 Stocking Hall.

MAJOR AND MINOR SUBJECTS

Dairy Chemistry

Dairy Microbiology

Dairy Management

Dairy Science

Students interested in undertaking a graduate career in the Field of Dairy Science should have adequate basic preparation in the area in which they intend to specialize. Prior training in dairy or food science is desirable but not essential; deficiencies can be made up with satisfactory programing.

In general, graduate students are expected to attain a broad mastery of the substance of their major Field and to demonstrate the ability to plan and conduct independent research.

The Field offers students challenging and interesting study and research opportunities in four major areas.

Students majoring in dairy management may look forward to study and research on the administration of industrial dairy manufacturing complexes and the organization of international milk development projects. Studies leading to minors in economics, business administration, and international agricultural development are encouraged.

Majors in dairy microbiology may elect study and scientific investigations in: food development from milk fermentations, dairy micology, immunology, and laboratory control of spoilage and disease-producing microorganisms. Courses in basic microbiology and pathogenic bacteriology will supplement those offered by the Field faculty.

Students majoring in dairy chemistry have a number of areas of inquiry in which to work, such as physiological, biological, organic, and physical chemistry.

Similarly, students with a major in dairy science may choose from a variety of specialized activities, such as engineering, technology, and sanitary and environmental health, beginning with milk handling processes on the farm and extending to milk processing in the plant.

**LANGUAGE REQUIREMENT FOR THE PH.D. DEGREE.** Students with a single minor must demonstrate proficiency in one language—Danish, Dutch, Finnish, French, German, Japanese, Norwegian, Russian, Spanish, or Swedish—

before the Final Examination. Students with two minors have no language requirement.

**EXAMINATION REQUIREMENT.** Examinations required by the Graduate School are described on p. 12 of this *Announcement*.

## Courses

All courses carry Food Science numbers unless otherwise indicated.

### [302. DAIRY AND FOOD ENGINEERING]

Fall term. Credit four hours. Offered in alternate years. Prerequisites: Physics 101 and 102 or the equivalent, and Dairy Science 100. Professor Jordan. Not offered in 1969-70.

Engineering aspects of dairy and food plant operations.

### 303. LIPID TECHNOLOGY

Fall term. Credit three hours. Assistant Professor Kinsella.

Sources, processing, and properties of edible fats and oils are covered. Factors affecting the physical properties and chemical composition of fatty foods are demonstrated through both lectures and experiments. All classes of lipids are considered.

### 310. SENSORY QUALITIES AND EVALUATIONS OF FOODS

Spring term. Credit two hours. Professor Shipe and assistants.

Deals with the factors affecting the color, odor, flavor, and texture of foods and the evaluation of these qualities. The techniques and interpretations of both objective and subjective evaluations are discussed. The laboratory exercises involve the evaluation of a variety of foods.

### [311. CONCENTRATION AND FREEZING PROCESSES]

Spring term. Credit four hours. Offered in alternate years. Professor Jordan and Associate Professor Potter. Not offered in 1969-70.

The principles and practice of condensing, drying, and freezing food products.

### [313. STERILIZATION PROCESSES]

Spring term. Credit three hours. Offered in alternate years. Prerequisites: Chemistry 353 or equivalent, Biological Sciences 394, and Physics 102. Recommended: a course in calculus and a course in biochemistry. Associate Professor Buck. Not offered in 1969-70.

The principles of food preservation and the fundamentals of food processing from raw materials to finished product. Heat transfer, unit operations, and unit processes employed by the canning industry will be emphasized, but sterilization by any means such as heat, chemicals, physical destruction, and filtration will be demonstrated. The effects of lethal energy treatment of biological fluids and systems on desirable components, such as nutritive factors and flavor components, will be considered along with the cost of operation. The laboratory involves actual participation in plant operations in the processing and preservation of various food products, and field trips.

### [314. MILK AND FOOD SANITATION AND PLANT OPERATIONS]

Fall term. Credit four hours. Offered in alternate years. Prerequisites: Dairy

Science 100 and Biological Sciences 394. Professor White and assistants. Not offered in 1969-70.

The biological and chemical control of milk and food processing. Federal, state, and local requirements for the production, collection, and processing of milk and food. The control of sanitation, composition, and production in the food plant is outlined, with special attention given to the fluid milk industry.

#### BIOLOGICAL SCIENCES 394. DAIRY AND FOOD MICROBIOLOGY

Spring term. Credit four hours. Prerequisite: Biological Sciences 290. Professor Naylor.

A systematic study of the major families of microorganisms of importance in dairy and food science with emphasis on the role played by these organisms in food preservation, food fermentations, and public health. The laboratory work includes practice in the use of general and special methods for microbiological testing and control of dairy and food products, as well as practice in the isolation and characterization of organisms found in foods.

#### 401. FOOD FROM FERMENTATIONS

Fall term. Credit five hours. Offered in alternate years. Prerequisite: beginning courses in microbiology and organic chemistry or biochemistry are recommended. Professor Kosikowski and Assistant Professor Ledford.

The chemistry, microbiology, and technology of processes leading to important foods, such as cultured milks, cheeses, wines, and beers. Consideration is also given to other fermentations from plant and animal sources resulting in high-protein foods, including those from petroleum and whey.

Line-flow processing and testing practices designed to acquaint students with the principles of fermentations and production of the above foods are carried out in the laboratory.

#### 403. INTERNATIONAL FOOD DEVELOPMENT

Fall term. Credit three hours. Offered in alternate years. Permission of the instructor required. Professor Kosikowski.

A study of programs, technical problems, and progress associated with developing acceptable milk and food supplies in critical world areas. Proposals for increasing world protein resources for humans are to be discussed. Special attention is to be directed to the organization, operations, relationships, and contributions of U.N. technical agencies, i.e., FAO, UNICEF, WHO, and governmental and non-governmental organizations in the field.

#### [404. CHEMISTRY OF MILK]

Fall term. Credit three hours. Offered in alternate years. Prerequisites: qualitative and quantitative analysis and organic chemistry. Assistant Professor Ledford. Not offered in 1969-70.

A study of milk constituents and physical properties. Deals with milk enzymes, lactose, milk fat, milk proteins, and minor constituents.

#### [410. FOOD BIOCHEMISTRY]

Spring term. Credit three hours. Offered in alternate years. Prerequisite: Biological Sciences 431. Professor Kinsella. Not offered in 1969-70.

A discussion of some of the important non-microbial changes in foods, such as denaturation and the Maillard Browning reaction. Emphasis is placed on the occurrence, significance, and prevention or control of the changes as they affect the color, odor, flavor, texture, or nutritive value of foods.

[413. ANALYTICAL METHODS]

Spring term. Credit four hours. Offered in alternate years. Prerequisites: Dairy Science 210 and one term of either organic chemistry or biochemistry. Assistant Professor Sherbon. Not offered in 1969-70.

A study of the analytical methods important to the food industry. The emphasis is on understanding the basic analytical chemistry applied in the various tests. General topics include sampling, gravimetric and volumetric methods, optical methods, electrochemistry, and the use of basic statistics.

512. INSTRUMENTAL METHODS

Spring term. Credit five hours. Offered in alternate years. Prerequisite: Dairy Science 413 or permission of the instructor. Assistant Professor Sherbon.

Deals with instrumental methods widely used in research and industry. The major emphasis is on chromatographic methods, spectroscopy, electrophoresis, and the use of computers in agricultural research. The stress will be on the practical use of the material presented.

514. THE BIOCOLLOIDAL CHEMISTRY OF FOODS

Spring term. Credit three hours. Offered in alternate years. Prerequisites: Biological Sciences 431 and 433 or the equivalent. Associate Professor Buck.

The principles of the science of colloidal systems and micelles of importance in biology and agriculture will be introduced; then the anisotropic morphology of cytoplasm, cell walls, plastids, biological gels and sols will be studied and the data applied to food. Polysaccharides and polypeptides in chain molecules which sometimes reach microscopical lengths will be intensely studied. Special attention will be given to the structural arrangement of complex polymers. The physical chemistry of surfaces (including adsorption, ion-exchange, and electric double layer), flocculation, viscosity, swelling, and gel formation will be discussed.

600. SEMINAR

Fall and spring terms. Required of graduate students in the Department.

ECOLOGY AND EVOLUTIONARY BIOLOGY

Faculty: M. Alexander, H. W. Ambrose, J. P. Barlow, C. O. Berg, A. L. Bloom, W. L. Brown, T. J. Cade, C. A. Carlson, R. T. Clausen, L. C. Cole, W. C. Dilger, W. R. Eadie, G. C. Eickwort, T. Eisner, S. T. Emlen, H. E. Evans, P. P. Feeny, J. G. Franclemont, G. G. Gyrisco, D. J. Hall, J. W. Hudson, W. T. Keeton, J. M. Kingsbury, R. P. Korf, J. P. Kramer, D. A. Lancaster, W. N. McFarland, L. N. Miller, A. N. Moen, H. E. Moore, H. F. Mulligan, L. L. Pechuman, D. Pimentel, E. M. Raffensperger, E. C. Raney, R. B. Root, E. L. Stone, D. Q. Thompson, B. V. Travis, C. H. Uhl, L. D. Uhler, D. A. Webster, J. W. Wells, J. H. Whitlock, R. H. Whittaker.

Field Representative: John P. Barlow, Langmuir Laboratory.

MAJOR AND MINOR SUBJECTS

Aquatic Ecology (including limnology, marine ecology, and oceanography)	Paleoecology
Community and Ecosystem Ecology	Parasitology
Environmental Physiology	Population Ecology
Evolutionary Biology	Terrestrial Ecology
General Ecology	Vertebrate Zoology (including herpetology, ichthyology, mammalogy and ornithology)

REQUIREMENTS. Applicants are strongly urged to present scores on the Graduate Record Examination Aptitude and Advanced Biology Test.

Language requirement for the Master's degree: college entrance (or the equivalent) in one language. Language requirement for the Ph.D. degree: proficiency in two languages or superior ability in one.

A written qualifying examination in ecology and evolutionary biology must be taken before the student can schedule an Admission to Candidacy Examination. A Final Thesis Examination is required by the Graduate School and is described on p. 12 of this *Announcement*.

## Special Interests of the Faculty

Members of the faculty will be especially interested in directing research in the areas mentioned below, although research will not be limited to these areas:

- M. Alexander: microbiological ecology.
- H. W. Ambrose: behavioral ecology of mammals.
- J. P. Barlow: plankton ecology and oceanography.
- C. O. Berg: bionomics of freshwater invertebrates.
- A. L. Bloom: coastal geomorphology.
- W. L. Brown: systematics of ants and evolutionary theory.
- T. J. Cade: environmental biology of vertebrates.
- R. T. Clausen: systematics and distribution of flowering plants and ferns.
- L. C. Cole: population ecology.
- W. C. Dilger: vertebrate ethology.
- W. R. Eadie: ecology and morphology of mammals.
- T. Eisner: chemical basis of behavior in invertebrates.
- S. T. Emlen: behavioral ecology of birds and amphibians.
- H. E. Evans: vertebrate development and gross anatomy.
- P. P. Feeny: chemical ecology of insect-plant relationships.
- J. G. Franclemont: systematics of Lepidoptera.
- G. G. Gyrisco: insect ecology.
- D. J. Hall: population dynamics and limnology.
- J. W. Hudson: physiological ecology of mammals.
- W. T. Keeton: bird behavior and arthropod systematics.
- J. M. Kingsbury: phycology.
- R. P. Korf: systematics and evolution of fungi, lichens, and mycetoza.
- J. P. Kramer: ecology of insect pathogens.
- D. A. Lancaster: behavior of neotropical birds.
- W. N. McFarland: comparative and environmental physiology of vertebrates.
- L. N. Miller: physiological plant ecology.
- H. E. Moore: systematics of flowering plants.
- H. F. Mulligan: aquatic plant ecology.
- L. L. Pechuman: systematics and ecology diptera.
- D. Pimentel: population ecology and genetics.
- E. M. Raffensperger: biology of the diptera.
- E. C. Raney: systematics, ecology, and behavior of fishes.
- R. B. Root: comparative population and community ecology.
- E. L. Stone: forest soils and nutrient cycles in natural vegetation.
- D. Q. Thompson: wildlife ecology.
- B. V. Travis: parasitology and biology of biting diptera.
- C. H. Uhl: chromosomes and cytotaxonomy.
- L. D. Uhler: insect ecology.
- D. A. Webster: population dynamics of fishes.

J. W. Wells: systematics and ecology of recent and fossil corals.  
 J. H. Whitlock: experimental epidemiology and endemiology.  
 R. H. Whittaker: plant communities.

## Courses

All courses carry Biological Sciences numbers unless otherwise indicated. This is not a final listing of courses; students should consult with their adviser concerning other offerings. Not all of the courses listed below will be offered in the academic year 1969-70.

### 270. BIOLOGY OF THE VERTEBRATES

Spring term. Credit four hours. Prerequisite: 101-102 or 103-104. Staff.

An introduction to the evolution, classification, life history and ecology, and behavior of vertebrate animals. Laboratory and field work are concerned with structure, classification, taxonomic methods, biology of local species, and studies of selected aspects of vertebrate life, including food habits, activity cycles, behavior, and physiological adaptation.

### AGRONOMY 306. SOIL MICROBIOLOGY

Spring term. Credit three hours. Prerequisite: 200 or 290. Professor Martin Alexander.

A study of the major groups of soil microorganisms, their ecological inter-relationships, and the biochemical functions of the soil population.

### PLANT PATHOLOGY 309. COMPARATIVE MORPHOLOGY OF FUNGI

### ENTOMOLOGY 331. INTRODUCTORY INSECT TAXONOMY

### 341. TAXONOMY OF VASCULAR PLANTS

Fall term. Credit four hours. Prerequisite: a course in botany. Professor Clausen.

An introduction to the classification of vascular plants with attention to principles, methods of identification, and literature. In the first part of the term, trips are held in laboratory periods.

### 343. BIOLOGY OF THE ALGAE

Fall term. Credit three hours. Prerequisite: a year of biology or permission of the instructor. Associate Professor Kingsbury.

Structure, ecology, physiology, relationships, evolution, and economic uses are presented as appropriate to a detailed understanding of the blue-green, green, yellow-green, golden brown, and euglenoid algae. Living material of a large number of genera is provided in laboratory to illustrate lecture topics, to demonstrate characteristics of algae of potential value in research on general biological problems, to provide practice in techniques of isolation and culture, and to develop a working familiarity with the local algal flora. Biologically important characteristics of ponds and streams are brought out in relation to the algae populating them.

### 344. BIOLOGY OF THE ALGAE

Spring term. Credit three hours. Prerequisite: a year of biology or permission of the instructor. Associate Professor Kingsbury.

A continuation of 343, covering the diatoms, dinoflagellates, brown and red

algae, and emphasizing the characteristics of the marine environment. Need not be preceded by 343.

#### ENTOMOLOGY 351. INTRODUCTORY PARASITOLOGY

##### 361. GENERAL ECOLOGY

Fall or spring term. Credit three hours. Prerequisite: 101-102 or 103-104 or the equivalent. Fall term, Assistant Professor Feehey. Spring term, Assistant Professor Root.

Principles concerning the interactions between organisms and their environment. Influence of competition, social behavior, predation, and other factors of population size and dispersion. Role of energy flow and mineral cycling in determining the structure and productivity of ecosystems. Succession and classification of natural communities. Influence of climate and past events on the diversity and stability of communities in different regions of the world. Interspecific competition and the niche concept. Chemical interactions between organisms. Application of ecological principles to human problems. Modern evolutionary theory will be stressed throughout and attention given to conflicting ecological hypotheses.

##### 362. LABORATORY AND FIELD ECOLOGY

Fall term. Credit two hours. Prerequisite: permission of instructor. Enrollment limited. Professor Cole and others.

A laboratory and field course to accompany or follow Course 361 for students who intend to concentrate in the area of ecology. This course will give the students a first-hand contact with ecological techniques.

##### 374. FIELD MARINE BIOLOGY

Credit two hours. Prerequisite: a full year of college biology. A special course is offered on Star Island, off Portsmouth, New Hampshire, in June. Professors Anderson, Gilbert, Hewitt, and Rancy; Associate Professors Barlow and Kingsbury (in charge).

Living material and habitats will be emphasized in introducing students to the major disciplines of marine biology and in rounding out the student's knowledge of these topics as presented at inland locations. For more details, see the *Announcement of the Summer Session* or consult Professor Kingsbury.

#### AGRONOMY 404. FOREST SOILS

#### NEUROBIOLOGY AND BEHAVIOR 421. COMPARATIVE VERTEBRATE ETHOLOGY

#### CONSERVATION 439. FISH ECOLOGY

##### 442. TAXONOMY AND ECOLOGY OF VASCULAR PLANTS

Spring term. Credit four hours. Prerequisite: 341. Professor Clausen.

A study of the principles of classification, the fundamentals of geographical distribution, and the evolutionary importance of environmental variation. Laboratory periods in the second half of the term are devoted to the study of natural populations in the field.

##### 460. MARINE ECOLOGY

Spring term. Credit three hours. Prerequisites: 361, 461, organic chemistry, and permission of the instructor. Enrollment limited. Associate Professor Barlow.

A consideration of the oceanographic aspects of the marine environment.

For graduate students and advanced undergraduates. Lectures and seminars, with demonstrations and field trips to be arranged.

**461. OCEANOGRAPHY**

Fall term. Credit three hours. Prerequisites: college physics and chemistry; college mathematics desirable. Associate Professor Barlow.

An introduction to general oceanography. Primarily for students with an interest in marine biology. Laboratory devoted to demonstration of equipment, analysis of some typical oceanographic observations, and work with simple models.

**462. LIMNOLOGY**

Fall term. Credit four hours. Prerequisites: 361, organic chemistry, and one year of college physics or permission of instructor. Assistant Professor Hall.

A study of processes and mechanisms in the biology, chemistry, and physics of inland waters taught from a functional and analytic point of view. Laboratories devoted to both field studies and experiments on model systems.

**463. PLANT ECOLOGY**

Fall term. Credit four hours. Prerequisite: 101-102 or 103-104 or equivalent. Assistant Professor Miller.

Principles of plant-environment interactions in relation to the distribution, structure and functioning of plant communities. These principles will be illustrated by analyzing representative plant communities and their environments in various parts of the world.

**469. BIOLOGY OF FISHES**

Fall term. Credit four hours. Prerequisites: 101-102 or 103-104 or 270, or the equivalent. Professor Raney.

An introduction to the study of fishes; their structure, classification, evolution, distribution, ecology, physiology, and behavior. Laboratory studies on structure, identification, classification, and nomenclature. Field studies of local species.

**470. ICHTHYOLOGY**

Fall term. Credit four hours. Given in even-numbered years. Prerequisite: 469 or permission of the instructor. Professor Raney.

Lectures on advanced aspects of the biology of fishes including systematics, ecology, life history, and literature. Laboratory studies of the orders, major families, and principal genera, and of systematic procedures. Field studies of the ecology and life history of local species.

**471. MAMMALOLOGY**

Fall term. Credit four hours. Prerequisites: 270 or equivalent work in vertebrate biology and permission of instructor. Associate Professor Hudson.

Lectures on the evolution, classification, distribution and adaptations, both physiological and morphological, of mammals. Laboratory and field work on ecology, behavior, physiology, and taxonomy of recent mammals with emphasis on the North American fauna.

**472. ORNITHOLOGY**

Spring term. Credit four hours. Prerequisites: 270 or equivalent work in vertebrate biology and permission of instructor. Assistant Professor Lancaster.

Lectures cover various aspects of the biology of birds including anatomy, physiology, classification, evolution, migration and orientation, behavior,

ecology and distribution. Laboratory will include studies of external and internal morphology, pterylosis, molts and plumages, skin identification of birds of New York and families of birds of the world. Several demonstration periods will emphasize hybridization, evolution, adaptive radiation, mimicry, and geographic variation. Field work includes identification of birds and familiarization of some techniques used in field research.

#### 475. EVOLUTIONARY THEORY

Fall term. Credit four hours. Prerequisites: 281; a course with some taxonomic content in botany or zoology is desirable, or else some experience with making and maintaining a personal collection of some plant or animal group. Professor W. L. Brown.

Lectures and class discussions on organic evolution, with primary emphasis on the mechanisms of speciation and adaptation. The course begins with a few lectures on taxonomic methodology.

#### 480. POPULATION GENETICS

Spring term. Credit three hours. Prerequisites: 281 or the equivalent and permission of the instructor. Professor B. Wallace.

A study of factors which influence the genetic structure of Mendelian populations and which are involved in race formation and speciation.

#### AGRONOMY 506. ADVANCED SOIL MICROBIOLOGY

#### 512. COMPARATIVE PHYSIOLOGY

Spring term. Credit four hours. Prerequisites: 413 or 414 and biochemistry or the equivalent.

A comparison of the principal physiological functions of vertebrates and invertebrates with emphasis on their adaptations to different environmental conditions.

#### 516. SPECIAL TOPICS IN COMPARATIVE PHYSIOLOGY

Spring term. Credit to be arranged. Prerequisites: consent of the instructor. Enrollment limited. Associate Professor McFarland.

Detailed consideration of selected topics in comparative physiology. Preparation of demonstration experiments stressing technique and individual research problems will be included. Topics vary from year to year.

#### NEUROBIOLOGY AND BEHAVIOR 523. ECOLOGICAL ASPECTS OF ANIMAL BEHAVIOR

#### ENTOMOLOGY 531. TAXONOMY OF THE SMALLER ORDERS OF INSECTS

#### ENTOMOLOGY 532. TAXONOMY OF THE IMMATURE STAGES OF HOLOMETABOLA

#### ENTOMOLOGY 533. TAXONOMY OF THE COLEOPTERA AND LEPIDOPTERA

#### ENTOMOLOGY 534. TAXONOMY OF THE DIPTERA AND HYMENOPTERA

#### ENTOMOLOGY 551. ADVANCED PARASITOLOGY (PROTOZOA AND HELMINTHS)

ENTOMOLOGY 553. ADVANCED PARASITOLOGY (INSECT PATHOLOGY)

561-562. QUANTITATIVE ECOLOGY

Throughout the year. Credit four hours a term. Offered in alternate years. Prerequisites: one year of biology and permission of instructor. Organic chemistry and some college mathematics are desirable. Professor Cole.

A quantitative course on selected ecological topics for advanced undergraduates and graduate students. Topics include the origin and interpretation of habitat differences, toleration and response physiology, population dynamics, construction and uses of life tables, spatial distribution patterns, and approaches to the quantitative analysis of biotic communities.

BOTANY 563. ADVANCED PLANT ECOLOGY

565. SPECIAL TOPICS IN LIMNOLOGY

Fall term. Credit three hours. Prerequisite: consent of the instructor. Assistant Professor Hall.

A laboratory and seminar course. Advanced discussion and experimentation in specific topics in limnology. Content variable from year to year, but in general dealing with topics related to the production and metabolism of biological associations in inland water.

ENTOMOLOGY 572. ADVANCED LIMNOLOGY

NEUROBIOLOGY AND BEHAVIOR 622. SEMINAR IN ECOLOGICAL ANIMAL BEHAVIOR

BOTANY 641. SEMINAR IN TAXONOMY AND ECOLOGY OF VASCULAR PLANTS

661. SEMINAR IN POPULATION AND COMMUNITY ECOLOGY

Fall term. Credit one hour. Prerequisites: a course in ecology and permission of instructor. Assistant Professor Root.

Topic for 1969 will be announced.

## ENTOMOLOGY AND LIMNOLOGY

Faculty: Clifford O. Berg, James L. Brann, William L. Brown, Jr., Jeffrey M. Camhi, James E. Dewey, George C. Eickwort, Thomas Eisner, Paul P. Feeny, John G. Franclemont, George G. Gyrisco, Donald J. Hall, Norman E. Johnson, Warren T. Johnson, William T. Keeton, John P. Kramer, Donald J. Lisk, John G. Matthyse, Roger A. Morse, Arthur A. Muka, Hugh F. Mulligan, Richard D. O'Brien, Charles E. Palm, Robert L. Patton, L. L. Pechuman, David Pimentel, Edgar M. Raffensperger, W. Arthur Rawlins, Richard B. Root, Edward H. Smith, Maurice J. Tauber, B. V. Travis, Lowell D. Uhler, Dwight A. Webster, Christopher F. Wilkinson, Roger G. Young.

Off Campus: J. Alfred Adams, Paul J. Chapman, Alexander C. Davis, Ralph W. Dean, Edward H. Glass, F. David Judge, Siegfried E. Lienk, Paul C. Lippold, Freeman L. McEwen, Wendell L. Roelofs, George A. Schaefer, Maurie Semel, E. Frederick Taschenberg, Haruo Tashiro.

Field Representative: Clifford O. Berg, 40 Comstock Hall.

## MAJOR AND MINOR SUBJECTS

Apiculture	Insect Physiology
Economic Entomology	Insect Taxonomy
Entomology (minor only)	Insect Toxicology
Insect Biochemistry	Insecticide Chemistry
Insect Ecology	Limnology
Insect Morphology	Medical Entomology
Insect Pathology	Parasitology

Graduate study in the Field of Entomology and Limnology includes all phases of the biology of insects including biochemistry, ecology, morphology, physiology, and systematics as well as apiculture and economic entomology. In addition, the Field has strong graduate programs in limnology, toxicology, and parasitology (including insect pathology). General biological concepts are studied using insects and other invertebrates. Insects are ideally suited as experimental animals in a wide variety of biological investigations because of their numbers and ease of manipulation in the laboratory and in nature.

To undertake graduate study, the student should be well prepared in the fundamentals of biology, chemistry, physics, mathematics, and humanities. In completing his graduate study, the student will have a sound foundation in fundamental knowledge and research methodology. Each student will be provided individual guidance by the Field faculty.

Special facilities for study and research include the outstanding Comstock Entomological Library, an extensive insect collection, an insectary, greenhouses, bioclimatic chambers, field stations, natural preserves, and numerous well-equipped laboratories. Brochures describing the facilities and activities are available from the Field Representative.

**LANGUAGE REQUIREMENT.** The minimum requirement for the Doctor of Philosophy degree is one appropriate language to be determined by the student's Special Committee. The Committee will also specify the level of proficiency (ETS or CEEB). Students in some specialized areas of study (e.g., systematic entomology) may expect to be required to demonstrate proficiency in two appropriate languages. No foreign language is required for the Master of Science degree.

**EXAMINATION REQUIREMENT.** The Field of Entomology and Limnology requires a proscriptio examination for both Master's and doctoral candidates, usually held during the first semester of work. It provides an opportunity for the student and his Committee to plan a complete course program. The Graduate School requires the Admission to Candidacy and Final Thesis Examinations of all Ph.D. candidates. These examinations are described on p. 12 of this *Announcement*.

## Specializations of the Faculty

## ECOLOGY

Behavior: Professors Camhi, Eisner, Morse, and Tauber.

Ecology: Professors Berg, Feeny, Gyrisco, Palm, Pimentel, Root, Tauber, and Uhler.

## ECONOMIC ENTOMOLOGY

Apiculture: Professor Morse.

Application equipment: Professor Brann.

- Floricultural insects: Professor Tauber.  
 Forage insects: Professors Gyrisco and Pimentel.  
 Forest insects: Professor N. E. Johnson.  
 Fruit insects: Professors Chapman, Dean, Glass, Lienk, Schaefer, Smith, and Taschenberg.  
 Household insects and insects affecting man: Professor Raffensperger.  
 Insects of ornamentals: Professors W. T. Johnson and Tashiro.  
 Livestock insects: Professor Matthyse.  
 Medical entomology: Professor Travis.  
 Vegetable insects: Professors Adams, Davis, McEwen, Muka, Rawlins, and Semel.

## LIMNOLOGY

- Aquatic entomology: Professors Berg, Hall, Pechuman, and Travis.  
 Limnology: Professors Berg, Hall, Mulligan, Pimentel, and Webster.

## MORPHOLOGY

- Morphology: Professors Eickwort and Eisner.

## PARASITOLOGY

- General parasitology: Professors Kramer and Travis.  
 Insect pathology: Professor Kramer.

## PHYSIOLOGY AND BIOCHEMISTRY

- Biochemistry: Professors Camhi, Patton, Wilkinson, and Young.  
 Physiology: Professors Camhi, Patton, Smith, Wilkinson, and Young.

## SYSTEMATICS

- Acarology: Professors Matthyse and Travis.  
 General systematics: Professors Brown, Eickwort, Franclemont, Keeton, and Pechuman.  
 Systematics of ants: Professor Brown.  
 Systematics of bees: Professor Eickwort.  
 Systematics of Diptera: Professors Berg and Pechuman.  
 Systematics of Lepidoptera: Professor Franclemont.  
 Systematics of millipeds: Professor Keeton.

## TOXICOLOGY

- Analytical Technology: Professors Lippold and Lisk.  
 Bioassay: Professor Dewey.  
 Biochemical aspects: Professors Wilkinson and Young.  
 General toxicology: Professors Lisk, Wilkinson, and Young.  
 Selective toxicants: Professor O'Brien.  
 Synergists: Professor Wilkinson.

## SPECIAL FIELD FELLOWSHIPS

**ALLIED CHEMICAL CORPORATION FELLOWSHIP.** \$2,000 plus tuition and General Fee. Available to candidates in the Field of Entomology and Limnology in alternate years. Candidates must be United States citizens, preferably in the final year of the doctoral program.

**COMSTOCK SCHOLARSHIP.** \$100 plus tuition and General Fee.

**DOW CHEMICAL COMPANY RESEARCH ASSISTANTSHIP.** \$3,090 plus tuition.

## Courses

### GENERAL ENTOMOLOGY

#### 210. INTRODUCTORY ENTOMOLOGY

Spring term. Credit three hours. Prerequisites: Biological Sciences 101 and 102, 103-104, or their equivalent. Associate Professor Raffensperger and assistants.

A survey of the structure, biology, and classification of insects; an introduction to the study of insects as a major segment of the biological community, with attention to representative species of economic importance and the techniques and consequences of their control. Laboratory exercises in the anatomy and biology of insects and practice in the techniques of insect identification.

#### 212. INSECT BIOLOGY

Fall term. Credit three hours. Prerequisites: Biological Sciences 101 and 102, 103-104, or their equivalent. Assistant Professor Eickwort and assistants.

Designed to introduce the science of entomology by focusing on the basic principles of the systematics, morphology, physiology, behavior, and ecology of insects. The laboratory in early fall includes field trips to study and collect insects in their natural environment.

#### [518. TECHNIQUES OF BIOLOGICAL LITERATURE]

Fall term. Credit two hours. Given in alternate years. Professor Franclemont. Not offered in 1969-70.

History of the development of entomological literature and a critical study of the biologists' works of reference and the principles of zoological nomenclature. Practice in the use of indices and bibliographies, and practice in the preparation of the latter.

### MORPHOLOGY

#### 322. INSECT MORPHOLOGY

Fall term. Credit four hours. Prerequisite: Biological Sciences 210 or 212 or permission of instructor. Assistant Professor Eickwort.

An introduction to the external and internal anatomy of insects, with emphasis on the comparative and functional aspects. The laboratory is devoted largely to dissection.

## TAXONOMY

### 331. INTRODUCTORY INSECT TAXONOMY

Spring term. Credit three hours. Prerequisite: Entomology 210 or 212. Professors Franclemont and Brown.

An introduction to the systematics and distribution of insects. Laboratory practice in the identification of orders, families, and representative genera of insects; methods of collection and preparation of insect specimens. Field trips are taken in the late spring.

### BIOLOGICAL SCIENCES 475. EVOLUTIONARY THEORY

Fall term. Credit four hours. Prerequisites: Biological Sciences 281; a course with some taxonomic content in botany or zoology is desirable, or else some experience with making and maintaining a personal collection of some plant or animal group. Professor Brown.

Lectures and class discussions on organic evolution, with primary emphasis on the mechanisms of speciation and adaptation. The course begins with a few lectures on taxonomic methodology.

### 531. TAXONOMY OF THE SMALLER ORDERS OF INSECTS

Fall term. Credit three hours. Offered in alternate years. Prerequisite: Entomology 331. Professor Brown.

Lectures on the classification, evolution, and bionomics of the orders and families of insects, exclusive of the larger orders of Holometabola. Laboratory studies on the literature and on the characters and classification of representative genera and species. Continuation of taxonomy of Holometabola is in Entomology 532, 533, and 534.

### [532. TAXONOMY OF THE IMMATURE STAGES OF HOLOMETABOLA]

Fall term. Credit three hours. Given in alternate years. Prerequisite: Entomology 531 or permission of the instructor. Professor Franclemont. Not offered in 1969-70.

Lectures on the structure and habits of insect larvae. Laboratory studies of the literature, comparative morphology, and identification of the immature stages of the Holometabola.

### [533. TAXONOMY OF THE COLEOPTERA AND LEPIDOPTERA]

Spring term. Credit three hours. Given in alternate years. Prerequisite: Entomology 331. Professor Franclemont. Not offered in 1969-70.

Laboratory studies on the literature and on the characters and classification of representative genera and species of these orders.

### 534. TAXONOMY OF THE DIPTERA AND HYMENOPTERA

Spring term. Credit three hours. Offered in alternate years. Prerequisite: Entomology 331. Professor Brown.

Laboratory studies on the literature and on the characters and classification of representative genera and species of these orders.

## ECONOMIC ENTOMOLOGY

### 441. GENERAL ECONOMIC ENTOMOLOGY

Fall term. Credit three hours. Prerequisite: Entomology 210 or 212 or the equivalent. Professor Gyrisco.

Principles and techniques in the control of insects.

[442. ENTOMOLOGY OF TREES AND SHRUBS]

Fall term. Credit three hours. Given in alternate years. Limited to twenty students with backgrounds in biological and agricultural science. Registration only by permission. Associate Professor N. E. Johnson. Not offered in 1969-70.

The nature, recognition, diagnosis, economic appraisal, biological evaluation, and treatment of insects attacking woody plants in the United States. Includes chemical, cultural, and biological control principles for insect pests. Laboratory exercises will be varied to fit the background of the individual student.

## BIOLOGICAL CONTROL

### 577. BIOLOGICAL CONTROL AND INSECT BEHAVIOR

Fall term. Credit three hours. Prerequisite: consent of the instructor. Assistant Professor Tauber.

Participants will critically review theory and method of biological control of pest species with emphasis on the role of behavior. This course may be repeated for credit.

## PARASITOLOGY

### 351A. INTRODUCTORY PARASITOLOGY

Every spring term. Credit four hours. Prerequisites: Biological Sciences 101-102, 103-104, or their equivalent. Entomology 210 or 212 and Biological Sciences 371 are also recommended. Limited to twelve students per section. Professor Travis.

An introduction to the symbiotic way of life among animals, primarily the protozoan, helminth, and arthropod species of temperate and tropical areas. Special emphasis is given to the recognition of selected symbiotic species and how they live with their hosts.

### 351B. INTRODUCTORY PARASITOLOGY, LECTURES

Every spring term. Credit two hours. Prerequisites: Biological Sciences 101-102, 103-104, or their equivalent. Biological Sciences 371 is recommended.

This course is the same as the lecture portion of 351A.

### [551. ADVANCED PARASITOLOGY (PROTOZOA AND HELMINTHS)]

Fall term. Credit three hours. Given in alternate years. Prerequisite: Entomology 351 or its equivalent. Professor Travis. Not offered in 1969-70.

A continuation of Entomology 351 for graduate students interested in the parasitic protozoa and helminths. Practical experience with methods of collection and preparation; detailed studies on recognition and life cycles. Special emphasis is given to the parasites that are transmitted by arthropods in the tropics.

### 552. ADVANCED PARASITOLOGY (MEDICAL ENTOMOLOGY)

Fall term. Credit three hours. Offered in alternate years. Prerequisites: Entomology 351 and 212 or the equivalent. Professor Travis.

A continuation of Entomology 351 for graduate students interested in medical or veterinary entomology. Practical experience with methods of collection and preparation; detailed studies on recognition, life cycles, and control. Special emphasis is given to causative agents, vectors, and intermediate hosts of disease-producing organisms. The study examples include species of worldwide distribution, especially those of the tropical areas.

**553. ADVANCED PARASITOLOGY (INSECT PATHOLOGY)**

Spring term. Credit three hours. Prerequisites: a course in entomology and a course in a microbiological science and permission of the instructor. By appointment. Associate Professor Kramer.

A survey of the microbial and zooparasitic diseases of insects with emphasis on the natural history of the pathogens. Pathogens considered include viruses, rickettsiae, bacteria, spirochetes, fungi, protozoa, nematodes, and selected arthropods.

**APICULTURE****262. BIOLOGY OF THE HONEY BEE**

Fall term. Credit one hour. Prerequisites: Biological Sciences 103-104 or the equivalent. Limited to ten students. Registration only by permission. Fifteen laboratories by arrangement in September and October only. Associate Professor Morse.

A laboratory and field course in which the classical experiments on the vision, chemical senses, and language of the honey bee, as described by von Frisch, are repeated. Laboratories include demonstration of the sex attractant, swarm orientation, the natural nest, and a study of wasp, bumble bee, and other social insect nests.

**562-563. SPECIAL TOPICS IN BEEKEEPING**

Throughout the year. Credit three hours a term. Registration by permission. By appointment. Associate Professor Morse.

A technical course designed for advanced studies and covering scientific investigation in all phases of the subject. Special attention is given to improved methods of apiary and honeyhouse management and the preparation of honey for market. Current literature on beekeeping is assigned, reviewed, and evaluated by students. Lectures and discussions are supplemented by field trips.

**ECOLOGY AND LIMNOLOGY****ECOLOGY AND EVOLUTIONARY BIOLOGY 361. GENERAL ECOLOGY**

Fall or spring term. Credit three hours. Prerequisite: Biological Sciences 101-102 or 103-104 or the equivalent. Assistant Professors Feeny and Root.

Principles concerning the interactions between organisms and their environment. Influence of competition, social behavior, predation, and other factors of population size and dispersion. Role of energy flow and mineral cycling in determining the structure and productivity of ecosystems. Succession and classification of natural communities. Influence of climate and past events on the diversity and stability of communities in different regions of the world. Interspecific competition and the niche concept. Chemical interactions between organisms. Application of ecological principles to human problems. Modern evolutionary theory will be stressed throughout and attention given to conflicting ecological hypotheses.

**ECOLOGY AND EVOLUTIONARY BIOLOGY 661. SEMINAR IN POPULATION AND COMMUNITY ECOLOGY**

Fall term. Credit one hour. Prerequisites: a course in ecology and permission of the instructor. Assistant Professor Root.

Discussion of recent advances in population and community ecology.

471. AQUATIC ENTOMOLOGY AND LIMNOLOGY

Spring term. Credit three hours. Prerequisite: Entomology 210 or 212. Biological Sciences 361 is recommended. Professor Berg.

A field and laboratory study of the bionomics of freshwater invertebrates. The course includes characteristics of freshwater habitats, identification of insects and other invertebrates found in them, understanding of life cycles, and consideration of the ecological relationships among organisms in various aquatic biotopes.

572. ENTOMOLOGY AND LIMNOLOGY SEMINAR

Fall term. Credit one hour. Prerequisites: Entomology 471 or Biological Sciences 462, and permission of the instructor. Professor Berg.

Discussions and analyses of current concepts and problems in limnology and aquatic entomology, including the critical study of selected reference works and research papers.

595. ENVIRONMENTAL BIOLOGY

Fall term. Credit three hours. Permission to register is required. Professor Pimentel.

Principles of the interaction between living systems and their resources are considered. Particular emphasis will be given to current problems in the management of our natural resources including new approaches in the management of insect populations. Biological and bioenvironmental controls will be discussed.

ECOLOGY AND EVOLUTIONARY BIOLOGY 462 and 565. LIMNOLOGY, AND SPECIAL TOPICS IN LIMNOLOGY

(Consult the course listing in this *Announcement* for the Field of Ecology and Evolutionary Biology.)

PHYSIOLOGY

483. INSECT PHYSIOLOGY

Fall term. Credit four hours. No prerequisites; biochemistry, physics, and a course in animal physiology recommended. Professor Patton.

An introductory to intermediate course in the physiology of insects primarily for graduate students in entomology.

TOXICOLOGY AND INSECTICIDAL CHEMISTRY

[590. INSECT TOXICOLOGY AND INSECTICIDAL CHEMISTRY]

Spring term. Credit four hours. Given in alternate years. Prerequisites: general chemistry and organic chemistry. Professor Lisk and Assistant Professor Wilkinson. Not offered in 1969-70.

The chemistry of insecticides and their metabolism and mode of action in insects and mammals. Analytical techniques in residue evaluation and laboratory techniques in evaluating effects on insects.

FLORICULTURE AND ORNAMENTAL HORTICULTURE

Faculty: James W. Boodley, John F. Cornman, Raymond T. Fox, Robert W. Langhans, Robert G. Mower, Robert J. Scannell, John G. Seeley, Peter L. Steponkus, Harold B. Tukey, Jr.

Field Representative: James W. Boodley, 8 Plant Science Building.

#### MAJOR SUBJECT

Floriculture and  
Ornamental Horticulture

#### MINOR SUBJECT

Floriculture and  
Ornamental Horticulture (when  
the major subject is in another  
Field)

Entering graduate students are expected to have adequate preparation in elementary horticulture, botany, plant physiology, genetics, pathology, agronomy, entomology, mathematics, chemistry, and physics.

There is no language requirement for the Master's degree. For the Ph.D. degree, a student must have a reading proficiency (at a high level) in one language other than his native language. French, German, or a substitute approved by his Special Committee may be selected.

The thesis for the Master's degree is to be based on results of a research project. Requirements for the Ph.D. degree include selection of two minor subjects, passing a qualifying examination usually given before the termination of the third residence unit, an Admission to Candidacy Examination normally given upon conclusion of course work, and a Final Thesis Examination on the dissertation and related material.

Members of the staff are concerned with the following specialities:

Greenhouse crops: Professors Boodley, Langhans, and Seeley.

Landscape design: Professor Scannell.

Nursery crops: Professor Tukey.

Ornamental Horticulture Physiology: Professor Steponkus.

Plant materials: Professor Mower.

Turfgrass: Professor Cornman.

Studies relating to physiology, propagation, nutrition, and culture may be undertaken as research for an advanced degree and should be approached from the standpoint of the basic sciences. Consequently, it is appropriate to select minor subjects from such areas as physiology, anatomy, morphology, taxonomy, pathology, genetics, agronomy, entomology, agricultural economics, and agricultural engineering.

For a Master's degree in landscape design, studies involving the use of plant materials and problems of design relating to landscape service for small properties may be suitable, in which case it is expected that the student will have an adequate background in the basic principles of horticulture and plant science as well as in design and drawing.

For graduate course listings, consult the pertinent Field listings in this *Announcement*. The Department of Floriculture and Ornamental Horticulture does not offer courses for graduate students only. However, graduate students may take selected undergraduate courses in the Department.

## FOOD AND NUTRITION

Faculty: Gertrude D. Armbruster, Marjorie Devine, Elizabeth A. Donald, E. Elizabeth Hester, Leo Lutwak, Nell Mondy, Mary A. Morrison, Katherine J. Newman, Jerry M. Rivers, Daphne A. Roe, Thomas J. Schoch, Jean T. Snook, Charlotte M. Young.

Field Representative: Gertrude D. Armbruster, 206 Martha Van Rensselaer Hall.

## MAJOR AND MINOR SUBJECTS

Food

Food and Nutrition

Nutrition

**AIMS AND OPERATIONS.** The program of graduate study in the Field of Food and Nutrition is designed to give in-depth study in the fundamental knowledge of food or nutritional sciences and in methods of research. Emphasis is placed on the application of the physical, biological, and social sciences to the basic principles of food and nutrition. Depending upon the student's interest, in nutrition he may choose to obtain laboratory experience with nutritional problems using either animals or human beings or field experience applying the social sciences to nutrition; in foods he may obtain experience in applying principles and laboratory techniques learned in organic chemistry, biochemistry, and bacteriology to problems with various foods and food components. With the aid of the Special Committee, specific programs are planned to fit the objectives of each student and to develop original thinking and independent research.

**ADMISSION REQUIREMENTS.** A candidate who wishes to major in this Field and whose previous studies include preparation in basic courses in food science and human nutrition, general and organic chemistry, biochemistry, bacteriology, and physiology may begin graduate studies toward an advanced degree immediately. A student whose preparation is deficient in one or more areas will be required to make up the deficiencies. Preparation in analytical chemistry, physics, and mathematics is strongly recommended.

**LANGUAGE REQUIREMENTS.** The Field makes no specific language requirement. The members of the Special Committee will ask that a Ph.D. candidate attain a degree of proficiency in a language or in some other subject matter area in which a degree of competence is important to his educational goals.

**EXAMINATIONS.** Each M.S. candidate must pass an oral examination on his major and minor subjects and on his thesis. Two examinations are required for Ph.D. candidates and are administered by the Special Committee. The comprehensive Admission to Candidacy Examination is given to judge competence in subject matter. It may be oral or oral and written. An oral Final Thesis Examination is required in defense of the thesis.

**RESEARCH AND STUDY OPPORTUNITIES.** Students with a major or minor in food or nutrition may select from a variety of courses, seminars, and experiences in independent study in many Fields. Each student plans his program in consultation with his Special Committee after consideration of his previous background and purpose in graduate study. A conference of the student admitted to the Ph.D. degree program and members of his Special Committee is arranged shortly after his admission to the Field to assess the competence of the student, to discuss his interests and goals, and to plan the direction of future work. For students with a major in the Field of Food and Nutrition, minor subjects should be selected from a wide variety of other Fields consistent with the student's objectives. Suggested minors in addition to those within the Field include biochemistry, physiology, bacteriology, botany, statistics, anthropology, sociology, education, and other areas of home economics. At least one minor chosen by candidates for the Ph.D. degree must be in a basic science related to the major.

## Special Interests of the Faculty

### HUMAN NUTRITION

- Professor Devine: nutrition education.  
 Professor Donald: human requirements for vitamin B<sub>6</sub>.  
 Professor Lutwak: mineral and energy metabolism.  
 Professor Morrison: utilization of protein and amino acids.  
 Professor Newman: nutrition as related to chemical and physical growth.  
 Professor Rivers: ascorbic acid metabolism.  
 Professor Roc: sulfur metabolism in the human subject.  
 Professor Snook: effects of diet on pancreatic enzymes.  
 Professor Young: body composition studies.

### FOOD SCIENCE

- Professor Armbruster: interrelationships of plant tissue properties and product quality.  
 Professor Hester: protein-polysaccharide complexes.  
 Professor Mondy: enzyme and lipid chemistry in plants.  
 Professor Schoch: starch chemistry.

Inquiries should be addressed to the Graduate Field Representative, Food and Nutrition, Martha Van Rensselaer Hall.

## Courses

Following is a recent, but not a final listing of courses. Students should check with departments as to definite offerings, times, and plans.

### 441. NUTRITION AND DISEASE

Fall term. Credit three hours. Prerequisite: Food and Nutrition 332 or equivalent. Miss Rivers.

Study of the physiological and biochemical anomalies in certain diseases and the principles underlying nutritional therapy. Independent survey of the technical literature in this field.

### 442. ADVANCED HUMAN NUTRITION

Fall term. Credit two hours. Prerequisite: 332 or equivalent. Miss Morrison.  
 Recent advances in nutrition. Emphasis on human nutrition.

### 446. SCIENCE OF FOOD

Fall term. Credit three (lectures only) or four hours. Prerequisites: 246 and a college course in organic chemistry or biochemistry. Students who have had limited laboratory experience in comparative foods should register for four hours. Misses Hester and Armbruster.

Scientific principles underlying modern food theory and practice. The relation to food quality of (a) the physical and chemical properties of proteins, lipids, carbohydrates, leavening agents and pigments; (b) stability of colloidal systems; (c) chemical composition and physical structure of natural and processed foods. Laboratory experiments designed to illustrate the effect of varying ingredients and treatment of the quality characteristics of food products.

### 447. SCIENCE OF FOOD, LABORATORY

Fall term. Credit one hour. Prerequisite or parallel: 446. Miss Armbruster.

Laboratory experiments designed to illustrate the physiochemical behavior of colloidal and crystalline systems and chemical reactions of food components.

#### 456. EXPERIMENTAL FOOD METHODS

Spring term. Credit three hours. Prerequisite: 446. A course in statistics and 447 are desirable but not required. Miss Armbruster.

Application of the scientific method in the design and performance of experimental food problems and in the interpretation and evaluation of results. Independent laboratory problems.

#### 500. SPECIAL PROBLEMS FOR GRADUATE STUDENTS

Fall and spring terms. Credit to be arranged. For graduate students recommended by their chairman and approved by the instructor in charge for independent, advanced work. Experience in research laboratories in the Department may be arranged. Department faculty.

#### ADVANCED NUTRITION SERIES

(Consult the course listing in this *Announcement* for the Field of Nutrition.)

#### 512. NUTRITION AND GROWTH

Fall term. Credit two hours. Prerequisite: 332 or equivalent. Miss Newman.

Information on growth which is of particular interest to nutritionists. Survey of methods used in studying physical and chemical growth. Relation between nutrition and growth. Offered in fall term of even-numbered years.

#### 514. READINGS IN NUTRITION

Spring term. Credit three hours. Prerequisite: 332 or the equivalent. Mrs. Snook.

Critical review of literature on selected topics in the area of nutrition. Emphasis is on human nutrition. Topics are changed each term so the course may be repeated for credit with permission of the instructor.

#### 516. READINGS IN FOOD

Fall term. Credit two hours. Prerequisite: 446 or the equivalent. Department faculty.

A critical review of selected topics in the current literature. Emphasis is on experimental data and basic scientific principles underlying modern theory and practice relative to food quality. Topics are changed each term so the course may be repeated for credit.

#### 524. RESEARCH METHODS IN HUMAN METABOLIC STUDIES

Spring term. Credit three hours. Prerequisites: 332 or the equivalent, laboratory experience in biochemistry or quantitative analysis, and permission of the instructor. Miss Donald and Department faculty.

Principles of human metabolic research; experimental design of human studies; dietary considerations; methods of collecting and analyzing biological material; and evaluation. Laboratory will include planning and management of a metabolic study, and the collection and the appropriate analyses of blood, urine, and feces.

#### 599. MASTER'S THESIS AND RESEARCH

Fall and spring terms. Credit to be arranged. Registration with permission of the instructor. Misses Armbruster, Donald, Hester, Mondy, Morrison, Newman, Rivers, and Young; Mrs. Devine, Mrs. Snook and Mrs. Roe; Messrs. Lutwak and Schoch.

**602. SEMINAR IN NUTRITION**

Fall term. Credit one hour. Department faculty.

**606. SEMINAR IN FOOD**

Spring term. Credit one hour. Department faculty.

**699. DOCTOR'S THESIS AND RESEARCH**

Fall and spring terms. Credit to be arranged. Registration with permission of the instructor. Misses Armbruster, Donald, Hester, Mondy, Morrison, Newman, Rivers, and Young; Mrs. Devine, Mrs. Snook, and Mrs. Roc; Messrs. Lutwak and Schoch.

**GRADUATE SCHOOL OF NUTRITION 100. PROBLEMS AND PROGRAMS IN INTERNATIONAL NUTRITION**

Fall term. Credit three hours (problems section only) or four hours. Registration by permission.

Problems section: To acquaint students who have a satisfactory knowledge of nutrition with the specific problems of human nutrition, food science, and food supplies in developing countries; emphasis is placed on the role of agriculture and public health. Among topics discussed are typical foods and dietary patterns in various parts of the world, assessment of food and nutrition conditions, protein-rich and other protective foods, food processing and preservation in developing countries, food standards, and food control.

Programs section: The planning of effective programs and policies in the areas of nutrition and food science for the purpose of improving nutrition conditions in developing countries.

**GRADUATE SCHOOL OF NUTRITION 392. CLINICAL AND PUBLIC HEALTH NUTRITION**

Spring term. Credit three hours. Prerequisites: a course in nutrition, physiology, and biochemistry. Registration by permission of the instructor. Professor C. M. Young and Assistant Professor Roc.

Designed to familiarize the student with some of the applications of nutrition to clinical and public health problems.

**FOOD SCIENCE AND TECHNOLOGY**

Faculty: Robert C. Baker, Paul A. Buck, N. C. Dondero, Robert K. Finn, John D. Hartman, Robert F. Holland, F. M. Isenberg, William K. Jordan, J. E. Kinsella, Frank V. Kosikowski, Richard Ledford, Nell Mondy, H. Brooks Naylor, N. N. Potter, John W. Sherbon, William F. Shipe, Jr., Laura Lee Smith, James R. Stouffer, D. V. Vadehra, J. J. Wanderstock, George H. Wellington, J. C. White.

At Geneva: Malcolm C. Bourne, Donald L. Downing, L. Ross Hackler, Robert L. LaBelle, Louis M. Massey, Jr., Leonard R. Mattick, James C. Moyer, Willard B. Robinson, George D. Saravacos, Robert S. Shallenberger, Don F. Splittstoesser, John R. Stamer, Keith H. Steinkraus, Gilbert Stoewsand, Jerome P. Van Buren, Walter F. Wilkins.

Field Representative: R. C. Baker, 112 Rice Hall.

**MAJOR AND MINOR SUBJECT**

Food Science and Technology

Excellent opportunities are offered in the Field of Food Science and Technology for graduate study. A wide variety of courses are offered as well as excellent research facilities. The members of this Field are associated with many different departments of the University. Research on meats, for example, is carried on in the Department of Animal Science and the Department of Poultry Science; research on potato processing takes place in the Department of Vegetable Crops. All course work is taken on the Ithaca campus, but Master's and doctoral candidates may elect to conduct their research at the Experiment Station in Geneva where a new pilot plant and laboratories are available. A smaller pilot plant is located on the Ithaca campus which supplements the very adequate research facilities of the Department specializing in the various raw materials.

Students planning graduate work in Food Science and Technology should have preparation in food science, chemistry, microbiology, biochemistry, or engineering.

A qualifying examination is required in the Field of Food Science and Technology to determine the student's need for future course work. An early date for this examination is considered essential, and it should take place soon after one term of course work is completed. The qualifying examination for the doctorate may be combined with the final examination for the Master's degree if approved by the student's Special Committee for the Ph.D. degree. The Admission to Candidacy and Final Thesis Examinations required by the Graduate School of all doctoral candidates are described on p. 12 of this *Announcement*.

There is no language requirement for the Field of Food Science and Technology. Language needs for the student, if any, will be decided by his Special Committee.

Candidates for the degree of M.S. are required to register for one major and one minor subject. Candidates for the degree of Ph.D. are required to register for a major and at least one minor subject.

A brochure describing the facilities and activities of the Field of Food Science and Technology is available from the Field Representative.

## Courses

### 210. PROPERTIES, STANDARDS AND ANALYSIS OF FOODS

Spring term. Credit three hours. Prerequisite: Chemistry 104 or 108. Professor Shipe and assistants.

The lecture portion of the course deals with the general properties of fats, proteins, carbohydrates, minerals, and vitamins and their specific effects on the properties of foods. Food standards and methods of analysis are discussed. The laboratory portion of the course is designed to acquaint the student with a variety of qualitative and quantitative tests used by the food analyst.

### [302. DAIRY AND FOOD ENGINEERING]

Fall term. Credit four hours. Offered in alternate years. Prerequisites: Physics 101 and 102 or the equivalent and Food Science 100. Professor Jordan. Not offered in 1969-70.

Engineering aspects of dairy and food plant operations.

### 303. FATS AND OILS

Fall term. Credit three hours. Assistant Professor Kinsella.

Certain phases of chemistry and quantitative analysis as applied to the quality control and improvement in the palatability and nutritional values of milk and other fat-containing food products, including the influence of the plant and animal.

### 310. SENSORY QUALITIES AND EVALUATIONS OF FOODS

Spring term. Credit two hours. Professor Shipe and assistants.

Deals with the factors affecting the color, odor, flavor, and texture of foods and the evaluation of these qualities. The techniques and interpretations of both objective and subjective evaluations are discussed. The laboratory exercises involve the evaluation of a variety of foods.

### [311. CONCENTRATED, DEHYDRATED, AND FROZEN FOODS]

Spring term. Credit four hours. Offered in alternate years. Professor Jordan and Associate Professor Potter. Not offered in 1969-70.

Deals with the principles and practices of condensing, drying, and freezing food materials. Such aspects as raw material selection, preparation, processing unit operations, packaging, and storage properties of foods will be considered in the light of current processing methods, and as related to the chemistry, microbiology, and technology of the ingredients and final products.

### [313. STERILIZATION PROCESSES]

Spring term. Credit three hours. Offered in alternate years. Prerequisites: Chemistry 353 or equivalent, Biological Sciences 394, and Physics 102. A course in calculus and a course in biochemistry are recommended. Associate Professor Buck. Not offered in 1969-70.

The principles of food preservation and the fundamentals of food processing from raw materials to finished product. Heat transfer, unit operations, and unit processes employed by the canning industry will be emphasized, but sterilization by any means such as heat, chemicals, physical destruction, and filtration will be demonstrated. The effects of lethal energy treatment of biological fluids and systems on desirable components such as nutritive factors and flavor components will be considered along with the cost of operation. The laboratory involves actual participation in plant operations in the processing and preservation of various food products, and field trips.

### [314. MILK AND FOOD SANITATION AND PLANT OPERATIONS]

Fall term. Credit four hours. Given in alternate years. Prerequisites: Course 100 and Biological Sciences 394. Professor White and assistants. Not offered in 1969-70.

The biological and chemical control of milk and food processing. Federal, state, and local requirements for the production, collection, and processing of milk and food. The control of sanitation, composition, and production in the food plant is outlined with special attention given to the fluid milk industry.

### 401. FOOD FROM FERMENTATIONS

Fall term. Credit five hours. Given in alternate years. Prerequisite: beginning courses in microbiology and organic chemistry or biochemistry are recommended. Professor Kosikowski and Assistant Professor Ledford.

The chemistry, microbiology, and technology of processes leading to important foods as cultured milks, cheeses, wines and beers. Consideration is given also to other fermentations resulting in high-protein foods from plant and animal sources, including those from petroleum and whey.

Line-flow processing and testing practices designed to acquaint students with the principles of fermentations and production of the above foods are carried out in the laboratory.

#### 403. INTERNATIONAL FOOD DEVELOPMENT

Fall term. Credit three hours. Given in alternate years. Professor Kosikowski.

A study of programs, technical problems, and progress associated with developing acceptable food supplied in critical world areas. Proposals for increasing world protein resources for the human are to be discussed. Special attention is to be directed to the organization, operations, relationships and contributions of United Nations technical agencies, FAO, UNICEF, WHO, and governmental and non-governmental organizations in the field.

#### [404. CHEMISTRY OF MILK]

Fall term. Credit three hours. Offered in alternate years. Prerequisites: qualitative and quantitative analysis and organic chemistry. Assistant Professor Ledford. Not offered in 1969-70.

A study of milk constituents and physical properties. Deals with milk enzymes, lactose, milk fat, milk proteins, and minor constituents.

#### [410. FOOD BIOCHEMISTRY]

Fall term. Credit three hours. Given in alternate years. Prerequisite: Biological Sciences 431. Assistant Professor Kinsella. Not offered in 1969-70.

A discussion of some of the important non-microbial changes in foods, such as denaturation and the Maillard Browning reaction. Emphasis is placed on the occurrence, significance, and prevention or control of the changes as they affect the color, odor, flavor, texture, or nutritive value of foods.

#### 412. AQUATIC MICROBIOLOGY

Spring term. Credit three hours. Given in alternate years. Prerequisite: introductory bacteriology (Biological Sciences 290 or equivalent, or Soil Science 306). Professor Dondero.

A consideration of the relation of microorganisms, especially the bacteria, to aquatic environments, both natural and artificial. The microbiology of waste waters will be included. Attention will be given to fundamental biological concepts and to applied aspects of the occurrence and activities of microorganisms in waters.

#### [413. ANALYTICAL METHODS]

Spring term. Credit four hours. Given in alternate years. Prerequisite: Biological Sciences 210, one term of either organic chemistry or biochemistry. Assistant Professor Sherbon. Not offered in 1969-70.

A study of the analytical methods important to the food industry. The emphasis is on understanding the basic analytical chemistry applied in the various tests. General topics include sampling, gravimetric and volumetric methods, optical methods, electrochemistry, and the use of basic statistics.

#### 512. INSTRUMENTAL METHODS

Spring term. Credit five hours. Offered in alternate years. Prerequisite: Food Science 413 or permission of the instructor. Assistant Professor Sherbon.

Deals with instrumental methods widely used in research and industry. The major emphasis is on chromatographic methods, spectroscopy, electrophoresis, and the use of computers in agricultural research. The stress will be on the practical use of the material presented.

## 514. THE BIOCOLLOIDAL CHEMISTRY OF FOODS

Spring term. Credit three hours. Offered in alternate years. Prerequisites: Biological Sciences 431 and 433 or the equivalent. Associate Professor Buck.

The principles of the science of colloidal systems and micelles of importance in biology and agriculture will be introduced; then the amiscropic morphology of cytoplasm, cell walls, plastids, and biological gels and sols will be studied and the data applied to food. Polysaccharides and polypeptides in chain molecules which sometimes reach microscopical lengths will be intensively studied. Special attention will be given to the structural arrangement of complex polymers. The physical chemistry of surfaces (including adsorption, ion exchange, and electric double layer), flocculation, viscosity, swelling, and gel formation will be discussed.

## 600. SEMINAR

Fall and spring terms.

Attendance required of all food science graduate students on the Cornell campus, and all dairy science students, at seminars sponsored by their respective fields.

Courses are also available to students in Food Science and Technology from other Fields such as Agricultural Economics, Animal Science, Biochemistry, Business and Public Administration, Industrial and Labor Relations, Microbiology, Pomology, Poultry Science, and Vegetable Crops.

## GENETICS

(See also the listing under Medical Sciences, page 103 of this *Announcement*.)

Faculty: Antonie Blackler, Joseph M. Calvo, Gerald R. Fink, Ross J. MacIntyre, Richard L. Russell, Adrian M. Srb, Harry T. Stinson, Charles H. Uhl, Bruce Wallace, Stanley A. Zahler.

Field Representative: Bruce Wallace, 158 Plant Science Building.

## MAJOR AND MINOR SUBJECT

## Genetics

Applicants are urged to submit scores of the Graduate Record Examination Aptitude and Advanced Biology Tests.

The foreign language requirements are: for the Ph.D. degree (major), two; for the M.S. degree, one. Any foreign language in which a sizeable genetics literature exists is acceptable. Candidates for the M.S. degree in genetics who intend to continue for the Ph.D. degree are urged to satisfy the requirement for one language.

The Field of Genetics requires a qualifying examination administered by the student's Special Committee usually at the end of the second year of study. The Admission to Candidacy and Final Thesis Examinations required by the Graduate School are described on p. 12 of this *Announcement*.

Faculty members in the Field of Genetics have widely different research interests ranging from molecular through cytological, physiological, and evolutionary genetics. The student should choose a professor whose interests coincide with his own.

## Courses

All courses carry Biological Sciences numbers unless otherwise indicated. Starred courses are not generally regarded as graduate courses, but may be so regarded in special cases.

### 280. HUMAN GENETICS\*

Spring term. Credit three hours. Prerequisites: Biological Sciences 101-102 or 103-104. Students who have had 281 may register only with the permission of the instructor. Professor Srb.

An introduction to biological heredity through consideration of the genetics of man. Advances in the science of genetics are having a profound effect on man's understanding of himself and on his potential for influencing his present and future well-being. The course is intended primarily to contribute to the student's general education in these matters, and although certain aspects of genetics will be considered with some rigor, the course is not designed to serve as a prerequisite to advanced courses in genetics.

### 281. GENETICS

Fall or spring term. Credit four hours. Prerequisites: 101-102 or 103-104. Students who have had 280 may register only with the permission of the instructor. Assistant Professors Fink, Russell, MacIntyre, and assistants.

A general study of the fundamental principles of genetics. Discussion of gene transmission, gene action and interaction, gene linkage and recombination, gene structure, gene and chromosome mutations, genetic aspects of differentiation, genes in populations, breeding systems, extrachromosomal inheritance. Animals, plants and microorganisms are used in the laboratory, which also includes, as independent study, inheritance in *Drosophila*.

### 347. CYTOLOGY

Fall term. Credit four hours. Prerequisites: 101-102 or 103-104 or the equivalent. Associate Professor Uhl.

The principal topics considered are protoplasm, cells and their components, nuclear and cell division, meiosis and fertilization, and the relation of these to the problems of development, reproduction, taxonomy, and heredity. Both plant and animal materials are used.

### 440. CYTOGENETICS

Spring term. Credit three hours. Prerequisites: 347 and 281 or the equivalent. Associate Professor Uhl.

An advanced course dealing mainly with the cellular mechanisms of heredity and including recent researches in cytology, cytogenetics, and cytotaxonomy.

### 480. POPULATION GENETICS

Spring term. Credit three hours. Prerequisite: 281 or the equivalent. Professor B. Wallace.

A study of factors which influence the genetic structure of Mendelian populations and which are involved in race formation and speciation.

### 482. PHYSIOLOGICAL GENETICS

Spring term. Credit three hours. Prerequisites: 281 and a course in organic chemistry. Professor Srb.

The nature and activities of chromosomal and nonchromosomal genetic material are considered in relation to the functional attributes of organisms.

**489. RESEARCH IN GENETICS AND DEVELOPMENT\***

Fall or spring term. Credit to be arranged. Prerequisite: permission of the professor under whom the work is to be taken. Staff.

Practice in planning, conducting, and reporting independent laboratory and/or library research programs.

**495. MICROBIAL GENETICS**

Fall term. Credit four hours. Prerequisites: 281 and 290 or permission of the instructor. Associate Professor Zahler.

Genetics of bacteria and their viruses with emphasis on the mechanisms of genetic phenomena.

**495A. MICROBIAL GENETICS, LECTURES**

Fall term. Credit two hours. Prerequisites: 281 and 290 or 290A. Associate Professor Zahler.

The course is the same as the lecture portion of 495.

**680. CURRENT TOPICS IN GENETICS**

Throughout the year. Credit two hours a term. Preference given to majors in the Field of Genetics. No auditors. Enrollment limited to twenty students. Staff.

A seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of the course and staff direction will vary from term to term and will be announced a semester in advance.

See also courses listed in the Fields of Animal Breeding, Biochemistry, Physiology, Plant Breeding, and Poultry Science.

## INTERNATIONAL AGRICULTURAL DEVELOPMENT

Faculty: Douglas E. Ashford, Solon L. Barraclough, Frederick T. Bent, Carl W. Boothroyd, Paul A. Buck, Marlin G. Cline, Royal Colle, Howard E. Conklin, Robert H. Crawford, Loy V. Crowder, Tom E. Davis, Matthew Drosdoff, Reeshon Feuer, Donald K. Freebairn, William H. Friedland, Frank H. Golay, Robert F. Holland, William K. Jordan, William C. Kelly, George C. Kent, Richard P. Korf, Frank V. Kosikowski, Douglas J. Lathwell, J. Paul Leagans, Gilbert Levine, John K. Loosli, Harry A. MacDonald, John G. Matthyse, Robert E. McDowell, John W. Mellor, Philip A. Minges, Robert B. Musgrave, Thomas T. Poleman, Jr., Robert A. Polson, Milton L. Scott, Robert M. Smock, Earl L. Stone, Jr., Robert D. Sweet, H. David Thurston, George W. Trimberger, Kenneth L. Turk, Frank W. Young.

Field Representative: Kenneth L. Turk, 102 Roberts Hall.

**MINOR SUBJECT**

International Agricultural Development

This Field is intended primarily for students who are preparing for service in foreign countries. The student will seek depth of knowledge by majoring in a biological, physical, or social science. The minor subject draws

from several disciplines with the objective of assisting the student in understanding the special conditions and problems of newly developing economies. While this minor is planned specifically for students majoring in one of the graduate fields of agriculture, other qualified students are welcome. It is intended for students from other countries as well as for those from the United States. Students will register for seminars, courses, and special problems offered by the several departments and colleges.

A student minoring in this Field is encouraged to gain speaking proficiency in a language likely to prove most useful in this area of service in addition to meeting the language requirements in his major Field.

A student may not minor in this Field if he is minoring in Asian Studies or Latin American Studies, and he may not select a professor for this minor who also serves on the Graduate Faculty in the student's major Field.

A complete listing of the courses offered by the Field of International Agricultural Development is found in the *Announcement of the Graduate School: Social Sciences*.

## MEDICAL SCIENCES (GRADUATE SCHOOL OF MEDICAL SCIENCES)

(See page 51 of this *Announcement*.)

Requests for information regarding the Fields in the Medical Sciences should be addressed to Professor Julian R. Rachele, Assistant Dean, Graduate School of Medical Sciences, Cornell University, Medical College, 1300 York Avenue, New York, N.Y. 10021.

### Anatomy

Graduate students interested in pursuing analyses of biological systems in terms of spatial relations, form, their development, functional modulation, and chemical significance at levels of organization ranging from the macromolecular to the organismic may find major or minor sponsorship for graduate study in the Field of Anatomy. Instruction by the graduate faculty is available in the disciplines of light and electron microscopy, microtomy and ultramicrotomy, histochemistry, cytochemistry, cytospectrophotometry, cell fractionation, autoradiography, x-ray and electron diffraction analysis, electrical and histological methods in neuroanatomy, and gross and microscopical dissection.

### Biochemistry

The Field of Biochemistry in the Graduate School of Medical Sciences provides the Ph.D. candidate with the opportunity and facilities for thesis research in various areas of biochemical investigation such as: enzymology; mechanism of enzyme action; intermediary metabolism; physical chemistry and structure of proteins, nucleic acids, and other macromolecules; neurochemistry; hormone chemistry and action; molecular biology; and synthesis and biochemical action of chemotherapeutic compounds. The Field also offers courses and seminars concerned with advanced topics in the chemistry and biochemistry of carbohydrates, lipids, nucleic acids, and proteins and in the methodology of physical biochemistry.

## Biomathematics

A new program of applied mathematics in biology is offered by the Biomathematics Division to students whose primary interests are mathematical or theoretical, but who wish to concentrate on biological applications. Programs leading to the Ph.D. degree are flexible to suit the particular area of biological application of the individual student, and appropriate courses of study in the relevant aspects of biology, chemistry, physics, and medicine are planned accordingly.

## Biophysics

Graduate work toward the Ph.D. degree in the Field of Biophysics and the M.S. degree in the Field of Radiation Physics is offered, as well as opportunities for postdoctoral research in biophysics. Active research programs are being conducted in fundamental radiation biophysics, including cellular radiobiology, and in the biophysics of membrane transport.

## Biostatistics

The graduate program in the Field of Biostatistics offered by the Biomathematics Division applies the quantitative methods of the theory of probability and statistics to biological or medical problems. The use of modern computers is an integral part of the program which leads to the Ph.D. degree.

## Cell Biology

The Field of Cell Biology deals with the structure and chemical composition of organelles, with the synthesis of their macromolecular components, and with the integration of their separate functions in the economy of the whole cell. The techniques employed include cell structure, electron microscopy, radioautography, isolation of organelles by differential centrifugation, enzymology, and biochemical analysis. The Field is concerned with the alterations of ultrastructure which are associated with differentiation, with disease, and with the initiation, control, and modification of growth in normal and neoplastic cells.

## Genetics

Courses, seminars, and opportunities for research training in the Field of Genetics are available in several different areas including cytogenetics, human biochemical and cell genetics, mammalian developmental genetics, microbial genetics, nucleic acid chemistry and biochemistry, and virology.

## Microbiology

The Graduate School of Medical Sciences offers a widely diversified Field of study in Microbiology covering both medically-oriented and more general

aspects of the science. To provide this coverage, the Field draws on both faculty and facilities in various departments and divisions of the Medical School and the Sloan-Kettering Institute. Courses, seminars, and thesis research are available in the areas of general and medical bacteriology, microbial chemistry and physiology, virology, immunology, genetics, and mycology.

## Neurobiology and Behavior

Seminars, courses, and research experience are designed to present an integrated, multidisciplinary approach to graduate training in the neurological and behavioral sciences with emphasis on neurochemistry, neurophysiology, and neuropsychology and perception. Special facilities are available for research with humans and with experimental primates.

## Pharmacology

Pharmacology is concerned with the interaction of exogenous chemical substances in living structures. Training is offered in the concepts and techniques of this science. Opportunities for thesis research include the influence of drugs and chemicals on biochemical systems; the peripheral, autonomic, and voluntary nervous systems; the central nervous system; the cardiovascular system; and the kidney. Also there is opportunity for using modern concepts of organic chemistry to analyze the relationship between chemical structure and biological activity.

## Physiology

Predoctoral and postdoctoral facilities are available for studies of function in intact animals, whole organs, subunits of organs, isolated cells, and sub-cellular systems. Supervision is provided by a staff whose specific areas of interest may be obtained from the *Announcement of the Graduate School of Medical Sciences*. Advanced course work is also available.

## MICROBIOLOGY

(See also the listing under Medical Sciences, page 103 of this *Announcement*.)

Faculty: Martin Alexander, Eugene A. Delwiche, Norman C. Dondero, Robert K. Finn, A. Jane Gibson, Russell E. MacDonald, H. Brooks Naylor, Harry W. Seeley, Jr., Lawrence I. Slobin, Paul J. VanDemark, Stanley A. Zahler.

At Geneva: Donald F. Splittstoesser, John R. Stamer, Keith H. Steinkraus.

Field Representative: Paul J. VanDemark, 311 Stocking Hall.

### MAJOR AND MINOR SUBJECT

Microbiology (See also Pathogenic Bacteriology, page 152.)

Applicants for admission are required to submit scores for the Graduate Record Examination Aptitude Test.

Although candidates for the M.S. degree will be admitted for graduate

study, preference for admission will be given to candidates for the Ph.D. degree.

Students planning graduate study in the Field of Microbiology should have preparation in general chemistry, qualitative and quantitative analysis, organic chemistry, physics, and should have introductory courses in the biological sciences. In addition, training in physical chemistry and calculus is desirable. Deficiency in any of the subjects listed does not necessarily preclude admission, but it may increase the time necessary to earn a degree.

The language requirement in the Field of Microbiology may be satisfied by demonstration of a reading proficiency in one language, including French, German, Russian, or a language approved by the student's Special Committee by passing the Educational Testing Service Graduate Foreign Language Examination.

Field requirements for candidates for the doctoral degree are those of the Graduate School as outlined on p. 12.

Well-equipped laboratories are available. Those branches of microbiological research in which the staff is experienced and especially interested include bacteriophage, genetics, morphology and cytology, physiology and biochemistry, and systematic and applied microbiology.

## Research and Study Opportunities

Some research and study opportunities related to the specializations of the various faculty members are as follows:

Bacterial photosynthesis: J. Gibson.

Bacteriophage: H. B. Naylor.

Food microbiology: H. B. Naylor, D. F. Splittstoesser, J. R. Stamer, K. H. Steinkraus.

Immunology: L. I. Slobin.

Industrial fermentations and bioengineering: E. A. Delwiche, R. K. Finn.

Microbial ecology: M. Alexander, E. A. Delwiche, H. W. Seeley, Jr.

Microbial genetics and differentiation: S. A. Zahler.

Microbial nutrition: H. W. Seeley, Jr., P. J. VanDemark.

Microbial physiology: E. A. Delwiche, J. Gibson, R. E. MacDonald, H. W. Seeley, Jr., P. J. VanDemark.

Soil microbiology: M. Alexander.

Water and waste microbiology: N. C. Dondero.

## Courses

All courses carry Biological Sciences numbers unless otherwise indicated.

### 390A. ADVANCED BACTERIOLOGY LECTURE

Fall term. Credit three hours. Prerequisites: organic chemistry and Biological Sciences 290, or permission of the instructor. Biochemistry is desirable and may be taken concurrently. Associate Professor MacDonald.

A study of the comparative physiological and ecological relationships among bacteria and some related organisms. A number of groups of bacteria will be discussed in detail as well as factors which influence their ability to survive in nature. In addition, a number of lectures will be devoted to the history of bacteriology and to the theory and development of bacterial classification.

### 390B. ADVANCED BACTERIOLOGY LABORATORY

Fall term. Credit three hours. Prerequisites: Registration in 390A and permission of the instructor. Associate Professor MacDonald.

Techniques for the isolation, cultivation, and detailed study of selected groups of organisms. Some of the more standard techniques of physiological study will be introduced.

#### 490A. MICROBIAL PHYSIOLOGY LECTURE

Spring term. Credit three hours. Prerequisites: Biochemistry 431 or equivalent; Biological Sciences 390 or permission of the instructor. Assistant Professor Gibson.

A study of the organization of physiological processes in microorganisms, including a study of structure, energy-yielding mechanisms, macromolecular biosynthesis, and of growth and regulation.

#### 490B. MICROBIAL PHYSIOLOGY LABORATORY

Spring term. Credit three hours. Prerequisites: a grade of B- or better in 390, coregistration in 490A, and permission of instructor. Assistant Professor Gibson.

Experiments on material covered in 490A will be used to introduce students to modern techniques used in physiological research, such as the use of radioisotopes, large-scale growth of microorganisms, and the isolation and characterization of specific cellular components.

#### 495A. MICROBIAL GENETICS LECTURE

Fall term. Credit two hours. Prerequisites: 281 and 290, or permission of the instructor. S and U grades optional. Associate Professor Zahler.

Genetics of bacteria and their viruses, with emphasis on the mechanism of genetic phenomena.

#### 495B. MICROBIAL GENETICS LABORATORY

Fall term. Credit two hours. Prerequisite or parallel: 495A and permission of the instructor. Associate Professor Zahler.

Laboratory methods in the genetics of bacteria and their viruses.

#### 496. CHEMISTRY OF MICROBIAL PROCESSES

Spring term. Credit two hours. Prerequisites: beginning courses in general microbiology, biochemistry, and organic chemistry. Professor Delwiche.

Selected topics pertaining to the energy metabolism, oxidative and fermentative abilities, and biosynthetic capacities of microorganisms. Where possible and appropriate the subject matter deals with the various microbial forms in a comparative sense.

#### 498. VIROLOGY

Spring term. Credit three hours. Given in alternate years. Prerequisites: 290 and 281 and permission of the instructor. Professor Naylor, assisted by Professor Ross and Associate Professor Carmichael.

#### 590. METHODS IN ADVANCED BACTERIOLOGY

Either term. Credit two hours. Prerequisite: permission of the instructor. Limited enrollment. Staff.

Intended to acquaint advanced students with some of the more important techniques used in the study of bacterial physiology. Emphasis will be placed on the use of radioisotopes; growth, structure, and function of cells.

#### 595. MOLECULAR IMMUNOLOGY

Spring term. Credit two hours. Prerequisite: an introductory course in biochemistry and permission of the instructor. Assistant Professor Slobin.

A study of the immune response with particular emphasis on the structure and evolution of immunoglobulins, the nature of antigen-antibody interactions and the molecular biology of antibody biosynthesis.

#### 691. GRADUATE SEMINAR IN MICROBIOLOGY

Fall and spring terms. Credit one hour per term. Staff.

Required of all graduate students majoring in microbiology.

#### 699. MICROBIOLOGY SEMINAR

Fall and spring terms. Without credit. Staff.

Required of graduate students majoring in microbiology and open to all who are interested.

#### AGRONOMY 506. ADVANCED SOIL MICROBIOLOGY

#### VETERINARY MEDICINE 941. SEROLOGY

#### VETERINARY MEDICINE 944. IMMUNOCHEMISTRY

#### VETERINARY MEDICINE 945. ANIMAL VIROLOGY

## NEUROBIOLOGY AND BEHAVIOR

(See also the listing under Medical Sciences, page 104 of this *Announcement*.)

Faculty: Harrison W. Ambrose, Jeffrey Camhi, William C. Dilger, Thomas Eisner, Stephen T. Emlen, Edgar L. Gasteiger, Perry W. Gilbert, Bruce P. Halpern, William T. Keeton, Richard D. O'Brien, Frank Rosenblatt, Miriam M. Salpeter, Martin E. Seligman, Fred Stollnitz, Daniel N. Tapper, Ari van Tienhoven.

Field Representative: Daniel N. Tapper, 147 Radiation Biology Field Laboratory.

#### MAJOR AND MINOR SUBJECTS

Neurobiology (including neurophysiology, neurochemistry, sensory physiology, neuroanatomy, theory of brain functions)

Behavioral Biology (including ethology)

Applicants must present scores on the Graduate Record Examination aptitude test and one of the advanced sciences tests.

**LANGUAGE REQUIREMENTS:** For the Ph.D. degree, two languages at ordinary proficiency or one at higher proficiency.

**EXAMINATION REQUIREMENTS.** The Field of Neurobiology and Behavior requires each student to attend an orientation meeting with his Special Committee. This meeting is held during the first semester of study and gives the student and his Committee an opportunity to discuss and plan a course and research program. The Admission to Candidacy and Final Thesis Examinations required by the Graduate School are held at a later date.

The Field also appoints a fourth member to each student's Special Committee.

The Field requires each student to acquire teaching experience during his graduate training at Cornell.

## Research Areas

Members of the faculty in the Field of Neurobiology and Behavior will be especially interested in directing research in the following areas, although research will not be limited to these areas:

- H. W. Ambrose: ecological aspects of animal behavior, social and orientation behavior.  
 J. Camhi: neurophysiological aspects of behavior, insect orientation.  
 W. C. Dilger: comparative aspects of vertebrate behavior.  
 T. Eisner: biocommunication, insect behavior and physiology.  
 S. T. Emlen: ecological aspects of vertebrate behavior, mechanisms of orientation and navigation.  
 E. Gasteiger: electrical activity of the nervous system, system analysis.  
 P. Gilbert: biology of the clasmobranch fishes, functional vertebrate anatomy.  
 B. Halpern: sensory psychobiology, taste mechanisms.  
 W. T. Keeton: orientation behavior, evolution of behavior.  
 R. D. O'Brien: neuropharmacology, neurochemistry.  
 F. Rosenblatt: neural networks, physiology of memory.  
 M. Salpeter: electron microscopy, functional ultrastructure of the nervous system.  
 M. E. Seligman: animal learning.  
 F. Stollnitz: discrimination learning in primates.  
 D. N. Tapper: sensory physiology, receptor and central integration processes.  
 A. van Tienhoven: neuroendocrinology.

## Courses

All courses carry Biological Sciences numbers unless otherwise indicated.

### 421. COMPARATIVE VERTEBRATE ETHOLOGY

Fall term. Credit three hours. Prerequisites: Biological Sciences 101-102 or 103-104 and permission of the instructor. Mr. Dilger.

A survey of the methods and principles of vertebrate ethology for students specializing in this field or for those in other branches of zoology wishing to broaden their knowledge of animal behavior. Emphasis is placed on the causation, function, biological significance, and evolution of species-typical behavior. The laboratories are designed to give firsthand knowledge of the material covered in lectures.

### PSYCHOLOGY 323. PHYSIOLOGICAL PSYCHOLOGY

### PSYCHOLOGY 326. COMPARATIVE PSYCHOLOGY

### PSYCHOLOGY 465. MATHEMATICAL BEHAVIOR THEORY

### 520. COMPARATIVE NEUROLOGY

Spring term. Credit four hours. Prerequisite: permission of the instructor.

A comparative study of the vertebrate nervous system with emphasis upon the primate. Studies include dissections of the brain and the identification of nuclei and tracts in sections of the brain and spinal cord. Functional aspects of anatomical relations are stressed.

### 521-522. BRAIN MECHANISMS AND MODELS

Throughout the year. Credit four hours a term. Prerequisites: calculus, introductory biology or psychology, and consent of the instructor. Acquaintance with modern algebra and probability theory is desirable. Mr. Rosenblatt.

Fall term: review of fundamentals of neurophysiology; psychological and physiological criteria for brain models; computers and digital automata in relation to brain mechanisms; review of representative models; theory of elementary perceptrons. Spring term: theory of multi-layer and cross-coupled perceptrons; recognition of temporal patterns; problems of figure organization, cognitive sets, sequential programs, and other problems of advanced models; contemporary theories of memory.

### 320. NEUROBIOLOGY AND BEHAVIOR

Spring term. Credit three hours. Prerequisites: 101-102 or 103-104. Mr. Eisner (in charge), Messrs. Gilbert, O'Brien, Dilger, Halpern, Rosenblatt, and Emlen.

Evolution of behavior, cueing of behavior, social and nonsocial behavior, neuroanatomy, neurophysiology, neurochemistry, neural networks, memory.

### 427. SENSORY FUNCTION (PSYCHOLOGY 427)

Fall term. Credit three hours. Prerequisite: 320 or equivalent. Mr. Halpern and Mr. Tapper.

Sensory receptors and the central nervous system transformation of afferent activity will be considered in relation to human and animal psychophysical data and to the adaptive significance of behavior. The receptor will be examined in terms of anatomy, biochemistry, biophysics of transduction, and the central nervous system control of peripheral input. Information and signal detection theories will be applied.

### 428. SENSORY FUNCTION, LABORATORY

Fall term. Credit two hours. Prerequisite: 427. Enrollment limited to fifteen students. Messrs. Halpern and Tapper.

Experiments on the principles of receptor function and afferent neural activity.

### 523. ECOLOGICAL ASPECTS OF ANIMAL BEHAVIOR

Fall term. Credit three hours. Prerequisites: 320 and 361 or equivalent, or permission of the instructor. Messrs. Emlen and Ambrose.

A discussion of the interrelationships of animal behavior and ecology, with emphasis placed upon the following topics: behavior adaptations to the environment; ecological significance of diverse social systems; spatial relationships (habitat selection, homing, orientation, and navigation); role of social behavior in population regulation; evolution of altruistic behavior.

### 524. BEHAVIORAL NEUROPHYSIOLOGY

Spring term. Credit three hours. Prerequisite: 320 or equivalent. Mr. Camhi.

A study of the relationship between animal behavior and the activity of individual nerve cells, considered empirically. Review of electrical properties of excitable tissue. Predictions from the study of animal behavior. Sensory coding of environmental energies. Principles of integration. Integration of sensory inputs. Neural control of muscle contraction. Correlating nerve activity and behavior, problems and prospects. Examples will be chosen from throughout the animal kingdom, with slight preference for invertebrate phyla.

### 524A. BEHAVIORAL NEUROPHYSIOLOGY LABORATORY

Spring term. Credit two hours. Course 524 must be taken concurrently. Enrollment limited to fifteen students. Mr. Camhi.

Experiments in neurophysiology, often related to specific behavior patterns.

620. SEMINAR IN NEUROBIOLOGY AND BEHAVIOR

Either term. Credit one hour. Intended primarily for senior undergraduates. Staff.

622. SEMINAR IN ECOLOGICAL ANIMAL BEHAVIOR

Spring term. Credit one hour. Open to qualified students who have taken courses in animal behavior and animal ecology and have secured the permission of the instructor. Mr. Ambrose.

## NUTRITION

Faculty: Richard H. Barnes, Andre Bensadoun, Cyril L. Comar, Carl E. Coppock, Marjorie Devine, Elizabeth A. Donald, J. Murray Elliot, James L. Gaylor, L. Ross Hackler, Harold F. Hintz, Douglas E. Hogue, Lennart Krook, Frederick W. Lengemann, John K. Loosli, Leo Lutwak, Donald B. McCormick, William G. Merrill, Mary A. Morrison, Malden C. Nesheim, Katherine J. Newman, Wilson G. Pond, J. Thomas Reid, Jerry M. Rivers, Daphne Roe, Milton L. Scott, Ben E. Sheffy, Sedgwick E. Smith, Jean T. Snook, Hugh F. Travis, Darrell R. Van Campen, P. J. Van Soest, Willard J. Visck, Richard G. Warner, Robert H. Wasserman, Lemuel D. Wright, Charlotte M. Young, Robert J. Young.

Field Representative: Wilson G. Pond, 252 Morrison Hall.

### MAJOR AND MINOR SUBJECT

#### Nutrition

**ADMISSION REQUIREMENTS.** Candidates for admission to this Field must meet the general requirements for admission to the Graduate School. In addition, they should be well prepared in the basic sciences.

For graduate study with nutrition as the major subject, preparation is highly desirable in analytical and organic chemistry, general biology or zoology, genetics, mathematics, physics, physiology, and a foreign language. Some deficiencies in background preparation can be made up after admission, but this usually prolongs the time necessary to complete degree requirements.

**LANGUAGE REQUIREMENTS.** There is no language requirement specified for the Master's degree. There is no language requirement imposed by the Field for candidates for the degree of Ph.D.; the requirements for the individual student for study in a foreign language are determined by his Special Committee.

**EXAMINATIONS.** The Special Committee conducts all examinations. For the Master's degree, the student must present an acceptable thesis and be examined in one major and one minor subject at the end of his course of study. For the Ph.D. degree two minor subjects are required. The Field requires a qualifying examination in addition to the two examinations required by the Graduate School (see p. 12).

**AIMS AND OPERATIONS OF FIELD OF NUTRITION.** The organization of the Field coordinates the programs in nutrition in the several separate colleges and units of the University including the Colleges of Agriculture, Home Economics, Veterinary Medicine and Graduate School of Nutrition. Strong programs in animal nutrition, nutritional biochemistry and in human and clinical nutrition, including international nutrition, are maintained within

this framework. A professional degree of Master of Nutritional Science is administered by the Graduate School of Nutrition. Students interested in this program should consult the *Announcement of the Graduate School of Nutrition* and should direct their correspondence to the secretary of the Graduate School of Nutrition, Savage Hall.

**RESEARCH AND STUDY OPPORTUNITIES.** In preparation for an advanced degree, candidates, according to their special interests, may acquire training in biochemistry, food technology, histology, nutrition, pathology, physiology, and other areas of science and technology. Candidates for the Ph.D degree may be expected to study a foreign language if they have not offered adequate foreign language training upon admission. Students are generally advised to select either biochemistry or physiology as a minor for the Master's degree and both of these subjects as minors for the doctorate. However, other minor subject matter areas may be selected, depending upon the student's interest.

A wide latitude is allowed in the selection of the research problem for the degree. Studies can be of a fundamental or applied nature and with application to animal or human nutrition, including international nutrition.

Within the broad Field of Nutrition, faculty interests encompass a wide range of research specializations. These include the following specific categories: proteins and amino acids, fats, energy metabolism, vitamins, minerals, digestion, absorption, nutrient transport, nutritional pathology, endocrine-nutrition interrelationships, and nutrition education.

Each of these special subjects can be studied with a variety of animal species. Clinical and human nutrition studies: Professors Barnes, Devine, Donald, Lutwak, Morrison, Newman, Rovers, Roe, Snook, Visek, C. M. Young.

Nonruminant nutrition studies with dogs, horses, laboratory animals, mink, poultry, swine: Professors Barnes, Bensadoun, Comar, Devine, Donald, Elliot, Gaylor, Hackler, Hintz, Hogue, Krook, Lengemann, Loosli, Nesheim, Pond, Reid, Rivers, Scott, Sheffy, Smith, Travis, Van Campen, Visek, Warner, Wasserman, Wright, R. J. Young.

Ruminant nutrition studies with beef cattle, dairy cattle, sheep: Professors Coppock, Elliot, Hogue, Krook, Lengemann, Loosli, Merrill, Reid, Smith, Van Soest, Warner.

## Courses

Consult individual Field listings in this *Announcement* for those courses offered outside the Field of Nutrition.

ANIMAL SCIENCE 410. PRINCIPLES OF ANIMAL NUTRITION

ANIMAL SCIENCE 510. SPECIAL TOPICS IN ANIMAL NUTRITION

ANIMAL SCIENCE 511. LABORATORY WORK IN ANIMAL NUTRITION

ANIMAL AND POULTRY SCIENCE 619. SEMINAR IN ANIMAL NUTRITION

Fall term. Credit one hour. Open to graduate students with their major Field of study in Nutrition. Registration by permission. Nutrition staff.

A critical review of the literature and other topics of special interest to graduate students in animal nutrition.

FOOD AND NUTRITION 441. NUTRITION AND DISEASE

## 112 NUTRITION

FOOD AND NUTRITION 442. ADVANCED HUMAN NUTRITION

FOOD AND NUTRITION 512. NUTRITION AND GROWTH

FOOD AND NUTRITION 514. READINGS IN NUTRITION

FOOD AND NUTRITION 524. RESEARCH METHODS IN HUMAN METABOLIC STUDIES

FOOD AND NUTRITION 602. SEMINAR IN NUTRITION

GRADUATE SCHOOL OF NUTRITION 100. PROBLEMS AND PROGRAMS IN INTERNATIONAL NUTRITION

Fall term. Credit four hours. Registration by permission.

To acquaint students with the planning of effective programs and policies in the areas of nutritional and food science with the purpose of improving nutrition conditions in developing countries and with proper emphasis on the role of agriculture and public health. Among topics considered are typical foods and diets in different parts of the world, assessment of food and nutrition conditions, protein-rich and other protective foods, food processing and preservation in developing countries, food standards, and food control.

GRADUATE SCHOOL OF NUTRITION 292. NUTRITION SEMINAR

Spring term. Credit one hour. Professor R. H. Barnes and faculty.

POULTRY SCIENCE 511. SPECIAL TOPICS IN NUTRITION

ADVANCED NUTRITION SERIES

A series of nutrition courses offered jointly by the Department of Food and Nutrition, College of Home Economics; Department of Animal Science, College of Agriculture; Department of Poultry Science, College of Agriculture; and the Graduate School of Nutrition. Prerequisites: courses in nutrition, physiology and biochemistry to include intermediary metabolism.

The subjects covered include the biochemical and physiological bases of digestion, absorption, transport, and metabolism of nutrients; species differences where applicable; historical as well as current concepts of nutrition.

FOOD AND NUTRITION 501. PROTEINS AND AMINO ACIDS

Fall term. Credit two hours. Associate Professor M. A. Morrison.

POULTRY SCIENCE 502. LIPIDS AND CARBOHYDRATES

Fall term. Credit two hours. Associate Professor Bensadoun.

ANIMAL SCIENCE 503. NUTRITIONAL ENERGETICS

Spring term. Credit two hours. Professor J. T. Reid.

POULTRY SCIENCE 504. MINERALS AND VITAMINS

Spring term. Credit two hours. Professor M. L. Scott.

## PHARMACOLOGY

(See pp. 51, 102, and 104.)

## PHYSIOLOGY

(See also the listing under Medical Sciences, page 104 of this *Announcement*.)

Faculty: Andre Bensadoun, John Bentinck-Smith, Emmett N. Bergman, Robert W. Bratton, Alison P. Casarett, R. K. Clayton, Cyril L. Comar, Alan Dobson, Thomas Eisner, Robert H. Foote, Edgar L. Gasteiger, Perry W. Gilbert, Bruce Halpern, William Hansel, J. W. Hudson, F. A. Kallfelz, R. M. Kenney, Frederick W. Lengemann, Samuel L. Leonard, Leo Lutwak, William N. McFarland, Robert S. Morison, Louis L. Nangeroni, Richard D. O'Brien, Robert L. Patton, Frank Rosenblatt, Miriam M. Salpeter, Glen H. Schmidt, Alvin F. Sellers, Charles E. Stevens, Daniel N. Tapper, Ari van Tienhoven, Willard J. Visek, Robert H. Wasserman, William A. Wimsatt, John F. Wootton, Donald B. Zilversmit.

Field Representative: C. E. Stevens, D-132, Veterinary College

### MAJOR AND MINOR SUBJECTS

Cellular Physiology

Physical Biology

Comparative Physiology

Vertebrate Physiology

See also listing under special interests of the faculty for major area subjects. Minors may be selected from such areas as biochemistry, biometry, chemistry, ecology, electrical engineering, genetics, histology, microbiology, nutrition, pathology, physics, and psychology.

All applicants, where possible, should submit the results of the Graduate Record Examination (Aptitude and Advanced Biology Tests). Students preparing for work in the Field of Physiology are urged to obtain a good knowledge of biology, chemistry, biochemistry, and physics. Calculus, statistics, and genetics are also advisable.

There is no foreign language requirement for the Master's degree. For the Ph.D. degree, the Field requires a single language other than English, chosen by the Special Committee in the area of study of the student. The proficiency of the candidate in this language must meet the minimal level prescribed by the Language Examination Board. This requirement must be fulfilled by the time the student takes his Admission to Candidacy Examination. The Special Committee may, in certain instances, require a second language or a higher level of proficiency for a single language.

In addition to the examinations specified by the Graduate School, the Field requires that doctoral candidates pass a qualifying examination. This should be taken before two residence units have been earned. The Field requires of each major, at least one semester of teaching except in instances where the Special Committee deems it inadvisable or inappropriate.

A doctoral candidate in Physiology must have two minor subjects with a representative from each on his committee. At least one of the minor committeemen must not be a member of the Field of Physiology. An additional voting member will be appointed to the candidate's committee by the Field of Physiology.

## Special Interests of the Faculty

Behavioral physiology: Professors Eisner and Gilbert.

Cardiovascular physiology: Professors Bergman, Dobson, and Sellers.

Comparative neurology and neuropharmacology: Professor O'Brien.

- Comparative physiology: Professor McFarland.  
 Endocrinology: Professors Hansel, Leonard, and van Tienhoven.  
 Environmental physiology: Professor Hudson.  
 Enzymology: Professor Wootton.  
 Gastrointestinal physiology: Professors Bensadoun, Dobson, Sellers, Stevens, Visek, and Wasserman.  
 Histology, cytology, and electron microscopy: Professors Salpeter and Wimsatt.  
 Insect physiology: Professors Eisner and Patton.  
 Lipid transport and metabolism: Professors Bensadoun and Zilvermit.  
 Metabolism: Professors Bergman, Lengemann, Lutwak, and Visek.  
 Neurophysiology: Professors Gasteiger, Gilbert, Rosenblatt, and Tapper.  
 Pathological physiology: Professor Bentinck-Smith.  
 Photobiology: Professor Clayton.  
 Physiology of lactation: Professor Schmidt.  
 Psychology: Professor Halpern.  
 Radiation biology and physical biology: Professors Casarett, Comar, Kallfelz, Lengemann, and Wasserman.  
 Reproduction: Professors Bratton, Casarett, Foote, Gilbert, Hansel, Kenney, Leonard, van Tienhoven, and Wimsatt.  
 Ruminant physiology: Professors Bergman, Dobson, Sellers, and Stevens.  
 Vertebrate physiology: Professors Gilbert, Nangeroni, Sellers, and Wimsatt.
- A prospective student is urged to correspond with the professor in the above list whose interests are nearest his own.

## Courses

### BIOLOGICAL SCIENCES 414. MAMMALIAN PHYSIOLOGY

Spring term. Credit six hours. Registration by permission. Prerequisite: a year of biological science. Courses in biochemistry, histology, and gross anatomy desirable. Lectures, M W F 8. Morrison 167. Discussion, S 10:10. Laboratory, M W 1:25. Morrison 174. Professors Visek (in charge), Bensadoun, Gasteiger, and Hansel.

A general course in mammalian physiology including circulation, respiration, digestion, metabolism, renal function, endocrinology, and the nervous system.

### BIOLOGICAL SCIENCES 513. EXPERIMENTAL ENDOCRINOLOGY

(Consult the course listing in this *Announcement* for the Field of Zoology.)

### BIOLOGICAL SCIENCES 516. SPECIAL TOPICS IN COMPARATIVE PHYSIOLOGY

(Consult the course listing in this *Announcement* for the Field of Ecology and Evolutionary Biology.)

### BIOLOGICAL SCIENCES 520. COMPARATIVE NEUROLOGY

(Consult the course listing in this *Announcement* for the Field of Neurobiology and Behavior.)

### BIOLOGICAL SCIENCES 521-522. BRAIN MECHANISMS AND MODELS

(Consult the course listing in this *Announcement* for the Field of Neurobiology and Behavior.)

### BIOLOGICAL SCIENCES 427. SENSORY FUNCTION

Fall term. Credit three hours. Prerequisite: Biological Sciences 320 or the equivalent. Lectures, T Th 10:10. Associate Professors Halpern and Tapper.

Sensory receptors and the central nervous system transformation of afferent activity will be considered in relation to human and animal psychophysical data and to the adaptive significance of behavior. The receptors will be examined in terms of anatomy, biochemistry, biophysics of transduction, and the central nervous system control of peripheral input. Information and signal detection theories will be applied.

[BIOLOGICAL SCIENCES 547. GENERAL PHOTOBIOLOGY]

(Consult the course listing in this *Announcement* for the Field of Botany.)

ANIMAL SCIENCE 427. FUNDAMENTALS OF ENDOCRINOLOGY

ANIMAL SCIENCE 451. PHYSIOLOGY AND BIOCHEMISTRY OF LACTATION

POULTRY SCIENCE 425. COMPARATIVE PHYSIOLOGY OF REPRODUCTION OF VERTEBRATES

VETERINARY MEDICINE 914. EXPERIMENTAL PHYSIOLOGY FOR GRADUATE STUDENTS

VETERINARY MEDICINE 915. METHODS IN PHYSIOLOGICAL RESEARCH

VETERINARY MEDICINE 920. ELEMENTS OF PHYSICAL BIOLOGY

VETERINARY MEDICINE 921. RADIOISOTOPES IN BIOLOGICAL RESEARCH

VETERINARY MEDICINE 922. BIOLOGICAL EFFECTS OF RADIATION

VETERINARY MEDICINE 923. BIOLOGICAL MEMBRANES AND NUTRIENT TRANSFER

VETERINARY MEDICINE 924. FUNCTIONAL ORGANIZATION OF THE NERVOUS SYSTEM

## PLANT BREEDING AND BIOMETRY

Faculty: Ronald E. Anderson, Loy V. Crowder, Thomas E. Devine, Herbert L. Everett, Walter T. Federer, Clarence O. Grogan, Neal F. Jensen, Carl C. Lowe, Henry M. Munger, Royse P. Murphy, William D. Pardee, Robert L. Plaisted, Douglas S. Robson, J. Neil Rutger, Robert R. Seaney, Shayle R. Searle, Adrian M. Srb, Harry T. Stinson, N. Scott Urquhart, Bruce Wallace, Donald H. Wallace.

At Geneva: Donald W. Barton, John Einset, Robert C. Lamb, Gerald A. Marx, Donald K. Ourecky, Richard W. Robinson, George L. Slate, Roger D. Way.

Field Representative: Neal F. Jensen, 420 Bradfield Hall

### MAJOR AND MINOR SUBJECTS

Plant Breeding

Biometry

The language requirement for each student will be determined by the Field following a recommendation from the Chairman of the student's Special

Committee. This may range from no foreign language training to fluency in one or more languages. All students must pass an English proficiency examination as specified by the Field.

Examinations required by the Graduate School are described on p. 12 of this *Announcement*.

Students interested in crop improvement through breeding, the genetics of higher plants, population dynamics, or quantitative inheritance studies with higher plants may choose plant breeding or plant genetics as a major. Problems for research may involve studies of breeding methods, the application of genetic principles to breeding, and the correlation of knowledge from other areas such as biochemistry and statistics in attacks on problems affecting yield, quality, adaptability, and disease-insect resistance. The Department now has active research projects with most of the important field and vegetable crops of New York, and certain materials from these projects are available for graduate students' problems. Plant genetics as a major subject generally involves research problems more specifically aimed towards the analysis of hereditary and evolutionary phenomena; almost any suitable biological materials can be used.

Students with mathematical interests in the development and application of statistical models in biology may elect a biometry major. Research problems may be purely theoretical studies, computer simulation studies, novel statistical analyses of real data, or may involve a combination of these approaches to various topics, e.g., such as estimation and sampling, the design and analysis of experiments, statistical genetics, quantitative ecology, or epidemiology. The department now has active research projects in these and other areas of statistics and biomathematics.

It is advisable that the student entering upon graduate work in this Field be well grounded in the fundamentals of the natural sciences. He should have had courses in advanced chemistry, biology, calculus, and physics. Students intending to specialize in biological statistics will find it to their advantage to have additional training in mathematics.

Students majoring in plant breeding or plant genetics will find it necessary to remain in Ithaca during the summer or to make satisfactory arrangements elsewhere for growing and studying the material used in connection with their research problems. Special provisions are available for students interested in international agriculture who would like to do their thesis research in Latin America.

## Research Areas

Members of the staff will be especially interested in directing research in the areas listed, although research will not be limited to those areas.

Staff listed under plant breeding direct thesis research on the genetics of the crop plants with which they are primarily concerned. Staff listed under biometry direct theses on various aspects of statistical and mathematical genetics.

Biometry: W. T. Federer, statistics and experimental design; D. S. Robson, statistics and biometrical genetics; S. R. Searle, statistics and computing; N. S. Urquhart, statistics and multivariate analysis.

Plant breeding: R. E. Anderson, sugarbeets; C. C. Lowe, R. P. Murphy, and T. E. Devine, forage crops; W. D. Pardee, extension and pure seed programs; C. O. Grogan, corn; N. F. Jensen, small grains; H. M. Munger and D. H. Wallace, vegetable crops; R. L. Plaisted, potatoes; L. V. Crowder, international agriculture; J. N. Rutger, extension and dry beans.

Prospective students will find it to their advantage to correspond with the staff members whose interests are most closely related to their own some months in advance of the time they wish to apply, since only a limited number of students can be accommodated.

## Courses

### PLANT BREEDING

#### 503. METHODS OF PLANT BREEDING I

Fall term. Credit three hours. Prerequisites: Biological Sciences 101-102 or 103-104, and 281, and a course in at least one of the following: field crops, vegetable crops, floriculture, or pomology. Professor Murphy.

A study of the principles and practices of plant breeding. Lectures, supplemented by periods in the greenhouse and experimental fields.

#### 505. PLANT BREEDING—APPLIED METHODS AND TECHNIQUES

Spring term. Credit two hours. Prerequisites: same as for 503, or consent of the instructor. Associate Professor Crowder.

Designed to acquaint students with the field, greenhouse, and laboratory techniques used in plant breeding research. Will include experience in the planning and conduct of field experiments and also acquaintance with useful methods from related fields of agricultural research.

#### 506. CROP IMPROVEMENT: A WORLD-WIDE REVIEW

Spring term. Credit two hours. Given in even-numbered years. Prerequisites: same as for 503 or consent of the instructors. Professors Crowder and MacDonald.

Discussion of plant breeding principles and procedures that have been evolved and applied in breeding certain groups of crops based on mode of pollination and the predominant type of gene action, especially as related to situations found in different parts of the world. Particular attention will be given to alternate approaches in breeding and crop improvement programs in developing countries and to cropping systems and agronomic practices which influence crop productivity. Specific reference materials and examples will be drawn from current activities in tropical agricultural regions. Student participation is expected.

#### 512. EXPERIMENTAL METHODS

Spring term. Credit two hours. Prerequisite: 511 or consent of the instructor. Professor Lowe.

Use of statistical methods and application of experimental designs and plot techniques to problems in plant breeding and related agricultural research.

#### 515. METHODS OF PLANT BREEDING II

Spring term. Credit two hours. Prerequisites: 511 or 503 or their equivalent. Professor Plaisted.

An introduction to quantitative genetics and its application to the understanding of various plant breeding and selection procedures.

#### 519. STATISTICAL GENETICS

Spring term. Credit three hours. Prerequisites: 514 and Mathematics 371. Professor Robson.

An introduction and application of the theory of Markov chains to mating systems including selfing, sibbing, backcrossing, and random mating with a discussion of genetic variance component analysis, and Monte Carlo simulation of such systems on high-speed computers.

## DEPARTMENTAL SEMINAR AND RESEARCH

### 622. SEMINAR

Fall and spring terms. Without credit. Members of the departmental staff.

Seminars of specific interest to the areas of plant genetics, plant breeding, and biometrics meet separately each week.

## STATISTICS AND BIOMETRY

### 407. COMPUTER TECHNIQUES FOR STATISTICS AND BIOLOGY

Fall term. Credit two hours. Prerequisite: an introductory course in statistics, which may be taken concurrently. Associate Professor Searle.

Introduction to uses of computers in statistics: calculation of elementary statistical analyses, techniques of sampling and simulation, and availability of library programs. CUPL, the Cornell University Programming Language, will be taught and used for problem solving; use may also be made of some library programs.

### 408. STATISTICAL ANALYSIS I

Fall term. Credit three hours. Prerequisites: Mathematics 112 and a statistical methods course, or equivalent. Professor to be appointed.

Methods of statistical analysis are developed for data classified into one- and two-way arrays. Mathematical derivations are given for exact, small sample procedures and approximate, large sample procedures. The methods covered include chi-square analysis, rank analysis, simple analyses of variance, multiple comparisons and confidence intervals. Concepts and techniques from probability theory including conditional probability, moments and moment generating functions are introduced as needed.

### 409. STATISTICAL ANALYSIS II

Spring term. Credit three hours. Prerequisite: Course 408. Professor to be appointed.

Methods developed in Course 408 are extended for the analysis of data arrayed in a multi-way classification with both qualitative and quantitative classification variables. These methods include the analysis of variance and covariance, multiple linear regression and nonlinear estimation procedures.

### 411. STOCHASTIC MODELS IN BIOLOGY

Spring term. Credit three hours. Offered in alternate years. Prerequisite: 410. Professor to be appointed.

An introduction to stochastic processes in biology. The necessary mathematics and statistics will be introduced as needed. Recurrent events, random walk models, Markovian processes, birth-and-death processes, epidemic processes, competition and predation, diffusion processes, and other models currently used in biological theory will be discussed and applied. Special emphasis will be given the various processes applied to genetics.

### 412. DETERMINISTIC MODELS IN BIOLOGY

Spring term. Credit three hours. Given in alternate years. Prerequisite: 410. Professor to be appointed.

An introduction to deterministic mathematical models in biology. The application will be from the biological viewpoint. The necessary mathematics, will be introduced as needed. Finite differences, differential equations, logistics, growth and decay, and other deterministic models corresponding to those introduced in 411 will be discussed.

#### 417. MATRIX ALGEBRA IN BIOLOGY AND STATISTICS

Fall term. Credit three hours. Prerequisite: the equivalent of one year of college algebra. Associate Professor Searle.

Elements of matrix algebra with applications in biology and statistics. Arithmetic procedures and other matrix operations; rank and linear independence, latent roots and vectors, solving linear equations, generalized inverses, direct sums and products; use of matrices in regression analysis and linear statistical models.

#### 510. STATISTICAL METHODS I

Fall term. Credit four hours. Assistant Professor Urquhart.

The distributions of statistics encountered in biological and other fields are considered from the point of view of elementary probability notions and by sampling from known populations. The results, with principles of experimentation, are applied to the conduct of experiments and interpretation of results. Topics include point and interval estimation, tests of hypotheses and of significance, the treatment of discrete data, methods involving rank sum procedures, the consideration of normal populations, and the one-way analysis of variance and simple linear regression. Emphasis is placed on basic statistical principles, criteria for selection of statistical techniques and the application of these techniques to a wide variety of biological situations.

#### 511. STATISTICAL METHODS II

Spring term. Credit four hours. Prerequisite: Course 510 or the equivalent. Assistant Professor Urquhart.

The work of Course 510 is continued. Topics include multiple and curvilinear regression, and complex analyses of variance and covariance. The analysis of variance discussion considers treatment designs; single degree of freedom contrasts; the simpler experimental designs; sampling errors; fixed, mixed and random models; and the effect of disproportionate numbers. When appropriate, the computer is considered as the reasonable way to have calculations done.

#### 513. DESIGN OF EXPERIMENTS I

Fall term. Credit four hours. Prerequisites: 409 and 511 or the equivalent. Professor Federer.

Principles and techniques of experimentation, theoretical concepts, extensions, and variations of the completely randomized, randomized complete block, and latin square designs; the factorial experiment and confounding, fractional replication including response surface designs, lattice designs, cross-over designs, augmented and other designs; covariance analyses, error rates, tests and interval estimation for ranked means, sample size, variance component analyses, and unequal number analyses; the place of orthogonality in design, and advanced statistical methodology under various fixed, mixed, and random models.

#### 514. DESIGN OF EXPERIMENTS II

Spring term. Credit four hours. Prerequisite: Course 513. Professor Federer.

A continuation of the work in Course 513 with emphasis on the role of

confounding in experimental and treatment designs. Generalized forms of analyses and construction are presented followed by a discussion from selected topics on long-term experiments, combination of results from several experiments, sequential experimentation, variance component analyses, estimation procedures, linear hypotheses, heritability studies, multivariate analyses, unequal numbers analyses, and related topics.

**517. LINEAR MODELS**

Spring term. Credit three hours. Prerequisites: 417, 511, and Mathematics 370 or 371. Associate Professor Searle.

Introduction to multinormal variables and distribution of quadratic forms; linear statistical models, estimable functions and testable hypotheses; and regression models, experimental design models, variance components models, and combinations thereof.

**518. SPECIAL TOPICS IN SEQUENTIAL SAMPLING, BIOASSAY, NONPARAMETRIC STATISTICS, ETC.**

Spring term. Credit three hours. Prerequisite: Course 511 or the equivalent. Professor Robson.

Topics include the principles and methodology of bioassay, discriminant functions, sequential analysis, nonparametric methods, mark-recapture methods, and path analysis.

**499. SPECIAL PROBLEM IN STATISTICS AND BIOMETRY**

Fall, spring, or summer. Credit one or more hours by arrangement with instructor. Prerequisite: permission to register. Biometry Unit staff.

**BIOLOGICAL SCIENCES 480. POPULATION GENETICS**

(Consult the course listing in this *Announcement* for the Field of Genetics.)

**BIOLOGICAL SCIENCES 482. PHYSIOLOGICAL GENETICS**

(Consult the course listing in this *Announcement* for the Field of Genetics.)

**PLANT PATHOLOGY**

Faculty: Durward F. Bateman, Carl W. Boothroyd, Robert S. Dickey, A. Watson Dimock, Warren T. Johnson, Edward D. Jones, George C. Kent, Richard P. Korf, James W. Lorbeer, William F. Mai, Roy L. Millar, Kenneth G. Parker, Lester C. Peterson, William F. Rochow, A. Frank Ross, Otto E. Schultz, Arden F. Sherf, Wayne A. Sinclair, H. David Thurston, Robert E. Wilkinson.

At Geneva: Alvin J. Braun, Willard F. Crosier, Robert M. Gilmer, John D. Gilpatrick, John J. Natti, William T. Schroeder, Michael Szkolnik.

At Farmingdale: Martin B. Harrison, Charles E. Williamson.

At Riverhead: Robert C. Cetas.

Field Representative: Durward F. Bateman, 351 Plant Science Building.

**MAJOR AND MINOR SUBJECTS**

Plant Pathology  
Mycology

**ADMISSION REQUIREMENTS.** Admission to graduate study in plant pathology or mycology is based on satisfactory completion of a baccalaureate degree from an accredited college or university. Broad training in the biological and physical sciences is essential; course work or experience in plant pathology is not required. Admission is based on quality of undergraduate work and promise as a graduate student, rather than on numbers and types of courses completed. Applicants must present scores on the Graduate Record Examination Aptitude Test.

**LANGUAGE REQUIREMENTS.** There is no general foreign language requirement for the M.S. and Ph.D. degrees; however, competence in one or more foreign languages may be required by the Chairman of the Special Committee.

**EXAMINATIONS.** All students majoring in plant pathology or mycology are expected to take an oral, or oral and written, qualifying examination within the first twelve months after registration. This examination, required by the Field, is designed to assist the student and his Committee in charting the student's program of study. Candidates for the M.S. degree will be held responsible for a terminal thesis and subject matter examination. Students in the Ph.D. degree program must pass a comprehensive Admission to Candidacy Examination before admission to Ph.D. candidacy. This examination is designed to test the student on his knowledge of subject matter pertinent to the doctoral degree. It may be oral, or oral and written, and will be administered by the Special Committee. An oral Final Examination on the thesis is required for the Ph.D. degree.

## Research and Study Opportunities

Excellent opportunities for graduate study and research are offered in all phases of plant pathology and mycology. Students become familiar with the basic principles of disease as caused by the major groups of plant pathogens (bacteria, fungi, nematodes, and viruses). Excellent equipment and facilities are available for research under the guidance of specialists in the department. Summer field trips with staff members give students experience in diagnosing disease and in observing up-to-date control practices. Each student is given an opportunity to assist with teaching in the elementary course in plant pathology and to become familiar with extension techniques.

Students electing plant pathology as a specialization may work with any of several staff members in crop-oriented research, e.g., diseases of forage, fruit, ornamentals, potatoes, vegetables, shade trees and shrubs, small grains, corn, and turf grasses; or they may specialize in research programs in specific areas of plant pathology, e.g., bacteriology, epidemiology, nematology, physiology of disease, and virology. Students will also find a stimulating program of research and teaching in mycology. Major students may concentrate their research in cytology, genetics, morphology, physiology, or taxonomy.

When the major is in either mycology or plant pathology, the faculty usually does not advise selection of a minor in the other subject.

An outstanding mycological and plant pathological herbarium, unexcelled library facilities, excellent controlled-environment facilities, modern equipment, and cooperation with faculties of related fields enable students to follow broad research programs.

A number of fellowships and scholarships are available, and many assistantships are awarded by the Department.

Further information concerning the Field is given in a brochure *Graduate Study in Plant Pathology and Mycology at Cornell* which may be obtained by writing the Field Representative.

The major interests of the staff members are as follows:

- D. F. Bateman: teaching and research, disease and pathogen physiology, root diseases.
- C. W. Boothroyd: teaching, general plant pathology; research, corn diseases, soil-borne pathogens.
- R. S. Dickey: teaching and research, phytopathogenic bacteria.
- A. W. Dimock: research, diseases of florist and ornamental crops, soil-borne pathogens, relation of environmental factors to disease development and disease control.
- W. T. Johnson: extension, pests of trees and shrubs on home grounds, 4-H Club work.
- E. D. Jones: extension and research, diseases of potatoes, potato certification, foundation seed programs.
- G. C. Kent: teaching, advanced plant pathology; research, diseases of cereal crops, pathological histology, epidemiology.
- R. P. Korf: teaching, mycology; research, taxonomy, morphology, cytology, ecology, and physiology of fungi.
- J. W. Lorbeer: teaching, mycology; research, diseases of vegetables, soil-borne pathogens, fungal genetics, epidemiology.
- W. F. Mai: teaching, nematology; research, etiology and control of diseases caused by nematodes, nematode physiology and taxonomy.
- R. L. Millar: teaching, general plant pathology; research, physiology of infection, diseases of field and forage crops.
- K. G. Parker: extension, diseases of fruits; research, virus diseases of stone fruits, bacterial and nematode diseases of tree fruits, fungicide application equipment.
- L. C. Peterson: research, development of disease-resistant potatoes, potato diseases, diseases caused by Phycomycetes.
- W. F. Rochow: research, virus diseases of cereal crops, aphid transmission of plant viruses.
- A. F. Ross: teaching, plant virology; research, viruses and virus diseases, interaction of plant viruses.
- O. E. Schulz: extension, diseases of potatoes, grain, and forage crops.
- A. F. Sherf: extension, vegetable diseases.
- W. A. Sinclair: teaching, extension and research, diseases of trees and shrubs.
- H. D. Thurston: teaching and research, international aspects of plant disease and disease control.
- R. E. Wilkinson: research, diseases of vegetable crops, virus diseases, disease control.
- Off-campus:
- A. J. Braun: research, small fruit diseases; nematology, virology, fungicides.
- R. C. Cetas: research, vegetable and potato diseases, fungicides, breeding for resistance.
- W. F. Crosier: research, seed pathology, seed treatment chemicals.
- R. M. Gilmer: research, deciduous fruit diseases, virology.
- J. D. Gilpatrick: research, fungus diseases, fungicides.
- M. B. Harrison: research, diseases caused by nematodes, turf diseases, soil fumigation.
- J. J. Natti: research, vegetable diseases, fungicides, breeding for resistance.
- W. T. Schroeder: research, vegetable diseases, fungicides, breeding for resistance.

M. Szkolnik: research, fruit diseases, fungicides, systemics.

C. E. Williamson: research and extension, diseases of florist crops, nematology, soil fumigation.

## Courses

### 301. ELEMENTARY PLANT PATHOLOGY

For graduates who have had no formal course work in plant pathology. Every fall and alternate spring terms. Credit three hours. Prerequisites: Biological Sciences 101-102 or 103, or the equivalent. Lecture, T Th 11:15. Plant Science 37. Laboratory, T W Th or F 2-4:25. Plant Science 341. Conferences to be arranged. Professor Boothroyd.

An introductory course dealing with the nature, cause, and control of disease in plants. Representative diseases of cultivated crops are studied in the laboratory.

### 309. COMPARATIVE MORPHOLOGY OF FUNGI

For graduates who have had no formal course work in mycology. Fall term. Credit four hours. Prerequisites: a one-year sequence of botany or its equivalent, and permission to register. Lecture, T Th 9:05. Plant Science 336. Laboratory, T Th 1:25-4:25. Plant Science 326. Professor Korf.

An introductory course in mycology. Emphasis is placed on morphology rather than on taxonomy.

### 403. PATHOLOGY OF TREES AND SHRUBS

Spring term. Credit three hours. Prerequisites: a course in introductory plant pathology and permission to register. Lecture, W F 10:10. Plant Science 336. Laboratory, F 1:25-4:25. Plant Science 342. Associate Professor Sinclair.

For students who desire some specialized knowledge of diseases of trees and shrubs and their diagnosis and control.

### 501. ADVANCED PLANT PATHOLOGY

Fall term. Credit four hours. Prerequisites: a course in introductory plant pathology and permission to register. Lecture, T Th 11:15. Plant Science 336. Laboratory, T Th or W F 2-4:25. Plant Science 342. Associate Professor Millar.

Designed to acquaint the student with the basic principles and techniques of the science of phytopathology and to provide an adequate foundation for successful prosecution of research in this area.

### [502. PRINCIPLES OF PLANT DISEASE CONTROL]

Spring term. Credit three hours. Offered in alternate years. Enrollment limited to twenty-four students. Prerequisites: Plant Pathology 501 or its equivalent, and permission to register. Lecture, T 11:15. Plant Science 336. Laboratory and discussion, T Th 2-4:25. Plant Science 342. Not offered in 1969-70.

For graduate students who expect to teach or perform research in educational institutions, experiment stations, or agricultural chemical companies in connection with the development and use of plant disease control materials and methods. Emphasis is placed upon the philosophies underlying the four principles of plant disease control: exclusion, eradication, protection, and immunization. Attention is given to the existing body of knowledge upon which present disease control practices are based. Objectives are to help the student interested in plant protection equip himself not only to apply

existing methods and materials but to enable him to improve upon them by developing new ideas, etc., especially in situations where control of plant diseases requires new approaches.

#### 505. PLANT VIROLOGY

Fall term. Credit three hours; in special cases, permission may be obtained to enroll for lectures only (two hours credit). For graduate students with majors or minors in plant pathology and, in special cases, for other graduate students interested in virology. Prerequisite: 501 or permission to register. Lecture, T Th 10:10. Plant Science 336. Laboratory, F 1:25-4:25. Virology-Nematology Laboratory. Professor Ross.

Designed to provide advanced graduate students with basic information on the plant viruses and on the diseases they cause.

#### 506. PLANT NEMATOTOLOGY

Spring term. Credit three hours. Offered in alternate years. For graduate students with majors or minors in plant pathology and, in special cases, other students interested in nematology. Prerequisite: 501 or permission to register. Two lectures and one or three two-hour morning laboratory periods per week. Hours to be arranged. Lectures, Plant Science 336. Laboratory, Virology-Nematology Laboratory. Professor Mai.

Anatomy, morphology, and taxonomy of plant parasitic forms and non-parasitic soil-inhabiting forms of nematodes are studied. Plant pathogenic forms also are considered from the standpoint of host-pathogen relationships, host ranges, life cycles, and the symptoms they cause. Principles and methods of control are discussed.

#### [507. BACTERIAL PLANT PATHOGENS]

Spring term. Credit two hours. Offered in alternate years. For graduate students with majors or minors in plant pathology; others by permission only. Prerequisite: 501 or permission to register. Lecture, F 9:05. Plant Science 336. Laboratory, F 2-4:25. Plant Science 304. Associate Professor Dickey. Not offered in 1969-70.

Designed to provide students with basic information on bacterial plant diseases and phytopathogenic bacteria. The laboratory will include some of the more important techniques used in the study of bacterial plant pathogens.

#### 508. DISEASE AND PATHOGEN PHYSIOLOGY

Fall term. Credit three hours. Offered in alternate years. For graduate students with majors or minors in plant pathology; others by permission only. Prerequisites: 501, Biological Sciences 433 and 544, and permission to register. Lecture, F 9:05. Plant Science 336. Laboratory, F 1:25-4:25 and one period to be arranged. Plant Science 344. Associate Professor Bateman.

Designed to provide students with insight into the mechanisms of pathogenesis and altered metabolism of diseased plants.

#### 531. SPECIAL PROBLEMS IN MYCOLOGY OR PLANT PATHOLOGY

Fall or spring term, or both. Credit three or five hours each term. For graduate students only. Registration by permission. Three to five weekly laboratory periods of three hours each. Staff members.

For work in mycology, modern techniques and the experimental approach are stressed in areas such as physiology, developmental morphology, genetic systems, or cytotaxonomy.

For work in plant pathology for minor thesis or problems, or for students wishing to develop familiarity with modern techniques in some phase of the science.

## [541. PHILOSOPHY OF PLANT PATHOLOGY]

Fall term. Credit two hours. Designed for Ph.D. students majoring in plant pathology. Prerequisites: 501, 569, and at least two other courses from 502, 505, 506, 507, and 508, or permission to register. Conferences, M W 8-9:55. Plant Science 422. Professor Kent. Not offered in 1969-70.

A conference with advanced graduate students examining the concepts of plant pathology as they relate to the approach to basic and applied research problems, teaching, and extension.

## 569. ADVANCED MYCOLOGY

Fall term. Credit three hours. Given in alternate years. Prerequisites: 309 or its equivalent, a course in genetics, and permission of the instructor to register. Lecture, M 10:10. Plant Science 336. Laboratory, M W 1:25-4:25. Plant Science 336. Professor Korf.

Part of a three-course sequence (569, 579, and 589) designed especially for students specializing in mycology or plant pathology. Each course is independent, and the sequence may be taken in any order. Emphasis is placed on taxonomy, but other aspects of mycology are embraced. Practice in identification of specimens is stressed as is critical evaluation of keys and monographs. Field work is *required*. Higher Basidiomycetes are covered in detail.

## 579. ADVANCED MYCOLOGY

Spring term. Credit four hours. Given in alternate years. Prerequisites: 309 or its equivalent, a course in genetics, and permission of the instructor to register. Lecture, M 10:10. Plant Science 336. Laboratory, M W 1:25-4:25 and one additional three-hour period to be arranged. Plant Science 326. Professor Korf.

Part of a three-course sequence (569, 579, and 589) described under Plant Pathology 569. Emphasis is placed on taxonomy and on mechanisms of variation in fungi. *Optional* field trips will be announced. Rusts, smuts, Phycomycetes, and Fungi Imperfecti are covered in detail.

## [589. ADVANCED MYCOLOGY]

Fall term. Credit three hours. Given in alternate years. Prerequisites: 309 or its equivalent, a course in genetics, a course in plant or animal taxonomy, and permission of the instructor to register. Lecture, M 10:10. Plant Science 336. Laboratory, M W 1:25-4:25. Plant Science 326. Professor Korf. Not offered in 1969-70.

Part of a three-course sequence (569, 579, and 589) described under Plant Pathology 569. Emphasis is placed on taxonomy and taxonomic methods, and on nomenclature. Field work is *required*. Ascomycetes are covered in detail.

## 645-654. CURRENT TOPICS

Fall and spring terms. Credit to be arranged. For graduate students with special interests in a particular area. Prerequisite: permission to register. Time to be arranged. Plant Science 422.

Weekly discussions of current topics in special areas of plant pathology and mycology. Students will be required to do extensive reading of current literature and to present oral and written reports.

## 645. PLANT VIROLOGY

Professors Ross and Rochow.

## 646. PLANT NEMATOLOGY

Professor Mai and Associate Professor Harrison.

## 126 POMOLOGY

### 647. BACTERIAL PLANT PATHOGENS

Associate Professor Dickey.

### 648. PHYSIOLOGY OF PLANT DISEASES

Associate Professor Bateman and Associate Professor Millar.

### 649. MYCOLOGY

Professor Korf.

### 650. DISEASES OF VEGETABLE CROPS

Associate Professors Lorbeer and Wilkinson.

### 653. PATHOLOGY OF TREES AND SHRUBS

Assistant Professor Sinclair.

### 654. DISEASES OF FLORIST CROPS

Professor Dimock.

### 655. PLANT DISEASES IN AGRICULTURAL DEVELOPMENT

Professor Thurston.

### 661. SEMINAR

Fall and spring terms. Credit one hour. Required of all graduate students taking work in the department. T 4:40-5:40. Plant Science Seminar Room. Professor Mai.

### 671. PLANT PATHOLOGY COLLOQUIUM

Fall and spring terms. Credit one hour. First and third Thursdays 8-10 P.M. Plant Science Seminar Room. Staff and graduate students.

## BIOLOGICAL SCIENCES 498. VIROLOGY

(Consult the course listing in this *Announcement* for the Field of Microbiology.)

## POMOLOGY

Faculty: G. D. Blanpied, L. L. Creasy, L. J. Edgerton, M. B. Hoffman, G. H. Oberly, L. E. Powell, Jr., R. M. Smock, J. P. Tomkins.

At Geneva: J. C. Cain, J. N. Cummins, O. F. Curtis, Jr., J. Einset, C. G. Forshey, R. C. Lamb, D. K. Ourecky, N. J. Shaulis, G. L. Slate, R. D. Way.

Field Representative: L. J. Edgerton, 120 Plant Science Building.

### MAJOR AND MINOR SUBJECT

Pomology

**GENERAL REQUIREMENTS.** To enter graduate work in Pomology it is not necessary for the student to have done his undergraduate work in horticulture. It is important, however, that the student have a good background in the basic sciences and an interest in fruit plants. A knowledge of botanical and chemical subjects is particularly helpful. It is expected that a student will become well acquainted with the Field of Pomology during the course of his graduate work and with other Fields closely allied to his

thesis problem. Candidates for the M.S. degree are required to pass a final examination. Students who are registered in a Ph.D. degree program must take a qualifying examination in addition to the examinations required by the Graduate School (see p. 12).

**MAJOR AND MINOR SUBJECTS.** Pomology is approved as a major subject and as a minor subject when the major is in another Field. However, pomology, vegetable crops, and floriculture are generally not permitted as major-minor combinations.

**LANGUAGE REQUIREMENT.** There is no general foreign language requirement for the M.S. and Ph.D. degrees; however, competence in one or more foreign languages may be required by the chairman of the Special Committee.

## Research and Study Opportunities

Cornell University has two Departments of Pomology under its jurisdiction: one on the main Ithaca campus and one on its Geneva campus, fifty miles away at the New York State Agricultural Experiment Station. Members of these Departments are currently engaged in a great variety of research projects concerning growth regulating substances, post-harvest physiology, mineral nutrition, cold hardiness, rest period, root initiation, root-stocks, fruit set and development, fruit breeding, plant pigments, and general cultural practices. Students satisfy their course work requirements at Ithaca but, depending on their thesis problem, may conduct their research either at the Ithaca or the Geneva campus. Ordinarily one to two years are required to meet the requirements of a Master's degree and three to four years for the Ph.D. degree, although individual students may progress at a faster or slower rate than the time periods listed.

## Courses

### 401. ADVANCED POMOLOGY

Fall term. Credit three hours. Offered in alternate year. Prerequisites: Pomology 101 and 102 and Botany 235. Lectures, M W F 8. Professor Hoffman.

A comprehensive study of the sources of knowledge and opinions as to practices in pomology. The results of experiences and research pertaining to pomology are discussed, with special reference to their application in the solution of problems in commercial fruit growing.

### 501. SPECIAL TOPICS IN EXPERIMENTAL POMOLOGY

Spring term. Credit three hours. Offered in alternate years. Professor Edgerton, Associate Professors Oberly and Powell, and Assistant Professor Creasy.

The student is expected to review critically and to evaluate the more important original papers relating to various phases of pomological research. Recent experimental methods applicable to the topic are fully considered.

### 502. RESEARCH

Fall, spring, or both terms. Credit two or more hours a term. Prerequisite: Course 401. Professors Edgerton, Hoffman, and Smock; Associate Professors Blanpied, Oberly, Powell, and Tomkins; Assistant Professor Creasy.

## 600. SEMINAR

Fall and spring terms. Without credit. Required of students taking 502, and graduate students in pomology. T 11:15. Members of the Departmental staff.

## POULTRY SCIENCE

Faculty: Robert C. Baker, Andre Bensadoun, J. Herbert Bruckner, Randall K. Cole, Malden C. Nesheim, Milton L. Scott, Ari van Tienhoven, Robert J. Young.

Field Representative: R. J. Young, 200 Rice Hall.

## MAJOR SUBJECT

Poultry Science (M.S. only)

## MINOR SUBJECT

Poultry Science (M.S. or Ph.D.)

**ADMISSION REQUIREMENTS.** Candidates for admission to this Field must meet the general requirements for admission to the Graduate School. In addition, they should be well prepared in the basic sciences.

**LANGUAGE REQUIREMENTS.** There is no language requirement for the Master's degree in this Field. Students who expect to become candidates for the doctorate should study one or more foreign languages, preferably German, Russian, or French.

**EXAMINATION REQUIREMENTS.** Examinations required by the Graduate School are described on p. 12 of this *Announcement*.

## Research and Study Opportunities

Students expecting to continue their graduate program beyond the Master's degree in this area should consider selecting a major in the Field of Nutrition, Animal Breeding, Food Science, or Physiology, where they will work under the direction of faculty members in the Department of Poultry Science. Further information regarding these Fields will be found elsewhere in this *Announcement*.

The Department has excellent research facilities in the above disciplines and strong research programs are maintained in each. The faculty and their primary interests are as follows:

Animal Breeding: J. H. Bruckner, R. K. Cole.

Nutrition: M. C. Nesheim, M. L. Scott, R. J. Young.

Food Science: R. C. Baker.

Physiology: A. Bensadoun, A. van Tienhoven.

## Courses

## [420. POULTRY GENETICS]

Spring term. Credit three hours. Offered in alternate years. Prerequisite: permission of the instructor. Professor Cole. Not offered in 1969-70.

A survey of inherited characters in domestic birds, cytology, linkage, inbreeding, hybrid vigor, resistance to disease, genetic principles in poultry breeding, physiology of avian reproduction, infertility, embryonic mortality, and avian endocrinology.

#### 425. COMPARATIVE PHYSIOLOGY OF REPRODUCTION OF VERTEBRATES

Spring term. Credit four hours. Prerequisites: Animal Science 427 and consent of the instructor. Associate Professor van Tienhoven.

A study of sex and its manifestations, endocrinology of reproduction, interactions between endocrine and nervous systems. The laboratory will provide an opportunity for students to design and independently execute experiments with limited objectives.

#### [440. ANATOMY OF THE FOWL]

Fall term. Credit three hours. Offered in alternate years. Professor Cole. Not offered in 1969-70.

The lectures, supplemented by laboratory periods for study and dissection, are designed to acquaint the student with the anatomy of the fowl.

#### 450. POULTRY MEAT AND EGG TECHNOLOGY

Spring term. Credit three hours. Offered in alternate years. Prerequisites: Chemistry 355 or its equivalent and Biological Sciences 290. Professor Baker.

A discussion and study of some of the important microbial and non-microbial changes in poultry meat and eggs as well as the chemical composition and preservation of these products. Development of new products is also emphasized.

#### ADVANCED NUTRITION SERIES

(Consult the course listing in this *Announcement* for the Field of Nutrition.)

#### 511. SPECIAL TOPICS IN NUTRITION

Fall or spring term. Credit to be arranged. Registration by permission of staff member concerned. Professors M. L. Scott and R. J. Young, Associate Professor Nesheim.

For students desiring experience in planning, conducting, and reporting independent research projects in poultry nutrition.

#### 609. SEMINAR IN POULTRY BIOLOGY

Fall and spring terms. Members of the Departmental staff.

A survey of recent literature and research in poultry biology.

#### 619. SEMINAR ON ANIMAL NUTRITION

Fall term. Credit one hour. Open to graduate students whose major Field of study is Nutrition. Registration by permission. Nutrition staff.

A critical review of the literature and other topics of special interest to graduate students in nutrition.

## PSYCHOLOGY

Faculty: Henry A. Alker, Moshe Anisfeld, Alfred L. Baldwin, Harley A. Bernbach, Urie Bronfenbrenner, Richard B. Darlington, William C. Dilger, Eleanor J. Gibson, James J. Gibson, Herbert F. Ginsberg, Bruce P. Halpern, Stephen C. Jones, William W. Lambert, Eric H. Lenneberg, Harry Levin, James B. Maas, Robert B. MacLeod, Leo Meltzer, Ulric Neisser, Dennis T. Regan, Henry N. Ricciuti, Bernard C. Rosen, Thomas A. Ryan, M. E. P. Seligman, Fred Stollnitz, George J. Suci, G. W. Wilcox.

Field Representative: Eleanor J. Gibson, Morrill Hall.

#### MAJOR AND MINOR SUBJECTS

Developmental Psychology	Mathematical Psychology
Differential Psychology and Psychological Tests	Personality and Social Psychology
Experimental Psychology	Physiological Psychology
History and Systems of Psychology	Psycholinguistics

The following are available only as minor subjects:

Comparative Psychology	General Psychology
Educational Psychology	Industrial Psychology
Experimental Psychopathology	

Applicants for admission in Psychology are required to submit scores for the Graduate Record Examination (Advanced Test in Psychology and Aptitude Test) and for the Miller Analogies Test. An undergraduate major in psychology is desirable, but not required. Records of applicants are judged in terms of performance in mathematics and natural sciences as well as in psychology. Candidates for a terminal Master's degree are not accepted.

**LANGUAGE REQUIREMENT.** A reading knowledge of one foreign language (French, German, or Russian) is required for the Ph.D. With the approval of the Special Committee, a requirement in Mathematics or Computer Science may be substituted for the language. For the Field of Psychology the language requirements are satisfied by passing the College Entrance Examination Board Test at the level required for qualification of Cornell undergraduates.

**EXAMINATION REQUIREMENTS.** A written qualifying examination is administered by the Field. This is to be taken by the end of the third term of graduate work at Cornell. Students entering with the Master's degree or equivalent will take the examination earlier. The student's Special Committee may also require a qualifying examination in the major and minor subjects.

The Examination for Admission to Candidacy is normally taken during the third year of graduate work and is both written and oral. The Final Examination is an oral defense of the thesis. All oral examinations are administered by the Special Committee with the addition of one member appointed by the Field Representative.

## Research Training and Facilities

**RESEARCH FACILITIES.** The headquarters of the Department of Psychology are on the top two floors of Morrill Hall and contain offices, classrooms, and teaching laboratories. Graduate and faculty research is conducted at the Cornell Research Park, at White Hall, and at Liddell Laboratory.

Most experimental research using human subjects is done at the Research Park. A large newly equipped shop is also located there.

Research facilities in White Hall provide special rooms for research in problems of perception and cognition and well equipped, one-way observation rooms for experiments in social psychology. Cooperation at the local schools permits field research in the area of Developmental Psychology.

The Howard S. Liddell Laboratory of Comparative and Physiological Psychology includes an electrophysiological laboratory, shops, darkroom,

surgery, histology laboratory, and facilities for research with monkeys, dogs, and other laboratory animals.

## Areas of Specialization

### DEVELOPMENTAL PSYCHOLOGY

M. Anisfeld, A. I. Baldwin, U. Bronfenbrenner, E. J. Gibson, H. P. Gifsborg, E. Lenneberg, H. Levin, H. N. Ricciuti, and G. J. Suci.

Specialization in this area normally involves participation in a program jointly sponsored by the Fields of Psychology and Child Development. The program, which emphasizes cognitive development, may be entered via either Field. Training in research skills in both Fields is recommended. Majors admitted to the program via Psychology take the Field Examinations administered by Psychology. Current research interests of the faculty include development of language, perception and thinking, intellectual development in natural settings, conceptual and affective behavior in infancy, behavioral maturation, and cognitive socialization.

### DIFFERENTIAL PSYCHOLOGY AND PSYCHOLOGICAL TESTS

H. A. Alker, R. B. Darlington, and G. W. Wilcox.

Training within the Field of Psychology emphasizes psychometric theory—test theory, scaling, and factor analysis—and its applications both in psychological research and in practical settings. Excellent relations are maintained with the Fields of Education and Child Development and Family Relationships, where training in the use of specific tests is offered.

### EXPERIMENTAL PSYCHOLOGY

M. Anisfeld, H. A. Bernbach, E. J. Gibson, J. J. Gibson, B. P. Halpern, E. Lenneberg, H. Levin, J. B. Maas, R. B. MacLeod, U. Neisser, T. A. Ryan, M. E. P. Seligman, F. Stollnitz, and G. W. Wilcox.

Experimental psychology is the study of basic processes in both humans and animals: learning, memory, motivation, perception, sensitivity, and thinking. An individual student will usually develop a special interest in one of these basic processes, although he should be familiar with the whole area. Both experimental method and the facts and theories derived from experimental observation are stressed. Some of the problems now under investigation are the nature of discrimination, the selection of sensory information, the perceiving of the environment, perceptual learning and development, the transmission of (visual and acoustic) information, the development of concepts, the functions of social stimuli, the formation of learning sets, classical conditioning and instrumental training, the acquisition of helplessness and fear, stress and emotion, memory, and the ability to respond to symbols.

### HISTORY AND SYSTEMS OF PSYCHOLOGY

H. A. Alker, R. B. MacLeod, M. E. P. Seligman.

This area is usually studied as a minor in conjunction with major specialization in one of the substantive subjects of psychology. Students who major in history and systems are expected to take a substantial minor in history or philosophy of science. A reading knowledge of the relevant foreign languages is considered essential for both majors and minors.

## MATHEMATICAL PSYCHOLOGY

H. A. Bernbach, G. W. Wilcox.

The major program in mathematical psychology is intended for students with a central interest in the application of mathematics to psychology, primarily in the area of mathematical behavior theory. Such applications take the form of mathematical models of behavior that draw on the full range of modern mathematics, and are appropriate to many content areas within psychology. Students are expected to develop competence in mathematical psychology and in a specific psychological content area. Thus, students will generally take a minor in mathematics, and perform an empirical dissertation rather than a purely methodological one.

The minor program in mathematical psychology is intended to give students the mathematical tools necessary to support their major area of interest. Courses in mathematics will generally be recommended in addition to departmental courses in mathematical behavior theory and methodology.

## PERSONALITY AND SOCIAL PSYCHOLOGY

H. A. Alker, U. Bronfenbrenner, S. C. Jones, W. W. Lambert, L. Meltzer, and B. Rosen.

Students may devote varying emphases to personality and to social psychology according to their interests, even concentrating exclusively upon one or the other aspect if they wish. Staff research interests in personality include: aggressive behavior, anxiety and defenses, experimental psychodynamics, personality assessment, and emotional communication. Social psychology is taught jointly by members of the Graduate Fields of Psychology and Sociology. Majors who are admitted via Psychology often choose one of their minors within Sociology. Other relevant minors include anthropology, child development, organizational behavior, or statistics. Some current research interests of the faculty include: character development in the Soviet Union, nonverbal communication, new approaches to observation methodology, interpersonal evaluations, guilt and persuasion, attitude change, and cross-cultural studies of socialization.

## PHYSIOLOGICAL PSYCHOLOGY

B. P. Halpern and E. Lenneberg.

The student is expected to develop his skill in a variety of biological techniques as well as to become firmly grounded in the experimental analysis of behavior. Students are advised to have one of their minor subjects in physiology, biochemistry, neurobiology and behavior, evolutionary biology, veterinary medicine, or physics. Research interests include brain-behavior relationships and sensory psychophysiology.

## PSYCHOLINGUISTICS

M. Anisfeld, E. J. Gibson, E. Lenneberg, H. Levin, R. B. MacLeod, U. Neisser.

This area combines aspects of psychology and linguistics in the study of the psychological representation of language, the acquisition of language, and its use in cognition and communication. Some of the interests currently pursued in the department are: the effects of linguistic structure on linguistic and nonlinguistic behavior, the generality of language processing mechanisms in other mental operations, the nature of the switching mechanisms in dialect and language choice, the acquisition of reading skill, and the genesis of language investigated by means of developmental and comparative methods.

Students majoring in psycholinguistics frequently select general linguistics as a minor. Public Health traineeships in psycholinguistics are available.

## COMPARATIVE PSYCHOLOGY

W. C. Dilger, M. E. P. Seligman, and F. Stollnitz.

Comparative psychology is the study of similarities and differences in the behavior of various species. Staff research interests include evolution of behavior, primate behavior, classical and instrumental conditioning, discrimination learning and perception, and pathological behavior.

## EDUCATIONAL PSYCHOLOGY

A. L. Baldwin, R. B. Darlington, E. J. Gibson, H. Levin, and J. B. Maas.

This area is offered as a minor subject in Psychology. Instruction in areas related to educational practice such as learning, perception, motivation, psychological measurement, and the teaching of psychology is available. Also, research experience in projects concerned with reading, cognitive socialization, behavior of disadvantaged children and the evaluation of teaching and courses can be related to this subject. This minor may be chosen in conjunction with research specialization in the Center for Educational Research.

## EXPERIMENTAL PSYCHOPATHOLOGY

H. A. Alker and M. E. P. Seligman.

This area may be elected only as a minor subject. It is concerned primarily with research on animal subjects relating to the effects of stress upon emotional behavior, disruption of performance, and "experimental neurosis," and the relation of these phenomena to human psychopathology.

## GENERAL PSYCHOLOGY

Staff.

General psychology is designed as a minor for students majoring in some other Field, who wish to study some special combination of topics which overlaps with several of the areas listed above.

## INDUSTRIAL PSYCHOLOGY

J. B. Maas, T. A. Ryan.

This area may be elected as a minor subject by students in Psychology or other Fields such as Industrial and Labor Relations, Business and Public Administration, and Engineering. The emphasis is on research methods and results concerning the efficiency of performance, development of skill in complex tasks, effects of environment and methods of work, motivation, job satisfaction, and the evaluation of performance.

## Financial Aid

In addition to the general fellowships open to all Fields, teaching fellowships and research assistantships are available in the Department of Psychology, and the following fellowships are specifically for students in this Field:

### NATIONAL INSTITUTES OF HEALTH TRAINEESHIPS IN PSYCHOLINGUISTICS AND SOCIAL PSYCHOLOGY

Stipend \$1800 to \$2400 plus tuition and General Fee.

SUSAN LINN SAGE FELLOWSHIP. Stipend \$400 plus tuition.

### JOHN WALLACE DALLENBACH FELLOWSHIP IN EXPERIMENTAL PSYCHOLOGY

Stipend \$2500 plus tuition and General Fee.

## Courses

### 301. AN INFORMATION PROCESSING APPROACH TO PSYCHOLOGY

Fall term. Credit three hours. Prerequisite: one year of mathematics or a physical science, or consent of the instructor. Mr. Bernbach.

Introductory treatment of human behavior as the behavior of an information processing system. Topics covered include input and coding of information (detection and perception), storage and retrieval of information (learning and memory), and output processes (skill learning and performance). Also covered is a treatment of behavior as a choice among alternatives and the bases of such choices (motivation).

### 305. PERCEPTION

Fall term. Credit four hours. Prerequisite: two courses in psychology including Psychology 101. Mr. Neisser.

The basic phenomena of visual and auditory perception studied in terms of the stimulus variables on which they depend and of the mechanisms involved. Topics include the detection of weak stimuli, perceptual constancy and illusion, visual and auditory space perception, motion, and perceptual adaptation.

### 306. LEARNING

Spring term. Credit four hours. Prerequisites: Psychology 101 or equivalent. Mr. Stollnitz.

The fundamental conditions and principles of learning, both animal and human. The basic phenomena of operant conditioning, human verbal and

motor learning, discrimination learning, and serial learning will be studied experimentally. Traditional and contemporary theories of learning will be reviewed, and selected experimental literature will be discussed with special emphasis upon recent developments in the field.

### 307. MOTIVATION

Fall term. Credit four hours. Prerequisites: Psychology 101 and 201, or 306, or consent of the instructor. Mr. Alker.

Factors controlling the initiation, direction, and intensity of activity. Methods of research with emphasis upon experimental and statistical controls. Evaluation of evidence on major theories of motivation such as instinct theory, psychoanalysis, and behavioristic drive theory.

### 309. DEVELOPMENT OF PERCEPTION AND ATTENTION

Spring term. Credit four hours. Prerequisite: Psychology 305. Mrs. Gibson.

The development of perception and attention in ontogeny and phylogeny, theories of perceptual learning and experimental methods of studying them.

### [311. FEELING AND EMOTION]

Fall term. Credit four hours. Prerequisite: nine hours in psychology or consent of the instructor. Not offered in 1969-70.

### 313. COGNITIVE PROCESSES

Fall term. Credit four hours. Prerequisites: six hours of psychology or consent of the instructor. Mr. Anisfeld.

An examination of the mental processes involved in language learning and use, concept formation, and problem solving, and the relation between language and thinking. Students are required to carry out a supervised experimental or observational study.

### BIOLOGICAL SCIENCES 320. NEUROBIOLOGY AND BEHAVIOR

Spring term. Credit three hours. Prerequisites: Biological Sciences 101-102 or 103-104. Messrs. Camhi, Eisner, Emlen, Gilbert, Halpern, Rosenblatt, and Mrs. Salpeter.

Evolution of behavior, cueing of behavior, social and non-social behavior, neuroanatomy, neurophysiology, neurochemistry, neural networks, and memory.

### 323. PHYSIOLOGICAL PSYCHOLOGY

Fall term. Credit four hours. Prerequisites: Psychology 101 or its equivalent, Psychology 201 or a 300-level laboratory course in psychology, Biological Sciences 101-102 or its equivalent, and Chemistry 103-104 or its equivalent. Mr. Halpern.

An examination of relationships between neuroendocrine, neural, metabolic, neuromotor behavior, and behavior.

### [324. PSYCHOBIOLOGY]

Spring term. Credit four hours. Prerequisites: a grade of at least B in Psychology 323 and consent of the instructor. Not offered in 1969-70.

### 325. ABNORMAL PSYCHOLOGY

Fall term. Credit four hours. Prerequisite: nine hours of psychology, or consent of the instructor.

An introduction to the study of disordered behavior. Description of major syndromes, investigations and theories of etiology, and approaches to treatment will be covered in an attempt to introduce the student to major concepts and problems in this area.

[326. COMPARATIVE PSYCHOLOGY]

Spring term. Credit four hours. Prerequisite: Psychology 101, or Biological Sciences 320, or consent of the instructor. Not offered in 1969-70.

Similarities and differences in the behavior of animals ranging from the unicellular forms to man. Psychological and ethological approaches to animal behavior will be discussed.

327. BEHAVIORAL MATURATION (Biological Sciences 327)

Fall term. Credit three hours. Prerequisites: familiarity with psychological theories of learning and development and one year of college biology. Mr. Lenneberg.

Emergence of behavior will be studied in the light of developmental biology, including behavior genetics, neuro-embryology and morphogenesis, physical maturation of the brain, transformation and allometry as well as retarding influences from the environment.

[335. PSYCHOLOGICAL PROBLEMS OF ADVERTISING AND MARKET RESEARCH]

Spring term. Credit four hours. Prerequisites: Psychology 101 and 350. Mr. Maas. Not offered in 1969-70.

Design of fundamental research in laboratory, field, and survey studies of advertising and consumer behavior. Special attention is given to techniques of questionnaire construction, scaling, sampling, interviewing, and testing. Students work on selected research projects, enabling them to become familiar with collection, processing, and analysis of data.

350. STATISTICS AND RESEARCH DESIGN

Spring term. Credit four hours. Prerequisite: Psychology 101. Mr. Darlington.

Devoted about equally to elementary applied statistics (both estimation and hypothesis testing) through one-way analysis of variance, and to general problems in the design and analysis of research projects.

381. SOCIAL PSYCHOLOGY (Sociology 381)

Either term. Credit four hours. Prerequisites: three hours of psychology and three hours of sociology.

Analysis of the history, concepts, methods, and theories used to describe and conceptualize the ways in which people react to one another in social settings and in the laboratory. Students will work individually or as teams on projects, using experimental or other empirical methods. The topics for investigation in lectures and reading will include socialization, attitude change, communication, interpersonal influence, impression formation, leadership, and propaganda.

385. THEORIES OF PERSONALITY (Sociology 385)

Fall term. Credit four hours. Prerequisite: Psychology 101 or 102 or consent of the instructor. Mr. Lambert.

A critical survey of the concept of personality in literature, the social sciences, and psychology. A number of the modern specialists will be discussed at some length, and recent empirical and experimental work that has grown out of their thought will be analyzed. The empirical relation of personality notions to some philosophical beliefs and literary production will be considered. The emphasis will be mainly upon "normal" personality.

BIOLOGICAL SCIENCES 521-522. BRAIN MECHANISMS AND MODELS

Throughout the year. Credit four hours a term. Prerequisites: one year of

calculus and one year of biological sciences or psychology, and consent of the instructor. Mr. Rosenblatt, with assistance of guest lecturers.

## PRIMARILY FOR SENIORS AND GRADUATE STUDENTS

### 401. PSYCHOLOGICAL TESTING I

Fall term. Credit four hours. Prerequisites: six hours in psychology and a course in elementary statistics. Mr. Darlington.

Emphasis is on the logical and mathematical problems in the interpretation, evaluation, and construction of tests. No training given in administering tests.

### 402. PSYCHOLOGICAL TESTING II

Spring term. Credit four hours. Prerequisite: Psychology 401 or consent of the instructor. Mr. Darlington.

A more advanced treatment of the topics discussed in Psychology 401.

### 410. INDIVIDUAL DIFFERENCES AND PERSONALITY

Spring term. Credit four hours. Prerequisites: seven hours of psychology, junior or senior standing, or consent of the instructor. Mr. Alker.

Survey of theory and research concerning individual differences in personality, intelligence, creativity, anxiety, learning, perception, motivation, attitudes, and attitude change. Emphasis will be given to the applicability of different research techniques.

### [412. RESEARCH DESIGN IN PERSONALITY AND SOCIAL PSYCHOLOGY]

Spring term. Credit four hours. Mr. Darlington. Not offered in 1969-70.

### [414. PRACTICUM AND SEMINAR IN PSYCHOLOGICAL TESTING]

Spring term. Credit four hours. Prerequisite: Psychology 401 or 402. All students must have consent of the instructor. Not offered in 1969-70.

### 416. PSYCHOLOGY OF LANGUAGE

Spring term. Credit four hours. Prerequisite: Psychology 313 or consent of the instructor. Mr. Anisfeld.

An advanced treatment of the nature of the human capacity for language, the reading process, social and psychological aspects of bilingualism, speech perception and production. Instruction will be supplemented by experimental exercises.

### BIOLOGICAL SCIENCES 421. COMPARATIVE VERTEBRATE ETHOLOGY

Fall term. Credit three hours. Prerequisites: Biological Sciences 101-102, or 103-104 and permission of the instructor. Primarily for graduate students. Mr. Dilger.

### 424. BRAIN AND BEHAVIOR (Biological Sciences 424)

Spring term. Credit three hours. Prerequisites: familiarity with theories of perception, memory, and physiological psychology, or permission of instructor. Dr. Lenneberg.

The first part is a theoretical introduction to human neurology for psychologists. This survey of clinical symptoms and their etiology is designed to enable students to make use of disease for research purposes.

The second part is concerned with the characterization of models of brain function.

**426. EXPERIMENTAL PSYCHOPATHOLOGY**

Spring term. Credit four hours. Prerequisite: a course in learning (Psychology 201 would be accepted) and a course in abnormal or personality psychology. Mr. Seligman.

The application of experimental methods to behavior disorders. A survey of current investigations of etiology and treatment with special emphasis upon a scientific approach to pathology.

**427. SENSORY FUNCTION (Biological Sciences 427)**

Fall term. Credit three hours. Prerequisite: Biological Sciences 320 or permission of instructors. Mr. Halpern and Mr. Tapper.

Sensory receptors and the central nervous system transformation of afferent activity will be considered in relation to human and animal psychophysical data and to the adaptive significance of behavior. The receptor will be examined in terms of anatomy, biochemistry, biophysics of transduction, and the central nervous system control of peripheral input. S and U grading optional.

**428. SENSORY FUNCTION LABORATORY (Biological Sciences 428)**

Fall term. Credit two hours. Prerequisite: Psychology 427 (or concurrent registration) and permission of instructors. Enrollment limited to fifteen students. Messrs. Halpern and Tapper.

Experiments on the principles of receptor function and afferent neural activity. S and U grading optional.

**429. PSYCHOPHYSICS AND SCALING**

Fall term. Credit four hours. Prerequisites: Psychology 201 or 305, junior or senior standing, or consent of the instructor. Mr. Wilcox.

Emphasis on the theory and application of quantification procedures in psychology. Topics include subjective magnitudes, auditory and visual discrimination, sensitivity, detection theory, data theory, scaling methods.

**461. HUMAN LEARNING AND MEMORY**

Fall term. Credit four hours. Prerequisites: Psychology 201 or 306 and junior or senior standing. Mr. Bernbach.

**462. ADVANCED LEARNING: DISCRIMINATION LEARNING**

Fall term. Credit four hours. Prerequisite: Psychology 306 or equivalent. Mr. Stollnitz.

Performance of human and nonhuman subjects on various types of discrimination problems. Discrimination reversal, transfer, and learning-set formation. Laboratory work will stress individual projects.

**465. MATHEMATICAL BEHAVIOR THEORY**

Spring term. Credit four hours. Prerequisite: one year of calculus. Mr. Bernbach.

The purpose of this course is to give a brief overview of current developments in mathematical psychology and to develop techniques for the application of mathematics to psychological theory. Topics covered include choice behavior, decision theory, psychophysics, memory and learning theory, and information processing models of behavior.

## [466. THEORIES OF VISION]

Spring term. Credit four hours. Prerequisite: consent of instructor. Not offered in 1969-70.

## 471-472. STATISTICAL METHODS IN PSYCHOLOGY

Throughout the year. Credit four hours each term. Prerequisites: Psychology 201 or consent of the instructor. Psychology 471 is prerequisite to 472. Mr. Ryan.

An analysis of the methods for treating various kinds of psychological data. Fall term: tests of significance and confidence limits, analysis of variance and correlation. Spring term: complex designs in analysis of variance, analysis of trends and covariance, multiple and curvilinear correlation, introduction to factor analysis.

## [476. RESEARCH METHODS IN PSYCHOLOGY—EXPERIMENTAL AND LABORATORY]

Fall term. Credit four hours. Prerequisite: consent of the instructor. Mr. Stollnitz and staff. Not offered in 1969-70.

Instrumentation for the behavioral sciences.

## [477. RESEARCH METHODS IN PSYCHOLOGY—INDUSTRIAL AND FIELD]

Spring term. Credit four hours. Prerequisite: Psychology 333 or consent of the instructor. Not offered in 1969-70.

## 480. ATTITUDES AND ATTITUDE CHANGE (Sociology 480)

Spring term. Credit four hours. Prerequisites: three hours of psychology and three hours of sociology.

A systematic survey of theory and research on attitudes and attitude change.

## 481. EXPERIMENTAL SOCIAL PSYCHOLOGY (Sociology 481)

Fall term. Credit four hours. Prerequisites: three hours of psychology and three hours of sociology or anthropology.

Emphasis is on the empirical study of social psychological phenomena. Students will be introduced to empirical laboratory and field methods used in social psychology. Substantive problems will provide the focus for the demonstration and use of these techniques.

## 483. GROUP DYNAMICS (Sociology 483)

Fall term. Credit four hours. Prerequisites: written consent of instructor and three hours in psychology and three hours in sociology. Mr. Hayes.

An analysis of group structures and processes. An essential feature of this course is training in observational methods and techniques of group analysis. Substantial laboratory and field study is required. Original readings are coordinated with the training, research and lectures.

## 484. EXPERIMENTAL GROUP DYNAMICS (Sociology 484)

Spring term. Credit four hours. Prerequisites: a course in statistics and a course in social or experimental psychology. Mr. Meltzer.

A practicum. Supervised research experience in the design, execution, and analysis of experimental research on topics such as group cohesiveness, group pressures, group goals, leadership, group performance, and interpersonal influence and communication. Students will read and discuss experimental studies as well as pertinent theoretical articles.

[488. INDIVIDUAL AND SOCIETY IN THE SOVIET UNION]

Spring term. Credit four hours. Prerequisite: consent of the instructor. Will be conducted as a seminar. Mr. Bronfenbrenner. Not given in 1969-70.

489. SELECTED PROBLEMS IN SOCIAL PSYCHOLOGY (Sociology 489)

Fall term. Credit four hours. Prerequisites: consent of the instructor and three hours of psychology and three hours of social psychology or sociology. Mr. Jones.

A small discussion seminar dealing with issues in both social and personality psychology. Initial discussions will focus on specific areas of the field such as interpersonal evaluation, attitude change, and group processes. Subsequently the discussions will become more general and raise such questions as what are the major themes social psychologists are or should be studying and what are the appropriate units of analysis of social behavior.

[490. PERSISTENT PROBLEMS IN PSYCHOLOGY]

Fall term. Credit four hours. Not offered in 1969-70.

496. SUPERVISED STUDY

Either term. Credit two hours. Staff.

497. SUPERVISED STUDY

Either term. Credit four hours. Staff.

## GRADUATE COURSES AND SEMINARS

Primarily for graduate students, but with the consent of the instructor may be taken by qualified undergraduates. Approximately five graduate courses or seminars will be offered each term, the selection to be determined by the needs of the students. During the preregistration period, the list of courses and seminars for the following term will be posted, specifying instructors, topics to be covered, and hours of meeting. Only grades of S or U will be given in the following courses:

501-502. GENERAL SEMINAR FOR BEGINNING GRADUATE STUDENTS

Either term. Credit three hours.

511-512. PERCEPTION

Either term. Credit four hours.

513-514. LEARNING

Either term. Credit four hours.

515-516. MOTIVATION

Either term. Credit four hours.

517-518. LANGUAGE AND THINKING

Either term. Credit four hours.

519-520. COGNITION

Either term. Credit four hours.

521-522. PSYCHOBIOLOGY

Either term. Credit four hours.

**523-524. PHYSIOLOGICAL PSYCHOLOGY**

Either term. Credit four hours.

**525-526. MATHEMATICAL PSYCHOLOGY**

Either term. Credit four hours.

**531-532. HISTORY OF PSYCHOLOGY**

Either term. Credit four hours.

**541-542. STATISTICAL METHODS**

Either term. Credit four hours.

**543-544. PSYCHOLOGICAL TESTS**

Either term. Credit four hours.

**545-546. METHODS OF SOCIAL ANALYSIS**

Either term. Credit four hours.

**547-548. METHODS OF CHILD STUDY**

Either term. Credit four hours.

**561-562. HUMAN DEVELOPMENT AND BEHAVIOR**

Either term. Credit four hours.

**575-576. PERSONALITY**

Either term. Credit four hours.

**577-578. INDUSTRIAL PSYCHOLOGY**

Either term. Credit four hours.

**583-584. PROSEMINAR IN SOCIAL PSYCHOLOGY**

Either term. Credit four hours. Fall term: Mr. Rosen. Spring term: Mr. Jones.

Critical analysis of the major current theories and research in social psychology. In the fall, sociological perspectives will be emphasized; in the spring, psychological ones.

**591-592. EDUCATIONAL PSYCHOLOGY**

Either term. Credit four hours.

**595-596. THE TEACHING OF PSYCHOLOGY**

Either term. Credit four hours.

**601-602. PRACTICUM IN THE TEACHING OF PSYCHOLOGY**

Either term. Supervisor and credit hours to be individually arranged.

**611-612. PRACTICUM IN RESEARCH**

Either term. Apprenticeship in research with individual staff members. The problem, the supervisor, and credit hours are to be individually arranged.

**621-622. THESIS RESEARCH**

Either term. Supervisor and credit hours to be individually arranged.

681-682. SEMINAR IN SOCIAL PSYCHOLOGY

Either term. Credit four hours. Fall term: Mr. Meltzer. Spring term: Mr. Lambert.

Research oriented analysis of selected topics in social psychology.

683. RESEARCH PRACTICUM IN SOCIAL PSYCHOLOGY

Fall term. Credit four hours. Mr. Hayes.

Research on interaction and social structure.

## STATISTICS

Faculty: Robert E. Bechhofer, Isadore Blumen, Lawrence D. Brown, Roger Farrell, Walter T. Federer, Harry Kesten, Jack Kiefer, Philip J. McCarthy, Narahari U. Prabhu, Douglas S. Robson, Shayle R. Searle, Frank L. Spitzer, Howard M. Taylor 3d, N. Scott Urquhart, Lionel Weiss, Jacob Wolfowitz.

Field Representative: Isadore Blumen, 360 Ives Hall.

### MAJOR SUBJECT

Statistics

### MINOR SUBJECTS

Provisions for minoring in statistics are given in the descriptions of the Fields of Operations Research, Industrial and Labor Relations, Mathematics, and Plant Breeding and Biometry contained in the Announcements of the various Areas of the Graduate School.

**ADMISSION REQUIREMENTS.** Since one of the principal aims of graduate work in the Field of Statistics is that of training individuals who will have a thorough knowledge of the theoretical basis of modern statistical method and will have demonstrated ability to make significant contributions to this theory, applicants should ordinarily have obtained nearly the equivalent of an undergraduate major in mathematics. It is strongly recommended that applicants resident in the United States during the year before entering the Graduate School present scores on the Graduate Record Examination Aptitude Test.

**LANGUAGE REQUIREMENT.** There is no foreign language requirement for the M.S. degree. A candidate for the Ph.D. degree must demonstrate reading ability in one language besides English, chosen from among French, German or Russian.

**PROGRAM OF STUDY.** A student majoring in the Field of Statistics must complete a graduate sequence of courses in mathematical statistics which has been approved by his Special Committee. Other course work required of majors in statistics will be chosen from among the offerings, as listed below, of the members of the Field. A doctoral student in the Field of Statistics ordinarily has two minor subjects but may, in consultation with the chairman of his Special Committee, choose to work in one minor subject. One minor subject will often be in an area of interest to the student in which the methods of statistics find extensive application. A second minor is usually devoted to mathematics, computing, or a similar subject.

**PH.D. EXAMINATIONS.** In addition to the Admission to Candidacy Examination, which will ordinarily be administered by the student's Special Committee during or at the end of the third year of graduate study, and the Final

Examination on the thesis, the student will be given a qualifying examination. This examination will occur shortly after the first year of graduate study. It will serve to determine the ability of the candidate to pursue doctoral studies and to assist the Special Committee in developing a program of study for the candidate.

## Teaching and Research Interests of the Faculty

In extremely broad terms, the teaching and research interests of faculty members are in the following general areas: biological applications of probability and statistics (Federer, Robson, Searle, Urquhart); engineering and operations research applications of probability and statistics (Bechhofer, Prabhu, Taylor, Weiss); mathematical theory of probability and statistics (Brown, Farrell, Kesten, Kiefer, Spitzer, Wolfowitz); social science applications of probability and statistics (Blumen, McCarthy).

Some of the more specific areas of current interest are: analysis and probability theory (Kesten, Spitzer); design and analysis of experiments (Bechhofer, Federer, Kiefer, Robson, Searle, Urquhart, Wolfowitz); high speed computing (Searle); mathematical theory of statistics (Farrell, Kiefer, Wolfowitz); multiple decision procedures (Bechhofer); multivariate analysis (Blumen, Urquhart); nonparametric statistics (Blumen, Weiss); queuing and inventory theory (Prabhu); sampling theory (McCarthy, Robson); sequential sampling methods (Kiefer, Weiss); statistical control theory (Taylor); statistical genetics (Federer, Robson, Searle).

## Courses

Descriptions of the following courses may be found in the *Announcements* of the various Areas of the Graduate School under the Fields with which they are identified; in those sections reference is also made to several advanced seminars, both formal and informal, the content of which varies from year to year.

### ADVANCED UNDERGRADUATE AND MASTER'S LEVEL COURSES

#### Operations Research

9460. INTRODUCTION TO PROBABILITY THEORY WITH ENGINEERING APPLICATIONS

9470. INTRODUCTION TO STATISTICAL THEORY WITH ENGINEERING APPLICATIONS

9512. STATISTICAL METHODS IN QUALITY AND RELIABILITY CONTROL

9570. INTERMEDIATE ENGINEERING STATISTICS

#### Industrial and Labor Relations

310. DESIGN OF SAMPLE SURVEYS

144 STATISTICS

311. STATISTICS II

410. TECHNIQUES OF MULTIVARIATE ANALYSIS

411. STATISTICAL ANALYSIS OF QUALITATIVE DATA

## Mathematics

371. BASIC PROBABILITY

472. STATISTICS

## Plant Breeding and Biometry

410-411. MATHEMATICAL AND STATISTICAL MODELS IN BIOLOGY

417. MATRIX ALGEBRA IN BIOLOGY AND STATISTICS

510. STATISTICAL METHODS I

511. STATISTICAL METHODS II

## ADVANCED MASTER'S AND DOCTOR'S LEVEL COURSES

### Operations Research

9560. APPLIED STOCHASTIC PROCESSES

9561. QUEUING THEORY

9564. STATISTICAL ASPECTS OF RELIABILITY ANALYSIS

9571. ADVANCED INDUSTRIAL AND ENGINEERING STATISTICS

9572. STATISTICAL DECISION THEORY

9573. STATISTICAL MULTIPLE DECISION PROCEDURES

### Industrial and Labor Relations

610. ECONOMIC AND SOCIAL STATISTICS

614. THEORY OF SAMPLING

## Mathematics

571. PROBABILITY

572. STATISTICAL INFERENCE

574. ADVANCED PROBABILITY

575. INFORMATION THEORY

673. ANALYSIS OF VARIANCE

- 674. DESIGN OF EXPERIMENTS
- 675. STATISTICAL ESTIMATION
- 676. DECISION FUNCTIONS
- 677-678. STOCHASTIC PROCESSES

## Plant Breeding and Biometry

- 513. DESIGN OF EXPERIMENTS I
- 514. DESIGN OF EXPERIMENTS II
- 517. LINEAR ESTIMATION AND TESTS OF HYPOTHESIS
- 518. SPECIAL TOPICS IN SEQUENTIAL SAMPLING, BIOASSAY, NONPARAMETRIC STATISTICS, ETC.
- 519. STATISTICAL GENETICS

## VEGETABLE CROPS

Faculty: Elmer E. Ewing, John D. Hartman, Frances M. R. Isenberg, William C. Kelly, Philip A. Minges, Peter L. Minotti, Henry M. Munger, Edwin B. Oyer, Jim L. Ozbun, Roger F. Sandsted, Raymond Sheldrake, Robert D. Sweet, Leonard D. Topoleski, Donald H. Wallace.

At Geneva: Donald W. Barton, Michael H. Dickson, Gerald A. Marx, Nathan H. Peck, Richard W. Robinson, Stanton Shannon, Morrill T. Vittum.

At Riverhead: Stewart L. Dallyn.

Field Representative: Edwin B. Oyer, 103 E. Roberts Hall.

### MAJOR AND MINOR SUBJECT

#### Vegetable Crops

**ADMISSION REQUIREMENTS.** Admission to the Field is based on the quality and nature of the applicant's prior training as well as on letters of recommendation. It is not necessary for the previous training to have been in horticulture. More important is a good background in biological and agricultural sciences together with an interest in economic plants. Farm experience is an advantage.

**LANGUAGE REQUIREMENTS.** Although there is no specific foreign language requirement by the Field, the Special Committee may recommend or require proficiency in a foreign language in individual instances depending on the candidate's objectives and previous training.

**EXAMINATION REQUIREMENTS.** For the Ph.D. degree the Field requires three oral examinations: qualifying, Admission to Candidacy, and a Final Examination on the thesis. In certain cases the Special Committee may require additional examinations.

The qualifying examination is taken early in the program, preferably no later than the second term of residence, and is utilized in planning the student's future course of study. Those in a Cornell M.S. degree program can utilize

the final examination for that degree as a qualifying examination, provided a representative of the second minor subject participates in the examination.

The Admission to Candidacy Examination covers primarily course work. It must be taken at least two terms in advance of the anticipated date of completion of the thesis investigation.

The Final Thesis Examination is taken upon completion of the written presentation of the thesis research.

**TEACHING REQUIREMENT:** All M.S. and Ph.D. degree candidates in the Field of Vegetable Crops will be required to obtain teaching experience before the granting of the degree.

## Research and Study

Research and study in the Field of Vegetable Crops involves the application of scientific knowledge and methods to the solution of problems in the production, handling, processing, and marketing of vegetables including potatoes and dry beans. The graduate program provides training not only in research but also in teaching and extension. Many staff members do teaching and/or extension in addition to research. They may be selected as Special Committee chairmen or members. Assistantships are available for training and experience in research, teaching, and extension.

Members of the staff are competent to direct research in many subjects and problems. The following is a partial listing of their interests:

Professors Kelly, Minges, Oyer, and Sandsted: vegetable crop physiology and production.

Professors Barton, Dickson, Marx, Munger, Robinson, and Wallace: breeding genetics, and variety performance.

Professor Sweet: chemical weed control.

Professor Isenberg: postharvest physiology, biological aspects of handling and marketing vegetables.

Professor Hartman: biological and food technological aspects of marketing, objective and subjective measurement of color, flavor, and texture.

Professor Sheldrake: plant growing structures and methods.

Professor Topoleski: youth extension work.

Professor Vittum: climatology and soil-plant-water relationships.

Professor Peck: mineral nutrition, fertilization, and cultural practices.

Professors Ozbun and Shannon: biochemistry, nutrition, and physiology.

Professor Minotti: mineral nutrition, muck studies, breeding.

Professor Dallyn: potatoes—blackspot, storage, sprout inhibitors, cooking quality. Other vegetables—cultural methods, fertilization, irrigation, chemical weed control.

Professor Ewing: potatoes, especially the interrelations among plant growth substances, enzyme and nucleic acid metabolism, and changes in plants and tubers.

## Courses

Specific course requirements are determined on an individual basis by the Special Committee. The courses listed below are usually taken by Ph.D. degree candidates. For those with little specialized course work in vegetable crops, additional courses at the 100–200 level are suggested. (See the *Announcement of the College of Agriculture* for details.)

**401. VEGETABLE CROP PHYSIOLOGY**

Fall term. Credit four hours. Prerequisites: Vegetable Crops 211 and Biological Sciences 240 or their equivalent. Lecture, M W F 11:15. Laboratory, M 2-4:25. Professor Kelly.

The physiological bases of cultural practice and the application of these principles to problems in vegetable production. Original literature is used to illustrate the principles involved. Experimental material is studied in the laboratory to amplify lecture topics. Subjects discussed include: mineral nutrition as influenced by fertilization programs and crop sequence; nutrient interactions and induced deficiencies; growth and development; flowering; fruit setting; growth correlation; senescence; sex expression; photoperiodism; vernalization; and environmental factors affecting growth.

**412. POST-HARVEST HANDLING AND MARKETING, ADVANCED COURSE**

Fall term. Credit four hours. Lectures, T Th 11:15. East Roberts 222. Laboratory, T or W 2-4:25. East Roberts 223. Professor Hartman.

Principles and procedures involved in the distribution, processing, and quality maintenance of vegetables from harvest to the ultimate consumer. Development, validation, and use, present and prospective, of instrumental measurements of color, texture, and flavor in vegetables. Specifications, purposes, and utilization of quality standards by food and health-control governmental agencies, by food manufacturers, and by research organizations. Laboratories include some field trips to see commercial operations. The course has the same lectures and laboratories as 212, but requires discussion periods and special readings and reports.

**413. KINDS AND VARIETIES OF VEGETABLES**

Fall term. Credit three hours. Given in even-numbered years. Prerequisite: permission to register. Lecture and laboratory, Th F 2-4:25. Two days of laboratory work preceding the beginning of regular instruction are required. Notify the instructor of intention to take this course early in September. Professor Minges.

Designed to help students achieve proficiency in the evaluation of vegetable varieties through study of their origin, characteristics, adaptation, and usage. An important part of the course is the study of crops in the field. The vegetable seed industry is also discussed.

**429. SPECIAL TOPICS IN PLANT SCIENCE EXTENSION**

Spring term. Credit one hour. (Additional credit by special arrangement.) Offered in even-numbered years. Lecture, F 8. Discussion period to be arranged. Professor Minges.

Designed for students in the several plant science specialties who wish to acquire a knowledge of extension activities in preparation for careers in extension and associated work, such as research and technical work in both public and commercial organizations. Topics are related to extension in other countries as well as in the United States. Staff members from other Plant Science Departments collaborate in teaching the course.

**501. RESEARCH METHODS IN VEGETABLE CROPS**

Spring term. Credit three hours. Given in odd-numbered years. Prerequisite: Vegetable Crops 401. It is recommended that Plant Breeding 510 and 511 precede or accompany this course. Lectures, M W F 9:05. Professor Kelly.

A study of research techniques peculiar to vegetable crops.

## 601. SEMINAR

Fall and spring terms. Required of graduate students taking either a major or minor in this Department. Th 4:30. Members of Departmental staff.

## 610. SPECIAL TOPICS IN VEGETABLE CROPS

Fall and spring terms. Credit to be arranged. For graduate students with special interest in plant physiology. Prerequisite: permission to register. Assistant Professor Ozburn.

Weekly discussions of current topics in plant physiology as related to vegetable crops. Students will be required to present oral reports on current literature and to prepare and present a research proposal.

## VETERINARY MEDICINE

Faculty: Marion Anders, Max J. G. Appel, Arthur L. Aronson, James A. Baker, John Bentinck-Smith, Emmett N. Bergman, Clyde I. Boyer, Jr., Dorsey W. Bruner, Bruce W. Calnek, Samuel G. Campbell, Leland E. Carmichael, Alison P. Casarett, Cyril L. Comar, Peter H. Craig, John F. Cummings, A. Gordon Danks, Donald D. Delahanty, Alexander de Lahunta, Alan Dobson, Henry O. Dunn, Howard E. Evans, Julius Fabricant, Francis H. Fox, Edgar L. Gasteiger, Jack C. Geary, Jay R. Georgi, James H. Gillespie, Robert E. Habel, Stephen B. Hitchner, Robert F. Kahrs, Francis A. Kallfelz, Robert M. Kenney, Robert W. Kirk, Lennart P. Krook, Kyu M. Lee, Frederick W. Lengemann, Ellis P. Leonard, Philip P. Levine, Kenneth McEntee, Louis L. Nangeroni, Neil L. Norcross, Fernando M. Noronha, Malcolm C. Peckham, George C. Poppensiek, John Post, Charles G. Rickard, Stephen J. Roberts, George E. Ross, Jr., O. Wolfgang Sack, Herbert F. Schryver, Alvin F. Sellers, Ben E. Sheffy, Charles E. Stevens, Daniel N. Tapper, John B. Tasker, John C. Thompson, Jr., Robert H. Wasserman, John H. Whitlock, Alexander Winter, John F. Wootton.

Field Representative: Lennart Krook, E-311 Veterinary College.

## MAJOR AND MINOR SUBJECTS

Animal Physiology	Veterinary Medicine
Immunochemistry	Veterinary Obstetrics and Diseases of the Reproductive Organs
Parasitology	Veterinary Pathology
Pathogenic Bacteriology	Veterinary Pharmacology
Physical Biology (including Radia- tion Biology)	Veterinary Surgery
Veterinary Anatomy	Veterinary Virology

Applicants for graduate study from countries other than the United States and Canada are requested to include in their credentials the results of the Graduate Record Examination (Aptitude) Test except in cases where this examination is not given in reasonable proximity to the student's home. When the Graduate Record Examination is not available, the student is requested to submit instead the results of the College Entrance Board Examination (Scholastic Aptitude Tests).

For the Master's degree a reading knowledge of an appropriate language is desirable but not required.

A candidate for the degree of Ph.D. must demonstrate reading ability in at least one language other than English at the minimum level established by the Language Board of the Graduate Faculty. This language requirement

must be completed before the Examination for Admission to Candidacy. The student's Special Committee selects the language appropriate to his area of study and can require additional languages or a higher degree of proficiency in language in order to achieve professional competence.

In addition to the Admission to Candidacy and Final Thesis Examinations required by the Graduate School, all Ph.D. degree candidates must pass a qualifying examination required by the Field. The latter precedes the Admission to Candidacy examination and usually occurs during the second semester of work.

Facilities for graduate study and research in all areas of basic and applied veterinary medicine offer many unique opportunities. In addition to the excellent University libraries, the College has a specialized collection of over 33,000 volumes and 570 current periodicals. A large and varied clinic representing all domestic animals is available as a source of material. In addition to the animal quarters, pastures, and laboratories on the main campus, the College operates several farms and research facilities within close proximity. These include the virus disease laboratories, poultry disease facilities, sheep and cattle disease farms, and the radiation biology laboratory.

Graduate students may work for the M.S. or Ph.D. degrees, or the D.Sc. in V.M. (Doctor of Science in Veterinary Medicine). The latter degree is characterized by a professional rather than a research objective. (See the *Announcement of the New York State Veterinary College* for a full description of the requirements.) A student who holds the D.V.M. degree from a recognized college in the United States or Canada may transfer one year's residence credit for that work toward the Ph.D. degree. In the clinical areas, only candidates with the D.V.M. degree are accepted for graduate work.

## Courses

### ANATOMY

Professors de Lahunta, Evans, Habel, Sack.

Facilities are provided for graduate study in all branches of the science of anatomy as they pertain to domestic and laboratory animals and wild vertebrates. Study and research are encouraged in other fields of veterinary science and animal biology which employ morphological techniques in the determination of experimental results. Graduate students have the opportunity to gain valuable experience and stimulation by taking part in teaching activities.

The basic requirements for a major in veterinary anatomy include: (1) satisfactory completion of the professional courses in gross, microscopic, neuro-, and developmental anatomy of the domestic animals, or equivalent formal instruction; (2) participation in the departmental seminars; (3) advanced course work selected from the offerings of the University to suit the special objectives of the student; (4) a thesis which gives evidence of a thorough review of the literature and a competent treatment of the research problem.

#### 505. NEUROANATOMY

Spring term. Credit two hours. Associate Professor de Lahunta, Assistant Gray.

A morphological and functional study of the central nervous system of the domestic animals.

### 507. DEVELOPMENTAL ANATOMY AND HISTOLOGY

Fall term. Credit four hours. Prerequisites: course work equivalent to that required for admission to the Veterinary College, plus completion of or concurrent registration in 501 or 900, or Zoology 321. A limited number of non-veterinary students will be admitted by permission of the instructor. Associate Professor de Lahunta, Assistant Professor Cummings, Assistant Gray.

Students are provided with serial sections of the chick and pig for laboratory use. The biology of the cells and tissues is illustrated with material taken from the domestic animals.

### 508. MICROSCOPIC ANATOMY

Spring term. Credit four hours. Prerequisites: 507 plus completion of or concurrent registration in 502 or 900 or Zoology 322. A limited number of non-veterinary students will be admitted by permission of the instructor. Assistant Professor Cummings, Assistant Gray.

The microscopic structure of the organs and the morphologic evidence of their function are described and illustrated with preparations from the domestic animals.

### 605-606. ADVANCED ANATOMY

Fall and spring terms. Credit to be arranged. Prerequisites: 501, 502, 507, and 508 or similar preparation in comparative anatomy and histology. Professors Habel and Evans, Associate Professors Sack and de Lahunta.

An opportunity for advanced study under personal direction.

### 900. VERTEBRATE MORPHOLOGY

Fall term. Credit three hours. Prerequisite: a course in zoology or biology. Professor Evans.

Designed primarily for graduate students in animal husbandry, nutrition, conservation, and zoology. Laboratory assignments include the dissection of the dog, cow, and chicken.

## AVIAN DISEASES

Professors Calnek, Fabricant, Hitchner, Levine, Peckham.

The facilities for research in Avian Diseases on the campus include offices, diagnostic and general laboratories, and a disease isolation building holding forty-one tight pens. A poultry disease research farm located on Snyder Hill, three miles from the campus, contains a well-equipped laboratory building and many small isolation buildings for work with less contagious diseases. A disease free breeding flock is also maintained for production of chickens and fertile eggs. Field material from the Ithaca and the four regional branch diagnostic laboratories is readily available.

The Veterinary College in cooperation with the Long Island Duck Research Cooperative, Incorporated, operates a fully equipped diagnostic and research laboratory for duck diseases at Eastport, Long Island. Living quarters at the laboratory are available for graduate students and investigators.

### 750. DISEASES OF POULTRY

Spring term. Credit three hours. Professor Levine.

Required of veterinary students. Diseases of domestic poultry and other birds are studied with special emphasis on differential diagnosis and control. Fresh and preserved specimens from the Poultry Diagnostic Clinic are presented during the laboratory period.

## 896-897. CLINICS ANCILLARY

Fall and spring terms.

A poultry disease diagnostic clinic open five and one-half days per week receives specimens from the surrounding area submitted by poultrymen, veterinarians, and poultry service men. Post-mortem examinations and microbiological techniques are employed to arrive at a diagnosis and to render assistance for disease control on the farm.

## ADVANCED WORK

Graduate students taking a minor in avian diseases may take advanced work with credits to be arranged.

## LARGE ANIMAL MEDICINE, OBSTETRICS, AND SURGERY

Professors Danks, Delahanty, Fox, Kahrs, Kenney, McEntee, Norcross, Roberts, Winter.

Courses are offered covering the general subjects of medicine, obstetrics, radiology, and surgery. The patients in the Ambulatory Clinic, the Large Animal Surgical Clinics, and the Mastitis Control Program supply an abundant source of valuable research material that is studied in cooperation with other departments in the College. This is particularly true in bacteriology, virology, parasitology, pathology, neurology, and metabolic diseases.

The Department has strong research programs in mastitis, especially in the field of immunochemistry, and in reproductive diseases of cattle. Two experimental herds of cattle are available for research in these areas.

The graduate program is designed to provide training in research methods in preparation for a career in teaching or research.

## 740. EPIDEMIOLOGICAL METHODS

Fall term. Credit two hours. Assistant Professor Kahrs.

A lecture course dealing with health and disease from a herd, flock, community, or population standpoint and emphasizing the use of knowledge about etiology, transmission, and distribution of disease in the development of preventive measures and control programs.

## 938. REPRODUCTIVE PATHOLOGY

Fall term of even-numbered years. Credit two hours. Prerequisites: Courses 630, 631, 632, and 633. Professor McEntee.

This is an advanced course in reproductive pathology of both male and female domestic animals with equal emphasis on gross and microscopic lesions of their genital tracts.

## 970-971. ADVANCED WORK IN REPRODUCTIVE PATHOLOGY AND BACTERIOLOGY, MEDICINE, OBSTETRICS, AND SURGERY

Fall and spring terms. Credit one to three hours, by appointment. Professors McEntee, Winter, Roberts, Fox, Delahanty, Associate Professors Loomis and Kenney, and Senior Research Associate Dunn.

Properly prepared students may undertake special problems or receive special assignments in the field of reproductive pathology, microbiology, medicine, obstetrics, and surgery.

The remainder of the courses offered by the Department of Large Animal Medicine, Obstetrics, and Surgery are primarily designed for the veterinary

undergraduate student. Since most of these students are in at least their fifth or sixth year of college, the offerings are at a graduate level. Most of these courses require as prerequisites many basic undergraduate courses offered in the Veterinary College; they are not generally open to non-veterinary students in the Graduate School. See the *Announcement of the New York State Veterinary College* or consult the professors offering the courses for more detailed information on the following courses.

570. HISTORY OF VETERINARY MEDICINE

670. FUNDAMENTALS OF ROENTGENOLOGY

671, 770. OBSTETRICS AND GENITAL DISEASES

771, 772, 870, 871. DISEASES OF LARGE ANIMALS

773, 774, 775. GENERAL AND SPECIAL SURGERY AND SURGICAL EXERCISES

872. JURISPRUDENCE, ETHICS, AND BUSINESS METHODS

## MICROBIOLOGY

Professors Baker, Bruner, Campbell, Carmichael, Gillespie, Lee, Poppensiek, Sheffy.

The laboratories are well equipped with modern apparatus providing opportunity for advanced work for those students who are properly prepared in pathogenic microbiology, immunity, immunochemistry, and virology.

340. PATHOGENIC BACTERIOLOGY

Spring term of odd-numbered years. Credit four hours. Professor Gillespie and Associate Professor Winter.

Includes microbiology, virology, and immunology.

941. SEROLOGY

Spring term of even-numbered years. Credit two hours. Limited to eight students, with preference given to graduate students. Permission to register must be obtained before the end of the preceding (fall) term. Prerequisites: 340 or 640, and 641. Professors Bruner and Campbell.

Includes complement fixation, conglutination complement absorption, hemagglutination inhibition, precipitation, fluorescent antibody techniques, neonatal isoelectrophoresis, and the antigen analysis of *Salmonella* cultures.

942-943. ADVANCED WORK IN BACTERIOLOGY, VIROLOGY, OR IMMUNOLOGY

Fall and spring terms. Credit one to three hours, by arrangement.

Properly prepared students may undertake special problems or receive special assignments.

944. IMMUNOCHEMISTRY

Spring term. Credit three hours. Registration by permission. Associate Professor Norcross.

Lectures include quantitative aspects of the antibody-antigen reaction, physical and chemical properties of antibodies and antigens, the mechanisms

of hypersensitivity, and tissue immunity. Laboratory experiments illustrate the phenomena covered in the lectures and familiarize the student with selected immunochemical techniques.

#### 945. ANIMAL VIROLOGY AND TISSUE CULTURE METHODS

Spring term of odd years. Credit one to four hours, by arrangement. Three credit hours for two lectures and one discussion section; one credit hour for one laboratory period. Courses 340 and/or 630 and 640 are considered prerequisites, except under special circumstances. Permission to register required. Associate Professors Lee and Carmichael.

Lectures will include the biology of animal viruses with emphasis on topics of general significance. Laboratory exercises emphasize methods of tissue culture preservation of cell lines, and the application of tissue culture methods to virology.

#### 946. MICROBIOLOGY SEMINAR

Fall and spring terms. No credit. Associate Professor Winter. Required of all graduate students.

### PATHOLOGY

Professors Bentinck-Smith, Boyer, Georgi, Krook, Noronha, Post, Rickard, Whitlock.

The laboratories are well equipped for advanced work in pathological anatomy, histochemistry, parasitology, tissue culture, and electron microscopy. The Department operates diagnostic facilities in which a large number of specimens for pathological, microbiological, and serological examinations are submitted. Principal emphasis is placed on necropsy and clinical pathology, nutritional pathology, parasite ecology, laboratory animal disease, and cancer research.

#### 630. GENERAL PATHOLOGY, LECTURES

Fall term. Credit two hours. Prerequisites: 507 and 508 or the equivalent. In addition, it is desirable that the student shall have had at least one year's work in anatomy and physiology. In special cases of students who are majoring in biology and expect to take no further work in pathology, these prerequisites may be waived in part. However, when this is done, the course will not be accepted as a prerequisite for other courses. Professor Rickard.

#### 631. GENERAL PATHOLOGY, LABORATORY

Fall term. Credit two hours. Prerequisite: Course 630 must be taken simultaneously or have been completed previously. Professor Rickard.

#### 632. SPECIAL PATHOLOGY LECTURES

Spring term. Credit two hours. Prerequisite: Course 631.

#### 633. SPECIAL PATHOLOGY LABORATORY

Spring term. Credit three hours. Prerequisite: Course 632 must be taken simultaneously or have been completed previously. Work in hematology is included.

#### 635. ANIMAL PARASITOLOGY

Spring term. Credit two hours. Prerequisite: a course in zoology or biology. Professor Whitlock.

A systematic study of the helminth and arthropod parasites of domestic animals with particular emphasis on the identification and bionomics of the forms of veterinary importance.

**636. CLINICAL PATHOLOGY**

Spring term. Credit two hours. Professor Bentinck-Smith.

Morphological studies of blood, cerebrospinal fluid, transudates, exudates, and urine.

**731-732. APPLIED PARASITOLOGY**

Fall and spring terms. Fall term, credit two hours. Spring term, credit one hour. Open only to veterinary students. Prerequisite: Course 635. Associate Professor Georgi.

An organized study of the parasitic diseases of domestic animals with particular emphasis on the features of diagnostic importance. Special attention will be given to the laboratory and post-mortem techniques that are of value in applied parasitology.

**930. PATHOLOGY SEMINAR**

Fall and spring terms. No credit. Required of all graduate students in Pathology.

**931. PATHOLOGY OF NUTRITIONAL DISEASES**

Spring term. Credit three hours. Designed primarily for graduate students of nutrition. Prerequisites: Courses 630 and 631. Professor Krook.

**932-933. ADVANCED WORK IN ANIMAL PARASITOLOGY**

Fall and spring terms. Credit one to three hours, by arrangement. For advanced students. Prerequisite: 635. Professor Whitlock and Associate Professor Georgi.

Special problems concerned with the parasites of domestic animals.

**936-937. ADVANCED WORK IN PATHOLOGY**

Fall and spring terms. Credit one to three hours, by appointment.

Properly prepared students may undertake special problems or receive special assignments.

**938. REPRODUCTIVE PATHOLOGY**

Fall term of even-numbered years. Credit two hours. Prerequisites: Courses 630, 631, 632, and 633. Professor McEntee.

**939. INTRODUCTION TO LABORATORY ANIMAL MEDICINE**

Spring term of even years. Credit two hours. Registration by permission. Professor Boyer.

A graduate course designed primarily to emphasize the use of laboratory animals as tools in biological research. Dogs, cats, mice, rats, guinea pigs, hamsters, rabbits, nonhuman primates, poultry and several unusual species will be considered. The course will provide an introduction to management and disease control as well as information on certain aspects of the comparative anatomy, ecology, behavior, and genetics of these animals. The selection of species for research as well as an appreciation of the scope and methodology used in the field of laboratory animal medicine will be covered.

## PHYSICAL BIOLOGY

Professors Casarett, Comar, Craig, Gasteiger, Georgi, Lengemann, Tapper, Thompson, Wasserman.

Master's degree and doctoral candidates may be accepted with a major in physical biology (or radiation biology). Emphasis is given to the development of methods and application of physical concepts to problems of normal and abnormal metabolism. Excellent facilities are available for work with laboratory and domestic animals and especially in all aspects of the use and effects of radiation. Some of the areas presently under active research include: fission product metabolism; biological effects of radiation, mineral metabolism; transport processes; central nervous system physiology; receptor physiology; use of radioisotopes in biological and clinical research; problems of radioactive contamination of the food chain.

Candidates are expected to have a strong background in biological sciences and either to have had, or to be in a position to take, one year of the following courses: physical chemistry, physics, biometry, and calculus.

It is recommended that those candidates for the Master's degree who expect to become candidates for the doctorate study one or more foreign languages.

### 920. ELEMENTS OF PHYSICAL BIOLOGY

Fall term. Credit three hours. Prerequisites: basic courses in physics, chemistry, biology, calculus, or consent of the instructor. Professor Comar and staff.

Lectures on atomic, molecular, and cellular aspects of matter; physiochemical concepts in biology; membrane phenomena; mathematical approaches, compartmental analysis; tissue culture; informational macromolecules; biological coding and control.

### 921. RADIOISOTOPES IN BIOLOGICAL RESEARCH— PRINCIPLES AND PRACTICE

Spring term. Credit four hours. Prerequisites: a course in quantitative chemistry and permission of the instructor. Professor Lengemann and staff.

Lectures, demonstrations, and laboratory on the fundamentals of atomic energy procedures and applications to biological research.

### 922. BIOLOGICAL EFFECTS OF RADIATION

Fall term. Credit three hours. Assistant Professor Casarett.

Lectures and demonstrations on radiation physics, radiation chemistry, radiation effects at the cellular level, radiation effects in multicellular organisms, genetic effects of radiation, and radioprotective and radiomimetic substances.

### 923. BIOLOGICAL MEMBRANES AND NUTRIENT TRANSFER

Spring term. Credit two hours. Prerequisites: animal or plant physiology, quantitative and organic chemistry, physics, and consent of instructor. Cellular physiology and elementary physical chemistry desirable. Professor Wasserman.

An introduction to elementary biophysical properties of biological membranes, theoretical aspects of permeability and transport, and mechanism of transfer of inorganic and organic substances across intestine, placenta, kidney, erythrocytes, bacteria, and other biological systems.

### 924. FUNCTIONAL ORGANIZATION OF THE NERVOUS SYSTEM

Fall term. Credit three hours for lecture, two hours for laboratory. Prerequisites: physiology, organic chemistry, physics, and/or consent of the instructor. Physical chemistry and neuroanatomy desirable. Professor Gasteiger.

Function of the nervous system will be considered primarily from an electrophysiological viewpoint. Where appropriate, important studies of reflexology, chemical and feedback control, and comparative anatomy will be utilized. Laboratory studies will include electrical activity of cells, reflexes, decerebrate rigidity, acoustic microphonic response, subcortical stimulation, and evoked and spontaneous cortical activity.

**926. PHYSICAL BIOLOGY GRADUATE SEMINAR**

Fall and spring terms. Credit one hour. Professor Comar and staff.

**927. SEMINAR—SPECIAL TOPICS IN PHYSICAL AND RADIATION BIOLOGY**

Fall and spring terms. Credit one hour. Assistant Professor Casarett.

**PHYSIOLOGY, BIOCHEMISTRY AND PHARMACOLOGY**

Professors Anders, Arion, Aronson, Bergman, Dobson, Nangeroni, Sellers, Stevens, Wootton.

Opportunities are offered for pursuit of graduate study toward the M.S. and Ph.D. degrees in the areas of physiological chemistry, physiology, and pharmacology. Areas of active research include enzyme kinetic studies, absorption from the digestive tract, carbohydrate and fat metabolic studies in ruminants, chelation of heavy metals in the animal body, chelate toxicity, electrolyte metabolism in digestive tract disease in ruminants, and gastric blood flow.

The M.S. degree is advised prior to undertaking work for the Ph.D. degree in the majority of instances. The minor subjects for the Masters' and Ph.D. degrees are taken in departments outside the Field of the major.

**511. PHYSIOLOGY**

Spring term. Credit three hours. Prerequisites: 510, 501, and 502, or Veterinary Medicine 900, or Biological Sciences 321-322 and Biochemistry 401. T Th F 8. Professors Dobson, Nangeroni, Stevens, Bergman, Sellers.

Physiology of cells, muscle, nerve, nervous system, digestive system, urine secretion, and temperature regulation.

**610. PHYSIOLOGY**

Fall term. Credit three hours. Prerequisite: Course 511. T Th F 8. Professors Sellers and Bergman.

Physiology of blood, lymph, circulation, respiration, endocrine organs, and reproduction.

**612. PHARMACOLOGY**

Second year, spring term. Credit six hours. Prerequisites: Anatomy 501, 502, 505, 507, 508; Physiology 510, 511, 610, 611; Pathology 630 and 631, or consent of the instructors. Associate Professors Aronson and Anders.

The primary emphasis of this course is on the physiological disposition and mechanism of action of drugs.

**613. TOXICOLOGY**

Spring term. Credit one hour. Prerequisite: consent of the instructor. Associate Professors Aronson and Anders.

**910. SPECIAL PROBLEMS IN PHYSIOLOGY**

Fall term. Credits to be arranged.

**911. SPECIAL PROBLEMS IN PHYSIOLOGY**

Spring term. Credits to be arranged.

**912. RESEARCH**

Fall term. Credits to be arranged.

**913. RESEARCH**

Spring term. Credits to be arranged.

**914. EXPERIMENTAL PHYSIOLOGY FOR GRADUATE STUDENTS**

Fall term. Credit three hours. Alternate years. Prerequisites: 510, 501, and 502, or 900, or Biological Sciences 321-322 and Biochemistry 401. Co-registration in Veterinary Medicine 610 and consent of the instructor are required. Registration limited. Associate Professor Nangeroni.

**915. METHODS IN PHYSIOLOGICAL RESEARCH**

Spring term. Credit four hours. Prerequisites: Biological Sciences 414 and a course in biochemistry, or Veterinary Medicine 914, or the equivalent and consent of the instructor. Enrollment limited. Professor Sellers and staff.

The course will emphasize principles and application of physiological methods for measurement of organ and tissue functions related to digestion, absorption, distribution, metabolism, and excretion.

**916. PHYSIOLOGICAL DISPOSITION OF DRUGS AND POISONS**

Spring term. Credit three hours. Prerequisites: a course in biochemistry and consent of instructor. Associate Professor Anders and staff of Toxicology Training Program.

Lectures on the absorption, distribution, metabolism, excretion, and selective toxicity of drugs as well as consideration of environmental aspects on the problem of toxicology.

**SMALL ANIMAL MEDICINE AND SURGERY**

Professors Kirk, Leonard, Ross.

Graduate students may elect to work for the M.S. degree, the Ph.D. degree, or for the D.Sc. in V.M. Special subjects of study include general and advanced canine medicine, general canine surgery, canine orthopedic surgery, and breeding diseases of small animals. Basic work in any one of these special areas will be reviewed, and advanced work will be given on an assignment basis. Minor subjects are required in one or more areas of the basic sciences.

Because of the close integration of the Small Animal Clinic with the Department, it is possible for the graduate student to have access to research material for whatever project he might like to undertake. The facilities are adequate for graduate study and research through the cooperation of other departments within the College.

Only candidates with the degree of D.V.M. or its equivalent are accepted, and the language requirement for the various degrees is the same as that required in the general Field of Veterinary Medicine.

## ZOOLOGY

Faculty: John M. Anderson, Antonie W. Blackler, LaMont C. Cole, Howard E. Evans, Perry W. Gilbert, Samuel L. Leonard, Edward C. Raney, Bernard V. Travis, William A. Wimsatt.

Field Representative: Antonie W. Blackler, 318 Stimson Hall.

## MAJOR AND MINOR SUBJECTS

Animal Cytology	Embryology
Comparative and Functional Anatomy	Endocrinology
Ecology	Histology
	Invertebrate Zoology

**ADMISSION REQUIREMENTS.** Applicants for admission to graduate study in zoology must submit scores of the Graduate Record Examinations Aptitude and Advanced Biology Tests. It is important that the examination be taken as early as possible in the year of application and that scores be submitted not later than mid-February.

All applicants should have completed the equivalent of a well-rounded college major in zoology and should have some foundation in the particular phase of zoology they desire to pursue. Courses in organic chemistry, elementary physics, and calculus should also have been completed. Although an exceptional student may be admitted without having finished one or more of these requirements, he should then expect to remain in residence beyond the minimum period to make up the deficiencies.

**LANGUAGE REQUIREMENT.** For the Master's and Ph.D. degrees, proficiency is required in French, German or Russian; other languages may be used only by special permission. For foreign students whose native language is not English, there is no language requirement for the Master's degree, but proficiency in French, German or Russian is required for the Ph.D. degree.

**EXAMINATION REQUIREMENTS:** Examinations for graduate candidates are described on p. 12 of this *Announcement*.

## Research and Study Opportunities

The Field of Zoology offers excellent opportunities for graduate study and research in all phases of zoology, but particularly in the descriptive and experimental aspects of the following special subjects: comparative and vertebrate anatomy with emphasis on the functional approach, developmental biology, endocrinology, general ecology, histology and descriptive embryology, invertebrate zoology, parasitology, and systematics and biology of fish.

Members of the staff are especially qualified to direct research in subjects listed, but research need not be limited to these subjects. The research interests of the members of the staff are broad; in general they may be summarized as follows:

- J. M. Anderson: general and comparative anatomy of invertebrates, with emphasis on the functional histology and histochemistry of organ systems.
- A. W. Blackler: origin of sex cells and nucleo-cytoplasmic interaction in development.
- L. C. Cole: general ecology with special emphasis on population phenomena and the mathematical theory of populations.

- H. E. Evans: comparative vertebrate morphology and the prenatal development of the dog.
- P. W. Gilbert: vertebrate functional anatomy, i.e., correlation of habits and activities of vertebrates with their morphology, biology of elasmobranch fishes with emphasis on reproductive patterns and sense organs.
- S. L. Leonard: general endocrinology with special emphasis on the anatomical, physiological, and biochemical aspects of the mechanisms of hormone action, reproduction, growth and metabolism.
- E. C. Raney: systematics, life history, and behavior of Eastern North American freshwater and shore fishes.
- B. V. Travis: biology and control of arthropods affecting man, taxonomy of parasitic protozoa.
- W. A. Wimsatt: histology, histophysiological, and histochemical approach of problems of reproduction, comparative placentation, and hibernation.

For summer research grants and assistantships in zoology at the Museum of Northern Arizona, consult the Field Representative.

## Courses

Only courses primarily of graduate interest are listed.

Students in the Field of Zoology are advised that the listing of courses below does not necessarily signify that all the courses will be offered in 1969-70.

### ENTOMOLOGY 351. INTRODUCTORY PARASITOLOGY

### BIOLOGICAL SCIENCES 412. SPECIAL HISTOLOGY: THE BIOLOGY OF THE ORGANS

Spring term. Credit four hours. Limited to eighteen students. Prerequisite: Biological Sciences 313 (Histology). Mr. Wimsatt.

The microscopic and ultrastructural organization of the principal vertebrate organ systems is studied in relation to their development, functional interaction, and special physiological roles. The organization of the course involves student participation in lecture-seminars and the prosecution of independent project work supplementary to the regular work of the laboratory. The latter enables students to gain practical experience with histological and histochemical preparative techniques.

### ECOLOGY 469. BIOLOGY OF FISHES

### 513. EXPERIMENTAL ENDOCRINOLOGY

Fall term. Credit two or three hours. Prerequisites: organic chemistry and physiology and consent of the instructor. Mr. Leonard.

Lectures on the anatomy and physiology and the vertebrate endocrine glands, glandular interrelationships, mechanisms of hormone action, chemical and physiological properties of the hormones, assay methods. Laboratory includes small animal surgery, microtechnique for the endocrines, and illustrative experiments on the effect of hormones.

### ENTOMOLOGY 551. ADVANCED PARASITOLOGY (PROTOZOA AND HELMINTHS)

160 ZOOLOGY

ENTOMOLOGY 552. ADVANCED PARASITOLOGY (MEDICAL ENTOMOLOGY)

ECOLOGY 561-562. QUANTITATIVE ECOLOGY

584. EXPERIMENTAL EMBRYOLOGY

Spring term. Credit four hours. Prerequisites: Biological Sciences 385 (Animal Embryology) and consent of the instructor, Mr. Blackler.

An advanced course in animal development in which stress is laid on practical manipulations carried out by the students.

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