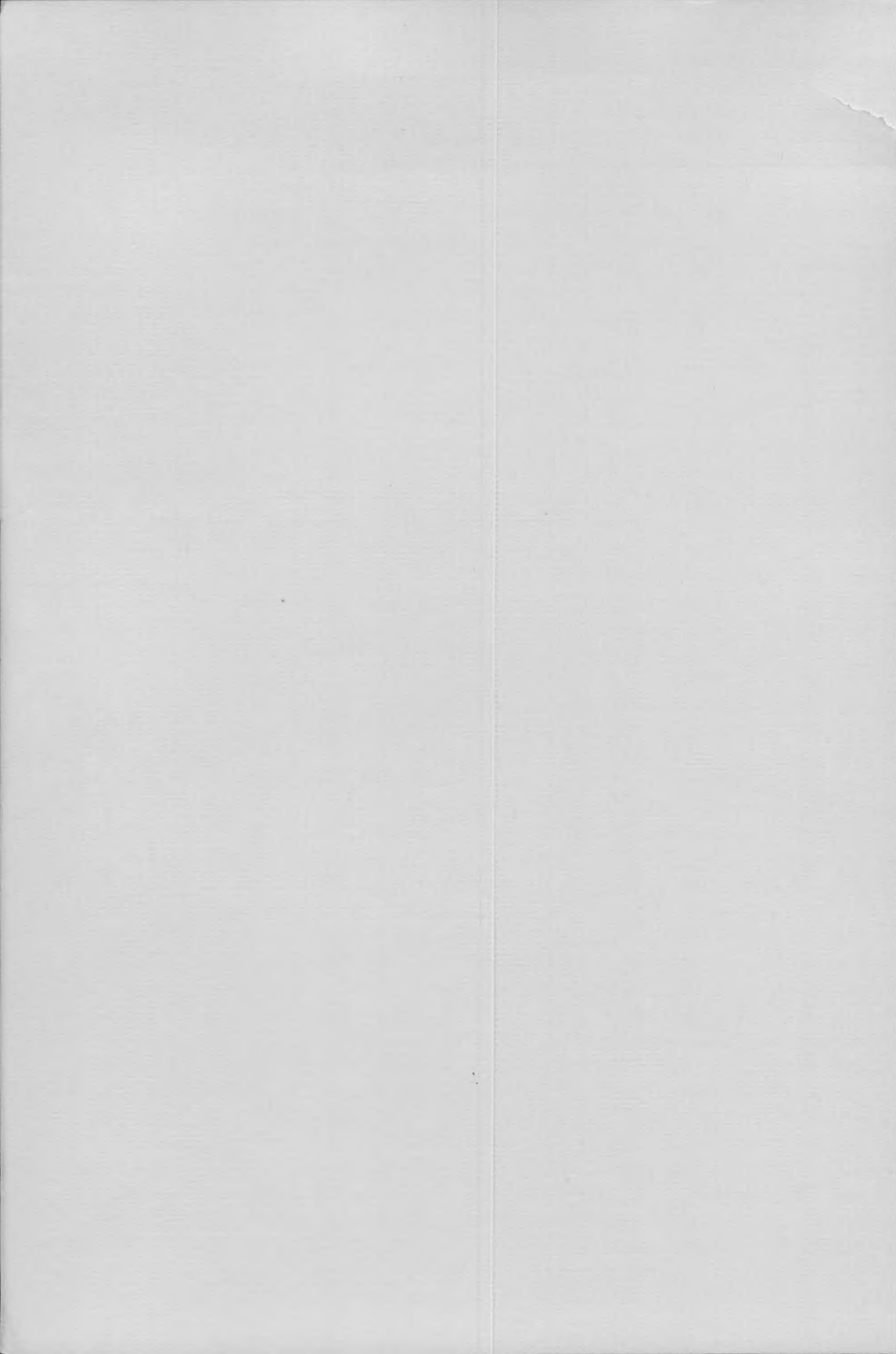


Cornell University
Announcements
Graduate School of
Medical Sciences
1972-73



Cornell University

Graduate School of Medical Sciences

1300 York Avenue

New York, New York 10021

Telephone 212/472-5670

1972-73

Cornell University Announcements

Volume 64 of the Cornell University Announcements consists of twenty-one catalogs, of which this is number 19, dated November 6, 1972. Publication dates: twenty-one times a year (Three times in September; three times in March and June; twice in January, July, October, and November; once in April, May, August, and December). Publisher: Cornell University, Sheldon Court, 420 College Avenue, Ithaca, New York 14850. Second-class postage paid at Ithaca, New York.

List of Announcements

Following is a list of *Announcements* published by Cornell University to provide information on programs, faculty, facilities, curricula, and courses of the various academic units.

New York State College of Agriculture and Life Sciences
College of Architecture, Art, and Planning
College of Arts and Sciences
Department of Asian Studies
Graduate School of Business and Public Administration
Field of Education (Graduate)
College of Engineering
Engineering at Cornell
Graduate Study in Engineering and Applied Sciences
General Information*
Graduate School
Graduate School: Course Descriptions
School of Hotel Administration
New York State College of Human Ecology
New York State School of Industrial and Labor Relations
Law School
Medical College (New York City)
Graduate School of Medical Sciences (New York City)
Cornell University-New York Hospital School of Nursing (New York City)
Graduate School of Nutrition
Officer Education (ROTC)
Summer Session
Veterinary College

*The *Announcement of General Information* is designed to give prospective students pertinent information about all aspects and academic units of the University.

Requests for the publications listed above should be addressed to

CORNELL UNIVERSITY ANNOUNCEMENTS
Edmund Ezra Day Hall
Ithaca, New York 14850.

(The writer should include his zip code.)

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

Calendar*

1972-73

Fall Semester

Registration

Wednesday, September 6-Friday

September 8

Opening Exercises, 3:00 p.m.

Friday, September 8

Instruction begins for first trimester and fall semester

Monday, September 11

End of first trimester

Wednesday, November 22

Thanksgiving recess

Thursday, November 23-Friday, November 24

Examinations for first trimester

Monday, November 27-Saturday, December 2

Instruction begins for second trimester

Monday, December 4

Christmas recess:

Instruction suspended, 5:00 p.m.

Friday, December 15

Instruction resumed, 9:00 a.m.

Tuesday, January 2

Last day for completing all requirements for

January degrees

Friday, January 5

Fall semester ends

Friday, January 26

Spring Semester

Registration

Monday, January 29

Instruction begins for spring semester

Monday, January 29

End of second trimester

Friday, March 2

Examinations for second trimester

Monday, March 5-Saturday, March 17

Instruction begins for third trimester

Monday, March 19

Spring recess:

Instruction suspended, 5:00 p.m.

Friday, April 13

Instruction resumed, 9:00 a.m.

Monday, April 23

Last day for completing all requirements for

May degrees

Friday, May 4

Memorial Day, holiday

Monday, May 28

Commencement, 3:00 p.m.

Wednesday, May 30

End of third trimester and spring semester

Friday, June 8

Examinations for third trimester

Monday, June 11-Wednesday, June 13

Summer

Summer research period begins

Monday, June 18

Registration for summer research

Monday, June 18

Last day for completing all requirements for

August degrees

Friday, August 24

Labor Day, holiday

Monday, September 3

Summer research period ends

Friday, September 7

* Courses in the Graduate School of Medical Sciences are either semestral or trimestral. The calendar for this School is based primarily on the academic semester but is coordinated as well with the trimestral calendar of the Medical College. The dates shown in the Calendar are subject to change at any time by official action of Cornell University.

In enacting this calendar, the Graduate School of Medical Sciences has scheduled classes on religious holidays. It is the intent of Senate legislation that students missing classes due to the observance of religious holidays be given ample opportunity to make up work.

Cornell University

Graduate School of Medical Sciences

Purpose and Nature of Graduate Study

The Graduate School of Medical Sciences, a semiautonomous component of the Graduate School of Cornell University, provides an environment for advanced study and research in specific areas of the basic biomedical sciences. Graduate programs leading to the degree of Doctor of Philosophy are currently offered in the Fields of Biochemistry, Biological Structure and Cell Biology, Biology, Biomathematics, Biophysics, Genetics, Microbiology, Neurobiology and Behavior, Pathology, Pharmacology, and Physiology. Certain of these Fields also offer programs leading to the degree of Master of Science. The Faculty recommends the award of advanced general degrees not only as the result of the fulfillment of certain formal academic requirements but also as evidence of the development and possession of a critical and creative ability in science. Proof of this ability is embodied in a dissertation which the candidate presents to the Faculty as an original research contribution in his area of study.

Freedom and independence are key qualities of scholarship, and graduate education at Cornell attempts to preserve them for teacher and student. Each graduate student is supervised by his own Special Committee, a small group of faculty members selected by the student. Within the broad framework of requirements for residence, examinations and thesis, and additional regulations of individual Fields, the Cornell graduate student and his Special Committee are completely free to plan a program of study. The Graduate School of Medical Sciences sets no overall course, credit-hour, or grade requirements. The Special Committee has extraordinary independence in guiding the student's program, and the student will be recommended for his degree whenever his Committee judges him qualified.

History

The opportunity for graduate study leading to advanced general degrees in the biomedical sciences was first offered at the Cornell University

Medical College in 1912 in cooperation with the Graduate School of Cornell University. In June of 1950, Cornell University, in association with the Sloan-Kettering Institute for Cancer Research, established a new division of the Medical College, the Sloan-Kettering Division, for the purpose of providing additional opportunities for graduate study in the biomedical sciences. The resultant expansion of the Graduate Faculty and facilities on the New York City campus prompted the organization in January 1952 of the Graduate School of Medical Sciences which, with the annual approval of the Graduate Faculty of Cornell University, has full responsibility for advanced general degrees granted for study in residence at the New York City campus.

Facilities

The Medical College Division. The buildings of the Medical College extend along York Avenue from 68th to 70th Streets. They contain the main library, lecture rooms, and study laboratories for the basic science departments, and extensive research facilities for faculty and students.

The Sloan-Kettering Division. The facilities of the Sloan-Kettering Institute for Cancer Research consist of the Howard Laboratory and the Kettering Laboratory on East 68th Street in New York City and the Walker Laboratory in Rye, New York. These provide lecture and seminar rooms and well-equipped laboratories for biomedical research.

Organization of the Graduate School

Faculty

The Graduate School of Medical Sciences is composed of two relatively separate divisions, the Medical College Division, consisting principally of the professorial staff of the basic science departments of the Cornell University Medical College, and the Sloan-Kettering Division, consisting of the professorial staff of the Sloan-Kettering Institute for Cancer Research. Within each of these divisions are

6 Degree Requirements

Fields or Units of graduate instruction formed by faculty members with similar research and teaching interests. An individual faculty member may elect to affiliate with the one or two Fields or Units in which he agrees to sponsor graduate students.

General Committee

The General Committee of the Graduate School of Medical Sciences is an administrative board whose membership has responsibility for the academic affairs of the School. The Committee considers matters referred to it by members of the faculty and offers recommendations to the faculty on questions involving the interests or policies of the Graduate School of Medical Sciences.

The General Committee is composed of the dean and the associate dean of the Graduate School of Medical Sciences, the associate director of the Sloan-Kettering Division, one elected representative from each of the Fields of the Medical College Division and from each of the Units of the Sloan Kettering Division, and two student representatives elected by the graduate student body. The General Committee approves new Fields, reviews the admission of students, approves major and minor subjects, reviews the curriculum of each Field, reviews the requirements for degrees, and acts on faculty and student petitions.

The chairman of the General Committee is the dean, who is the academic administrative officer of the Graduate School of Medical Sciences and is also an associate dean of the Graduate School of Cornell University. The secretary of the General Committee is the associate dean, who is also an assistant dean of the Graduate School of Cornell University.

Admission

Applications

For admission to the Graduate School of Medical Sciences an applicant must (1) have a baccalaureate degree or the equivalent from a college or university of recognized standing, (2) have adequate preparation in his chosen field of study, and (3) show promise of ability to pursue advanced study and research, as judged by his previous record.

Candidates may be admitted in September, February, or July. All credentials must be received at least two months prior to enrollment, and the complete application with all supporting credentials must have been approved by the dean at least one month prior to enrollment.

Inquiries about graduate study should be addressed to the Associate Dean of the Graduate School of Medical Sciences, 1300 York Avenue, New York, New York 10021 or to the Associate Director of the Sloan-Kettering Division, 444 East 68th Street, New York, New York 10021. These inquiries are referred to the appropriate Field Representative(s) or Unit Chairman who then corresponds directly with the prospective applicant and sends pertinent

application material. This must be completed and returned to the Field Representative together with (1) official transcripts of records from all colleges and universities attended, (2) a statement of purpose of graduate study, and (3) two letters of recommendation from individuals in academic positions who know the applicant professionally. In addition, scores from the Graduate Record Examinations may be required by individual Fields to aid in their evaluation.

The completed application and all supporting documents are reviewed by the Field or Division Credentials Committee. Applicants considered potentially acceptable are usually called for a personal interview. At the time of interview, after discussing his interests with the members of the Field, the applicant may tentatively select a major sponsor. If accepted by the Field, his application is forwarded to the dean who may refer it to the General Committee for final review and decision. A student is formally notified of his acceptance for study in the Graduate School of Medical Sciences by a letter from the associate dean.

It is the policy of Cornell University actively to support the American ideal of equality of opportunity for all, and no student shall be denied admission or be otherwise discriminated against because of race, color, creed, religion, or national origin.

Categories of Admission

An applicant is accepted by the Graduate School of Medical Sciences (1) as a degree candidate for the M.S. or Ph.D., or (2) as a provisional candidate.

Provisional candidacy provides opportunity for a prospective degree candidate, whose educational preparation is difficult to evaluate, to begin graduate studies. On the basis of the record of accomplishment in the first half of the academic year, the adviser or temporary Special Committee of a provisional candidate may recommend to the dean that (1) provisional candidacy be changed to degree candidacy, (2) provisional candidacy be continued for the remainder of the academic year, or (3) provisional candidacy be terminated. A maximum of one academic year in the status of provisional candidacy is permitted and credit of a maximum of one residence unit may be allowed on petition, provided there is convincing evidence that performance has been of the same quality as would have been required of a degree candidate.

Degree Requirements

Major and Minor Subjects

The faculty members of each Field specify major and minor subjects of study for fulfillment of the requirements for the degrees of Master of Science and Doctor of Philosophy. A candidate for the degree of Master of Science is required to register for one major and one minor subject. A candidate for the degree of Doctor of Philosophy is required to register for three subjects, one major and two

minors. At least one of the minors must be outside the area of his major subject.

The Special Committee

The general degree requirements of the Graduate School of Medical Sciences are minimal in order to give maximal flexibility in choosing a desirable program of study. The student's program is determined with the aid and direction of a Special Committee of faculty members chosen by the student from those Fields which best fit his areas of interest. Satisfactory progress toward a degree is judged by the Committee rather than by arbitrary standards imposed by the Graduate School of Medical Sciences. There are no regulations of the Faculty of the Graduate School of Medical Sciences governing the specific content of instruction, courses, or grades to which the Special Committee must subscribe, except those imposed by the Fields. The Committee is the agent primarily responsible for the candidate's development as an independent scholar and scientist.

No later than four weeks after enrollment, a candidate must file a statement of the major and minor subjects he has selected for study, after which he must choose one member of the faculty to represent each subject and to serve on his Special Committee. The faculty member representing the major subject usually advises the student in his other selections and serves as chairman of his Committee. At least one member of the Committee must represent a Field different from the candidate's major Field. Members may agree to serve temporarily during the candidate's first year of residence until he has had the opportunity to become acquainted with areas of research in the Fields of his choice. On completion of this year of residence, a permanent Special Committee will be formed, the membership of which can be changed with agreement of all members of the old and newly formed Committees and the approval of the dean. The members of the Special Committee decide upon the student's program of study and research and judge whether his progress toward a degree is satisfactory. After consulting with the other members, the chairman of the Special Committee prepares term reports on the candidate for submission to the dean. The members of the Committee serve on all of the candidate's examining committees and they approve his thesis.

Registration and Course Grades

At the beginning of each term, the student is required to register with the dean of the Graduate School of Medical Sciences and to file a Registration of Courses form indicating all courses he will take. A fee of ten dollars is charged for late registration. No student may double-register for an advanced general or professional degree with any other school or college except the Cornell University Medical College.

All courses for which the student registers for credit will be entered in his official record. Grades of graduate students are reported as: Excellent (E),

Satisfactory (S), Unsatisfactory (U), Incomplete (I), Absent (Abs), or Unofficially Withdrawn (W). A grade of Incomplete or Absent cannot be changed later than one term following that in which the course was taken.

Residence

The Faculty of the Graduate School of Medical Sciences regards study in residence as essential. Each candidate for an advanced general degree is expected to complete his residence requirements with reasonable continuity. He must register each term from the time of his first registration in the Graduate School of Medical Sciences until he either withdraws or completes his degree unless he is granted a leave of absence. Full-time study for one half academic year with satisfactory accomplishment constitutes one residence unit. Two units of residence are the minimal requirement for the Master's degree and six units are the minimum for the Ph.D. degree. However, the time necessary to obtain the degree generally exceeds the minimal requirements. A candidate for the Ph.D. degree must spend two of the last four units of required residence in successive terms on the New York City or the Ithaca campus of Cornell University. No more than seven years may intervene between the time of first registration and the completion of all requirements for the doctoral degree. A student must complete all requirements for the Master's degree in four years.

The graduate student who participates in teaching or assists in research qualifies for full residence credit only if his duties are in the field of his major subject and do not require more than twenty hours per week. Part-time graduate study, if it is necessitated by off-campus employment non-contributory to the major field of study, is not encouraged. Requests for part-time study must be reviewed by the General Committee. If permission is granted for part-time study, the student must be in residence at least half-time.

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

Employment	Residence Units Allowable Per Half Academic Year		
	Contributory in the major field of study and on campus	Non-contributory but on campus	Off campus
Total clock hours per week			
0-10 hrs.	1 unit	1 unit	$\frac{3}{4}$ unit
11-20 hrs.	1 unit	$\frac{3}{4}$ unit	$\frac{3}{4}$ unit
21-30 hrs.	$\frac{3}{4}$ unit (teaching)	$\frac{1}{2}$ unit	_____
	$\frac{3}{4}$ -1 unit (research)*		

* Time spent assisting in research, if it is contributory to the major field of study, shall be credited toward allowance of a full residence unit.

8 Examinations

Transfer of Residence Credit

No residence credit will be granted for study outside the Graduate School of Medical Sciences to fulfill the requirements of the M.S. degree. No commitment can be made about granting residence credit toward the Ph.D. requirements for previous study in another graduate school until after the candidate has entered into residence at the Graduate School of Medical Sciences. At that time, the student's Special Committee may recommend acceptance of study outside the Graduate School of Medical Sciences to the General Committee which will determine the number of residence units to be awarded. In general, a maximum of two units may be transferred, but the dean may approve acceptance of a maximum of three units and, on petition, the General Committee may approve a maximum of four units. No credit can be transferred for study undertaken as an undergraduate or as a special student even in courses designed for graduate students.

A student, who has satisfactorily completed two or more academic years of study toward the degree of M.D. at the Cornell University Medical College or another accredited medical school in the United States with a curriculum equivalent to that of the Cornell University Medical College, may transfer a maximum of two units of residence credit after passing an evaluation examination administered by a committee appointed by the General Committee of the Graduate School of Medical Sciences.

Study in Absentia

A candidate for the degree of Ph.D. may petition for permission to earn residence units for study away from Cornell University while regularly registered in the Graduate School of Medical Sciences. A candidate to whom this privilege has been granted may work temporarily under the immediate supervision of an individual designated by his Special Committee, but his program will continue to be directed by the Committee. For study in absentia, not more than two residence units may be earned toward fulfillment of the minimal residence requirements for the degree of Ph.D.

Leave of Absence

A candidate who finds it necessary to interrupt the continuity of his residence must petition the Dean for an official leave of absence. His written petition must specify the term of absence, state the reason for the requested leave of absence, and be approved by his Special Committee.

A candidate who will *not* be in residence but will return to the Graduate School of Medical Sciences to present and defend his thesis at the final examination, having completed all requirements for his degree except for the final examination, must petition for a leave of absence.

Tuition and fees are not charged to degree candidates while they are on leave of absence; however, candidates on leave of absence are not

eligible to utilize university facilities or to receive student health benefits or student hospitalization insurance.

Examinations

Three examinations are required by the Faculty of the Graduate School of Medical Sciences: (1) final examination for the M.S. degree; (2) examination for admission to doctoral candidacy; and (3) final examination for the Ph.D. degree. Examinations are administered by an Examining Committee consisting of a chairman appointed by the dean, the members of the candidate's Special Committee, and, in Fields that so specify, other members of the Faculty of the Graduate School of Medical Sciences and outside examiners designated by the Field. In addition to these examinations, the candidate's major Field may require a qualifying examination as part of its evaluation of the candidate after he has completed two units of residence credit.

For the M.S. degree the final examination may be oral or both oral and written.

For the Ph.D. degree the admission to candidacy examination is both oral and written and certifies that the student is eligible to present a thesis to the Faculty of the Graduate School of Medical Sciences. The examination may not be taken until two units of residence credit have been accumulated; a minimum of two units of residence credit is required after passing this examination before the final examination can be scheduled. The final examination for the Ph.D. degree is an oral defense of the candidate's thesis. It must be passed within four years after completion of the required residence units, or within seven years from the date of first registration, whichever is sooner.

Foreign Language Requirements

Each Field of study has its own foreign language requirements. The student's Special Committee may require knowledge of foreign languages beyond the requirements of the Fields listed in this *Announcement*.

Examinations in foreign languages will be administered by the Office of the Dean at the beginning of each term. As an alternative to this examination, the candidate may demonstrate proficiency by passing the reading part of the language qualification tests administered by the College Entrance Examination Board.

Theses

A principal requirement for both the M.S. and the Ph.D. degrees is the presentation of a thesis constituting an imaginative contribution to knowledge. Ordinarily, the thesis is written on a research topic in the candidate's major field of study, under the direction of the chairman of his Special Committee. The faculty requires that the Ph.D. thesis be published in abstract and be recorded on microfilm.

Tuition and Fees

Tuition for a student regularly matriculated in the Graduate School of Medical Sciences is \$2500 for the academic year and is payable in either two or three equal parts, the first of which is due at initial registration. Tuition includes fees for matriculation, hospitalization insurance, graduation, and miscellaneous thesis expenses.

A graduate student who has previously fulfilled all other degree requirements, who has been granted a leave of absence, and who returns to the Graduate School of Medical Sciences to present his thesis and to take the final examination must register as a Candidate for Degree Only and pay a fee of \$35.

Part of the tuition fee will be refunded to a student who officially withdraws or takes a leave of absence during the first nine weeks of a term.

A student who is to receive partial residence credit because of his employment should apply for proration of tuition on forms obtainable at the Office of the Dean.

The amount, time, and manner of payment of tuition, fees, or other charges may be changed at any time without notice.

Financial Assistance

Financial assistance is usually available to qualified applicants. Individual Fields or Units may offer predoctoral research fellowships, research assistantships, or teaching assistantships. These positions may provide a stipend in addition to tuition. Information about these positions may be obtained directly from the Field or Unit at the time of application.

Nationwide, competitive predoctoral fellowships are also available from the National Science Foundation, the National Research Council, and the

U. S. Public Health Service. Information about these fellowships should be requested directly from the appropriate governmental agency.

New York State residents are eligible for several predoctoral fellowships and for Scholar Incentive Awards which assist in tuition payment. Application forms may be obtained from the Regents Examination and Scholarship Center, State Education Department, Albany, New York 12224.

Opportunity for part-time employment is often available in departmental research projects or other activities. Applications should be made directly to individual departments.

Student Health Service

Complete ambulatory medical care is provided for all students enrolled in the Graduate School of Medical Sciences through the Personnel Health Service of the Medical Center. The student matriculating for the first time is required to have a physical examination by a member of the Health Service staff. In addition, the student must report for a chest x-ray examination, tuberculin test, and necessary immunizations. No charge is made for medical care through the Health Service or for any X rays, laboratory tests, or procedures which may be needed.

The student is required to carry Associated Hospital Service (Blue Cross) hospitalization insurance unless similar hospitalization insurance is currently in effect. The cost of this insurance for an unmarried student is included in the tuition fee. Wives and dependents of students may be covered by the hospitalization insurance policy for a small additional fee. Wives and families of students are not eligible for care through the Personnel Health Service but will be referred to appropriate members of the hospital staff for medical care.

Fields of Instruction

Instruction at the Medical College Division

Biochemistry

Faculty

Roy W. Bonsnes, Esther Breslow, George W. Dietz, Jr., Gordon F. Fairclough, Helena Gilder, Jack Goldstein, Rudy H. Haschemeyer, S. Steven Hotta, Alton Meister, Aaron S. Posner, Julian R. Rachele, Charlotte Ressler, Robert R. Riggio, Albert L. Rubin, W. Bruce Rowe, Brij Saxena, Edward T. Schubert, Kurt H. Stenzel, Suresh S. Tate, Daniel Wellner, Kenneth Woods

Field Representative

Rudy H. Haschemeyer, Department of Biochemistry, Room E-113, Medical College

Graduate instruction is offered leading to the Ph.D. or M.S. degree. Within the framework of degree requirements and in consultation with the student, the course of study is planned to fit the needs of the individual. Although formal course work is required, emphasis is placed on research. Research opportunities exist in various areas of biochemistry including enzymology, structure and function of proteins and nucleic acids, molecular biology, physical biochemistry, and the intermediary metabolism of amino acids, carbohydrates, nucleic acids, and lipids. Entering graduate students usually work for short periods in several of the laboratories of the faculty members of the Field before beginning thesis research. Students are encouraged to choose challenging and fundamental research problems that are on the frontiers of biochemistry.

The laboratories of the faculty members are equipped with virtually all of the instruments and facilities required for modern biochemical research; thus, graduate students are instructed in such methodology as chromatography, counter-current distribution, radioactive and stable isotope techniques, spectrophotometry, electrophoresis, and analytical ultracentrifugation.

Students undertaking graduate study in biochemistry must have a sufficiently comprehensive background in chemistry to pursue the proposed course of study and must present evidence of knowledge of biology, general experimental physics, and mathematics (including differential and integral calculus). Opportunity is offered to remedy deficiencies in these areas during the first year of graduate study. The Graduate Record Examinations (the

Aptitude Test and the Advanced Test in Chemistry) are ordinarily required.

The language requirement for the Ph.D. degree is proficiency in two modern foreign languages which are acceptable to the student's Special Committee. For the M.S. degree, proficiency in one foreign language suffices.

Proficiency in a computer science language, as demonstrated by executing a meaningful program, may substitute for proficiency in one of the required foreign languages.

Special Interests of the Faculty

- R. Bonsnes: Intermediary metabolism; static and dynamic composition of body fluids.
- E. Breslow: protein-protein and metal ion-protein interactions; chemistry of the neurophysins.
- G. Dietz, Jr.: nucleic acid biochemistry; biochemical mechanisms of transport.
- G. Fairclough: protein chemistry; clinical biochemistry.
- H. Gilder: metabolic response to surgery; electrolyte studies of gastric juice; studies in experimental shock.
- J. Goldstein: role of RNA in protein synthesis; fractionation of nucleic acids; role of macromolecules and protein synthesis in the maturation of red blood cells.
- R. Haschemeyer: structure of fibrinogen and subunit interactions in protein and nucleoproteins; electron microscopy of enzymes and viruses.
- S. Hotta: intermediary metabolism of brain; fundamental aspects of maintenance of cellular sulfhydryl groups.
- A. Meister: enzymology; proteins and amino acids.
- A. Posner: crystal chemistry; ultrastructural biochemistry; atomic structure of bone; hard tissue chemistry.
- J. Rachele: metabolism of amino acids, one-carbon units, and methyl groups; isotope effects.
- C. Ressler: relationship of amino acid metabolism in certain plants and microorganisms to human nutrition and disease; special aspects of the chemistry of amino acids and peptides.
- A. Rubin: collagen structure and function; biomaterials research; dialysis; transplantation research.
- W. Rowe: urea formation; action of methionine sulfoximine.
- B. Saxena: chemistry, measurement, and mechanism of action of pituitary protein hormones.
- E. T. Schubert: enzyme studies of the developing kidney; investigation of renal dysfunction at enzyme level.
- K. Stenzel: transplantation; dialysis and biomaterials research.
- S. Tate: structure-activity relationships in enzymes; vitamin B₆ enzymes.
- K. Woods: physicochemical understanding of human blood fractions; blood coagulation; structure of antibodies.

Courses

1. General Biochemistry (Biochemistry 2A and 2B). This introductory course is designed to provide the student with a knowledge of the fundamentals of biochemistry and an appreciation of the molecular basis of biological phenomena. Graduate students in Biochemistry are required to pass this course (or its equivalent) prior to pursuing advanced courses. First trimester: M T Th F 2–3. Second trimester: T Th F 2–3. The staff.

2. Introduction to Research. Experimental biochemistry dealing with the isolation, synthesis, and analysis of substances of biochemical importance (enzymes, coenzymes, various metabolites and intermediates), and study of their properties by various chemical and physical techniques. The student obtains this varied research experience by spending approximately two months in the laboratory of each of four faculty members of his choice. For incoming graduate students majoring in Biochemistry. The staff.

3. Selected Topics in Biochemistry. Advanced study in selected topics will be offered in areas such as (1) nucleic acids and protein synthesis; (2) intermediary metabolism; (3) kinetics and enzyme mechanism; (4) protein chemistry; and (5) structure of membranes and the biochemistry of transport. Generally, one or two of these courses will be offered yearly in the third trimester. The staff.

4. Advanced Biochemistry. Offered jointly by the Faculties of the Medical College and Sloan-Kettering Divisions. Details are given on p. 21 under Interdivisional Courses.

Biological Structure and Cell Biology

Faculty

Carl G. Becker, Dorothea Bennett, Dana C. Brooks, Peter G. Bullough, John T. Ellis, James L. German III, Michael D. Gershon, Fakhry G. Girgis, Jack Goldstein, Roger L. Greif, Wilbur D. Hagamen, Martin D. Hamburg, Myron S. Jacobs, Thomas H. Meikle, Jr., C. Richard Minick, Ralph Nachman, Leonard L. Ross, Charles A. Santos-Buch, Edward T. Schubert, John F. Seybolt, Julio L. Sirlin, David Soifer, Kurt H. Stenzel, Dieter H. Sussdorf, Roy C. Swan, John C. Weber

Field Representative

Michael D. Gershon, Department of Anatomy, Room A-016, Medical College

Graduate study in the Field of Biological Structure and Cell Biology leads to a Ph.D. degree and emphasizes the basic relationships between structure and function of biological systems at all levels of organization. Thus the Field is fundamentally concerned with the nature, development and functional modulation, and significance of configuration, pattern, and other spatial relations in biological systems. The scope of interest extends from the molecular level to that of the whole organism and embraces normal as well as pathological structure.

Opportunities for research training include the investigation of cellular fine structure, using such techniques as light and electron microscopy, isolation and analysis of cellular sub-fractions by differential ultracentrifugation, histochemistry, cytochemistry, and enzyme neuroanatomy, including the physiological correlates of changing neural structure.

For graduate study in the Field of Biological Structure and Cell Biology, adequate undergraduate preparation in biology, chemistry (including organic chemistry), physics, and mathematics is recommended. Requirements for admission are flexible in proportion to the promise and

accomplishments of the applicant. Applicants are generally requested to present the results of the Graduate Record Examinations.

Requirements for minor sponsorship in the Field of Biological Structure and Cell Biology will be arranged with individual students, but research experience in the minor sponsor's laboratory is strongly encouraged.

In addition to the courses offered by the Field and listed below, appropriate courses for graduate students in the Field are General Biochemistry and those courses given by the Field of Neurobiology and Behavior.

A reading knowledge of French, German, Spanish, or Russian is desirable; proficiency in a foreign language may be required for a candidate by his Special Committee.

The Field requires a qualifying examination at the end of the first year of residence. At the discretion of the examining committee, the qualifying examination may be written or oral, or both written and oral. The admission to candidacy examination required by the Graduate School of Medical Sciences must be taken before six units of residence credit have been accumulated and before substantial progress has been made on the candidate's thesis research. The written part of the admission to candidacy examination shall consist of a detailed thesis proposal in accordance with guidelines obtainable from the Field Representative.

Special Interests of the Faculty

- D. Bennett: mammalian genetics, with special reference to genetic regulation during early embryonic development.
- D. C. Brooks: spontaneous electrical activity of the central nervous system; brain stem influences upon the visual system during sleep and wakefulness in the cat.
- P. G. Bullough: combined clinical, biochemical, and histological study of osteogenesis imperfecta; and histological study of the pathogenesis of chondromalacia and cartilage breakdown.
- J. T. Ellis: experimental pathology.
- J. L. German: clinical and laboratory investigation in the field of human and medical genetics, particularly emphasizing cytogenetics.
- M. D. Gershon: the role of monoamines and the action of psychotomimetic drugs in the mammalian nervous system.
- F. G. Girgis: the cranial and facial sutures; their development, structure and the analysis of sutural position. Special attention is given to factors inducing chondrogenesis in the cranial vault.
- W. D. Hagamen: self-stimulation, habituation, and changes in affective behavior in cats; artificial intelligence in computers.
- M. S. Jacobs: anatomy of the cetacean central nervous system.
- T. H. Meikle, Jr.: animal studies of neural mechanisms basic to learned behaviors, particularly visual learning.
- R. L. Nachman: biology of platelets.
- T. C. Rodman: analytical cytology of cell nuclei; cytogenetics.
- L. L. Ross: morphological and biochemical studies of central nervous system synapses.
- J. Sirlin: biology of RNA.
- D. Soifer: structure and function of microtubules.
- R. C. Swan: fine structure of excitable cells.
- J. C. Weber: vitamin D and mineral metabolism in hard tissue.

Courses

1. Microscopic Anatomy. The course in microscopic anatomy and development offered by the Department of Anatomy in the Medical College to the first-year medical

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class is open to graduate students. Selected concepts of fine structure, the mechanisms by which structure develops, differentiates, and ages, and genetic control of these mechanisms are presented in the lectures to indicate a pattern of study and depth of analysis which the student can be expected to apply to his informal study of cells and tissues. First trimester and second trimester. The staff.

2. Laboratory in Microscopic Anatomy. The laboratory consists of a series of discussions and exercises designed to acquaint the student with the fundamental principles of microscopic anatomy. The students are issued slides to view through their own microscopes. Kodachrome transparencies are shown to supplement the slide collection. The lectures in microscopic anatomy and development are corequisites or prerequisites. First trimester and second trimester. Professor Gershon.

3. Gross Anatomy. Regional anatomy is studied principally through dissection of the human body. Supplementing this are prosections by instructors, tutorial group discussions and radiographic and endoscopic demonstrations. First trimester and second trimester. The staff.

4. Seminar. Seminars are scheduled on selected topics in biological structure including fine structure, development, cell biology, neuroanatomy, and genetics. Senior members of the staff and guest speakers conduct informal discussions on current research in their respective fields. Hours to be arranged. The staff.

Biomathematics

Faculty

Betty J. Flehinger, Richard P. Kelisky,
Joel L. Lebowitz, Sol I. Rubinow

Field Representative

Sol I. Rubinow, Division of Biomathematics,
Room 219, Kips Bay Building, Medical College

The Field of Biomathematics offers a wide range of opportunities for the development of quantitative methods in the biological and medical sciences, with special emphasis on the application of mathematics. Graduate study programs leading to advanced degrees in the Field of Biomathematics are available to students whose primary interests are mathematical, but who wish to concentrate on biological or medical applications.

Graduate students are admitted to study in this Field from a variety of educational backgrounds, including the several branches of engineering and the physical and biological sciences as well as mathematics. Their programs of study include a thorough grounding in mathematical methods and a particular biological area of interest.

The thesis in Biomathematics must be a mathematical contribution toward the solution of a problem arising in a biomedical area.

Graduate students in the Field of Biomathematics are required to obtain thorough training in linear algebra, complex variables, partial differential equations, and boundary value problems. In addition to other courses, an appropriate plan of study in the relevant aspects of biology, chemistry, physics, and medicine will be made to suit the particular area of application of the individual student. A programming language such as Fortran is required in lieu of a foreign language.

Special Interests of the Faculty

B. J. Flehinger: biostatistics, medical diagnosis with computers, clinical trials.

R. P. Kelisky: computers in medicine.

J. L. Lebowitz: cell proliferation, enzyme kinetics.

S. I. Rubinow: blood flow, cell proliferation, enzyme kinetics, physiological systems.

Courses

1. Introductory Biomathematics I, II, and III. An introduction to the use of elementary mathematics in various areas of medicine and biology. The course is divided into three parts, offered separately in each trimester. Topics treated mathematically include the simplest rate processes in biology, cell growth, theory of enzyme kinetics, compartment equations, and transport processes, especially convection, diffusion, and sedimentation. 2 hours per week; hours to be arranged. Prerequisite: elementary calculus. Unlimited enrollment. Professor Rubinow.

2. Biomathematics Seminar. Presentation of research investigations by the staff and student reports on various topics chosen from the current literature. Required of Biomathematics majors. 1 hour per week; hours to be arranged. The staff.

3. Biostatistics. It is the aim of this course to help graduate students in the life sciences gain some insight into the theory underlying a probabilistic approach to the treatment of observational or experimental data and to acquaint them with the major techniques of statistical analysis. There are no prerequisites. Th 2-4, second trimester. Professor Miké.

Genetics

Faculty

Alexander G. Bearn, Dorothea Bennett, June L. Biedler (SKD), Edward A. Boyse (SKD), Liebe F. Cavaliere (SKD), Hartwig Cleve, Betty S. Danes, James L. German III, Zsolt Harsanyi, Stephen D. Litwin, Lloyd J. Old (SKD), D. Russell Pollard, Toby C. Rodman, Selma Silagi, Julio L. Sirlin

Field Representative

Hartwig Cleve, Division of Human Genetics,
Department of Medicine, Room F-202, Medical College

Academic and research training is available chiefly in the following areas: cytogenetics, developmental genetics, genetics and cell differentiation, human biochemical genetics, human somatic cell genetics, immunogenetics, microbial genetics, and nucleic acid biochemistry. The faculty includes members of the preclinical and clinical departments of the Medical College and faculty members of the Sloan-Kettering Division; a unique opportunity for integrating the study of genetics with other biological and medical interests is thus provided. Within broad limits, each student pursues his own program according to his particular interests.

The usual prerequisites for admission to graduate study for an advanced degree in genetics are: undergraduate work in chemistry or biology, and courses in general genetics, general chemistry, organic chemistry, general biology, general physics, and mathematics through calculus. Applicants are required to present Graduate Record Examinations scores in the Aptitude Tests and in the Advanced Test in Chemistry or Biology.

Courses generally required of genetics majors are those numbered 1 through 3 below, and General Biochemistry and Microscopic Anatomy given by the Fields of Biochemistry and of Biological Structure and Cell Biology, respectively. Other courses appropriate for students in

genetics include those numbered 4 through 6 and Molecular Genetics and Advanced Virology offered by the Biochemistry Unit of the Sloan-Kettering Division and by the Field of Microbiology, respectively.

Students minoring in genetics are required to take four semesters of the genetics seminar. A limited period of work in the laboratory of the minor sponsor is encouraged.

Requirements for foreign language are at the discretion of the student's Special Committee, although the Field recommends a reading knowledge of French or German.

The Field requires an oral qualifying examination at the end of the first year of residence. The Field requires that the admission to candidacy examination be taken at the end of the second year of graduate work, and that the written portion consist of two parts: (1) a research proposal defining the candidate's prospective thesis work and (2) answers written over a period of two weeks to general questions submitted by a committee of the field. The oral examination will include discussion of the specific research proposal and general biological topics.

Special Interests of the Faculty

- A. G. Bearn: biochemical and somatic cell genetics of man.
- D. Bennett: mammalian developmental genetics, immunogenetics.
- J. L. Biedler: cytogenetics.
- E. A. Boyse: mammalian immunogenetics.
- L. Cavalieri: DNA replication in bacteria and bacteriophage.
- H. Cleve: human biochemical genetics, genetic variability of serum proteins, enzymes, and membrane proteins.
- B. S. Danes: somatic cell genetics (with particular emphasis on human genetic metabolic errors).
- J. L. German: mammalian cell genetics and cytogenetics.
- Z. Harsanyi: biochemical genetics of microorganisms.
- S. D. Litwin: genetics of immunoglobulins and serum proteins.
- L. J. Old: tumor immunovirology.
- D. R. Pollard: mammalian developmental genetics and teratology.
- T. C. Rodman: cytogenetics with emphasis on mechanisms of genetic control.
- S. Silagi: gene action and cellular differentiation in culture.
- J. L. Sirlin: molecular biology of brain function.

Courses

- 1. Genetics Seminar.** The seminar will cover the following topics during 1972-73: Fall 1972, Cytological Genetics; Spring 1973, Genetics of Differentiation in Higher Organisms. Unlimited enrollment. Prerequisite: at least one course in formal genetics. First and second semesters. T 3-5. Professors Bennett, Cleve, and German.
- 2. Human Genetics Rounds.** The course consists of a conference at which a patient with a genetic disorder is presented for discussion of both medical and genetic aspects of the condition. Offered every two weeks throughout the year. M 4. Professor Litwin.
- 3. Genetics Journal Club.** An informal meeting of students and staff at which current literature or research is discussed. Held every two weeks throughout the year. F 12. Professor Cleve.
- 4. Medical Genetics Lectures.** This course deals specifically with genetics as it pertains to human population and human disease, covering the topics of human cytogenetics, Mendelian principles in man, and gene action pertaining to gene interaction, regulation of gene activity, inborn errors of metabolism, Hardy-Weinberg equilibrium, and mutation and selection. Second trimester: W 3-4. Professors Bennett, Bearn, Cleve, Danes, German, and Litwin.

5. Clinical Cytogenetics. Practical experience in chromosome analysis in the laboratory. Introduction to tissue culture techniques. Participation in medical genetics rounds (pediatrics). Review in depth of assigned subjects pertaining to clinical problems actually encountered on rounds or in the cytogenetics laboratory. The course will be limited to two students. Third trimester: 1 day a week for 7 weeks; hours to be arranged. Professor German.

6. Advanced Genetics. Designed to give the student a sound background in genetic theory, this course is an in-depth consideration of the gene as a unit of heredity. First trimester: 2 days per week; hours to be arranged. Dr. Pollard.

7. Advanced Microbial Genetics. Dr. Harsanyi. (See Microbiology).

8. Genetic and Biochemical Correlates of Development. A series of lectures and student seminar-workshops, will approach embryology from both a molecular biologist's and a geneticist's viewpoint. The problems of early differentiation will be explored in the light of available biochemical and morphological evidence. Selected examples of gene-environment interactions and drug-induced malformations will be discussed. First trimester: 11 weeks. Unlimited enrollment. Drs. Bachvarova and Pollard.

9. Introduction to Research in Genetics. Students are offered the opportunity during their first year to spend time and perform experiments in each of the laboratories of the faculty members of the Field of Genetics.

10. Medical Genetics Clinic. Students participate in the activities of the Medical Genetics Clinic by assisting in the taking of family histories, construction of pedigrees, and in genetic counselling. The staff of the Division of Human Genetics.

Microbiology

Faculty

Robert W. Dickerman, Leonhard Korngold, Michael J. Lyons, William M. O'Leary, William F. Scherer, Laurence B. Senterfit, Gregory W. Siskind, Dieter H. Sussdorf
In addition, the following members of the Department of Microbiology in the Medical College participate in the graduate program: James L. Beebe, Zsolt Harsanyi.

Field Representative

Dieter H. Sussdorf, Department of Microbiology, Room B-403, Medical College

The Field of Microbiology offers graduate training leading to the Ph.D. degree. Candidates can select an area of research from such microbiological topics as general and medical bacteriology, microbial chemistry and physiology, microbial genetics, immunology, mycology, and virology.

Prospective students should complete at the undergraduate level a minimum of one year (or its equivalent) in general chemistry, organic chemistry, general physics, mathematics (including college algebra), botany or zoology (preferably both), and one semester or its equivalent of analytical or quantitative chemistry. General microbiology or bacteriology and calculus are strongly recommended. Students who have not completed the above requirements may be admitted to graduate study on the condition that deficiencies be removed soon after admission. Applicants are ordinarily required to present Graduate Record Examinations scores for the Aptitude Tests and Advanced Test in Chemistry or Biology.

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Individual programs are determined by the student's Special Committee, composed of faculty members representing his major and minor subjects. Students majoring in microbiology select their primary courses from those listed below. The nature and number of other courses, which may be taken at this institution or at nearby universities, will depend on the student's minor subjects, his research activities, his individual interests, and the advice of his Special Committee.

The Ph.D. candidate is required to be proficient in (a) two modern foreign languages acceptable to his Special Committee or (b) one foreign language and a computer science language in which proficiency is demonstrated by the execution of a meaningful program.

Although a qualifying examination is not ordinarily given, a student's Special Committee has the prerogative of requiring it. The admission to candidacy examination is administered by a committee consisting of a chairman appointed by the dean, the student's Special Committee, and three additional faculty members in the Field of Microbiology. The written portion of this examination tests for basic facts and concepts in the candidate's areas of study and for his problem-solving ability within and across disciplinary boundaries. The oral examination provides an opportunity for the student to correct deficiencies in the written examination, to be examined further on general knowledge, and to discuss and be questioned on his planned or current research.

Special Interests of the Faculty

- J. L. Beebe: microbial lipids and fatty acids, biochemistry of non-transferable drug resistance in bacteria, especially *Neisseria*.
- R. W. Dickerman: involvement of birds and mammals in the ecology of mosquito-transmitted viruses.
- Z. Harsanyi: genetic control of enzyme structure, drug and chemically induced chromosomal aberrations, genetics of *Aspergillus nidulans*.
- L. Korngold: antigenic structure of immunoglobulins and of various human tissues.
- M. J. Lyons: biochemical and morphological aspects of the interaction of arboviruses with vertebrate and ecologically related arthropod cells; morphogenetic and ultrastructural studies of viruses.
- W. M. O'Leary: microbial cellular composition, exo- and endotoxin structure and function, mechanisms of pathogenesis, microbial lipids, antibiotic function.
- W. F. Scherer: cell-virus relationships, virus virulence, host defense mechanisms, ecology and epidemiology of arboviruses, especially mosquito-borne encephalitis viruses of tropical North and Central America.
- L. B. Senterfit: antigenic structure of mycoplasma; pathogenesis of respiratory viral and mycoplasmic disease, vaccine development, clinical microbiology.
- G. W. Siskind: factors involved in control of the immune response; changes in antibody affinity and heterogeneity with increasing time after immunization.
- D. H. Sussdorf: function of the thymus and related lymphoid tissues in development of immunocompetence; cellular and molecular aspects of antigen degradation.

Courses

Students who wish to attend any of the following courses either for credit or as an auditor should contact the office of the Department of Microbiology or the faculty member responsible for each course well in advance of the beginning of each course. In general, as many students as possible are accommodated in lectures; however, participation in laboratory sections is restricted.

1. General Microbiology. Offered by the staff of the Field of Microbiology of the Medical College

Division and of the Biology Unit of the Sloan-Kettering Division. For details, refer to Interdivisional Courses, p. 21. Offered every second year. Offered in 1972-73. Professors Hutchison (SKD) and O'Leary.

2. Microbiology and an Introduction to Infectious Disease.

Presented in the first and second trimesters and consists of laboratory experiments, lectures, and group discussions. The laboratory work includes an introduction to the procedures used in studying microorganisms, experiments on various physical and biological manifestations of antigen-antibody reactions, the actions of chemotherapeutic agents, a survey of the microbial flora of the upper respiratory and lower intestinal tracts of healthy humans, and an intensive study of the causal agents of specific infections, including fungi, spirochetes, rickettsiae, and viruses, as well as bacteria. The lectures are directed toward the development of basic concepts, particularly the principles involved in microbial growth, the principles underlying active immunization, and the factors that enter into host-parasite relationships. Emphasis is placed on aspects related to the etiology, pathogenesis, epidemiology, and prevention of infectious disease. Special attention is also given to the immunological principles underlying such noninfectious conditions as hypersensitivity, autoimmunity, and rejection of tissue transplants. Offered every year. Professor Scherer.

3. Advanced Diagnostic Microbiology. The lecture and laboratory sessions acquaint the student with the procedures used in and technique of management of a clinical microbiology laboratory. Emphasis is upon developing the student's capability in the isolation and rapid identification of organisms from various types of clinical specimens. Liberal use is made of clinical materials available through the diagnostic laboratories of the New York Hospital. Offered every year in the third trimester. Professor Senterfit.

4. Microbial Chemistry and Physiology. Lectures cover literature and methodology pertinent to physicochemical properties of microorganisms and their environments, the growth and death of microorganisms, chemical composition of cells and subcellular structures, nutritional requirements, microbiological assay and auxotrophic mutants, energy metabolism, degradations and biosyntheses, the physiology of pathogenesis, and important microbial products. Laboratory sessions provide experience with large-scale culture and recovery of cells, synthetic media, microbiological assay, extraction of cellular constituents, respirometry, and studies of substrate utilization employing radioactive metabolites. Minimal prerequisites are general microbiology, qualitative and quantitative analysis, organic chemistry, and at least one semester (or its equivalent) of biochemistry. Offered every year in the third trimester. T Th, lectures 10-11; laboratory 2-5. Professor O'Leary.

5. Advanced Microbial Genetics. Selected concepts of molecular genetics are examined using both prokaryotic and eukaryotic microorganisms as models. Topics include intra- and interchromosomal complementation, mitotic and meiotic recombination, genetic control mechanisms, gene conversion, polyploidy and aneuploidy, genetic interference, mechanisms of suppression, and polarity. The course is designed to elucidate the genetic methods available for studying hereditary material. Offered every second year in the third trimester, one lecture weekly. Not offered in 1972-73. Dr. Harsanyi.

6. Advanced Immunology. Two lectures and two laboratory periods weekly. Lectures emphasize current concepts regarding antigen and antibody structure, the physical and biological manifestations of antigen-antibody reactions, and recent developments in studies on the cellular basis of immunity, including antibody formation.

The laboratory will cover the isolation, purification, quantitation and characterization of antibodies; the critical measurement of antigen-antibody reactions; and the dynamics of the *in vivo* antibody response. Minimal prerequisites are introductory immunology (as given in courses in general microbiology) and at least one semester (or its equivalent) of biochemistry. A semester course in histology or microscopic anatomy is desirable. Offered every third year in the third trimester. Two lectures and two laboratory sessions weekly. Not offered in 1972-73. Professor Sussdorf.

7. Advanced Virology. Presents, in lectures and laboratory sessions, modern concepts and techniques of virology. Virus structure, chemical composition, physical and biologic properties, and relationships with host cells are considered in depth. Minimal prerequisites for credit are general microbiology and at least one semester (or its equivalent) of biochemistry. Offered every second year. Offered in 1972-73. Professor Lyons.

8. Arthropod-Borne Virology and Related Ecology and Epidemiology.

Section A. Principles of arthropod-borne virology.
Section B. Entomology in relation to arthropod-borne virology.
Section C. Ornithology in relation to arthropod-borne virology.
Section D. Mammalogy in relation to arthropod-borne virology.
Section E. Human and veterinary diseases caused by arthropod-borne viruses.

Section A is offered at Cornell University Medical College usually during late June and early July, and sections B-E at field laboratory sites in Central America during late July and August. Section A and one or two others are offered each summer. Members of the faculty are from Cornell and collaborating institutions in Central America. Each section follows a syllabus and consists of literature review and analysis at Cornell University Medical College and other New York libraries, including the American Museum of Natural History, and seminars and practical experience at the field laboratory. Classes are limited to six students. The following Cornell University students are eligible: New York campus—graduate students majoring or minoring in microbiology, postdoctoral fellows in microbiology, medical students with special interest; Ithaca campus—graduate students majoring in entomology or fields of vertebrate zoology, veterinary students with special interest, undergraduate students beyond third year with special interest and sufficient background in biology. Students from other universities or research institutions may enroll provided spaces are available. Offered in most but not all years. Those interested should inquire at the departmental office well in advance of beginning dates. Professor Dickerman.

9. Advanced Mycology. Initial consideration is given to gross vegetative organization of fungi relating cellular and subcellular structure and function. In addition to physiological and morphological characteristics of microscopic fungi, mechanisms of biosynthesis and energy metabolism are described in reference to the interaction between fungi and their environment. Other topics considered include natural and induced variation of fungi, fungi as tools of genetic investigation, biochemical and traditional systematics, bioassays, and steroid transformations.

Basic features of fungal growth are considered, and attention is also directed to the various associations between fungi and man. These include the role of fungi as sources of important microbial products, as causes of spoilage and destruction, and as pathogenic, toxigenic and allergenic agents of human disease.

Lectures are supplemented with laboratory exercises designed to provide familiarity with specialized mycological procedures, with the handling of fungi as genetic models and in bioassay systems, and with the methods for isolation and identification of fungi from clinical materials. Two lectures weekly. Two laboratory sessions weekly for five weeks. Offered in ten weeks from March to mid-May, every third year. Not offered in 1972-73.

10. Microbial Ecology. This course examines the manifold and indispensable roles of microorganisms in the biosphere and their significance in the survival and well-being of other forms of life including man. Topics covered include: our microbial environment; the diversity, distribution and dispersal of microflora; biogeochemistry; the recycling of bio-atoms and maintenance of the biosphere; interactions between microbial populations; interactions between microorganisms and macroorganisms; energy flow and the food chain; and the relationships between changes in microecosystems and the effects on macroecosystems. Offered every second year in the third trimester, one or two lectures weekly. Not offered in 1972-73. Dr. Beebe and Professor O'Leary.

11. The Methods and Materials of Research. This is intended to be an experimental and wide-ranging course presented by all the faculty of the Field. It covers such diverse and essential subjects as logic and scientific method, manuscript preparation, the nature and use of the scientific literature, scientific photography, evaluation and choice of equipment, national scientific resources, and other matters yet to be determined. The purpose of this course is to provide students with some familiarity, even if limited, with many subjects not covered by any other course and yet essential to the practicing scientist. Offered every third year. Not offered in 1972-73.

12. Research on Special Problems. Designed for students in other Fields who wish to obtain some significant experience in microbiological research. For these students and others who want such experience, this Field offers individualized research on special problems. The nature, complexity, and time required for such research vary according to the needs and desires of each student. Such experience is available in each specialty covered by the faculty of this Field and can be arranged by consultation of the student with the appropriate faculty member. Available each year and throughout the year. The staff.

13. Thesis Research in Microbiology. Required of all students taking a major in microbiology. Offered yearly and throughout the year. The staff.

14. Microbiology Seminar. These seminars consist of reports on surveys of the literature in the Field and on current research and are presented by graduate students, faculty and visiting scientists. Attendance is required of all students majoring or minoring in microbiology throughout their programs of study. Offered yearly and throughout the year. One-hour sessions on alternate weeks. Professor Lyons.

Neurobiology and Behavior

Faculty

Dana C. Brooks, Michael D. Gershon, Sanford Goldstone, Bernice Grafstein, Wilbur D. Hagamen, Martin Hamburg, S. Steven Hotta, Myron S. Jacobs, Thomas H. Meikle, Jr., Michiko Okamoto, Robert S. Porro, Donald J. Reis, Walter F. Riker, Jr., Leonard L. Ross, William N. Schoenfeld, Jeri A. Sechzer, Gerard P. Smith, Roy C. Swan

Field Representative

Gerard P. Smith, Bourne Laboratories,
21 Bloomingdale Road, White Plains, New York 10605

The Field of Neurobiology and Behavior provides training in the study of the nervous system. It includes the disciplines of neuroanatomy, neuroembryology, neurophysiology, neuropharmacology, neurochemistry, neuroendocrinology, and neuropsychology and perception. The program of the Field emphasizes a multidisciplinary approach to the study of the nervous system, based on the belief that future advances in our understanding of the nervous system will be derived from a knowledge of the thinking and research techniques employed by more than one discipline. Towards this end, the program of the student entering the Field is planned in consultation with several staff members, and the student is expected to spend some period of time working closely with members of the faculty whose interests are related to his. In addition there are regularly scheduled seminars in the Field during which various aspects of work in progress are presented and discussed. By this means, the student is afforded the broadest possible view of the Field during his total training experience.

The student who chooses Neurobiology and Behavior as a major field will be required to satisfy the requirements of the courses in neural sciences, statistics, and biomathematics, and two of the following: microscopic anatomy, physiology, biochemistry, or pharmacology. In addition, participation in the seminar program is expected. While there are no language requirements, it is suggested that the student achieve mastery of a modern foreign language or a computer language. When Neurobiology and Behavior is chosen as a minor field of study, the student is required to participate in the neural science course and the seminar program as well as any additional experience which the minor adviser may suggest.

Special Interests of the Faculty

- D. Brooks: brain stem influence upon the electrical activity of the visual system during both sleep and waking.
- M. Gershon: development of the autonomic innervation of the gut.
- B. Grafstein: growth of nerve and the transport of materials in axons.
- M. Hamburg: neural code of hunger motivation utilizing the techniques of single unit recording.
- M. Jacobs: comparative cytomorphological organization of the cetacean nervous system.
- T. H. Meikle: animal studies of neural mechanisms basic to learned behavior, particularly visual learning.
- R. Porro: histological, histochemical and electron microscopic studies of human neurological disorders.
- D. J. Reis: central neural regulation of cardiovascular function and biogenic amines and aggressive behavior.
- W. F. Riker: pharmacology and physiology of neuromuscular transmission.
- L. L. Ross: biochemical morphology of central nervous system synapses.
- W. N. Schoenfeld: effects of long-term stress upon selected behavioral and physiological systems and reinforcement schedules in behavior theory.
- J. Sechzer: learning and memory in split-brain animals.
- G. Smith: feeding behavior, emotional behavior and learning in rats and monkeys, utilizing the concepts of neuroendocrinology.
- R. C. Swan: fine structure of the cerebellar cortex.

Courses

1. Neurosciences. This is the basic undergraduate medical course and is required of all major and minor candidates in the Field. It is a broadly based course taught by members of the Field and introduces the student to neuroanatomy, neurophysiology, and pertinent neurology.

Third trimester. Professors Hamburg and Grafstein.

2. Brain Catecholamines and Behavior. The anatomy, physiology and pharmacology of brain catecholamine neurons will be briefly reviewed. The seminar will focus on the function of these neurons in movement, posture, feeding and drinking, memory, and depression and schizophrenia. Unlimited enrollment. No prerequisites. Admission by permission of instructor. Second trimester; hours to be arranged during January, February, and March. Professor Smith.

3. Neurobiology Elective. Each year the Field offers an elective course which considers various special aspects of Neurobiology and Behavior. In the past the courses have explained, in depth, the synapse, the developmental neurobiology, and the impact of the environment on the nervous system. Offered in the third trimester. 2 hours per week; hours to be arranged. 4–20 students. Professor Grafstein and staff.

Pathology

Faculty

Daniel R. Alonso, Carl G. Becker, Peter G. Bullough, Margaret H. S. Clements, M. Renate Dische, John T. Ellis, Milton Helpern, William Insull, Jr., Aaron Kellner, John G. Kidd, Robert C. Mellors, C. Richard Minick, George E. Murphy, Robert S. Porro, Alfred M. Prince, Charles A. Santos-Buch, John E. Seybolt, Myron Susin, Carolyn W. Watson, Jack Woodruff

Field Representative

Carl G. Becker, Department of Pathology,
Room C-444, Medical College

Pathology is the study of the causes and mechanisms of disease processes. The purpose of a graduate program in pathology is to provide individuals with a baccalaureate or medical degree with a basic knowledge of disease processes by a study of the disciplines of anatomic and clinical pathology and by learning modern techniques of biologic investigation. It is hoped that a student completing this program will have both the information and technical skills to make significant inquiries into the nature of disease processes and to bridge the gap between classical, descriptive pathology and such disciplines as biochemistry and molecular biology.

The graduate program in pathology includes the observation of diseases in their various forms at autopsy and in clinical laboratories and study and research in the areas of immunology and immunopathology, oncology, virology, cellular biology, and electron microscopy. It may also include study in advanced mathematics, physiology, biophysics, pharmacology, anatomy, cytochemistry and histochemistry, advanced biochemistry, genetics, and microbiology.

New students are expected to have completed mathematics through integral calculus, chemistry through organic chemistry (although physical chemistry is recommended), basic physics, and at least general biology. A reading knowledge of at least one foreign language is suggested but not required. For those students entering the program with baccalaureate degrees only, the Graduate Record Examinations, including the Aptitude Tests and the Advanced Test in Biology or Chemistry, are required.

Graduate students in pathology are required, as an initial part of their program, to take the course in general and systemic pathology offered to second-year medical students. They are required to minor in at least one and not more than two other biomedical Fields. Courses in biomathematics, advanced biochemistry, genetics, and microbiology are also required. Additional courses not

available at the Graduate School of Medical Sciences can be taken at neighboring institutions with approval of the Department of Pathology and the candidate's Special Committee.

Special Interests of the Faculty

- D. R. Alonso: cardiovascular pathology.
- C. G. Becker: cardiovascular and renal diseases; immunopathology; host-parasite relationships.
- P. G. Bullough: diseases and metabolism of bone.
- M. H. S. Clements: exfoliative cytopathology.
- M. R. Dische: pediatric pathology; biochemistry of metabolic diseases; biochemistry.
- J. T. Ellis: electron microscopy; kidney disease and muscle diseases.
- M. Helpert: forensic pathology.
- W. Insull, Jr.: arteriosclerotic cardiovascular disease.
- A. Kellner: immunohematology; lipid metabolism; pathogenesis of arteriosclerosis.
- J. G. Kidd: virology and oncology.
- R. C. Mellors: studies in immunopathology relating to the role of viruses in autoimmune disease and leukemogenesis.
- C. R. Minick: pathogenesis of arteriosclerosis and hypertension; lipid metabolism; immunopathology; electron microscopy.
- G. E. Murphy: cardiovascular diseases; host-parasite relationships.
- R. S. Porro: neuropathology; ultrastructure and histochemistry of diseases of central nervous system and skeletal muscle.
- A. M. Prince: virology; pathogenesis of liver diseases.
- C. A. Santos-Buch: cellular biology; immunopathology; cardiovascular disease; electron microscopy.
- J. E. Seybolt: exfoliative cytopathology.
- M. Susin: pathology of renal disease; electron microscopy.
- C. W. Watson: exfoliative cytopathology.
- J. Woodruff: virology.

Courses

- 1. General and Systemic Pathology.** Lectures, practical classes and seminars. First trimester: M W F 9–1. Second trimester: M W 10–1, Th 9–1. The staff.
- 2. Correlative Pathology.** Gross and microscopic material is correlated and related to the disease processes. The staff.
- 3. Forensic Pathology.** Courses are offered in the above by special arrangement with the chief medical examiner of the City of New York. Professor Milton Helpert.
- 4. Seminars in Pathology.** Discussions outlining the scope of modern pathology are given weekly. These include reports on original research by members of the staff and by visiting lecturers. Hours to be announced. The staff.
- 5. Experimental Pathology.** Independent research projects in various areas of pathology are offered. The staff.

The following courses are offered by various members of the Field in collaboration with faculty members of related Fields. The terms and hours are by arrangement.

Immunopathology

- Cardiovascular pathology**
- Autopsy pathology**
- Orthopedic pathology**
- Renal pathology**
- Gastrointestinal pathology**
- Neuropathology**
- Surgical pathology**
- Cytopathology**
- Tumor pathology**

Clinical Biochemistry

Hematology and Immunohematology

Clinical Microbiology

Pharmacology

Faculty

Amir Askari, Barry A. Berkowitz, John J. Burns, Walter W. Y. Chan, Raymond W. Houde, Charles E. Inturrisi, Henn Kutt, Roberto Levi, Walter Modell, Michiko Okamoto, Walter F. Riker, Jr., Arthur K. Shapiro, Alan Van Poznak

Field Representative

Michiko Okamoto, Department of Pharmacology, Room E-411, Medical College

In graduate training, emphasis is placed on sound basic training in general pharmacology. By means of individual instruction, the candidate is later afforded an exposure to several specialized aspects of pharmacology. The latter part of the graduate curriculum is devoted to research in an area of the candidate's choice.

An adequate preliminary training in organic chemistry, physical chemistry, biochemistry, and physiology is prerequisite to graduate work in pharmacology. Training in statistics is strongly recommended.

Proficiency in one foreign language is required of all Ph.D. candidates majoring in pharmacology.

Special Interests of the Faculty

- A. Askari: biochemical pharmacology; mechanisms of drug effects on the transport of ions through biological membranes.
- B. A. Berkowitz: vascular pharmacology; catecholamines; pharmacology of drug abuse.
- J. J. Burns: biochemical pharmacology; drug metabolism.
- W. W. Y. Chan: renal pharmacology; endocrine pharmacology; polypeptide pharmacology.
- R. W. Houde: clinical pharmacology of the analgesic drugs; development of methods of evaluating the effects of drugs on subjective responses.
- C. E. Inturrisi: biochemical pharmacology; drug metabolism.
- H. Kutt: clinical pharmacology; neuropharmacology (anticonvulsant drugs; drug metabolism.)
- R. Levi: cardiovascular pharmacology and electrophysiology; immunopharmacology.
- W. Modell: clinical pharmacology; pharmacology of cardiac drugs; adverse drug reactions.
- M. Okamoto: neuropharmacology, pharmacology of muscular transmission; drug dependence.
- W. F. Riker, Jr.: general pharmacology, neuropharmacology, pharmacology of neuromuscular transmission.
- A. K. Shapiro: clinical pharmacology; psychopharmacology.
- A. Van Poznak: pharmacology of general anesthetics; neuropharmacology.

Courses

- 1. General Pharmacology.** The basic pharmacology course offered to second-year medical students is open to graduate students. The course consists of lectures, laboratory work, demonstrations, and seminars given during the first and second trimesters. The purpose of these exercises is to teach the principles of pharmacology. Detailed consideration is given to the parameters of drug action to provide the student with the fundamental concepts essential for the evaluation of any drug. Consequently, emphasis is placed on the scientific basis of pharmacology. Prototype drugs, considered essentially systemically, serve to illustrate several mechanisms and parameters of drug action. Therapeutic applications are considered only insofar as they illustrate principles of pharmacology or drug

hazards. Prerequisites: biochemistry and physiology. The staff.

2. Research in Pharmacology. Research opportunities may be arranged throughout the year for graduate students who are not majoring in pharmacology but who wish some investigative experience in the discipline. Special opportunities are offered for work on the nervous and cardiovascular systems and in biochemical aspects of pharmacology. The staff.

3. Advanced Courses and Seminars. The Field of Pharmacology offers several advanced courses and seminars in the areas that are of interest to the faculty of the Field and the graduate students. The content, the format, and the schedule of these courses are determined each year on the basis of the number and the backgrounds of the interested students. The staff.

Physiology

Faculty

S. Balagura-Baruch, W. A. Briscoe, W.W.Y. Chan, C. Fell, B. Grafstein, R. L. Greif, N. B. Javitt, R. Levi, M. Lipkin, T. M. Maack, R. F. Pitts, E. E. Windhager

Field Representative

Thomas M. Maack, Department of Physiology and Biophysics, Room D-407, Medical College

Opportunities are offered toward the Ph.D. degree in several areas of physiology and biophysics. Ample space is available and laboratories are well equipped to provide predoctoral training in a medical environment. Interested individuals are urged to contact the Field Representative before preparing a formal application. Letters of inquiry should include an indication of educational background and possible areas of emphasis in graduate study. There has been a tendency to encourage applications from individuals who have a probable interest in one or more of the areas of physiology represented within the Field.

Formal applications should include full college transcripts, at least two letters of recommendation, and recent Graduate Record Examination scores. Introductory courses in biology, inorganic and organic chemistry, physics, and mathematics through the level of differential and integral calculus are required. Additional course work in these disciplines at the undergraduate level is encouraged. Although not required, candidates are urged to take the Graduate Record Examinations, since performance in these examinations is an important factor in the selection of applicants. Applicants with otherwise exemplary records, who lack certain course requirements, will be considered for acceptance provided that candidates remedy such deficiencies while in training.

The course of study emphasizes the importance of teaching and research in the preparation and development of individuals for careers in physiology. This goal is achieved by a combination of didactic courses, seminars, and closely supervised research leading toward the preparation of a satisfactory thesis.

A special program of study will be developed for each student in consultation with his Special Committee. In addition to the general requirements set by the Graduate School for all Fields, all candidates for the doctoral degree in physiology will be expected to meet the following specific requirements:

1. Evidence of a satisfactory background in neurosciences. Ordinarily, the course in neurosciences described under the Field of Neurobiology and Behavior, or an equivalent course, will be taken concurrently with the course in, physiology and biophysics.

2. Satisfactory completion of the course in physiology and biophysics, or an equivalent course.

3. For majors and minors in the Field, a minimum of two elective courses in the Field ordinarily will be required, in addition to the course in physiology and biophysics.
4. Proficiency in reading scientific literature in one modern foreign language.

5. Satisfactory completion of an individualized laboratory experience in an area of research different from that chosen for the doctoral dissertation.

Special Interests of the Faculty

- S. Balagura-Baruch: renal metabolism and transport of Krebs cycle intermediates.
- W. A. Briscoe: blood gas transfer in health and disease.
- W.W.Y. Chan: pharmacology of neurohypophyseal hormones and related polypeptides.
- C. Fell: cardiovascular function: in particular, blood flow distribution, blood volume, and blood volume distribution.
- B. Grafstein: nerve regeneration and transport of materials in nerve axons.
- R. L. Greif: physiology of the thyroid gland and its secretions.
- N. B. Javitt: gastrointestinal and hepatic physiology and pathophysiology.
- R. Levi: heart electrophysiology; heart hypersensitivity reactions; histamine in cardiac function.
- M. Lipkin: proliferation and differentiation of normal and diseased gastrointestinal cells.
- T. M. Maack: protein transport and metabolism by the kidney.
- R. F. Pitts: renal metabolism of amino acids; renal regulation of acid-base balance.
- E. Windhager: renal electrolyte metabolism.

Courses

Students planning to register for the course in Physiology and Biophysics must consult the Field representative before the start of the second trimester. Students who wish to take a third-trimester course (2-8) are advised to consult the Field representative no later than the seventh week of the second trimester in order to assure a place in the course.

1. Physiology and Biophysics. Lectures and conferences in body fluids, bioelectric phenomena, circulation, respiration, and gastrointestinal function. Second trimester: 4 hours per week. The staff.

Lectures and conferences on kidney function, acid-base regulation, endocrinology, and metabolism, and a weekly laboratory on selected aspects of physiology. Third trimester: 11 hours per week. The staff.

2. Respiratory and Renal Mechanisms of Regulation of Acid-Base Balance. Each session consists of an informal lecture and a succeeding seminar discussion based on assigned reading in the area of the immediately preceding lecture. Third trimester: 3 hours per week. 5-15 students. Professor Pitts and staff.

3. Selected Topics in Endocrinology. Important scientific papers dealing with certain aspects of endocrinology are distributed to the participants one week in advance of discussion. Each paper is considered in detail in a seminar directed by an investigator in the area under discussion. One or two preliminary orientation sessions are given by Professor Greif before distribution of the first scientific paper, and, if feasible, one or two laboratory days are planned. Third trimester: 3 hours per week. 6-12 students. Professor Greif and staff.

4. Selected Topics in Gastrointestinal and Hepatic Physiology and Pathophysiology. Topics include bilirubin metabolism and excretion, cholesterol metabolism bile salt excretion, bile formation, esophageal motility, gastric

function, intestinal cell turnover, absorption of fat, absorption of carbohydrate, the malabsorption syndrome. Third trimester: 2 hours per week. 5–12 students. Professor Javitt.

5. Selected Topics in Respiratory Physiology. Topics covered include: (1) physiological anatomy of the lung; (2) logical formulation and solution of clinical problems; (3) ventilation, alveolar air diagram, nitrogen washout; (4) relevant lung function tests; (5) lung volumes, effect of posture and disease; (6) diffusion, Fick equation, Bohr integration; (7) acid-base considerations in blood; (8) mechanical properties of lung; (9) ventilation-perfusion ratio and Bohr integral isopleths; (10) ecology, sealed spaces, altitude, diving; (11) lung function in the first week of life. Students wishing to take this course must consult with Professor Briscoe no later than the seventh week of the second trimester. Third trimester: 2 hours per week. Maximum of 12 students. Professor Briscoe.

6. Selected Topics in Kidney and Electrolyte Physiology and Pathophysiology. Lectures, seminars, and demonstrations. Topics include: (1) GFR, clearance concept, reabsorption and secretion of electrolytes; (2) concentrating mechanism; (3) electrophysiology of the nephron; (4) pathophysiology of potassium; (5) renal blood flow and its intrarenal distribution; (6) renal physiology in the newborn; (7) control of body fluid volume and tonicity; (8) pathology of renal failure; urinary sediment; pathophysiology of renal failure; (9) radiology of the kidneys; (10) dialysis; (11) transplantation. Third trimester: 2 hours per week. Maximum of 12 students. Professor Windhager and staff.

7. Special Topics in Cardiovascular Physiology. Original research papers will be made available in advance of each session, and these and the general problems associated with each topic will serve as the basis for the discussion. Insofar as possible, experimental approaches to each problem will be demonstrated. To some extent, choice of topics can be determined by the interests of the group. Probable topics include: (1) regulation of peripheral blood flow; (2) integrated cardiovascular responses to hypoxia; (3) pulsatile flow in arteries; (4) measures of myocardial performance; (5) blood volume, hemorrhage, and hemorrhagic shock; (6) cardiac catheterization in man, congenital heart disease, valvular heart disease. Third trimester: 3 hours per week. 6–12 students. Professor Fell.

8. Neurobiology Elective. This course is described under courses offered by the Field of Neurobiology and Behavior.

Instruction at the Sloan-Kettering Division

Graduate Seminar. This weekly graduate seminar is offered each year and is attended by all first- and second-year students of the Division. Two or three topics are selected for discussion each year. Topics are usually chosen from the following: nucleic acid and protein chemistry and biochemistry; chromosome structure and function; special topics in bacterial genetics; regulation; radiobiology; mammalian and bacterial viruses. The discussion is carried principally by graduate students under the guidance of faculty members whose area of specialization coincides with the topic. From time to time outstanding authorities are invited as guest speakers. In addition, students in the third and later years of graduate study address the seminar on the progress being made in their thesis work.

Topics in Cancer Research. A weekly meeting of graduate students throughout the academic year which is addressed by faculty and staff of the Sloan-Kettering Institute. The objective of the course is to provide students

with an introductory account of the major currents in cancer research. The topics are divided into the following units each of which represents a major approach to the understanding and control of neoplastic disease: Cell Regulation and Metabolism, Immunovirology, Radiobiology and Radiation Therapy, Nuclear Medicine, Endocrinology, Chemotherapy, Carcinogenesis, and Clinical Research.

Biochemistry

Faculty

N. W. Alcock, M. E. Balis, A. Bendich, V. G. Bethune, R. S. Bockman, E. Borenfreund, G. B. Brown, L. F. Cavaliere, J. D. Fissekis, M. Fleisher, J. J. Fox, A. Giner-Sorolla, S. Green, M. G. Hamilton, U. Hämmerling, J. S. Karam, L. Kopelovich, W. Kreis, S. J. Lenard, F. P. Mamaril, J. S. Nisselbaum, J. C. Parham, M. L. Petermann, B. H. Rosenberg, J. S. Salser, M. K. Schwartz, M. R. Sherman, V. P. Skipski, M. Sonenberg, C. C. Stock, N. I. Swislocki

Unit Chairman

Ellen Borenfreund, Sloan-Kettering Division, Room 411K, Kettering Laboratory

Opportunities are available for advanced work and research in chemistry and metabolism, bio-organic chemistry, enzymology, hormone chemistry and action, and molecular biology.

Undergraduate requirements for a major in biochemistry include courses in inorganic chemistry, qualitative and quantitative chemistry, organic chemistry, physical chemistry, physics, general biology, and mathematics (through calculus). Any of these requirements not completed at the undergraduate level must be completed during graduate study. Applicants are urged strongly to support their applications with Graduate Record Examinations scores in both the Aptitude Test (verbal and quantitative) and the Advanced Test in Chemistry or Biology.

Students electing biochemistry as a major or minor subject must complete the first term of the General Biochemistry course (Biochemistry 2A, Medical College Division) and the Advanced Biochemistry course as minimal requirements.

All students are required to take an oral qualifying examination. A written examination may be required at the discretion of the student's Special Committee. The admission to candidacy examination is both written and oral.

The only language requirements are those imposed by the student's Special Committee.

Special Interests of the Faculty

Biochemical analysis: N. W. Alcock, V. G. Bethune, M. Fleisher, M. K. Schwartz, V. Skipski.
Biochemical genetics: A. Bendich, E. Borenfreund.
Biochemical pharmacology: M. E. Balis, A. Giner-Sorolla, S. Green, W. Kreis, J. S. Salser, C. C. Stock.
Biochemistry of cancer and carcinogenesis: M. E. Balis, A. Bendich, E. Borenfreund, G. B. Brown, M. Fleisher, S. Green, L. Kopelovich, W. Kreis, J. C. Parham, M. K. Schwartz, M. R. Sherman, C. C. Stock.
Biosynthesis of macromolecules: L. F. Cavaliere, M. G. Hamilton, J. Lenard, M. L. Petermann, B. H. Rosenberg, M. Sonenberg.
Chemistry and biochemistry of hormones: R. S. Bockman, J. Lenard, M. Sonenberg, N. I. Swislocki.
Chemistry and biochemistry of lipids and membranes: A. Bendich, R. S. Bockman, U. Hämmerling, J. Lenard, V. Skipski, M. Sonenberg, N. I. Swislocki.

Chemistry of natural products: G. B. Brown, J. D. Fissekis, J. J. Fox, A. Giner-Sorolla, J. C. Parham.

Intermediate metabolism: N. W. Alcock, M. E. Balis, G. B. Brown, L. Kopelovich, W. Kreis, F. Mamaril, N. I. Swislocki.

Mechanism of enzyme activity: G. B. Brown, S. Green, L. Kopelovich, F. Mamaril, J. S. Nisselbaum, M. K. Schwartz.

Structure and function of macromolecules: M. E. Balis, A. Bendich, R. S. Bockman, E. Borenfreund, L. F. Cavalieri, M. G. Hamilton, U. Hämmerling, W. Kreis, J. Lenard, M. L. Petermann, B. H. Rosenberg, J. S. Salser, M. R. Sherman, V. Skipski, M. Sonenberg.

Courses

1. Advanced Biochemistry. The course and the hours are described on p. 21 under Interdivisional Courses.

2. Bacterial and Viral Envelopes. A series of lectures is planned to introduce students to the problems and important foci of activity in cell surface research with emphasis on bacterial and viral envelopes. About fifteen meetings are planned for the spring semester of 1973. The topics will include discussion of structural and functional components of bacterial and viral membranes and the mode of replication and growth of the cell surface with emphasis on modern approaches to chemistry and structure. The lectures will be offered by the staff of the Rockefeller and Cornell Universities. Detailed programs will be available in the fall and interested students should contact either Dr. Tomasz or Dr. Lenard. Professors Tomasz, Choppin (Rockefeller University), and Lenard.

Biology

Faculty

A. M. Albrecht, J. L. Beidler, E. A. Boyse, A. T. Burness, E. P. deHarven, E. S. Essner, E. Fleissner, J. E. Fogh, F. W. Foote, Jr., P. J. Gomas, D. J. Hutchison, N. Ikegami, R. M. Krug, H. W. J. Marquardt, M. Michel, H. F. Oettgen, L. J. Old, F. S. Philips, F. K. Sanders, F. M. Sirotnak, S. S. Sternberg, E. H. Stonehill, M. N. Teller, L. Wade, M. S. Zedeck.

Unit Chairman

Dorris J. Hutchison, Walker Laboratory, Sloan-Kettering Institute for Cancer Research, Rye, New York

The program in biology is oriented toward an understanding of factors which initiate control and modify growth and biological development. Opportunity is offered for advanced work and research in cell biology, cytology, genetics, immunology, microbiology, pharmacology, and virology.

Undergraduate prerequisites for a major in biology include courses in inorganic chemistry, organic chemistry, qualitative and quantitative chemistry, physical chemistry, physics (mechanics, electricity, and magnetism; sound, heat, and light), mathematics (through calculus), and general biology or zoology or botany or microbiology. Any of these requirements not completed at the undergraduate level must be completed during the first year of graduate study. Applicants are urged strongly to support their applications with scores attained on the Graduate Record Examinations in both the Aptitude Test (verbal and quantitative) and the Advanced Test in Biology or Chemistry.

Programs are determined individually on the basis of interest, training, and prior experience. Elective courses in basic medical sciences include those described for the Medical College. Formal graduate courses, seminars, and tutorials are arranged with the faculties of the Sloan-Kettering Division and the Medical College Division. Degree requirements include successful completion of three

examinations: (1) qualifying, (2) admission to candidacy, and (3) defense of thesis. A major and two minor subjects are also required. The foreign language requirement will be determined by the student's Special Committee.

Special Interests of the Faculty

Cell biology, cell differentiation, and viral and chemical carcinogenesis: A. T. Burness, J. E. Fogh, F. K. Sanders, E. H. Stonehill, M. N. Teller.

Cytology, fine structure of cancer cells: E. P. de Harven, E. S. Essner, S. S. Sternberg.

Genetics, drug resistance, membranes and transport: J. L. Biedler, F. M. Sirotnak.

Immunology, tumor immunology and immunogenetics: E. A. Boyse, H. F. Oettgen, L. J. Old.

Microbiology, drug resistance and chemotherapy: A. M. Albrecht, D. J. Hutchison.

Pharmacology, mechanism of drug action and chemical carcinogenesis: H. W. J. Marquardt, F. S. Philips, M. S. Zedeck.

Virology, genetics, and physical and chemical structure of viruses: E. Fleissner, P. J. Gomas, N. Ikegami, R. M. Krug, M. Michel.

Courses

1. Microscopy for Cancer Research. A Laboratory Course. An introduction to the biology of cancer. Various methods of light microscopy are primary teaching techniques. Sessions consist of lectures and/or demonstrations, followed by a laboratory in which students will examine specially prepared materials. Microscopes will be provided. Methods of light microscopy, autoradiography, enzyme-cytochemistry, immunofluorescence, cytology of tissue culture etc. will be emphasized. Other materials will deal with microscopic anatomy of normal and neoplastic tissues (i.e. liver and hepatoma; white blood cells and leukemia). First trimester. Professors deHarven, Sternberg, and Essner.

2. Virology. A formal course in which major emphasis is placed on the basic mechanisms in the biology of animal viruses. The topics considered include virus structure and composition; assay of viruses and viral-specific products; interaction of viruses with receptors and antibodies; syntheses of viral nucleic acids and proteins and assembly of viral particles; structural and functional alterations in viral-infected cells; pathogenesis of viral diseases; and viral genetics. Not offered in 1972-73.

3. Tumor Biology. A series of lectures on basic aspects of the cancer cell including cell differentiation, viral and chemical carcinogenesis, tumor antigens, genetics, and the physical and biochemical behavior of cancer cells. Not offered in 1972-73.

4. Tumorigenesis. A series of lectures dealing with carcinogenesis and related subjects. Topics include the nature of neoplastic changes *in vivo* and *in vitro*; comparison of chemicals, viruses, and physical agents; metabolism and mechanism of action of chemical carcinogens; and genetic, hormonal, and immunological factors involved in carcinogenesis. Professor Philips.

5. Genetics Seminar. Described on p. 13 under the Field of Genetics.

6. General Microbiology. Described on p. 21 under Interdivisional Courses.

Biophysics

Faculty

B. Djordjevic, E. R. Epp, J. Fried, A. S. Gelbard, E. W. Hahn, N. D. Kessar, J. S. Laughlin, W. G. Monahan, R. S. Tilbury, L. Zeitz.

Unit Chairman

Louis Zeitz, Sloan-Kettering Division, Room 206K, Kettering Laboratory

Graduate work is offered leading to the Ph.D. degree in biophysics and the M.S. in radiation physics. A candidate for the Ph.D. must have a B.A. or B.S. degree with a major in physics, or with a major in biology, chemistry, or mathematics and a minor in physics. A candidate for the M.S. must have a B.A. or B.S. in physics from a recognized university.

Undergraduate prerequisites for the Ph.D. candidate include courses in general physics, electricity and magnetism, mechanics, mathematics (through calculus), and thermodynamics, and acceptable laboratory experience in these subjects. Any of those requirements not completed at the undergraduate level must be completed during graduate study. Graduate course work required for the Ph.D. is flexible depending upon the student's background and basic interests but ordinarily would include advanced quantum mechanics, electrodynamics, and nuclear physics and courses in the student's minor subjects. In addition, a month spent full time on a laboratory project is required in each of his two minor disciplines. The student must pass both a qualifying examination covering various basic aspects of his major and minor subjects and the examination for admission to Ph.D. candidacy. The thesis required for the Ph.D. in biophysics should demonstrate the ability of the student to make a thorough and original investigation in an important area of biophysics. There is no mandatory foreign language requirement.

Some of the research projects in biophysics which are pertinent to the Ph.D. program include: kinetics of the distribution of various isotope-labeled compounds in man; metabolism of biologically important compounds in tissue cultures of human tumor cells, in bacteria, and in viruses; the mechanism of radiation action on bacteria and small animals, including metabolism studies with human and other tumors influenced by radiation under different environmental conditions; fundamental radiobiological studies of mammalian cells in tissue culture, trace element analysis of tissue sections by means of fluorescent x-ray spectrometers; study of the early radiation-induced processes in cells using high-intensity pulsed irradiation techniques; the investigation, using existing computer facilities, of mathematical models which simulate the behavior of biological systems, e.g. the proliferation of cells in human leukemia; the measurement of radiation by calorimetric, chemical, and solid-state techniques.

A candidate for the M.S. must have a B.A. or B.S. in physics from a recognized university having completed undergraduate courses in general physics, mechanics, electronics, electricity and magnetism, modern physics, and mathematics through differential equations. The candidate is expected to pass, satisfactorily, courses selected from some of the following subjects: physics, biophysics, biology, radiobiology, biochemistry, and biomathematics and must minor in one of those subjects other than physics. The thesis subject must be in the field of radiation physics and must represent a comprehensive study demonstrating a thorough knowledge of the chosen subject. A final oral examination will be given primarily on the subject of the thesis and may be preceded by a written examination covering the fundamental principles of the course work. There is no mandatory foreign language requirement.

The course of study leading to the M.S. degree in radiation physics trains physicists in the various aspects of production, measurement, and application of radiation to various medical and biological problems. These problems particularly involve the use of radiation in the diagnosis

and treatment of cancer. A variety of radiation sources is available, capable of generating photons and electrons with energies ranging from 5 Kev to 25 Mev and with electron dose-rates up to 10^{14} rads per second. Experience is also provided in the handling and use of many different radioisotopes. The magnitude and variety of facilities and unique radiation projects at the Sloan-Kettering Institute and the Memorial Hospital are particularly pertinent for training in this area. An important feature is the coexistence of fundamental research and practical and clinical applications in the same center.

Special Interests of the Faculty

Radiobiology: B. Djordjevic, E. R. Epp, J. S. Laughlin, L. Zeitz.

Theoretical Biophysics: E. R. Epp, J. Fried, N. Kessaris. Biological Radiation Dosimetry: E. R. Epp, N. Kessaris, J. S. Laughlin.

Radioactive Isotope Metabolism: J. S. Laughlin, W. G. Monahan.

Isotope Data Analysis and Instrumentation: J. S. Laughlin, W. G. Monahan, L. Zeitz.

Radiation Chemistry: A. Gelbard, R. S. Tilbury.

Courses

1. Radiological Physics. Lectures and problems. A series of hourly lectures and assigned problems in applied mathematics, fundamentals of radiation physics, x-ray and radium treatment planning, diagnostic x-ray principles, radiation protection, and uses of radioactive isotopes.

2. Radiobiology. A semester course in fundamental radiobiology dealing with the effects of radiation on cells, viruses, and macromolecules, as well as on whole animals. The course also covers areas of radiation physics and radiation chemistry pertinent to radiobiology.

3. Advanced Biophysics. Laboratory courses in each of the topics of radiation biophysics.

4. Biophysics Colloquia. Reports on research in progress by faculty and outside lecturers. Required for majors in biophysics.

Interdivisional Courses

Advanced Biochemistry. A graduate course in biochemistry is offered jointly by the faculties of the Medical College Division and the Sloan-Kettering Division. In each trimester, two lectures are given each week. It is not essential that students take the course in any particular sequence. The course includes consideration at an advanced level of the following subjects, with particular attention to contributions of recent research: Fall 1972 – Physical Biochemistry: Methodology; Winter 1972 – Biochemistry of Macromolecules; Spring 1973 – Membrane Phenomena and Regulatory Mechanisms. T Th 10:30–12:00. Professors Bendich, Haschemeyer and staff.

General Microbiology. Offered by the staff of the Field of Microbiology of the Medical College Division and of the Biology Unit of the Sloan-Kettering Division. Intended to provide a general knowledge of the subject for students minoring in microbiology and for nonminors who want a background in the subject. It is not primarily intended for students majoring in the subject who already have an extensive background from undergraduate study. Lectures are offered weekly during both semesters. Aspects of microbiology covered include fundamental procedures, microbial growth and physiology, genetics, immunology and serology, virology, plant and animal pathogens and applied microbiology. Auditors from all Fields and Units are welcome. Every second year. Offered 1972–73. Th 3:00–5:00 p.m. Professors Hutchison and O'Leary.

Special Programs

Ph.D.-M.D. Program

Students enrolled in the Graduate School of Medical Sciences are eligible for admission into the Ph.D.-M.D. Program, jointly sponsored by the Medical College and the Graduate School of Medical Sciences. This program is designed for those few graduate students whose teaching and research goals require the acquisition of the M.D. degree in addition to the Ph.D. degree. Students accepted in this program must complete all of the required course work of the first two years of medical school during their course of study and research leading to the Ph.D. degree. Upon completion of all requirements for the Ph.D. degree, including the defense of their theses, students in this program will be accepted for admission to the Medical College with advanced standing. After satisfactory fulfillment of the required clinical rotations of the Cornell third-year medical curriculum, these students may receive credit for their graduate studies to satisfy the elective requirements of the fourth-year medical curriculum and will then be recommended for award of the M.D. degree by Cornell University.

Only students enrolled in the Graduate School of Medical Sciences, or accepted for enrollment, are eligible for admission to the Ph.D.-M.D. Program at Cornell University Medical College. To apply, graduate students must submit a completed application for admission to Cornell University Medical College together with a plan of graduate study incorporating the required course work of the first two years of medical school and endorsed by their Special Committee. Only applicants who are found to be acceptable for admission to Cornell University Medical College by its Committee on Admissions, after review of the application and personal interview of the applicant, will be accepted into the Ph.D.-M.D. Program.

M.D.—Ph.D. Programs

Programs of study leading to the Ph.D. degree are available to (1) students entering Cornell University Medical College, (2) medical students already matriculated at the Medical College, and (3) resident physicians in hospitals affiliated with the Medical College.

Entering Medical Students

The applicant to this program for entering medical students must apply to both the Cornell University Medical College and the Graduate School of Medical Sciences and be

accepted under the admissions procedures of both schools.

The purpose of this program is to expose the student to both medical and graduate disciplines from the outset. The student spends his first two years as a medical student studying the basic medical sciences and attending regular graduate seminars. The summer months are spent in the laboratory learning experimental techniques and doing research. The third and fourth years of the student's program are spent as a full-time graduate student and are devoted exclusively to laboratory research and writing the thesis. The fifth year of the program is spent as a medical student in clinical study. The sixth year can be spent in either laboratory or clinical work. This six-year program represents the minimum time required to satisfy residence requirements of both the M.D. and Ph.D. degrees at Cornell University.

Matriculated Medical Students

A medical student enrolled in the Cornell University Medical College may interrupt his medical studies at any time to pursue full-time graduate study leading to the Ph.D. degree. The student must fulfill all regular requirements of the Graduate School of Medical Sciences. A maximum of two residence credits for basic science course work taken in the medical curriculum can be granted toward the Ph.D. degree after the student passes an evaluation examination.

A medical student who elects to begin graduate work leading to the Ph.D. degree in his senior year of medical school may register in both the Cornell University Medical College and the Graduate School of Medical Sciences. He begins his graduate didactic work during that year, and, ordinarily, the M.D. degree is granted at the end of that year. Research in the area of the Ph.D. thesis topic is begun during the fifth year. A two-year period of full-time research is a realistic minimum estimate for the time required to execute the experimental and theoretical work necessary to fulfill the requirements for the Ph.D. degree.

Resident Physicians

The resident physician may enroll in the Graduate School of Medical Sciences as a full-time graduate student working toward the Ph.D. Part-time graduate study is not permitted. A maximum of two residence credits for medical school course work in the basic sciences can be granted toward the residence requirements of the Ph.D. degree after the student passes an evaluation examination.

Prospective applicants to these programs should communicate with the associate dean of the Graduate School of Medical Sciences.

Register

Administration

Cornell University

Dale R. Corson, President of the University
Robert A. Plane, University Provost
W. Donald Cooke, Vice President for Research
Lewis H. Durland, University Treasurer
William D. Gurowitz, Vice President for Campus Affairs
Samuel A. Lawrence, Vice President for Administration
E. Hugh Luckey, Vice President for Medical Affairs
Thomas W. Mackesey, Vice President for Planning
Paul L. McKeegan, Vice Provost
Arthur H. Peterson, University Controller
Richard M. Ramin, Vice President for Public Affairs
Robert F. Risley, Vice Provost
Neal R. Stamp, Secretary of the Corporation and
University Counsel

Graduate School of Medical Sciences

Dale R. Corson, President of the University
E. Hugh Luckey, Vice President for Medical Affairs
W. Donald Cooke, Dean of the Graduate School
Thomas H. Meikle, Jr., Dean of the Graduate School of
Medical Sciences; Associate Dean of the
Graduate School
Julian R. Rachele, Associate Dean of the Graduate School
of Medical Sciences; Assistant Dean of the
Graduate School
Leo Wade, Acting Director, Sloan-Kettering Division
Frederick S. Phillips, Associate Director,
Sloan-Kettering Division

Faculty

Professors

M. Earl Balis, Professor of Biochemistry. B.A. 1943,
Temple University; Ph.D. 1949, University of
Pennsylvania.
Alexander G. Bearn, Professor of Medicine. M.B., B.S.
1946, M.D. 1951, University of London.
Aaron Bendich, Professor of Biochemistry. B.S. 1939,
City College of New York; Ph.D. 1946, Columbia
University.
Dorothea Bennett, Professor of Anatomy. A.B. 1951,
Barnard College; Ph.D. 1956, Columbia University.
Edward A. Boyse, Professor of Biology. B.S. 1952,
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- James J. Zazra, B.S. 1972, Illinois Institute of Technology. Major: Biochemistry. Chicago, Illinois.

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Cornell University Medical College

- 1 Anatomy Building
- 2 William Hale Harkness Medical Research Building
- 3 Samuel J. Wood Library and Research Building
- 4 Biochemistry-Pharmacology Building
- 5 Olin Hall
- 6 Livingston Farrand Apartments

Sloan-Kettering Institute for Cancer Research

- 7 Kettering Laboratory
- 8 Howard Laboratory

9 Margaret Caspary Research Building

10 Institute for Muscle Disease

- 11 **The New York Hospital**
- 12 Payne Whitney Psychiatric Clinic
- 13 Nurses' Residence
- 14 Payson House

15 Memorial Hospital

- 16 Ewing Pavilion
- 17 Sloan House
- 18 Norman Winston House

19 Rockefeller University