

University of Puerto Rico
Medical Sciences Campus
School of Medicine
Division of Biomedical Sciences



Manual for Graduate Studies in the Division of Biomedical Sciences



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Message



Welcome to the Biomedical Sciences Graduate Program (BSGP) at the University of Puerto Rico Medical Science Campus (MSC), where education and research are our highest priority. Our goal is to educate individuals dedicated to pursue an exciting and rewarding career, in an academic environment leading to excellence in research and teaching. We are the only academic institution in Puerto Rico that offer programs leading to a Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees with specialties in our basic departments of Anatomy & Neurobiology, Biochemistry, Microbiology & Zoology, Pharmacology & Toxicology and Physiology. In addition, we provide doctoral degree sub-specialties (tracks) in Neuroscience, Virology and Molecular Genetics. Moreover, we support combined MD/PhD degrees programs in our academic institution or in collaboration with Mayo Clinic and MD Anderson Cancer Center. Our BSGP cosponsor an intercampus Ph.D. program with the Department of Biology at the Río Piedras Campus.

We have an outstanding, motivated and experienced faculty who has taken a leadership role in and outside Puerto Rico. These qualifications guarantee a comprehensive and stimulating environment for our students to pursue a career in the research and/or academic arena. Our graduate faculty fosters interdisciplinary collaboration between basic and clinical scientists (within Puerto Rico and with well-know investigators around the world) in an effort to broaden the exposure of our students beyond what is traditionally expected in biomedical research. Students participate in a wide variety of courses, seminars, workshops, and similar activities scheduled by our five departments. We currently have over 100 doctoral and master students that have been exposed to the most recent discoveries at the molecular and system level, state-of-the-art instruments and techniques. Our well-trained graduates obtain positions in the pharmaceutical industry, teaching institutions (colleges and/or universities), and postdoctoral positions in Puerto Rico or in main research institutions in the USA mainland.

We invite you to consider this as a place where you can find forms, policies, procedures, news, and other information related to our graduate program. No matter which of our five Biomedical Science departments you concentrate in, or how ambitious your goals are, I am confident that you will find our BSGP an exciting and supportive environment to pursue your graduate training and personal goals.

Sincerely,

Staff
Associate Deanship for
Biomedical Sciences Graduate Program
School of Medicine, MSC-UPR

Governance

ADMINISTRATIVE OFFICERS

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CORRESPONDENCE AND INFORMATION

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GRADUATE COMMITTEE

Associate Dean & Director of Graduate Studies

Graduate School Coordinator

Director & Graduate Studies Coordinator, Dept. of Anatomy & Neurobiology

Director & Graduate Studies Coordinator, Department of Biochemistry

Director & Graduate Studies Coordinator, Dept. of Microbiology & Medical Zoology

Director & Graduate Studies Coordinator, Department of Pharmacology & Toxicology

Director & Graduate Studies Coordinator, Dept. of Physiology

Graduate Student Association Doctoral Student Representative

Graduate Student Association Master Student Representative

General Information

Graduate work in the School of Medicine falls under the auspices of the Division of Graduate Studies and is carried out in close coordination with its Basic Sciences Departments. An Advisory Graduate Committee composed of Departmental chairmen, Program Directors, Graduate Faculty and student representatives advises the Director of the Graduate Division on all graduate matter. The Director, in consultation with the Graduate Committee, is responsible for the setting standards of excellence and the quality of all graduate programs. The Graduate Division has final responsibility for both the academic standards and uniform degree requirements of all programs within the basic sciences.

The Division of Graduate Studies grants the academic degrees of Master of Sciences (M.S.) and Doctor of Philosophy (Ph.D.) in the Departments of Anatomy, Biochemistry and Nutrition, Microbiology and Medical Zoology, Pharmacology and Toxicology, and Physiology and Biophysics. In addition to the basic requirements, it establishes additional requirements. Within each Department, however, individual latitude is permitted of the choice of areas of study and final program selection. All students are encouraged to utilize the full spectrum of available university resources throughout their graduate career.

Graduate degrees are granted after presentation of evidence that the student is capable of independent investigation leading to an original contribution to his/her chosen scientific field of interest, as judged by the Thesis Committee and approved by the Graduate Committee.

An Intercampus Ph.D. in Biology is also offered by the University of Puerto Rico with resources provided by the Río Piedras Campus (Department of Biology and the Resources Center for Science and Engineering, College of Natural Sciences) and the Medical Science Campus (Basic Sciences Departments of the School of Medicine, the Laboratory of Neurobiology and the Caribbean Primate Research Center).

HISTORICAL SKETCH

Medical research in Puerto Rico had its beginning with the First Anemia Commission which was established by the Insular Government in 1904 as a result of the discovery by Bailey K. Ashford that hookworm infestation was the principal causative of the anemia present in this island. In 1912 the Institute of Tropical Medicine was created to further the research initiated by the Anemia Commissions, and in 1926 new legislation expanded the Institute of Tropical Medicine into the School of Tropical Medicine of the University of Puerto Rico which was operated under the sponsorship of Columbia University.

Courses were initiated at the School of Tropical Medicine in 1927 for students interested in tropical medicine and nutrition. This was the same year the courses for the degree of Master of Arts in Spanish Studies were begun at the University of Puerto Rico in Río Piedras. Although most of the students continued their graduate work at Columbia University the University of Puerto Rico gave two degrees of Master of Arts in May, 1930 for work done at the School of Tropical Medicine.

In 1948, by mutual consent, the agreement between the University of Puerto Rico and Columbia University was terminated, and in May of the following year, 1949, the creation of the School of Medicine of the University of Puerto Rico was authorized by an act of the Legislature of Puerto Rico. The School of Medicine, which evolved from the former School of Tropical Medicine, admitted its first class in August 1950. In 1956 by joint resolution of the Legislature of Puerto Rico, the School of Dentistry was established to operate in conjunction with the Medical School and accepted its first class in August 1957. In 1960 the Council of Higher Education of the University of Puerto Rico approved the graduate programs of the Departments of Anatomy, Biochemistry and Nutrition, Medical Zoology, Microbiology, and Physiology. In August of the same year the Chancellor of the University of Puerto Rico appointed an Executive Graduate Committee with responsibility to administer Graduate Studies in the Basic Sciences. The Graduate Program of Histopathology in the Dental School was approved by the Council of Higher Education in October 1962. Graduate programs in Pharmacology (Toxicology) and Pathology were approved by the Council in 1964 and 1965, respectively.

The present Medical Sciences Campus (MSC), which encompasses the Schools of Medicine, Dentistry, Pharmacy, Public Health, and Health Related Professions, was created as a result of the 1966 reform of the organization of the University of Puerto Rico. Within the Medical Sciences Campus the Graduate Programs were structured under the Chancellor's office.

In 1976 the Medical Sciences Campus underwent an internal re-organization and the Graduated Division became academically and administratively a part of the School of Medicine, under the Associate Dean for Biomedical Sciences.

The first degree of Master of Science was granted by the Graduate Division in June 1963, and the first degree of Doctor of Philosophy in May, 1967. A total of 88 master's degrees and 31 doctoral degrees have been conferred so far.

In recent years opportunities for graduate studies in the Medical Sciences Campus have been greatly, strengthened both in quality and scope as the result of the concerted effort of faculty and administration to improve research, research-related activities, and the research infrastructure within the Campus.

Some of the accomplishments already achieved are the increase in the number of research-oriented faculty members, the building of new research facilities (e.g., the 6th floor addition to the Medical Sciences Building, the remodeling of the Animal House facilities in the 10th floor of the same building); the creation of the Division of

Comparative Medicine; the organization of scientific forums like Research Week and the Student's Research Congress, the publication of the Puerto Rico Health Sciences Journal; the incorporation of the Campus to the PROPHET research computer network; the awarding of a MBRS grant to the Medical Sciences Campus by the National Institutes of Health; and the establishment research assistantships for the support of graduate students.

MISSION & GOALS

❖ Mission

The mission of the Associate Deanship of Biomedical Sciences is to transmit, enrich and enhance knowledge in the basic biomedical sciences through its Graduate Program, and the conduct of basic and clinical research.

❖ Goals

The Division of Biomedical Sciences was created by Council of Higher Education's Certification number 48 (1975-76). Its goals are:

- To provide education in Biomedical Sciences and foster the development of the Graduate Program in the basic sciences.
- To achieve an education of excellence in the Graduate Programs in Basic Sciences by awarding Master of Sciences and Doctorates in Philosophy degrees.
- Stimulate and increase knowledge, develop critical thinking skills, and foster professional ethical values.
- To stimulate basic and clinical faculty research development.

DEGREES CONFERRED

The Division of Graduate Studies has as its objective the advancement and dissemination of scientific knowledge through research in the biomedical sciences. For this purpose the Division coordinates graduate education leading to two advanced academic degrees: the Master of Science (M.S.) and the Doctor of Philosophy (Ph.D).

Graduate studies are presently carried out in close coordination with the Basic Sciences Departments of the School of Medicine, with M.S. and Ph.D degrees offered in Anatomy, Biochemistry, Microbiology, Pharmacology, Physiology, and Toxicology.

The School of Medicine recognizes that the meaningful teaching of medicine requires the support provided by the research in the Basic Sciences and, thus, is committed to sustain a strong program of graduate biomedical education.

APPLICATION DEADLINE

APPLICATION DATES *
(LAST DAY)

STARTING DATES

February 15

next August
(next semester)

September 15

next January
(second semester) **

* Students not able to complete the application by this dates, should contact the program office.

** Second semester entrance is not available at this moment.

GRADUATE STUDENT ASSOCIATION

❖ History and Purpose

The Biomedical Sciences Graduate Students Society of the Biomedical Sciences Associate Deanship-School of Medicine was created in 1990 and officially accepted in the University in 2000. Established as a non-profit organization, it is a forum to discuss and work situations concerning the academic interests of the graduate students in the aforementioned deanship.

Specific objectives include:

- To promote scientific research in our institution in the undergraduate, graduate and post-graduate levels.
- To guide and teach the student community and health-related professionals about the latest technologies and methodologies in the biomedical sciences.
- To expand intellectual and professional development of students and faculty committed to the biomedical sciences area, not discriminating on political

reasons, religion, age, civil status, race, sex, ethnicity, economical or national status, physical or mental disability.

- Represent and fight for the rights of the graduate students that belong to the Associate Deanship for Biomedical Sciences and the Inter-Campus Program of the University of Puerto Rico, Medical Sciences and Río Piedras Campus.

❖ **Directive Members** (elected by the students)

- *President*
- *Vice President*
- *Secretary*
- *Treasurer*
- *Department Representatives (one of each department)*
- *Graduate Committee Representatives (one of each program)*
- *Academic Senate Representatives*
- *Vocals (2)*
- *Medicine Council Vocal (1)*

OATH OF THE BIOMEDICAL SCIENCES PROFESSIONAL

As a professional in the Biomedical Sciences I firmly pledge:

To work for a better world, where science and technology are used wisely and ethically.

To use my knowledge to protect the environment and human life.

To dedicate my career and time in deliberating the ethical implications of my work, in a way that actions will always reflect not only my knowledge, but also sensibility toward others.

To do my research in rigorous manner and share the findings with discretion.

To disclose findings in publications and symposia dedicated to the biomedical sciences.

To recognize as a responsible investigator the importance of collaborating in joint projects and to instruct future generations.

As a professional I will be constantly committed to my endeavors and will honor this oath that I solemnly and freely manifest.

So help me God.

Graduating Class
Medical Sciences Campus
University of Puerto Rico

Creation AEG 2001 / Translation AEG 2006

STUDENT FINANCIAL ASSISTANCE

❖ *Cost of Study*

Tuition for Puerto Rico residents is \$132.00 per credit hour. Nonresidents from other parts of the United States pay the same tuition that Puerto Rico residents pay at their respective state universities. For international nonresidents, tuition is \$5,446 per year, plus additional fees. An additional fee of approximately \$430 is necessary for all students to cover the construction and laboratory fees, as well as medical insurance.

○ *Tuition and Fees*

- Application Fee ----- \$ 20.00
- Tuition
 - ❖ Tuition for credits ----- \$132.00 per credit / semester
 - ❖ Tuition for Labs ----- \$ 33.00 per credit / semester
- Institutional Fee
 - ❖ Facilities Fee ----- \$ 47.00 per semester
 - ❖ Technological Fee ---- \$ 25.00 per semester & Summer
 - ❖ Special Fee-----\$400.00 per semester
- Other Fees:
 - ❖ Medical care contract (regular students only)

❖ *Living and Housing Cost*

Housing costs vary widely in the vicinity of the Medical Sciences Campus. Apartments generally rent for between \$300 and \$600 per month. Prices for food and other articles are similar in major United States cities.

❖ *Sources of Financial Aid*

Graduate students can apply for financial assistance through teaching or research assistantships funded by the University, the National Institutes of Health (NIH), the National Science Foundation (NSF), the Ford Foundation and the Department of Energy

Funds are available from the Division to support the thesis research projects of graduate students.

The Medical Sciences Campus is recipient of the MBRS Program from the National Institutes of Health. This program has as one of the specific purposes to provide stipends for attracting undergraduate and graduate students to biomedical

research. A listing of the component projects and researchers participating in MBRS programs can be obtained at the appropriate MBRS Program offices. Applications for MBRS support should be submitted to the above-Mentioned Program Directors.

The Office of the Chancellor administers university funds aimed to provide support of graduate students as Research Assistantships.

Other sources of financial aid could be available from individual investigator grants.

The office of Economic Assistance, Deanship of Students, handles all other types of fellowships and loans for graduate students.

Academic Regulations

The regulations and requirements herein contained have been extracted from documents approved by the Academic Senate as of July, 1976. Amendments were introduced and approved by the Graduate Committee in 1977.

It is the responsibility of the student to become fully familiar with the contents of this section.

The Division of Graduate Studies for Biomedical Sciences of the School of Medicine, University of Puerto Rico, offers two advanced degrees: the Master of Science and the Doctor of Philosophy. In administering these academic degrees the Division Imposes certain minimum requirements upon the student while permitting free latitude in choice of studies and the utilization of all resources of the University relevant to his or her work. The Division emphasizes that the exercise of initiative and the development of independent, creative research work and of critical, objective thinking are necessary for the pursuit of scientific truth and thus, are essential aspects of graduate education. If no instance shall it be implied or inferred that the faithful performance of work in completion of the minimum requirements set down by the division will necessarily fully qualify the candidate for the degree.

At present M.S. and Ph.D. degrees are offered in the departments of Anatomy, Biochemistry and Nutrition, Microbiology and Medical Zoology, Pharmacology and Toxicology, and Physiology.

Anyone interested in these programs should write to the Director, Division of Graduate Studies, Medical Sciences Campus, University of Puerto Rico, PO Box 365067, San Juan, Puerto Rico 00936-5067.

ACADEMIC CALENDAR

A complete Academic Calendar is yearly published by the Registrar's Office, Deanship of Academic Affairs. The Division of Graduate Studies has copies available of this calendar.

ADMISSION REQUIREMENTS

The minimum requirements for admission are:

- ❖ Have a Bachelor's degree or its equivalent (as determined by the Registrar's Office) with a grade index of at least 3.00 overall and 3.00 in science subjects (on a 4.00 scale).
- ❖ Be proficient in English and Spanish.
- ❖ Submit scores of the Graduate Record Examination (GRE), general and subject test in Biology, Chemistry, physics or related areas.
- ❖ Submit three (3) letters of recommendation; two (2) from professors in the major field, one (1) from a professor in another department.
- ❖ Participate of an interview with a graduate faculty member.

* A course of analytical chemistry at sub-graduate level is required for applying to MS and PhD in Biochemistry.

* Previews research training is highly recommended. (Must present evidence).

ENROLLMENT DETAILS

A student who fully satisfies the requirements and is admitted to the program, becomes a regular student. If the student lacks some of the less critical requirements, he may be admitted as a special student for one semester. Failure to satisfy the missing requirements during the first calendar semester automatically disqualifies the student from the program for this reason may reapply; however, he must have satisfied the missing requirements before his new application is considered. Special students are not eligible for financial assistant from the Graduate School.

Under very special circumstances a student who has a grade index of less than 3.00 may be admitted as a conditional student for one semester. This can only be done upon recommendation of the Department and approval of the Graduate Committee when evidence other than his average indicates that the student is qualified. The conditional student must show his capacity for graduate work by compiling at least a 3.00 grade average during the conditional semester. At the end of the conditional semester the student must pass to regular status, or is barred from the program. Conditional students are eligible for financial assistance from the Graduate School.

No one may be enrolled in the Graduate Program as a regular, special or conditional graduate student without approval of the Graduate Committee.

STUDY PROGRAM

Each Department will have one faculty member designated as Graduate Advisor by the Department Chairman. (He may be the chairman himself). In general, a student's program for the first year is in the hands of the Graduate Advisor. If a student has defined research interests, his program may be handled from the beginning by a research committee (see below). The Graduate Advisor or research committee plans together with the student his program for at least the first year, and forwards a copy to the Graduate Division Office at the beginning of the first term.

At the end of the first academic year, the Department, through the Graduate Advisor or the Research Committee, evaluates the student's performance and sends a report to the Graduate Committee in the forms provided for the purpose. At this time any recommendations for change in status are made. If the department decides that the student's performance is not satisfactory it may recommend that he be dropped from the Program, or placed on probation for one semester. There must be specific areas in the student's performance which he can improve in one semester for probationary status to be granted. These recommendations are reviewed by the Graduate Committee before they become effective. In the case of probationary status, a further report and decision must be made at the end of the probationary semester. The evaluation must take into consideration the student's performance in course work, participation in departmental graduate seminars and other seminars, and other considerations reflecting upon his capacity for, and dedication to, graduate studies.

At the end of the first year the student will select his Research Advisor, if he has not done so before. His committee is then chosen by himself and the Advisor, subject to approval by the Graduate Committee. It consists of the Research Advisor, two other Department faculty members (one in the case of a Master's student), and at least one member from another Department. This committee is then responsible for the continuation and termination of the student's work. It must submit a program of studies for the student to the Graduate Division, meet with the student at least every six months, and submit a yearly report on his activities. Specially qualified students may, subject to Departmental recommendation and approval by the Graduate Committee, continue directly towards a Ph.D degree without first completing the M.S. degree.

COURSE LOAD

A full-time load is 9 or more credits per semester. A maximum of 15 credits per semester is allowed. Part-time students are allowed a maximum of 9 credits per semester. Students must register every term; failure to do so disqualifies the student from the program. A new application would then have to be submitted.

RESIDENCE REQUIREMENTS

The Graduate Faculty regards study in residence as essential. Residence implies full time dedication to graduate studies. It is considered that a graduate student needs the acquaintance, company, aid, and stimulus of others engaged in work like his own; he should form the habit of attending lectures and meetings of groups in whose activities he takes an interest. And he should be able to take full advantage of the libraries, laboratories and other facilities of the University.

For a Master's degree the student must be in residence for at least one calendar year at the University of Puerto Rico. For a Doctor's degree two calendar years are required.

If the M.S. degree is taken at this campus only one additional year of residence is required for the Ph.D. This rule may also apply to students with M.S. degree obtained at other campuses of the University Puerto Rico, subject to approval of the student's Department and the Graduate Committee.

It is expected that each student will dedicate full-time effort to his research for at least a year.

TRANSFER OF CREDITS

For the M.S. degree a maximum of 9 credits may be transferred from an accredited institution.

For the Ph.D degree a maximum of 24 credits taken at another accredited institution may be transferred, subject to approval by the Department, and the Graduate Committee.

SCHOLARS STANDARDS

A student must maintain a 3.0 average (4.0 scale) during his studies. If at the end of any academic year he is below that average, he must be placed on probationary status for a semester.

All courses in the Graduate School will be graded as:

| | |
|-------------|------------------|
| A- 4 points | C- 2 points |
| B- 3 points | D or F- 0 points |

Grades lower than C do not carry graduate credit, but are computed for the average. Courses can not be dropped unless written approval is given both by the instructor and by the Graduate faculty Director of the student's Department in a letter signed by the Graduate Advisor.

LANGUAGE REQUIREMENTS

A working knowledge of both English and Spanish is a basic requirement for study in this program. There will be no foreign language requirements set by the Graduate Committee. However, a student's research committee is empowered to set any language requirements which it feels will be essential for the particular student.

TIME LIMITATIONS

Five years are allowed for earning the M.S. Degree and seven years for the Ph.D Degree.

Courses taken more than five years previous to the granting of the M.S. degree, and more than seven years previous to the granting of the Ph.D degree may be accepted, with the following provisions:

- a. The time limitations for the degrees themselves cannot be exceeded.
- b. An examination showing that the student's knowledge is equivalent to that obtained in a current course must be passed.
- c. Approval of the Associate Dean or Graduate Committee is required.

CANDIDACY FOR PH.D. DEGREE

A student shall be admitted to candidacy when he or she has complied with the following requirements:

- a. Approval of at least 25 credits
- b. Overall average of 3.0 in graduate courses taken, and also 3.0 average in the courses of the student's major Department.
- c. Satisfied any language requirements set by student's Research Committee.
- d. Submitted a thesis proposal which was approved both by the Research and the Graduate Committees.
- e. Received a favorable recommendation from his Research Committee based on the student's dedication to, and capacity for, graduate study.
- f. Passed a comprehensive examination administered by the Department. (This examination can be taken only twice).

g. Satisfied any departmental requirements in addition to the above.

The student should complete the candidacy requirements by the end of his or her second year in the Graduate Committee.

DISSERTATION AND THESIS DEFENSE FOR M.S. AND PH.D. DEGREES

The student is expected to submit a proposal to his research committee as early as possible. The committee will meet with the student to discuss the proposal.

The dissertation is required of every graduate student and must be an original contribution to scholarship resulting from investigation in the student's research committee, both with regard to scholarship and to literary quality.

The final oral examination will cover the dissertation and the general field of the dissertation, and such other parts of the student's program as the Research Committee may determine. If the examiners are satisfied with the candidate's performance, then they sign the approval sheets for the dissertation and an official recommendation of the candidate to the Graduate School.

Two (2) bound original copies of the thesis are required. One (1) original copy will go to the Library and the other one stays in the Associate Deanship. Other copies will go to the Advisory Committee members, the Advisor, the Major Department, and the student. Details for the preparation of the thesis can be found in appendix 1.

SUMMARY OF REQUIREMENTS

- ❖ Grade Index - 3.0
- ❖ Credits - for M.S. degree, a minimum of 30
- for Ph.D. degree, a minimum of 60
- ❖ Residence - one calendar year for the M.S. degree
- two calendar years for the Ph.D degree
- ❖ Candidacy - required only for Ph.D. degree students dissertation
- ❖ Final examinations - Thesis Defense
- ❖ Other special Departmental requirements

Research Program & Facilities

The divisions facilities are housed in the Medical Sciences Campus building, with ancillary facilities at the:

- ACTU - AIDS Clinical Trials Unit (<http://medweb.rcm.upr.edu/actu5401/>)
- BREP - Puerto Rico Biomedical Research Education Program (<http://brep.rcm.upr.edu/indexsp.html>)
- Cancer Center (<http://medweb.rcm.upr.edu/ccpr/eng/index.htm>)
- Caribbean Primate Research Center (<http://ucm.rcm.upr.edu/cprc.html>)
- Center for Energy and Environmental Research
- RCMI-CRC - Clinical Research Center (<http://rcii.rcm.upr.edu/>)
- Institute of Neurobiology (<http://www.neuro.upr.edu/>)
- Latin American Center for the Study of Sexually Transmitted Diseases
- MBRS-RISE - Minority Biomedical Research Support – Research Initiative for Scientific Enhancement (<http://mbrs-rise.rcm.upr.edu/>)
- MBRS-SCORE - Minority Biomedical Research Support – Support of Continuous Research Excellence (<http://mbrs-score.rcm.upr.edu/>)
- RCMI - Research Center in Minority Institutions (<http://rcmi.rcm.upr.edu/>)
- SNRP - Specialized Neurosciences Research Program (<http://snrp.rcm.upr.edu/index.html>)

Each department has its own laboratories and office space for faculty and students as well as specialized equipment. A system of core laboratories serves the needs of several departments, providing facilities for tissue culture, electron microscopy, flow cytometry and cell sorting, histocompatibility testing, and hybridoma preparation, as well as a BL3 virology laboratory, an AIDS Clinical Trials Group (ACTG) certified laboratory, facilities for molecular biology and molecular parasitology, and state-of-the-art animal facilities, including BL3 areas for primates. These facilities house research and teaching laboratories, faculty offices, lecture rooms, and specialized libraries.

A central library serves the general needs of the academic community, and there are electronic linkages with other local and national libraries. Students are granted access to the resources they may need to carry out their research program.

Graduate Programs

ANATOMY & NEUROBIOLOGY

❖ Faculty Research Interests

- Jennifer L. Barreto-Estrada, Assistant Professor; Ph.D., UPR-RPC, 2001. CNS molecular/cellular changes linked to reproductive health after exposure to androgens during puberty.
- Martine L. Behra, Assistant Professor; Ph.D., University Louis Pasteur Strasbourg, France, 2002. Genetic and genomic approaches to study hair cell regeneration in the zebrafish lateral line.
- Rosa E. Blanco, Professor; Ph.D., Cambridge, 1987. Visual system nerve regeneration.
- Franklin Carrero-Martínez, Adjunct Professor; Ph.D., U. Illinois, 2005. Molecular, genetic, and structural influences on the development of the neuromuscular junction in *Drosophila melanogaster*.
- Manuel E. Díaz-Ríos; Assistant Professor; Ph.D., UPR-MSU, 2003. Central pattern generators and control of locomotion in mammals.
- Donald C. Dunbar, Professor; Ph.D., Oregon, 1980. Mammalian functional morphology and biomechanics, and neural control of locomotion and posture.
- Jaime Inserni, Adjunct Professor; M.D., UPR-MSU, 1983. Clinical neurosurgery.
- Juan Carlos Jorge, Associate Professor; Ph.D., Brandeis University, 1997. Behavioral neuroendocrinology; steroid effects in synaptic physiology, neural structure, and behavior in vertebrates.
- Robert W. Kensler, Professor; Ph.D., SUNY at Stony Brook, 1978. Macromolecular structure of muscle thick filaments.
- Bruno Marie, Adjunct Professor; Ph.D., U. Sussex UK, 1999. Molecular and genetic control of synaptic growth and homeostasis in *Drosophila*.
- Robert I. Meléndez, Assistant Professor; Ph.D., Purdue U, 2002. Neural regulation of ethanol intake and ethanol relapse propensity.

- Mark W. Miller, Professor; Ph.D., Connecticut, 1980. Cellular basis of natural behavior patterns in invertebrates; neuropeptides.
- Alexis Ortiz, Adjunct Professor; Ph.D., Texas Woman's University, 2006. Sports biomechanics, injury risk factors and injury prevention programs especially in women with lower injuries.
- N. L. Pérez-Acevedo, Assistant Professor; Ph.D., UPR-RPC, 2001. Synaptic physiology and cellular basis of emotional memory.
- Gregory J. Quirk, Adjunct Professor; Ph.D., SUNY at Brooklyn, 1990. Interactions at the prefrontal amygdala associated with fear conditioning.
- Maria A. Sosa, Professor & Director; Ph.D., Florida, 1993. Synaptic physiology and neural basis of aggressive behavior in crustaceans.
- Steven N. Treistman, Adjunct Professor and Director Institute of Neurobiology; Ph.D., U. of North Carolina, 1972. Neural mechanism of action of alcohol and opiate drugs.
- Guillermo A. Yudowski, Assistant Professor; Ph.D., Universidad Nacional de Córdoba, Argentina, 2003. Molecular mechanisms of neuronal function regulation through receptor trafficking and signaling in normal and pathological CNS conditions.

❖ Curriculum Sequence

ANATOMY Ph.D.
Department of Anatomy & Neurobiology

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|---|---|---|--|
| 1ST S E M E S T E R | ANAT 8501 <i>Human Gross Anatomy</i> 8 ANAT 8503 <i>Human Embryology</i> 2 ANAT 8504 <i>Human Cell Biol. & Microscopic Anatomy</i> 4 ANAT 8532 <i>Sem./Jour. Club Comb. I</i> 1 <p style="text-align: right;"><i>Credits = 15</i></p> | BCHM 8500 <i>Biochemistry</i> 6 FISA 8601 <i>Physiology Vert. I</i> 4 CBIO 8500 <i>Statis. for Biom. Scs.</i> 3 ANAT 8532 <i>Sem./Jour. Club Comb. III</i> 1 <p style="text-align: right;"><i>Credits =14</i></p> | ANAT 8525 <i>Practice in Teaching</i> 2 or ANAT 8526 <i>Practice in Teaching</i> 3 Electives (<i>Departmental</i>) 4 <p style="text-align: right;"><i>Credits = 6 or 7</i></p> | ANAT 8599 <i>Doc. Disser. Reser.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |
| 2nd S E M E S T E R | ANAT 8505 <i>Human Neuroanatomy & Neuroscience</i> 5 ANAT 8532 <i>Sem./Jour. Club Comb. II</i> 1 <p style="text-align: right;"><i>Credits = 6</i></p> | FISA 8602 <i>Physiology Vert. II</i> 4 ANAT 8532 <i>Sem./Jour. Club Comb. IV</i> 1 ANAT 8525 <i>Practice in Teaching</i> 2 or ANAT 8526 <i>Practice in Teaching</i> 3 <p style="text-align: right;"><i>Credits = 10</i></p> | (Thesis Proposal & Qualification Examination) ANAT 8599 <i>Doc. Disser. Reser.</i> 15 <p style="text-align: right;"><i>Credits = 15</i></p> | ANAT 8599 <i>Doc. Disser. Res.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

ANATOMY M.S.
Department of Anatomy & Neurobiology

| | YEAR 01 | YEAR 02 |
|---|---|--|
| 1 ST S E M E S T E R | ANAT 8501 <i>Human Gross Anatomy</i> 8 ANAT 8503 <i>Human Embryology</i> 2 ANAT 8504 <i>Human Cell Biol. & Microscopic Anatomy</i> 4 ANAT 8532 <i>Sem./Jour. Club Comb. I</i> 1 <p style="text-align: right;"><i>Credits = 15</i></p> | CBIO 8500 <i>Statistics for the Biom. Scs.</i> 3 ANAT 8525 <i>Practice in Teaching</i> 2 or ANAT 8526 <i>Practice in Teaching</i> 3 <p style="text-align: right;"><i>Credits = 5 or 6</i></p> |
| 2 nd S E M E S T E R | ANAT 8505 <i>Human Neuroanatomy & Neuroscience</i> 5 ANAT 8532 <i>Sem./Jour. Club Comb. II</i> 1 <p style="text-align: right;"><i>Credits = 6</i></p> | ANAT 8595 <i>Master Thesis Research</i> 6 THESIS EXAMINATION <p style="text-align: right;"><i>Credits = 6</i></p> |

❖ Graduating Student Profile

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| <p style="text-align: center;">GRADUATE PROGRAM IN ANATOMY STUDENT PROFILE MASTER'S LEVEL (M.S.)</p> |
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Upon completion of studies for a Master's Degree from the Department of Anatomy and Neurobiology Graduate Program, the graduating student will have attained the needed knowledge, and developed the necessary skills and attitudes to perform with excellence in the following areas:

- Teaching of Anatomy, at the graduate and undergraduate level, in educational institutions and/or professional schools, in and outside of Puerto Rico.
- Scientific research, as a collaborator or assistant, in university academic centers, government laboratories, industry, or scientific research institutes.
- Public or government service, as a consultant, trainer, administrator or advisor for agencies or laboratories responsible for supervising health issues, among others.

The student that completes the University of Puerto Rico School of Medicine Master's Graduate Program in Anatomy (M.S.) will have attained and/or developed the following base of knowledge, skills and attitudes:

KNOWLEDGE

- Will understand and master the basic principles of human and animal anatomy, which encompasses physical structure, general function and development of said structure.
- Will understand and master de basic science and clinical foundations of subspecialties of Anatomy, including Macroscopic Anatomy/Functional Morphology, Histology/Cellular Biology, Embryology/Developmental Biology, and Neuroanatomy/Neurosciences.
- Will understand and be able to apply basic principles of Biostatistics (data analysis and experimental design) and Scientific Instrumentation.
- Will have experience in periodic searching and analysis of scientific literature in the fields of Basic and Biomedical Sciences.
- Will understand and master the basic techniques for presenting educational and scientific work in local and national forums, in oral or written form, in various formats, including posters, slide talks, or articles in scientific or professional journals.
- Will be an expert in the field of Anatomy in which he/she develops the Master's Thesis.

- Will understand the relations that exist between basic biomedical knowledge and its clinical relevance, in areas associated with the subspecialties of Anatomy.
- Will understand the ethical and moral principles that rule the scientific research endeavor in areas such as good scientific research conduct, use and care of animals in research, research with humans, biosecurity, among others.

SKILLS

- Will master the background and foundations, theoretical basis and practice of the basic scientific methodology related to his/her area of specialty within the field of Anatomy.
- Will possess the necessary skills to obtain pertinent information from the scientific literature and to keep a current knowledge base throughout his/her professional career.
- Will have obtained the skills needed to efficiently manage laboratory instrumentation and equipment used in teaching and scientific research related to his/her area of specialty.
- Will possess skills in basic statistics needed to design scientific experiments and analyze data obtained from these experiments.
- Will possess the necessary fundamental knowledge and skills on the use of computers.
- Will possess the basic skills needed for an efficient communication of his/her knowledge and research work.
- Will possess the needed knowledge and skills to become capable of pursuing further and more advanced academic training, such as doctoral studies.

ATTITUDES

- Will possess a professional attitude that is objective, capable of critical analysis, inquisitive, constructive, and conducive to solving scientific problems, evaluating new knowledge, and establishing public policy related to Anatomy.
- Will act following the highest ethical and moral principles while conducting scientific research and teaching activities.
- Will cultivate an attitude that will empower him/her to perform in a professional manner, with excellence, responsibility and a spirit of comradeship.
- Will cultivate awareness of his/her social contract and compromise, dignifying the labor of service towards colleagues, students and the community in general.

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| <p style="text-align: center;">GRADUATE PROGRAM IN ANATOMY STUDENT PROFILE</p> <p style="text-align: center;">DOCTORAL LEVEL (Ph.D.)</p> |
|--|

Upon completion of studies for a Doctoral Degree from the Department of Anatomy & Neurobiology Graduate Program, the graduating student will have attained the needed knowledge, and developed the necessary skills and attitudes to perform with excellence in the following areas:

- Teaching of Anatomy, at the graduate and undergraduate level, in educational institutions and/or professional schools, in and outside of Puerto Rico.
- Scientific research, as a collaborator or assistant, in university academic centers, government laboratories, industry, or scientific research institutes; will possess the skills and capabilities to participate as a principal investigator or collaborator in research projects.
- Consultant or Project Leader in the private sector in areas related with research and development.
- Public or government service, as a consultant, trainer, administrator or advisor for agencies or laboratories responsible for supervising health issues, among others.

The student that completes the University of Puerto Rico School of Medicine Doctoral Graduate Program in Anatomy (Ph.D.) will have attained and/or developed the following base of knowledge, skills and attitudes:

KNOWLEDGE

- Will understand and master the basic principles of human and animal anatomy, which encompasses physical structure, general function and development of said structure.
- Will understand and master de basic science and clinical foundations of subspecialties of Anatomy, including Macroscopic Anatomy/Functional Morphology, Histology/Cellular Biology, Embryology/Developmental Biology, and Neuroanatomy/Neurosciences.
- Will also understand and master basic principles of Physiology, Biochemistry, Biostatistics (data analysis and experimental design) and Scientific Instrumentation.
- Will have experience in periodic searching and analysis of scientific literature in the fields of Basic and Biomedical Sciences.
- Will be familiar with the principal sources of funding for scientific research, its support mechanisms, and the procedures to search and apply for them.
- Will be an expert in the field of Anatomy in which he/she develops the Doctoral Dissertation.

- Will understand the relations that exist between basic biomedical knowledge and its clinical relevance, in areas associated with the subspecialties of Anatomy.
- Will understand the ethical and moral principles that rule the scientific research endeavor in areas such as good scientific research conduct, use and care of animals in research, research with humans, biosecurity, among others.
- Will be prepared to apply for competitive funding of his/her research projects to the pertinent state and federal agencies or private entities.
- Will understand and master the basic techniques for presenting educational and scientific work in local, national and international forums. This includes the writing and submission of reports, platform presentations, posters, slide talks, or articles in scientific or professional journals and/or books.

SKILLS

- Will master the background and foundations, theoretical basis and practice of the basic scientific methodology related to his/her area of specialty within the field of Anatomy.
- Will possess the necessary skills to obtain pertinent information from the scientific literature and to keep a current knowledge base throughout his/her professional career.
- Will have obtained the skills needed to efficiently manage laboratory instrumentation and equipment used in teaching and scientific research related to his/her area of specialty.
- Will possess skills in basic statistics needed to design scientific experiments and analyze data obtained from these experiments.
- Will possess the necessary fundamental knowledge and skills on the use of computers, and will be capable of applying them in experimental design and in the collection, storage and analysis of scientific data.
- Will possess the basic skills needed for an efficient communication, in written and oral format, of his/her knowledge and research work.
- Will possess the basic skills for writing grant proposals to seek competitive funding for research projects from pertinent state and federal agencies and/or private entities.
- Will possess the needed knowledge and skills to become capable of pursuing further and more advanced academic training, such as postdoctoral studies.

ATTITUDES

- Will possess a professional attitude that is objective, capable of critical analysis, inquisitive, constructive, and conducive to solving scientific problems, evaluating new knowledge, and establishing public policy related to Anatomy.
- Will act following the highest ethical and moral principles while conducting scientific research and teaching activities.

- Will cultivate an attitude that will empower him/her to perform in a professional manner, with excellence, responsibility and a spirit of comradeship.
- Will cultivate awareness of his/her social contract and compromise, dignifying the labor of service towards colleagues, students and the community in general.

❖ **Additional Requirements and Regulations**

- General Chemistry
- General Physics
- Mathematics including Trigonometry
- 12 credits in Biology or equivalent

❖ **Course Description**

ANAT 8501. Graduate Course in Human Gross Anatomy – 8 credits

The course provides students with a basic understanding of the organization and three-dimensional gross structure of the human body, with emphasis on the relation between structure and function. At the end of the course, the students will have gained knowledge of the segmental and compartmental organization of the human body, as well as of the basic organization and morphology of the vascular and lymphatic systems of all major organs and regions of the body, the musculoskeletal and peripheral nervous system, and all visceral organs. They'll also understand clinically important aspects of surface anatomy and the basic principles of various imaging modalities. The laboratory component of the course consists of complete dissection of a human cadaver, with the primary intent of identifying and describing the structures and their relations to each other. The structured time of the course consists of lectures, laboratory dissection and small group discussions. It is expected the students will also spend time on independent study.

ANAT 8503. Graduate Course in Human Embryology – 2 credits

Human development mechanisms are emphasized in this lecture course, including congenital malformations. This course will provide the student with an understanding of the prenatal period of human development, particularly between fertilization and the end of the 8th prenatal week, from a developmental and clinical perspective. The student will also learn about the

major abnormalities that can occur during early human development which can result in congenital malformations. The structured component of the course will be offered through lectures. It is expected the students will also spend time on independent study.

ANAT 8504. Graduate Course in Human Cell Biology and Microscopic Anatomy – 5 credits

Through lectures, group discussion and laboratory, the student will receive an introduction on: (1) the structure and function of the cell; and (2) the microscopic anatomy of human tissues and organs as visualized with light and electron microscopy. Emphasis will be placed on correlating the arrangement and structure of component cells with the function and physiology of the tissue/organ. After completion of the course a student should have: (1) knowledge of the normal microscopic structure of the cells, tissues, and organs of the human body; and (2) the ability to correlate structure and function in cells, tissues, and organs at both light and electron microscopic levels. The structured time of the course consists of lectures, group discussions and laboratory. It is expected the students will also spend time on independent study.

ANAT 8505. Graduate Course in Human Neuroanatomy and Neuroscience – 5 credits

The course includes study of the structure and function of individual nerve cells, basic anatomical connections and organization of the human central nervous system, as well as integrative and systems neuroscience. These topics are reinforced by laboratories in neuroanatomy/neuroscience as well as clinical correlation conferences in which physicians' present clinical material related to basic neurosciences topics. The structured component of the course will be offered through lectures, laboratory experiences and small group discussions. It is expected the students will also spend time on independent study.

ANAT 8525. Practice in Teaching – 2 credits

Revised practice of teaching methods in the various anatomical courses for medical, dental and allied health students.

ANAT 8528. Topics in Anatomy – 1-3 credits

Provides graduate students the opportunity to obtain credit in concentrated courses of 10-20 hours duration.

ANAT 8532. Seminar/Journal Club Combination – 1 credit

Attendance to all scientific seminars.

ANAT 8591. Special Problems in Anatomy – 1 credit

Special research projects in Anatomy may be carried out by students that qualify, through special arrangements with the faculty. This course includes laboratory work.

ANAT 8595. Master's Thesis Research – 6 credits

Laboratory research work for Master's Thesis.

ANAT 8599. Doctoral Dissertation Research – 15 credits

Provide graduate students the opportunity to obtain credits for their Doctoral Dissertation research.

BIOCHEMISTRY

❖ Faculty Research Interests

- Abel J. Baerga, Assistant Professor; Ph.D., U. California, San Diego, 2001. Biosynthesis of natural products; Enzyme structure, function and mechanisms.
- Dipak K. Banerjee, Professor; Ph.D., Calcutta, 1976. Cell signaling and Angiogenesis, Dolichol Cycle and Cell Cycle Dynamics, Glycoprotein Biochemistry, Catecholamine Homeostasis, Breast Cancer, Glucose Transporter, and Type I Diabetes.
- Carlos Basilio Reyes, Professor; M.D., Chile, 1956. Modulation of Eukaryotic transcription by Stressor Agents.
- Carmen L. Cadilla, Professor; Ph.D., Tennessee, Knoxville, 1986. Hormonal Regulation of Gene Expression; Genetic Diseases affecting Puerto Ricans.
- Suranganie Dharmawardhane, Associate Professor; Ph.D., Massachusetts, 1987. Signal transduction in breast cancer metastasis, natural therapeutics for breast cancer, and Rho GTPase signaling.

- Sixto García-Castiñeiras, Joint Professor; M.D., Complutense (Madrid), 1967; Ph.D., PR-MSc, 1976. Mechanisms of Lens Aging and Cataract Formation; Redox Active Components in Aqueous Humor; Oxidative Stress; Protein Biochemistry.
- Braulio D. Jiménez, Professor; Ph.D.; PR-Mayagüez, 1981. Molecular and Environmental Toxicology.
- Sherly Pardo Reyes, Assistant Professor; M.D., Puerto Rico, Medical Sciences Campus, 2002. Human molecular genetics and translational stem cell biology.
- Jose R. Rodríguez-Medina, Professor and Chairman; Ph.D., Brandeis, 1986. Function of Myosin II in Yeast; cell wall biogenesis.
- Jose F. Rodríguez-Orengo, Professor; Ph.D., Texas A&M, 1989. Biochemical and Pharmacological Processes of Antiretroviral and Anticancer Drugs.
- Pablo E. Vivas Mejía, Assistant Professor; Ph.D., Puerto Rico, UPR-Río Piedras, 2002. Small interference RNA nanomedicine, role of leptin in cancer metastasis, mechanisms of drug resistance.

❖ Curriculum Sequence

BIOCHEMISTRY Ph.D.
Department of Biochemistry

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|--|---|--|---|
| 1 st S E M E S T E R | BCHM 8500 <i>Biochemistry</i> 6 BCHM 8551 <i>Meth. In Protein and Nucleic Acid Biochem.</i> 2 BCHM 8552 <i>Meth in Lipid and Carbohydrates Biochem.</i> 2 BCHM 8531 <i>Res. Sem. Series I</i> 1 CBIO 8500 <i>Statistic for the Biom. Scs.</i> 3 <p style="text-align: right;"><i>Credits = 14</i></p> | BCHM 8533 <i>Res. Sem. Series III</i> 1 BCHM 8515 <i>Enzyme Kinetics & Mechanis.</i> 2 BCHM 8517 <i>Phys. Chem of Macromolec. (Enzyme Reaction Mechanisms)</i> 3 Electives Recommended by department 3 <p style="text-align: right;"><i>Credits = 9</i></p> | BCHM 8526 <i>Spec. Topic in Biochemistry</i> 3 (Thesis Proposal & Qual. Exam) <p style="text-align: right;"><i>Credits = 3</i></p> | BCHM 8599 <i>Research for Doctoral Thesis</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |
| 2 nd S E M E S T E R | BCHM 8532 <i>Res. Sem. Series II</i> 1 BCHM 8504 <i>Biochemistry of Proteins</i> 3 BCHM 8502 <i>Molecular Biology</i> 3 BCHM 8507 <i>Special Biom. Lab Techn. I</i> 3 or Elective Recom. by the Dept. 3 <p style="text-align: right;"><i>Credits = 10</i></p> | BCHM 8534 <i>Res. Sem. Series IV</i> 1 BCHM 8525 <i>Recent Adv Bioc & Mol. Biol.</i> 2 BCHM 8530 <i>Regulation of Gene Expression in Eukaryotes</i> 3 BCHM 8526 <i>Special Topics in Biochem. Electives</i> 3 <p style="text-align: right;"><i>Credits = 12</i></p> | BCHM 8599 <i>Research for Doctoral Thesis</i> 15 <p style="text-align: right;"><i>Credits = 15</i></p> | BCHM 8599 <i>Research for Doctoral Thesis</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

BIOCHEMISTRY M.S.
Department of Biochemistry

| | YEAR 01 | YEAR 02 |
|---|---|----------------------------------|
| 1 st S E M E S T E R | BCHM 8500 <i>Biochemistry</i> 6 | BCHM 8595 <i>Master Thesis</i> 6 |
| | BCHM 8551 <i>Meth. In Protein and Nucleic Acid Biochem.</i> 2 | <i>Electives</i> 3 |
| | BCHM 8552 <i>Meth in Lipid and Carbohydrates Biochem.</i> 2 | |
| | BCHM 8531 <i>Res. Sem. Series I</i> 1 | |
| | CBIO 8500 <i>Statistic for the Biom. Scs.</i> 3 | |
| | <i>Credits = 14</i> | <i>Credits = 9</i> |
| 2 nd S E M E S T E R | BCHM 8532 <i>Res. Sem. Series II</i> 1 | BCHM 8595 <i>Master Thesis</i> 0 |
| | BCHM 8507 <i>Spe. Biochem. Lab Tech. I</i> 3 | |
| | <i>or Equivalent recommended by the Department</i> 3 | |
| | BCHM 8504 <i>Biochem. of Proteins</i> 3 | |
| | BCHM 8502 <i>Molecular Biology</i> 3 | |
| <i>or Equivalent Molecular Biology course recommended by the department</i> 3 | | |
| <i>Credits = 10</i> | <i>Credits = 0</i> | |

Evening Program
Master of Science in Biochemistry at the
University of Puerto Rico, Medical Sciences Campus

A. Justification:

This evening graduate program (“Programa Vespertino”) in Biochemistry is a non-thesis Master of Science program targeted towards applicants with a B.S. degree in science that 1) qualify for regular admission to the Graduate Program in Biomedical Sciences 2) who prefer an evening studies schedule and seek further academic training as a means of professional advancement, and 3) are committed to pursuing graduate studies in Biochemistry at the UPR-Medical Sciences Campus.

Because this population will not be participating in the regular diurnal M.S. program activities, they are limited in their ability to conduct a thesis dissertation research project. This non-thesis degree option allows these students to obtain further graduate training without having to conduct a thesis dissertation. Furthermore, because some of our potential students may work in an industrial setting, they may prefer more theoretical and applied technical training than hands-on basic research training.

We propose to address the needs of this potential student population by offering a Master of Science degree in Biochemistry as an evening program.

The curriculum offers:

- 1) 26 credits in required courses derived from the same curriculum offered to Biochemistry graduate students enrolled in the diurnal M.S. program.
- 2) In place of the 6 credits in electives required for the diurnal M.S. program, we will require a minimum of 2 credits and will offer a maximum of 7 credits in elective courses for this degree option. These courses are also derived from the same selection of courses offered to students in the diurnal M.S. program.
- 3) In place of 6 credits of M.S. thesis dissertation required in the diurnal M.S. program, 9 course credits will be required in the form of a 6-credit “Research Course” and a 3-credit “Thesis Proposal” course currently offered by the department. These courses are intended to provide the student with one-semester of laboratory experience where each student, aided by an assigned faculty mentor, will identify a proper research question, analyze the problem by reading the current scientific literature, develop a short written proposal, and conduct supervised experiments that will be programmed not to exceed one semester. The research can be conducted at a lab in the Biochemistry department, a specific industrial lab setting, or at a combination of these sites with

prior approval by the program coordinator(s) and administrator(s) of the company involved. Performance will be evaluated by a written and oral presentation of the results of the project that must be presented to a selected evaluation committee composed of selected Biochemistry faculty members at the end of the final semester.

- 4) If a student of this program should apply and qualify to enter the Ph.D. program at a future date, up to 24 credits (except for Thesis Proposal, BCHM 8526) can be transferred towards the requirements for the Ph.D. degree in Biochemistry subject to the conditions described in the "Regulations of the Graduate Program in the Biomedical Sciences of the School of Medicine" and the "Biochemistry Graduate Program Guidelines"

B. Recommended Schedule for Course Work throughout the M.S. Evening Program

Courses for the 1st year

| First Semester | | |
|-----------------------|-------------------|-----------------------|
| Course ID | Credit hrs | Description |
| *BCHM 8500 | 6 | Graduate Biochemistry |
| TOTAL | 6 | |

| Second Semester | | |
|------------------------|-------------------|---------------------------|
| Course ID | Credit hrs | Description |
| *BCHM 8551 | 2 | Bioch. Lab. Techniques I |
| *BCHM 8552 | 2 | Bioch. Lab. Techniques II |
| *BCHM 8995 | 1 | Experimental Design I |
| *CBIO 8500 | 3 | Biostatistics |
| TOTAL | 8 | |

Courses for the 2nd year

| First Semester | | |
|-----------------------|-------------------|----------------------------|
| Course ID | Credit hrs | Description |
| *BCHM 8517 | 3 | Phys. Chem. Macromolecules |
| *BCHM 8504 | 3 | Biochemistry of Proteins |
| *BCHM 8995 | 1 | Experimental Design II |
| TOTAL | 7 | |

| Second Semester | | |
|------------------------|-------------------|----------------------------------|
| Course ID | Credit hrs | Description |
| *BCHM 8502 | 3 | Molecular Biology |
| *BCHM 8515 | 2 | Enzyme Kinetics and Mechanism |
| *BCHM 8995 | 1 | Response and Surface Methodology |
| *BCHM 8995 | 1 | Quality Assurance |
| TOTAL | 7 | |

Courses for the 3rd year

| First Semester | | |
|---------------------------------|-------------------|-----------------------|
| Course ID | Credit hrs | Description |
| ***BCHM 8558-83 [select only 1] | 6 | Investigation Courses |
| ***BCHM 8526 | 3 | Research Proposal |
| TOTAL*** | 9 | |

Total credits required for the degree = minimum 37 credits

Time to degree = 3 years

* Required courses (26 credits)

*** Thesis equivalent (9 credits)

See also pages 14, 15 and 16 of the "Biochemistry Program Regulations" for this information.

C. Other general information:

- 1) To be self-financed (“auto-liquidable”), the program must generate sufficient revenue to provide the salaries for Ph.D.-level faculty members that will be contracted to teach and supervise students and coordinate the program activities, as well as administrative and support staff, equipment and supplies. To meet these obligations, we will require a minimum enrollment of 8 students/semester.
- 2) The cost per year to the student will be **\$6,000 per year** (payable as **\$3,000 per semester**).
- 3) The duration of the degree program is 3 years. The official deadline for applications will be February 15 of each year although late applications can be considered if approved by the campus Admissions Office. A **Late Fee** will be applied to all applications received after this date. Information will be posted on the Biochemistry department website <http://medweb.rcm.upr.edu/biochemistry/index.htm>
- 4) The students and faculty will be subject to the Regulations of the Graduate Program in Biomedical Sciences of the School of Medicine and The Biochemistry Graduate Program Guidelines.
- 5) All courses will be offered on condition that a pre-determined minimum number of students registered is obtained at the beginning of each semester.
- 6) The department will honor its commitment to offer these courses in the time frame presented in the sequential curriculum. However (with the exception of Semester 1) their order may change subject to availability of the qualified faculty each semester.

Last Revised 11/7/06
JRRM

❖ Graduating Student Profile

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| <p style="text-align: center;"><i>GRADUATES OF THE BIOCHEMISTRY DEPARTMENT LEVEL: MASTER (M.S.)</i></p> |
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When the graduate students of the Graduate Program of the Biochemistry Department finish his/her M.S. studies, he/she would have acquired the necessary knowledge, skills and attitudes to excel in the following areas:

- In the teaching of biochemistry, at the graduate or undergraduate level, in educational institutions and professional schools in PR or abroad.
- In scientific research, at academic campuses, government, as well as in industry. He/she will possess the skills and capacity to participate as a principal investigator or as a collaborator in research projects.
- As a consultant or project leader in the private sector, (Research Development), quality control laboratories, and in compliance with environmental laws of occupational and health security.
- In public service or government as a consultant, instructor or administrator for the public sector or government. He/she can be in charge of supervising health and quality control issues among others.

The graduates of the Biochemistry Department of the School of Medicine of the University of Puerto Rico, Medical Sciences Campus would have obtained and developed the following knowledge, skills and attitudes.

KNOWLEDGE

- Would obtain complete knowledge of the basic principles that govern the science of biochemistry and molecular biology.
- Would acquire dominion of the basic and clinical foundations of the biochemistry of protein, carbohydrates, lipids, nucleic acid and other molecules of biological

interest in biochemistry (metabolism, enzyme action, protein chemistry and nucleic acids).

- Would demonstrate that he/she acquired oral, written and visual capacities in both Spanish and English languages in their area of specialization.
- Would possess knowledge of the ethical and moral principles that govern the scientific management, this includes: research with human subjects, research use and care of animals, good scientific conduct, and other areas such as laboratory safety among others.

SKILLS

- Would master in his research area of specialization the background and fundamentals, theoretical and practical basis of scientific methodology.
- Apply modern methods of molecular biology in biochemistry studies.
- Would have the required skills to apply for external funding from governmental, state, federal and private entities.
- Would possess the necessary skills to obtain adequate information of scientific literature and maintain their knowledge up to date in his/her professional career.
- Would acquire the necessary skills for the effective use of laboratory equipment and instrumentation used for teaching and for scientific investigation.
- Would acquire the knowledge and fundamental skills in the use of computers and statistical analysis in the experimental design, collection, storing, and analysis of scientific data.
- Would have the necessary skills for fluent communication in both oral and written about his/her knowledge and research work.
- Should demonstrate ability to design experimental protocols and realize independent and productive research.

ATTITUDES

- As a M.S., would possess a professional an objective, critical, analytical, inquisitive and constructive professional attitude conducive to the solution of scientific problems, new knowledge evaluation, and the establishment of biochemistry related public policy.
- Would perform in compliance with the highest ethical and moral principles in the scientific conduct of research and as an instructor.
- Will promote an attitude in our graduates that leads to excellence in a responsible manner and in the spirit of camaraderie.
- Will promote in our graduates the conscience of their contract and social compromise, to dignifying their colleagues, students, and community labor.

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| <p style="text-align: center;"><i>GRADUATES OF THE BIOCHEMISTRY DEPARTMENT</i> <i>LEVEL: DOCTOR IN PHILOSOPHY (Ph.D.)</i></p> |
|---|

When the student finishes his/her doctoral studies in the Graduate Program of the Biochemistry Department, he/she would have acquired the necessary knowledge, skills and attitudes to excel in the following areas:

- In the teaching of biochemistry, at the graduate or undergraduate level, in the educational institutions and professional schools in PR or abroad.
- In scientific research, at academic campuses, government, as well as in industry. He/she will possess the skills and capacity to participate as a principal investigator or as a collaborator in research projects.
- As a consultant or project leader in the private sector, (Research Development), quality control laboratories, and in compliance with environmental laws of occupational and health security.
- In public service or government as a consultant, instructor or administrator for the public sector or government. He/she can be in charge of supervising health and quality control issues among others.

The graduates of the Biochemistry Department of the School of Medicine of the University of Puerto Rico, Medical Sciences Campus would have obtained and developed the following knowledge, skills and attitudes.

KNOWLEDGE

- Would obtain complete knowledge of the basic principles that govern the science of biochemistry and molecular biology and detailed knowledge in his/her research area.
- Would acquire dominion of the basic and clinical foundations of the biochemistry of protein, carbohydrates, lipids, nucleic acid and other molecules of biological interest in biochemistry (metabolism, enzyme action, protein chemistry and nucleic acids).
- Would demonstrate that he/she acquired oral, written and visual capacities in both Spanish and English languages in their area of specialization.
- Would possess knowledge of the ethical and moral principles that govern the scientific management, this includes: research with human subjects, research use and care of animals, good scientific conduct, and other areas such as laboratory safety among others.
- Would demonstrate his/her ability to identify important questions and problems in biochemical research.

SKILLS

- Would master in his research area of specialization the background and fundamentals, theoretical and practical basis of scientific methodology.
- Apply modern methods of molecular biology in biochemistry studies.
- Would have the required skills to apply for external funding from governmental, state, federal and private entities.
- Would possess the necessary skills to obtain adequate information of scientific literature and maintain their knowledge up to date in his/her professional career.

- Would acquire the necessary skills for the effective use of laboratory equipment and instrumentation used for teaching and for scientific investigation.
- Would acquire the knowledge and fundamental skills in the use of computers and statistical analysis in the experimental design, collection, storing, and analysis of scientific data.
- Would have the necessary skills for fluent communication in both oral and written about his/her knowledge and research work.
- Should demonstrate ability to design experimental protocols and realize independent and productive research.

ATTITUDES

- As a Doctor in Philosophy, would possess an objective, critical, analytical, inquisitive and constructive, professional attitude conducive to the solution of scientific problems, new knowledge evaluation, and the establishment of biochemistry related public policy.
- Would perform in compliance with the highest ethical and moral principles in the scientific conduct of research and as an instructor.
- Will promote an attitude in our graduates that leads to excellence in a responsible manner and in the spirit of camaraderie.
- Will promote in our graduates the conscience of their contract and social compromise, to dignifying their colleagues, students, and community labor.

❖ **Additional Requirements and Regulations**

- | | |
|------------------------|-----------------------|
| ○ General Chemistry | ○ Physical Chemistry* |
| ○ Analytical Chemistry | ○ Physics |
| ○ Organic Chemistry | ○ Calculus |

* This requisite can be substituted by the Physical Chemistry of Macromolecules that is offered in the Department.

❖ Course Description

REGULAR COURSES

BCHM 8500. Biochemistry – 6 credits

This course is designed specifically for graduate and professional students with interests in laboratory research. This will be a lecture course in general biochemistry. Topics to be covered include catabolic and anabolic pathways in living organisms, nucleic acid, protein, carbohydrate, and lipid structures and functions, the basics of DNA, RNA, and protein synthesis, enzyme kinetics, photosynthesis, electron transport, biochemical endocrinology, physiological biochemistry (including excitable membranes, blood biochemistry, and allosteric effectors), and organ specific biochemistry.

BCHM 8502. Molecular Biology – 3 credits

A research oriented lecture course in molecular biology. Topics to be covered include biophysics of macromolecules; recombinant DNA and biotechnology; regulation of transcription, including considerations of promoters, DNA binding proteins and oncogenes; the processing of RNA including capping, splicing, polyadenylation and editing, translation including targeting, frame shifting, folding and post translational modifications; and applications of biochemical genetics and cell biology. Resource material will be scholarly scientific publications. (For a state of art, research oriented course, the specific topics to be considered will vary from one semester to the next in order to enable the most important and latest scientific discoveries to be covered.

BCHM 8504. Biochemistry of Proteins – 3 credits

The structure and function of various proteins (i.e. antibodies, enzymes, nucleic acid, binding proteins, cytoskeletal proteins, and membrane associated proteins) will be examined in detail. Protein folding, denaturation, and refolding will be reviewed. Applications of site directed mutagenesis, nuclear magnetic resonance, X-ray crystallography, and molecular modeling will be covered. Enzyme kinetics will be examined in detail with emphasis on the analyses of catalytic mechanisms, subunit interactions, allosteric effectors, and inhibitors. Sieve, affinity, and high-pressure liquid column chromatography, Western blotting, mass spectrometry, Edman degradation, composition analyses, SDS gel electrophoresis, isoelectric focusing, and pKa determinations, and other procedures that are used in the purification and analysis of proteins will be considered.

BCHM 8506. Membrane Biochemistry – 3 credits

This is an advanced biochemistry course focusing on biomembranes. The following topics will be discussed: 1) membrane structure; 2) approaches to study membrane dynamics; 3) membrane transport (influx/efflux) and transporter protein; 4) excitable membrane, pump, and ion channel; 5) membrane component biogenesis and their trafficking; and finally 6) liposomes for targeted delivery of membrane impermeable drugs, macromolecules, etc. of therapeutic interest. This is a highly specialized course dealing with membranes from higher eukaryotic cells. The students will be engaged in classroom lectures/exercises for 3 hours per week. (Pre-requisite: BCHM 8500 and/or completed graduate level biochemistry, physiology, microbiology, pharmacology or biology course).

BCHM 8507. Special Biochemical Laboratory Techniques I – 3 credits

This is a tutorial type exposure to laboratory experiences. The student rotates through different departmental laboratories where research work is being conducted by faculty members and familiarizes with techniques at the same time that performs introductory experiments. The rotation is intended to expose the student to the research project of his choice. At the end of this experience, the student is supposed to be ready to follow a research project of interest to him/her and begin writing his thesis proposal. The course is open only to students registered in the Department of Biochemistry.

BCHM 8515. Enzyme Kinetics and Mechanism – 2 credits

In this course the students will work with the concepts and applications of enzyme mechanisms with emphasis on the key kinetic and thermodynamic concepts that rule the activity of enzymes, steady state kinetics, transient kinetics, mechanisms of catalysis, and mechanisms of inhibition. Methods to elucidate kinetic and chemical mechanisms will be explored such as kinetic isotope effect, spectroscopy and stopped-flow techniques. The students will have hands-on experience in the analysis of data by using software for kinetics research.

BCHM 8517. Physical Chemistry of Macromolecules – 3 credits

This course may be taken by graduate students in order to fulfill a Physical Chemistry deficiency in the required prerequisites for admission to graduate Programs in Biochemistry. This course consists of lectures and class discussions about the methodology used in the characterization of macromolecules biological interest, and the theory upon which this methodology is based. Topics to be covered include classical thermodynamics, thermodynamic properties of solutions, viscosity, osmotic pressure, diffusion, sedimentation theory, and applications of electromagnetic

radiation, including atomic absorption, fluorescence, optical rotatory dispersion, circular dichroism and light scattering. Also, this course will cover investigations involving nuclear magnetic resonance, mass spectrometry, molecular crystallization, and X-ray diffraction from the point of view of both theory and practical applications. The last section of the course will focus on methods used to determine protein composition and sequence.

BCHM 8521. Practice and Teaching of Biochemistry – 3 credits

Students registered in this course conduct class discussions under the supervision of a faculty member. These discussion groups are made of a minimum of twelve first year dental or medical students and are part of the course work required in the respective biochemistry courses offered to dental or medical students. Graduate students in charge of the discussions lead the group, prepare self-evaluation quizzes for the students, report to faculty members about their observations as to the proficiency of students under their supervision. Two group discussions per week. This course is open only to graduate students registered in the Department of Biochemistry.

BCHM 8525. Recent Advances in Biochemistry & Molecular Biology – 2 credits

Recently published scientific literature will be discussed on a weekly basis through oral presentations made by the course participants followed by group discussions. Topics relevant to diverse aspects of Biochemistry and Molecular Biology will be discussed.

BCHM 8526. Special Topics in Biochemistry – 3 credits

This will be a course on a special topic in Biochemistry. Recent research findings will be emphasized. (Note: This course is designed to complete requirements of the dissertation proposal and comprehensive exam, in conjunction with a graduate seminar confers regular student status).

BCHM 8527-8529. Special Topics in Biochemistry - 1 credit ea.

These will be short, intensive courses on a special topic in Biochemistry that will be offered by visiting professors. Recent research findings will be emphasized. These courses will not usually last more than two weeks (but with minimum of 16 hours of class time). The format may vary from lectures to lectures with assigned reading, discussions, and/or laboratory exercises.

BCHM 8530. Genetic Regulation of Gene Expression – 3 credits

This is an advanced course designed for graduate students pursuing a Master or a Ph.D. degree in Biochemistry, Cell Biology, Physiology, Microbiology, Pharmacology or other biology based discipline. It requires either of the following courses: general biochemistry, molecular biology or microbial biochemistry. The course is based on the review of the latest molecular mechanisms of control of gene expression described in the scientific literature of the last two years. Emphasis is made on regulatory mechanisms associated to chromatin remodeling, transcription, mRNA stability, translation and postranslational modifications. Transcription factors required for basic transcription, regulatory nuclear factors of the steroid, retinoid, thyroid and Vitamin D3 receptor superfamily, proteins involved in the regulation of the cell cycle and the basic mechanisms of cell development and differentiation are discussed in detail. The course is student centered who are required to prepare and present material for open discussions.

BCHM 8531-8536. Biochemistry, Pharmacology & Physiology Seminar Series - 1 credit per semester

This seminar series will meet an average of once per week throughout the semester, for approximately 1.0-1.5 hours during which doctoral level scientists will give presentations about their research investigations or about subjects relevant to pursuing a career in science.

BCHM 8550. Introduction to Human Biochemistry – 6 credits

This course in Biochemistry is intended for first year Medical Students. Topics covered include introduction to the physical chemistry of molecules of biological interests, enzymology, biological oxidations, metabolism of the main group of nutrients, biosynthesis of cell constituents with emphasis in biosynthesis of proteins, regulation of cellular processes, nutrition and the influence of lifestyle on health and disease, the role of plasma proteins on body physiology, and an introduction to immunochemistry, respiration, and acid base balance. A number of specific topics include clinical correlations.

BCHM 8551. Methods in Protein and Nucleic Acid Biochemistry – 2 credits

This laboratory course will meet once a week during which there will be a one hour lecture followed by a minimum of a 2-3 hour laboratory exercise with possible follow-up requirements. Procedures to be covered include the purification of proteins and nucleic acids, restriction analysis of DNA, Polymerase Chain Reaction (PCR) sieve and/or ion exchange chromatography, HPLC chromatography, gel electrophoresis, ultra centrifugation, UV/visible spectrophotometry, and scintillation spectrometry.

BCHM 8552. Methods in Lipid and Carbohydrates Biochemistry, Nutrition, and Biochemical Pharmacology – 2 credits

This laboratory course will meet once a week during which there will be a one hour lecture followed by a minimum of a 2-3 hour laboratory exercise with possible follow-up requirements. Focus will be directed toward metabolic aspects of lipid and carbohydrate chemistry including nutrition. Techniques employed will include use of radioisotopes, radio-immunoassay, differential centrifugation, spectrophotometry, and dietary analysis utilizing computerized programs. Other procedures covered will be separations of mono-, di-, and oligosaccharides, digestion of exo- and endo-glycosidases, thin layer chromatography, molecular sieve and/or ion exchange chromatography, HPLC, periodic acid-Schiff's (PAS) staining, and lectin blots.

BCHM 8557. Chemical Modification of Proteins – 1 credit

The course will deal with methods to modify different aminoacid residues in proteins (e.g. lysine, arginine, histidine, methionine, cystine, tryptophan and tyrosine).

BCHM 8558. Investigations in the Biochemistry of Aging – 6 credits

This course will involve training in how to design, conduct, and analyze independent research on the biochemistry of aging using the ocular lens as a model. In this course students will investigate post translational modifications in lens proteins that are associated with human disease and/or aging. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8559. Investigations in Angiogenesis I – 6 credits

This course will involve training in how to design, conduct, and analyze independent research to study the biochemistry of Angiogenesis. For this course the student will study the biochemistry of differentiation of capillary endothelial cells. Studies will include screening of angiogenic factors affecting capillary endothelial cell proliferation, the mapping of cell cycle, and the characterization of factors responsible for cell proliferation and differentiation. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8560. Investigations in Angiogenesis II – 6 credits

This course will involve training in how to design, conduct, and analyze independent research to study the biochemistry of Angiogenesis. For this course the student will identify the gene products responsible for endothelial cell proliferation and capillary

formation. Translational regulation of the process will be studied and any modification at the pre-golgi compartment will be examined. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8561. Investigations in Complex Carbohydrate Biochemistry I – 6 credits

This course will involve training in how to design, conduct, and analyze independent research in complex carbohydrate biochemistry. For this course the student will identify a glyco-conjugate and its glycan structure as a complex, high-mannose or hybrid type will be determined. Enzymatic and chemical methods will be followed for the structural studies and the role of the carbohydrate residues for biological function will be determined. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8562. Investigations in Complex Carbohydrate Biochemistry II – 6 credits

This course will involve training in how to design, conduct, and analyze independent research in complex carbohydrate biochemistry. For this course the enzymatic synthesis and subsequent processing of the glycan chains in the post-golgi compartment and network will be investigated. In vitro assays of glycosyltransferases will also be performed to understand the regulatory events. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8563. Investigations in Enzyme Biochemistry I – 6 credits

This course will involve training in how to design, conduct, and analyze independent research in enzyme biochemistry. For this course the student will purify and study a native or recombinant enzyme. Studies will include specific activity determinations during purification and analyses of the steady state kinetics of enzyme catalyzed reaction for the purified enzyme. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8564. Investigations in Enzyme Biochemistry II – 6 credits

This course will involve training in how to design, conduct, and analyze independent research in enzyme biochemistry. For this course the student will use various screening procedures, enzyme assays, and kinetic studies to identify potential ligands and inhibitors of an enzyme. These studies will be expected to answer new questions

and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8565. Investigations in Filamentous Proteins I – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the structure and function of filamentous proteins. This course will include studies in identification, isolation, and mutagenesis of selected DNA regions encoding a portion of a filamentous protein. These selected DNA fragments will be obtained by PCR techniques from a cloned DNA template. Mutations generated will be confirmed by direct DNA sequencing of the mutated DNA fragment. The resulting experiments will inquire into the role of specific amino acids in the function and control of filamentous proteins. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8566. Investigations in Filamentous Proteins II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the structure and function of filamentous proteins. Mutated filamentous protein gene(s) will be used for generating chromosomal mutants. This course will include studies in the functional analysis of filamentous protein mutants through assays for secretory function, distribution of cell polysaccharides and cytoskeletal proteins, protein phosphorylation of the mutant protein, and effects on cell division. The course will incorporate the techniques of fluorescence microscopy, for analysis of immunochemical and other protein specific dyes, and immunoprecipitation of radiolabelled filamentous proteins. These experiments will generate novel information on the function of filamentous proteins in non-muscle cell systems.

BCHM 8567. Investigations in Hybridomas I – 6 credits

This course will involve training in how to design, conduct, and analyze independent research in the preparation of hybridomas. For this course the student will use a purified antigen to immunize a mouse whose lymphocytes will subsequently be fused with tumor cells and these hybridomas will be cloned. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8568. Investigations in Hybridomas II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the utilization of hybridomas. For this course students will screen hybridoma clones for those producing monoclonal antibodies, to a specific antigen.

These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8569. Investigations in Membrane Biochemistry I – 6 credits

This course will involve training in how to design, conduct, and analyze independent research in membrane biochemistry. This course will provide training in the procedures to investigate cell membrane fluidity, chemical composition, and external factors that modify these parameters (i.e. diet, drugs, ethanol and/or toxic agents). EPR and lipid analysis by HPLC will be used. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8570. Investigations in Membrane Biochemistry II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in membrane biochemistry. This course will give students the opportunity to prepare membrane cell components such as mitochondria, plasma membranes and microsomes or membrane derivatives such as liposomes, synaptosomes or synaptoneuroosomes and to study the biological activities of proteins (i.e. receptors, ion channels) associated with the membranes. Ligand binding, ion uptake, enzyme activity, HPLC and EPR will be among the procedures employed for these investigations. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8571. Investigations in Molecular Genetics I – 6 credits

This course will training in how to design, conduct and analyze experiments in Molecular Genetics. For this course, students will learn and acquire hands on experience in bacterial culture and the use of prokaryotic and eukaryotic cloning vectors. Cloning from a genomic or cDNA library, and physical characterization of selected DNA will be performed using procedures such as restriction mapping and DNA sequencing. Computer aided analysis of DNA and amino acid sequences will be used. These studies will provide information leading to the identification of gene sequences from a variety of organisms. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed above.

BCHM 8572. Investigations in Molecular Genetics II – 6 credits

This course will involve training in how to design, conduct and analyze experiments in Molecular Genetics. In this course, students will participate in the generation of mutant cells by site specific recombination of mutant constructs introduced into

diploid yeast cells. The mutant gene constructs will be generated by the students in the laboratory by the deletion and/or insertion of DNA or DNA markers respectively into a selected target gene clone. Traditional transformation and electroporation techniques will be used for generation of mutants. Candidate mutant cells will be analyzed by diagnostic Southern blot and PCR analysis of genomic DNA. Techniques for genetic analysis of gene function through analysis of haploid cells will be applied. The results of these experiments will generate novel mutants that will reveal information on gene structure-function relationships.

BCHM 8573. Investigations in Nucleic Acid Biochemistry I – 6 credits

This course will involve training in how to design, conduct and analyze independent research in nucleic acid biochemistry. For this course the student will clone and sequence a gene or cDNA of interest. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8574. Investigations in Nucleic Acid Biochemistry II – 6 credits

This course will involve training in how to design, conduct and analyzed independent research in nucleic acid biochemistry. For this course the student will purify and study a native or recombinant nucleic acid. Studies may involve the synthesis, evaluation and/or probing of a genomic or cDNA library. These studies will be expected to answer new questions and to generate novel data as opposed to reproducing experiments that have been performed above.

BCHM 8575. Investigations in Nutritional Biochemistry I – 6 credits

This course will involve training in how to design, conduct and analyze independent research in nutritional biochemistry. Methods employed will be computer assisted dietary evaluations and performance of dietary interviews. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8576. Investigations in Molecular Genetics II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in nutritional biochemistry. Methods employed will be analysis of nutrients in blood using HPLC and enzymatic techniques. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8577. Investigations in Ocular Biochemistry I – 6 credits

This course will involve training in how to design, conduct and analyze independent research on the biochemistry of eye tissues and fluids. For this course students will specifically investigate natural antioxidants (i.e. ascorbic acid, glutathione, vitamins and proteins) and free radicals as related to the protection of ocular tissues against photo-oxidative stress. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed above.

BCHM 8578. Investigations in Protein Structure/Function I – 6 credits

This course will involve training in how to design, conduct and analyze independent research in protein structure/function relationships. Methods employed will be involve investigations of the functional roles of specific amino acids in substrate binding and catalytic mechanism of a recombinant enzyme using techniques such as site directed mutagenesis. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8579. Investigations in Protein Structure/Function II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in protein structure/function relationships. In this course students will learn to grow X-ray diffraction quality protein crystals. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8580. Investigations in Tumorigenesis I – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the area of tumorigenesis. In this course students will search for genetic alterations during development of the malignant phenotype. Methods employed will be involve state of the art procedures in molecular biology. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8581. Investigations in Tumorigenesis II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the area of tumorigenesis. In this course students will search for molecular alterations during development of the malignant phenotype. Methods employed will involve state of the art procedures in molecular biology. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed before.

BCHM 8582. Investigations in Vaccine Development I – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the area of vaccine development. In this course students will use a variety of selection procedures to identify potential vaccine antigens for the treatment of human disease. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed above.

BCHM 8583. Investigations in Vaccine Development II – 6 credits

This course will involve training in how to design, conduct and analyze independent research in the area of vaccine development. In this course students will investigate potential vaccine in animal models of human disease. These studies will be expected to answer new questions and to generate novel data, as opposed to reproducing experiments that have been performed above.

BCHM 8595. Research for Master Thesis – 6 credits

This is a requirement for all students registered for a Master of Science with concentration in Biochemistry. The proposed research must be pre approved by the student's advisory committee.

BCHM 8599. Research for Doctoral Dissertations – 15 credits

This is a requirement for all students registered for a Doctor of Philosophy with concentration in Biochemistry. The proposed research must be pre approved by the student's advisory committee.

MICROBIOLOGY AND MEDICAL ZOOLOGY

❖ Faculty Research Interests

- Edna E. Aquino, Associate Professor; Ph.D., UPR-MSU, PR. 2000.
Serpentine receptor trafficking in the lipid raft membrane microdomains in glial and lymphoid cells.
- Benjamin Bolaños, Associate Professor; Ph.D., Duke University, NC. 1983.
Pathobiology of *Cryptococcus neoformans*, yeast susceptibilities to antimycotic agents, environmental fungal allergens and fungal contamination in buildings.
- Ana Maria Díaz, Professor; D.Sc., Univ. Buenos Aires, Argentina. 1981.
Characterization of mites antigens involve in allergic reactions and asthma.
Production of monoclonal antibody.

- Ana M. Espino, Associate Professor; Ph.D., Institute of Tropical Medicine, Havana, Cuba. 1997. Characterization of T- and B-cell epitopes of multiple antigenic peptides for a *Fasciola/Schistosoma* cross-reactive vaccine.
- Mariano García Blanco, Adjunct Professor; M.D., Ph.D., Harvard, 1977. Molecular Genetics and Microbiology.
- Elizabeth Hunsperger, Adjunct Professor; Ph.D., CDC-San Juan; Diagnosis, pathogeny and control of Flavivirus.
- Wieslaw J. Kozek, Professor; Ph.D., Tulane University, LA. 1969. Antigenicity and ultrastructure of medically important nematodes, parasite-host communication and *Wolbachia* symbionts of filariae.
- Edmundo N. Kraiselburd, Professor; Ph.D., SUNY at Buffalo, NY. 1972. Design and evaluation of DNA vaccines against human and simian immunodeficiency viruses. Research in NeuroAIDS.
- Idalí Martínez Martínez, Associate Professor; Ph.D., Rutgers University, NJ. 1995. Molecular biology and immune response in viral infection. Development of Dengue DNA vaccines.
- Loyda M. Meléndez, Professor; Ph.D., Emory University, GA. 1990. Immunology of HIV; HIV tropism and its role in the placenta vertical transmission; Monocyte immunity and NeuroAIDS including HIV dementia.
- Jorge Muñoz Jordán, Adjunct Professor; Ph.D., CDC-San Juan, Dengue pathogeny and dengue virus-interferon pathway interactions.
- Miguel Otero, Adjunct Professor, Ph.D., UCC Bayamón, DNA-Vaccines against HIV.
- Iraida E. Robledo, Associate Professor; Ph.D., UPR-Río Piedras Campus, PR, 2000. Molecular mechanisms and epidemiology of antimicrobial resistance in Gram negative bacteria. *H. pylori* antimicrobial susceptibility and genotyping characterization.
- José Rodríguez, Adjunct Professor, Ph.D.; UCC Bayamón. Immunology of HIV.
- Nuri Rodríguez-del Valle, Professor; Ph.D., UPR-MSU, PR. 1978. The mechanisms involve in signal transduction in the regulation in the expression of dimorphism in fungi utilizing *Sporothrix schenckii* as a model system.

- Carlos A. Sariol, Associate Professor; M.D., U. Havana, Cuba, 1987. Dengue pathogenesis in animals model (non-human primates) and dengue virus-interferon pathway interactions.
- Ramón Scharbaai, Adjunct Professor, Ph.D., UPR-MCS, 2006. Escuela de Medicina San Juan Bautista. Bacterial genetic.
- Adelfa E. Serrano, Professor; Ph.D., Univ. Georgia, GA. 1987. Molecular mechanisms of multidrug resistance in *Plasmodium* sp., biology and immunology of parasitic infections.
- Luis J. Torres-Bauzá, Professor; Ph.D., UPR-MSC, PR. 1980. Molecular analysis and characterization of *Neisseria gonorrhoeae* beta-lactamase plasmids.
- Guillermo J. Vázquez, Professor and Chairman; M.D., Jefferson Medical College, PA. 1974. Molecular mechanisms and epidemiology of antimicrobial resistance in Gram negative bacteria. Experimental therapies for HIV/AIDS infected patients (AIDS Clinical Trials Unit).

❖ Curriculum Sequence

MICROBIOLOGY Ph.D.

Department of Microbiology and Medical Zoology

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|--|---|---|--|
| 1 st S E M E S T E R | MICR 8499 <i>Introd. Med. Microbiology</i> 6 BCHM 8500 <i>Biochemistry</i> 6 <p style="text-align: right;"><i>Credits = 12</i></p> | CBIO 8500 <i>Statistics for the Biom. Scs.</i> 3 MICR 8580 <i>Graduate Seminar</i> 1 Electives 2 courses from department 6 <p style="text-align: right;"><i>Credits = 10</i></p> | MICR 8580 <i>Graduate Seminar</i> 1 Adv. Top. in Area of Spec. 3 (Thesis Proposal & Qual. Exam) <p style="text-align: right;"><i>Credits = 4</i></p> | MICR 8599 <i>Doctoral Dissert.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |
| 2 nd S E M E S T E R | MICR 8580 <i>Graduate Seminar</i> 1 MICR 8540 <i>Princ. of Immunology</i> 3 ZOME 8502 <i>Introd. to Parasitology</i> 3 Electives 2 courses from department 6 <p style="text-align: right;"><i>Credits = 13</i></p> | MICR 8590 <i>Teaching Practice</i> 1 Advanced Topics in Area of specialization 3 <p style="text-align: right;"><i>Credits = 4</i></p> | MICR 8599 <i>Doctoral Dissert.</i> 15 <p style="text-align: right;"><i>Credits = 15</i></p> | MICR 8599 <i>Doctoral Dissert.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

* Electives course from department (Molecular Biology, Protozoa, Nematodes, etc.) or from another department (BCHM 8551, BCHM 8552, Bioinformatics, etc.)

MICROBIOLOGY M.S.
Department of Microbiology and Medical Zoology

| | YEAR 01 | YEAR 02 |
|---|--|--|
| 1 st S E M E S T E R | MICR 8499 <i>Intro. to Med. Microbiology</i> 6 BCHM 8500 <i>Biochemistry</i> 6 <p style="text-align: right;"><i>Credits = 12</i></p> | CBIO 8500 <i>Statistics for the Biom. Scs.</i> 3 MICR 8590 <i>Teaching Practice</i> 1 MICR 8580 <i>Graduate Seminar</i> 1 MICR 8595 <i>Master Thesis</i> 6 <p style="text-align: right;"><i>Credits = 11</i></p> |
| 2 nd S E M E S T E R | MICR 8540 <i>Principles of Immunology</i> 3 ZOME 8502 <i>Introduction to Parasitology</i> 3 <i>Electives 2 courses from department</i> 5 (minimum) <p style="text-align: right;"><i>Credits = 11</i></p> | MICR 8595 <i>Master Thesis</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

❖ Graduating Student Profile

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|---|
| <p style="text-align: center;">PROFILE OF GRADUATE FROM THE MASTER'S DEGREE PROGRAM IN MICROBIOLOGY (M.S.)</p> |
|---|

Upon completion of M.S. program at the Department of Microbiology and Medical Zoology, the graduate will have acquired the knowledge, skills and attitudes that would enable him/her to provide excellent service in the following areas:

- Teaching of Medical Microbiology in institutions and professional schools in, and outside, of Puerto Rico.
- He/she will have the necessary skills and capacities to participate in scientific research conducted at academic centers, government or industry.
- As a consultant, or leader, in projects related to research and development, manufacture, production and in quality control laboratories in private industry.
- In public or government service: as a consultant, trainer, administrator or advisor to agencies or laboratories responsible for supervision of matters related to health or quality control.

The graduate of the M.S. program in Microbiology and Medical Zoology of the School of Medicine, University of Puerto Rico, will have obtained and developed the knowledge and the following skills and attitudes:

KNOWLEDGE

- Will dominate the fundamental and basic principles of Microbiology and Medical Zoology
- Will know the ethical and moral principles of scientific investigations in areas that include: research involving human subjects, research, use and care of animals in research, good scientific conduct, and other areas such as biosecurity, among others.
- Will dominate the basics of the following subjects: biochemistry, scientific instrumentation, biostatistics, critical evaluation of literature, among others.
- Will have basic knowledge of the existing relationships between basic and clinical sciences.
- Will know how to publish and present scientific and educational works at local, national and international forums. This includes editing and presenting

reports, oral presentations, poster presentations and publication in scientific journals.

SKILLS

- Will have the theoretical and practical bases of the scientific methodology related to his/her area of expertise within the area of Microbiology.
- Will possess the necessary skills to obtain pertinent information from scientific literature and will maintain his knowledge updated during his profession life.
- Will have acquired the necessary skills in effective operation of laboratory equipment and instruments used in teaching and scientific research.
- Will have acquired the fundamental knowledge and skills in the use of computers and statistical handling of data.
- Will have the basic skills to effectively communicate, both orally and in writing, his knowledge and research studies.
- Will have acquired the knowledge and skills needed to obtain more advanced academic training.

ATTITUDES

- Will have an objective, analytical and inquisitive attitude to fulfill his/hers professional duties.
- Will conduct his/hers scientific research and teaching activities according to the highest standards of ethical and moral principles/standards.
- An attitude will be fostered in each graduate that will enable him/her to execute his/her professional obligations responsibly and in the spirit of friendship/cooperation.
- An attitude will be fostered in each graduate about his/her awareness of his/her social contract and obligations, dignifying his/her service to his/her colleagues, students, community and the people of Puerto Rico.

PROFILE OF A GRADUATE FROM THE DOCTORAL PROGRAM IN MICROBIOLOGY (Ph.D.)

Upon completing his/her doctoral studies in the Graduate Program of the Department of Microbiology and Medical Zoology, the graduate will have acquired the knowledge, skills and attitudes required for excellent performance in the following areas:

- Teaching of Medical Microbiology, at undergraduate and graduate levels, in teaching institutions and professional schools in and outside of Puerto Rico.
- He/she will have the necessary skills and capacities to participate as a principal investigator, or a collaborator, in scientific research conducted at academic centers, government or industry.
- He/she will be able to act as a consultant, or a leader, of projects related to research and development, production, manufacturing and in quality control laboratories in private industry
- In public or government service he/she will be able to consult, train, administer or advise agencies or laboratories responsible for supervision of matters related to health or quality control.

The graduate from the Doctoral Program in Microbiology and Medical Zoology, School of Medicine, University of Puerto Rico, will have obtained and developed the following knowledge, skills and attitudes:

KNOWLEDGE:

- Will have dominion of the basic principles of Microbiology and Medical Zoology, including the disciplines of Bacteriology, Mycology, Virology, Parasitology, Immunology, Molecular Biology, Microbial Physiology and Microbial Genetics.
- Will have mastered in the basic and clinical aspects of different organisms.
- Will apply modern methods of molecular biology to study of the biology, diagnosis, rapid identification and treatment of bacteria, fungi, viruses and parasites of medical importance.
- Will have a broad mastery of the following areas: biochemistry, scientific instrumentation, biostatistics, critical review of the literature, among others.

- Will be an expert in the area of Microbiology in which he/she has conducted his/her doctoral dissertation.
- Will have knowledge embracing the existing relationships between basic biomedical science and its clinical relevance.
- Will possess the moral and ethical principles that govern the execution of scientific research in areas such as: research involving human subjects, use and care of laboratory animals, good scientific conduct, and biosecurity, etc.
- Will be capable of generating his/her own independent research project and apply for competitive funding for his/her studies from state or federal agencies or pertinent private organizations.
- Will be able to present for publication and presentation of his/her scientific and educational works in local, national and international forums. This includes editing and presentation of reports, oral and poster presentations and publications in scientific journals.

SKILLS

- Will have mastered the depth, fundamentals, and the theoretical and practical bases of the scientific methodology related to his/her area of specialization within the area of Medical Microbiology.
- Will have the necessary skills to obtain the pertinent information from scientific literature and will maintain him/herself updated during his/her professional life.
- Will have acquired the necessary skills in the effective utilization of instruments and laboratory equipment used in teaching and research.
- Will have acquired the knowledge and fundamental skills in the use of computers, application of statistics in experimental design, collecting, storing and analysis of scientific data.
- Will have the basic skills needed for effective communication, written and oral, of his/her knowledge and research projects.
- Will have acquired the skills and knowledge needed to obtain advanced training, e.g. as in post-doctoral studies.

ATTITUDES

- As a Doctor of Philosophy, he/she will have a professional attitude that is objective, critical, analytical, inquisitive, and constructive that will be conducive to solution of scientific problems, evaluation of new knowledge, and establishing public policy related to medical microbiology.
- Will execute his/her teaching and scientific activities in accordance to the highest standards of moral and ethical principles.
- The graduate will have instilled in him/her an attitude that will allow him/her to fulfill his/her his/her professional responsibilities in an excellent manner and in the spirit of camaraderie/cooperation.
- An attitude will be fostered in the graduate about his/her awareness of his/her social contract and obligations, dignifying his/her service rendered to his/her colleagues, students, community and the people of Puerto Rico.

❖ **ADMISSION REQUIREMENTS:**

- **Degree Required:** Bachelor in Science or Master in Science
- **"Graduate Record Examination (GRE)"**
 - GRE General
 - GRE Subject Test
- **Academic Index:** A grade index of at least 3.0 overall and in science subjects.
- **Language requirements:**
 - Spanish
 - English
- **Other Requirements**
 - 3 letters of recommendation
 - Interview
 - Short essay
- **Required Undergraduate Courses**
 - General Chemistry
 - Organic Chemistry
 - General Physics
 - General Biology
 - Calculus I

- **Optional Undergraduate Courses (Recommended)**

- Analytical Chemistry
- Biochemistry
- Molecular Biology
- Human Biology
- Biostatistics
- English Writing for Science major

❖ **Course Descriptions**

Professional Courses:

MSEG 7216. Introduction to Infectious Diseases (Medical Students)

This course is offered during the first semester of the second year of the MD Program. It introduces the students to the basic concepts of medical microbiology including: microbial structure, physiology, genetics and metabolism, antimicrobial therapy and basic immunology and host response to infectious diseases. The epidemiology, pathogenesis, clinical presentation, diagnostic and prevention of infectious conditions cause by bacteria, virus and parasites will be discussed.

CBIO 7150. Microbiology (Dental Students)

The course emphasizes fundamental principles of the genetics, growth metabolism and death of microbes. These principles are balanced with medical and dental aspects of host-parasite relations, immunologic phenomena, and the biological and clinical manifestations induced by major pathogens. Stress is placed on organisms related to dental caries and periodontal and periapical diseases. Further, the student should understand the influence of microorganisms and its associated biologic phenomena on patient' health. The course is based on lectures, laboratory exercises and clinical correlations.

FARM 7285. Microbiology (Pharmacy Students)

This course includes the fundamentals of microbiology, specifically the concepts related to medical microbiology, such as: bacterial physiology, metabolism, genetics, sterilization and disinfections, and immunology. In addition, syndromes caused by different types of organisms are studied. Active learning strategies and methodologies will be utilized.

MICR 3345. Microbiology (Nurse Students)

Includes general aspects of immunology, physiology and genetics of microorganisms. The most important pathogenic organisms are discussed including bacteria, fungi, virus and protozoa with special emphasis directed toward the needs of nursing students.

MICR 4006. Medical Bacteriology (Medical Technology Students)

Microbiology and Immunology lectures and laboratories with emphasis in the technical procedures used in the isolation and identification of bacteria, viruses and fungi pathogenic to man.

ZOME 6503. Medical Parasitology (Medical Technology Students)

The study of helminths and protozoa of medical importance. The course consists of lectures and laboratory sessions.

Graduate Courses:

MICR 8499. Introduction to Medical Microbiology – 6 credits

Subject matter will include the study of microbial physiology, microbial genetics and different infectious agents such as bacteria, viruses and fungi. The course will cover the distinguishing characteristics of these organisms, culture methods, pathological processes in which they are involved, and immune responses, which they stimulate in the infected host. This is an introductory course, consisting of lectures and laboratory sessions, which is a requirement for all graduate students who are entering the Graduate Program in Microbiology and is designed to provide the basis for more specialized courses in Microbiology.

MICR 8501. Diagnostic Bacteriology – 3 credits

The course consists of lectures, laboratory and discussion sessions related to the laboratory methods and techniques for isolation and identification of the most important bacterial pathogens.

MICR 8504-06. Advanced Topics in Medical Bacteriology – 1-3 credits

The course entails discussion of topics of interest that are pertinent to medical bacteriology. The topics must be approved by a faculty member and can be taken more than once, to the maximum of 3 credits.

MICR 8510. Virology and Tissue Culture – 3 credits

The course entails the study of the fundamental characteristics of viruses and the methods of tissue culture. The course will cover the basic characteristics of viruses that affect humans, including structure, replication, and evolution, their pathogenic effects in the host and host responses to infection.

MICR 8514-16. Advanced Topics in Virology – 1-3 credits

Topics of interest related to virology will be discussed. The topic to be discuss needs to be approve by the departmental faculty.

MICR 8517. Selected Topics in Microbiology – 1 credits

Selected and current topics in microbiology will be discussed. This course will be offered by one or more members of the department, or by invited professors. The topic to be discuss needs to be approve by the departmental faculty. Students may register for this course up to three times, each time in a different semester.

MICR 8518. Advanced Microbiology – 2 credits

Selected and current topics in microbiology will be discussed.

MICR 8525. Molecular Biology of the Microorganisms – 3 credits

This course is offered to the second-year students in the Biomedical Sciences Program. It will include the study of the basis of genetic expression in eukaryotic organisms, the theoretical aspects of recombinant DNA and RNA and current topics of molecular biology of microorganisms.

MICR 8530. Mycology – 2 credits

The study of the fundamentals characteristics of pathogenic fungi and its pathology, immunology and diagnosis of the disease they cause.

MICR 8530-31. Mycology Laboratory – 1-2 credits

The laboratory techniques used in the diagnosis of fungal diseases.

MICR 8532-34. Advanced Topics in Mycology – 1-3 credits

Topics of interest related to medical or environmental mycology will be discussed.

MICR 8540. Principles of Immunology – 3 credits

The course entails basic concepts of immunology and hypersensitivity at the humoral and cellular level, tumor immunology, cancer and transplant. It includes, in addition, basic concepts in immunochemistry.

MICR 8542-44. Advanced Topics in Immunology – 2-3 credits

The course will cover topics related to immunology or immunochemistry.

MICR 8550. Microbial Physiology – 2-3 credits

This course will cover the most important aspects of bacterial metabolism.

MICR 8552-54. Advanced Topics in Microbial Physiology – 1-3 credits

Topics of interest related to microbial physiology.

Selected topics will be discussed by one or more members of the faculty or by invited professors. The topic to be discuss needs to be approve by the departmental faculty.

MICR 8560. Microbial Genetics – 3 credits

This course includes the study of the mechanisms of storage, expression and information of genetic transfer among microorganisms and the genetic variation by mutation. The effect of the selective pressures over the microbial population will also be discussed.

MICR 8562-64. Advanced Topics in Microbial Genetics – 1-3 credits

This course will discuss topics of interest related to microbial genetics.

MICR 8580. Graduate Seminar – 1-3 credits

The graduate student will attend the seminars presented by other members of the Department and will present a one-hour seminar during the semester.

MICR 8590. Teaching Practice – 1 credit

The student will be an instructor, under supervision of one of the faculty members, in one of the laboratories of the undergraduate or professional courses offered by the Department of Microbiology and Medical Zoology.

MICR 8595. Master's Thesis – 6 credits

The student will dedicate at least one semester to full-time research on his/her thesis. Academic credits for this work will be awarded once the thesis is presented by the student and approved by his/her Thesis Committee.

MICR8599. Doctoral Dissertation – 15 credits

The student will dedicate at least one year to full-time research on his/her dissertation. Academic credits for this work will be awarded once the thesis is presented by the student and approved by his/her Dissertation Committee.

ZOME 8502. Introduction to Parasitology – 3 credits

This course covers the general concepts of parasitism, with emphasis on the impact that parasites have on human health and on that of domestic animals. Discussed topics will include the biology, transmission, and identification of parasites.

ZOME 8504. Nematodos – 2 credits

The course covers the general characteristics and morphological details of selected parasitic nematodes. In addition to the lectures, discussion will include previous publications, epidemiological, historical and evolutionary aspects of each organism of interest. A weekly laboratory will enable the student to learn the most frequently used techniques in diagnosis and research on these organisms.

ZOME 8506. Protozoa – 2 credits

The objective of this course is to familiarize the student with current areas of emphasis in a) studies of protozoan parasites of medical importance, and b) protozoan diseases of global importance. The student will become familiar with recent publications relevant to the topics of the course, critical analysis of the published material and of the interpretation of the results.

N.B. Students who are not enrolled in the Department of Microbiology and Medical Zoology will require the permission of the department's Director, or the course coordinator, to enroll in this course.

ZOME 8513-18. Laboratory Methods in Parasitology – 1-6 credits

This course consists of lectures and laboratory exercises during which methods and most refined techniques, appropriate to the assigned special problems, will be taught to each student.

PHARMACOLOGY AND TOXICOLOGY

❖ Faculty Research Interests

- Sylvette Ayala, Assistant Professor, Ph.D., Texas, 1998. Molecular biology; biochemistry; aging and oxidative stress.
- Adriana Báez, Professor; Ph.D., Madrid, 1977. Molecular basis of differentiation; induction by antitopoisomerase drugs; molecular epidemiology of head and neck cancer.
- Walmor C. De Mello, Professor and Chairman, M.D., 1955, Ph.D., 1964, Rio de Janeiro. Intercellular communication: variation in junctional permeability.
- Emma Fernández-Repollet, Professor; Ph.D., UPR-MSU, 1979. Role of T-cells in Diabetes Mellitus.
- Yamil Gerena, Adjunct Professor; Ph.D., UPR-MSU, 2008. Diabetes and cardiovascular disease.
- Diógenes Herreño-Saenz, Associate Professor; Ph.D., UPR-MSU, 1986. Toxicology, chemical carcinogenesis, biomarkers, and risk assessment.
- Jose G. Ortiz, Professor; Ph.D., Connecticut, 1982. Modulation of neurotransmitter uptake and release in experimental neurological models.
- Philip C. Specht, Associate Professor; Ph.D., SUNY Upstate Medical Center, 1972. Computer simulation of pharmacokinetics; contagious diseases.
- Susan Corey Best, Associate Professor; Ph.D., SUNY Upstate Medical Center, 1971. Na pump studies.

❖ Curriculum Sequence

Pharmacology Ph.D.
Department of Pharmacology & Toxicology

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|---|---|---|---|
| 1ST S E M E S T E R | BCHM 8500 <i>Biochemistry</i> 6 FISA 8601 <i>Physiology Vert.</i> 4 PHAR 8513 <i>Pharmacology Sem.</i> 1 BCHM 8551 <i>Meth. In Protein and Nucleic Acid Biochem.*</i> 2 BCHM 8552 <i>Meth in Lipid and Carbohydrates Biochem.*</i> 2 <p style="text-align: right;"><i>Credits = 15</i></p> | PHAR 8500 <i>Pharmacology</i> 5 PHAR 8513 <i>Pharmacology Sem.</i> 1 PHAR 8525 <i>Pharmacolo. Meth.</i> 3 CBIO 8500 <i>Statis. for Biom. Scs</i> 3 <i>Electives Course in Physiology</i> 2 <p style="text-align: right;"><i>Credits = 14</i></p> | PHAR 8513 <i>Pharma. Sem.</i> 1 <p style="text-align: right;"><i>Credits = 1</i></p> | PHAR 8513 <i>Pharma. Sem</i> 1 PHAR 8599 <i>Doctoral Dissert.</i> 0 <p style="text-align: right;"><i>Credits = 1</i></p> |
| 2ND S E M E S T E R | PHAR 85__ <i>Basic Con. of Pharm**</i> 3 FISA 8602 <i>Physiology Vert. II</i> 4 PHAR 8513 <i>Pharmacology Sem.cont 0</i> <p style="text-align: right;"><i>Credits = 7</i></p> | PHAR 8500 <i>Pharmacology</i> 0 PHAR 8513 <i>Pharmacology Sem.</i> 0 PHAR 85__ <i>Survival Skills**</i> 3 <i>Electives</i> 5 <p style="text-align: right;"><i>Credits = 8</i></p> | PHAR 8599 <i>Doctoral Dissert.</i> 15 PHAR 8513 <i>Pharma. Sem.</i> 0 <p style="text-align: right;"><i>Credits = 15</i></p> | PHAR 8599 <i>Doctoral Dissert.</i> 0 PHAR 8513 <i>Pharma. Sem.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

*Courses are in the process of credit hour revision.

Courses 43

**Courses are in the process of registration.

Tesis

15

TOTAL

48 Credits

Pharmacology M.S.
Department of Pharmacology & Toxicology

| | YEAR 01 | YEAR 02 |
|---|--|---|
| 1 ^s T S E M E S T E R | BCHM 8500 <i>Biochemistry</i> 6 FISA 8601 <i>Physiology Vert. I</i> 4 PHAR 8513 <i>Pharmacology Sem.</i> 1 BCHM 8551 <i>Meth. In Protein and Nucleic Acid Biochem. *</i> 2 BCHM 8552 <i>Meth in Lipid and Carbohydrates Biochem.*</i> 2 <div style="text-align: right;"><i>Credits = 15</i></div> | PHAR 8500 <i>Pharmacology</i> 5 PHAR 8513 <i>Pharmacology Sem.</i> 1 CBIO 8500 <i>Statistics for Biom. Scs.</i> 3 <div style="text-align: right;"><i>Credits = 9</i></div> |
| 2 ⁿ d S E M E S T E R | PHAR 85__ <i>Basic Concept of Pharm.**</i> 3 FISA 8602 <i>Physiology Vert. II</i> 4 PHAR 8513 <i>Pharmacology Sem.</i> 0 <div style="text-align: right;"><i>Credits = 7</i></div> | PHAR 8500 <i>Pharmacology</i> 0 PHAR 8513 <i>Pharmacology Sem</i> 0 PHAR 8595 <i>Master Thesis</i> 6 <div style="text-align: right;"><i>Credits = 6</i></div> |

* Courses are in the process or credit hour revision.
Courses 28 Tesis 6

** Course is in process of registration
TOTAL 34 Credits

Toxicology Ph.D.
Department of Pharmacology & Toxicology

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|---|---|--|--|
| 1ST S E M E S T E R | BCHM 8500 <i>Biochemistry</i> 6 FISA 8601 <i>Physiology Vert.</i> 4 TOXI 8501 <i>Basic of Toxicology</i> 3 TOXI 8509 <i>Seminar in Toxicology</i> 1 <p style="text-align: right;"><i>Credits = 14</i></p> | PHAR 8500 <i>Pharmacology (cont.)</i> 0 TOXI 8502 <i>Adv. Toxic. Techn.</i> 2 CBIO 8500 <i>Statis. for Biom. Scs</i> 3 TOXI 8509 <i>Seminar in Toxicology</i> 1 <i>Electives Course from department</i> 3 <p style="text-align: right;"><i>Credits = 9</i></p> | TOXI 8599 <i>Doctoral Dissertat.</i> 15 TOXI 8509 <i>Seminar in Toxicology</i> 1 <p style="text-align: right;"><i>Credits = 16</i></p> | TOXI 8599 <i>Doctoral Dissertat.</i> 0 TOXI 8509 <i>Seminar in Toxicology</i> 1 <p style="text-align: right;"><i>Credits = 1</i></p> |
| 2ND S E M E S T E R | FISA 8602 <i>Physiology Vert. II</i> 4 TOXI 8515 <i>Special Topics *</i> 2 TOXI 85__ <i>Bioinformatics**</i> 3 PHAR 8500 <i>Pharmacology</i> 5 <p style="text-align: right;"><i>Credits = 14</i></p> | TOXI 8515 <i>Special Topics</i> 2 TOXI 8508 <i>Problem in Forensic Tox.</i> 5 <i>Electives Course from department</i> 2 <p style="text-align: right;"><i>Credits = 9</i></p> | TOXI 8599 <i>Doctoral Dissertat.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> | TOXI 8599 <i>Doctoral Dissertat.</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

*Special Topic in different areas.

** Courses in process of registration.

Toxicology M.S.
Department of Pharmacology & Toxicology

| | YEAR 01 | YEAR 02 |
|---|---|---|
| 1 ST S E M E S T E R | BCHM 8500 <i>Biochemistry</i> 6 FISA 8601 <i>Physiology Vert.</i> 4 TOXI 8501 <i>Basic of Toxicology</i> 3 TOXI 8509 <i>Seminar in Toxicology</i> 1 <p style="text-align: right;"><i>Credits = 14</i></p> | TOXI 8515 <i>Special Topics *</i> 2 CBIO 8500 <i>Statis. for Biom. Scs</i> 3 TOXI 8595 <i>Research for Master Thesis</i> 6 <p style="text-align: right;"><i>Credits = 11</i></p> |
| 2 nd S E M E S T E R | FISA 8602 <i>Physiology Vert. II</i> 4 TOXI 8515 <i>Special Topics *</i> 2 TOXI 8515 <i>Special Topics *</i> 2 <p style="text-align: right;"><i>Credits = 8</i></p> | TOXI 8595 <i>Research for Master Thesis</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

*Special Topic in different areas.

❖ Graduating Student Profile

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|---|
| <p style="text-align: center;">PROFILE OF THE GRADUATE OF PHARMACOLOGY AND TOXICOLOGY MASTER'S DEGREE (MS)</p> |
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Upon completion of the studies of the Master's Degree of the Graduate Program of the Department of Pharmacology and Toxicology, the graduate shall have acquired the knowledge, skills, and attitudes necessary for excellence in the following areas:

- In the teaching of Medical Pharmacology and Toxicology in educational and professional institutions, in and outside of Puerto Rico.
- In scientific investigation, in academic, governmental, or private centers, possessing the skills and capabilities necessary for participating in research projects.
- In private industry, as consultant or leader of projects related to research and development, production, manufacturing, and quality control laboratories.
- In public service or government, as consultant, trainer, administrator, or advisor to agencies or laboratories responsible for supervising matters of health or quality control, among others.

The graduate of the Master's Program of the Department of Pharmacology and Toxicology in the School of Medicine shall have obtained and developed the following knowledge, skills, and attitudes:

KNOWLEDGE

- A mastery of the basic principles that underlie Medical Pharmacology and Toxicology
- Possess knowledge of the ethical and moral principles that guide the conduct of scientific research in areas such as: research involving human subjects; research methods, use, and care of animals; good scientific conduct, and other areas such as biosafety.
- Have a basic mastery of sciences such as biochemistry, physiology, biostatistics, scientific instrumentation, and critical evaluation of scientific literature, among others.
- Have a basic knowledge of the existing relation between basic and clinical sciences.

- Possess the knowledge of presentation and publication of scientific work in local, national, and international forums. This includes writing of reports, oral presentations, poster presentations, and publication in scientific journals.

SKILLS

- Have a knowledge of the theoretical base and practice of the basic science methodology related to the area of specialization within the field of Pharmacology and Toxicology.
- Have the necessary skills for obtaining pertinent information from the scientific literature, and maintain this knowledge current throughout their professional life.
- Have acquired the necessary skill for the effective use of the instrumentation and laboratory equipment utilized in teaching and scientific research.
- Have acquired the knowledge and skills needed for the effective use of computers and statistical analysis of data.
- Have the basic skills necessary for effective communication, both oral and written, of their knowledge and research work.
- Have acquired the knowledge and skills needed to obtain training and research projects.

ATTITUDES

- Possess an objective, analytic, and inquisitive attitude for their professional duties.
- Comply with the highest level of ethical and moral principles in the conduct of scientific research, and teaching.
- Stimulate an attitude which will enable them to achieve a level of professional excellence, and a spirit of cooperation.
- Stimulate a consciousness of social awareness, dignifying the labor of service to their colleges, students, to the public and the community.

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|--|
| <p style="text-align: center;">PROFILE OF THE GRADUATE OF PHARMACOLOGY AND TOXICOLOGY DOCTOR OF PHILOSOPHY (PH.D)</p> |
|--|

Upon completion of the studies of the Doctor of Philosophy Degree of the Graduate Program of the Department of Pharmacology and Toxicology, the graduate shall have acquired the knowledge, skills, and attitudes necessary for excellence in the following areas:

- In the teaching of Medical Pharmacology and Toxicology in educational and professional institutions, in and outside of Puerto Rico.
- In scientific investigation, in academic, governmental, or private centers, possessing the skills and capabilities necessary for participating in research projects.
- In private industry, as consultant or leader of projects related to research and development, production, manufacturing, and quality control laboratories.

- In public service or government, as consultant, trainer, administrator, or advisor to agencies or laboratories responsible for supervising matters of health or quality control, among others.

The graduate of the Doctoral Program of the Department of Pharmacology and Toxicology in the School of Medicine shall have obtained and developed the following knowledge, skills, and attitudes:

KNOWLEDGE

- A mastery of the basic principles that underlie Medical Pharmacology and Toxicology, including basic principles; pharmacology of the cardiovascular, respiratory, renal, gastrointestinal, and endocrine systems; and pharmacology of antibiotics, antineoplastics, antiparasitics, and antifungals; and toxicology.
- Possess knowledge of the ethical and moral principles that guide the conduct of scientific research in areas such as: research involving human subjects; research methods, use, and care of animals; good scientific conduct, and other areas such as biosafety.
- Have a mastery of sciences such as biochemistry, physiology, biostatistics, scientific instrumentation, and critical evaluation of scientific literature, among others.
- Have a mastery of the basic and clinical basis of the mechanism of action of drugs.
- Be an expert in the area of Pharmacology and Toxicology in the area of their doctoral dissertation.
- Possess the knowledge of presentation and publication of scientific work in local, national, and international forums. This includes writing of reports, oral presentations, poster presentations, and publication in scientific journals.
- Have a basic knowledge of the existing relation between basic and clinical sciences.
- Be capable of generating their own independent research, and of submitting proposals for research to local and federal agencies, and private institutions.

SKILLS

- Have a knowledge of the theoretical base and practice of the basic science methodology related to the area of specialization within the field of Pharmacology and Toxicology.
- Have the necessary skills for obtaining pertinent information from the scientific literature, and maintain this knowledge current throughout their professional life.

- Have acquired the necessary skill for the effective use of the instrumentation and laboratory equipment utilized in teaching and scientific research.
- Have acquired the knowledge and skills needed for the effective use of computers and statistical analysis of data.
- Have the basic skills necessary for effective communication, both oral and written, of their knowledge and research work.
- Have acquired the knowledge and skills needed to obtain training and research projects.

ATTITUDES

- As a Doctor of Philosophy, have a professional attitude. that is objective, critically analytical, inquisitive, and constructive, leading to the solution of scientific problems, evaluating new knowledge, and establishing public policy relating to Medical Pharmacology and Toxicology.
- Comply with the highest level of ethical and moral principles in the conduct of scientific research, and teaching.
- Stimulate an attitude which will enable them to achieve a level of professional excellence, and a spirit of cooperation.
- Stimulate a consciousness of social awareness, dignifying the labor of service to their colleges, students, to the public and the community.

❖ **Additional Requirements and Regulations**

- General Chemistry
- Organic Chemistry
- Analytical Chemistry
- General Physics
- General Biology

❖ **Course Description**

PHAR 8500. Pharmacology - 5 credits

The course offers an introduction to the basic vocabulary and principles of pharmacology and clinical therapeutics, stressing mechanisms of action, pharmacokinetics, therapeutic and adverse effects of prototype drugs in all of the important classes. Drug interactions, toxic effects, and general toxicology are also covered, in relation to pharmacological effects. The content is organized both in relation to families of similar mechanisms of action, and in relation to diseases of organ systems.

PHAR 8501. Biophysics Excitable Membranes - 2 credits

The course offers an introduction to the basic vocabulary concept of cell membrane morphology, membrane transport and basic concepts of diffusion. Discussion of basic principles.

PHAR 8503. Muscles: Biophysics, Physiology and Pharmacology - 3 credits

The course offers an introduction to the basic concepts of muscle biophysics, physiology and pharmacology including general morphology and ultrastructure.

PHAR 8504. Molecular Pharmacology and Biophysics of Excitable Tissue - 3 credits

The course offers an introduction to the basic concepts of molecular pharmacology and its importance in the understanding of intimate mechanisms of drug action.

PHAR 8505. Topics in Pharmacology - 1 credit

Conferences or seminars given by members of the Department of Pharmacology or by visiting professors about pharmacological subject material.

PHAR 8506. Topics in Pharmacology - 2 credits

Conferences or seminars given by members of the Department of Pharmacology or by visiting professors about pharmacological subject material.

PHAR 8507. Topics in Pharmacology - 3 credits

Conferences or seminars given by members of the Department of Pharmacology or by visiting professors about pharmacological subject material.

PHAR 8508. Topics in Pharmacology - 4 credits

Conferences or seminars given by members of the Department of Pharmacology or by visiting professors about pharmacological subject material.

PHAR 8509. Topics in Pharmacology - 5 credits

Conferences or seminars given by members of the Department of Pharmacology or by visiting professors about pharmacological subject material.

PHAR 8510. Topics in Pharmacology - 6 credits

Conferences or seminars given by members of the Department of Pharmacology or by visiting professors about pharmacological subject material.

PHAR 8512. Neuropharmacology - 3 credits

Lectures and student presentations about the biophysics and neuropharmacology of the mammalian central nervous system.

PHAR 8513. Pharmacology Seminar - 1 credit

Presentation of important articles and laboratory results by students and faculty members. All pharmacology department students are required to attend the course.

PHAR 8514. Heart Physiology and Pharmacology - 2 credits

The course offers an introduction to the basic vocabulary and principles of cardiovascular pharmacology and physiology and discussion of basic principles.

PHAR 8519. Cellular Neuropharmacology: An Integrative Approach - 3 credits

The special properties of central nervous system cells will be discussed, emphasizing the integration of anatomical, biochemical, physiological and pharmacological aspects. Various systems, cerebellum for example, and clinical aspects will be discussed.

PHAR 8525. Pharmacological Methods - 3 credits

The purpose of this course is to expose the student to the theory and practice of techniques used in pharmacological investigation. Also includes certification in the use of animals and radioisotopes.

PHAR 8527. Mode of Antibiotic Action - 2 credits

The molecular basis of action of antibiotics will be studied. Also interactions of antibiotics with different sites of action and the development of bacterial tolerance to drugs.

PHAR 8595. Research for Master Thesis - 6 credits

Thesis research.

PHAR 8599. Doctoral Dissertation Research - 15 credits

Thesis research.

TOXI 8501. Principles of Toxicology - 3 credits

Fundamentals and principles of toxicology including absorption, distribution, metabolism and excretion of toxic chemicals in mammalian systems. Discussion of molecular mechanisms, cellular targets, and biological consequences of exposure to toxic agents. Chemical carcinogenesis, mutagenesis, and teratogenesis; molecular mechanisms of toxic action. Regulatory toxicology and Risk Assessment.

TOXI 8502. Advanced Toxicological Techniques - 2 credits

Discussion of basic principles involved and their implementation in analytical methods used in Toxicology research. Laboratory methods for the determination of toxicity of chemicals and techniques to determine the interaction of toxicants with biochemical and physiological processes.

TOXI 8508. Problems in Toxicology - 5 credits

The advanced course is limited to candidates for the Doctor's degree in toxicology area and is designed to test the ability of advance students to solve some of the most difficult problems in forensic, clinical, environmental, or industrial toxicology. The problem could include laboratory research and /or library research. Will provide students with in-depth information concerning the use of basic medical sciences to assess chemical and drug-induced toxicity and to evaluate public health problems.

TOXI 8509. Journal Club - 1 credit

The Journal Club (Seminar) requirement serves to give the student experience in presenting scientific matter to an audience of peers, to expose the student to research areas quite different from their thesis research, and to assist in the development of the student's ability to identify critical problems and ask critical questions regarding a particular research area.

TOXI 8515. Special Topics in Toxicology - 2 credits

Gives in-depth treatment to topics of current importance and to specialized subjects not covered in general courses. Each topic is narrowly defined. Representative topics include: biomarkers and toxicology, chemical carcinogenesis, regulatory toxicology, neurotoxicology, environmental toxicology, metabolism and disposition of xenobiotics, topics in cardiotoxicity, and molecular toxicology. May be taken for multiple credit with permission of instructor.

TOXI 8595. Research for Master Thesis - 6 credits

Thesis research.

TOXI 8599. Doctoral Dissertation Research - 15 credits

Thesis research.

PHYSIOLOGY

❖ Faculty Research Interests

- Jaime Blagburn, Professor; Ph.D., Thames Polytechnic (London), 1982. Physiology of invertebrate ganglia.
- María José Crespo, Professor; Ph.D., UPR-MSU, 1993. Vascular alterations in cardiovascular disease.
- Nelson Escobales, Professor and Chairman; Ph.D., UPR-MSU, 1982. Membrane physiology.

- Walter R. Frontera, Professor; M.D., UPR-MSU, 1979; Ph.D., Boston U., 1986. Exercise Physiology.
- Sabzali A. Javadov; Associate Professor, M.D., Ph.D., USSR Academy of Medical Sciences, 1986. Mitochondria-mediated mechanisms of cardiac injury and cardioprotection.
- Carlos Jiménez, Associate Profesor; Ph.D., New Mexico, 1986. Neurophysiology.
- Jorge D. Miranda, Associate Professor; Ph.D.; Baylor College of Medicine, 1996. Axonal regeneration in the adult spinal cord.
- Guido Santacana, Professor; Ph.D., UPR-MSU, 1982. Changes in the physiology and pharmacology of airway smooth muscle that are induced by mechanisms of temperature and drugs of abuse.
- Annabell C. Segarra, Professor; Ph.D., NYU, 1988. Neuroendocrinology of the reproductive system; estrogen, opioids, and cocaine sensitization.
- Walter I. Silva, Professor; Ph.D.; NYU, 1986. Cellular and molecular physiology of vascular and brain cells.
- Carlos A. Torres, Assistant Professor; Ph.D., Texas Medical Branch, 1996. Repair of AP sites and aging in *Saccharomyces cerevisiae*.
- Conchita Zuazaga, Professor; Ph.D., University of Minnesota, 1974. Electrical excitability of biological membranes.

❖ Curriculum Sequence

PHYSIOLOGY PH.D.
Department of Physiology

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|---|--|--|--|
| 1 st S E M E S T E R | FISA 8601 <i>Vertebrate Physiol. I</i> 4 BCHM 8500 <i>Biochemistry</i> 6 FISA 8503 <i>Seminar in Phys.</i> 1 <p style="text-align: right;"><i>Credits = 11</i></p> | CBIO 8500 <i>Statis. for Biom. Scs.</i> 3 FISA 8541 <i>Prob. in Physiology I</i> 3 Electives from Dept. 4 <p style="text-align: right;"><i>Credits = 10</i></p> | FISA 8585 <i>Prep. Physiol Proposal</i> 3 FISA 8503 <i>Sem. in Physi.</i> 1 <p style="text-align: right;"><i>Credits = 4</i></p> | FISA 8599 <i>Doctoral Thesis</i> 0 FISA 8503 <i>Sem. in Phys.</i> 1 <p style="text-align: right;"><i>Credits = 1</i></p> |
| 2 nd S E M E S T E R | FISA 8602 <i>Vertebrate Physiol. II</i> 4 FISA 8532 <i>Adv. Phys. Instru.</i> 3 FISA 8540 <i>Cell Mol. Physiol.</i> 3 FISA 8503 <i>Seminar in Phys.</i> 1 <p style="text-align: right;"><i>Credits = 11</i></p> | FISA 8503 <i>Seminar in Phys.</i> 1 Electives from Dept. 9 <p style="text-align: right;"><i>Credits = 10</i></p> | FISA 8599 <i>Doctoral Thesis</i> 15 <p style="text-align: right;"><i>Credits = 15</i></p> | FISA 8599 <i>Doctoral Thesis</i> 0 <p style="text-align: right;"><i>Credits = 0</i></p> |

*Courses are in the progress of credit hour revision from one (1) to two (2).

PHYSIOLOGY M.S.
Department of Physiology

| | YEAR 01 | YEAR 02 |
|---|---|---|
| 1 st S E M E S T E R | FISA 8601 <i>Vertebrate Physiol. I</i> 4 | CBIO 8500 <i>Statis. for the Biom. Scs.</i> 3 |
| | BCHM 8500 <i>Biochemistry</i> 6 | FISA 8503 <i>Sem. in Physi.</i> 1 |
| | FISA 8503 <i>Seminar in Phys.</i> 1 | FISA 8595 <i>Master Thesis</i> 6 |
| | <i>Credits = 11</i> | <i>Credits = 10</i> |
| 2 nd S E M E S T E R | FISA 8602 <i>Vertebrate Physiol. II</i> 4 | FISA 8595 <i>Master Thesis</i> 0 |
| | FISA 8532 <i>Adv. Phys. Instru.</i> 3 | |
| | FISA 8540 <i>Cell Mol. Physiol.</i> 3 | |
| | <i>Credits = 10</i> | <i>Credits = 0</i> |

*Courses are in the progress of credit hour revision from one (1) to two (2).

❖ Graduating Student Profile

Profile of the Masters' Graduate of the Physiology Program (M.S.)

At the completion of studies in the Masters' Degree Program the graduate of Physiology will have acquire the knowledge, skills, and attitudes necessary to perform effectively in any of the following areas:

As a Scholar in Academics: Teaching courses in areas related to biology and biomedical sciences, in particular physiology. This role can be undertaken at academic institutions training undergraduate students and Technical Schools.

As an Investigator: Collaborating in scientific investigation projects at academic centers, government managed laboratories, the private industry, or other institutions of scientific research.

In the Private Sector: As a consultant or project supervisor. Consulting can be provided in teaching, research, and in the generation of grant proposals and scientific manuscript writing.

In the Field of Biotechnology: The graduate could participate in research projects in the area of biotechnology, in particular in the area of research and development.

In general, the graduate of the Masters' Degree Program in Physiology will develop the following skills, knowledge, and attitudes:

Skills

The Graduate will have the necessary skills to obtain information regarding tendencies and basic scientific literature in the biomedical sciences. These skills will enable him(he) for a continuing and dynamic updating of knowledge once formal graduate studies are completed.

He(he) will be well-informed on the background, the fundamentals and the theoretical basis of the scientific methodologies applied in the biomedical sciences.

The Graduate will have acquired the necessary skills to make effective use of laboratory equipment and basic instrumentation used in teaching and scientific investigation.

The Graduate will have acquire the knowledge and basic skills on the use of statistics and the effective use of computers in the experimental design, data collection, storage, and analysis.

He(he) will have the necessary skills for an effective oral and written communication. These skills will be applied in the presentation of educational and scientific projects in local, national, and international forums. The communication skills will be used in the generation and presentation of reports, the preparation and presentation of posters, and the publication of manuscripts in scientific journals.

Knowledge

He(he) will master the basic principles and fundamentals of Physiology. Knowledge will be acquired in the various areas of the discipline such as cellular-molecular, muscle, cardiovascular, respiration, renal, gastrointestinal, endocrine, and neurophysiology. The Graduate will be knowledgeable in Scientific Instrumentation, Biostatistics, among others.

The graduate will specialize in an area of physiological research that will enable him(he) to become well-informed in the field of interest.

He(he) will be well-informed in biomedical sciences so as to understand the clinical relevance of basic physiological concepts.

The Graduate will be well-informed on basic scientific literature of its field of interest and its tendencies.

The Graduate will master the statistical construct of a research project. This includes the statistical design, the design of experiments, and collection and analyses of data.

He(he) will be well-informed on the background, the fundamentals, and the theoretical basis of scientific methodologies applied in the biomedical sciences.

The Graduate will be knowledgeable in the basic techniques of presentations of educational and scientific projects in local, national, and international forums. This includes the generation and presentation of reports, the preparations of posters, visual aids and the publication of manuscripts in scientific journals.

The Graduate of the Masters' Degree in Physiology will have gained knowledge of the moral and ethical principles that rule the conduction of scientific research in areas

such as biosafety, use and care of animals, and the maintenance of an ethical scientific conduct.

Attitudes

The Graduate will have a professional and objective attitude characterized by an inquisitive, analytical, critical perspective that will enable him(her) to find proper solutions to scientific problems, and to evaluate the development of new knowledge in the area of biomedical sciences, with particular emphasis in Physiology.

He(her) will fulfill his(her) teaching and scientific duties according to the highest moral and ethical standards. The Graduate Program will promote in the student an attitude conducive to professional and responsible execution of duties in a friendly environment.

The Graduate Program will make the student aware of his(her) social commitment in a way that dignifies his(her) service to students, colleagues, and the community.

| |
|--|
| <p style="text-align: center;">Profile of the Doctoral Graduate of the Physiology Program (Ph.D.)</p> |
|--|

At the completion of doctoral studies, the graduate of the Physiology Program will have acquired the skills, Knowledge, and necessary attitudes to perform effectively in any of the following areas:

As a Scholar in Academics: Teaching courses in areas related to biology and biomedical sciences, in particular physiology. This role can be undertaken at academic institutions training undergraduate students and Technical Schools.

As an Investigator: Collaborating in scientific investigation projects at academic centers, government managed laboratories, the private industry, or other institutions of scientific research.

In the Private Sector: As a consultant or project supervisor. Consulting can be provided in teaching, research, and in the generation of grant proposals and scientific manuscript writing.

In the Field of Biotechnology: The graduate could participate in research projects in the area of biotechnology, in particular in the area of research and development.

In general, the graduate of the Ph.D Degree Program in Physiology will develop the following skills, knowledge, and attitudes:

Skills

The Graduate will have the necessary skills to obtain information regarding tendencies and basic scientific literature in the biomedical sciences. These skills will enable him(he) for a continuing and dynamic updating of knowledge once formal graduate studies are completed.

He(he) will be well-informed on the background, the fundamentals, and the theoretical basis of the scientific methodologies applied in the biomedical sciences.

The Graduate will have acquired the necessary skills to make effective use of laboratory equipment and basic instrumentation used in teaching and scientific investigation.

The Graduate will have acquire the knowledge and basic skills on the use of statistics and the effective use of computers in the experimental design, data collection, storage, and analysis.

He(he) will have the necessary skills for an effective oral and written communication. These skills will be applied in the presentation of educational and scientific projects in local, national, and international forums. The communication skills will be used in the generation and presentation of reports, the preparation and presentation of posters, and the publication of manuscripts in scientific journals.

The Graduate of the Ph.D. Program in Physiology will have acquired the necessary skills and knowledge to continue further education as a post-doctoral student.

Knowledge

He(he) will master the basic principles and fundamentals of Physiology. Knowledge will be acquired in the various areas of the discipline such as cellular-molecular, muscle, cardiovascular, respiration, renal, gastrointestinal, endocrine, and neurophysiology. The Graduate will be knowledgeable in Scientific Instrumentation, Biostatistics, among others.

The graduate will specialize in an area of physiological research that will enable him(he) to become an expert in the field.

He/she) will be well-informed in biomedical sciences so as to understand the clinical relevance of basic physiological concepts in areas such as heart failure, atherosclerosis, asthma, drug addiction, neuroregeneration, and aging among others.

The Graduate will be well-informed with the basic scientific literature of its field of interest and its tendencies.

The Graduate will master the statistical construct of a research project. This includes the statistical design, the design of experiments, and collection and analyses of data.

He/she) will be well-informed on the background, the fundamentals, and the theoretical basis of scientific methodologies applied in the biomedical sciences.

The Graduate will be knowledgeable in the basic techniques of presentations of educational and scientific projects in local, national, and international forums. This includes the generation and presentation of reports, the preparations of posters, visual aids and the publication of manuscripts in scientific journals.

He/she) will be knowledgeable of sources of funding for scientific projects, its supporting mechanisms, and the application process.

The Graduate of the Ph.D. Degree Program in Physiology will have gained knowledge of the moral and ethical principles that rule the conduction of scientific research in areas such as biosafety, use and care of animals, and the maintenance of an ethical scientific conduct.

Attitudes

The Graduate will have a professional and objective attitude characterized by an inquisitive, analytical, critical perspective that will enable him/she) to find proper solutions to scientific problems, and to evaluate the development of new knowledge in the area of biomedical sciences, with particular emphasis in Physiology.

He/she) will fulfill his/her) teaching and scientific duties according to the highest moral and ethical standards. The Graduate Program will promote in the student an attitude conducive to professional and responsible execution of duties in a friendly environment.

The Graduate Program will make the student aware of his/her) social commitment in a way that dignifies his/her) service to students, colleagues, and the community.

❖ **Additional Requirements and Regulations**

- Mathematics
- Physics
- General Chemistry
- Organic Chemistry

❖ **Course Description**

FISA 8503. Seminar in Physiology - 1 credit

The seminars are designed, prepared, and presented by the students following the advise of a faculty member. The dates for the presentations are scheduled at the convenience of the students and the professor coordinating the activity. Each student is responsible for presenting 1 or 2 seminars per semester depending on the number of students registered in the course. The central focus of the course will be the physiology of the human organism, but may also include topics in general physiology. The material will be presented by guest lecturers and conferences given by experts in their respective fields of research, or related to specific topics recently published in the scientific literature. *Attendance to all seminars sponsored by the Physiology Department is mandatory for students registered in the course during the academic year.* Faculty from other departments may also participate by offering seminars that the students will analyze based on the content, organization, communication skills of the presenter, audiovisual techniques used, etc. The ultimate goal of this course is to teach students the art and science of delivering a professional-quality seminar to a group of scientific colleagues. The work includes the selection of a topic, the preparation of the talk, and the presentation of the material to a scientific audience in a manner that is both comprehensive and understandable. The course also offers students the opportunity to interact with visiting scientists, faculty, and other graduate students of the Department of Physiology and the Basic Sciences.

FISA 8510. Seminar in Biophysics – 3 credits

This course is an in depth look at the biology and physics of ionic channels embedded on excitable membranes. Ionic channels are indispensable for the production and transduction of electrical signals in excitable cells. This course will attempt to merge classical principles and analogies of the biophysics of

ionic channels with current areas of physiological research, specially, in the neurosciences. The properties and physiological functions of classical and newly discovered channels will be discussed and their significance in the central nervous system will be highlighted.

FISA 8511 Seminar in Endocrinology – 2 credits

This course offers recent information regarding endocrinology above and beyond what is available in the basic endocrinology textbooks. New advances in endocrinology will be discussed in detail, depending on the students enrolled in the course. Students will pick topics of interest to them, research the topic in detail and present a seminar, or a group discussion of information contained in the collection of papers. All students will be required to read background information about each seminar topic in advance of the seminar. Students will normally discuss methodologies, which integrate basic concepts, theories and research strategies.

FISA 8512. Cardiovascular Physiology – 2 credits

A course on comparative cardiovascular physiology based on some of the most recent advances in the field. The course includes heart mechanics, electrophysiology, hemodynamics and regulation.

FISA 8513. Advanced Exercise Physiology I – 3 credits

This course will address how the body adapts to exercise during acute and chronic time frames. It will also review and discuss basic terminology and concepts of cellular metabolism, muscle contraction and neuromuscular function for enhanced understanding of acute and chronic adaptations to exercise. The course is concluded with a review of recent findings on various pharmacological, hormonal, physiological, and environmental agents known to either enhance or impair exercise performance. The course consists of three sections: fundamentals of exercise physiology, systemic response to exercise and aids to exercise performance.

FISA 8514. Advanced Exercise Physiology I – 3 credits

This course will review and discuss the latest research findings in exercise physiology/biochemistry related to: fatigue, aging, gender, children, environmental conditions and genetics. It will also review the measurement of endurance, anaerobic capacity, strength and body composition as well as applications of exercise physiology to exercise testing. The course consists of three sections: measurement of physiologic composition and capacities, special topics within exercise physiology, and exercise and health.

FISA 8515. Respiratory Physiology – 3 credits

The course consists of both lecture and discussion sessions. Discussions are developed primarily to critical analyses of important scientific papers. Topics covered: (a) O₂ and CO₂ exchange between the atmosphere and blood, with particular emphasis on the role of matching alveolar ventilation and pulmonary capillary diffusion; (b) nervous and chemical regulation of respiration. In addition exercise and/or aviation physiology will also be discussed.

FISA 8516. Renal Physiology – 2 credits

This course explores various aspects of renal physiology. Emphasis is placed on providing insight and understanding into the major functions of the kidneys, which are as follows: Regulation of body fluid osmolarity and volume, Regulation of electrolyte balance, Regulation of acid-base balance, Excretion of metabolic products and foreign substances, and Production and secretion of hormones. In addition, the students registered in the course will discuss and present in the form of seminars, critical papers on the various issues of the renal function. The course will consist of 14 hours of lectures, 14 hours for papers discussions, 6 hours of independent study, and two hours for evaluations for a total of 36 hours per semester or two credits

FISA 8518. Mathematics for Biologists: Graphic Data Analysis – 2 credits

Studies of the following concepts: the function concept; function derivative; rules to obtain derivatives; exponential functions; integral calculus; geometric interpretation of derivatives; some differential equations. The course deals with concepts and methods applicable to analysis of data, specifically graphic data analysis, using software programs routinely used in research programs across the nation. The course also consists of hands-on experience in curve fitting, enzyme kinetics, pharmacologic analysis, and physiologic processes in general, including peak analysis.

FISA 8525. Introduction to Neuroscience – 2 credits

This course offers essential information of spinal cord circuits, neural development and plasticity, integrating basic concepts, theories and research strategies from different disciplines like Anatomy, Physiology, Biochemistry, Pharmacology, Cell & Molecular Biology. Topics within this course include Neuroanatomy of axonal tracts in the spinal cord, control of movement, circuits related to pain, glial cells, myelin formation, axonal transport, neural development and plasticity in the adult central nervous system. The central

focus of this course will be the biochemistry, cellular and molecular analysis of neural development and behavior of the nervous system. In addition, the sensory and motor systems in relation to the spinal cord will be discussed. The material will be presented as conferences of specific topics recently published in scientific journals. The ultimate goal of this course is to teach students the basic molecular and cellular concepts of neural development and behavior, and demonstrate the main tracts used by the central nervous system to control movement.

FISA 8526. Seminar in Central Nervous System and Behavior – 3 credits

The main focus of this course is to study the neural basis of behavior. The first few lectures provide a brief overview of neuroscience, from systems to signal transduction. Each week a different behavior is discussed (eating, sexual behavior, fear, learning, etc). The components of the behavior are discussed, as well as the cellular and molecular mechanisms that regulate that behavior. This is followed by a student presentation of a recent scientific publication that deals with disorders of that behavior (bulimia, hypersexuality, learning disabilities, etc).

FISA 8532. Advanced Scientific Instrumentation – 3 credits

The main objective of this course is to teach the students the theoretical basis behind the practical application of instruments that are used in scientific studies in biological sciences. This also includes a whole section on basic electronics theory with practical applications. The basic electronics section starts with AC/DC circuits followed by the theory behind the volt ohm meter and oscilloscope with practice exercises and demonstrations on their use. This is followed by theory and design of power supplies and amplifiers. The last section overviews the design and function of electrical stimulators, spectrometers, pH meters, and conductivity meters. Each student is assigned a presentation on the electronic circuit theory and practical use of a specific instrument. The presentation includes a demonstration on the use of the instrument.

FISA 8540. Cellular and Molecular Physiology – 3 credits

This course will provide students with basic concepts of cell physiology from a molecular point of view. The main emphasis of the course is protein synthesis, sorting and final targeting (endocytosis and exocytosis-vesicular trafficking) to different organelles of an eukaryotic cell (Endoplasmic reticulum, Golgi Apparatus, lysosome, peroxisome, mitochondria, nucleus and plasma membrane). In addition, some time has been dedicated to receptor regulation at the transcriptional, posttranscriptional, translational and

postranslational level. Finally, the course will cover cellular processes that are related to proteins involved in cell communication and cytoskeletal proteins. The material will be presented as lectures and presentation of specific recent publications. The final goal of this course is to teach the students the molecular basis of cell physiology and learn the approaches used to determine the role of specific proteins and organelles.

FISA 8541. Problems in Physiology I – 3 credits

Assigned topics for laboratory work, lectures, and readings in any area of Physiology. It is expected that at the end of the course, students have identified a research project for his/her thesis. To achieve this, students will do two rotations in different laboratories of the department. In these rotations the student will learn the rationale and experimental approach of specific research projects. The goal of this course is that each student define a mentor and pick a research project for their thesis.

FISA 8542. Directed Readings – 1 credits

This course offers recent information regarding physiology above and beyond what is available in the basic textbooks. New advances in physiology will be discussed in detail, depending on the students enrolled in the course. Students will pick topics of interest to them, research the topic in detail and present a seminar, or a group discussion of information contained in the collection of papers. All students will be required to read background information about each seminar topic in advance of the seminar. Students will normally discuss methodologies, which integrate basic concepts, theories and research strategies.

FISA 8543. Problems in Physiology II – 3 credits

Special topics assigned for laboratory work, conferences, and lectures. This course offers the opportunity to examine recent information in the various areas of physiology and supplement that provided in the literature. New advances in physiology will be discussed in detail. Students will pick topics of their interest to research and present as a seminar or group discussion. Students will integrate basic concepts, theories, discuss methodologies and research strategies. All participating students are expected to read background information in advance and to actively participate in class discussions. Laboratory exercises may be integrated to the course depending on the topic of discussion.

FISA 8551. Problems in Physiology III – 3 credits

Special topics assigned for laboratory work, conferences, and lectures. This course offers the opportunity to examine recent information in the various areas of physiology and supplement that provided in the literature. New advances in physiology will be discussed in detail. Students will pick topics of their interest to research and present as a seminar or group discussion. Students will integrate basic concepts, theories and methodologies and research strategies. All participating students are expected to read background information in advance and to actively participate in class discussions. Laboratory exercises may be integrated to the course depending on the topic of discussion.

FISA 8552. Problems in Physiology IV – 3 credits

Special topics assigned for laboratory work, conferences, and lectures. This course offers the opportunity to examine recent information in the various areas of physiology and supplement that provided in the literature. New advances in physiology will be discussed in detail. Students will pick topics of their interest to research and present as a seminar or group discussion. Students will integrate basic concepts, theories, discuss methodologies and research strategies. All participating students are expected to read background information in advance and to actively participate in class discussions. Laboratory exercises may be integrated to the course depending on the topic of discussion.

FISA 8585. Development of Research Proposals in Physiology – 3 credits

This course provides the essential information for the preparation of a thesis proposal by integrating basic physiological concepts with research strategies. Topics include the analysis of scientific literature to define a research problem, establishment of an hypothesis and specific aims, design of methodology to evaluate the research problem, and interpretation of preliminary results. The central theme of this course is the development of a thesis proposal using NIH guidelines. Possible pitfalls during the development of the research proposal will be discussed. Specific topics chosen by the student and his/her mentor should include a review of the literature including the most recent events relevant to the research topic.

FISA 8595. Master Thesis Investigation – 6 credits

Research work in a laboratory for the completion of a Master thesis. This course provides the student with training in all areas of scientific research. The

student, under the guidance of a mentor and the members of the thesis committee, formulates a hypothesis and designs experiments to prove or disprove the hypothesis according to the scientific method. During this process, the student is expected to become an expert in laboratory techniques, experimental design, and data analysis. Effective communication and teaching skills are expected to be developed during this process.

FISA 8599. Doctoral Thesis Investigation – 15 credits

Laboratory work directed towards the completion of a doctoral thesis. This course provides training in all aspects of the scientific investigation. The student, under the guidance of his mentor and the thesis committee formulates a hypothesis and then designs experiments to prove or disprove this hypothesis according to the scientific method. During this process the student is expected to become an expert in experimental design, laboratory techniques and data analysis. Effective communication and teaching skills are expected to be developed during this process.

FISA 8601. Vertebrate Physiology I – 3 credits

This course is designed to offer students the basic concepts in vertebrate physiology, emphasizing the human vertebrate. The course develops from the cell, discussing membrane properties and the physiology of muscle cells, and continues with a discussion of the two integrative systems: the nervous and endocrine systems. The final portion of the course is dedicated to discuss reproductive physiology and its neuroendocrine regulation. The ultimate goal of the course is to enable students to understand the basic physiological processes of vertebrates, and in particular, humans.

FISA 8602. Vertebrate Physiology II – 3 credits

This course is designed to offer students the basic concepts in vertebrate physiology, emphasizing human organs and systems. The course consists of four sections. The first section is renal physiology with emphasis in ionic transport and osmotic regulation. The second section is respiratory physiology emphasizing gas interchange between the organism and the environment. The third section is physiology of the gastrointestinal system with emphasis in motility, secretion, digestion, and absorption of nutrients. The fourth section is exercise physiology. Classes will include formal lectures, reading of scientific literature, and computer demonstrations.

Opportunities for Combined MD/PhD Studies

Mayo Foundation and University of Puerto Rico
Integrated MD-PhD Program

Admission Regulations

❖ **Creation of the Integrated Program**

During the 1998-99 academic year the Mayo School of Medicine Graduate School (MGS) and the University of Puerto Rico Medical School (UPR-MS) joined forces by signing an agreement to create a combined MD-PhD Program. The main objective of this program is to foster the development of biomedical research leaders in Puerto Rico by offering outstanding medical students in the UPR the opportunity to combine their medical studies at the UPR-MS with a competitive PhD program at the Mayo Graduate School.

❖ **Description of the Integrated MD-PhD Program**

A student enrolled in the Program will be required to complete the same academic requirements, standards and certifications of degree completion established by MGS for the other M.D./Ph.D. students, including all qualifying exams and thesis proposals. Like other students in the Mayo M.D./Ph.D. program, students from the UPR-MS-MGS combined program will spend their first year of the Ph.D. at the Mayo Clinic Rochester. After the first year, in consultation with Mayo M.D./Ph.D. Program staff, the student may do his or her thesis research at Mayo Clinic Rochester, Mayo Clinic Jacksonville or Mayo Clinic Arizona. In addition, the Program will contain the following elements:

- Students will participate in laboratory rotations at MGS with other students enrolled in the Mayo M.D./Ph.D. Program beginning the first summer following the student's first year of medical studies.

- A faculty member from UPR-MSC Medical School will serve as a member of the Qualifying Exam and Thesis Committee for students enrolled in the Program. Students must have written and defended their thesis at MGS before returning to medical school at UPR-MSC. Students will also be expected to present their completed thesis research to the UPR-MSC Medical School Faculty upon their return to the UPR-MSC.

Students will be awarded their M.D. at UPR-MSC Medical School and their Ph.D. at MGS upon the student's completion of medical school at UPR-MSC.

❖ **Clinical Training**

During the Ph.D. phase of the training, students admitted to the Program will have access to limited clinical training (e.g., one or two half-days per month) at MMS by working with a clinical mentor to sustain their clinical skills in anticipation of their return to UPR-MSC Medical School. Students are not required to pay any additional tuition or fees related to obtaining such clinical training at MMS. Following completion of the Ph.D. degree, the students shall return to UPR-MSC Medical School to complete their medical education training at UPR-MSC and to obtain their M.D. degree from UPR-MSC. During the 4th year of medical school at UPR-MSC students may carry out up to eight (8) weeks of elective clinical rotations at MMS.

❖ **Application**

Each student interested in applying to the Program will submit the following information to the Mayo M.D./Ph.D. Committee, the Mayo Medical School Admissions Committee, and the UPR-MSC Medical School Promotions I (if first year student) or II (if second year student) Committees "Promotions Committee": the AMCAS application, the secondary Mayo M.D./Ph.D. application, and at least four letters of recommendation (the Application"). In addition, MGS will invite students who appear to be the most qualified for the Program to interview in Rochester, Minnesota, at MGS's expense. A student may apply during the student's first or second year at UPR-MSC Medical School. Completed applications must be received by the Mayo M.D./Ph.D. Committee, the Mayo Medical School Admissions Committee, and by the UPR-MSC Medical School Promotions Committee by December 31. Applications may be accepted after these dates with permission from the applicable committees.

The UPR-MSC will review applicants based on a good academic standing, a grade point average of 3.0 or more, undergraduate or graduate research experience and appropriate non-cognitive factors including a genuine commitment to the program.

❖ **Selection Process**

Each of the Mayo M.D./Ph.D. Committee, the Mayo Medical School Admissions Committee, and the UPR-MSC Medical School Promotions Committee will individually review an Application submitted by a student and each Committee will approve or reject the applicant based on criteria developed by the particular Committee.

The Mayo M.D./Ph.D. Committee and the Mayo Medical School Admissions Committee will look for applicants who have an outstanding academic record, evidence of extensive and successful laboratory research, personal qualities exemplary of future leaders in clinical medicine and research, and applicants who meet other criteria developed by the particular Committee. Priority will be given to applicants who are most likely to become future biomedical leaders in Puerto Rico. A student whose Application is approved by all three Committees will be accepted into the Program. Students will be expected to take the USMLE Step I at the same time as the other UPR-MSC medical students in June following the second year of medical school. If a student does not pass the USMLE Step I, the student will be expected to retake and pass the exam the next time it is offered. In the event the student fails the USMLE Step I after a second attempt he/she will not be accepted in the M.D./Ph.D. Program.

The UPR-MSC will receive applications to the Program before June 30. The applications will be submitted to the office of the Associate Dean of Biomedical Sciences who in conjunction with an UPR-MSC MD-Ph.D. Committee will proceed with a primary review of the applications.

The Promotions Committee who will submit the recommended applications to the Dean of Medicine for final approval, will then review the applications. Successful applicants will then be referred to the Mayo M.D./Ph.D. Admissions Committee for their individual review.

❖ **Financial Aid**

Funding of students in each individual degree program will remain the responsibility of the respective institutions. In general, the parties shall cooperate in obtaining extramural support for students to cover both the M.D. and Ph.D. phases of the Program. Specifically,

- *MGS* = MGS shall use reasonable efforts to provide full funding of students in the Program as is currently provided to Mayo M.D./Ph.D. students. Students will be expected to work with Mayo faculty to apply for extramural awards where possible.
- *UPR-MSC* = UPR-MSC shall provide tuition scholarship, including healthcare insurance coverage, and other registration fees.

THE MD-PHD PROGRAM AT THE UNIVERSITY OF PUERTO RICO SCHOOL OF MEDICINE

❖ Overview

The M.D. Ph.D. Program at the University of Puerto Rico Medical School is designed for students who have decided to become physicians and scientists at the same time. The program offers excellent medical and scientific training in an environment where both research and clinical training are highly encouraged and supported. Due to the fact that the medical school resides in a huge medical center that house several tertiary care facilities, there is a significant availability of a diverse patient population. Coupled to well established research facilities this offers the student the opportunity to choose among a tremendously varied set of areas for biomedical research.

The M.D.- Ph.D. Program, like many of the other programs at the UPR Medical School is student oriented. The institution will guarantee the best possible educational environment that will provide the student with the tools necessary to become a successful medical scientist.

The student who decides to enter the M.D.- Ph.D. Program must be both highly qualified and motivated in order to successfully complete what will become a period of 6 to 8 years of intense clinical and graduate studies. In fact this student is combining two very rigorous careers into one. It is expected that as the program develops the student will be able to integrate clinical and basic sciences studies into one. The program is designed to provide this integration by means of special clinical activities embedded in the Ph.D. years and culminating in the last year of graduate studies.

UPR's Medical School M.D.- Ph.D. Program runs under the direct and combined supervision of the Dean of Medicine and the Associate Dean of Academic Affairs with a Committee acting in conjunction with both deanships. The M.D.- Ph.D. Committee carries representatives from faculty of both the basic and clinical sciences.

❖ General Curriculum

Years 1-2 During the first two years of the program the student is enrolled in the normal Medical School curriculum. It is expected that the student participates in some research activities during the summer after the first year. This research activity should be continued into the summer after the second year as soon as the student takes and passes the USMLE Step I medical licensure examination.

Years 3-6 These are the Ph.D. studies years in which the student will enroll in the required basic science courses and develop his/her thesis research. Clinical research experiences will be provided during the summers in the form of rotations or personal preceptorships. At the end of this period the student should have passed the comprehensive examinations for the Ph.D. and the thesis defense. The thesis is the primary component of the Ph.D. and as such it will receive special attention. The Ph.D. project is expected to meet high standards of scientific research. This is the reason why it is important for the student to start an early research program in the summer after the first year that will facilitate the selection of a thesis mentor.

Years 6-7 The last two years of the program comprise the 3rd and 4th year of medical studies in which the student should complete all the requirements for an M.D. degree. This includes passing the USMLE part II.

The Ph.D. segment of the M.D.- Ph.D. carries the same components as the program for students enrolled only in the Ph.D. As the M.D.- Ph.D. student starts the Ph.D. program after the second year he/she must choose an area or track of specialization. These areas are available in the Biomedical Sciences departments. The areas are:

- Anatomy
- Microbiology- Immunology
- Physiology
- Biochemistry
- Pharmacology
- Neurosciences

❖ The Faculty

The M.D.- Ph.D. student at the UPR Medical School will have access to a compendium of more than 500 faculty members from the basic and clinical sciences departments. This means that there are human resources available in all the areas of interest both clinical and basic sciences. More information about specific departments can be accessed by visiting the University of Puerto Rico Medical School website at, <http://medweb.rcm.upr.edu/>

❖ **Research Facilities**

The University of Puerto Rico Medical School is housed in a 10 floor structure of 655,005 sq. ft. space in gross area. Some 58,758 sq. ft. are totally devoted to research. Additional research facilities are located at the Neurosciences Institute in San Juan and at the Primate Research Center of Cayo Santiago. There are active collaborations with research projects being carried out in other medical schools in the island.

Common research facilities are also available in the campus and include:

- Electron Microscopy
- Mass Spectrometry
- Animal Housing Facility
- Confocal Microscopy
- Computer Center
- Molecular Biology

Training is available in the use of these facilities with special sessions offered through the year. Specific laboratories usually share their equipment and technical expertise thus creating an atmosphere of group work and cooperation.

❖ **Admission Requirements**

Applicants to the UPR M.D. – Ph.D. program must meet both the requirements for admission into the School of Medicine as candidates for the M.D. degree and the requirements of the Graduate Division of the Medical Sciences Campus as candidates for the Ph.D. degree. This means that applicants must take both the MCAT and Graduate Record Examinations.

❖ **Application Process**

All the applicants for the M.D. – Ph.D. Program must make a written request to the Dean of the School of Medicine indicating their interest in being considered for the M.D.- Ph.D. Program. This request will then be referred to the M.D.- Ph.D. Committee for their consideration and subsequent recommendation to the Dean of the School of Medicine as to the suitability of the candidate. Initial acceptance to the program is of a tentative nature until the student shows good academic standing during the first two years, passes the USMLE Step I examination and is accepted by a specific department to pursue graduate studies in a given specialty area.

A student applying for the program will be interviewed by the M.D.- Ph.D. Committee and members of the faculty in his/her area of interest. This interview will form an important part of the admission process for the program.

❖ **Financial Aid**

Students accepted in the M.D.- Ph.D. Program will be provided with financial aid including full tuition and a stipend for each year in the program.

❖ **Accreditation**

The University of Puerto Rico School of Medicine is a fully Liaison Committee on Medical Education (LCME) accredited institution. Our Graduate Program based in the Deanship of Biomedical Sciences is fully accredited by the Middle States Association.

❖ **Curriculum Sequences**

MD-PHD PROGRAM in BIOMEDICAL SCIENCES

| | YEAR 01 | SUMMER | YEAR 02 | SUMMER |
|---|---|---------------|---|---|
| 1 st S E M E S T E R | First Semester courses in Medicine Anatomy Biochemistry Clinical Skills Integration Seminar | LAB. ROTATION | SECOND YEAR FIRST SEMESTER MEDICAL COURSES LAB ROTATION CONT. | Seminars in Basic Science USMLE STEP I |
| 2 nd S E M E S T E R | Second Semester Courses in Medicine Neurosciences Physiology Human Development Public Health | | SECOND YEAR SECOND SEMESTER MEDICAL COURSES | |

MD-PHD PROGRAM CONT.

| | YEAR 03 | SUMMER | YEAR 04 | SUMMER |
|---|---|---|--|---|
| 1 ST S E M E S T E R | Three Graduate Courses Directed Readings in Basic Science | Basic Science COMPREHENSIVE EXAMS | CBIO 8500 (Statistics) THESIS PROPOSAL SURVIVAL SKILLS | Doctoral Thesis CLINICAL INTEGRATION ACTIVITIES |
| 2 ND S E M E S T E R | Three Graduate Courses FISA 8503- Seminar in Basic Science | | Doctoral Thesis Seminars in Basic Science | |

MD-PHD PROGRAM Cont.

| | YEAR 05 | SUMMER | YEAR 06 | YEAR 07 |
|---|--|---|----------------------------|--------------------------------|
| 1 st S E M E S T E R | Doctoral Thesis | Doctoral Thesis Thesis defense CLINICAL INTEGRATION ACTIVITIES | THIRD YEAR MEDICAL STUDIES | FOURTH YEAR MEDICAL STUDIES |
| 2 nd S E M E S T E R | Doctoral Thesis Seminars in Basic Science | | | |

*Multidisciplinary
Tracts*

†MULTIDISCIPLINARY TRAINING TRACT IN BIOTECHNOLOGY: IMMUNOLOGY AND VACCINE DEVELOPMENT

THE DEPARTMENT OF MICROBIOLOGY AND MEDICAL ZOOLOGY

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|--|--|---|---|
| 1 st S E M E S T E R | <p>MICR 8499 <i>Introd. Med. Microbiology</i> 6 BCHM 8500 <i>Biochemistry</i> 6</p> <p style="text-align: right;"><i>Credits = 12</i></p> | <p>CBIO 8500 <i>Statistics for Biom. Scs.</i> 3 MICR 8580 <i>Graduate Seminar</i> 1 MICR 8590 <i>Teaching Practice</i> 1 MICR 8525 <i>Molecular Biology</i> 3 One Elective Course* 3</p> <p style="text-align: right;"><i>Credits = 11</i></p> | <p>MICR 8599 <i>Advanced Topics</i> 3 (Comprehensive Exam and Thesis Proposal) MICR 8580 <i>Graduate Seminar</i> 1</p> <p style="text-align: right;"><i>Credits = 4</i></p> | <p>MICR 8599 <i>Dissertation Work</i> 0 MICR 8580 <i>Graduate Seminar</i> 1</p> <p style="text-align: right;"><i>Credits = 1</i></p> |
| 2 nd S E M E S T E R | <p>MICR 8540 <i>Princ. of Immunology</i> 3 ZOME 8502 <i>Introd. to Parasitology</i> 3 Two Electives courses* 6</p> <p style="text-align: right;"><i>Credits = 12</i></p> | <p>Three Elective Courses* 9</p> <p style="text-align: right;"><i>Credits = 9</i></p> | <p>MICR 8599 <i>Dissertation Work</i> 15</p> <p style="text-align: right;"><i>Credits = 15</i></p> | <p>MICR 8599 <i>Dissertation Work</i> 0</p> <p style="text-align: right;"><i>Credits = 0</i></p> |

* Electives course or Advanced Topics from department or from outside department.

†For the multidisciplinary training tract in microbial molecular biology and genetics the following courses are required:

| | | |
|-------------------------------------|--|---------|
| MICR 8525 | Molecular Biology | 3 crs |
| BCHM 8551 or BCHM 8526 | Biochem Lab or Bioinformatics | 2-3 crs |
| MICR 8544 | Adv Top Immunol | 3 crs |
| ZOME 8515 or MICR 8516 | Lab Meth Parasitol or Adv Top Virol | 3 crs |
| MICR 8544 or ZOME 8515 or MICR 8516 | Adv Top Immunol or Lab Meth Parasitol or Adv Top Virol | 3 crs |

**†MULTIDISCIPLINARY TRAINING TRACT† IN BIOTECHNOLOGY: MICROBIAL MOLECULAR BIOLOGY AND GENETICS
THE DEPARTMENT OF MICROBIOLOGY AND MEDICAL ZOOLOGY**

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|--|--|---|---|
| 1 st S E M E S T E R | <p>MICR 8499 <i>Introd. Med. Microbiology</i> 6 BCHM 8500 <i>Biochemistry</i> 6</p> <p style="text-align: right;"><i>Credits = 12</i></p> | <p>CBIO 8500 <i>Statistics for Biom. Scs.</i> 3 MICR 8580 <i>Graduate Seminar</i> 1 MICR 8590 <i>Teaching Practice</i> 1 MICR 8525 <i>Molecular Biology</i> 3 One Elective Course* 3</p> <p style="text-align: right;"><i>Credits = 11</i></p> | <p>MICR 8599 <i>Advanced Topics</i> 3 (Comprehensive Exam and Thesis Proposal) MICR 8580 <i>Graduate Seminar</i> 1</p> <p style="text-align: right;"><i>Credits = 4</i></p> | <p>MICR 8599 <i>Dissertation Work</i> 0 MICR 8580 <i>Graduate Seminar</i> 1</p> <p style="text-align: right;"><i>Credits = 1</i></p> |
| 2 nd S E M E S T E R | <p>MICR 8540 <i>Princ. of Immunology</i> 3 ZOME 8502 <i>Introd. to Parasitology</i> 3 Two Electives courses* 6</p> <p style="text-align: right;"><i>Credits = 12</i></p> | <p>Three Elective Courses* 9</p> <p style="text-align: right;"><i>Credits = 9</i></p> | <p>MICR 8599 <i>Dissertation Work</i> 15</p> <p style="text-align: right;"><i>Credits = 15</i></p> | <p>MICR 8599 <i>Dissertation Work</i> 0</p> <p style="text-align: right;"><i>Credits = 0</i></p> |

* Electives course or Advanced Topics from department or from outside department

† For the multidisciplinary training tract† in microbial molecular biology and genetics the following courses are required:

| | | |
|--|--|---------|
| MICR 8525 | Molecular Biology | 3 crs |
| BCHM 8551 or BCHM 8526 | Biochem. Lab or Bioinformatics | 2-3 crs |
| MICR 8560 | Microbial Genetics | 3 crs |
| ZOME 8506 or MICR 8550 | Protozoa or Microbial Physiology | 3 crs |
| MICR 8564 or MICR 8516 or ZOME 8515 or MICR 8554 | Adv Top Genetics or Lab Meth Parasitol or Adv Topics Microbial Physiol | 3 crs |

MULTIDISCIPLINARY DOCTORAL TRAINING TRACT IN EXERCISE PHYSIOLOGY

Department of Physiology

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 | YEAR 05 |
|---|---|--|--|---|---------|
| 1 ^s T S E M E S T E R | FISA 8501 <i>Prob. Physiolo I</i> 3† BCHM 8500 <i>Biochem</i> 6 BCHM 8551 <i>Lab. Biochem</i> 2 BCHM 8552 <i>Lab. Biochem</i> 2 <p style="text-align: right;"><i>Credits = 13</i></p> | CBIO 8500 <i>Statis. for Biom. Scs.</i> 3 FISA 8541 (<i>rotation</i>) 3*† Dr. MA Rivera Dra M Correa Dr Rodríguez-Santana FISA8513 (<i>Ex Fis I</i>) 3*† Team Teaching Approach _____ <i>Directed Reading</i> 1† <p style="text-align: right;"><i>Credits = 10</i></p> | _____ <i>PhD Thesis</i> 15† _____ <i>Elective (Thes Prop)</i> 3† <p style="text-align: right;"><i>Credits = 18</i></p> | _____ <i>PhD Thesis</i> (IP) <p style="text-align: right;"><i>Credits = 0</i></p> | |
| 2 ⁿ d S E M E S T E R | FISA 8502 <i>Prob. Fisiol. II</i> 3† FISA 8532 <i>Instrumentation</i> 3**† FISA 8540 <i>Cell Mol Fisiol</i> 3*† FISA 8503 <i>Seminar</i> 1† <p style="text-align: right;"><i>Credits = 10</i></p> | FISA 8514 (<i>Ex Fis II</i>) 3 † Team Teaching Approach _____ <i>Elect. Out Dept.</i> 6 FISA 8503 _____ 1† <p style="text-align: right;"><i>Credits = 10</i></p> | FISA 8503 _____ 1† _____ <i>PhD Thesis</i> (IP) <p style="text-align: right;"><i>Credits= 1</i></p> | _____ <i>PhD Thesis</i> (IP) FISA 8503 _____ 1† <p style="text-align: right;"><i>Credits: 1</i></p> | |

** to become elective

* to become core course

† Exercise Physiology = 29credits

*Qualified Examination: on 1st week of July, after 2nd year

*Thesis proposal: by the end of 1st semester (December) of 3rd year

DOCTORAL TRAINING TRACT in MOLECULAR GENETICS
Department of Biochemistry

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|---|--|--|---|
| 1 st S E M E S T E R | <ul style="list-style-type: none"> • Biochemistry (6) • Biochem Labs 8551, 8552 (4) • Research Seminar Series I (3) • Research (MG) (3) • Electives in Biochem: 1. Molecular Biology (3) <p style="text-align: right;">Credits = 19</p> | <ul style="list-style-type: none"> • Physical Chemistry of Macro. (3) • Research Seminar Series II (3) • Research (MG) (3) • Statistics (3) • Electives in Biochem: 1. (3) • Electives in Microbiology 1. Adv. Topics Microbio. (3) <p style="text-align: right;">Credits = 15</p> | <ul style="list-style-type: none"> • Special Topic (Thesis) (3) • Research Seminar V (3) <p style="text-align: right;">Credits = 6</p> | <ul style="list-style-type: none"> • Dissertation work (5) <p style="text-align: right;">Credits = 5</p> |
| 2 nd S E M E S T E R | <ul style="list-style-type: none"> • Special Biomedical Lab Techs (3) • Research Seminar Series II (3) • Research (MG) (3) • Electives in Biochem: 1. Regul. Gene Expression (3) • Electives in Physio C&M (3) <p style="text-align: right;">Credits = 15</p> | <ul style="list-style-type: none"> • Special Topics (Isotopes) (3) • Seminar in Physiology (NS) (3) • Research Seminar Series II (3) • Research (MG) (3) • Electives in Biochem: 1. Recent Adv MB & Bioch. (2) • Electives in Biochem: <p style="text-align: right;">Credits = 14</p> | <ul style="list-style-type: none"> • Dissertation work (5) • Research Seminar VI (3) <p style="text-align: right;">Credits = 8</p> | <ul style="list-style-type: none"> • Dissertation work (5) <p style="text-align: right;">Credits = 5</p> |

MULTIDISCIPLINARY DOCTORAL TRAINING TRACT in NEUROSCIENCES

Department of Physiology and Biophysics

| | YEAR 01 | YEAR 02 | YEAR 03 | YEAR 04 |
|---|--|--|--|---|
| 1ST S E M E S T E R | <ul style="list-style-type: none"> • FISA8601 (NS) (3) • Biochemistry (6) • Biochem Labs 1,2 (4) <p align="right">Credits = 13</p> | <ul style="list-style-type: none"> • FISA8541 (NS) (3) • Statistics (3) • Intro.Neurosciences (NS) (3) • FISA8542 (NS) (1) <p align="right">Credits = 10</p> | <ul style="list-style-type: none"> • Dissertation work • FISA8585 (NS) 3 • FISA8503 (NS) 1 <p align="right">Credits = 4</p> | <ul style="list-style-type: none"> • Dissertation work • FISA8503 (NS) 1 <p align="right">Credits = 1</p> |
| 2nd S E M E S T E R | <ul style="list-style-type: none"> • FISA8602 (3) • Adv, Phys. Instrument. (NS) (3) • Seminar in Physiology (NS) (1) • FISA 8540 (3) <p align="right">Credits = 10</p> | <ul style="list-style-type: none"> • FISA8543 (NS) (3) • Seminar in Physiology (NS) (1) • Neuroanat. (ANAT) (NS) (3) or Comp. Neuroanat. (ANAT) (3) • Survival Skills (PHAR) (3) or Neuropharm (PHAR) (NS) (3) <p align="right">Credits = 10</p> | <ul style="list-style-type: none"> Dissertation work FISA8599 (NS) 15 <p align="right">Credits = 15</p> | <ul style="list-style-type: none"> • Dissertation work <p align="right">Credits = 0</p> |

