Chair: Tracy Christofero | **GC#9: Non-Curricular**

Request for Graduate Non-Curricular Changes

PLEASE USE THIS FORM FOR ALL NON-CURRICULAR CHANGE REQUESTS (changes in admission requirements or requirements for graduation, changes in or new policies/procedures, changes in program descriptions in catalog, general language changes in catalog.)

SIGNATURES may not be required, depending on the nature of the request and from where it originates. Consult Graduate Council chair.

1. Prepare one paper copy with all signatures and supporting material and forward to the Graduate Council Chair.
2. E-mail one PDF copy without signatures to the Graduate Council Chair.
3. ***The Graduate Council cannot process this application until it has received both the PDF copy and the signed hard copy.***

College: Medicine

Dept/Division: Biomedical Sciences

Contact Person: Todd L. Green, Ph.D.

Phone: 696-3531

Rationale for Request

(May attach separate page if needed)

A number of changes and clarifications need to be made in the catalog entry for the Biomedical Sciences program, including courses.
There are also additional approved degree programs that are not in the catalog.

Signatures: if disapproved at any level, do not sign. Return to previous signer with recommendation attached.
NOTE: all requests may not require all signatures.

Department/Division Chair Todd L. Green	Date 4/11/16
Registrar	Date
College Curriculum Committee Chair Todd L. Green (or Dean if no college curriculum committee)	Date 4/11/16
Graduate Council Chair	Date

NOTE: please complete information required on the following pages before obtaining signatures above.

Request for Graduate Non-Curricular Changes-Page 2

1. **Current Catalog Description (if applicable):** Please insert the catalog description from the current catalog for entries you would like to change. (May attach separate page if needed)

Request for Graduate Non-Curricular Changes-Page 3

2. **Edits to current description:** Attach a PDF copy of the current catalog description prepared in MS WORD with strikethroughs to mark proposed deletions and use the highlight function to indicate proposed new text.

Graduate Council
Request for Non-Curricular Changes-Page 4

3. **New Catalog Description:** Provide a "clean" copy of your proposed description without strikethroughs or highlighting. This should be what you are proposing for the new description. (May attach separate page if needed)

Graduate Council
Request for Non-Curricular Changes-Page 5

Please insert in the text box below your proposed change information for the Graduate Council agenda. Please enter the information exactly in this way (including headings):

Type of change request:
Department:
Degree program:
Effective date *(Fall/Spring/Summer, Year)*

Type of change request: Non-curricular
Department: Biomedical Sciences
Degree program: M.S., Ph.D., M.D./Ph.D.
Effective date: Fall 2016

1. Current Catalog Description

School of Medicine

Dr. Joseph Shapiro, Dean

http://musom.marshall.edu

BIOMEDICAL SCIENCES, M.S., Ph.D.

Areas of Emphasis

- Cancer Biology
- Cardiovascular Disease, Obesity, and Diabetes
- Infectious and Immunological Diseases
- Medical Sciences (M.S. only)
- Neuroscience and Developmental Biology
- Toxicology and Environmental Health Sciences

Program Description

The basic science departments of the Joan C. Edwards School of Medicine offer an interdisciplinary program leading to the Master of Science and Doctor of Philosophy degrees in Biomedical Sciences. The primary aim of the Biomedical Sciences (BMS) program is to produce graduate students who are broadly based in the biomedical sciences with definite interests and special in-depth training in one of the following areas of emphasis: cancer biology; cardiovascular disease, obesity, and diabetes; infectious and immunological diseases; neuroscience and developmental biology; and toxicology and environmental health sciences. These areas are designed to be flexible and research oriented in order to develop the interests, capabilities and potential of all students pursuing careers in academic or industrial biomedical sciences.

In addition, the BMS program offers a non-thesis Master of Science degree in a medical sciences area of emphasis to improve the science foundation of students seeking admission into doctoral programs in medicine. This area of emphasis is also for students wishing to pursue non-research careers in the health professions or in the biotechnology and pharmaceutical industries.

Admission into this program does not guarantee admission into medical school. Students in this area of emphasis are required to pay a Health Professions Fee each semester while enrolled in the program. Because of the nature of the curriculum, applicants to the medical sciences area of emphasis will only be considered for admission for the Fall semester.

The Biomedical Sciences Doctor of Philosophy Degree program accepts a very limited number of students to study concurrently with the Doctor of Medicine degree.

Admission Requirements

Applicants should follow the admissions process described in this catalog or at the Graduate Admissions website at *www.marshall.edu/graduate/admissions/how-to-apply-for-admission.*

Applicants must also meet the admissions requirements of the Graduate Studies Committee of Marshall University's Joan C. Edwards School of Medicine. Interested persons should contact the Biomedical Sciences Graduate Program, Byrd Biotechnology Science Center, Marshall University School of Medicine, One John Marshall Drive, Huntington, WV 25755 or via the Internet at *www.marshall.edu/bms/future-students/application-information*.

Minimum Requirements for Admission into Master of Science or Doctor of Philosophy Program

All applicants must have baccalaureate degrees in one of the sciences, with one year of general biology, physics, general chemistry, and organic chemistry, all with associated laboratories. Although calculus and physical chemistry are not requirements for admission, they may be required for certain areas of emphasis and are highly recommended.

- Graduate Record Examination (GRE) General Test scores (scores may not be more than three (3) years old at the application deadline for the Ph.D. program or at the start of the semester when matriculating for the M.S. program) or MCAT scores (Medical Sciences area of emphasis only, minimum of 22 total)
- Three letters of recommendation from references familiar with the applicant's relevant academic/professional performance
- a personal statement describing educational and career goals.

Ph.D. Applications

The completed application, application fee, official transcripts and official GRE or MCAT scores should be received in the Graduate Admissions Office by January 15th for summer or fall applications in order for the application to be considered by the program.

Letters of recommendation and personal statements should be received in the BMS Office by January 15th for summer or fall applications in order for the application to be considered complete and for an admission decision to be rendered.

Applications completed very soon after the above stated deadlines may be considered at the discretion of the BMS Graduate Studies committee.

New Ph.D. students will matriculate in July (Summer III term).

M.S. Applications

The completed application, application fee, official transcripts, three letters of recommendation, written statement, and official GRE or MCAT scores (MCAT scores accepted for medical sciences area of emphasis only) should be received in the Graduate Admissions Office by June 1st for summer or fall applications in order for the application to be considered by the Program.

Duration of Degree Programs

Students generally complete the requirements for the Master of Science degree within two to three years. Those who pursue the doctoral degree usually complete the requirements within five to six years. Students who possess a M.S. degree in Biomedical Sciences or the equivalent when admitted into the doctoral degree program generally require three to four years to complete the Doctor of Philosophy degree.

BIOMEDICAL SCIENCES, M.S.

All students are required to meet the general requirements of the Graduate College for receipt of a master's degree. A minimum of 36 credit hours is required for a non-thesis degree, while a minimum of 32 credit hours is required for the thesis degree. No more than six hours of thesis (BMS 681) may be credited toward the thirty-two-hour requirement. Each student will specialize in one of the six areas of emphasis as defined in the program overview. All students are required to successfully complete:

BMS 600	Foundations of Biomedical Sciences
BMS 617	Statistical Techniques for the Biomedical Sciences (or MTH 518, BSC 517, PSY 517, EDF 517 or equivalent)
BMS 644	Responsible Conduct of Research
BMS 660/661	Communication Skills for Biomedical Sciences

BMS 685	Introduction to Research (min. of 3 hrs.)
BMS 680	Seminar (minimum of 6 hrs.)

In addition, the student must successfully complete other courses required by his/her area of emphasis and advisory committee and pass a written and/or oral comprehensive examination.

BIOMEDICAL SCIENCES, Ph.D.

The doctorate is a research or performance degree and does not depend solely on the accumulation of credit hours. The degree requirements are admission to candidacy, residency, and successful completion and defense of a dissertation. The degree signifies that the holder has the competence to function independently at the highest professional level.

Degree Requirements

To qualify for the Doctor of Philosophy degree, the student must pass (*C* or better or *CR*) the following courses:

BMS 600	Foundations of Biomedical Sciences
BMS 644	Responsible Conduct of Research
BMS 617	Statistical Techniques for the Biomedical Sciences
BMS 660/661	Communication Skills for Biomedical Sciences
BMS 680	Seminar (minimum of 6 hrs.)

In addition, the student must successfully complete other courses required by his/her area of emphasis and advisory committee. All courses will be defined in the student's Course of Study.

Advisory Committee

The advisory committee should be formed no later than the end of the first year of graduate education or upon completion of 18 semester hours of credit. As soon as the committee has been identified, an Approval for Dissertation Topic and Committee Membership form is completed and submitted to the Director of Graduate Studies and the Dean of the Graduate College.

The committee will be selected by the student and research advisor and approved by the Director of Graduate Studies and the Dean of the Graduate College. The advisory committee will be composed of at least five faculty members with appropriate expertise.

One of the members may be from another institution. The student's research advisor will act as the chairperson of the committee.

Approval of Course of Study

It is essential for the student and advisory committee to carefully define a Course of Study by the end of the first year. This is considered a basic contract between the student and the program and includes:

1. All transfer credits.
2. Required and elective courses to be taken at Marshall University.
3. All competencies to be achieved by the student during graduate study. These details must be recorded on a Course of Study form and submitted for approval by the Director of Graduate Studies and the Dean of the Graduate College.

Graduate Assistantships for the Doctor of Philosophy Program

Research assistantships are available for students in the doctoral degree program on a competitive basis.

The base stipend is renewable annually for up to six years. Priority consideration for the Doctor of Philosophy graduate assistantships will be given to West Virginia residents.

Academic Performance

- The student must maintain a Grade Point Average of 3.0, and no more than six hours of C and no grades below C may be applied toward the degree.
- If the GPA falls below 3.0, the student will be placed on academic probation. Following notification of probation, the student will be counseled by his/her advisor. At this time, the deficiency will be identified and a written plan will be prepared for removing it within the next nine semester hours. This plan, co-signed by the student and the advisor, must be approved by the Dean of the Graduate College before the student can register for additional coursework.
- If probationary status is not removed within nine semester hours, the Dean of the Graduate College, in consultation with the Senior Associate Dean for the Biomedical Sciences and the Graduate Studies Committee will determine whether the student is retained or dismissed from the program. Retention must be recommended by the interim advisor or student's advisory committee and endorsed by the Graduate Studies Committee.

Transfer Credit

The student may transfer credits completed at other regionally accredited graduate institutions. Approval of the Graduate Studies Committee and the Dean of the Graduate College is contingent on:

1. the grades earned were B's or better;
2. the credits are appropriate to the student's program and acceptable to the advisory committee; and
3. the time limitations were not exceeded.

The number of transfer hours acceptable for the Ph.D. degree will be determined by the student's advisory committee. Approval must be received from both the Graduate Studies Committee and the Dean of the Graduate College. Transfer credit will not become part of the Marshall University Grade Point Average.

Transfer of credits should be accomplished as early as possible. This should be accomplished either when the student is admitted to candidacy or submits an approved Course of Study. Attempts to transfer credits during the last semester may delay graduation. Official transcripts must be on file in the Graduate College office by the date that grades are due in the Marshall University Registrar's Office.

Validation of Outdated Coursework

The advisory committee has the option to require validation, by special examination, of courses which members deem to be outdated.

Time Limitations

Students must meet all requirements for the Doctor of Philosophy degree within seven years from the date of enrollment in the first course to be used in the degree program. The Graduate Dean may grant an extension upon recommendation by the Graduate Studies Committee. Absence due to military obligations, long serious illnesses, or similar circumstances beyond the student's control may be considered valid reasons for an extension. It is the option of the advisory committee to require validation of outdated courses by special examination.

Admission to Candidacy

Admission to graduate study and enrollment in graduate courses does not guarantee acceptance as a candidate for the Doctor of Philosophy degree. This is only accomplished by satisfactorily passing a comprehensive qualifying examination and

meeting all other specified requirements. The qualifying examination assesses whether the student has attained sufficient knowledge to undertake independent research. The examination should be completed at the end of the second year of study. The examination consists of written and oral components covering all areas specified in the Course of Study. The examination is prepared, administered and graded by the advisory committee. The written portion includes all coursework and relevant topics determined by the advisory committee. The student will be given 2-3 days to complete the written component of the examination. Upon passing the written examination, the student must submit a grant proposal on the topic of his/her dissertation research or a related topic approved by the advisory committee. The proposal must be in the style of an NIH Predoctoral grant proposal. Links to the instructions for the proposal format can be found on the BMS Graduate Program website. The grant proposal must be submitted within 2 months of completion of the written exam and given to the advisory committee members at least 2 weeks in advance of the oral defense. The oral examination consists of a defense of the grant proposal and, at the discretion of the advisory committee, may include topics from the written portion of the exam in which the student was deemed to be deficient. Successful completion of the qualifying examination is based on approval of the committee. Only one dissenting vote is permitted on each component. If necessary, a single portion of the examination may be repeated at the discretion of the advisory committee. The student must have the approval of the advisory committee to repeat either the written or oral component of the qualifying examination. The committee assesses the deficiencies and determines the time required for the student to make corrections. A student may take a given component of the qualifying examination no more than three times. Failure to pass this examination on the third attempt will result in dismissal. The advisory committee must complete an Admission to Candidacy for Ph.D. form after the student completes the examinations and submit it for approval by the Senior Associate Dean for the Biomedical Sciences and the Dean of the Graduate College.

Dissertation

All candidates must successfully complete a biomedical research project and prepare, submit, and defend a dissertation. The dissertation must present the results of the candidate's individual investigation and make a definite contribution to the current state of knowledge. While conducting research and writing a dissertation, the student must register for Research (BMS 882) at the beginning of each semester or summer term for which progress is to be earned. No more than 15 hours of doctoral research may be credited toward the degree.

Candidates are to follow the general guidelines outlined in Publishing Your Dissertation: How to Prepare Your Manuscript for Publication and General Information About Dissertations. Copies of these documents are on file in the Biomedical Sciences Graduate Program office.

Oral Defense of the Dissertation

The oral defense of the dissertation is held during the semester or summer session in which all other degree requirements have been met. The advisory committee must read and tentatively approve the dissertation before the examination can be scheduled. The committee chairperson will complete an Approval to Schedule Dissertation Defense form and submit it for approval of the Director of Graduate Studies and the Dean of the Graduate College before the examination can be given. Such notification must occur at least two weeks before the proposed date of the defense. A portion of the defense is an open examination and sufficient time is required for adequate public notice.

The open examination usually takes the form of a one-hour seminar. This is followed by a thorough review of the dissertation by the advisory committee and the candidate. Successful completion of the defense requires the approval of all but one of the members of the advisory committee. The results (pass/fail) must be recorded on a Results of Dissertation Examination form, which is to be reported to the Office of Research and Graduate Education and forwarded to the Graduate College Office within 24 hours. Should the candidate fail the defense, reexamination may not be scheduled without the approval of the advisory committee, the Senior Associate Dean for the Biomedical Sciences, and the Dean of the Graduate College.

All advisory committee members are to be present for the defense. If this is not possible, the Dean of the Graduate College, or designee, may permit one substitute for any member of the committee except

the chairperson. A request for a substitute must be submitted in writing to, and approved by, the Senior Associate Dean for the Biomedical Sciences and the Dean of the Graduate College. The committee chairperson, the student, and both the original member of the committee to be replaced, and the substitute must sign this request. The substitute must have the same, or higher, graduate faculty status as the original member and represent the same academic discipline or area of emphasis.

Acceptance of Dissertation

Acceptance of the dissertation is a requirement for the doctoral degree. An accepted dissertation must bear the original signatures of at least all but one member of the advisory committee. If more than one member cannot approve the dissertation, the doctoral degree cannot be recommended. If the substitute member attends and approves the dissertation defense, he or she signs the dissertation. For complete information on the preparation and submission of electronic theses and dissertations see *www.marshall.edu/graduate/current-students/edt*.

Survey of Earned Doctorates

Please complete and submit the online Survey of Earned Doctorates. Survey of Earned Doctorate information is used by a number of government agencies to assess the state of doctoral education in the U.S., and also to inform their decisions concerning funding of U.S. graduate institutions. The online survey is available at *http://survey.norc.uchicago.edu/doctorate/index.jsp*.

Publication

All doctoral dissertations and their abstracts will be microfilmed through University Microfilms, Ann Arbor, Michigan. This requirement cannot be satisfied by any other publication, but other publication of material in the dissertation is both permitted and encouraged.

Process Summary

1. Inquiry from prospective student to the Biomedical Sciences Graduate Program or Graduate Admissions Office.
2. Submission of the application to the Biomedical Sciences Graduate Program, the Graduate Admissions Office, or online.
3. Receipt of the following official application materials and required fee by the Graduate Admissions Office: application, GRE scores, and transcript(s). International students must apply through the Center for International Programs.
4. Referral of application materials by the Graduate Admissions Office.
5. The Biomedical Sciences Graduate Program notifies the Graduate Admissions Office and the prospective student of the admission decision of the Graduate Studies Committee.
6. The accepted student arrives, reports to the Biomedical Sciences Graduate Program, is assigned an interim advisor, and registers for coursework.
7. Selection of an area of emphasis/advisor must be achieved by the end of the first year. After a permanent advisor has been selected, an advisory committee is formed. A Course of Study should be developed by the end of the first year.
8. The student completes requisite coursework and other program requirements.
9. The student takes written and oral qualifying examinations for admission to candidacy to the Ph.D. These examinations should be scheduled within two months of each other.
10. The student continues doctoral research under the guidance of his/her advisory committee. The dissertation phase begins with the approval of a dissertation prospectus by the advisory committee, the Biomedical Sciences Graduate Program and the Graduate College Dean.
11. The student applies for graduation at the beginning of his or her last semester no later than the university deadline in the academic calendar. The diploma fee must be paid by this time.
12. A copy of the preliminary draft of the dissertation is given to each member of the advisory committee no later than two weeks prior to the final defense of the dissertation.
13. The chair of the advisory committee requests clearance for the defense from the Biomedical Sciences Graduate Program and the Graduate College for approval no later than two weeks before the scheduled

date of the defense.

14. The time and place of the defense of the dissertation are announced.
15. The student defends the dissertation in an oral defense.
16. The student follows the steps to prepare and submit the electronic thesis or dissertation at *www.marshall.edu/graduate/current-students/edt.*

1. Current Catalog Description

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BIOMEDICAL SCIENCE (BMS)

600 **Biochemical, Cellular and Molecular Foundations of Biomedical Science. 7 hrs. I.**
A study of the structure and metabolism of biological compounds, the molecular biology of the cell, and the interactions of cell components. (PR: One year of Biology and Organic Chemistry and consent of instructor)

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MICROBIOLOGY, IMMUNOLOGY AND MOLECULAR GENETICS (MCB)

631 **Medical Microbiology I. 3 hrs.**
This course will present the major aspects of the field of microbiology with emphasis on selected pathogenic organisms. (PR: BMS 600 or equivalent)

632 **Medical Microbiology II. 3 hrs.**
This course will present a continuation of the major aspects of the field of medical microbiology with emphasis on the major pathogenic organisms. (PR: BMS 600 and MCB 631)

643 **Principles of Immunology. 3 hrs. I.**
Basic principles of the immune response system of humans and related mammals. Concepts of B & T cell function and interrelationships emphasized. (PR: Cellular and Molecular Biology)

648 **Molecular Aspects of Pathogenesis. 3 hrs.**
An in depth study of molecular mechanisms of bacterial, viral, and immune mediated disease processes. Course Requirements: BMS 600 and BIC 620

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PHARMACOLOGY (PMC)

621 **Medical Pharmacology I. 6 hrs.**
This course will encompass the core pharmacology concepts as well as drugs used in the treatment of infectious diseases, cancer, hematological matters, nervous system agents and cardiovascular drugs. (PR: BMS 600 or equivalent; REC: PHS 629 desirable)

622 **Medical Pharmacology II. 2 hrs.**
This course will encompass the core pharmacology concepts as well as drugs used in the treatment of pulmonary, gastrointestinal, endocrine, renal and musculoskeletal diseases, drugs specific for men's and women's health, dermatological agents and toxicology. (PR: BMS 600 or equivalent; REC: PHS 629 desirable)

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PHYSIOLOGY (PHS)

626 **Neurophysiology I: Neuron Function and Introduction to Neural Systems. 1 hr**.
To study and understand the basic functional principles of the cells of the nervous system, and organization of cells into functional systems. (PR: BMS 600 or permission of instructor)

627 **Neurophysiology II: Neuronal Systems. 1 hr.**
To study and understand the major functional systems of the brain. (PR: PHS 626)

2. Edits to current description

School of Medicine

Dr. Joseph Shapiro, Dean
http://musom.marshall.edu

BIOMEDICAL SCIENCES, M.S., Ph.D., M.D./Ph.D.

Areas of Emphasis

Cancer Biology
Cardiovascular Disease, Obesity, and Diabetes
Infectious and Immunological Diseases
Medical Sciences (M.S. only)
Neuroscience and Developmental Biology
Toxicology and Environmental Health Sciences

Program Description

The basic science departments of the Joan C. Edwards School of Medicine offer an interdisciplinary program leading to the Master of Science and Doctor of Philosophy degrees in Biomedical Sciences. The primary aim of the Biomedical Sciences (BMS) program is to produce graduate students who are broadly based in the biomedical sciences with definite interests and special in-depth training in one of the following areas of emphasis: cancer biology; cardiovascular disease, obesity, and diabetes; infectious and immunological diseases; neuroscience and developmental biology; and toxicology and environmental health sciences. These areas are designed to be flexible and research oriented in order to develop the interests, capabilities and potential of all students pursuing careers in academic or industrial biomedical sciences.

In addition, the BMS program offers a non-thesis Master of Science degree in a medical sciences area of emphasis to improve the science foundation of students seeking admission into doctoral programs in medicine or other health-related professions. ~~This area of emphasis is also for students wishing to pursue non-research careers in the health professions or in the biotechnology and pharmaceutical industries~~.

Admission into this program does not guarantee admission into medical school. Students in this area of emphasis are required to pay a Health Professions Fee each semester while enrolled in the program. Because of the nature of the curriculum, applicants to the medical sciences area of emphasis will only be considered for admission for the ~~Fall~~ fall semester.

The Biomedical Sciences Doctor of Philosophy Degree program accepts a very limited number of students to study concurrently with the Doctor of Medicine degree.

Admission Requirements

~~Applicants should follow the admissions process described in this catalog or at the Graduate Admissions website at *www.marshall.edu/graduate/admissions/how-to-apply-for-admission.*~~

Applicants must ~~also~~ meet the admissions requirements of the Graduate Studies Committee of Marshall University's Joan C. Edwards School of Medicine. Interested persons should contact the Biomedical Sciences Graduate Program~~,~~ at Byrd Biotechnology Science Center, Marshall University School of Medicine, One John Marshall Drive, Huntington, WV 25755, ~~or~~ via the Internet at ~~*www.marshall.edu/bms/future-students/application-information*~~ *www.marshall.edu/bms/future-students/contact-us*, mubiomed@marshall.edu, or 304-696-3365.

Minimum Requirements for Admission into Master of Science or Doctor of Philosophy Program

All applicants must have a baccalaureate degree~~s in one of the sciences~~, with one year of general biology, physics, general chemistry, and organic chemistry, all with associated laboratories. ~~Although calculus and physical chemistry are not requirements for admission, they may be required for certain areas of emphasis and are highly recommended.~~ Biochemistry is not currently a requirement, but it is highly recommended to take it.

- Graduate Record Examination (GRE) General Test scores (scores may not be more than three (3) years old at the application deadline for the Ph.D. program or at the start of the semester when matriculating for the M.S. program) or MCAT scores (Medical Sciences area of emphasis only, minimum of 22 total for the old exam and 20th percentile for the new exam)
- Three letters of recommendation from references familiar with the applicant's relevant academic/professional performance
- A personal statement describing educational and career goals~~.~~

Ph.D. Applications

The completed application, application fee, official transcripts and official GRE ~~or MCAT~~ scores should be received in the Graduate Admissions Office by January 15th for summer ~~or fall~~ applications in order for the application to be considered by the program.

Letters of recommendation and personal statements should be received in the BMS Office by January 15th for summer ~~or fall~~ applications in order for the application to be considered complete and for an admission decision to be rendered.

Applications completed very soon after the above stated deadlines may be considered at the discretion of the BMS Graduate Studies ~~committee~~ Committee.

New Ph.D. students will matriculate in July (Summer III term).

M.S. Applications

The completed application, application fee, official transcripts, three letters of recommendation, written statement, and official GRE or MCAT scores (MCAT scores accepted for medical sciences area of emphasis only) should be received in the Graduate Admissions Office by June 1st for summer or fall applications in order for the application to be considered by the ~~Program~~ program.

Duration of Degree Programs

Students ~~generally~~ are expected to complete the requirements for the Master of Science degree within two ~~to three~~ years. ~~Those who pursue the doctoral degree usually complete the requirements within five to six years~~. Doctoral students are expected to complete the degree requirements with five years. Students who possess ~~a~~ an M.S. degree in Biomedical Sciences or the equivalent when admitted into the doctoral degree program generally require three ~~to four years~~ to complete the Doctor of Philosophy degree.

BIOMEDICAL SCIENCES, M.S. - Cancer Biology; Cardiovascular Disease, Obesity, and Diabetes; Infectious and Immunological Diseases; Neuroscience and Developmental Biology; Toxicology and Environmental Health Sciences Areas of Emphasis

Degree Requirements

~~All students are required to meet the general requirements of the Graduate College for receipt of a master's degree.~~ A minimum of 36 credit hours is required for a non-thesis degree, while a minimum of 32 credit hours is required for the thesis degree. No more than six hours of thesis (BMS 681) may be credited toward the ~~thirty-two~~ 32-hour requirement. Each student will specialize in one of the ~~six~~ five research areas of emphasis as defined in the program ~~overview~~ description. All students are required to successfully complete:

~~BMS 600~~	~~Foundations of Biomedical Sciences~~
BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 603	Regulation of Cell Function
BMS 604	Cellular Basis of Disease
BMS 617	Statistical Techniques for the Biomedical Sciences (~~or MTH 518, BSC 517, PSY 517, EDF 517 or equivalent~~)
BMS 644	Responsible Conduct of Research
BMS 660/661	Communication Skills for Biomedical Sciences
BMS 680	Seminar (minimum of ~~6~~ 4 hrs.)
BMS ~~685~~ 785	Introduction to Research ~~(min. of 3 hrs.)~~

In addition, the student must successfully complete other courses required by his/her area of emphasis and advisory committee and pass ~~a written and/or~~ an oral comprehensive examination.

Advisory Committee for M.S. Students

The advisory committee should be formed no later than the end of the first year of graduate education. As soon as the committee has been identified, a Thesis Committee Formation form is completed and submitted to the Director of Graduate Studies.

The committee will be selected by the student and research advisor and approved by the Director of Graduate Studies. The advisory committee will be composed of at least three faculty members with appropriate expertise. One of the members may be from another institution. The student's research advisor will act as the chairperson of the committee.

In addition, after 12 hours of coursework has been completed, the student must submit to the Dean of the Graduate College a Plan of Study form.

BIOMEDICAL SCIENCES, M.S. - Medical Sciences Area of Emphasis

A minimum of 36 credit hours is required for the non-thesis degree. In addition, the student must pass a written comprehensive examination covering BMS 601-604, MCB 631, MCB 632, and PHS 628. All students will also participate in laboratory-based research, and either present at a research conference or submit a peer-reviewed publication. All students are required to successfully complete:

BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 604	Cellular Basis of Disease
BMS 603	Regulation of Cell Function
BMS 617	Statistical Techniques for the Biomedical Sciences (or MTH 518, BSC 517, PSY 517, EDF 517 or equivalent)
BMS 680	Seminar (minimum of 4 hrs.)
BMS 785	Introduction to Research
MCB 631	Medical Microbiology I
MCB 632	Medical Microbiology II
PHS 628	Neurophysiology

Elective classes include PHS 629 (Mammalian Physiology), PMC 621 (Medical Pharmacology I), and PMC 622 (Medical Pharmacology II).

In addition, after 12 hours of coursework has been completed, the student must submit to the Dean of the Graduate College a Plan of Study form.

Biomedical Sciences, M.S., and School of Pharmacy, Pharm.D.

Students can receive both an M.S. degree from the Biomedical Sciences Program and a Pharm.D. degree from the School of Pharmacy. Prospective students must apply to and meet the admission requirements for both programs. The curriculum takes five years to complete. In the first year students take BMS courses; in years 2-5 students take School of Pharmacy courses. All students are required to successfully complete:

Year 1 Fall

BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 680	Seminar
PHS 628	Neurophysiology

Year 1 Spring

BMS 603	Regulation of Cell Function
BMS 604	Cellular Basis of Disease
BMS 680	Seminar
BMS 785	Introduction to Research
PHS 629	Mammalian Physiology

Year 2 Fall

PHAR 511	Clinical Immunology
PHAR 531	Biopharmaceutics I
PHAR 541	Pharmacy Practice I
PHAR 542	Immunology and Microbiology
PHAR 551	Biomedical Chemistry
PHAR 811	Introductory Pharmacy Practice Experiences in Community Settings I

Year 2 Spring

PHAR 521	Integrated Laboratory I
PHAR 532	Biopharmaceutics II
PHAR 543	Pharmacy Practice II
PHAR 544	Principles of Disease and Drug Action
PHAR 545	Therapeutics I
PHAR 812	Introductory Pharmacy Practice Experiences in Institutional Settings I

Year 3 Fall

PHAR 611	Integrated Laboratory II
PHAR 621	Pharmacy Law and Ethics
PHAR 622	Drug Information and Communication Skills
PHAR 631	Pharmacometrics
PHAR 632	Pharmacy Practice Management I
PHAR 661	Therapeutics II
PHAR 813	Introductory Pharmacy Practice Experiences in Community Settings II

Year 3 Spring

PHAR 612	Therapeutic Drug Dosing
PHAR 633	Patient Care Skills Lab
PHAR 634	Pharmacy Practice Management II
PHAR 635	Bridging Research Outcomes and Patient Care

PHAR 671	Therapeutics III
PHAR 814	Introductory Pharmacy Practice Experiences in Institutional Settings II

Year 4 Fall

PHAR 711	Medication Therapy Management
PHAR 722	Pharmacy Practice Management III
PHAR 741	Therapeutics V
PHAR 751	Therapeutics IV
PHAR 815	Ambulatory Care Skills
PHAR 816	Inpatient Practice Skills
	Elective 1

Year 4 Spring

PHAR 721	Therapeutics VII
PHAR 731	Case Studies in Pharmacy Practice
PHAR 761	Therapeutics VI
PHAR 817	Introductory Pharmacy Practice Experiences in Practice Management
PHAR 818	Introductory Pharmacy Practice Experiences in Education
	Elective 2

Year 5 Fall + Spring

PHAR 881	Advanced Pharmacy Practice Experiences in General Medicine
PHAR 882	Advanced Pharmacy Practice Experiences in Ambulatory Care/Primary Care
PHAR 883	Advanced Pharmacy Practice Experiences in Community Pharmacy
PHAR 884	Advanced Pharmacy Practice Experiences in Institutional Settings
PHAR 885	Advanced Pharmacy Practice Experiences in Geriatrics
PHAR 886	Advanced Pharmacy Practice Experiences in Diverse Populations
	Elective 3
	Elective 4
	Capstone 1
	Capstone 2

PHAR 635 substitutes for MTH 518, Biostatistics, a BMS Program requirement.
PHAR 542 substitutes for the BMS course MCB 631, Medical Microbiology I.
PHAR 531 and PHAR 551 substitute for the BMS courses PMC 625, Drug Metabolism, and PMC 630, Chemical Aspects of Pharmacology.
PHAR 545 and PHAR 671 substitute for the BMS course BMS 680, Seminar. This will meet the 4 hr. minimum requirement for Seminar for the M.S. degree.

A minimum of 36 credit hours is required for a non-thesis degree in the BMS Program.

BMS 601	3 hrs.
BMS 602	3 hrs.
BMS 680	1 hr.
PHS 628	2 hrs.
BMS 603	2 hrs.
BMS 604	1 hr.
BMS 680	1 hr.
BMS 785	3 hr.
PHS 629	6 hrs.
PHAR 531	3 hrs.
PHAR 542	4 hrs.
PHAR 545	4 hrs.
PHAR 551	5 hrs.
PHAR 635	3 hrs.
PHAR 671	7 hrs.

In addition, the student must pass a written and/or an oral comprehensive examination to receive the M.S. degree.

BIOMEDICAL SCIENCES, Ph.D.

The doctorate is a research or performance degree and does not depend solely on the accumulation of credit hours. The degree requirements are admission to candidacy~~, residency,~~ and successful completion and defense of a dissertation. The degree signifies that the holder has the competence to function independently at the highest professional level.

Degree Requirements

To qualify for the Doctor of Philosophy degree, the student must pass (*C* or better or *CR*) the following courses:

~~BMS 600~~	~~Foundations of Biomedical Sciences~~
BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 603	Regulation of Cell Function
BMS 604	Cellular Basis of Disease
BMS 644	Responsible Conduct of Research
BMS 617	Statistical Techniques for the Biomedical Sciences
BMS 660/661	Communication Skills for Biomedical Sciences
BMS 680	Seminar (minimum of 6 hrs.)
BMS 785	Introduction to Research
BMS 882	Research

In addition, the student must successfully complete other courses required by his/her area of emphasis and advisory committee. All courses will be defined in the student's Course of Study. The student must also pass a written and oral exam prior to becoming a Ph.D. candidate. These exams are set by the advisory committee and are outlined below under **Admission to Candidacy**.

Students are required to write and publish three peer-reviewed manuscripts, two of which must be first author.

BIOMEDICAL SCIENCES, M.D./Ph.D.

The Joan C. Edwards School of Medicine offers a combined M.D./Ph.D. degree in partnership with the Biomedical Sciences Graduate Program at Marshall University. The curriculum takes seven to eight years to complete. Students first take years one and two of medical school. During that time they complete the requirements for BMS 785 (Introduction to Research). After passing the USMLE Step 1 exam at the end of year two, students begin their Ph.D. coursework and research. This takes three to four years. After completing the Ph.D. requirements, students then complete years three and four of medical school. All of the requirements for both the M.D. and Ph.D. degrees must be met.

The medical student course Elements of Medicine (MDC 710) meets the requirements for BMS 601, 602, 603, and 604. Other medical school courses can meet area of emphasis requirements, as determined by the student's advisory committee and the Graduate Studies Committee.

M.D./Ph.D. Applications

Students interested in pursuing combined degree should indicate this on their medical school

AMCAS application. A separate M.D./Ph.D. admissions subcommittee consisting of members of the medical school and BMS graduate admission committees will review the applications.

All applicants must take the MCAT. A score of 30 or better on the MCAT taken between January 2013 and January 2015 is preferred for consideration for admission. An MCAT score of 28 will be considered if the applicant has extensive research experience. A minimum score of 505 on the new MCAT is required for consideration for admission.

AMCAS applications must be submitted by November 1. Completed applications should be received by December 1. Completed applications received after December 1 may be reviewed for a position on a waiting list.

Advisory Committee for Ph.D. and M.D./Ph.D. Students

The advisory committee should be formed no later than the end of the first year of graduate education or upon completion of 18 semester hours of credit. As soon as the committee has been identified, an Approval for Dissertation Topic and Committee Membership form is completed and submitted to the Director of Graduate Studies and the Dean of the Graduate College.

The committee will be selected by the student and research advisor and approved by the Director of Graduate Studies and the Dean of the Graduate College. The advisory committee will be composed of at least five faculty members with appropriate expertise. One of the members may be from another institution. The student's research advisor will act as the chairperson of the committee.

Approval of Course of Study

It is essential for the student and advisory committee to carefully define a Course of Study by the end of the first year. This is considered a basic contract between the student and the program and includes:

1. Proposed dissertation topic
2. All transfer credits.
3. Required and elective courses to be taken at Marshall University.
4. All competencies to be achieved by the student during graduate study. These details must be recorded on a Course of Study form and submitted for approval by the Director of Graduate Studies and the Dean of the Graduate College.

Graduate Assistantships for the Doctor of Philosophy Program

Research assistantships are available for students in the doctoral degree program on a competitive basis. The base stipend is renewable annually for up to ~~six~~ five years. Priority consideration for the ~~Doctor of Philosophy graduate~~ Ph.D. assistantships will be given to West Virginia residents.

Academic Performance

- The student must maintain a Grade Point Average of 3.0, and no more than six hours of C and no grades below C may be applied toward the degree.
- If the GPA falls below 3.0, the student will be placed on academic probation. Following notification of probation, the student will be counseled by his/her advisor. At this time, the deficiency will be identified and a written plan will be prepared for removing it within the next ~~nine~~ semester ~~hours~~. This plan, co-signed by the student and the advisor, must be approved by the Graduate Studies Committee and the Director of Graduate Studies, ~~and the Dean of the Graduate College~~ before the student can register for additional coursework.
- If probationary status is not removed within ~~nine~~ the next semester ~~hours~~, ~~the Dean of the Graduate College, in consultation with the Senior Associate Dean for the Biomedical Sciences and~~ the student is

dismissed from the program. The dismissal is automatically appealed to the Graduate Studies Committee, who will determine whether the student is retained or dismissed from the program. Retention must be recommended by the ~~interim~~ advisor ~~or~~ and student's advisory committee and endorsed by the Graduate Studies Committee.

Transfer Credit

The student may transfer credits completed at other regionally accredited graduate institutions. Approval of the Graduate Studies Committee and the Dean of the Graduate College is contingent on:

1. the grades earned were B's or better;
2. the credits are appropriate to the student's program and acceptable to the advisory committee; and
3. the time limitations were not exceeded.

The number of transfer hours acceptable for the Ph.D. degree will be determined by the student's advisory committee. Approval must be received from both the Graduate Studies Committee and the Dean of the Graduate College. Transfer credit will not become part of the Marshall University Grade Point Average.

Transfer of credits should be accomplished as early as possible. This should be accomplished either when the student is admitted to candidacy or submits an approved Course of Study. Attempts to transfer credits during the last semester may delay graduation. Official transcripts must be on file in the Graduate College office by the date that grades are due in the Marshall University Registrar's Office.

Validation of Outdated Coursework

The advisory committee has the option to require validation, by special examination, of courses which members deem to be outdated.

Time Limitations

Students must meet all requirements for the Doctor of Philosophy degree within seven years from the date of enrollment in the first course to be used in the degree program. The Graduate Dean may grant an extension upon recommendation by the Graduate Studies Committee. Absence due to military obligations, long serious illnesses, or similar circumstances beyond the student's control may be considered valid reasons for an extension. It is the option of the advisory committee to require validation of outdated courses by special examination.

Admission to Candidacy

Admission to graduate study and enrollment in graduate courses does not guarantee acceptance as a candidate for the Doctor of Philosophy degree. This is only accomplished by satisfactorily passing a comprehensive qualifying examination and meeting all other specified requirements. The qualifying examination assesses whether the student has attained sufficient knowledge to undertake independent research. The examination should be completed at the end of the second year of study. The examination consists of written and oral components covering all areas specified in the Course of Study. The examination is prepared, administered and graded by the advisory committee. The written portion includes all coursework and relevant topics determined by the advisory committee. The student will be given 2-3 days to complete the written component of the examination. Upon passing the written examination, the student must submit a grant proposal on the topic of his/her dissertation research or a related topic approved by the advisory committee. The proposal must be in the style of an NIH Predoctoral grant proposal. Links to the instructions for the proposal format can be found on the BMS Graduate Program website. The grant proposal must be submitted within 2 months of completion of the written exam and given to the advisory committee members at least 2 weeks in advance of the oral defense. The oral examination consists of a defense of the grant proposal and, at the discretion of the advisory committee, may include topics from the written portion of the exam in which the student was deemed to be deficient. Successful completion of the qualifying examination is based on approval of the committee. Only one dissenting vote is permitted on each component. If necessary, a single portion of the examination may be repeated at the discretion of the

advisory committee. The student must have the approval of the advisory committee to repeat either the written or oral component of the qualifying examination. The committee assesses the deficiencies and determines the time required for the student to make corrections. A student may take a given component of the qualifying examination no more than three times. Failure to pass this examination on the third attempt will result in dismissal. The advisory committee must complete an Admission to Candidacy for Ph.D. form after the student completes the examinations and submit it for approval by the ~~Senior Associate Dean for the Biomedical Sciences~~ Director of Graduate Studies and the Dean of the Graduate College.

Dissertation

All candidates must successfully complete a biomedical research project and prepare, submit, and defend a dissertation. The dissertation must present the results of the candidate's individual investigation and make a definite contribution to the current state of knowledge. While conducting research and writing a dissertation, the student must register for Research (BMS 882) at the beginning of each semester or summer term for which progress is to be earned. No more than 15 hours of doctoral research may be credited toward the degree.

Candidates are to follow the general guidelines outlined in Publishing Your Dissertation: How to Prepare Your Manuscript for Publication and General Information About Dissertations. Copies of these documents are on file in the Biomedical Sciences Graduate Program office.

Oral Defense of the Dissertation

The oral defense of the dissertation is held during the semester or summer session in which all other degree requirements have been met. The advisory committee must read and tentatively approve the dissertation before the examination can be scheduled. The committee chairperson will complete an Approval to Schedule Dissertation Defense form and submit it for approval of the Director of Graduate Studies and the Dean of the Graduate College before the examination can be given. Such notification must occur at least two weeks before the proposed date of the defense. A portion of the defense is an open examination and sufficient time is required for adequate public notice.

The open examination usually takes the form of a one-hour seminar. This is followed by a thorough review of the dissertation by the advisory committee and the candidate. Successful completion of the defense requires the approval of all but one of the members of the advisory committee. The results (pass/fail) must be recorded on a Results of Dissertation Examination form, which is to be reported to the Office of Research and Graduate Education and forwarded to the Graduate College Office within 24 hours. Should the candidate fail the defense, reexamination may not be scheduled without the approval of the advisory committee, the ~~Senior Associate Dean for the Biomedical Sciences~~ Director of Graduate Studies, and the Dean of the Graduate College.

All advisory committee members are to be present for the defense. If this is not possible, the Dean of the Graduate College, or designee, may permit one substitute for any member of the committee except the chairperson. A request for a substitute must be submitted in writing to, and approved by, the ~~Senior Associate Dean for the Biomedical Sciences~~ Director of Graduate Studies and the Dean of the Graduate College. The committee chairperson, the student, and both the original member of the committee to be replaced, and the substitute must sign this request. The substitute must have the same, or higher, graduate faculty status as the original member and represent the same academic discipline or area of emphasis.

Acceptance of Dissertation

Acceptance of the dissertation is a requirement for the doctoral degree. An accepted dissertation must bear the original signatures of at least all but one member of the advisory committee. If more than one member cannot approve the dissertation, the doctoral degree cannot be recommended. If the substitute member attends and approves the dissertation defense, he or she signs the dissertation. For complete information on the preparation and submission of electronic theses and dissertations see *www.marshall.edu/graduate/current-students/edt*.

Survey of Earned Doctorates

Please complete and submit the online Survey of Earned Doctorates. Survey of Earned Doctorate

information is used by a number of government agencies to assess the state of doctoral education in the U.S., and also to inform their decisions concerning funding of U.S. graduate institutions. The online survey is available at *http://survey.norc.uchicago.edu/doctorate/index.jsp*.

Publication

All doctoral dissertations and their abstracts will be microfilmed through University Microfilms, Ann Arbor, Michigan. This requirement cannot be satisfied by any other publication, but other publication of material in the dissertation is both permitted and encouraged.

Process Summary

1. Inquiry from prospective student to the Biomedical Sciences Graduate Program or Graduate Admissions Office.
2. Submission of the application to the Biomedical Sciences Graduate Program, the Graduate Admissions Office, or online.
3. Receipt of the following official application materials and required fee by the Graduate Admissions Office: application, GRE scores, and transcript(s). International students must apply through the Center for International Programs.
4. Referral of application materials by the Graduate Admissions Office.
5. The Biomedical Sciences Graduate Program notifies the Graduate Admissions Office and the prospective student of the admission decision of the Graduate Studies Committee.
6. The accepted student arrives, reports to the Biomedical Sciences Graduate Program, is assigned an interim advisor, and registers for coursework.
7. Selection of an area of emphasis/advisor must be achieved by the end of the first year. After a permanent advisor has been selected, an advisory committee is formed. A Course of Study should be developed by the end of the first year.
8. The student completes requisite coursework and other program requirements.
9. The student takes written and oral qualifying examinations for admission to candidacy to the Ph.D. These examinations should be scheduled within two months of each other.
10. The student continues doctoral research under the guidance of his/her advisory committee. The dissertation phase begins with the approval of a dissertation prospectus by the advisory committee, the Biomedical Sciences Graduate Program and the Graduate College Dean.
11. The student applies for graduation at the beginning of his or her last semester no later than the university deadline in the academic calendar. The diploma fee must be paid by this time.
12. A copy of the preliminary draft of the dissertation is given to each member of the advisory committee no later than two weeks prior to the final defense of the dissertation.
13. The chair of the advisory committee requests clearance for the defense from the Biomedical Sciences Graduate Program and the Graduate College for approval no later than two weeks before the scheduled date of the defense.
14. The time and place of the defense of the dissertation are announced.
15. The student defends the dissertation in an oral defense.
16. The student follows the steps to prepare and submit the electronic thesis or dissertation at *www.marshall.edu/graduate/current-students/edt.*

2. Edits to Current Description

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BIOMEDICAL SCIENCE (BMS)

~~**600 Biochemical, Cellular and Molecular Foundations of Biomedical Science. 7 hrs. I.**~~
~~A study of the structure and metabolism of biological compounds, the molecular biology of the cell, and the interactions of cell components. (PR: One year of Biology and Organic Chemistry and consent of instructor)~~

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MICROBIOLOGY, IMMUNOLOGY AND MOLECULAR GENETICS (MCB)

631 Medical Microbiology I. 3 hrs.
This course will present the major aspects of the field of microbiology with emphasis on selected pathogenic organisms. (PR: BMS ~~600~~ 601, 602, 603, and 604 or equivalent)

632 Medical Microbiology II. ~~3~~ 2 hrs.
This course will present a continuation of the major aspects of the field of medical microbiology with emphasis on the major pathogenic organisms. (PR: BMS ~~600~~ 601, 602, 603, and 604 and MCB 631)

643 Principles of Immunology. 3 hrs. I.
Basic principles of the immune response system of humans and related mammals. Concepts of B & T cell function and interrelationships emphasized. (PR: Cellular and Molecular Biology)

648 Molecular Aspects of Pathogenesis. 3 hrs.
An in depth study of molecular mechanisms of bacterial, viral, and immune mediated disease processes. ~~Course Requirements~~ PR: BMS ~~600~~ 601, 602, 603, 604 ~~and BIC 620~~

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PHARMACOLOGY (PMC)

621 Medical Pharmacology I. 6 hrs.
This course will encompass the core pharmacology concepts as well as drugs used in the treatment of infectious diseases, cancer, hematological matters, nervous system agents and cardiovascular drugs. (PR: BMS ~~600~~ 601, 602, 603, 604 or equivalent; REC: PHS 629 or PHS 667 desirable)

622 Medical Pharmacology II. 2 hrs.
This course will encompass the core pharmacology concepts as well as drugs used in the treatment of pulmonary, gastrointestinal, endocrine, renal and musculoskeletal diseases, drugs specific for men's and women's health, dermatological agents and toxicology. (PR: BMS ~~600~~ 601, 602, 603, 604 or equivalent; REC: PHS 629 or PHS 667 desirable)

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PHYSIOLOGY (PHS)

~~**626 Neurophysiology I: Neuron Function and Introduction to Neural Systems. 1 hr.**~~
~~To study and understand the basic functional principles of the cells of the nervous system, and organization of cells into functional systems. (PR: BMS 600 or permission of instructor)~~

~~**627 Neurophysiology II: Neuronal Systems. 1 hr.**~~
~~To study and understand the major functional systems of the brain. (PR: PHS 626)~~

667 Experimental Approaches to Physiology. 4 hrs. II.
The course introduces students to the fundamental principles and research underlying the normal functioning of the cardiovascular, respiratory, renal, endocrine, reproductive, nervous, and gastrointestinal systems.

3. New Catalog Description

School of Medicine

Dr. Joseph Shapiro, Dean
http://musom.marshall.edu

BIOMEDICAL SCIENCES, M.S., Ph.D., M.D./Ph.D.

Areas of Emphasis

- Cancer Biology
- Cardiovascular Disease, Obesity, and Diabetes
- Infectious and Immunological Diseases
- Medical Sciences (M.S. only)
- Neuroscience and Developmental Biology
- Toxicology and Environmental Health Sciences

Program Description

The basic science departments of the Joan C. Edwards School of Medicine offer an interdisciplinary program leading to the Master of Science and Doctor of Philosophy degrees in Biomedical Sciences. The primary aim of the Biomedical Sciences (BMS) program is to produce graduate students who are broadly based in the biomedical sciences with definite interests and special in-depth training in one of the following areas of emphasis: cancer biology; cardiovascular disease, obesity, and diabetes; infectious and immunological diseases; neuroscience and developmental biology; and toxicology and environmental health sciences. These areas are designed to be flexible and research oriented in order to develop the interests, capabilities and potential of all students pursuing careers in academic or industrial biomedical sciences.

In addition, the BMS program offers a non-thesis Master of Science degree in a medical sciences area of emphasis to improve the science foundation of students seeking admission into doctoral programs in medicine or other health-related professions. Admission into this program does not guarantee admission into medical school. Students in this area of emphasis are required to pay a Health Professions Fee each semester while enrolled in the program. Because of the nature of the curriculum, applicants to the medical sciences area of emphasis will only be considered for admission for the fall semester.

The Biomedical Sciences Doctor of Philosophy Degree program accepts a very limited number of students to study concurrently with the Doctor of Medicine degree.

Admission Requirements-

Applicants must meet the admissions requirements of the Graduate Studies Committee of Marshall University's Joan C. Edwards School of Medicine. Interested persons should contact the Biomedical Sciences Graduate Program at Byrd Biotechnology Science Center, Marshall University School of Medicine, One John Marshall Drive, Huntington, WV 25755, via the Internet at *www.marshall.edu/bms/future-students/contact-us*, mubiomed@marshall.edu, or 304-696-3365.

Minimum Requirements for Admission into Master of Science or Doctor of Philosophy Program

All applicants must have a baccalaureate degree, with one year of general biology, physics, general chemistry, and organic chemistry, all with associated laboratories. Biochemistry is not currently a requirement, but it is highly recommended to take it.

- Graduate Record Examination (GRE) General Test scores (scores may not be more than three (3) years old at the application deadline for the Ph.D. program or at the start of the semester when matriculating for the M.S. program) or MCAT scores (Medical Sciences area of emphasis only, minimum of 22 total for the old exam and 20th percentile for the new exam)
- Three letters of recommendation from references familiar with the applicant's relevant academic/professional performance
- A personal statement describing educational and career goals

Ph.D. Applications

The completed application, application fee, official transcripts and official GRE scores should be received in the Graduate Admissions Office by January 15th for summer applications in order for the application to be considered by the program.

Letters of recommendation and personal statements should be received in the BMS Office by January 15th for summer applications in order for the application to be considered complete and for an admission decision to be rendered.

Applications completed very soon after the above stated deadlines may be considered at the discretion of the BMS Graduate Studies Committee.

New Ph.D. students will matriculate in July (Summer III term).

M.S. Applications

The completed application, application fee, official transcripts, three letters of recommendation, written statement, and official GRE or MCAT scores (MCAT scores accepted for medical sciences area of emphasis only) should be received in the Graduate Admissions Office by June 1st for summer or fall applications in order for the application to be considered by the program.

Duration of Degree Programs

Students are expected to complete the requirements for the Master of Science degree within two years. Doctoral students are expected to complete the degree requirements with five years. Students who possess an M.S. degree in Biomedical Sciences or the equivalent when admitted into the doctoral degree program generally require three to complete the Doctor of Philosophy degree.

BIOMEDICAL SCIENCES, M.S. - Cancer Biology; Cardiovascular Disease, Obesity, and Diabetes; Infectious and Immunological Diseases; Neuroscience and Developmental Biology; Toxicology and Environmental Health Sciences Areas of Emphasis

Degree Requirements

A minimum of 36 credit hours is required for a non-thesis degree, while a minimum of 32 credit hours is required for the thesis degree. No more than six hours of thesis (BMS 681) may be credited toward the 32-hour requirement. Each student will specialize in one of the five research areas of emphasis as defined in the program description. All students are required to successfully complete:

BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 603	Regulation of Cell Function
BMS 604	Cellular Basis of Disease
BMS 617	Statistical Techniques for the Biomedical Sciences
BMS 644	Responsible Conduct of Research
BMS 660/661	Communication Skills for Biomedical Sciences

BMS 680	Seminar (minimum of 4 hrs.)
BMS 785	Introduction to Research

In addition, the student must successfully complete other courses required by his/her area of emphasis and advisory committee and pass an oral comprehensive examination.

Advisory Committee for M.S. Students

The advisory committee should be formed no later than the end of the first year of graduate education. As soon as the committee has been identified, a Thesis Committee Formation form is completed and submitted to the Director of Graduate Studies.

The committee will be selected by the student and research advisor and approved by the Director of Graduate Studies. The advisory committee will be composed of at least three faculty members with appropriate expertise. One of the members may be from another institution. The student's research advisor will act as the chairperson of the committee.

In addition, after 12 hours of coursework has been completed, the student must submit to the Dean of the Graduate College a Plan of Study form.

BIOMEDICAL SCIENCES, M.S. - Medical Sciences Area of Emphasis

A minimum of 36 credit hours is required for the non-thesis degree. In addition, the student must pass a written comprehensive examination covering BMS 601-604, MCB 631, MCB 632, and PHS 628. All students will also participate in laboratory-based research, and either present at a research conference or submit a peer-reviewed publication. All students are required to successfully complete:

BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 604	Cellular Basis of Disease
BMS 603	Regulation of Cell Function
BMS 617	Statistical Techniques for the Biomedical Sciences (or MTH 518, BSC 517, PSY 517, EDF 517 or equivalent)
BMS 680	Seminar (minimum of 4 hrs.)
BMS 785	Introduction to Research
MCB 631	Medical Microbiology I
MCB 632	Medical Microbiology II
PHS 628	Neurophysiology

Elective classes include PHS 629 (Mammalian Physiology), PMC 621 (Medical Pharmacology I), and PMC 622 (Medical Pharmacology II).

In addition, after 12 hours of coursework has been completed, the student must submit to the Dean of the Graduate College a Plan of Study form.

Biomedical Sciences, M.S., and School of Pharmacy, Pharm.D.

Students can receive both an M.S. degree from the Biomedical Sciences Program and a Pharm.D. degree from the School of Pharmacy. Prospective students must apply to and meet the admission requirements for both programs. The curriculum takes five years to complete. In the first year students take BMS courses; in years 2-5 students take School of Pharmacy courses. All students are required to successfully complete:

Year 1 Fall

BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 680	Seminar
PHS 628	Neurophysiology

Year 1 Spring

BMS 603	Regulation of Cell Function
BMS 604	Cellular Basis of Disease
BMS 680	Seminar
BMS 785	Introduction to Research
PHS 629	Mammalian Physiology

Year 2 Fall

PHAR 511	Clinical Immunology
PHAR 531	Biopharmaceutics I
PHAR 541	Pharmacy Practice I
PHAR 542	Immunology and Microbiology
PHAR 551	Biomedical Chemistry
PHAR 811	Introductory Pharmacy Practice Experiences in Community Settings I

Year 2 Spring

PHAR 521	Integrated Laboratory I
PHAR 532	Biopharmaceutics II
PHAR 543	Pharmacy Practice II
PHAR 544	Principles of Disease and Drug Action
PHAR 545	Therapeutics I
PHAR 812	Introductory Pharmacy Practice Experiences in Institutional Settings I

Year 3 Fall

PHAR 611	Integrated Laboratory II
PHAR 621	Pharmacy Law and Ethics
PHAR 622	Drug Information and Communication Skills
PHAR 631	Pharmacometrics
PHAR 632	Pharmacy Practice Management I
PHAR 661	Therapeutics II
PHAR 813	Introductory Pharmacy Practice Experiences in Community Settings II

Year 3 Spring

PHAR 612	Therapeutic Drug Dosing
PHAR 633	Patient Care Skills Lab
PHAR 634	Pharmacy Practice Management II
PHAR 635	Bridging Research Outcomes and Patient Care
PHAR 671	Therapeutics III
PHAR 814	Introductory Pharmacy Practice Experiences in Institutional Settings II

Year 4 Fall

PHAR 711	Medication Therapy Management
PHAR 722	Pharmacy Practice Management III
PHAR 741	Therapeutics V
PHAR 751	Therapeutics IV
PHAR 815	Ambulatory Care Skills
PHAR 816	Inpatient Practice Skills
	Elective 1

Year 4 Spring

PHAR 721	Therapeutics VII
PHAR 731	Case Studies in Pharmacy Practice
PHAR 761	Therapeutics VI
PHAR 817	Introductory Pharmacy Practice Experiences in Practice Management
PHAR 818	Introductory Pharmacy Practice Experiences in Education
	Elective 2

Year 5 Fall + Spring

PHAR 881	Advanced Pharmacy Practice Experiences in General Medicine
PHAR 882	Advanced Pharmacy Practice Experiences in Ambulatory Care/Primary Care
PHAR 883	Advanced Pharmacy Practice Experiences in Community Pharmacy
PHAR 884	Advanced Pharmacy Practice Experiences in Institutional Settings
PHAR 885	Advanced Pharmacy Practice Experiences in Geriatrics
PHAR 886	Advanced Pharmacy Practice Experiences in Diverse Populations
	Elective 3
	Elective 4
	Capstone 1
	Capstone 2

PHAR 635 substitutes for MTH 518, Biostatistics, a BMS Program requirement.
PHAR 542 substitutes for the BMS course MCB 631, Medical Microbiology I.
PHAR 531 and PHAR 551 substitute for the BMS courses PMC 625, Drug Metabolism, and PMC 630, Chemical Aspects of Pharmacology.
PHAR 545 and PHAR 671 substitute for the BMS course BMS 680, Seminar. This will meet the 4 hr. minimum requirement for Seminar for the M.S. degree.

A minimum of 36 credit hours is required for a non-thesis degree in the BMS Program.

BMS 601	3 hrs.
BMS 602	3 hrs.
BMS 680	1 hr.
PHS 628	2 hrs.
BMS 603	2 hrs.
BMS 604	1 hr.
BMS 680	1 hr.
BMS 785	3 hr.
PHS 629	6 hrs.
PHAR 531	3 hrs.
PHAR 542	4 hrs.
PHAR 545	4 hrs.
PHAR 551	5 hrs.
PHAR 635	3 hrs.
PHAR 671	7 hrs.

In addition, the student must pass a written and/or an oral comprehensive examination to receive the M.S. degree.

BIOMEDICAL SCIENCES, Ph.D.

The doctorate is a research or performance degree and does not depend solely on the accumulation of credit hours. The degree requirements are admission to candidacy and successful completion and defense of a dissertation. The degree signifies that the holder has the competence to function independently at the highest professional level.

Degree Requirements

To qualify for the Doctor of Philosophy degree, the student must pass (*C* or better or *CR*) the following courses:

BMS 601	Introduction to Nucleic Acids and Proteins
BMS 602	Introduction to Cell Structure and Metabolism
BMS 603	Regulation of Cell Function
BMS 604	Cellular Basis of Disease
BMS 644	Responsible Conduct of Research
BMS 617	Statistical Techniques for the Biomedical Sciences
BMS 660/661	Communication Skills for Biomedical Sciences
BMS 680	Seminar (minimum of 6 hrs.)
BMS 785	Introduction to Research
BMS 882	Research

In addition, the student must successfully complete other courses required by his/her area of emphasis and advisory committee. All courses will be defined in the student's Course of Study. The student must also pass a written and oral exam prior to becoming a Ph.D. candidate. These exams are set by the advisory committee and are outlined below under **Admission to Candidacy**.

Students are required to write and publish three peer-reviewed manuscripts, two of which must be first author.

BIOMEDICAL SCIENCES, M.D./Ph.D.

The Joan C. Edwards School of Medicine offers a combined M.D./Ph.D. degree in partnership with the Biomedical Sciences Graduate Program at Marshall University. The curriculum takes seven to eight years to complete. Students first take years one and two of medical school. During that time they complete the requirements for BMS 785 (Introduction to Research). After passing the USMLE Step 1 exam at the end of year two, students begin their Ph.D. coursework and research. This takes three to four years. After completing the Ph.D. requirements, students then complete years three and four of medical school. All of the requirements for both the M.D. and Ph.D. degrees must be met.

The medical student course Elements of Medicine (MDC 710) meets the requirements for BMS 601, 602, 603, and 604. Other medical school courses can meet area of emphasis requirements, as determined by the student's advisory committee and the Graduate Studies Committee.

M.D./Ph.D. Applications

Students interested in pursuing combined degree should indicate this on their medical school AMCAS application. A separate M.D./Ph.D. admissions subcommittee consisting of members of the medical school and BMS graduate admission committees will review the applications.

All applicants must take the MCAT. A score of 30 or better on the MCAT taken between January 2013 and January 2015 is preferred for consideration for admission. An MCAT score of 28 will be considered if the applicant has extensive research experience. A minimum score of 505 on the new MCAT is required for consideration for admission.

AMCAS applications must be submitted by November 1. Completed applications should be received by December 1. Completed applications received after December 1 may be reviewed for a position on a waiting list.

Advisory Committee for Ph.D. and M.D./Ph.D. Students

The advisory committee should be formed no later than the end of the first year of graduate education or upon completion of 18 semester hours of credit. As soon as the committee has been identified,

an Approval for Dissertation Topic and Committee Membership form is completed and submitted to the Director of Graduate Studies and the Dean of the Graduate College.

The committee will be selected by the student and research advisor and approved by the Director of Graduate Studies and the Dean of the Graduate College. The advisory committee will be composed of at least five faculty members with appropriate expertise. One of the members may be from another institution. The student's research advisor will act as the chairperson of the committee.

Approval of Course of Study

It is essential for the student and advisory committee to carefully define a Course of Study by the end of the first year. This is considered a basic contract between the student and the program and includes:

1. Proposed dissertation topic
2. All transfer credits.
3. Required and elective courses to be taken at Marshall University.
4. All competencies to be achieved by the student during graduate study. These details must be recorded on a Course of Study form and submitted for approval by the Director of Graduate Studies and the Dean of the Graduate College.

Graduate Assistantships for the Doctor of Philosophy Program

Research assistantships are available for students in the doctoral degree program on a competitive basis. The base stipend is renewable annually for up to five years. Priority consideration for the Ph.D. assistantships will be given to West Virginia residents.

Academic Performance

- The student must maintain a Grade Point Average of 3.0, and no more than six hours of C and no grades below C may be applied toward the degree.
- If the GPA falls below 3.0, the student will be placed on academic probation. Following notification of probation, the student will be counseled by his/her advisor. At this time, the deficiency will be identified and a written plan will be prepared for removing it within the next semester. This plan, co-signed by the student and the advisor, must be approved by the Graduate Studies Committee and the Director of Graduate Studies, before the student can register for additional coursework.
- If probationary status is not removed within the next semester, the student is dismissed from the program. The dismissal is automatically appealed to the Graduate Studies Committee, who will determine whether the student is retained or dismissed from the program. Retention-must be recommended by the advisor and student's advisory committee and endorsed by the Graduate Studies Committee.

Transfer Credit

The student may transfer credits completed at other regionally accredited graduate institutions. Approval of the Graduate Studies Committee and the Dean of the Graduate College is contingent on:

1. the grades earned were B's or better;
2. the credits are appropriate to the student's program and acceptable to the advisory committee; and
3. the time limitations were not exceeded.

The number of transfer hours acceptable for the Ph.D. degree will be determined by the student's advisory committee. Approval must be received from both the Graduate Studies Committee and the Dean of the Graduate College. Transfer credit will not become part of the Marshall University Grade Point Average.

Transfer of credits should be accomplished as early as possible. This should be accomplished either when the student is admitted to candidacy or submits an approved Course of Study. Attempts to

transfer credits during the last semester may delay graduation. Official transcripts must be on file in the Graduate College office by the date that grades are due in the Marshall University Registrar's Office.

Validation of Outdated Coursework

The advisory committee has the option to require validation, by special examination, of courses which members deem to be outdated.

Time Limitations

Students must meet all requirements for the Doctor of Philosophy degree within seven years from the date of enrollment in the first course to be used in the degree program. The Graduate Dean may grant an extension upon recommendation by the Graduate Studies Committee. Absence due to military obligations, long serious illnesses, or similar circumstances beyond the student's control may be considered valid reasons for an extension. It is the option of the advisory committee to require validation of outdated courses by special examination.

Admission to Candidacy

Admission to graduate study and enrollment in graduate courses does not guarantee acceptance as a candidate for the Doctor of Philosophy degree. This is only accomplished by satisfactorily passing a comprehensive qualifying examination and meeting all other specified requirements. The qualifying examination assesses whether the student has attained sufficient knowledge to undertake independent research. The examination should be completed at the end of the second year of study. The examination consists of written and oral components covering all areas specified in the Course of Study. The examination is prepared, administered and graded by the advisory committee. The written portion includes all coursework and relevant topics determined by the advisory committee. The student will be given 2-3 days to complete the written component of the examination. Upon passing the written examination, the student must submit a grant proposal on the topic of his/her dissertation research or a related topic approved by the advisory committee. The proposal must be in the style of an NIH Predoctoral grant proposal. Links to the instructions for the proposal format can be found on the BMS Graduate Program website. The grant proposal must be submitted within 2 months of completion of the written exam and given to the advisory committee members at least 2 weeks in advance of the oral defense. The oral examination consists of a defense of the grant proposal and, at the discretion of the advisory committee, may include topics from the written portion of the exam in which the student was deemed to be deficient. Successful completion of the qualifying examination is based on approval of the committee. Only one dissenting vote is permitted on each component. If necessary, a single portion of the examination may be repeated at the discretion of the advisory committee. The student must have the approval of the advisory committee to repeat either the written or oral component of the qualifying examination. The committee assesses the deficiencies and determines the time required for the student to make corrections. A student may take a given component of the qualifying examination no more than three times. Failure to pass this examination on the third attempt will result in dismissal. The advisory committee must complete an Admission to Candidacy for Ph.D. form after the student completes the examinations and submit it for approval by the Director of Graduate Studies and the Dean of the Graduate College.

Dissertation

All candidates must successfully complete a biomedical research project and prepare, submit, and defend a dissertation. The dissertation must present the results of the candidate's individual investigation and make a definite contribution to the current state of knowledge. While conducting research and writing a dissertation, the student must register for Research (BMS 882) at the beginning of each semester or summer term for which progress is to be earned. No more than 15 hours of doctoral research may be credited toward the degree.

Candidates are to follow the general guidelines outlined in Publishing Your Dissertation: How to Prepare Your Manuscript for Publication and General Information About Dissertations. Copies of these

documents are on file in the Biomedical Sciences Graduate Program office.

Oral Defense of the Dissertation

The oral defense of the dissertation is held during the semester or summer session in which all other degree requirements have been met. The advisory committee must read and tentatively approve the dissertation before the examination can be scheduled. The committee chairperson will complete an Approval to Schedule Dissertation Defense form and submit it for approval of the Director of Graduate Studies and the Dean of the Graduate College before the examination can be given. Such notification must occur at least two weeks before the proposed date of the defense. A portion of the defense is an open examination and sufficient time is required for adequate public notice.

The open examination usually takes the form of a one-hour seminar. This is followed by a thorough review of the dissertation by the advisory committee and the candidate. Successful completion of the defense requires the approval of all but one of the members of the advisory committee. The results (pass/fail) must be recorded on a Results of Dissertation Examination form, which is to be reported to the Office of Research and Graduate Education and forwarded to the Graduate College Office within 24 hours. Should the candidate fail the defense, reexamination may not be scheduled without the approval of the advisory committee, the Director of Graduate Studies, and the Dean of the Graduate College.

All advisory committee members are to be present for the defense. If this is not possible, the Dean of the Graduate College, or designee, may permit one substitute for any member of the committee except the chairperson. A request for a substitute must be submitted in writing to, and approved by, the Director of Graduate Studies and the Dean of the Graduate College. The committee chairperson, the student, and both the original member of the committee to be replaced, and the substitute must sign this request. The substitute must have the same, or higher, graduate faculty status as the original member and represent the same academic discipline or area of emphasis.

Acceptance of Dissertation

Acceptance of the dissertation is a requirement for the doctoral degree. An accepted dissertation must bear the original signatures of at least all but one member of the advisory committee. If more than one member cannot approve the dissertation, the doctoral degree cannot be recommended. If the substitute member attends and approves the dissertation defense, he or she signs the dissertation. For complete information on the preparation and submission of electronic theses and dissertations see *www.marshall.edu/graduate/current-students/edt*.

Survey of Earned Doctorates

Please complete and submit the online Survey of Earned Doctorates. Survey of Earned Doctorate information is used by a number of government agencies to assess the state of doctoral education in the U.S., and also to inform their decisions concerning funding of U.S. graduate institutions. The online survey is available at *http://survey.norc.uchicago.edu/doctorate/index.jsp*.

Publication

All doctoral dissertations and their abstracts will be microfilmed through University Microfilms, Ann Arbor, Michigan. This requirement cannot be satisfied by any other publication, but other publication of material in the dissertation is both permitted and encouraged.

Process Summary

1. Inquiry from prospective student to the Biomedical Sciences Graduate Program or Graduate Admissions Office.
2. Submission of the application to the Biomedical Sciences Graduate Program, the Graduate Admissions Office, or online.
3. Receipt of the following official application materials and required fee by the Graduate Admissions Office: application, GRE scores, and transcript(s). International students must apply through the Center

for International Programs.

4. Referral of application materials by the Graduate Admissions Office.
5. The Biomedical Sciences Graduate Program notifies the Graduate Admissions Office and the prospective student of the admission decision of the Graduate Studies Committee.
6. The accepted student arrives, reports to the Biomedical Sciences Graduate Program, is assigned an interim advisor, and registers for coursework.
7. Selection of an area of emphasis/advisor must be achieved by the end of the first year. After a permanent advisor has been selected, an advisory committee is formed. A Course of Study should be developed by the end of the first year.
8. The student completes requisite coursework and other program requirements.
9. The student takes written and oral qualifying examinations for admission to candidacy to the Ph.D. These examinations should be scheduled within two months of each other.
10. The student continues doctoral research under the guidance of his/her advisory committee. The dissertation phase begins with the approval of a dissertation prospectus by the advisory committee, the Biomedical Sciences Graduate Program and the Graduate College Dean.
11. The student applies for graduation at the beginning of his or her last semester no later than the university deadline in the academic calendar. The diploma fee must be paid by this time.
12. A copy of the preliminary draft of the dissertation is given to each member of the advisory committee no later than two weeks prior to the final defense of the dissertation.
13. The chair of the advisory committee requests clearance for the defense from the Biomedical Sciences Graduate Program and the Graduate College for approval no later than two weeks before the scheduled date of the defense.
14. The time and place of the defense of the dissertation are announced.
15. The student defends the dissertation in an oral defense.
16. The student follows the steps to prepare and submit the electronic thesis or dissertation at *www.marshall.edu/graduate/current-students/edt.*

3. New Catalog Description

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MICROBIOLOGY, IMMUNOLOGY AND MOLECULAR GENETICS (MCB)

631 **Medical Microbiology I. 3 hrs.**
This course will present the major aspects of the field of microbiology with emphasis on selected pathogenic organisms. (PR: BMS 601, 602, 603, and 604 or equivalent)

632 **Medical Microbiology II. 2 hrs.**
This course will present a continuation of the major aspects of the field of medical microbiology with emphasis on the major pathogenic organisms. (PR: BMS 601, 602, 603, and 604 and MCB 631)

643 **Principles of Immunology. 3 hrs. I.**
Basic principles of the immune response system of humans and related mammals. Concepts of B & T cell function and interrelationships emphasized. (PR: Cellular and Molecular Biology)

648 **Molecular Aspects of Pathogenesis. 3 hrs.**
An in depth study of molecular mechanisms of bacterial, viral, and immune mediated disease processes. PR: BMS 601, 602, 603, 604

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PHARMACOLOGY (PMC)

621 **Medical Pharmacology I. 6 hrs.**
This course will encompass the core pharmacology concepts as well as drugs used in the treatment of infectious diseases, cancer, hematological matters, nervous system agents and cardiovascular drugs. (PR: BMS 601, 602, 603, 604 or equivalent; REC: PHS 629 or PHS 667 desirable)

622 **Medical Pharmacology II. 2 hrs.**
This course will encompass the core pharmacology concepts as well as drugs used in the treatment of pulmonary, gastrointestinal, endocrine, renal and musculoskeletal diseases, drugs specific for men's and women's health, dermatological agents and toxicology. (PR: BMS 601, 602, 603, 604 or equivalent; REC: PHS 629 or PHS 667 desirable)

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PHYSIOLOGY (PHS)

667 **Experimental Approaches to Physiology. 4 hrs. II.**
The course introduces students to the fundamental principles and research underlying the normal functioning of the cardiovascular, respiratory, renal, endocrine, reproductive, nervous, and gastrointestinal systems.