The Graduate School of Arts and Sciences

Biomedical Graduate Programs

2025 – 2026

The Graduate Bulletin

For Biomedical Graduate Programs
Administered on the School of Medicine Campus

WAKE FOREST
UNIVERSITY

On the Cover: Biomedical Graduate Students Gathered to Learn from Each Other at the 2025 Graduate Student and Postdoctoral Fellow Research Day event.

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2025-2026 Academic Calendar

SUMMER 2025		
May	21	New Student Orientation
May	26	MEMORIAL DAY HOLIDAY
May	27	Classes Begin
June	**11**	Last day to add/drop a course; **Deadline for September graduates: Statement of Intent to Graduate module**
June	19	JUNETEENTH HOLIDAY
July	4	INDEPENDENCE DAY HOLIDAY
July	14	Course Registration for the next term opens
August	**13**	**Deadline for September graduates: Last day to defend**
August	20	Classes End; **Deadline for September graduates: ETD Student Advisor Agreement, submission of final copy of thesis/dissertation, Exit Survey**
August	21-23	Examinations
August	28	Grades Due
September	5	Graduation (Degrees Conferred)
FALL 2025		
August	26	New Student Orientation
August	29	Ethics RCR Bootcamp (GRAD 713)
September	1	LABOR DAY HOLIDAY
September	2	Classes Begin
September	**19**	Last day to add/drop a course; **Deadline for January graduates: Statement of Intent to Graduate module**
November	10	Course Registration for the next term opens
November	26 – 28	THANKSGIVING HOLIDAY
December	**5**	**Deadline for January graduates: Last day to defend**
December	11	Classes End
December	12-16	Examinations
December	**16**	**Deadline for January graduates: ETD Student Advisor Agreement, submission of final copy of thesis/dissertation, Exit Survey**
December	29	Grades Due
January	12	Graduation (Degrees Conferred)
SPRING 2026		
January	7	New Student Orientation
January	12	Classes begin
January	19	MARTIN LUTHER KING JR. HOLIDAY
January	**30**	Last day to add/drop a course; **Deadline for May graduates: Statement of Intent to Graduate module**
March	2 – 6	SPRING BREAK
March	16	Course Registration for the next term opens
April	**20**	**Deadline for May graduates: Last day to defend**
April	27	Classes end
April 28 – May 1		Examinations
May	**1**	**Deadline for May graduates: ETD Student Advisor Agreement, submission of final copy of thesis/dissertation, Exit Survey**
May	8	Grades Due
May	16	Hooding and Awards Ceremony/Graduation (Degrees Conferred)
May	18	Wake Forest University Commencement

Programs of Study

The Graduate School administers programs on the Wake Forest School of Medicine campus and the Reynolda campus, home of the undergraduate college and Arts and Sciences graduate programs.

On the School of Medicine campus, the Biomedical Graduate Programs Office administers 9 Doctor of Philosophy programs in the biomedical sciences, Master of Science programs in 11 biomedical disciplines, and graduate certificates in 4 biomedical disciplines. All other programs, including the Doctoral programs in biology, chemistry, and physics, and Master's degree programs in 19 disciplines, are administered by the Graduate School office based on the Arts and Sciences campus and covered by a separate Graduate Bulletin. The Graduate School also offers 15 combination degree programs in conjunction with the Wake Forest School of Medicine, School of Business, School of Divinity, and School of Law, as well as 13 certificate programs. Contact information on all programs and certificates of study administered by the Biomedical Graduate Programs office may be found on our website at http://school.wakehealth.edu/biomedgrad.

All programs of study, joint or combination degree programs, certificates, and concentrations subject to this Graduate Bulletin are noted in bold below.

Doctoral Programs of Study

Biology (PhD)
Biomedical Engineering (PhD)*; Joint degree program with Virginia Tech*
Chemistry (PhD)
Integrative Physiology and Pharmacology (PhD)
Medical Physics (PhD)
Molecular & Cellular Biosciences
(a non-degree granting admissions pathway to the following degree-granting programs)

- **Biochemistry and Molecular Biology (PhD)**
- **Cancer Biology (PhD)**
- **Microbiology and Immunology (PhD)**
- **Molecular Genetics and Genomics (PhD)**
- **Molecular Medicine and Translational Science (PhD)**

Neuroscience (PhD)
Physics (PhD)

Master's Programs of Study

Addiction Research and Clinical Health (MS)
Bioethics (MA)
Biology (MS)

Biomedical Engineering (MS)*; Joint degree program with Virginia Tech*
Biomedical Research (MS)
Biomedical Science (MS)
Chemistry (MS)
Clinical Research Management (MS - online)
Communication (MA)
Computer Science (MS)
Counseling (MA)
Counseling (MA - online)
Counseling - Human Services (MAHS - online)
Documentary Film (MA/MFA)
Education (MAEd)
English (MA)
Genetic Counseling (MS)
Health and Exercise Science (MS)
Interpreting and Translation Studies (MA):

- Interpreting and Translation Studies
- Intercultural Services in Healthcare
- Teaching of Interpreting

Liberal Arts Studies (MA)
Mathematics (MS)
Medical Physics (MS)
Molecular Medicine and Translational Science (MS)
Neuroscience (MS)
Physics (MS)
Psychology (MA)
Religious Studies (MA)
Statistics (MS)
Sustainability (MA)
Translational & Health System Science (MS)
Translational Biotechnology (MS)

Combination Degree Programs

MS & BS/A (Bioethics)
MS & BS/A (Clinical Research Management)
MS & BS/A (Computer Science)
MS & BS/A (Neuroscience)
MA/JD (Bioethics)
MA/JD (Religious Studies)
MA/JD (Sustainability)
MA/MD (Bioethics)
MS/MD (Translational and Health System Science)
PhD/MD (All Biomedical PhD programs)

MA/MDiv (Bioethics)
MA/MDiv (Counseling)
MAEd/MDiv (Education)
MA/MDiv (Sustainability)
PhD/MMS (Molecular Medicine and Translational Science)
PhD/MBA (All Biomedical PhD programs)

Graduate Certificates

Bioethics:

- Bioethics
- Biomedical Research Ethics
- Clinical Bioethics

Clinical and Translational Investigation
Computer Science
Data Science
Curriculum, Instruction, and Assessment
Interpreting and Translation Studies:

- Intercultural Services in Healthcare
- Interpreting Studies
- Teaching of Interpreting (Postgraduate)
- Translation Studies

Learning Health System Science
Medical Physics
Medieval and Early Modern Studies
Statistical Sciences
Data Science
Structural and Computational Biophysics
Sustainability
Translational Biotechnology

Concentrations

Antimicrobial Stewardship & Infection Prevention
Cancer Biology
Integrative Physiology and Pharmacology
Regenerative Medicine
Religion and Public Engagement
Women's Gender, and Sexuality Studies

The University

Wake Forest University is characterized by its devotion to liberal learning and professional preparation for men and women, its strong sense of community and fellowship, and its encouragement of free inquiry and expression.

Wake Forest Institute was founded in 1834 by the Baptist State Convention of North Carolina. The school opened its doors on February 3 with Samuel Wait as principal. Classes were first held in a farmhouse on the Calvin Jones plantation in Wake County, North Carolina, near which the village of Wake Forest later developed.

Rechartered in 1838 as Wake Forest College, Wake Forest is one of the state's oldest institutions of higher learning. The School of Law was established in 1894, followed by a two-year medical school in 1902. Wake Forest was exclusively a college for men until World War II, when women were admitted for the first time.

In 1941, the medical school moved to Winston-Salem to become affiliated with North Carolina Baptist Hospital and was renamed the Bowman Gray School of Medicine. In 1946, the trustees of Wake Forest and the Baptist State Convention of North Carolina accepted a proposal by the Z. Smith Reynolds Foundation to relocate the College to Winston-Salem.

The late Charles and Mary Reynolds Babcock donated much of the R.J. Reynolds family estate as the site for the campus and building funds were received from many sources. From 1952 to 1956, the first fourteen buildings were constructed in Georgian style on the new campus. The move to Winston-Salem took place in the summer of 1956; the original, or "old" campus, is now home to Southeastern Baptist Theological Seminary.

The Division of Graduate Studies, established in 1961, is now organized as the Graduate School and encompasses advanced work in the arts and sciences on both the Arts and Sciences and Bowman Gray campuses. In 1964, the first PhD degree was awarded from the School of Medicine program to Dr. Russel Reiter. In 1968, Dr. Dolores Evans became the first woman, and first woman of color, to receive their PhD at Wake Forest University. In 1970, the first PhD degrees were awarded from the Reynolda campus graduate programs.

After moving to Winston-Salem, Wake Forest grew considerably in enrollment, programs, and stature and became a university in 1967. The School of Business Administration, first established in 1948, was named the Charles H. Babcock School of Business Administration in 1969 and admitted its first graduate students in 1971. In 1972, the school enrolled only graduate students, and the name was changed to the Charles H. Babcock Graduate School of Management; departments of business and accountancy and economics were established in the College. In 1980, the Department of Business and Accountancy was reconstituted as the School of Business and Accountancy; the name was changed to the Wayne Calloway School of Business and Accountancy in 1995. On July 1, 2009, the Wayne Calloway School of Business and Accountancy and the Charles H. Babcock Graduate School of Management officially merged under the name Wake Forest University Schools of Business.

In 1997, the medical school was renamed the Wake Forest School of Medicine (The name was switched back to the Wake Forest University School of Medicine in 2022); its Winston-Salem campus is now known as the Bowman Gray Campus. A second campus was established in Charlotte in 2022. The School of Divinity was established in 1999. In 1999, the first PhD/MBA program in the nation was established.

Wake Forest governance is by an independent Board of Trustees; there are advisory boards of visitors for the College and each professional school. A joint board of university trustees and trustees of the North Carolina Baptist Hospital is responsible for Atrium Health Wake Forest Baptist Medical Center, which includes the hospital and the medical school.

The College, School of Business, School of Law, and the School of Divinity are located on the Arts and Sciences Campus in northwest Winston-Salem and the Morrocroft Campus in Charlotte, NC. The Wake Forest School of Medicine (Winston-Salem campus) is about five miles away, located in the city's downtown area and the Atrium Health Wake Forest Baptist Medical Center. The Graduate School maintains operations on both the Arts and Sciences and School of Medicine campuses depending on the program of study. The University also offers regular instruction at Casa Artom in Venice, at Worrell House in London, at Flow House in Vienna, and in other places around the world.

The College offers courses in more than forty fields of study leading to the baccalaureate degree. The School of Divinity offers the Master of Divinity degree. The Wake Forest School of Business offers a four-year Bachelor of Science degree, with majors in accountancy, business and enterprise management, finance, and mathematical business (offered in combination with the Department of Mathematics); and three graduate degree programs, Master of Science in Accountancy (MSA), Master of Arts in Management (MA), and Master of Business Administration (MBA).

The School of Law offers the Juris Doctor and Master of Laws in American law degrees. The school also offers a combination JD/MBA degree with the Schools of Business. The Wake Forest School of Medicine offers the Doctor of Medicine degree (MD) as well as the Master of Medical Science (MMS) through the Physician Assistant program, and the Master of Science (MS) in Nurse Anesthesia, and the Doctor of Nursing Practice (DNP degree). The School of Medicine and the Schools of Business offer a combination MD/MBA program.

The Graduate School confers the Master of Arts, Master of Arts in Education, Master of Arts in Human Services, Master of Arts in Liberal Studies, Master of Fine Arts, Master of Healthcare Leadership, Master of Science, and the Doctor of Philosophy degree. The Graduate School also offers an MD/MS, MD/PhD, PhD/MMS, an MD/MA in bioethics in combination with the School of Medicine, and a PhD/MBA program in combination with the School of Business. In addition, the Graduate School offers an MDiv/MA in bioethics, counseling, or sustainability as well as an MDiv/MAED in combination with the School of Divinity; and a JD/MA in bioethics, religious studies, or sustainability in combination with the School of Law. Certificates are offered in Bioethics, Clinical and Translational Investigation, Learning Health System Science,

Interpreting and Translation Studies, Structural and Computational Biophysics, and Sustainability.

STATEMENT OF PURPOSE OF THE UNIVERSITY

The following is the official statement of the purposes and objectives of the University: *Wake Forest is a university dedicated to the pursuit of excellence in the liberal arts and in graduate and professional education. Its distinctiveness in its pursuit of its mission derives from its private, coeducational, and residential character; its size and location; and its Baptist affiliation. Each of these factors constitutes a significant aspect of the unique character of the institution.* The University is comprised of Wake Forest College, the Graduate School, the School of Law, the School of Medicine, the School of Divinity, and the School of Business. It seeks to honor the ideals of liberal learning, which entail commitment to transmission of cultural heritages; teaching the modes of learning in the basic disciplines of human knowledge; developing the critical appreciation of moral, aesthetic, and religious values; advancing the frontiers of knowledge through in-depth study and research; and applying and using knowledge in the service of humanity.

Wake Forest has been dedicated to the liberal arts for over a century and a half; this means education in the fundamental fields of human knowledge and achievement, as distinguished from education that is technical or narrowly vocational. It seeks to encourage habits of mind that ask "why," that evaluate evidence, that are open to new ideas, that attempt to understand and appreciate the perspectives of others, that accept complexity and grapple with it, that admit error, and that pursue truth. Wake Forest College has by far the largest student body in the University, and its function is central to the University's larger life. The College and the Graduate School are most singularly focused on learning for its own sake; they, therefore, serve as exemplars of specific academic values in the life of the University.

Beginning as early as 1894, Wake Forest accepted an obligation to provide professional training in a number of fields as a complement to its primary mission of liberal arts education. This responsibility is fulfilled in the conviction that the humane values embodied in the liberal arts are also centrally relevant to the professions. Professional education at Wake Forest is characterized by a commitment to ethical and other professional ideals that transcend technical skills. Like the Graduate School, the professional schools are dedicated to the advancement of learning in their fields. In addition, they are specifically committed to the application of knowledge to solving concrete problems of human beings. They are strengthened by values and goals that they share with the College and Graduate School, and the professional schools enhance the work of these schools and the University as a whole by serving as models of service to humanity.

Wake Forest was founded by private initiative, and ultimate decision-making authority lies in a privately appointed Board of Trustees rather than in a public body. Funded to a large extent from private sources of support, Wake Forest is determined to chart its own course in the pursuit of its goals. As a coeducational institution, it seeks to "educate together" persons of both sexes and from a wide range of backgrounds—racial,

ethnic, religious, geographical, socioeconomic, and cultural. Its residential features are conducive to learning and the pursuit of a wide range of co-curricular activities. It has made a conscious choice to remain small in overall size; it takes pride in being able to function as a community rather than a conglomerate. Its location in the Triad area of North Carolina engenders an ethos that is distinctively Southern, and more specifically North Carolinian. As it seeks to broaden its constituency further and receive national recognition, it is also finding ways to maintain the ethos associated with its regional roots.

Wake Forest is proud of its Baptist and Christian heritage. For more than a century and a half, it has provided the University with an indispensable basis for its mission and purpose, enabling Wake Forest to educate thousands of ministers and lay people for enlightened leadership in their churches and communities. Far from being exclusive and parochial, this religious tradition gives the University roots that ensure its lasting identity and branches that provide a supportive environment for various faiths. The Baptist insistence on the separation of church and state and local autonomy has helped protect the University from interference and domination by outside interests, whether commercial, governmental, or ecclesiastical. The Baptist emphasis upon revealed truth enables a strong religious critique of human reason, even as the claims of revelation are put under the scrutiny of reason. The character of intellectual life at Wake Forest encourages open and frank dialogue and assures that the University will be ecumenical and not provincial in scope, and that it must encompass perspectives other than the Christian. Wake Forest thus seeks to maintain and invigorate what is noblest in its religious heritage.

LIBRARIES

The libraries of Wake Forest University support instruction and research at the undergraduate level and in the disciplines that award graduate degrees. The University libraries hold membership in the American Library Association and the Association of Southeastern Research Libraries.

The Wake Forest University libraries include the Z. Smith Reynolds (ZSR) Library, which is located on the Arts and Sciences Campus and primarily supports the undergraduate College, the Wake Forest School of Business, the Arts and Sciences programs of the Graduate School, and the School of Divinity. The Professional Center Library, housed in the Worrell Professional Center on the Arts and Sciences Campus, serves the School of Law. The Coy C. Carpenter Library primarily serves the Wake Forest School of Medicine and the biomedical science programs of the Graduate School of Arts and Sciences.

The three library collections total over 2.4 million titles, including over 1.4 million e-books, more than 100,000 electronic journals, and over 15,000 DVDs, as well as streaming media and other formats. The ZSR Library serves as a congressionally designated selective federal depository. The Professional Center Library holds nearly 130,000 volumes, and the Coy C. Carpenter Library holds almost 27,000 volumes. The three libraries share an online search portal, providing access to books, electronic

resources, journals, and databases. Through the interlibrary loan service, students, faculty, and staff may obtain materials from other libraries at no charge.

School of Medicine Campus and Innovation Quarter Library Resources

All faculty, staff, and students in the Wake Forest University Graduate School of Arts and Sciences and Biomedical Sciences have full and unrestricted access to the Coy C. Carpenter Library of Wake Forest School of Medicine at its main facility on the first floor of the Gray Building. The library is centrally located within the Wake Forest-affiliated hospital (Atrium Health Wake Forest Baptist Medical Center), and most of the resources are available online. The main library facility is also well-stocked with print volumes covering all medical and surgical specialties, as well as the basic sciences. There is a library branch located on the third floor of the Bowman Gray Center for Medical Education (BGCME) building in Innovation Quarter that is reserved mostly for students. The Carpenter Library's website, www.wakehealth.edu/library, offers access to PubMed, UpToDate, Journal Citation Reports, Micromedex, PsycINFO, and Web of Science, as well as over 70 other bibliographic and full-text databases.

Graduate students receive free document delivery service for materials the library owns and interlibrary loan service for materials from other libraries when the library does not own or license a particular journal or book. In addition, all graduate students have unlimited copying and printing services at both locations.

The library assists graduate students as they complete the Graduate School's requirement to archive an electronic full-text copy of their thesis or dissertation in Wake Forest University's institutional repository, WakeSpace at etd.wfu.edu.

Librarians also offer publication assistance, Research ID and ORCID setup, copyright guidance, NIH and other government-funded public access compliance instruction, BioSketch creation, and individual database instruction on products such as PubMed, EndNote, and more.

Arts and Sciences Campus Library Resources

The Z. Smith Reynolds Library (ZSR) provides comprehensive reference and research services in person and online. Research Librarians work with individual classes across the disciplines on research papers, and library users can request personal research sessions with Research Librarians at all phases of their research process. Library faculty also teach elective courses in the fundamentals of research and information literacy, and upper-level courses geared towards research in the disciplines and special topics in information. The Digital Initiatives & Scholarly Communication librarians and staff support and empower faculty scholarship through digital tools, methods, publication, and preservation.

Special Collections & Archives (SCA) in ZSR is the repository for the Baptist Historical Collection of North Carolina (the Ethel Taylor Crittenden Collection), Personal Collections & Manuscripts, the Rare Book Collection, and the University Archives. All are welcome to use the SCA online collections and to visit the Research Room. It is a beautiful space for researchers to delve into the collections, where SCA hosts many events and exhibits.

The library has ten group study rooms with large screen monitors that can be booked online. Publicly available Windows and Macintosh computers are available in the Scholars Commons and Reference areas, and media viewing stations are available in the Media Room. Multimedia equipment, Chromebooks, tablets, and other technology devices may be reserved for checkout. The Reference Desk and online chat are available to help library visitors find resources and receive research assistance. The library has an 118-seat auditorium for Wake Forest community groups to use for programs, lectures, and film screenings. There is also the ZieSta Room, a space for students to take a break from studying to nap or rest in comfortable loungers.

ZSR houses the Information Systems Service Desk, the Teaching and Learning Collaborative, and The Writing Center. The Teaching and Learning Collaborative is a resource center for Wake Forest faculty at all stages of their careers. The Writing Center provides help to guide students through their writing process.

ZSR library is committed to creating an accessible, enriching, and welcoming community space for all. The library is open for students continuously during the fall and spring terms, 24 hours a day from Sunday through Thursday, and daytime hours Friday and Saturday. Two 24-hour study rooms are located near the entrance to the library and may be accessed by keycard even when the library is closed. The study room on one side houses a coffee bar. Check out the hours and events calendar to stay up to date.

INFORMATION TECHNOLOGY/ACADEMIC COMPUTING

The Office of Academic Computing is dedicated to developing and supporting technology innovations in graduate education. Its mission is to provide the infrastructure for faculty and students to utilize technologies to augment the lifelong learning process effectively. A key role of the department is to facilitate basic understanding about the uses of technology, not only within education but also within the workplace.

The department has developed a ubiquitous computing environment, focusing on hardware, software, and networking technology standards. The main strategic initiative has been the development of a Web-based curriculum for individual biomedical graduate programs. The Web-based curriculum provides an organizational framework for the digitized lectures and course materials of each program, education-oriented websites, schedules, collaborative discussions, and links to specialty content applications.

The Medical Center's Information Technology group provides continuous technical support for faculty, staff, and students 24 hours per day, each day of the year. Both hardware and software support are covered through various groups in this department. In addition to the technical support functions, the office also provides services to the faculty to develop teaching applications and assist with digitizing curriculum content. Three software developers are employed for this specific purpose.

Wake Forest has a gigabit Ethernet connection to the Internet. Wake Forest is also a key member of Internet 2, which is focused on providing advanced network

technologies, and the North Carolina Research and Education Network (NCREN), which offers statewide educational programs.

Recognition and Accreditation

Wake Forest University is accredited by the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC) to award baccalaureate, master's, and doctoral degrees. Wake Forest University may also offer credentials such as certificates and diplomas at approved degree levels. Questions about the accreditation of Wake Forest University may be directed in writing to the Southern Association of Colleges and Schools Commission on Colleges at 1866 Southern Lane, Decatur, GA 30033-4097, by calling (404) 679-4500, or by using information available on SACSCOC's website (http://www.sacscoc.org/).

The Wake Forest School of Medicine is a member of the Association of American Medical Colleges and is fully accredited by the Liaison Committee on Medical Education, the joint accrediting body of the Association of American Medical Colleges and the American Medical Association. The Wake Forest University Physician Assistant Program is accredited by the Accreditation Review Commission on Education for the Physician Assistant Inc. (ARC-PA). For more information on the accreditation status of the program, visit the ARC-PA website (https://www.arc-pa.org/Acc_Programs/acc_programs. html) or the medical school website (https://www.wakehealth.edu/Academic-Programs/Physician-Assistant-Program/Accreditation.htm). The School of Law is a member of the Association of American Law Schools, the American Bar Association, and is listed as an approved school by the Council of the Section of Legal Education and Admissions to the Bar of the American Bar Association and by the Board of Law Examiners and the Council of the North Carolina State Bar. Wake Forest University School of Business is accredited by the Association to Advance Collegiate Schools of Business. The counseling program leading to the Master of Arts in Education degree is accredited by the Council for the Accreditation of Counseling and Related Educational Programs. The Genetic Counseling program is a graduate-level program that awards a Master of Science degree. The Genetic Counseling Program was granted full accreditation by the Accreditation Council for Genetic Counseling (7918 Jones Branch Drive, Suite 300, McLean, VA 22102, phone: 703-506-7667) on December 16, 2024, for a period of six years. The Medical Physics program is a graduate-level program that offers three separate pathways, a Master of Science degree, a Doctor of Philosophy degree, and a Graduate Certificate. The Medical Physics programs were accredited in 2023 by the Commission on Accreditation of Medical Physics Education Programs (CAMPEP), which is located at 1631 Prince Street, Alexandria, VA 22314. Their phone number is 571-298-1239. The Divinity School is accredited by the Association of Theological Schools in the United States and Canada (ATS).

Wake Forest University is a member of many of the major institutional organizations and associations at the national, regional, and statewide levels, including the following:

The American Council on Education, the Association of American Colleges, the National Association of Independent Colleges and Universities, the Council of Graduate Schools in the United States, the Commission on Colleges of the Southern Association of Colleges and Schools, Oak Ridge Associated Universities, Southern Universities Conference, the North Carolina Conference of Graduate Schools, the North Carolina Association of Colleges and Universities, the North Carolina Department of Public Instruction, and the North Carolina Independent Colleges and Universities. In addition, many offices of the University are members of associations that focus on particular aspects of university administration.

Oak Ridge Associated Universities

Since 1993, students and faculty of Wake Forest University have benefited from its membership in Oak Ridge Associated Universities (ORAU). ORAU is a consortium of over one hundred colleges and universities and a contractor for the U.S. Department of Energy (DOE) located in Oak Ridge, Tennessee. ORAU works with its member institutions to help their students and faculty gain access to federal research facilities throughout the country; keep its members informed about opportunities for fellowship, scholarship, and research appointments; and organize research alliances among its members.

Through the Oak Ridge Institute for Science and Education (ORISE), the DOE facility that ORAU operates, undergraduates, graduates, postgraduates, and faculty enjoy access to many opportunities for study and research. Students can participate in programs covering various disciplines, including business, earth sciences, epidemiology, engineering, physics, geological sciences, pharmacology, ocean sciences, biomedical sciences, nuclear chemistry, and mathematics. Appointment and program length range from one month to four years. A comprehensive listing of these programs and other opportunities, their disciplines, and details on locations and benefits can be found at https://orise.orau.gov/.

ORAU's Office of Partnership Development seeks opportunities for partnerships and alliances among ORAU's members, private industry, and major federal facilities. Activities include faculty development programs, such as the Ralph E. Powe Junior Faculty Enhancement Awards, the Visiting Industrial Scholars Program, consortium research funding initiatives, faculty research, support programs, and services to chief research officers.

For more information about ORAU and its programs, review the ORAU website at https://www.orau.org.

THE ADMINISTRATION

The Bulletin of Wake Forest University contains a full accounting of the leadership, reflecting the leader's year of hire, their role, and their degree histories, for the university and its schools (the College, Law, Business, Divinity, and the Graduate School's Arts and Sciences programs). The full list of administrators may be reviewed at https://about.wfu.edu/leadership/senior-officers/.

In addition, the Bulletin of Wake Forest University contains a full listing of all members of the university's governing and advisory boards, including the Board of Trustees and its Officers. The full list of governing and advisory board members may be reviewed at https://about.wfu.edu/leadership/board-of-trustees/.

Owing to this Bulletin's applicability to programs administered by and hosted at the School of Medicine's campus, this document provides a link to key administrative personnel based on the School of Medicine campus. The full list of governing and advisory board members may be reviewed at https://school.wakehealth.edu/about-the-school/leadership. The Biomedical Graduate Programs Office administration can be found after the section describing the Graduate School.

The Graduate School

In accord with the prevailing custom among American colleges during the antebellum period, Wake Forest granted honorary master's degrees to selected alums. By 1862, when the College closed temporarily because of the Civil War, twenty-nine such degrees had been awarded. The first announcement of a program of study leading to an earned graduate degree at Wake Forest was made in 1866. Between 1871, when the first degrees earned under the plan were awarded to John Bruce Brewer (grandson of Samuel Wait) and Franklin Hobgood, and 1951, 383 Master of Arts and Master of Science degrees were granted. In 1949, the School of Arts and Sciences discontinued admitting applicants for the Master of Arts degree because the rapid increase in the size of the undergraduate student body following World War II had overloaded the faculty. The School of Medicine did not interrupt its graduate program. The first Master of Science degree conferred by the school after it moved to Winston-Salem was awarded in 1943, and the degree was offered regularly thereafter by the departments of Anatomy, Biochemistry, Microbiology, Pharmacology, and Physiology.

During the fifteen years the College and the School of Medicine were located in different towns, the study of graduate education continued on both campuses. The self-study report adopted by the School of Arts and Sciences faculty immediately before its move to Winston-Salem recommended that graduate study leading to the master's degree be resumed as soon as practicable. In 1958, the administration of the School of Medicine, given an increasing demand for graduate instruction in basic medical and clinical sciences, appointed a Committee on Graduate Studies to reorganize the graduate program.

As a result of these two parallel studies and in recognition of the need for an institution-wide approach to graduate education, the trustees, on January 13, 1961, established the Division of Graduate Studies and authorized it to grant the Master of Arts degree in the School of Arts and Sciences and the Master of Science and Doctor of Philosophy degrees in the School of Medicine. The first PhD degree was awarded in 1964. In 1967, the Master of Arts in Education degree was added to the graduate program in arts and sciences. A program, leading to the Master of Arts in Liberal Studies, was begun in the summer of 1987. The first PhD program on the Arts and Sciences campus was begun in 1970.

MISSION OF THE GRADUATE SCHOOL

The WFU Graduate School of Arts and Sciences mission is, "*To train and mentor future leaders in research, teaching, and innovation for serving humanity*". This embodies the Graduate School's vital role as an engine of discovery that fuels the nation's scholarly and creative enterprise. The Graduate School contributes to the university's academic reputation by educating the next generation of teachers and scholars and providing mentors and role models for educating undergraduates. A strong graduate program also helps support faculty research and is critical for faculty recruitment and retention.

We seek to instill in our students a sense of professionalism, which includes the ethical behavior inherent in their professional role, and respect for their colleagues,

their field, and society as a whole. We want our students to be critical, independent thinkers and good citizens. They should be motivated to apply their scholastic efforts to enlighten and improve the wellbeing of society. Thus, the Graduate School is a key link for collaboration between departments and schools and achieving WFU's goal of becoming a collegiate university and major academic medical center.

Our steadfast values consist of critical thinking, service, diversity, discovery, mentoring, and ethics. These are integral to all our activities in the classroom, the laboratory, or other research environments, the broader communities of which we are a part. Our vision is for the Graduate School to be a diverse community of excellence. We achieve our vision and fulfill our mission through strategic activities that build pillars of excellence in:

- Student experience: to create an optimized learning and mentoring experience that prepares students to lead in any career path
- Research: to provide high-quality research partnerships for promoting innovation, discovery, and creation of value to the community
- Faculty and staff support: to enable seamless, effective, aligned services for maximizing time and resources for instruction and research
- Internal and external communication: to celebrate the prominence and value of the Graduate School and the University

GRADUATE SCHOOL ADMINISTRATION

The Graduate School is administered by two Senior Associate Deans (one on each campus), and an administrative staff that supports students and faculty based on each campus. The Biomedical Graduate Programs are supported by a central administrative staff on the School of Medicine campus. The leadership for the Biomedical Graduate Programs Office Administration on the School of Medicine campus is shown below.

KEY BIOMEDICAL GRADUATE PROGRAMS ADMINISTRATORS

Dwayne W. Godwin (2013)
Senior Associate Dean
BA, University of West Florida; PhD, University of Alabama-Birmingham

Allyn Howlett (2015)
Assistant Dean and Director, Office of Postdoctoral Education
BS, Pennsylvania State University; PhD, Rutgers University

Janet Tooze (2024)
Assistant Dean, Clinical & Translational Research and Education
AB, Earlham College; PhD, University of Colorado Anschutz; MPH, Harvard University

Erik D. Brady (2015)
Director
BS, Appalachian State University; MS, PhD, Vanderbilt University

Jennie McGuire (2017)
Manager, Curriculum & Outcomes
BA, MA, EdD, Appalachian State University

THE GRADUATE COUNCIL

The administration of the Graduate School and its programs is further supported by a Graduate Council composed of ex-officio administrative officials, twelve faculty members elected by the Graduate School faculty, and two graduate students elected by the Graduate Student Association. Six of the twelve are members of the College of Arts and Sciences (representing the Arts and Sciences graduate programs) and six are members of the School of Medicine faculty (representing the Biomedical graduate programs).

Dwayne Godwin	Senior Associate Dean, Biomedical (BG)	dgodwin@wakehealth.edu
Anthony Marsh	Senior Associate Dean, Arts & Science (AS)	marshap@wfu.edu
Allyn Howlett	Assistant Dean (BG)	ahowlett@wakehealth.edu
Janet Tooze	Assistant Dean (BG)	jtooze@wakehealth.edu
Jennifer Rogers	Associate Dean (AS)	rogersjh@wfu.edu
Ron Von Burg	Associate Dean (AS)	vonburrl@wfu.edu

A listing of members from each campus, their academic departmental affiliation, contact information, and the expiration of their term of service as programmatic representatives on Graduate Council can be viewed at: https://graduate.wfu.edu/graduate-council-members/. In addition, Graduate Student Association representatives also found therein.

THE GRADUATE FACULTY

The graduate faculty are key contributors to the educational and research experience offered by the Graduate School through a system of shared faculty governance. To review a full list of current graduate faculty members, with their year of appointment and department affiliations, please access the searchable database at: https://graduate.wfu.edu/faculty-search/. School of Medicine faculty and students with questions about the graduate faculty appointment process or seeking to secure an appointment as a graduate faculty member, should contact Dr. Jennie McGuire (Jennie.McGuire@wakehealth.edu).

Representatives and liaisons to the following bodies or committees, with their departmental affiliation, contact information, and term of appointment, can be viewed at: https://graduate.wfu.edu/graduate-council-members/:

- University Senate
- Committee on Information Technology
- Committee on Academic Freedom and Responsibility
- Faculty Liaisons for Faculty Grievances
- Faculty Liaisons for Graduate Student Grievances

GRADUATE STUDENT RIGHTS AND RESPONSIBILITIES

Introduction

Wake Forest University exists for the transmission of knowledge, the pursuit of truth, the development of students, and the wellbeing of society. Free inquiry and free expression are indispensable to the attainment of these goals. The Graduate School of Arts and Sciences is committed to providing an environment that will encourage graduate students to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. The Graduate School is also dedicated to honor, mutual respect, and trust among the faculty and students. The common observance of professional ethics is basic to the study and research in which we are engaged.

a. Rights

The minimal standards of academic freedom of graduate students outlined below are essential to any community of scholars. Any violations of these standards may be grounds for a student to initiate the grievance process.

1. Freedom of Access to Higher Education:

The facilities and services of the University should be open to all of its enrolled students, and the University should use its influence to secure equal access for all graduate students to public facilities in the local community.

2. The Classroom and Research Environment:

Graduate student performance will be evaluated solely on an academic basis, not on opinions or conduct unrelated to academic standards.

a. Protection of Freedom of Expression

Graduate students are free to take reasoned exception to the data or views offered in any course of study or research activity and to reserve judgment about matters of opinion. Still, they are responsible for learning the content of any course of study for which they are enrolled.

b. Protection Against Improper Academic Evaluation

Graduate students have protection through orderly procedures (described in the section on Grievance Procedures) against prejudiced or capricious academic evaluation. At the same time, they are responsible for maintaining standards of academic performance established for the program in which they are enrolled.

c. Protection Against Improper Disclosure

Information about graduate students' views, beliefs, and political associations that professors acquire in the course of their work as instructors, advisors, and counselors is considered confidential. Protection against improper disclosure is a serious professional obligation. Judgments of ability and character may be provided under appropriate circumstances, always with the knowledge or consent of the graduate student.

d. Protection Against Harassment

Graduate students have protection through orderly procedures (described in the section on Grievance Procedures) against physical (sexual, etc.) harassment and/or psychological abuse.

3. Student Records:

To minimize the risk of improper disclosure, access to academic and disciplinary records should be considered separately. Transcripts of academic records will contain only information about academic status. Information from disciplinary or counseling files will not be available to unauthorized persons on campus, or any person off campus without the written consent of the graduate student involved, except where a judicial order or subpoena compels disclosure or health safety emergency cases are involved. No records will be kept that reflect the graduate students' political activities or beliefs. The Dean of the Graduate School should make provision for periodic review and possible destruction of non-current disciplinary records. Administrative staff and faculty members should respect confidential information about graduate students that they acquire while working with them.

4. Student Affairs:

a. Freedom of Association

Graduate students bring to the campus a variety of interests previously acquired and develop many new interests as members of the academic community. They are free to organize and join associations to promote their common interests.

b. Freedom of Inquiry and Expression

Graduate students and their organizations are free to examine and discuss all questions of interest to them, and to express opinions publicly and privately. They are free to support causes by orderly means that do not disrupt the regular and essential operation of the University. Graduate students and their organizations will be allowed reasonable access to university facilities for academic purposes, organizational meetings, sponsored lectures, etc. Those routine procedures required by the University for obtaining access to facilities are designed only to ensure that there is orderly scheduling of facilities and adequate preparation for the event, and that the occasion is conducted in a manner appropriate to an academic community. Graduate students and their organizations can invite and hear from any person of their own choosing. The University's control of campus facilities cannot be used as a censorship device.

c. Student Participation in University Government

As constituents of the academic community, graduate students are free, individually and collectively, to express their views on University policy issues and matters of general interest to the graduate student body.

5. Off-Campus Freedom of Students

If activities of graduate students upon occasion result in a violation of the law, University officials should be prepared to apprise students of sources of legal counsel

and may offer other assistance. Graduate students who violate the law may incur penalties prescribed by civil authorities. Only where the University's interests as an academic community are clearly involved should the special authority of the University be asserted to consider off-campus violations. The graduate student who incidentally violates University regulations in the course of his/her off campus activity is subject to no greater penalty than would normally be imposed for such infractions.

b. Responsibilities

The faculty expects students to be mature and responsible members of the community, offers guidance in their freedom to learn, and subscribes to the statement of their rights.

Those rights are linked to the student's commitment to academic integrity and responsible behavior as a University community member.

Infractions of academic integrity include plagiarism, cheating on examinations, misrepresentation of the work of other scholars, and the falsification or fabrication of data in reporting one's research. These infractions, acts that disrupt the educational environment, and any violations of local or federal law that occur on the university campus or during university sponsored activities, can be grounds for disciplinary action, including dismissal from graduate school.

STATEMENT OF PHILOSOPHY ON THE MENTORING RELATIONSHIP BETWEEN STUDENTS AND ADVISORS

Master's and doctoral graduate student training is comprised of both classroom instruction and an apprenticeship relationship with one or more faculty members. Each individual who pursues a graduate degree has ultimate responsibility for their education and professional development. Likewise, a faculty member who advises a student has a responsibility to foster the successful development of the student into a member of the profession. Additionally, Wake Forest University Graduate School of Arts and Sciences has responsibilities to both the student and the faculty advisor to maintain and promote an environment that supports quality training programs.

This document serves as a Statement of Philosophy about the mentoring relationship between graduate students and faculty mentors, and the institutional responsibility to facilitate that relationship. This document is meant to function as a statement of guiding principles that can promote the student's successful completion of training and guide their mentors' efforts. It does not supersede institutional rules and regulations.

Core Tenets of Graduate Training

Institutional Commitment

Institutions that train graduate students must be committed to establishing and maintaining high-quality training programs that adhere to scientific, humanistic, and ethical professional standards. WFU will work to ensure that students who complete its programs are well-trained and possess the foundational skills and values that will allow them to mature into independent professionals with integrity. WFU's commitment in this regard includes oversight for the length of training, maintenance of scholarly integrity, appropriate financial support, established procedures for addressing grievances, and various professional development-related opportunities. These opportunities can include effective and regular career guidance activities, reasonable access to institutional services, and other matters relevant to the graduate students' education and professional development. Additionally, WFU will strive to recognize and reward its graduate training faculty in support of their education of graduate students.

Program Commitment

The WFU Graduate School endeavors to establish and maintain robust training programs that provide students with the knowledge and career skills needed to function and succeed as independent professionals in their chosen fields. This commitment implies the maintenance of relevant course offerings and appropriate research opportunities. Each program of study in the Graduate School should have clearly defined procedures for the assessment of students and closely monitor students' progress during their courses of study.

Commitment to Outstanding Faculty Mentoring

Effective mentoring is crucial for graduate school trainees preparing for their careers. Faculty mentors should understand that such mentoring requires substantial time and energy to ensure each student's professional and personal development. Furthermore, the mentor must recognize that the relationship's success hinges on mutual trust and respect. Effective mentoring should include teaching the method of inquiry for the specialty, providing regular constructive feedback and constructive criticism to foster professional maturation, teaching the conventions of the field of study, and promoting students' careers by providing appropriate opportunities for independent work and recognition. Effective mentors should strive to facilitate the student's completion of their thesis or dissertation, to help guide the student through the requirements for completion of the degree, and to advise the student to be knowledgeable of and act in accordance with all university policies and procedures.

Graduate student mentors should encourage students seeking a novel approach to achieving personal success. Good mentors should possess and exemplify high ethical standards, competent communication skills, recognize students' contributions in all endeavors, including publications and development of patentable devices or methods, and have a strong commitment to original research and scholarship. Good mentors should work to provide their students with an environment that is intellectually stimulating, emotionally supportive, safe, and free of harassment. Lastly, where appropriate, the mentor should maintain or identify financial support that is appropriate for the program of study and that will allow the student to complete the requirements for the degree.

Commitments of Graduate Students

Effective mentoring is a dynamic relationship between the faculty advisor and the graduate student. As such, in addition to the desired commitments of faculty members, students share an equal responsibility for their educational success as they prepare for their careers. First and foremost, students are primarily responsible for successfully completing their degree. Towards that end, students must dedicate themselves to their scholarship and research, as the faculty mentor advises. This includes pursuing opportunities to develop the necessary skills to succeed in the desired field of study and chosen profession, and when appropriate, taking advantage of the various resources that are made available for personal and professional development. The student must also recognize that the success of the mentoring relationship with their faculty advisor hinges on mutual trust and respect. Like their faculty advisor, students should possess and exemplify high ethical standards, strive to manifest competent communication skills, recognize fellow students' contributions, and have a strong commitment to original research and scholarship. Students should also work to provide themselves, fellow students, staff, and faculty with an intellectually stimulating environment, emotionally supportive, safe and free of harassment. The student is to know and act according to all university policies and procedures. Lastly, where appropriate, the student should work with their mentor to identify financial support that is appropriate for the program of study and that will allow the student to complete the requirements for the degree.

The Honor Code and Code of Conduct

All students in a biomedical graduate program at Wake Forest University are expected to abide by two codes that govern behavior and conduct.

The first of these, the Honor Code, applies to all academic pursuits and all forms of academic endeavor undertaken by any graduate student enrolled on a part-time or full-time basis. The Honor Code applies to, but is not limited to, your actions in:

- Coursework
- Laboratories
- Research, inclusive of capstone projects, theses, or dissertations
- Teaching duties

You are expected to acknowledge your responsibility to adhere to the Honor Code, as well as report suspected infractions, prior to enrollment and annually for as long as you remain enrolled.

The Honor Code, and the process that governs reported violations of it, may be reviewed at: https://prod.wp.cdn.aws.wfu.edu/sites/275/2025/04/Honor-Code-Policy_Approved-4-8-2025.pdf

Members of the Honor Council, to whom any suspected violation can be reported, can be reviewed on our Canvas pages as shown below. Those without access to one of these pages may request a listing of members from Dr. Jennie McGuire (Jennie.McGuire@wakehealth.edu).

All Graduate Students page: https://wfusm.instructure.com/courses/1664

Graduate Faculty page: https://wfusm.instructure.com/courses/2424

The second code that governs biomedical graduate student behavior and conduct is the Non-Academic Code of Conduct. The Graduate School's conduct policy is consistent with the wider Wake Forest University campus community expectations stated in the general student conduct expectations and campus standards found in the Wake Forest Student Code of Conduct available at: https://studentconduct.wfu.edu/undergraduate-student-handbook-2/, and in hard copy at the Office of Dean of Students, 139 Benson University Center. We expect good citizenship and responsible behavior from students. When these expectations are not met, the non-academic misconduct process may be used to redirect students into more acceptable patterns of behavior. This process encourages students to take responsibility for their choices and actions, while also allowing the University to determine an appropriate disciplinary response.

You are expected to acknowledge your responsibility to adhere to the Non-Academic Code of Conduct prior to enrollment and annually for as long as you remain enrolled.

The Graduate School's Non-Academic Code of Conduct policy, and the process that governs reported violations of it, may be reviewed at: https://prod.wp.cdn.aws.wfu.edu/sites/275/2019/12/Graduate-School-of-Arts-and-Sciences-Non-Academic-Code-of-Conduct-11.19.19.pdf

Suspected violations of this policy may be reported to any member of the Honor Council.

Definitions and Policies

Policies applying to all students in School of Medicine-based programs may be reviewed in the Wake Forest University School of Medicine Policy and Compliance Companion (WFUSM) and on the website here.

The Policy and Compliance Companion contains the following policies that apply to biomedical graduate students:

Wake Forest University School of Medicine Policies

- Compliance Requirements
- Compliance Policies for All School of Medicine Students (Title IX)
- Diversity and Inclusion
- Code of Conduct
- Title IX and Non-Title IX Sexual Misconduct Policy and Grievance Procedures (WFUSM)
- Conflict of Interest Related to Student Assessment Policy (WFUSM)
- Student Disability Accommodations Requests Policy and Procedures (WFUSM)
- Student Appeal of Dismissal Policy (WFUSM)
- Anti-Harassment Policy (WFUSM)
- Mistreatment Reporting Policy (WFUSM)
- Student Substance Use Policy (WFUSM)
- Student Health Insurance Requirements and Responsibilities Policy (WFUSM)
- Medical Health Requirements and Immunizations Policy (WFUSM)
- Exposure to Infectious and Environmental Hazards Policy (WFUSM)
- Effects of Infectious Disease or Disability on Student Learning Activities Policy (WFUSM)
- Student Education Records Policy (WFUSM)
- Distance Education Policy (WFUSM)
- Military Leave of Absence Policy (WFUSM)
- Exit Policy (School of Medicine)

Hospital Based Policies

- Information Security Policy (NC/GA Division)
- Enterprise Drug Diversion Policy
- Nepotism and Consensual Relationships Policy (Wake Market)
- Medical Student Documentation in the Medical Record Policy
- Authorship on Scientific and Scholarly Publications Policy (Greater Charlotte Market, Navicent Health, Wake Forest)
- Policy on Research Integrity (Greater Charlotte Market, Navicent Health, Wake Forest)

- Data Ownership Policy
- Acceptable Use Policy (Enterprise)
- HIPAA Privacy and Security Sanctions Policy (Enterprise)
- Infectious Disease Prevention Policy (SE Region)

Financial Aid Policies

- Fees & Expenses
- Tuition Payments
- Financial Assistance
- VA Compliance
- Loans
- Exit Interview
- Forfeit of Scholarship Funds
- Return of Federal Financial Aid Funds Policy (WFUSM)
- Policy on Satisfactory Academic Progress (SAP) for Financial Aid Eligibility
- Student Payment Policy (School of Medicine)
- Refund of Tuitions and Fees Policy (WFUSM)

STUDENT-FOCUSED RESOURCES

- Office of Student Records
- Office of Student Inclusion and Diversity
- Resources for Academic Assistance
- General Resources
- Resources for Personal Assistance
- Student Health Services
- Resources for Off-Campus Education

In addition to the definitions and policies required of all students enrolled in programs administered on the School of Medicine campus, biomedical graduate students are responsible for familiarizing themselves with the definitions and policies that are specific to biomedical graduate students, as outlined below.

ENROLLMENT STATUS

Full-Time Status

A graduate student who devotes full-time effort to a graduate program as outlined by his or her faculty committee and is in full-time geographic residence with a minimum of 9 credit hours in all terms, including, if applicable, thesis research, is considered a full-time student. Students registered as "Student Continuation Fee"

are also reported as full-time students. Half-time status is defined as 4.5 credit hours.

Part-Time Status

A student registered for fewer hours than the amount listed for full-time status, or enrolled in a part-time graduate program, is considered a part-time student. Each graduate program determines whether it is possible to pursue a degree on a part-time basis. All biomedical graduate students enrolled part-time must register for at least one course or three research/project/internship credit hours in fall and spring terms. All biomedical graduate students enrolled for full-time or part-time study are entitled to full privileges regarding libraries and laboratories and may have access to Arts and Sciences campus extra-curricular activities.

Switching Between Full-Time and Part-Time Status

Biomedical graduate students should consult their original offer letter to determine if they were initially enrolled as a full- or part-time student. Biomedical graduate students may request a switch from full-time to part-time status or vice versa. Students should consult their program director about the viability of their desired change in enrollment classification. Once the student has obtained permission to switch from full-time to part-time, or vice versa, the request should be directed to the Director, Biomedical Graduate Programs.

Continuous Enrollment

Degree-seeking students must maintain continuous enrollment through the academic term in which they graduate. Continuous enrollment may be achieved by registering for courses, including research, internship, or project hours, or by registering as Student Continuation Fee as outlined in the previous section under the Full- or Part-time status.

"Student Continuation Fee" Registration

Registration for "Student Continuation Fee" is restricted and requires permission from the Director, Biomedical Graduate Programs. To register as Student Continuation Fee, one condition must be met: 1) the student defends the thesis at a point in time that precludes them from being able to have their degree conferred within the current term; requiring registration in the next term for no reason other than to confer the degree. In such a case, Student Continuation Fee allows a student to continue their relationship with the school, and will be considered continuously enrolled, until their degree can be conferred.

EXTERNAL REMUNERATION

A student supported on a full stipend from their Biomedical Graduate Program, faculty grant, student fellowship, or other sources may be allowed to engage in additional remunerative work with written permission from their research mentor and program

director, provided the work does not delay or interfere with the duties required for timely completion of the degree. A student who receives no support beyond a partial tuition scholarship may engage in outside remunerative work without approval from their Biomedical Graduate Program. All students will be monitored for satisfactory academic progress. Failure to make satisfactory academic progress may result in dismissal from their Biomedical Graduate Program as detailed in the policy on Satisfactory Academic Progress.

INVENTIONS AND PATENTS

During a student's course of study, they may participate in research or other work that leads to an invention or discovery. These inventions or discoveries are the property of the University. The University's Inventions and Patent Policy applies to student inventions with respect to the definition of inventions covered, resolution of disputes, and the division of proceeds, including the determination of the inventor(s)' share of any proceeds. Under this policy, a program exists to determine the patentability and commercial value of each invention. Advice and guidance regarding this policy are available from Wake Forest Innovations.

COPYRIGHT

The Copyright Policy of Wake Forest University is intended to: 1. Encourage research and teaching by rewarding the authors of intellectual works, assisting them in implementing their ideas, and by providing a system for encouraging scholarship and creative activity; 2. Serve the public interest by providing means through which intellectual works may be made available to the public; and 3. Protect the rights of the University, its faculty, its staff, and its students with regard to intellectual works developed at the University.

Procedures

All students are responsible for familiarizing themselves with the portions of this bulletin that pertain to their course of study. Procedures are subject to updates at any time within the student's term of enrollment.

ADMISSIONS

How to Apply

Information on the process of applying to a Wake Forest biomedical graduate program, as well as a link to the online application may be found on the School of Medicine's website at https://school.wakehealth.edu/Education-and-Training/Graduate-Programs/How-to-Apply.

Eligibility

Undergraduate seniors and graduates of accredited U.S. colleges and universities or recognized foreign institutions may apply for admission into a graduate program of study. Undergraduates must complete their degree requirements before entering Graduate School. The Graduate School also accepts applications from holders of the MD, DDS, or DVM degrees, or from candidates for these degrees who will have satisfactorily completed the prescribed medical curriculum before matriculation in the Graduate School.

Whatever their previous academic training, all applicants should have superior records. This requirement is usually interpreted as at least a B average or standing in the upper quarter of the class, or both.

Students with Disabilities

Wake Forest University will consider the application of any qualified student, regardless of disability, based on the selection criteria established by the University, which includes personal and academic merit. Upon matriculation, all students will be required to meet the same standards for graduation.

The University endeavors to provide facilities that comply with all laws and regulations regarding access for individuals with disabilities. Additionally, special services are available to accommodate students with disabilities reasonably. For more information on assistance for graduate students, please contact the Learning Assistance Center at 336-758-5929 or lacds@wfu.edu, or consult their student portal/website at https://lac.wfu.edu to establish an account that allow the student to request an accommodation.

Any graduate student may request disability accommodation provided that the accommodation is reasonable and does not compromise the standards of their graduate program. Accommodation is not approved retroactively, so students are encouraged to request accommodation before or at the beginning of the academic term in which an accommodation is desired. The Graduate School also considers granting other academic

accommodations, e.g., religious accommodations, through the Biomedical Graduate Programs office. Biomedical graduate students should contact the Curriculum & Outcomes Manager to request non-disability, academic accommodation.

Admission Categories

Regular Status in a Degree Program. A person with a superior undergraduate record (at least a B average or upper quarter of the class and with the appropriate courses), TOEFL or IELTS scores (for international students), strong recommendations, and who meets the graduate program's admission criteria, may apply for regular admission.

Provisional Status in a Degree Program. Provisional admission may be granted in certain circumstances and is limited to not more than one term of full-time study or its equivalent in part-time study.

Unclassified Non-Degree Graduate Status. Applicants seeking to enroll in or audit biomedical graduate program coursework for credit, but not wishing to formally seek a graduate degree, may apply to take graduate coursework as an unclassified or non-degree seeking student. Applicants must complete an application, submit the application fee, meet the School of Medicine's onboarding requirements, and submit an official transcript showing a baccalaureate degree at least one month before enrollment. Instructor approval is required for each course before enrollment.

COST OF ATTENDANCE

Detailed Cost of Attendance is available on the School of Medicine's website: http://www.wakehealth.edu/School/Financial-Aid/Graduate/Cost-of-Attendance.htm.

2025-2026 Cost of Attendance	PhD Program (12 months)	MS Program (12 months)	MS Online (12 months)
Tuition	$ 53,950	$ 53,950	$ 35,700
Books	$ 600	$ 600	$ 600
Laptop	$ 1,222	$ 1,222	$ 1,222
Food	$ 5,760	$ 5,760	$ 5,760
Health Insurance	$ 5,029	$ 5,029	$ 5,029
Loan Fees	$ 50	$ 3,565	$ 2,800
Lodging	$ 21,600	$ 21,600	$ 21,600
Miscellaneous	$ 2,304	$ 2,304	$ 2,304
Transportation	$ 5,700	$ 5,700	$ 5,700
Utilities	$ 3,540	$ 3,540	$ 3,540
Total	$ 99,755	$ 103,270	$ 84,255

Fees and Expenses

Tuition is payable at the beginning of each semester. As a requirement for graduation, all students are required to pay full annual tuition for each academic year enrolled in Wake Forest University School of Medicine. Students who do not make tuition payments or satisfactory arrangements with the Student Financials office will not be eligible to continue classes or receive credit for course work.

Breakage deposits are not required but students will be held financially responsible for loss or damage to School of Medicine property.

Cost of attendance includes only those expenses associated with the student. Living expenses for the spouse and/or other dependents are not recognized as part of the student's standard cost of attendance. The cost of attendance, as defined by the school, represents the maximum amount of student financial aid a student can receive.

Statements in the Graduate Bulletin concerning expenses and courses cannot be considered an irrevocable contract between the student and the School of Medicine. The School of Medicine reserves the right to change requirements for graduation, schedules, and costs of instruction at any time during the student's enrollment.

Tuition changes authorized by the Board of Trustees will become effective at the opening of the next session after adoption.

The Office of Financial Aid at Wake Forest University School of Medicine helps students obtain the resources needed to finance their graduate medical education. We also serve as an educational resource for financial planning and debt management. We know that deciding how to manage funding for education requires careful consideration of your options, and we're here to help.

We encourage:

· Prospective students begin the financial planning process early.

· Current students to stay abreast of their financial situation and knowledgeable of all options.

· Alumni to understand available repayment options for their field of medicine, helping them make wise financial decisions to balance student loan debt with financial wellness.

Loans

NCFELS- North Carolina Forgivable Education Loan for Service:	NC FELS (Forgivable Education Loan for Service) is a loan forgiveness program that provides monies to eligible students from North Carolina in exchange for a service obligation once the student has become a licensed practitioner. The service obligation requires recipients to return to NC to work for each year the loan was awarded.
Unsubsidized Federal Direct Stafford Loan	The Unsubsidized Federal Direct Stafford Loan program is a federal student loan program that allows eligible medical students to borrow up to $47,167; the amount is dependent upon length of academic year. Eligible graduate and physician assistant students may borrow up to $20,500. The federal government does not pay interest. The interest rate is a variable/fixed rate. Any interest that accrues during enrollment is capitalized at repayment. Aggregate loan limits are $224,000 minus subsidized loan amounts for medical students and $138,500 minus subsidized loan amounts for physician assistant students and graduate students.
Federal Direct Grad PLUS Loan	Graduate and professional students may borrow through the Federal Direct Grad PLUS loan. Students may borrow up to the cost of education minus other financial aid. A borrower's creditworthiness is a consideration for lender approval. The interest rate is a variable/fixed rate.
Alternative Loan Programs	Alternative loan programs are credit-based loans that may be used to supplement other forms of financial assistance. In general, alternative loans should be considered as a last resort. Not all alternative loan programs are alike. Always consult the Financial Aid Office before applying for an alternative loan.

Exit Interview

Any student who has received financial aid and who ceases enrollment at Wake Forest University School of Medicine for any reason- leave of absence, dismissal, withdrawal, graduation- must have an exit interview within seven days with the Office of Financial Aid. This interview covers "Borrower Rights and Responsibilities" for all student loan programs and is required by law.

Forfeit of Scholarship Funds

Students who are enrolled in a special program and have received scholarships from that program will forfeit those scholarship funds upon withdrawal or dismissal from the program.

Tuition Schedule

Summer Term 2025

- Full-time students (minimum 9 hours) $15,300
- Part-time students (minimum 4.5 hours) $1,700/credit hour

Fall 2025/Spring 2026Terms

- Full-time students (minimum 9 hours) $19,325 per term
- Part-time students (minimum 4.5 hours) $1,700/credit hour

All Terms

- On-line degree program students $1,700/credit hour

Fee Schedule

Application fee	$70
Audit fee	$150/credit hour
Student Continuation Fee (administrative registration)	$150/term
Graduation fee (administrative)	$175/student's final term
Late registration fee	$40/term

Statements concerning expenses are given as information to prospective students. They should not be regarded as forming an irrevocable contract between the student and the university. The costs of instruction and other services outlined here are those in effect on the date this material was printed. Wake Forest University may change the cost of instruction, fee schedule, and other services at any time during the student's term of enrollment.

Tuition Concession

The School of Medicine offers a tuition concession benefit to some Advocate Health enterprise teammates. If the Biomedical Graduate Program Office offers a faculty or staff member a scholarship, that scholarship is designated for tuition and the tuition concession benefit will be applied to net remaining tuition and fees after the tuition scholarship has been applied. For further information, contact the Benefits office.

Tuition for Courses Taken in Arts and Sciences graduate programs

During fall and spring terms, full-time graduate students may, with the permission of the course director, take graduate courses drawn from an Arts and Sciences program without additional tuition. During the summer term, full-time graduate students wishing to take a course drawn from an Arts and Sciences program are charged tuition consistent with Arts and Science's tuition fees.

Student Graduation Fees

All students pay the graduation fee shown in the fee schedule during the term in which the student files an intent to graduate form. This is a non-refundable fee and is charged once per degree.

Past Due Balances

Consistent with the policy on Student Payments, which can be reviewed in the Wake Forest University School of Medicine Policy and Compliance Companion (WFUSM) for students on the School of Medicine campus, a student carrying a past-due balance will be restricted from:

- Registering for future academic terms
- Receiving regalia and participating in the Hooding ceremony
- Returning from leave of absence
- Being reinstated as a student

In addition, a student with a past-due balance may be subject to having their:

- Current course registration cancelled

- Access to parking and facilities eliminated
- Their stipend held, if applicable

A long-standing past due balance will result in administrative withdrawal from the Biomedical Graduate Program. If the university deems it necessary to engage the services of a collection agency or attorney to collect or to settle any dispute in connection with an unpaid balance on a student account, the student will be liable for all attorney's fees, reasonable expenses, and costs incurred.

Students expecting tuition or fee payments from a third party should contact the Bursar to request an invoice to be sent to the third-party source. Students using Veteran's Affairs (VA) education benefits should refer to eligibility and payment requirements at https://school.wakehealth.edu/Education-and-Training/Student-Records/Veteran-Certification.

Tuition Refunds Due to Withdrawal

A student who withdraws from the university during a term or drops a course before completing it may be entitled to a refund. It is important to note that a withdrawal/course drop may affect financial aid eligibility. Graduate students who wish to explore a tuition refund should refer to the Refund of Tuition and Fees Policy, which includes the Schedule of Adjustments for Withdrawal, as found in the Wake Forest University School of Medicine Policy and Compliance Companion (WFUSM) for students on the School of Medicine campus.

A student using scholarships, grants, or loans to help pay educational expenses, whose account was paid in full before withdrawal, is likely to owe the university after withdrawal. Return of Title IV funds are handled in accordance with federal law. Please refer to the Return of Financial Aid Funds Policy. Students should consult the Office of Financial Aid for more information.

Students with VA Educational Benefits

Wake Forest University School of Medicine complies with the requirements of section 3679 of Title 38, U.S. Code.

A student who has been admitted to a Wake Forest University School of Medicine program and who is entitled to educational assistance under chapter 31, Vocational Rehabilitation and Employment, or chapter 33, Post-9/11 GI Bill benefits, is permitted to attend or participate in the course of education without making payment for tuition and fee amounts to be covered by the VA education benefits. Such attendance or participation may begin on the date on which the student provides a VA Certificate of Eligibility and end on the earlier of the following dates:

· The date on which payment from the VA is made to the School of Medicine.

· Ninety (90) days after the date the School of Medicine certified tuition and fees following the receipt of the certificate of eligibility.

Students receiving VA educational benefits will be required to pay the difference between the amount owed on their student account and the amount of the VA education benefit disbursement within 10 days of the start of the term.

Wake Forest University School of Medicine will not impose any penalty, including the assessment of late fees, the denial of access to classes, libraries, or other institutional facilities, or the requirement that a student receiving Chapter 31 or 33 benefits borrow additional funds due to the delayed disbursement of funding from the VA.

Using VA Education Benefits

Questions about eligibility for benefits should be directed to the VA. Apply for benefits: https://www.va.gov/education/how-to-apply

While the application for VA benefits may begin while the student is in the process of applying to a School of Medicine program, students should be admitted to the program before submitting documents to the Office of Student Records.

· Admitted students must receive a Certificate of Eligibility (COE) from the VA outlining the benefits and eligibility period and submit the COE to the Office of Student Records. A screen shot of the eBenefits Web page, or a VAF 28-1905 form for chapter 31 authorization purposes will also be accepted. The COE can be submitted via email to: finaid@wakehealth.edu or delivered in person or mailed to: 475 Vine Street, Winston Salem, NC 27101

· Shortly after receiving the COE, the Office of Student Records will conduct a review of documents needed for the student's VA file. Students will be notified by the Office of Student Records if they are responsible for providing any further documentation.

FINANCIAL AID

Financial support for students may be provided from various sources, including Senior Associate Dean's fellowships, graduate fellowships, and tuition scholarships. In addition, many students are supported as graduate research assistants or associates from externally funded sources, typically from federal grants. Fellowships often include some form of tuition scholarship. Students should consult their offer letter for details on the awards offered.

Satisfactory Academic Progress

The Office of Student Records evaluates the student's satisfactory academic progress at the end of each term to determine continuing financial aid eligibility. Receiving federally controlled aid requires half-time enrollment, defined as 4.5 or more hours in all terms. In addition to the enrollment requirements, a minimum cumulative grade point average of 2.5 is required. Certain programs have higher academic requirements, which are communicated directly to students by their graduate program. The Senior Associate Dean may revoke institutionally controlled financial aid for violating

university regulations, including its Honor Code or Non-Academic Code of Conduct policies, or for violating federal, state, or local laws. For additional information, students may review the Policy on Satisfactory Academic Progress for Financial Aid Eligibility in the Wake Forest University School of Medicine Policy and Compliance Companion (WFUSM) for students on the School of Medicine campus.

Should a student fail to meet the requirements described in the policy statement, the Biomedical Graduate Program Office will notify the student in writing of their status.

Graduation At-Risk Status

Any graduate student who, at the end of a term, has a GPA between 2.5 and 3.0 will receive a letter from the Biomedical Graduate Program Office specifying that they will need to take additional graded coursework to raise their GPA to the minimum requirement for graduation. At-risk status does not confer any change in federal financial aid eligibility.

Academic Probation

Any student who, at the end of an academic term, is not making satisfactory progress, either through a) the graduate program's satisfactory academic progress definitions, b) an assignment of an Unsatisfactory grade in a Research, Capstone Project, or Internship course, or c) a cumulative GPA below 2.5, will receive a letter from the Biomedical Graduate Program Office that specifies that they are on academic probation, the reason for the probation, and the requirements to restore themselves to satisfactory academic standing. Students on academic probation are placed on financial aid warning for one term and remain eligible to receive federal aid during that term. If the student has not re-established satisfactory academic standing at the end of the probationary term, the student will become ineligible for federal financial aid and may be dismissed or withdrawn from their Biomedical Graduate Program.

Appeal to Financial Aid Ineligibility Status

The Senior Associate Dean may grant a one-term probationary reinstatement of financial aid to any student who can demonstrate extenuating circumstances and appropriate documentation of those circumstances. The student is re-evaluated for satisfactory academic progress at the end of the term.

Student Loans

Graduate students may contact the Office of Financial Aid for information on federal student loans by phone: 336-716-4264; email: finaid@wakehealth.edu; or in-person at the Bowman Gray Center for Medical Education, 1st floor, Enrollment Services, Monday-Friday, 7:30 AM - 4:30 PM.

The financial aid team contacts all students annually to remind them to complete a Free Application for Federal Student Aid (FAFSA). Students must complete a FAFSA to apply for financial aid and should use the school code E00524. The team also maintains a Canvas resource that includes an orientation to provided services and a set of useful links to financial resources.

A student must be enrolled more than half-time in each term and be in good academic standing/making satisfactory academic progress toward the degree to be eligible for a student loan. Unclassified (non-degree seeking), certificate program students, and provisionally accepted students are not eligible for federal financial aid.

Graduate School Scholarship Awards

A limited number of merit-based scholarships are available for highly qualified students. Any student interested in the awards below should contact their program director for additional information.

- *Gordon A. Melson Outstanding Doctoral and Master's Student Awards* provide a cash award to the students selected as being most outstanding in research, productivity, and quality in the PhD and MS programs at the time of commencement each year. Other factors that are considered are academic record, activity in the discipline, and university and departmental citizenship.
- *The Louis Argenta Physician-Scientists Scholar Award Scholarship* seeks to develop leaders in translational science by providing funds to support MD/PhD students during their research years. The new calling for the physician-scientist is to lead these diverse teams. This scholarship will be awarded to MD/PhD students who have outstanding interpersonal skills, superior communication, and the potential to develop into a leader in translational science.
- *The Norman M. Sulkin Scholarship Fund* provides scholarship assistance to a student conducting research in neurobiology and anatomy.
- *The Camillo Artom Scholarship* provides annual scholarship grants to one or more students enrolled in programs leading to the MD or PhD degrees, with special preference given to biochemistry and molecular biology students.
- *Herbert C. Cheung PhD Award* provides a cash award to recognize an outstanding graduate student in the Department of Biochemistry and to promote excellence in research in the broad field of biochemistry.
- *The Sandy Lee Cowgill Memorial Scholarship Fund* provides scholarships to at least two students, the first of whom shall be enrolled in the MD program and the second of whom may be enrolled in the MD or PhD program, with preference given to a student in biochemistry and molecular biology.
- *The Mike and Lucy Robbins Fellowship Fund* provides a stipend for a current graduate student conducting cancer-related research.
- *The David K Sundberg Award* provides a cash award to recognize a PhD student with outstanding academic proficiency and professionalism, as well as exemplary character as a citizen and colleague in the Department of Translational Neuroscience.

ACADEMIC & COURSEWORK PRACTICES

Statement on Student Rights and Responsibilities

The graduate faculty has adopted formal statements regarding student rights and responsibilities and a statement of philosophy on the mentoring relationship between graduate students and mentors. Both statements serve as guidelines to be used by students and graduate faculty about respectful and supportive interactions and expectations that extend to conduct in teaching, learning, and research endeavors. These statements may be reviewed in full elsewhere in the Graduate Bulletin.

Honor Code & Non-Academic Code of Conduct

The graduate faculty has adopted a formal Honor Code and a Non-Academic Code of Conduct policy to guide student conduct concerning academic and non-academic pursuits. These policy statements are available in elsewhere in the Graduate Bulletin.

Grievance Procedures

Faculty are appointed as liaisons on both campuses to serve as resources to faculty and students seeking to file a grievance. Graduate students interested in filing a grievance are encouraged to speak with the chair(s) of the Graduate Student Association or another of its officers to seek advice regarding the grievance procedure. The name and e-mail address for the faculty liaisons and GSA co-chairs may be obtained from the Biomedical Graduate Program Office or the All Biomedical Graduate Student Canvas Resource page.

Non-Academic Grievance Procedures

If a student wishes to file a non-academic grievance, i.e., mistreatment in the form of discrimination (on the basis of sex, sexual orientation, gender identity, and gender expression), harassment, physical harm/violence, or general misconduct or unprofessional behavior, these matters should be referred to the Learning Environment Liaison in the School of Medicine's Compliance office. The Learning Environment Liaison will help ensure that other appropriate parties, e.g., Employee Relations or the Title IX office, are appropriately engaged or notified. Students who have experienced gender-based or sexual misconduct may report that misconduct directly to the Title IX office.

Academic Grievance Procedures

1. Initial Response to Perceived Academic Grievance: Situations may arise in which a student believes that he or she has not received fair treatment from a faculty member in an academic matter. In such cases, within two weeks of the student's awareness of the treatment he or she should talk with the faculty member. If the student and faculty member cannot resolve the problem, the student should consult his or her advisor, and their Program Director. If a resolution satisfactory to both parties cannot be reached in a reasonable time, which can vary according to the complexity of the matter, the student may choose to initiate the Graduate

Student Academic Grievance Procedure. The procedure must be initiated no later than three months after failure to achieve resolution within the program. Failure to initiate the procedure within three months forfeits the student's right to file a grievance with the Graduate School.

2. Liaisons for Student Grievances: The student should first contact either of the two WFU graduate faculty members, one from the School of Medicine Campus and one from the Arts and Sciences Campus, who serve as liaisons for graduate students wishing to file a grievance. The faculty liaisons, who serve a three-year term, are appointed by the Senior Associate Dean of the Graduate School from two candidates from each campus nominated by the Graduate Student Association. They serve as counsel for the student and are available to advise the student concerning academic problems and grievances and help the student initiate and continue the grievance procedure. At the student's request, a faculty liaison may be present during any hearings by the Grievance Committee to monitor the proceedings and ensure fair treatment of the student. Graduate students interested in filing a grievance are also encouraged to speak with the chair(s) of the Graduate Student Association or other officers of the association to seek advice regarding the grievance procedure. Names and email addresses of the faculty liaisons and GSA co-chairs can be obtained from the Biomedical Graduate Program Office.
3. Written Petition: After consulting a Faculty Liaison, the student should submit a written petition to the Senior Associate Dean of the Biomedical Graduate Programs requesting initiation of the Graduate Student Academic Grievance Procedure. The petition must include the name of the faculty member against whom the grievance is filed, the specific charge, information about the grievance, and the action or relief requested by the student. If appropriate, documentary material may be submitted in support of the grievance, although such material may be reserved until requested by the Chair of the Grievance Committee. When the grievance is submitted, the Senior Associate Dean of the Biomedical Graduate Programs shall confer with the student to ensure that the student has spoken with the faculty member involved, gone through the program's grievance procedure, and contacted a Faculty Liaison.
4. Grievance Committee: Upon receiving a grievance petition, the Senior Associate Dean of the Biomedical Graduate Programs shall appoint a five-member Grievance Committee composed as follows: a Chair who is a member of the Graduate Council; two faculty members from the graduate faculty at large; and two graduate students selected from a list provided by the Graduate Student Association. Both the student filing the grievance and the faculty member against whom it is filed shall be informed of the names of all members of the Grievance Committee. In appointing members of the Grievance Committee, the Senior Associate Dean of the Biomedical Graduate Programs will ensure that no conflict of interest will occur. A new committee shall be appointed for each grievance.
5. Grievance Procedure: The Senior Associate Dean of the Biomedical Graduate Programs will forward copies of the grievance petition to the Grievance

Committee, the Faculty Liaison with whom the student has consulted, and the faculty member against whom the grievance is filed. The faculty member will then have fourteen days to respond in writing to the grievance. This response will be returned to the Senior Associate Dean of the Biomedical Graduate Programs, who will forward copies to the Grievance Committee, the Faculty Liaison, and the student filing the grievance. Within fourteen days of receiving the faculty member's response to the grievance, the Chair shall convene the Grievance Committee to review the charges, to determine if more information and documentation are needed, and to plan and schedule the Grievance Hearing. The Hearing shall be scheduled for no sooner than fourteen days but no later than twenty-eight days after the initial committee meeting. The Chair of the Grievance Committee shall ask the parties involved to submit any further documentation to the Biomedical Graduate Programs Office. In addition, each party will submit a list of witnesses who will appear at the Hearing supporting their position, with a one-sentence summary of the information each witness will present. All documentation and the list of witnesses must be submitted at least seven school days before the scheduled Hearing. After that time, no additional material or witnesses may be introduced or presented, unless of a compelling nature relevant to either the student or faculty member. In such cases, the Chair of the Grievance Committee may allow additional material or witnesses. The Biomedical Graduate Programs Office shall ensure that each committee member and both parties involved receive copies of all material and a list of witnesses at least five school days before the scheduled Hearing, and immediately if additional material or witnesses are allowed.

6. Grievance Hearing: The Chair shall preside over the Grievance Hearing and will vote only to break tie votes of the Grievance Committee. All voting shall be done by secret written ballot. All proceedings during the Hearing shall be recorded on equipment provided by the Biomedical Graduate Programs Office. At all times during the Hearing, the student may have the Faculty Liaison present, and legal counsel or another representative may represent both parties.
   The purpose of the Hearing is to obtain information that the Grievance Committee can use to make a final evaluation and recommendation to the Senior Associate Dean of the Biomedical Graduate Programs. The Chair of the Grievance Committee shall always maintain a civil, reasonable atmosphere. The Hearing shall proceed in the following manner. First, the student who filed the grievance, or a representative, will be allowed to discuss the grievance and to review the documentation submitted by both parties, including the response by the faculty member to the grievance. The faculty member, or representative, will then have the opportunity to ask the student questions, after which any or all members of the Grievance Committee may ask questions. The student may then present witnesses, who can be asked questions by the faculty member and the Grievance Committee. When the student has presented all of his or her material and witnesses, the faculty member, or representative, will be allowed to discuss the grievance and to review the documentation submitted by both parties, including

the original grievance petition. The student, or representative, may then ask questions, followed by questions from the Grievance Committee. The faculty member may then present witnesses, who can be asked questions by the student and the Grievance Committee. The Chair of the Grievance Committee may allow reasonable variations of this general procedure. During the Hearing, witnesses will be present only while they are giving information to the Hearing and being asked questions. They will wait outside the hearing room until called by the Grievance Committee and leave the Hearing after they have spoken. If at any time during the Hearing either side, in the opinion of the Chair, in any way violates civil, reasonable conduct, the Chair may recess the Hearing for ten minutes. If such behavior continues, the Chair may postpone the Hearing for a maximum of one week. After both sides have presented all material and witnesses, the faculty member and then the student, or their representatives, may make a concluding summary statement, touching on all matters they consider relevant to the grievance as filed. Following the student's summary statement, the Hearing will adjourn, and the Grievance Committee shall deliberate.
The Grievance Procedure may be stopped at any time upon request of the student to withdraw the grievance. Once withdrawn, that grievance cannot be reactivated. The grievance procedure may be postponed only if either party has an emergency that prevents them from preparing for or appearing at a Hearing. The party with the emergency must notify the Chair of the Grievance Committee, with documentation of the nature of the emergency, as soon as possible, and the Chair will determine if a postponement is justified.

7. Recommendation to the Senior Associate Dean of the Biomedical Graduate Programs: Within three days after completion of the Grievance Hearing, the Grievance Committee will make a recommendation which will be sent in writing to both parties and the Senior Associate Dean of the Biomedical Graduate Programs.
8. Decision by the Senior Associate Dean of the Biomedical Graduate Programs: From the time the recommendation is received by the involved parties and the Senior Associate Dean of the Biomedical Graduate Programs, either party will have five days to appeal to the Senior Associate Dean of the Biomedical Graduate Programs, in writing, the recommendation of the Grievance Committee. Within two weeks after receiving the recommendation, the Senior Associate Dean of the Biomedical Graduate Programs will decide and provide a written explanation of the reasons for the decision to the Chair of the Grievance Committee and the parties involved. The Senior Associate Dean of the Biomedical Graduate Programs will also convey the decision to the Program Director involved. The decision of the Senior Associate Dean of the Biomedical Graduate Programs is final.
9. Records: All material related to the Grievance Hearing, including tapes of all sessions, shall be placed in a confidential file in the Biomedical Graduate Programs Office for two years. After that time, all material except the written

decision of the Senior Associate Dean of the Biomedical Graduate Programs shall be destroyed.

10. Flow Chart: A chart that summarizes the Graduate Student Academic Grievance Procedure may be found in the Canvas All Graduate Student Resource page.

REGISTRATION PRACTICES

Term Registration

Late Registration. A continuing student who fails to register for any courses by the first day of classes will be charged a late registration fee.

Course Registration

Repeating a Course. A graduate student may repeat a course in which a B- or lower grade has been received. The course may be counted only once for credit. The higher grade earned will be factored into the grade point average calculation. Both grades will appear on the transcript, but it will be noted which grade is included in the GPA calculation. In addition, federal financial aid rules dictate that federal aid can only be used twice for the same graded course.

Dropping a Course. During the Add/Drop period, a student may drop a course without penalty or notation on the transcript. After the Add/Drop period, a student may drop a course with the approval of the Senior Associate Dean or Director of the Biomedical Graduate Programs Office, with the agreement of the course director. The student is assigned a Drop (DRP). Courses marked Drop are not counted in determining the grade point average. Students should reach out to Student Records to request a course drop. Students are responsible for officially dropping courses to be eligible for a tuition refund. Nonpayment for classes for which a student is registered or non-attendance in a registered class does not release the student from financial obligation, nor does it result in a withdrawal from the course.

Auditing a Course. Auditing a course consists of participating without receiving a letter grade or credit hours. When space is available after registration of students enrolled for credit, others may request permission from the course director to enter the course as auditors. In no case may anyone register to audit a course before the first meeting of the class. No additional charge is made to full-time students in the Biomedical Graduate Programs; for unclassified or non-degree seeking students, an audit fee is assessed. An auditor is subject to attendance regulations and to other performance requirements established by the course director. Although an auditor receives no credit, a notation of audit is made on the final grade report and entered on the record of enrolled students who have met the course director's requirements.

Registering for a Course Offered by an Arts and Sciences Graduate Program. Graduate students are permitted to take graduate coursework offered by Arts and Sciences graduate programs for no additional tuition fee in fall and spring terms. To register, the student must contact the course director for the Arts and Sciences program course and request a seat in the course. Once the student has obtained permission, the student should contact student records. Student records will ensure that registration is completed on behalf of the student and that the course and grade will appear on the transcript. Registration for summer term courses may be possible; however, there is an additional tuition fee that will be due from the student. Registration in undergraduate

coursework on the Arts and Sciences campus may also result in an additional tuition fee due to the university.

Transfer of Credit. Transfer of graduate credits earned at other universities. A course that was completed at another college or university may be considered for transfer by a Master's program within a Biomedical Graduate Program, provided that: a) the course was taken at an accredited institution in the United States; b) the course is classified as a graduate course; c) the course was not taken as part of a previous earned degree at another institution; d) the grade in the course is B (or the equivalent thereof as determined by the Biomedical Graduate Programs Office) or better. The maximum number of hours that may be transferred toward a Master's degree within a Biomedical Graduate Program from another college or university may not exceed one-third of the total credits required by the program. Transfer of courses from another college or university for PhD degree candidates is held to the same standards for transfer credits but is not limited in terms of the count of credit hours. International students wishing to transfer credits are responsible for having their transcript evaluated by a translation service, *e.g.*, World Educational Services (WES), and are to have the evaluation sent directly to Student Records.

Transfer of graduate credits earned while enrolled in a previous graduate degree program at Wake Forest University. A graduate course that was completed while the student was enrolled previously in another graduate or professional program at Wake Forest University may be considered for transfer by a program within a Biomedical Graduate Program, provided that the course was not counted toward the first degree and a grade of B (or the equivalent thereof as determined by the Biomedical Graduate Programs Office) or better was earned. The maximum number of hours that may be transferred to a Master's degree within a Biomedical Graduate Program from a different program within the University may not exceed two-thirds of the total credit hour requirement of the accepting program.

Students seeking to follow their mentor and enroll at Wake Forest. A student seeking to follow their mentor from another institution and enroll in a Biomedical Graduate Program must apply to that Biomedical Graduate Program using standard application processes. The student may be accepted as a Wake Forest student, and credits may be transferred if the criteria described for the Transfer of Credits Earned at Other Universities are met, and if the student has not yet advanced to candidacy. A student who has advanced to candidacy before following their mentor to Wake Forest should remain a student at their current institution.

Grading Practices

Records of progress are kept by the institution for all students enrolled. Grade reports are furnished to students at the end of each term.

Grade of I. The grade of I (Incomplete) may be assigned only when a student fails to complete the work of a course because of illness or some other emergency. If the work recorded as I is not completed within thirty days after the beginning of the student's

next enrolled term, the grade automatically becomes F or Unsatisfactory. The instructor must report the final grade to the registrar within forty-five days after the student's next enrolled term begins. In no case is a graduate degree awarded to a student who has an I on record. Incomplete grade forms are available from the Biomedical Graduate Programs Office.

Grade of NR. The grade of NR (Not Reported) must be resolved within forty-five days after the beginning of the student's next enrolled term, or the grade automatically becomes F or Unsatisfactory. In no case is a graduate degree awarded to a student who has an NR on record.

Grade of U (Unsatisfactory) in Thesis/Dissertation Research/Capstone Project/Internship. A student who receives a U in one of these courses may be placed on academic probation even if the student's cumulative GPA is above 2.5. A student who receives a grade of U in one of these courses in two terms may be dismissed from their Biomedical Graduate Program by the Senior Associate Dean upon recommendation of the program.

Minimum Grade Requirements. A student whose cumulative grade point average (GPA) falls below 2.5, or below the biomedical graduate program's GPA standard, may be placed on academic probation. The student will have one academic term to bring his/her GPA to 2.5 or greater; otherwise, the student may be dismissed from their Biomedical Graduate Program by the Senior Associate Dean upon the program's recommendation. The grade point average is obtained by dividing the total number of grade points earned by the total number of hours attempted for a grade, including hours for courses in which the grade is F. Satisfactory/unsatisfactory grades do not factor into the GPA calculation.

Grades Assigned		Grade Points
A	Excellent	4.00
A-		3.67
B+		3.33
B	Good	3.00
B-		2.67
C+		2.33
C	Low Pass	2.00
F	Failed (counted as hours attempted)	
I	Incomplete (becomes passing grade, F, or U)	
S	Satisfactory	
U	Unsatisfactory	
AUD	Audit	
DRP	Official Drop (not counted as hours attempted)	

NC	No credit
NR	Grade not reported (becomes passing grade, F, or U)
RPT	Course repeated (see repeating a course)
WD	Withdrew (not counted as hours attempted)
WP	Withdrew passing (not counted as hours attempted)
WF	Withdrew failing (not counted as hours attempted)

Individual programs may require a higher grade point average than 2.5 for ongoing enrollment. If there is such a requirement, it is stated in the program's policies. A student may be dismissed from their Biomedical Graduate Program by the Senior Associate Dean upon recommendation of the program if the student fails to make satisfactory progress. Satisfactory progress is determined by the program standards in which the student is enrolled.

The minimum grade point average required for graduation is 3.0. PhD candidates must have a grade point average of 3.0 in graduate courses at the time of the preliminary examination. A 3.0 grade point average is also required to earn a graduate certificate.

Changes in Status

Leave of Absence. A leave of absence allows a student enrolled in the Wake Forest University Graduate School of Arts and Sciences to interrupt his or her studies for a compelling reason, for example, a medical condition or a personal or family matter requiring absence from campus. A leave of absence is defined as a temporary separation from Graduate School. To be eligible for a leave of absence, students should be in good academic standing, fulfilling research, service, and course obligations.

Students who intend to take a leave of absence must submit a Request for a Leave of Absence form to the School of Medicine's Compliance Office, which is advisory to the Biomedical Senior Associate Dean and ensures that the policy is followed. A letter of support may be provided to the Senior Associate Dean, co-signed by the student's graduate program director and advisor. This letter must indicate all unsatisfied degree requirements for the student. Other supporting letters should be included in the request for a Leave of Absence if available.

Until students are notified by the Office of Education Institutional Effectiveness and Compliance that the leave has been approved, they remain registered and are expected to fulfill their responsibilities. A Leave of Absence will not be granted retroactively. The maximum time for a leave of absence is one year. The effective date of a Leave of Absence might consider a reasonable time to arrange for the suspension or completion of ongoing experiments and projects, as well as proper withdrawal from courses.

Students on leave of absence should submit a request to return to the School of Medicine's Office of Education Institutional Effectiveness and Compliance at least one month before the first date of the term in which a return is planned. This request may

require a letter that addresses the suitability of the student's return. Students who have decided not to return from a leave of absence should inform the Office of Education Institutional Effectiveness and Compliance in writing. Students who fail to petition to return after a leave of absence will be withdrawn from their program and the school and will need to apply for readmission to return.

Unless allowed by the external funding agency or source supporting the student's stipend, a student may not qualify for stipend support during a Leave of Absence. In all cases, the guidelines provided by the supporting agency will apply. Since these guidelines may vary from one agency to another, students are encouraged to consult agency program officials to determine the agency-specific guidelines governing leaves of absence. If internal funds support the student's stipend, the Senior Associate Dean might be able to provide limited stipend support during a Leave of Absence.

If applicable, tuition is refunded on a prorated basis, and the refund schedule is set by the Wake Forest University Board of Trustees.

Approved leaves of absence automatically extend milestone deadlines by the length of the leave. This includes university and program requirements such as the qualifying exam deadline and prospectus deadline for PhD students, and the degree deadline for Master's and PhD students. Leaves of absence do not exempt students from meeting the residency requirement or other Graduate School degree requirements.

Students on a leave of absence may not fulfill any degree requirements during their leave. If a student plans to be away from the University to work on a thesis, dissertation, or other degree requirements, this does not constitute a leave of absence and requires enrollment.

A student on a leave of absence will have limited access to university facilities normally available to enrolled students. To facilitate communication between the student and the Graduate School, access to the campus network will be continued during the leave, but will be deactivated if the student does not return. Library access will be continued during the leave period but will be revoked if the student does not return. Badge access will be deactivated during the leave period.

Students who are granted a Leave of Absence must consult with their health insurance provider about their policy status while on leave. Students who have contracted for health insurance through the university should immediately contact the Bursar. Health insurance is subject to federal and state laws and regulations.

International students who are granted a Leave of Absence must notify the Center for Immigration Services and Support. Visa status is subject to federal laws and regulations.

Students on an approved leave of absence are not eligible for federal financial aid, including Federal Direct Loans. In some cases, student loans may not be deferred for the entirety of a leave. Students should contact the Office for Financial Aid for additional information.

Transferring to a Different Program. A student who wishes to transfer from one program to another is allowed to do so, provided the standards of the new program are met. The student should contact the program director of the program to which the student wishes to transfer. After consultation with the program director, the student should interview with one or more prospective advisors. If a prospective advisor is identified, the student's transfer request may be considered further.

Upon receipt of a written request from the student, the Biomedical Graduate Programs Office will forward credentials from the student's file to the program director for evaluation and consideration of financial aid. After this process, the program director sends a transfer recommendation to the Senior Associate Dean of the Biomedical Graduate Programs for approval. The student is not required to withdraw from an existing program until the transfer request to the new program has been approved.

It is understood that the program from which the student is transferring would have no further financial responsibility for the student. The student must, however, complete the formal process of withdrawing from the original program by the end of the current term.

Accommodation for Students of Faculty Who Leave the Institution. If a student has advanced to candidacy, and their faculty advisor leaves the institution before completion of the degree by his or her student(s), the Dissertation Committee (or Program Director) is responsible for recommending an appropriate plan for the completion of the degree. The plan should address the following: support of stipend and research funding (including lab space), designation of a primary mentor, and designation of a manager to carry out the plan. This plan must be submitted within six weeks of the faculty member's resignation and approved by the Senior Associate Dean.

If a student has advanced to candidacy and chooses to leave the institution with their faculty advisor, the student will be required to continue to register in each term for the remainder of their course of study.

In the case where a student has not yet advanced to candidacy and chooses to leave the institution with their faculty advisor, the student will be required to transfer to the new institution.

Withdrawal from the University. Students who wish to withdraw from their Biomedical Graduate Program must complete the appropriate form, which requires approval from the program and the Senior Associate Dean of the Biomedical Graduate Programs. Students who leave without following this procedure will receive a grade of F, or U if appropriate, in each course in progress. If issued by the institution, students are required to return their laptop computers to the Academic Computing office. During the academic year, all full- and part-time students receive tuition refunds according to the stated schedule. This policy applies to students dropping courses as well as to those withdrawing. Withdrawals must be official, and students must return all institutional materials (badges, keys, etc.) before claiming refunds. Graduate students receiving Title

IV federal financial aid should refer to the Return of Financial Aid Funds Policy in the Wake Forest University School of Medicine Policy and Compliance Companion (WFUSM).

A student who withdraws by the drop date for the term, as established by the academic calendar, will not have a grade recorded for courses in progress. A student who withdraws after the drop date will be assigned a grade of withdraw-passing or withdraw-failing for each course in progress. The withdrawal date for a student enrolled in an on-line program will be determined by the last time the student participated in an online discussion or contacted a faculty member. Simply logging in to a course is not determinative of participation in the course.

Reinstatement. A student who has withdrawn from their Biomedical Graduate Program and wishes to return within one academic year must request reinstatement in writing to the Senior Associate Dean of the Biomedical Graduate Programs at least one month before the term in which they wish to re-enter. To be reinstated, the student must be in good academic standing and receive approval from the graduate program and the Senior Associate Dean of the Biomedical Graduate Programs. The time spent during an approved leave or while withdrawn will not count towards the maximum time allotted for the degree. Students who have withdrawn from their Biomedical Graduate Program and wish to re-enter after one academic year must reapply for admission as stated in the Graduate Bulletin by the application deadline. They must be recommended by the program and accepted by the Senior Associate Dean of the Biomedical Graduate Programs.

If a student is approved for readmission to their Biomedical Graduate Program within five years, previous coursework may count towards the degree requirements at the discretion of the Senior Associate Dean of the Biomedical Graduate Programs on the recommendation of the program. If the student re-enters their Biomedical Graduate Program after a five-year period, previous courses will not count toward the degree requirements.

Dismissal. A student failing to make satisfactory academic progress, determined based on the GPA, multiple Unsatisfactory grades, or as determined by the program, may be dismissed from their Biomedical Graduate Program.

STUDENT WELLNESS

Health Services

Students in a graduate program administered by the Biomedical Graduate Programs office must have adequate and applicable hospitalization insurance. Any charges generated that are not covered by the student's insurance policy will be the student's personal responsibility. Students eligible to continue coverage under a parent's or spouse's policy may do so. Alternatively, the School of Medicine offers an affordable student health plan. The cost of this insurance is billed to the student twice a year, with charges routed through the student account. Students must waive out or enroll in the plan during open enrollment periods. Notifications of open enrollment periods are sent by the Bursar to the student's institutional email address. Students who fail to waive or enroll will be automatically enrolled in the plan and will be responsible for all premium costs.

Additional Insurance. Optional dental and vision insurance is offered to all students. Premiums for dental and vision are paid annually and have a single open enrollment period each year. Unlike the student health plan, students are not automatically enrolled in dental or vision coverage if they fail to waive during the open enrollment period.

Before matriculation, each student is required to comply with the Medical Health Requirements and Student Immunization Policy, available in the Wake Forest University School of Medicine Policy and Compliance Companion (WFUSM). The student may visit the Student & Teammate Health clinic within 2 weeks of their orientation date and receive required immunizations or tests at no cost. The student is responsible for all costs required to meet matriculation (and continuing/renewal) requirements if obtained outside of Teammate Health.

Immunizations. Wake Forest University and North Carolina State law require that all new, transfer, readmitted, unclassified, or visiting students, except those in distance education, or those with a valid exemption, submit certification of certain immunizations prior to matriculation. Documentation should be submitted through an online data portal that is provided to students during the pre-enrollment period. All documentation must be received by the term's orientation day. Acceptable documentation is (1) the signature of the appropriate official(s) having custody of the immunization records, such as a physician or county health department official, or (2) a certificate from the student's former school containing the approved dates of immunizations, or (3) photocopies of the original records. Teammate Health is responsible for monitoring compliance with the immunization requirements.

The North Carolina requirements must be documented within thirty days following enrollment. After that time, students not compliant with required immunizations cannot attend classes until their immunizations are documented. Please note that the Hepatitis B series requires several months to complete.

Questions regarding these requirements should be directed to Teammate Health at 336-716-4801.

In addition, students accepted to programs of study that are conducted on-campus are required to complete a criminal background check and may be subject to random drug screening before enrollment. If selected, random drug screenings are conducted during orientation day activities.

Counseling Services

Counseling & Well-being Services (CAWS) is located on the 1st floor of the Bowman Gray Center for Medical Education (Building 60N), Room 1213. Paige Bentley, PhD, MAEd., LPC-S, RYT is the Director of Counseling & Well-being Services. The office provides counseling and consultation and oversees well-being activities for currently enrolled biomedical graduate students. All counseling and consultation services are confidential and are free of charge to students.

Counseling & Well-being Services offers counseling for a variety of concerns, including depression, anxiety, personal adjustment, disordered eating, managing stress, school/life balance, sexuality, and relationship issues.

Well-being activities include activities such as yoga, mindfulness meditation, fitness, dancing, and facilitated discussions related to helping students manage the demands of graduate school.

Appointments are available to students from 8 am - 5 pm, Monday-Friday. Well-being activities will be posted on the Counseling & Well-being Website Calendar. Although CWS is not a 24/7 crisis center, arrangements can be made for emergent, urgent situations. To make an appointment for counseling, please email counselingservices@wakehealth.edu. If you do not hear back from one of the counselors within two days of requesting an appointment, please contact Dr. Paige Bentley directly at pbentley@wakehealth.edu.

Requirements for Degrees

Degrees Offered

The Graduate School of Arts and Sciences offers graduate programs leading to the Master of Arts (MA), Master of Arts in Education (MAEd), Master of Arts in Human Services (MAHS), Master of Fine Arts (MFA), Master of Science (MS), and Doctor of Philosophy (PhD) degrees. On the School of Medicine campus, the Biomedical Graduate Programs Office offers the MS and PhD degrees in select programs of study. For information on the requirements for all other graduate degrees (MA, MAEd, MAHS, MFA), please consult the Graduate Bulletin maintained and administered through the Arts and Sciences Graduate Office.

The following pages contain information on the degree requirements for the MS and PhD degrees only.

Thesis/Dissertation Committee Composition & Review Guidelines

For Master's degrees: When required by the program, a thesis is written under the supervision of the student's advisory committee. The thesis committee must have no fewer than three members, including:

- The student's advisor
- A second member from within the student's graduate program - co-advisors may occupy this place on the committee
- A third member from outside a) the advisor's academic department or b) the student's area of concentration who serves as the chair and represents the Graduate Council

For the PhD degree: The examining committee for the dissertation must have no fewer than five members, including:

- The program director, or a faculty member appointed by the program director
- The student's advisor
- A third member from within the student's graduate program - co-advisors may occupy this place on the committee
- A fourth member from a related area - this member may be drawn from inside or outside of the student's program
- A fifth member from outside a) the advisor's academic department or b) the student's area of focus who serves as the chair and represents the Graduate Council

For all degrees: All members of the student's advisory or examining committee must be graduate faculty members. With the approval of his or her advisor, a student may recommend a person not on the graduate faculty to serve on the examining committee as a voting member; however, the committee must have a minimum of two members from the graduate faculty. The thesis advisor must justify the participation of this person based on research, publications, and/or professional activities in a letter to the Senior Associate Dean of the Biomedical Graduate Programs requesting approval. Confirming the committee and its members rests with the Senior Associate Dean of the Biomedical Graduate Programs.

Final Examination Assessment

Requirements for thesis submission and format are posted in the student's Canvas program page in the Defense and Ballot Module. The examination verifies the work stated in the thesis and knowledge in related areas. The possible committee decision is unconditional pass, pass upon rectifying minor deficiencies, pass upon rectifying major deficiencies, and fail. If a student fails, the student may be reexamined only once. The defense must occur by the stated graduation deadlines on the academic calendar, or the student will be required to register for a subsequent term to have their degree conferred.

Unconditional Pass

If all committee members agree that the student has passed unconditionally, there is consensus to pass the examination. The committee chair will sign the ballot, submit the ballot to the Biomedical Graduate Programs Office, and the student shall be recommended for the award of the degree.

Pass Upon Rectifying Minor Deficiencies

If minor reservations are expressed by committee members, for example, correction of typographical, grammatical, or spelling errors, the chair of the committee will ensure that the reservations are communicated to the student and the Senior Associate Dean of the Biomedical Graduate Programs by signing and submitting the ballot to the Biomedical Graduate Programs Office. The student and the advisor are jointly responsible for ensuring that the thesis is modified to address the committee's reservations. Once the thesis has been modified, the student passes the examination, and the student will be recommended for an award of the degree.

Pass Upon Rectifying Major Deficiencies

If major reservations are expressed by committee members, for example, new data collection is required for an acceptable work, the chair of the committee will ensure that the reservations are communicated to the student and the Senior Associate Dean of the Biomedical Graduate Programs by signing and submitting the ballot to the Biomedical Graduate Programs Office. The student and the advisor are jointly responsible for ensuring that the thesis is modified to address the committee's reservations. Once the thesis has been modified, the student passes the examination, and the student will be recommended for an award of the degree.

Fail

If, in the opinion of more than one member of the thesis committee, the student has failed the examination, there is no consensus to pass. The committee chair will advise the student that the thesis fails to meet the requirements of the Biomedical Graduate Programs. The chair will ensure that the student knows the reason(s) for failure and will submit the ballot to the Biomedical Graduate Programs Office. If the student resubmits or submits a new thesis for consideration by their Biomedical Graduate Program, at least three members for the thesis will be drawn from the original committee. If the modified or new thesis fails to meet the requirements of the Biomedical Graduate Programs, the student shall be dismissed.

REQUIREMENTS FOR THE MASTER OF SCIENCE

The Master of Science (MS) degrees administered by the Biomedical Graduate Programs Office include Addiction Research and Clinical Health, Biomedical Engineering, Biomedical Research, Biomedical Science, Clinical Research Management, Medical Physics, Molecular Medicine and Translational Science, Neuroscience, Translational & Health System Science, and Translational Biotechnology.

Residence Requirement

In general, a minimum of 12 months of full-time work or its equivalent in residence is required for the Master's degree (or the equivalent in Wake Forest online instruction). The total allowable time to complete the degree must not exceed six years. Course credit may be allowed as described in the section on credit transfers at the discretion of the program director and Senior Associate Dean of the Biomedical Graduate Programs, but the minimum residence requirement is not thereby reduced.

Course Requirements

An MS candidate must have a minimum of 30 hours of graduate credit, including at least 24 hours of coursework. When a thesis is required, 6 hours of thesis research is the minimum requirement. All of the required 24 hours of coursework must be taken for a grade, although additional courses may be taken Pass/Fail if offered in that mode. Some programs require more than 30 hours for graduation. Additional degree requirements are listed at the beginning of the applicable program section.

The course of study, consisting of classes, seminars, and research, capstone project, or internship hours, is compiled by the student, the student's advisor, and the program director. It is recommended that the course of study includes courses in fields other than those of major interest.

Special Skill or Technical Requirement

Some programs may require students to demonstrate either competence in one or more special skills or a minimum number of hours in a discipline. See the additional degree requirements for the applicable program in the Programs of Study section.

Training in Integrity and Responsible Conduct

Successfully completing a research, clinical, or behavioral ethics program is required before admission to degree candidacy. This requirement is fulfilled either by participating in courses designated by the Biomedical Graduate Programs Office or by satisfactory completion of approved program electives that incorporate extensive discussion of responsible conduct in the research, clinical, or workplace settings.

Admission to Degree Candidacy

An MS student pursuing a thesis-based degree is admitted to degree candidacy by the Senior Associate Dean of the Biomedical Graduate Programs after recommendation by the program director. The student must have satisfactorily met any special skills,

technical requirements, or integrity requirements and is expected to complete the MS degree requirements within one term.

Thesis Requirement

Some programs granting an MS require a thesis; the student should verify whether a thesis is required with the individual program. If a thesis is required, 6 of the 30 hours required for the MS degree are allocated to thesis research at a minimum. Thesis research courses are graded S (Satisfactory) or U (Unsatisfactory). If a U is assigned, the course must be repeated, and an S must be earned before the degree can be awarded. A student who receives a grade of U in research in two terms may be dismissed from their Biomedical Graduate Program by the Senior Associate Dean upon recommendation of the program. See the previous section on Thesis/Dissertation Committee Composition & Review Guidelines for details on the assessment of the Thesis.

Requirements for the Doctor of Philosophy

The Doctor of Philosophy (PhD) degree administered by the Biomedical Graduate Programs Office includes Biochemistry and Molecular Biology, Biomedical Engineering, Cancer Biology, Integrative Physiology and Pharmacology, Medical Physics, Microbiology and Immunology, Molecular Genetics and Genomics, Molecular Medicine and Translational Science, and Neuroscience.

Residence Requirement

A minimum of three years of full-time study, of which at least two must be in full-time residence at the University (or the equivalent in Wake Forest online instruction). The total allowable time to complete the degree must not exceed seven years. Course credit may be allowed as described in the section on credit transfers at the discretion of the program director and Senior Associate Dean of the Biomedical Graduate Programs, but the minimum residence requirement is not thereby reduced.

Course Requirements and Advisory Committee

The Biomedical Graduate Programs Office does not prescribe the number of required courses for PhD study. The individual graduate program committees or student advisory committees set coursework requirements. Certain programs have required courses; students should consult individual programs for specific course requirements. Coursework plans, or plans of study, are typically arranged by the student's advisory committee with the approval of the program's graduate committee, to assess mastery in appropriate fields of concentration. Courses required by programs cannot be taken as Pass/Fail, and graduate committees may designate that certain courses may not be taken Pass/Fail. The program director appoints the advisory committee and consists of the student's advisor and a minimum of two other members of the graduate faculty as described above in the Thesis/Dissertation Review Requirements.

Special Skill or Technical Requirement

Some programs may require students to demonstrate either competence in one or more special skills or a minimum number of hours in a discipline. See the additional degree requirements for the applicable program in the Programs of Study section.

Scientific Integrity and Responsible Conduct of Research

Successfully completing a research, clinical, or behavioral ethics program is required before admission to degree candidacy. This requirement is fulfilled either by participating in courses designated by the Biomedical Graduate Programs Office or by satisfactory completion of approved program electives that incorporate extensive discussion of responsible conduct in the research, clinical, or workplace settings.

Professional Development

The successful completion of a professional development program is required before admission to degree candidacy. This requirement is typically fulfilled by participating in the Career Planning in the Biomedical Sciences and Seminars in Professional Development courses, often taken during the first year of graduate study. The Senior Associate Dean may approve alternative methods for meeting this degree requirement.

Preliminary Examination

The individual graduate program defines and conducts this examination. The examining committee selected by the program includes at least five members, one representing a related concentration area. A single written examination or a series of written examinations should cover all concentration and collateral studies areas. There may also be an oral examination in which any faculty member invited by the examining committee may participate. The examining committee passes or fails the student and notifies the Biomedical Graduate Programs Office of the results. In case of failure, the committee may recommend dismissing the candidate from the program. A re-examination may be allowed no earlier than six months from the first examination date. A student may be reexamined only once. The preliminary examination is normally given near the end of the student's second year of graduate study. It must be passed at least twelve months before the date of the awarding of the PhD.

Admission to Degree Candidacy

A student is admitted to degree candidacy by the Senior Associate Dean of the Biomedical Graduate Programs after recommendation by the program director. The student must have passed the preliminary examination, satisfactorily met any special skills or technical requirements, integrity, and professional development requirements.

Dissertation Requirement

Under the supervision of an advisor committee, the candidate prepares a dissertation embodying the results of investigative efforts in the field of concentration. Students must submit an electronic copy of the dissertation to the examining committee at least three weeks before the final examination. The committee is polled by the chair of the examining committee at least ten days before the proposed examination date to

determine the dissertation's acceptability. Other faculty members may attend the final examination and participate in the questioning. Dissertation research courses are graded S (Satisfactory) or U (Unsatisfactory). If a U is assigned, the course must be repeated, and an S must be earned before the degree can be awarded. A student who receives a grade of U in research in two terms may be dismissed from their Biomedical Graduate Program by the Senior Associate Dean upon recommendation of the program. See the section on Thesis/Dissertation Committee Composition & Review Guidelines for details on the assessment of the Dissertation.

Degree Programs

Credit hours are shown by numerals immediately after the course title, for example, (3) or (3, 3). Some laboratory courses have numerals after the course descriptions showing hours of recitation and laboratory per week, for example, (2-4). The symbols P— and C— followed by course numbers or titles are used to show prerequisites and co-requisites. POI indicates permission of instructor is required. Because graduate study occurs at a level of complexity and specialization exceeding that of undergraduate education, the work required of graduate students in any course in which instruction is combined with undergraduate students will reflect this difference.

General Studies (GRAD)

Overview

The Biomedical Graduate Programs Office offers courses for students spanning the range of biomedical graduate programs. Some courses are required by the degree or program, while others serve as general electives. Please consult the degree requirements and the individual program requirements to determine which courses are mandatory.

Courses of Instruction

GRAD 700 – Independent Study (1-9). This course allows an interested student to pursue a topic covered in another class in greater depth under the guidance of a faculty member. The faculty member will work with the student to clarify the expectations; usually the course requires a combination of extensive reading, tutorial sessions, and a written paper. *May be repeated.*

GRAD 701 – Special Topics (1-9). This course allows an interested student or students to pursue a topic covered in another class in greater depth under the guidance of a faculty member. The faculty member will work with the student or students to clarify the expectations; usually the course requires a combination of extensive reading, tutorial sessions, and a written paper. *May be repeated for different topics.*

GRAD 702 – Internship (1-9). The objective of this experiential course is to prepare graduate students to practice their biomedical science expertise within one of a variety of career settings. The course is appropriate for those seeking either a Master's or PhD in biomedical sciences, preparing the student for roles in pharmaceutical/biotech (research, safety, marketing), law and regulatory agencies, medical writing, science policy, and grants management, among others. *Students should register for this course if their internship placement is located within the Wake Forest umbrella. Students with placement outside of the Wake Forest umbrella should register for GRAD 703. Credit hours may be adjusted based on the length of the internship. May be repeated. Satisfactory/Unsatisfactory.*

GRAD 703 – Externship (1-9). The objective of this experiential course is to prepare graduate students to practice their biomedical science expertise within one of a variety of career settings. The course is appropriate for those seeking either a Master's or PhD in biomedical sciences, preparing the student for roles in pharmaceutical/biotech

(research, safety, marketing), law and regulatory agencies, medical writing, science policy, and grants management, among others. Students should register for this course if their placement is located outside of the Wake Forest umbrella. Students with placement inside of the Wake Forest umbrella should register for GRAD 702. Credit hours may be adjusted based on the length of the internship. May be repeated. *Satisfactory/Unsatisfactory*.

GRAD 704 – Principles of Intellectual Property Development (2). Designed for late-stage graduate students to supplement their scientific background with a greater understanding of intellectual property protection, commercialization, and start-up company formation. Numerous aspects of our knowledge-based economy will be covered including an overview of the diverse types of intellectual property protection available to protect inventions (with a focus on patents), the technology transfer process in an academic setting, a primer of company formation and organization, and an analysis of the different agreements (including confidential disclosure agreements, material transfer agreements, and license agreements) necessary to move a technology from the bench to the bedside. *P—Scientific graduate students only*.

GRAD 705 – Commercializing Innovation (3). This course will explore the processes that are involved from taking an interesting and innovative idea through to successful commercial or organizational application - in going from why something is a promising innovation on to how to develop a potentially successful business. It will look at product and process innovation, as well as the increasingly important area of business model innovation. There will be strong emphasis on practical application, group work and learning from experience. Guest lecturers will be used to illuminate some of the key issues in the commercialization process. *Typically offered in spring terms*.

GRAD 706 – Regulation and Reimbursement of Novel Drugs, Biologics & Medical Devices (3). This course is an overview of the key areas of strategic clinical development, Regulatory Affairs and the FDA-imposed regulations pertinent to the product lifecycle in the pharmaceutical, biologics, and medical device industries. The course also explores the basics of market access and reimbursement as a "second approval" prior to the product entering the market. The implications for available scientific and clinical evidence in light of market access issues will be discussed and linked back to the design of successful clinical development programs. Students will gain insight into the key elements of the regulatory process and market access in various health sector industries, governmental agencies and consultancies.

GRAD 707 – Professional Responsibilities and Conduct I (1). Students learn to identify general and discipline-specific professional norms and obligations for the responsible practice of science. Emphasizes development of professional decision-making skills. *This course or equivalent is required for Arts and Sciences Master's students who will be supported on federal grants. Pass/Fail.*

GRAD 708 – Communicating Science (1). This course is meant to train students in the best practices of taking highly technically scientific content and translating into formats that can be more easily comprehended by non-scientists and laypersons. The course will rely heavily on student presentations, often of their own research, followed

by constructive critique from other class members. *Typically offered in the summer term*.

GRAD 709/710 – Scientific Outreach (1). This course provides hands-on engagement with teaching and educational opportunities directed at the lay public or other, non-university groups. Planning outreach events and communicating scientific concepts to the lay public are essential skills for any scientist-in-training, especially those who may be involved in academic lecturing or public policy. The scope of such activities will derive from the scientific disciplines of the students involved but will include activities involving the informal teaching of basic and translational science concepts in the biomedical sciences and other STEM-related disciplines. Examples of such engagement include K-12 school visits, involvement in public symposia related to science for lay audiences, or any similar activity performed under faculty guidance. *May be repeated for credit not to exceed 6 hours each. Satisfactory/Unsatisfactory*.

GRAD 711 – Introduction to College Teaching (1). Prepares graduate teaching assistants for teaching roles. Coursework includes a 1–2-day orientation introducing students to the role and responsibility of being a teaching assistant, departmental orientation to teaching in the discipline, a series of educational workshops conducted by the Teaching and Learning Center, and classroom observation. *Satisfactory/Unsatisfactory*.

GRAD 712 – Clinical Integrity and Professionalism (2). This course offers foundational ethics and integrity training to Bowman Gray graduate students focused in pre-clinical studies. This course will utilize a combination of didactic presentations and small group, problem-based learning experiences to teach students methodology for addressing future ethical concerns in clinical and research practice. The course will provide an overview of the historical context and theoretical frameworks of biomedical ethics. Emphasis will be placed on the use of case studies to discuss topics including but not limited to the doctor-patient relationship, professionalism, the principles of biomedical ethics, informed consent, privacy and confidentiality, medical research, social factors in healthcare, and ethical issues at the beginning and end of life. *This course satisfies graduation requirements for ethics training for biomedical graduate students. Satisfactory/Unsatisfactory*.

GRAD 713 – Foundations of Scientific Integrity and Professionalism (1). A short course designed to offer foundational ethics and integrity training to incoming Bowman Gray graduate students. Key concepts will include introduction to key professional norms in science, including, but not limited to, responsible conduct of research, new professional expectations, as well as student life. An introduction to topics, that will be further explored using case-studies in GRAD 714, will include: plagiarism, animal & human subject research, record keeping, data management, grant writing, the student and advisor relationship, laboratory dynamics, and managing conflicts of interest. *Typically offered immediately following fall orientation. Satisfactory/Unsatisfactory*.

GRAD 714 – Scientific Integrity and Professionalism (2). A small-group, problem-based learning formatted course designed to teach discipline-specific and broad, professional norms and obligations for the ethical practice of science, primarily

for first-year graduate students on the Bowman Gray campus. The content will present ethical dilemmas and promote professional behavior on, but not limited to, the responsible conduct of research and the current regulatory climate with emphasis on the underlying principles that shape these concepts. Topics will include plagiarism, animal & human subject research, record keeping, data management, grant writing, the student and advisor relationship, laboratory dynamics, and managing conflicts of interest. *Typically offered weekly as 2-hour discussion sections during the spring term. This course satisfies graduation requirements for ethics training for biomedical graduate students. Satisfactory/Unsatisfactory.*

GRAD 715 – Career Planning in the Biomedical Sciences (1). A weekly seminar course, primarily for first-year graduate students on the Bowman Gray campus, in which invited alumni panelists share details on career options in the biomedical sciences, typically grouped by industry, highlighting a wide range of career paths. Speakers will share details from their own experiences in preparing for their chosen career paths, and may include undergraduate college teaching, pharmaceutical research, law careers, medical writing, science policy, and grants management, among other careers. In addition to the panel discussions, students will have the opportunity to complete self-assessment exercises to help narrow their career focus, will begin to discuss best practices in resume, curriculum vitae, cover letter writing, and interviewing skills. *Recommended for all students in biomedical graduate programs. Typically offered in fall terms.*

GRAD 716 – Seminars in Professional Development (1). A weekly seminar course, primarily for first-year graduate students on the Bowman Gray campus, in which invited speakers give presentations organized around offering students best practices in professional behaviors on topics, including: animal & human subjects research, record keeping, authorship, grant writing, preparing talks and posters, and managing conflicts of interest. *Required for biomedical PhD; recommended for biomedical MS students whose plan of study includes a thesis. Typically offered in spring terms.*

GRAD 720 – Topics in College-Level Teaching (1-3). Students participate in the preparation and delivery of one or more lectures, homework assignments, and examinations, and facilitate small group learning sessions. Students attend at least two professional development workshops on a variety of aspects of the educational process. *P—Successful completion of the first year of coursework in a biomedical graduate training program and POI.* Satisfactory/Unsatisfactory.

GRAD 722 – Teaching Skills and Strategies Seminar (2). Designed to provide students with formal training and development in teaching strategies and teaching scholarship. A variety of theories and pedagogies are reviewed and discussed. Students receive some practical experience in developing and delivering instructional materials and assessment tools. *Meets weekly for two hours throughout the spring term.*

GRAD 724 – Biosafety in Research Laboratories (3). This one-term course provides an overview of the types of biohazards that may be encountered while conducting scientific research, with emphasis on laboratories, and effective methods to

minimize the risks associated with those hazards. *P—At least one microbiology course and laboratory experience.*

GRAD 725 – Speaking with Confidence (3). Introduction to logic and rhetoric as well as grammar, comprehension, idioms, pronunciation, and vocabulary. Focuses on increasing self-confidence to improve speaking abilities as well as future employment opportunities.

GRAD 726 – Written English for the Professional Graduate (3). Explores the different forms of written English and their application. Focuses on increasing understanding the application of grammar, structure, rhetoric, and idioms to improve future employment opportunities.

Other Graduate Coursework Available Through Arts and Sciences Programs of Study

Overview

Most Arts and Sciences Graduate Programs offer additional coursework that is available for no additional tuition fee in fall and spring terms. Courses offered in the summer term may require a biomedical graduate student to pay additional tuition. The Bioethics graduate program requires biomedical graduate students to pay extra tuition in all terms. Students interested in registering in graduate courses hosted by Arts and Sciences-campus based programs should obtain permission to enroll from the course director of the course. Once permission is received, the student should contact the Biomedical Graduate Program's Student Records team to complete enrollment in the course. For course listings and descriptions, please consult the Arts and Sciences-campus Course Registration Instructions and Information page at: https://graduate.wfu.edu/reynolda-campus-registration-procedures-2/.

ADDICTION RESEARCH AND CLINICAL HEALTH (ARCH)

Program Director	Elizabeth Shilling
Associate Professors	Jennifer Check, Katie Duckworth
Assistant Professors	Yasmin Gay, Elizabeth Shilling
Adjunct Graduate Faculty	Kiana Booth, Holly Sopko

Overview

To meet the critical needs for addiction care and treatment, the Addiction Research and Clinical Health (ARCH) Master of Science program at Wake Forest University provides graduate training at the master's level to prepare specialists in addiction services.

The ARCH program provides three track options, one focused on a clinical outcome, and another focused on addictions research with an emphasis on neuroscience, and a third health services track focused on the overall health implications of addiction.

ARCH integrates student learning and research experiences throughout our medical community. The program, considered the first of its kind, is perfectly suited for the innovative environment at Wake Forest and is helping to create a workforce that will make a direct impact on the addiction crises faced by our patients, our community, and our nation.

The program goals are to: (1) Provide evidence-based integrated care effectively and ethically; (2) Value diversity, life-long learning, self-awareness, and personal growth; (3) Champion empathy, multicultural competencies, and the highest quality of skills; and (4) Base care on treating others with dignity and respect.

ARCH welcomes students from multiple disciplines and can enhance the likelihood for further advanced studies in psychology, counseling, social work, medicine, or nursing, as well as provide opportunities for those who already hold an advanced degree and want to pursue further addiction specialized education.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: All students are required to take 16 course credit hours in core courses.

Clinical Track: Students must complete a minimum of 39 course credit hours, including core courses, and 9 credit hours of clinical internship experiences amounting to a minimum of 600 hours of clinical experience.

Research Track: Students must complete a minimum of 39 course credit hours, including core courses, and 9 credit hours of a research internship.

Health Services Track: Students must complete a minimum of 30 course credit hours, including core courses, 6 project hours, and a capstone project on a topic agreed upon by the advisor and student.

Courses of Instruction

ARCH 701 – Foundations of Addiction (3). This course is designed as a broad introduction to foundational concepts of addictive substances and disorders. Major topics of the course include the primary categories of substances of abuse; epidemiology, etiology, and effects of substance use; and current scientific findings related to addictive behaviors. *Typically offered in fall term.*

ARCH 702 – Human Development, Addictive Disorders, & Human Services (3). The course addresses development and cognitive processes governing learning from conception to death with an emphasis on the implications for addictive disorders and the treatment of addictive disorders. Normative, non-normative and historical effects within childhood, adolescence, adulthood and later life are presented. Formal developmental and learning theory is emphasized in conjunction with practical interpretation and application. The course provides an orientation and background for sound educational and clinical practices. *Typically offered in fall term.*

ARCH 703 – Helping Skills in Addiction & Human Services (3). Helping Skills in Addiction & Human Services investigates techniques of helping skills and multi-disciplinary intervention options for addictive disorders. The course teaches fundamental helping skills such as relationship building, basic assessment, goal setting, selecting interventions and evaluation of client outcomes in the context of addictive disorders in human services settings. *Typically offered in fall term.*

ARCH 704 – Theories of Addictive Disorders (3). Theories of Addictive Disorders is designed to introduce students to the theoretical, philosophical, and historical premises upon which addictive disorders are explained and treatment and prevention of addictive disorders are based. Biological, psychological, and sociological aspects of substance abuse and dependence will be the frameworks upon which the course will be taught. *Typically offered in fall term.*

ARCH 705 – Addictive Disorders Treatment: Individuals, Families, and Groups (3). This course is an introduction to basic therapeutic counseling skills for use with chemically dependent clients and/or their families. It is designed for counseling students who have worked as professional substance abuse counselors and for those who have little or no such experience. The course helps prepare students for certification as North Carolina Licensed Clinical Addictions Specialists (LCAS). *Typically offered in spring term.*

ARCH 706 – Assessment & Diagnosis: Addictive Disorders (3). This course is an introduction to assessing and diagnosing risky misuse and addiction disorders with the use/abuse & dependency continuum. It is designed for graduate students preparing to work as a professional Clinical Addiction Specialist. The course helps prepare students for certification as North Carolina Licensed Clinical Addictions Specialists (LCAS) through the approved program at Wake Forest Graduate School – Biomedical campus. *Typically offered in spring term.*

ARCH 707 – Addictive Disorders Symposium (3). The Addictive Disorders Symposium will explore contemporary issues in the field of addictive disorders and their influences on the roles of clinical addictive specialists and researchers. This course is designed to benefit clinical addictive disorders researchers, scientists and specialists. Students will actively participate in discussions related to the theme and sessions will feature researchers who will share their current thinking and agenda relevant to the concerns of addictive disorders professionals. *P—POI.*

ARCH 708 – Advanced Study in Addictive Disorders (3). The Advanced Study in Addictive Disorders is a course designed to provide an in-depth look at special topics related to addictive disorders such as process disorders, codependency, emerging practices and more. The disease of substance abuse and dependence has many unique characteristics when it occurs in persons and groups outside the typical family unit. In this course, an examination of those characteristics is explored among special populations including adolescents, the elderly, racial and ethnic minorities, gas/lesbians, the physically and developmentally disabled and the chronically ill. *P—ARCH 703.*

ARCH 709 – Ethics in Health, Addictive Disorders & Human Services (3). The Ethics in Health, Addictive Disorders & Human Services course is designed to examine the ethical and legal standards required by the industry, state entities, or federal entities that affect the practice of addiction prevention and addiction treatment of adults and minors. This course discusses five principles of ethical decision-making in addictive disorders clinical practice and provides a step-by-step model for resolving ethical dilemmas. The course also explores specific ethical and legal issues as they relate to addictive disorders treatment.

ARCH 710 – Addictive Disorders Clinical Experience I & Lab (3). The Addictive Disorders Clinical Experience I & Lab is the introductory professional experience in a student's program. It is an opportunity to increase an understanding of addictive disorders treatment and the clinical, personal and professional skills necessary to be successful in this profession. Through experiences at a clinical addiction site and with classmates, students will grow in the use of intervention and helping skills, case conceptualization skills and self-awareness. *P—ARCH 703.*
Satisfactory/Unsatisfactory.

ARCH 711 – Addictive Disorders Clinical Experience II & Lab (3). The Addictive Disorders Clinical Experience II & Lab is the second comprehensive

professional experience in a student's program. It is an opportunity to continue to synthesize and apply knowledge with supervised training at a site congruent with the student's career goals, while also helping clients representative of the ethnic, lifestyle, and demographic diversity in the community. Through the sharing of experiences in the lab experiences, students refine previously learned skills in an increasingly autonomous role with clients. *P—ARCH 706, ARCH 710. Satisfactory/Unsatisfactory.*

ARCH 712 – Addictive Disorders Clinical Experience III & Lab (3). The Addictive Disorders Clinical Experience III & Lab is the final comprehensive professional experience in a student's program. It is an opportunity to continue to synthesize and apply knowledge with supervised training at a site congruent with the student's career goals, while also helping clients representative of the ethnic, lifestyle, and demographic diversity in the community. Through the sharing of experiences in the lab experiences, students refine previously learned skills in an increasingly autonomous role with clients. *P—ARCH 710. Satisfactory/Unsatisfactory.*

ARCH 713 – Addictive Disorders Research Internship I (3). The Addictive Disorders Research Internship sequence of courses represent the final comprehensive professional experience in a research student's program. It is an opportunity to synthesize and apply knowledge with supervised training in up to three research laboratory experiences with the student's career goals. *Satisfactory/Unsatisfactory.*

ARCH 714 – Addictive Disorders Research Internship II (1-9). The Addictive Disorders Research Internship sequence of courses represent the final comprehensive professional experience in a research student's program. It is an opportunity to synthesize and apply knowledge with supervised training in up to three research laboratory experiences with the student's career goals. *P—ARCH 713; Satisfactory/Unsatisfactory.*

ARCH 715 – Capstone Project (1-6). This course provides students with the opportunity to work one-on-one with a faculty member on a particular topic or creative project. Students will be engaged in directed study through readings, projects, papers, and other activities.

ARCH 719/720 – Addiction Research & Clinical Health Journal Club (1). This journal club focuses on articles related to current trends in addiction research and addictive disorders treatment. Students are encouraged to review current research articles on addictive disorders with particular attention given to the implications of sociocultural, demographic, and lifestyle diversity. Each week a different student presents an article providing a thorough review of the article and relevant background information. *Typically offered in the summer term.*

ARCH 721 – Social & Cultural Diversity in Additive Disorders (2). The clinical addiction profession strives to account for and thoroughly consider issues of cultural and ethnic diversity. The purpose of this course is to help students gain awareness of their cultural values and biases, of other's worldviews, and of culturally appropriate

research and intervention strategies related to addictive disorders. *Typically offered in the summer term.*

ARCH 722 – Addictive Disorders Seminar Series (3). This course includes presentations and discussions by faculty, guest speakers, and graduate students on current topics within the realm of addition, including areas of focus within basic science, clinical practice, prevention, public health, and others. *Typically offered in the spring term.*

BIOCHEMISTRY AND MOLECULAR BIOLOGY (BAMB)

Program Director	Tom Hollis
Professors	Rebecca Alexander, Nichole Allred, Reto Asmis, Keith Gagnon, Cristina Furdui, Greg Hawkins, Tom Hollis, Tim Howard, Allyn Howlett, Greg Kucera, Todd Lowther, Jian-Xing Ma, Jed Macosko, Gloria Muday, John Parks, Leslie Poole
Associate Professors	Gennadiy Moiseyev, Susan Sergeant, Allen Tsang, Yusuke Takahashi
Assistant Professors	Derek Parsonage, Terrence Smalley

Overview

The graduate training program in Biochemistry and Molecular Biology is designed to prepare students for careers of investigation and teaching in biochemistry, molecular biology, and in related sciences that involve biochemical, structural and molecular approaches and techniques. Although the programs of study are individually planned, all students are expected to possess competence in certain basic areas of biochemistry and related sciences. Programs leading to the PhD degree in biochemistry and molecular biology are offered.

Students enter the program through the Molecular and Cellular Biosciences Track and participate in the MCB common curriculum in the first year. Curriculum in subsequent years includes participation in Scientific Communication, Topics in Biochemical Literature and electives of the student's choice. The student also participates in the program's research seminars.

Dissertation research under the supervision of a faculty member may be pursued in various areas of biochemistry, including enzymology, NMR and X-ray structure determination of macromolecules, virus assembly, relation of lipid and protein metabolism and of protein-lipid association to membrane structure and function, biological oxidations and bioenergetics, molecular genetics and nucleic acid function, biophysics, biochemical pharmacology of anticancer agents, leukocyte metabolism and function, signal transduction mechanisms in normal and cancerous cells, and molecular mechanisms of blood coagulation. The program has specialized equipment and facilities to support training and investigation in these areas.

The biochemistry program participates in the Interdisciplinary Graduate Track in Structural and Computational Biophysics. For more information, refer to the pages in this bulletin regarding the program. The graduate program was begun in 1941, and the PhD degree has been offered since 1962.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: Students are required to take BAMB 700/701 Scientific Communication in year 2 and BAMB 709/710 Special Topics in Biochemical Literature in years 2 and 3.

Courses of Instruction

MCB Track Electives

MCB 711 – Biological Systems and Structures (2). In depth study of macromolecular assembly and interactions, as well as the application of structural biology and proteomics technology. Contemporary concepts of the principles of protein and nucleic acid structure are discussed. Other topics include methods for structure determination such as X-ray diffraction, NMR spectrometry, and molecular modeling. Typically offered in the fall term. *Intended for all graduate students in biochemistry and molecular biology (BAMB), open to students in other tracks or programs.*

MCB 712 – Biological Spectroscopy (2). Principles and practicalities of the study of biomolecules using spectroscopic techniques such as absorbance, fluorescence and circular dichroism analyses. Other biophysical approaches such as mass spectrometry and sedimentation analysis will be included. Topics in the study of enzymes utilizing these techniques will be discussed. Typically offered in the fall term. *Intended for all graduate students in biochemistry and molecular biology (BAMB), open to students in other tracks or programs.*

MCB 715 – Fundamentals of Redox Biology and Medicine (2). Redox chemistry as it applies to biological systems is a specialized field where a fundamental understanding of the underlying biochemistry and appropriate methodologies for evaluating redox regulation and its effects on cellular function are essential. This course will provide the theoretical background and emphasize highly quantitative and robust approaches to evaluate redox changes when these are investigated 1) at the level of single molecules (e.g. working with redox-regulated recombinant proteins; 2) in vitro at the cellular level; 3) in vivo using animal models; and 4) in clinical studies.

BAMB Advanced Courses

BAMB 700/701 – Scientific Communication (1). Instruction and practice in oral and written scientific communication. *Meets weekly.*

BAMB 706 – Intracellular Signaling (3). Advanced study of the biochemical mechanisms involved in intracellular signaling of normal and malignant cells, including 1) growth factor and G protein-coupled receptors 2) second messengers, 3) protein kinase cascades, 4) gene regulation, and 5) oncogenes. Lectures and discussions provide in-depth coverage of each topic with emphasis on recent advances and current literature.

BAMB 709/710 – Special Topics in Biochemical Literature (2). Critical reading and interpretation of the recent literature in biochemistry. Emphasis is decided by students and staff. *Meets weekly. Required of second- and third-year graduate students in the Biochemistry and Molecular Biology program.*

BAMB 711 – Advanced Topics in Protein Structure Determination (2). Emphasizes methods for modern structure determination using X-ray crystallographic methods. Students are exposed to practical techniques in growth of protein crystals, collection and processing of X-ray diffraction data, phase determination, model building and refinement. Students are also expected to develop an in-depth understanding of the latest instrumentation and programs used in protein structure determination.

BAMB 713 – Large Experimental Datasets and Analysis: Advanced (3). Conducted as a combination of lectures, reading assignments, and student-led discussions. Lectures detail experimental methods that generate large-scale datasets. Topics will include genotyping, expression profiling, metabolomics, high-content cellular imaging techniques and practical examples of bioinformatic software and statistical analyses.

BAMB 714 – Instrumental Techniques (3). Theoretical and technical aspects of instrumentation currently employed in the biological sciences. Experience is provided on a variety of instruments including high performance liquid chromatographs; gas chromatographs; gas chromatograph/mass spectrometer; nuclear magnetic resonance spectrometer; electron paramagnetic resonance spectrometer; ultraviolet, visible, and infrared spectrophotometers; spectrofluorometers; and cell sorter/cytofluorograph. *P—general chemistry through physical chemistry and two terms of physics or POI. Offered in odd-numbered years.*

BAMB 715/716 – Special Topics in Biochemistry (1-9). Advanced conference course that considers various areas of current interest or rapid development. Topics are developed depending on the interests of students and staff.

BAMB 717/718 – Principles and Practice of Teaching Biochemistry (2). Structured participation of students as mentors in existing biochemistry classes. Under the supervision of biochemistry faculty, students create laboratory demonstrations, field questions, write and grade exam questions, conduct review sessions and participate in one-on-one instruction. *P—POI*

BAMB 719/720 – Dissertation Research (1-9). The program offers opportunities for investigation in a wide variety of biochemical subjects under the guidance of staff members. *Satisfactory/Unsatisfactory*

BAMB 734 – Human Molecular Genetics (2). Combined lecture/seminar course providing an overview of current theoretical and technical approaches for locating, identifying, and cloning human genes.

BIOMEDICAL ENGINEERING (BMES)

Program Director	Scott Gayzik
Professors	Graça Almeida-Porada, Anthony Atala, Jessica Bon, Daniel Bourland, Arjun Chatterjee, Kerry Danelson, Gagan Deep, Scott Gayzik, William Gmeiner, Dwayne Godwin, Metin Gurcan, Adam Katz, Kylie Kavanagh, Daniel Kim-Shapiro, Paul Laurienti, Sang Jin Lee, Jeong Ok Lim, Francois Modave, Michael Munley, Emmanuel Opara, Giuseppe Orlando, Olga Pierrakos, Christopher Porada, Edgar Alfonso Romero-Sandoval, Timothy Sell, Sean Simpson, Shay Soker, Joel Stitzel, Xiuzhi Susan Sun, Charles Tegeler, Chris Whitlow, Jeff Willey, Timothy Williams, Saami Yazdani, James Yoo, Wei Zhang, Dawen Zhao
Associate Professors	Kristin Beavers, Philip Brown, Christina Cramer, Tracy Criswell, Jingzhong Ding, Xin Feng, Adam Hall, Craig Hamilton, Erin Henslee, James Jordan, Ken Kishida, Nicole Levi, Ryan McGinnis, Patrick McNutt, Xin Ming, Sean Murphy, Lucas Neff, Christopher Runyan, Kiran Solingapuram Sai, Thomas Shupe, Ravi Singh, Jim Ververs, Ashley Weaver
Assistant Professors	Bumsoo Ahn, Amish Asthana, Mohsen Bahrami, Paul Black, Garrett Bullock, Karan Devane, Alexandre Guevel, Xu Han, Yuming Jiang, Young Min Ju, Jeongchul Kim, Ji Hyun Kim, Megan Lipford, Qing Lyu, Da Ma, Sophie Maiocchi, Josh Maxwell, Ellen McGinnis, Mohammad Moghimi, Arezoo Movaghar, Kristen Nicholson, Ellen Quillen, Hooman Sadri, Heather Shappell, Jillian Urban, Jared Weis, Victoria Weis
Adjunct Graduate Faculty	Darren Coleman, David Klorig, Hui-Wen Lo, Samuel Lockhart, Ellie Rahbar

Overview

The Biomedical Engineering graduate program offers PhD and MS degrees in biomedical engineering in conjunction with the joint degree program in the Virginia Tech–Wake Forest University School of Biomedical Engineering and Sciences (SBES). The program emphasizes medical applications, particularly in image and signal processing and analysis, regenerative medicine/tissue engineering, biomechanics, medical physics, nanotechnology, and translational cancer research. Qualified applicants should have undergraduate degrees in technical fields, including engineering,

computer science, mathematics, and physics. Additional training in life sciences is desirable but not essential.

The program consists of traditional classroom instruction, independent research with a mentoring team, and clinical experience. Courses come from engineering and life science core courses and selected electives in engineering, life sciences, and related physical sciences, offerings include courses in the physics, mathematics, and computer science programs. The program is very flexible, and selection of elective courses can be individualized to complement the student's background and interests.

A clinical rotation is required of PhD students during their first year of study. Students are exposed to technical equipment with medical applications, and to patient care and procedures used in medical centers, thus providing relevance and context for their classroom studies and research.

Office and laboratory space are located throughout Biotech Place and include the Image Analysis Lab, the Movement Biomechanics Lab, the Tissue Mechanics Lab, the Center for Injury Biomechanics, the Wake Forest Institute for Regenerative Medicine, Radiation Oncology, Plastic and Reconstructive Surgery, and other campus locations. Facilities also include a chemistry lab and a machine shop with associated instrumentation and tools, including the Wake Health Additive Manufacturing core lab. Academic space is provided in the Wake Forest Biotech Place Building and the Medical Center. Computer and network facilities are state of the art, and several projects utilize the cluster computer facility, the DEAC Cluster. Associated labs in clinical and basic science departments also provide equipment for student research.

More information is available on the website: https://beam.vt.edu/graduate/biomedical.html. Prospective students are encouraged to contact individual faculty members or schedule a visit to the program.

Degree Requirements: As applicable, please see "Requirements for the Doctor of Philosophy Degree" of the "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: For the MS degree, students must take a minimum of 21-24 course credit hours and 6-9 hours in research for a minimum of 30 credit hours. For the PhD degree, students must take 30-50 course credit hours and 40-55 dissertation research hours for a total of 90 credit hours.

Courses of Instruction

BMES 602 – Biomedical Engineering and Human Disease (3). Comprehensive overview of a variety of human diseases, including neurological disorders, cardio-vascular disease, infectious disease, and cancer, designed primarily for graduate students majoring in engineering and other related areas who have a long-term academic and professional goal in the field of biomedical engineering and life sciences. Introduction to state-of-the-art biomedical engineering approaches used for the study of early detection/diagnosis, treatment, and prevention of human disease. *Typically offered in spring term.*

BMES 605 – Quantitative Cell Physiology (3). This course in mathematical modeling and simulation will include the following: quantitative descriptions of cell physiology and control pathways; numerical simulations of cellular physiologic processes such as, reaction kinetics, inhibition and cooperatively, passive transport, facilitated and carrier-mediated reaction kinetics; cell membrane resting potential in nerve and muscle tissue. Additionally, the course will cover modeling of neuronal processes such as voltage-gated channels, neurotransmitter release and uptake kinetics, and postsynaptic membrane potentials. *For SBES graduate students only. Typically offered in fall term.*

BMES 606 – Quantitative Organ Systems Physiology (3). Mathematical modeling, simulation, quantitative description of organ physiology and control. Numerical simulation of cardiovascular physiologic processes including regulation of cardiac output, the baroreceptor - stroke volume model, venous return, and closed-loop control. Respiratory ventilation mechanics, gas exchange, pulmonary circulation, alveolar-capillary diffusion, and respiratory ventilation control. Nephron countercurrent mechanism and hemodialysis. Modeling of endocrine system functions. For SBES graduate students only. *P—MATH 5495/ESM 5725/BMES 5044 or equivalent; BMES 605 and/or experience with computer programming (Matlab) for MS students only; coursework in Ordinary Differential Equations. Typically offered in spring term.*

BMES 607 – Biomedical Research Design (3). Biomedical engineering leverages a wide array of investigative techniques ranging from observational to experimental and formalized through epidemiological techniques, laboratory and field experiments, and clinical trials, to name a few. Understanding how to approach the design, execution, and statistical analysis of these approaches is essential for Biomedical Engineers. This course is intended to introduce students to these techniques in an applied manner, exposing students to approaches for selecting the appropriate experimental designs, designing and implementing a research plan, and performing inferential statistical tests on the resulting data.

BMES 615 – Advanced Commercialization of Biomedical Engineering Research (3). Commercialization process applied to translational research. Regulatory aspects of biomedical engineering products and technologies (e.g., devices, diagnostics, drugs, biologics). Intellectual property, technology transfer processes, clinical trial design, commercialization of university research, modeling of development costs (e.g., cash flow and revenue projections). Small business startup approaches.

BMES 616 – Advanced Impact Biomechanics (3). Review of impact biomechanics and critical investigation of the impact response of the human body. Participants study the dynamic response of the head, neck, chest, abdomen, upper and lower extremities. Real-world examples from automobile safety, military applications, and sport biomechanics. *Typically offered in fall term, odd years. P—POI.*

BMES 617 – Biomechanics of Crash Injury Prevention (3). Presents an introduction to the design and analysis of crash injury prevention methods in vehicle crashes. Encompasses three major focus areas: crash energy absorption in (1) the vehicle structure, (2) the occupant, and (3) the occupant restraints. *Typically offered in spring term, even years.*

BMES 618 – Injury Physiology (3). Presents an introduction to the physiology of injury. Focuses on the pathophysiology, mechanisms, and outcomes of injury in mammalian tissues. Explores injury physiology at the organ, tissue, and cellular level. Topics include physiology of injury to tissues of the peripheral and central nervous systems, the musculoskeletal system, the pulmonary system, the abdomen, the pregnant female, and the eye. *Typically offered in fall term, even years.*

BMES 619 – Machine Learning for Biomedical Data (3). This course will provide an overview of key modeling intuitions and implementation of popular machine learning models for biomedical datasets, including linear classifiers, support vector machines, and neural networks, and unsupervised learning models, such as K-Means clustering. Students will develop and implement suitable learning pipelines and models for biomedical datasets. Basic algebra, calculus, and coding skills required.

BMES 621 – Human Physical Capabilities (3). Examination of human physical attributes in human-technology systems, with emphasis on models of anthropometry and biomechanics, on intero- and exteroreceptors, and on the work environment; force fields (transitory and sustained), sound, light, and climate. *Typically offered in fall term, even years. P—POI.*

BMES 630 – Biological Transport Phenomena (3). The fundamental principles of mass transport phenomena are introduced and applied to the characterization of transport behavior in biological systems (e.g. cell, tissues, organs, people). Topics include active, passive, and convective molecular transport mechanism. These fundamentals will be used to develop analytical and predictive models and describe phenomena such as oxygen transport, kidney function, systemic drug delivery, and design of extracorporeal devices. *Typically offered in fall term, even years. P—Undergraduate courses in fluid mechanics and transport phenomena.*

BMES 631 – Introduction to Regenerative Medicine I (3). The course explores the current state of the field of regenerative medicine with specific emphasis on the technological challenges that limit the efficacy and clinical translation of engineered tissues and therapies. Course content will be presented from both the life science (e.g., cell biology, organ physiology, biochemical methods) and engineering perspective (e.g. transport phenomena, materials engineering) to compare and evaluate alternative approaches and strategies that are being developed and tested. Emphasis is placed on the promising roles of stem cells, biologically-inspired materials, and gene therapies. *Typically offered in fall term. P—Graduate standing or POI. Undergraduate biology and calculus are suggested.*

BMES 636 – Enterprise Data @Scale (3). This course provides an Enterprise Data foundation, overview of data-driven methods, organizational ways of working and decision-making application. Specific topics include decision analysis, comparative effectiveness research, and technology assessment; program evaluation; the critical review and interpretation of published studies, institutional oversight of research programs; and the key four steps of statistical analysis (identification of scientific programs or problems of interest, collection of the required data, analysis and summary of data, and generation of a conclusion). In this course, students will work

collaboratively to develop and implement data strategy and analytical plan that relates to real world applications.

BMES 641 – Advanced Biomaterials (3). Lectures and problems dealing with materials used to mimic/replace body functions. Topics include basic material types and possible functions, tissue response mechanisms, and considerations for long-term usage. Issues of multicomponent materials design in prosthetic devices for hard and soft tissues are discussed. *Typically offered in spring term, even years.*

BMES 643 – Polymeric Biomaterials (3). The major objective of this course is to introduce principles and concepts critical to the successful design of polymer-based biomaterials, drug-delivery devices, and bio-implants. The course will be broken down into the following four areas, polymer design and processing, inflammatory responses to polymers, interaction of blood with polymeric materials, and the effect of mechanical, chemical, and surface properties of polymers on cells. *Typically offered in spring term, even years.*

BMES 651 – Digital Signal Processing (3). The fundamentals of digital signal processing of data experimentally obtained from mechanical systems is covered. Attention is given to data acquisition, A/D conversion, aliasing, anti-aliasing filtering, sampling rates, valid frequency ranges, windowing functions, leakage, and various transform methods. Special attention is given to random, transient, and harmonic function data processing. Various methods of estimation of frequency response function (FRF) are explored. The estimation methods are assessed as to their impact on FRF estimation errors. *Typically offered in spring term.*

BMES 652 – Stochastic Signals and Systems (3). An introductory graduate course on the engineering applications of probability theory, random variables, and random processes. Major topics will include: probability theory, random variables, random vectors, stochastic processes, analysis and processing of random signals, and Markov chains. *Typically offered in fall term. P—Probability and Statistics for Electrical Engineers or equivalent background.*

BMES 658 – Engineering Mathematics (3). This course equips graduate Biomedical Engineering students with essential mathematical tools needed for research, particularly in preparation for the PhD Qualifying Exam at the end of the first year. The course focuses on differential equations and statistics, with practical applications in BME research.

BMES 660 – Biomedical Research Design (3). Biomedical engineering leverages a wide array of investigative techniques ranging from observational to experimental and formalized through epidemiological techniques, laboratory and field experiments, and clinical trials, to name a few. Understanding how to approach the design, execution, and statistical analysis of these approaches is essential for Biomedical Engineers. This course is intended to introduce students to these techniques in an applied manner, exposing students to approaches for selecting the appropriate experimental designs, designing and implementing a research plan, and performing inferential statistical tests on the resulting data.

BMES 661 – Advanced Commercialization of Biomedical Engineering Research (3). Commercialization process applied to translational research. Regulatory aspects of biomedical engineering products and technologies (e.g. devices, diagnostics, drugs, biologics). Intellectual property, technology transfer processes, clinical trial design, commercialization of university research, modeling of development costs (e.g. cash flow and revenue projections). Small business startup approaches.

BMES 662 – Cancer Engineering: Biology, Detection, and Therapeutics (3). A fundamental understanding of cancer as a mechanistic and 'predictable' series of processes is essential for students to be successful in their graduate work. Many students in engineering disciplines do not have a robust background in biological sciences and may benefit from a course that helps recognize and bridge this gap in background.

BMES 671 – Biomedical Microdevices (3). Builds the foundation necessary for engineering research in micro- and nano- biotechnology. Covers micro- and nano-fabrication techniques; the fundamentals of microfluidics; micro- and nano-particle manipulation; and engineering aspects of cells and their membranes. Provides students with the knowledge required to create biomedical micro- and nano-devices with a focus on the unique physics, biology and design aspects at these scales. Students are expected to know undergraduate engineering, physics, and calculus. *Typically offered in spring term, odd years.*

BMES 676 – Biomedical Nanoengineering (3). Biomedical Nanoengineering is an interdisciplinary course intended for graduate students (and undergraduates by permission of instructor) that will introduce major concepts in the design, production, and utility of micro- and nanotechnologies in biomedicine. The learning objectives of the course are to: (i) understand techniques critical to the fabrication of molecular sensors and nanodevices; (ii) explain fundamental physical and engineering principles at play in such devices; and (iii) describe practicable applications of the technologies to biomedicine. Students will learn about contemporary and emerging technologies, understand their working concepts, and read and critique high-impact papers in the field to appreciate the current state-of-the-art. *Typically offered in spring term, odd years.*

BMES 694 – Seminar (1). The focus of this course is on presentation of scientific work. Attendance at all SBES-sponsored, invited lectures is required. Students must attend 2/3 of all invited SBES seminars. First year graduate students are required to attend additional lectures aimed toward presentation skills, grant writing, and other special topics. A short formal presentation of research is required of all first year graduate students. *Typically offered every term.*

BMES 697 – Independent Study (3). Opportunity to pursue a topic covered in a regular course in greater depth. Usually involves extensive reading and tutorial sessions with a faculty supervisor. Written papers may be required.

BMES 698 – Special Study (3). Designed for a group of students. It may be used to study a timely topic—one in which there is current, but not necessarily lasting interest.

It also may be used to launch an experimental course before the course is incorporated into the regular curriculum.

BMES 702 – Leveraging Big Data for Data-Driven Decision-Making (3). This course provides an overview of the methods and applications of therapy economics, biostatistics, and epidemiology in healthcare decision-making. Specific topics include: pharmaco-economics, decision analysis, comparative effectiveness research, and technology assessment; program evaluation; the critical review and interpretation of published epidemiological studies, institutional oversight of epidemiological research programs; and the key four steps of statistical analysis (identification of scientific programs or problems of interest, collection of the required data, analysis and summary of data, and generation of a conclusion).

BMES 706 – Clinical Rotation (2). Offers both a broad view of the use of engineering principles in medicine and general clinical care, together with an in-depth study of a particular aspect of medicine under the direct supervision of a physician. The student sees the operation and maintenance of various clinical modalities, systems, and devices under the guidance of a working engineer or technician. Students participate in clinical rounds and in image reading sessions to gain insight into the actual operation and needs of departments using medical imaging modalities. *For SBES PhD students only. Typically offered in spring term.*

BMES 708 – Topics in Biomedical Engineering (1-6). Topics in biomedical engineering that are not considered in regular courses.

BMES 710 – Multi-scale Cancer Engineering (3). A multidisciplinary, multi-scale approach to analyzing cancer etiology, progression, detection, and therapy. Traditional and emerging methods of analyzing bio-molecular aspects of cancer. Tumor micro-environment modeling and analysis. Physical oncology-inspired cancer therapy.

BMES 716 – Computational Modeling in Impact Biomechanics (3). Dynamic modeling of the human body subjected to impact loading. A combination of finite element analysis and multi-body simulation techniques. Utilizes software packages with dynamic solvers. Applications include computer-aided design for automobile safety, sports, biomechanics, and military restraint systems. *Typically offered in spring term, odd years.*

BMES 717 – Advanced Human Modeling: Injury and Tissue Biomechanics (3). Serves as a continuation of BMES 616 and BMES 716. It covers the basics of the finite element method as it applies to high-rate phenomenon. Focus is on practical problems and the use of commercial codes for solving vehicle crash-worthiness and biomechanics problems. Real-world examples from biomedical engineering, automobile safety, military applications, and sport biomechanics are used to augment lecture material. *Typically offered in spring term, even years. P—BMES 616 and 716.*

BMES 718 – Advanced Computational Methods and Modeling for Biomedical Applications (3). Computational development and analysis of biomedical simulations using advanced numerical techniques for the solution of ordinary and partial differential equations. Emphasis will be on graduate research related topics within biomedical modeling: biotransport, biomechanics, tumor growth

dynamics, model-based medical imaging techniques, etc. Methods for analyzing the limitations of these techniques and for understanding their proper use. *Typically offered in spring term, odd years.*

BMES 721 – Basic Concepts in Cancer Biology (2). This course will cover fundamental concepts in cancer biology including etiology, genetic abnormalities, gene expression reprogramming, signal transduction aberration, and stem cell regulation in various tumor types, such as, cancers of the breast, prostate, lung, CNS, lung, ovary, and bladder. *This course is cross listed as MCB 721.*

BMES 722 - Basic Concepts in Cancer Research (2). Over the last half century scientists have generated a complex body of knowledge illuminating the origins of cancer and revealed it to be a dynamic interplay between the genome and the cellular environment. MCB 722 is a hypothesis-driven and problem solving-based course that explores this interplay and the requirements for malignant transformation. This course is offered in the spring term. The course is open to all students in thesis driven tracks and required for all graduate students in cancer biology (CABI). Students not performing thesis research are able to register but should recognize the course requires an understanding of experimental design and data analysis for course assignments. *This course is cross listed as MCB 722.*

BMES 723 – Special Topics in Cancer Biology (2). Teaches students how to evaluate and communicate scientifically in the area of cell biology and cancer. Examples are taken from all areas of cancer in this advanced course. Uses current peer-reviewed journal articles to teach fundamental concepts and act as a medium for allowing the students to communicate ideas with an emphasis on presentation skills. Typically offered in the spring term. Intended for all graduate students in cancer biology (CABI); open to students in other tracks or programs. *This course is cross listed as MCB 722.*

BMES 732 – Fundamentals of Continuum Mechanics for Biomedical Engineers (3). Students will discover the theoretical foundations of modern mechanics, also known as continuum mechanics, in a biomedical context. They will learn how to translate the fundamental laws of physics into rigorous numerical simulations, via the finite-element method. The goal is for students to better understand the inner workings of the commercial software they may have to use, but also to create numerical models that are more suited to their needs. Applications will range from basic biomedical processes to advanced multiphysics processes involving the potential coupling of mechanical, hydraulic, thermal, chemical, and electrical effects, and also poromechanics. Depending on students' interest, these advanced topics may include tumor growth, blood flow, and bone mechanics.

BMES 753 – Advanced Topics in Regenerative Medicine (3). The remarkable advances in biomaterials, stem cell biology, and genetic manipulation over the last several years have now made it possible to begin devising means of treating diseases that were previously incurable, and developing corrective therapies for crippling injuries. These advances have led to the emergence of the field of research/clinical investigation that is known as Regenerative Medicine, and this field promises to revolutionize the way we treat/manage both disease and injury. In this course, students will learn about the major organ/tissue systems of the body, the key enabling

technologies that make regenerative medicine possible, and how these technologies can be applied to each organ/tissue to mediate regeneration/repair to treat disease/repair injury. Students will then embark on projects that will require them to apply the knowledge gained from the lectures to develop realistic and clinically translational solutions to generate specific organs for transplantation. Students will present their projects to the class at the end of the term. *This course is cross listed as MCB 753. Typically offered in spring term, even years. P—BMES 631.*

BMES 771 – Radiological Physics (3). The nature and fundamental concepts of ionizing radiation including: ionizing radiation, radiation quantities, attenuation and stopping power, charged particle and radiation equilibria, radioactive decay, photon interactions, charged and uncharged particle interactions, x-ray production and quality, dosimetry concepts, ionization cavity theory, and calibration of ionizing radiation beams. *This course is cross listed as MPHY 771 and PHY 771. P—POI.*

BMES 773 – Radiation Therapy Physics (3). The physics of radiation treatment including: radiation producing equipment, character of photon and electron radiation beams, radiation dose functions, computerized radiation treatment planning, brachytherapy, special radiation treatment procedures, quality assurance, and radiation shielding for high energy facilities. *This course is cross listed as MPHY 773 and PHY 773. P—POI.*

BMES 774 – Ionizing Medical Imaging (2). The physical principles, mathematical algorithms and devices used in diagnostic medical imaging, covering the following imaging modalities: x-ray physics, x-ray digital imaging, digital image receptors, computerized tomography and reconstruction algorithms, ultrasound imaging, magnetic resonance imaging, and nuclear medicine imaging. *This course is cross listed as MPHY 774 and PHY 774.*

BMES 776 – Medical Health Physics of Radiation (3). Physical and biological aspects for the use of ionizing radiation in medical environments, biological consequences of human radiation exposure, principles of ionizing radiation protection, operational dosimetry, radiation exposure recommendations and regulations, physical principles of radiation shielding design, personnel monitoring, medical health physics instrumentation, and waste disposal. *This course is cross listed with MPHY 776 and PHY 776.*

BMES 778 – Radiation Biophysics (3). This course provides students with an overview of the biology of cancer and of the current methods used to diagnose and treat the disease. Lectures from faculty throughout the Biological Sciences Division will include presentations on cancer incidence and mortality, cancer prevention, a molecular biology perspective, the role of genetic markers, methods of treatment (radiation, chemotherapy) and prognosis. The course will be primarily for medical physics graduate students. *This course is cross listed as MPHY 778 and PHY 778.*

BMES 797, 798 – Research (1-9). *Satisfactory/Unsatisfactory.*

BIOMEDICAL RESEARCH (BMR)

Program Director	Tim Howard
Professors	Martha Alexander-Miller, Nichole Allred, Graça Almeida-Porada, Jamy Ard, Anthony Atala, Colin Bishop, Goldie Byrd, Ramon Casanova, Mark Cline, Laura Cox, Paul Czoty, Waldemar Debinski, Gagan Deep, James Eisenach, Clark Files, Cristina Furdui, William Gmeiner, Dwayne Godwin, Vijay Gorantla, Karen Haas, Rob Hampson, Greg Hawkins, Tom Hollis, Tim Howard, Allyn Howlett, Kylie Kavanagh, Sang Jin Lee, Todd Lowther, Tao Ma, Michael Olivier, Emmanuel Opara, Leslie Poole, Christopher Porada, Tom Register, Scott Rhodes, Edgar Alfonso Romero-Sandoval, John Sanders, Carol Shively, Joey Skelton, Shay Soker, Jeff Willey, Leah Solberg-Woods, Peiqing Sun, Saami Yazdani
Associate Professors	Rita Cervera-Juanes, Rong Chen, Tracy Criswell, Swapan Das, Jason Grayson, TanYa Gwathmey-Williams, Adam Hall, Christina Hugenschmidt, Ken Kishida, Steve Kridel, Nicole Levi, Baisong Lu, Giselle Melendez, Sean Murphy, David Ornelles, Scott Otallah, Kiran Solingapuram Sai, Neveen Said, Rebecca Sappington, Susan Sergeant, Yusuke Shiozawa, David Soto Pantoja, Andrew South, Allen Tsang, Ashley Weaver, Marlena Westcott
Assistant Professors	Eva Bach, Genesio Karere, Chia-Chi Chuang Key, Kristen Nicholson, Ellen Quillen, Kimberly Reeves, Jillian Urban, Kip Zimmerman
Adjunct Graduate Faculty	Andrew Bishop, Jason Roberge

Overview

The graduate program in Biomedical Science offers a program of study leading to the MS degree. This program is a full-time, graduate degree that is designed to help students with a bachelor's degree, preferably having majored in the sciences, improve their academic foundation in the biomedical sciences and improve their credentials for admission into PhD programs or entrance to the biomedical workforce. All students will take 20 core credit hours, a three-hour Ethics requirement, and one elective course.

Core courses are in disciplines that include molecular and cellular biosciences, pharmacology, scientific professionalism, responsible conduct of research, biostatistics, and career development. Elective credits are offered in a variety of

disciplines with the option for focused studies in addiction medicine, biomedical science, pharmacology, and molecular bioscience. Coursework will improve critical thinking skills, study skills, and enhance the student's preparation for professional schools or entrance to the workforce.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Degree Options

- Option 1 – **MS Degree with a Thesis:** Requires a minimum of 24 credit hours, including the 3-credit hour Ethics requirement, 21 credit hours in core coursework, and 6 credit hours of thesis (BMSC 796).
- Option 2 – **MS Degree with an Internship:** Requires a minimum of 24 credit hours, including the 3-credit hour Ethics requirement, 21 credit hours in core coursework, and 6 credit hours of internship (GRAD 703).
- Option 3 – **MS Degree without Thesis or Internship:** Requires a minimum of 36 credit hours, including the 3-credit hour Ethics requirement, and 33 credit hours from either the list of core coursework and electives or as approved by the program director. This option exists only for students wishing to exit a PhD program or other MS program without the completion of a thesis or internship.

Courses of Instruction

BMR 705/706 – Biomedical Research Journal Club (2). This journal club course is designed to introduce MS students to the evaluation of existing literature and improvement of presentation skills. Students will select primary data journal articles of interest to them, critically evaluate the articles, and then present the articles to the class. Participation and discussion are expected from the entire class. Each student is expected to present two to three articles throughout the course. *Satisfactory/Unsatisfactory*

BIOMEDICAL SCIENCE (BMSC)

Program Director	Andrew South
Professors	Nichole Allred, Alain Bertoni, Goldie Byrd, Lisa David, Nancy Denizard-Thompson, Steven Feldman, Lauren Fowler, Cristina Furdui, Kristen Hairston, Tim Howard, Allyn Howlett, Brenda Latham-Sadler, Dave Manthey, Amy McMichael, Michael Nader, Shahla Namak, Michael Olivier, Don Penzien, Rita Pichardo, Katherine Poehling, Scott Rhodes, Jimmy Ruiz, John Sanders, Avi Shetty, Joey Skelton, Shay Soker
Associate Professors	Parissa Ballard, Callie Brown, Tracy Criswell, Ashton Chen, Michelle Curtin, Robert Gould, Giya Harry, Christina Hugenschmidt, Nicole Levi, Candice McNeil, Christopher Miles, David O'Brien, Scott Otallah, Candace Parker-Autry, Jamehl Shegog, Andrew South, Allen Tsang
Assistant Professors	Kiri Bagley, Leah Chapman, Liliane Ernst, Megan Irby, Laura Lintner, Matt Lisi, Xue Ma, Matthew Martin, Ellen McGinnis, Rebecca Palmer, Tom Perrault, Chris Schaich, Elizabeth Shilling, Nick Trasolini, Andrea Triplett, Chinenye Usoh, Rachel Zimmer
Adjunct Graduate Faculty	Keyma Clark, Rachel Conway, Artina Dawkins, Mohamed Essa, Tonya Fulton Henighan, John Laisure, Carla Lema-Tomé, Olivia Mills, Shannon Moran, Bita Nickkholgh, Jason Roberge, Bernard Roper, Leah Snipe, Chris York

Overview

The graduate program in Biomedical Science offers a program of study leading to the MS degree. This program is a full-time, graduate degree that is designed to help students with a bachelor's degree, preferably having majored in the sciences, improve their academic foundation in the biomedical sciences and improve their credentials for admission into health professional programs, including medical and physician assistant schools. All students will take 24 core credit hours and 6 capstone credit hours, with the option to take additional electives. Courses are in disciplines that include biochemistry, anatomy, human physiology, pharmacology, epidemiology, professionalism, health inequity, clinical reasoning, and medical career development. Elective credits are offered in a variety of disciplines both within and outside of the BMSC program with the option for focused studies in genetics and human development, addiction medicine, and clinical trial investigations. Coursework will improve critical thinking skills, study skills,

and enhance the student's preparation for professional schools or entrance to the workforce.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Academic advising is provided to all students by faculty academic coaches.

Degree Options

- Option 1 – **MS Degree with Capstone Project:** Requires a minimum of 24 credit hours, including the 2-credit hour Ethics requirement, 22 credit hours in core coursework, and 6 credit hours of capstone project.
- Option 3 – **MS Degree without a Capstone Project:** Requires a minimum of 36 credit hours, including the 2-credit hour Ethics requirement, and 34 credit hours from either the list of core coursework and electives or as approved by the program director. This option exists only for students wishing to exit the program who are deemed unable to complete the capstone project.

Courses of Instruction

BMSC 620 – Roots of Health Inequity (1). The Roots of Health Inequity course is designed to examine the social processes that produce health inequities in the distribution of disease and illness. In this course, students will strategize more effective ways to act on the root causes of health inequity and discuss approaches to remove health inequities. A combination of online modules and in-class discussions will be used. This course is recommended for all Biomedical Science Pre-Health students. *Typically offered in summer terms.*

BMSC 700 – Independent Study (1-9). This course allows an interested student to pursue a topic covered in another class in greater depth under the guidance of a faculty member. The faculty member will work with the students to clarify the expectations; usually the course requires a combination of extensive reading, tutorial sessions, and a written paper. *May be repeated.*

BMSC 701 – Career Development in the Health Sciences (1). This seminar course will expose students to a variety of professions in the healthcare field. Presentations will be conducted by professionals in their respective fields. Students will also participate in group research projects investigating different healthcare professions, with the goal of examining team-based healthcare. This course will also examine effective tools to further professional development, and students will be required to complete an Individualized Development Plan (IDP). *Satisfactory/Unsatisfactory.*

BMSC 702 – Medical Career Path (1). This course is designed for individualized career exploration, serves as an adjunct to career mentoring and provide students with a reasonable path/map for career goals. They will learn about professionalism, explore real life opportunities for building their professional portfolio and pathway to medical licensure and practice of medicine. *Satisfactory/Unsatisfactory.*

BMSC 706 – Problem Based Learning (2). Small group sessions designed to integrate history taking skills and basic science into more advanced clinical reasoning. Students will be asked to use patient history, as well as laboratory data and imaging to solve weekly cases. In addition to topics on ethics, professionalism and the doctor-patient relationship, issues regarding health equality and high value health care will be discussed. A combination of case studies, reading assignments, course notes, group discussion and group presentations will be used. This course is required for all students.

BMSC 707/708 – Topics in Biomedical Science (1-6). This course will consider current topics in Biomedical Science that are not considered in regular courses. Course requirements and grading may be based on participation in written assignments or hands-on projects. Content will vary.

BMSC 709 – Special Topics (1-9). Designed for a group of students interested in a timely topic, or in a topic not covered in other coursework. This course may also be used to test a new course prior to its incorporation into the standing curriculum. *May be repeated*.

BMSC 710 – Human Gross Anatomy (4). A regional and systemic approach to the study of human gross anatomy, incorporating cross-sections, x-ray films, CT and MRI scans with clinical implications. *Course fees may apply. Typically offered in spring terms.*

BMSC 711 – Medical Genetics (3). Introduction to the principles and clinical evaluation of human genetic diseases. Covers modes of inheritance, etiology, characteristics, epidemiology, pathogenesis, and clinical features of a wide variety of medical genetic disorders. Procedures for diagnostic confirmation (cytogenetic, molecular, biochemical), considerations for management, and aspects of genetic counseling are presented. Advanced math skills, specifically an understanding of probability and basic statistics, are encouraged. *Typically offered in fall terms.*

BMSC 712 –Applied Biochemistry (3). Conducted as a combination of lectures, case studies, reading assignments, course notes, and group conferences. The sequence of topics is a) protein structure, b) enzyme mechanisms, c) bioenergetics, d) signal transduction, e) intermediary metabolism and f) interorgan metabolism. The principles of each topic are discussed in relation to clinical disease entities, e.g., protein structure: hemoglobin/sickle cell anemia/sickle cell hemoglobin/sickle cell disease due to abnormal hemoglobin structure. *Typically offered in summer and fall terms.*

BMSC 713 – Applications of Epidemiology (3). This course is designed to give students an introductory understanding of the concepts of epidemiology as it applies to public health. The course will also help students understand and evaluate the research reported by others and apply epidemiologic concepts to public health practice. The course will cover topics such as measures of disease occurrence and association, epidemiologic study design, threats to validity, data interpretation, and reporting research results. Application of epidemiological principles to contemporary public health challenges will be introduced throughout the course. *Typically offered in spring terms.*

BMSC 721 – Cellular and Molecular Biology of Medicine (3). Foundation of Clinical Pharmacology is a 3-credit hour course designed as a basic translational scientific course to provide pre-health students a strong foundation in basic concepts of pharmacology necessary for clinical practice. This course is specifically designed for pre-health master students who would like to pursue medicine as medical doctors or physician assistants. The students who enroll in this course should have basic knowledge of biochemistry to be able to understand the lectures and class discussions. This course discusses the Drug-receptor concept, pharmacokinetics, drug metabolism and transport, pharmacodynamics, pharmacogenomics, assessment of drug effects, drug interaction, drug therapy in special populations, and drug discovery and development.

BMSC 723 – Foundations of Clinical Neuroanatomy (3). Foundations of Clinical Neuroanatomy is a 3-credit hour course designed to introduce students in the pre-health program to the structure, organization, and function of the human nervous system, with application both to clinical reasoning and basic science inquiry. Students should have a strong foundation in biology, anatomy and physiology; organic, and biochemistry. This 16-week course will explore neuroanatomy from the cellular to systems level, focusing on anatomical and functional divisions, neuroanatomical circuits and how communication between them is mediated, as well as how perturbations to these system at any level can lead to clinical deficits.

BMSC 724 – Clinical System Physiology (4). This course provides a general foundation of human physiology in normal and diseased conditions alongside the related pharmacological targeting principles. The course is composed of five units targeting clinical physiology broadly in major organ systems. The topics of this course included the cardiovascular, respiratory, immune, endocrine, kidney and genitourinary, gastrointestinal, and neural systems, as well as the basics of regenerative physiology and stem cells.

BMSC 792 – Capstone Catalyst I (2). This course is the first of a three-course series that prepares students to identify a problem in a healthcare-relevant area and conceptualize, design, and implement a solutions-based Capstone Project in partnership with key stakeholders that has real-world applicability to improve health. Students work collaboratively with peers, colleagues, and their mentor to integrate various perspectives across sectors to develop possible solutions to the identified challenge. Students draw upon knowledge and skills from their career and coursework with an emphasis on team-based problem solving, consideration of ethical implications, communicating effectively, and developing feasible, sustainable, and transformative solutions. The course is designed to support new students as they develop their Capstone Project as well as current students as they implement and disseminate their Capstone Project. *Satisfactory/Unsatisfactory*.

BMSC 793 – Capstone Catalyst II (2). This course is the second of a three-course series that prepares students to identify a problem in a healthcare-relevant area and conceptualize, design, and implement a solutions-based Capstone Project in partnership with key stakeholders that has real-world applicability to improve health. Students work collaboratively with peers, colleagues, and their mentor to integrate various perspectives across sectors to develop possible solutions to the identified challenge. Students draw upon knowledge and skills from their career and coursework with an emphasis on team-

based problem solving, consideration of ethical implications, communicating effectively, and developing feasible, sustainable, and transformative solutions. The course is designed to support new students as they develop their Capstone Project as well as current students as they implement and disseminate their Capstone Project. *Satisfactory/Unsatisfactory*.

BMSC 794 – Capstone Catalyst III (2-9). This course is the third of a three-course series that prepares students to identify a problem in a healthcare-relevant area and conceptualize, design, and implement a solutions-based Capstone Project in partnership with key stakeholders that has real-world applicability to improve health. Students work collaboratively with peers, colleagues, and their mentor to integrate various perspectives across sectors to develop possible solutions to the identified challenge. Students draw upon knowledge and skills from their career and coursework with an emphasis on team-based problem solving, consideration of ethical implications, communicating effectively, and developing feasible, sustainable, and transformative solutions. The course is designed to support new students as they develop their Capstone Project as well as current students as they implement and disseminate their Capstone Project. *Satisfactory/Unsatisfactory*.

CANCER BIOLOGY (CABI)

Program Director	Ravi Singh
Professors	Waldemar Debinski, Gagan Deep, Cristina Furdui, William Gmeiner, Karen Haas, Greg Hawkins, William Hinson, Greg Kucera, Frank Marini, Lance Miller, Tim Pardee, William Petty, Shay Soker, Peiqing Sun, Pierre Triozzi, Kounosuke Watabe, Konstantinos Votanopoulos, Wei Zhang, Dawen Zhao
Associate Professors	David Caudell, Katherine Cook, Lawrence Druhan, Kelsey Fisher-Wellman, Steve Kridel, Liang Liu, Linda Metheny-Barlow, Xin Ming, Sean Murphy, David Ornelles, Jai Patel, Neveen Said, Yusuke Shiozawa, Ravi Singh, David Soto Pantoja
Assistant Professors	Elizabeth Alli, Guangxu Jin, Ashish Kumar, Fei Xing

Overview

The Cancer Biology graduate program was established in 1997. The graduate training program is designed to prepare students for future research careers focused on the issues relevant to human cancer. Applicants must have completed college-level fundamental courses in biology, and general and organic chemistry. Courses in physics and mathematics through calculus are encouraged but not required.

Students enter the Cancer Biology training program through the Molecular and Cellular Biosciences (MCB) track. During the first year, in addition to the MCB common curriculum, students considering the Cancer Biology training program should consider taking one or more of the following electives: MCB 721 Basic Concepts in Cancer Biology, MCB 722 Basic Concepts in Cancer Research, and MCB 723 Topics in Cancer Biology. If not taken as electives in Year 1, students matriculating in the Cancer Biology training program will be required to complete these courses in subsequent years. Additional coursework in subsequent years will include Advanced Topics in Cancer Biology, Statistical Experimental Design, Cancer Cell Biology, Tutorials in Cancer Biology, and elective courses of the students' choice. Students also participate in the Cancer Biology seminar series.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Courses of Instruction

MCB Track Electives

MCB 721 – Basic Concepts in Cancer Biology (2). This course will cover fundamental concepts in cancer biology including etiology, genetic abnormalities, gene expression reprogramming, signal transduction aberration, and stem cell regulation in various tumor types, such as cancers of the breast, prostate, lung, CNS, lung, ovary, and bladder. *The course is open to all students.*

MCB 722 – Basic Concepts in Cancer Research (2). Over the last half century scientists have generated a complex body of knowledge illuminating the origins of cancer and revealed it to be a dynamic interplay between the genome and the cellular environment. MCB 722 is a hypothesis-driven and problem solving-based course that explores this interplay and the requirements for malignant transformation. This course is offered in the spring term. *The course is open to all students in thesis driven tracks and required for all graduate students in cancer biology (CABI). Students not performing thesis research are able to register but should recognize the course requires an understanding of experimental design and data analysis for course assignments.*

MCB 723 – Topics in Cancer Biology (2). Teaches students how to evaluate and communicate scientifically in the area of cell biology and cancer. Examples are taken from all areas of cancer in this advanced course. Uses current peer-reviewed journal articles to teach fundamental concepts and act as a medium for allowing the students to communicate ideas with an emphasis on presentation skills. *Typically offered in the spring term. Intended for all graduate students in cancer biology (CABI), open to students in other tracks or programs.*

CABI Advanced Courses

CABI 701/702 – Cancer Biology Seminar Series (1). The course will consist of weekly student and postdoctoral presentations to the Cancer Biology faculty and their peers based on their ongoing research projects. Required of all students who matriculate in Cancer Biology starting in their second year and continuing throughout their training period. Students and postdoctoral fellows will be expected to present at least once per year. Emphasis will be based on developing presentation skills and learning to critique colleagues in a professional manner. *Satisfactory/Unsatisfactory.*

CABI 705 – Cancer Cell Biology (3). This is an intensive treatment to learn how to critically review the literature and requires the writing of a proposal that is critically reviewed. The course covers apoptosis, cell-cycle, angiogenesis, cancer genomics, metastasis, cancer immunology, and tumor suppressor genes. The translational aspects of research are emphasized.

CABI 707/708 – Topics in Cancer Lecture Series (1). A weekly lecture series taken during the second year. Each week throughout the fall and spring terms, a different topic in the clinical presentation, course, and treatment of human malignancies is presented. Designed to be a comprehensive overview of clinical oncology for clinical medical and radiation oncology fellows and cancer biology graduate students. *Satisfactory/Unsatisfactory.*

CABI 711/712 – Advanced Topics in Cancer Biology (1). Focuses on new and important aspects of research in cancer biology with an emphasis on the current

literature. Themes are chosen by the course director and a topic is selected for presentation by each student. With the help of a faculty expert on the assigned topic, the student prepares a short lecture on a recent, high-impact cancer research article and leads a discussion of key experimental findings. Broad participation from faculty, postdoctoral fellows, and graduate students is encouraged. *Satisfactory/Unsatisfactory*.

CABI 713/714 – Cancer Biology Tutorials (2). Focuses on specific topics related to cancer predisposition, development, progression, and treatment. Topics include, but are not limited to, DNA damage and repair, damage signaling, cell death response, cell cycle checkpoint control, animal models and cancer treatment. The purpose of the tutorial is to provide an opportunity to discuss one of the above-mentioned topics in more detail than is possible in an overview-based lecture. The topic for upcoming terms will be determined by the faculty. The class is a combination of lectures providing background information and student presentations introducing specific topics and related research articles in the field, followed by group discussions. Attendance and at least one full-length presentation are mandatory to obtain credit.

CABI 716 – Special Topics: Teaching in the Small Group Setting (2). Teaches students how to use a problem-based interactive approach to facilitate student self-learning. Introduces students to general methods of teaching with a focus on teaching in the small group setting of a literature-based course. Topics covered include teaching skills for reading scientific papers, oral presentation techniques, and scientific writing. Each student facilitates two weeks (4 class sessions) of the course including in-class participation as well as assisting with the written evaluation portion of the class.

CABI 718 – Introduction to Radiation Biology (3). Focuses on the biological changes which follow the interaction of ionizing and non-ionizing radiation with living matter. Emphasis is on the role of ionizing radiation in the treatment of cancer, mechanisms of radiation-induced carcinogenesis, and changes in normal and tumor cells at the molecular, cellular and tissue levels.

CABI 723/724 – Research in Cancer Biology (1-9). Opportunities for investigation in a variety of facets of cancer biology under the guidance of staff members. *Satisfactory/Unsatisfactory*.

CABI 730 – Approaches to Cancer Prevention and Treatment (2). This elective course will offer an overview of various methods to intercept cancer. The overall goals are to provide a mechanistic understanding of current anti-cancer strategies and to introduce tools for the discovery and development of novel approaches. It is intended for graduate students interested in 1) relating basic science mechanisms to preventing or treatment cancer, 2) exploring translational cancer research, and/or 3) understanding the clinical applications of anti-cancer drugs. *P—MCB 701 and MCB 702 (or equivalent) or POI*.

CABI 740 – Omics Data: Generation, Analysis & Exploration (3). This course will provide a firm foundation in central concepts related to large-scale "omics" data generation, structure, analysis and mining. An emphasis will be placed on teaching students' practical know-how via familiarization with robust tools and data resources. Topics to be covered in blocks: 1) basic introduction to R programming and utilization of

common R scripts for data generation and visualization; 2) germline/somatic mutation detection and analysis, common tools and public data repositories; 3) transcriptomics, including RNAseq and single cell RNAseq, clustering and gene ontology enrichment analysis, TCGA/GDC, cBioPortal and FireBrowse tools and data repositories; 4) epigenetics, including DNA methylation detection and analysis, and Chip-Seq/ENCODE resource; 5) proteomics/metabolomics; and 6) functional genomics approaches, CRISPR/Cas9, and gene discovery. *P- POI*.

CLINICAL RESEARCH MANAGEMENT (CRM)

Program Director	Ralph D'Agostino Jr.
Professor	Ralph D'Agostino Jr.
Associate Professor	Elizabeth Jensen
Assistant Professor	Lucy McGowan
Adjunct Graduate Faculty	Allison Booth, Dan Fogel, Lyn Hardy, Carol Hayes, Jim Kremidas, Carla Lema-Tomé, Beth Loots, Patrick McGowan, Rebecca Neiberg, Mary Shatzoff, Mary Veazie

Overview

Clinical research management is a vast and expanding field that involves the processes by which products (drugs, devices, biologics) and treatment protocols are developed to improve patient care. Clinical research management continues to evolve into a more global and complex set of integrated research and business processes. This online Master of Science in Clinical Research Management (CRM) program will provide participants with state-of-the-art information on clinical, regulatory and business requirements in the development of new therapeutics and conduct of clinical trials. Designed for working clinical research professionals, or those in a related field, this degree program expands participants' knowledge of drug and medical device development, clinical trial conduct, monitoring, and the business, ethical and legal perspectives of the clinical research industry.

The Master of Science in Clinical Research Management (CRM) online program will be an accelerated, intense course of study focused on leading transformative change in the clinical research industry as well as the National Institutes of Health (NIH) supported clinical research environment. The program's faculty and participants will have deep experience in the clinical research industry and will be fully engaged in addressing the gaps and constraints of the current clinical research system as we look at our systems and others around the globe. The material will be tailored to this industry for current and future leaders. This program will provide a range of learning experiences that add up to a powerful transformative experience.

Clinical research management includes studies in the following areas:

1. Scientific Concepts and Research Design
2. Ethical and Participant Safety Consideration
3. Medicines Development and Regulation
4. Clinical Trials Operations (GCPs)
5. Study and Site Management

6. Data Management and Informatics
7. Leadership and Professionalism
8. Communication and Teamwork

A minimum requirement of 20 months of part-time online work will be needed for the master's degree. Students will learn to explore the commercial and ethical dimensions of medical innovation and be prepared to lead in clinical research while earning 35 credit hours.

The program will culminate with the Capstone Experience in which students will complete an independent or group project that spans the duration of the CRM program. We ask each participant to identify a critical challenge related to healthcare while applying to the CRM program and confirm the selection early in their coursework. The challenge could relate to his/her organization or to a personal interest. Throughout the CRM, each student will work collaboratively with a variety of people including their CRM peers, professional colleagues, course faculty, advisors, and chairs, integrating various perspectives across healthcare sectors to develop possible solutions to his/her challenge.

Participants draw upon knowledge and skills from their coursework with an emphasis on collaborating across healthcare sectors, considering strategic and ethical implications, communicating effectively and developing feasible, viable, and transformative solutions.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: Students are required to take a minimum of 35 graduate course credit hours, with 4 hours in an elective area. Students are required to take the following set of courses:

CRM 701, CRM 702, CRM 703, CRM 704, CRM 711, CRM 712, CRM 715, CRM 721, CRM 722, CRM 731, and CRM 732

Courses of Instruction

CRM 701 – Research Design and Methods in Clinical Research (3). The Research Design and Methods in Clinical Research course addresses scientific, clinical, and regulatory concepts required in medical agent and/or device development. Students will explore ethical design and methods used in clinical research, measurement issues in conducting research across diverse populations, and appropriate statistical measurement and analysis for given study designs. Issues concerning practical considerations and rare disease studies will also be included. Intended for all graduate students in Clinical Research Management (CRM). This course is cross listed as GRAD 731.

CRM 702 – Data Analysis and Interpretation in Clinical Research (3). The Data Analysis and Interpretation in Clinical Research course introduces the principles of

biostatistical methods used in biomedical and public health research. Analysis of clinical trials data and interpretation of statistical results in biomedical studies will be emphasized. Intended for all graduate students in Clinical Research Management (CRM). This course is cross listed as GRAD 732.

CRM 703 – Leadership and Professionalism I (1). The Leadership and Professionalism I course covers essential skills and knowledge areas related to clinical research management. Participants assess their own leadership skills and knowledge and develop a specific plan for leadership skills development. This course also develops skills for team management and leading an organization toward goals accomplishment. Participants acquire knowledge and develop skills through case studies, experimentation with their own behaviors, and feedback from faculty and peers. Intended for all graduate students in Clinical Research Management (CRM).

CRM 704 – Leadership and Professionalism II (1). The Leadership and Professionalism II course covers essential skills and knowledge areas related to organizational and external leadership in clinical research management. Participants will gain knowledge to develop a specific plan for enhancing their leadership skills and using them to influence the industry. These skills include recognizing themselves as a leader outside their organization to impact public health via engaging politically and socially - often requiring courage to challenge the status quo. Participants acquire knowledge via a series of interviews with industry thought leaders who share their personal journey and experiences. Intended for all graduate students in Clinical Research Management (CRM). *P—CRM 703.*

CRM 711 – Ethical and Participant Safety Considerations (3). The Ethical and Participant Safety Considerations course examines clinical trials management topics within an ethical context. Ethical issues confronted by most organizations and the approach to ethical decision making are discussed. Topics include conducting research with vulnerable populations, conflict of interest, and scientific misconduct. The course may also provide opportunities for students to develop the ethical aspects of any study protocols, journal publications, or scientific presentations they prepare in other courses in the program. Intended for all graduate students in Clinical Research Management (CRM).

CRM 712 – Medicines Development, Regulation, Industry (3). The Medicines Development, Regulation, Industry course explores legal and regulatory decision making as well as the structure and role of key U.S. and international regulatory bodies. Participants explore how healthcare is regulated. Risk management, public health, and product/drug regulations are discussed. Other topics include changes to health care and advancement in technology. Intended for all graduate students in Clinical Research Management (CRM).

CRM 715 – Capstone Experience I (1). The Capstone Experience course is an independent or group project that spans the duration of the Clinical Research Management graduate program. Students enroll in part 1 (CRM 715) during the 2nd

term, part 2 (716) during the 3rd term, part 3 (717) during the 4th term, and part 4 (718) during the 5th term. Participants identify a critical challenge related to healthcare and work collaboratively with peers, colleagues, course faculty, advisors, and chairs to integrate various perspectives across healthcare sectors and develop possible solutions to the identified challenge. Participants draw upon knowledge and skills from their coursework with an emphasis on collaborating across healthcare sectors, considering strategies, and ethical implications, communicating effectively, and developing feasible, viable, and transformative solutions. Intended for all graduate students in Clinical Research Management (CRM).

CRM 716 – Capstone Experience II (1). The Capstone Experience course is an independent or group project that spans the duration of the Clinical Research Management graduate program. Students enroll in part 1 (CRM 715) during the 2nd term, part 2 (716) during the 3rd term, part 3 (717) during the 4th term, and part 4 (718) during the 5th term. Participants identify a critical challenge related to healthcare and work collaboratively with peers, colleagues, course faculty, advisors, and chairs to integrate various perspectives across healthcare sectors and develop possible solutions to the identified challenge. Participants draw upon knowledge and skills from their coursework with an emphasis on collaborating across healthcare sectors, considering strategic and ethical implications, communicating effectively, and developing feasible, viable, and transformative solutions. Intended for all graduate students in Clinical Research Management. *P – CRM 715*

CRM 717 – Capstone Experience III (1). The Capstone Experience course is an independent or group project that spans the duration of the Clinical Research Management graduate program. Students enroll in part 1 (CRM 715) during the 2nd term, part 2 (716) during the 3rd term, part 3 (717) during the 4th term, and part 4 (718) during the 5th term. Participants identify a critical challenge related to healthcare and work collaboratively with peers, colleagues, course faculty, advisors, and chairs to integrate various perspectives across healthcare sectors and develop possible solutions to the identified challenge. Participants draw upon knowledge and skills from their coursework with an emphasis on collaborating across healthcare sectors, considering strategic and ethical implications, communicating effectively, and developing feasible, viable, and transformative solutions. Intended for all graduate students in Clinical Research Management. *P – CRM 716*

CRM 718 – Capstone Experience IV (3). The Capstone Experience course is an independent or group project that spans the duration of the Clinical Research Management graduate program. Students enroll in part 1 (CRM 715) during the 2nd term, part 2 (716) during the 3rd term, part 3 (717) during the 4th term, and part 4 (718) during the 5th term. Participants identify a critical challenge related to healthcare and work collaboratively with peers, colleagues, course faculty, advisors, and chairs to integrate various perspectives across healthcare sectors and develop possible solutions to the identified challenge. Participants draw upon knowledge and skills from their coursework with an emphasis on collaborating across healthcare sectors, considering

strategic and ethical implications, communicating effectively, and developing feasible, viable, and transformative solutions. Intended for all graduate students in Clinical Research Management. *P – CRM 717*

CRM 721 – Clinical Operations and Project Management (3). The Clinical Operations and Project Management course integrates project management principles and clinical operations by exploring regulatory, policy, ethical, and practical considerations associated with the engagement, recruitment, retention, and interaction with human research subjects. Operational planning of clinical trials is discussed, including budgeting, study timeline, site evaluation and selection, study initiation, content and timing of monitoring visits, quality assurance, study closure procedures, decision-making models, cross cultural competency, and interdisciplinary team dynamics. Intended for all graduate students in Clinical Research Management (CRM). *P—CRM 701 or POI*.

CRM 722 – Clinical Studies Development (2). The Clinical Studies Development course examines the nonclinical, clinical, commercial, regulatory, and risk assessment strategies required to develop a clinical development plan for an approvable, marketable new therapeutic or device. Intended for all graduate students in Clinical Research Management (CRM).

CRM 731 – Quality Systems and Risk Management (3). The Quality Systems and Risk Management course explores how to manage risk and safety assessments to ensure quality in clinical research. Students will examine how management concepts and training methods are used in managing risk and ensuring quality. Other topics include post marketing for new products and data quality assurance methods. Intended for all graduate students in Clinical Research Management (CRM).

CRM 732 – Data Management and Informatics (3). The Data Management and Informatics course provides an introduction to database design, data management, quality assurance and technology assessment in clinical research administration and conduct. Topics include understanding budgets and calendars for clinical trials, methods for tracking participants and corresponding data, complexities of ethical data management, and evaluation of data sources and data quality. Intended for all graduate students in Clinical Research Management (CRM).

Electives for Strategic Leadership/Communications Concentration

CRM 751 – Conflict Resolution and Negotiations (2). This course studies key management concepts and roles of management and how they apply in successful, dynamic organizations. Students will examine the competencies of effective managers in developing customer focus, planning, selecting and developing individuals and teams, communicating, managing resources, using technology and being adaptable. Additional topics include the theory and process of effective negotiation and various team building and conflict resolution strategies in a variety of contexts.

CRM 752 – Design Thinking (2). In this course, participants will learn how to solve complex business challenges and promote industry leadership with a systematic approach to creativity and innovation. Design will be used as a practical, everyday process to spur innovation, organic organizational growth, and effective strategy implementation. Topics include the best procedures for generating and testing concepts, how to engage customer feedback and solicit new ideas, and testing assumptions to discover which problems/solutions matter the most to customers.

CRM 753 – Business Communication Skills for Healthcare Professionals (2). This course focuses on developing effective business communication skills for professionals in managerial/senior roles in healthcare and life sciences. The course is focused on students leveraging sound critical analysis to craft dynamic, persuasive presentations to address a business question. Students will be exposed to the theoretical underpinning of logical reasoning to provide the philosophical basis for constructing sound and valid arguments. The theoretical components will then be used as a foundation for practical application throughout the remainder of the course. The practical aspect of the course focuses on preparing students to integrate presentation software (Microsoft PowerPoint) to enhance the efficacy of presentations and arguments. In conjunction with the technological focus, the course will require students to analyze their own communication style with the purpose of striving to maximize the effectiveness of each student's individual strengths. The course culminates in students presenting a clinically focused business case using the skills developed in the course. On-the-job examples from each participant's workplace are used throughout the course.

Electives for Operations Concentration

CRM 761 – Project Management (2). This course integrates project management principles, decision-making models, cross cultural competency, and interdisciplinary team dynamics to facilitate effective and efficient conduct of clinical trials. The curricula is designed to take participants through the entire life cycle of a project, while assessing organizational, cultural, and personnel factors that influence successful clinical trial performance.

CRM 762 – Financial Management for Clinical Research Professionals (2). This course focuses on the area of financial management as applied to healthcare and life sciences organizations. The emphasis in this course is to apply the principles and concepts of financial management to health and life science providers that represent innovative new structures and organizations, such as Accountable Care Organizations (ACOs) offering integrated patient care. Participants will gain competency in the application of financial and analysis tools and techniques internationally through a case study approach. Upon completion of this course, participants will be able to utilize a comprehensive range of tools and techniques that can assist them in future financial decision making in complex, multinational healthcare and life science organizations.

CRM 763 – Technical Writing for the Regulatory Professional (2). This course focuses on the technical writing skills required for the regulatory professional. Students

will construct coherent written regulatory documents using “Plain Language” techniques, synthesize valid, scientific information to support regulatory decisions, and appraise supporting regulatory documents and exhibits for appropriate use in argument development. Additional topics include how to constructively critique, evaluate, and revise written documents and oral presentations.

GENETIC COUNSELING (GENC)

Program Director	Emily Lisi
Program Assistant Director	Lauren Baldwin
Medical Director	Amelia Kirby
Professors	Nichole Allred, Tim Howard
Associate Professors	Caitlin Allen, Katie Duckworth, Amelia Kirby
Assistant Professor	Emily Lisi
Adjunct Graduate Faculty	Aly Athens, Alexandra Bailey, Lauren Baldwin, Peggy Berry, Daragh Conrad, Karen Corneliussen, Kristen Deak, Shelley Dills, Adel Gilbert, Mariah Gleason, Megan Irby, Dana Mittag, Gretchen Rosso, Christy Stanley, Thuy My Vu, Kelly Warsinske

Overview

The Genetic Counseling graduate program at Wake Forest University is designed to train students for a healthcare career in genetic counseling. The program involves didactic curriculum, clinical rotations, and a capstone research requirement. Students will attain a deep understanding of the etiology and pathogenicity of hereditary disease, clinical genetic and genomic testing strategies, and current bioethical issues associated with advances in genomic medicine. Additionally, students will develop advanced counseling skills needed to facilitate patient decision-making and assist patients in adapting to genetic disease. Progression of clinical skill development will be achieved through rotations through various clinical settings throughout the region which are supervised by certified genetic counselors. The capstone requirement for this degree has two options: a clinical research track and a community outreach track. The former involves conducting a clinical research study and disseminating the results in a publishable manuscript, while the latter involves planning and implementing a genetics education or advocacy project to meet an identified need in the community. At graduation, students will have developed the Practice-Based Competencies required by the Accreditation Council of Genetic Counseling (ACGC) and will be prepared to take the American Board of Genetic Counseling (ABGC) certification exam. This program will emphasize critical review and reflection of the current practice of genetic counseling and how genetic counselors can best meet the growing need for patient education and support surrounding genomic medicine now and in the future.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Courses of Instruction

GENC 701 – Introduction to Genetic Counseling (2). Introduction to the foundations of genetic counseling with an emphasis on practical skill development. Topics to include history of the practice, code of ethics, pedigree drawing and analysis, risk assessment, contracting with clients, agenda development, genetic counseling focus areas, and technologies used in genetic counseling practice. Includes clinical observations. *P – POI. This course is only open to Genetic Counseling MS students.*

GENC 705 – Professional Issues in Genetic Counseling (2). A seminar course developed to address professional issues that arise as a practicing genetic counselor, including professionalism, job searching, CV development, negotiation techniques, billing and reimbursement, stress management, and self-care techniques. *P - GENC 701.*

GENC 711 – Human Genetics for the Genetic Counselor (3). This course will provide instruction on the principles of human genetics pertinent for the genetic counseling profession, including Mendelian and non-Mendelian inheritance, the central dogma, population and quantitative genetics, complex diseases, human variation and disease susceptibility, risk analysis, and mechanisms of cytogenetic abnormalities. *P – POI.*

GENC 713 – Prenatal Genetics (3). This 2-credit course (half-term) provides an introduction to the practice of prenatal genetic counseling, including typical pregnancy experiences, indications for referral, preconceptual and prenatal screening modalities, prenatal diagnostic testing, ultrasound anomalies, teratogenic exposures, assisted reproductive technologies, and fetal therapy. *C - GENC 721.*

GENC 714 – Psychosocial Impact of Genetic Disease (3). This course supports the development of more advanced counseling skills, with emphasis on genetic counseling strategies and techniques and appreciation of psychosocial impacts of genetic disease across the lifespan, dynamics of grief and bereavement, and crisis intervention. *P - GENC 701 and ARCH 703, or POI.*

GENC 716 – Genes, Environment, and the Developing Human I (2). This is the first course in a two-part course series that addresses development and cognitive processes governing learning from conception to death with an emphasis on the implications and the treatment of genetic disorders. Normative, non-normative and historical effects within childhood, adolescence, adulthood, and later life are presented. Formal developmental and learning theory is emphasized in conjunction with practical interpretation and application. The course provides an orientation and background for sound educational and clinical practices. *P – POI for non-GENC students.*

GENC 717 – Genes, Environment, and the Developing Human II (2). This is the second course in a two-part course series that addresses development and cognitive

processes governing learning from conception to death with an emphasis on the implications and the treatment of genetic disorders. Normative, non-normative and historical effects within childhood, adolescence, adulthood, and later life are presented. Formal developmental and learning theory is emphasized in conjunction with practical interpretation and application. The course provides an orientation and background for sound educational and clinical practices. *P – POI for non-GENC students.*

GENC 718 – Clinical Genetic Testing in the 21st Century (2). This course is designed to give students an in-depth understanding of the process and applicability of clinically available genetic testing, including cytogenetic testing (karyotype, chromosomal microarray, SNP array), molecular genetics (Sanger sequencing, Next generation sequencing, Panel testing, whole exome/genome sequencing), and biochemical testing strategies. Emphasis will be placed on available bioinformatics strategies for variant interpretation. The role of the genetic counselor in the clinical laboratory will also be explored. *P – POI.*

GENC 721 – Embryology and Abnormal Fetal Development (2). This half-term course covers human development from fertilization to birth through the lens of a genetic counselor. The influence of genes, gene variants, epigenetics, and teratogens will be explored. Topics will include how these influences impact normal and abnormal development in embryogenesis, neural tube folding, limb formation, cardiac maturation, craniofacial and musculoskeletal development. Emphasis will also be placed on fetal anomalies that are identified in prenatal screening. This class will be held online with both live virtual classes and online learning. *C - GENC 713.*

GENC 722 – Basic Concepts in Cancer Genetic Counseling (3). This course will cover fundamental concepts in cancer biology including etiology; genetic abnormalities; gene expression reprogramming; cancers of the breast, ovary, and colon, etc. The course will provide emphasis on the practice of oncology and hereditary cancer syndromes and their management. *P - GENC 701 or POI.*

GENC 725 – Ethics in Genetic Counseling Practice (2). This course is designed for genetic counseling students to learn the basics of bioethical principles and how they are applied directly to genetic counseling practice. A variety of ethical concepts will be discussed in the context of common moral issues in health care at the beginning and end of life as well as issues arising as a result of current genomic technologies. Important over-arching themes in clinical care will be reviewed, including privacy and confidentiality, informed consent, resource stewardship, and social determinants of health. *P-POI*

GENC 732 – Precision Medicine and the Future of Genomics (2). Seminar course discussing current hot topics in genetics and genomics and future directions of the field of genetic counseling using recently published journal articles and societal position statements. Topics will include epigenetics, pharmacogenomics, metabolomics, studies of the microbiome, and gene editing. Includes both didactic instruction from

faculty as well as student literature review and presentation on relevant topics. *P - GENC 701 and GENC 711, or POI.*

GENC 734 – Healthcare Delivery Systems/Public Health (2). Designed to help students develop an appreciation for current health and social policy, local and national public health resources, population-based screening methods and their impact, and healthcare delivery and insurance models both in the United States and internationally. Includes lectures from experts in the field and potential implications on changes to healthcare policies. *P – POI.*

GENC 742 – Medical Genetics I (3). Introduction to clinical genetic counseling and management strategies for a variety of common genetic conditions including chromosome abnormalities, imprinting disorders, trinucleotide repeat disorders, mitochondrial disorders, overgrowth conditions, neurogenetic conditions, hereditary cardiovascular conditions, etc. psychiatric genetics, etc. Elements of medical history intake and dysmorphology will also be discussed. *P - GENC 711.*

GENC 743 – Medical Genetics II (2). This course is the second part focusing on clinical genetic counseling and management strategies for a variety of medical specialties, including dysmorphology, neurogenetics, cardiovascular genetics, pharmacogenetics, etc. Most lectures will be proved by a guest speaker with expertise in each field. Coursework includes clinical observations within some of these specialties. *P - GENC 742.*

GENC 761 – Clinical Rotation I (3). Clinical training and fieldwork experiences with opportunities to have first-hand experience with individuals and families affected by a broad range of genetic conditions. Clinical rotation experiences will include, but are not limited to prenatal, cancer, general genetics, metabolic genetics, cardiovascular genetics, neurogenetics, teleogenetic, and others. Clinical Rotation I will encompass 4 weeks of full-time, on-site training (or equivalent). Clinical Rotations II A and B will involve 2-3 days a week of training for 8 weeks each. Clinical Rotations III A and B will involve 4 days a week of training for 4 weeks. *This course is only open to Genetic Counseling MS students.*

GENC 762 – Clinical Rotation II A (3). Clinical training and fieldwork experiences with opportunities to have first-hand experience with individuals and families affected by a broad range of genetic conditions. Clinical rotation experiences will include, but are not limited to prenatal, cancer, general genetics, metabolic genetics, cardiovascular genetics, neurogenetics, teleogenetic, and others. Clinical Rotation I will encompass 4 weeks of full-time, on-site training (or equivalent). Clinical Rotations II A and B will involve 2-3 days a week of training for 8 weeks each. Clinical Rotations III A and B will involve 4 days a week of training for 4 weeks. *This course is only open to Genetic Counseling MS students.*

GENC 763 – Clinical Rotation II B (3). Clinical training and fieldwork experiences with opportunities to have first-hand experience with individuals and families affected

by a broad range of genetic conditions. Clinical rotation experiences will include, but are not limited to prenatal, cancer, general genetics, metabolic genetics, cardiovascular genetics, neurogenetics, teleogenetic, and others. Clinical Rotation I will encompass 4 weeks of full-time, on-site training (or equivalent). Clinical Rotations II A and B will involve 2-3 days a week of training for 8 weeks each. Clinical Rotations III A and B will involve 4 days a week of training for 4 weeks. *This course is only open to Genetic Counseling MS students*.

GENC 764 – Clinical Rotation III A (3). Clinical training and fieldwork experiences with opportunities to have first-hand experience with individuals and families affected by a broad range of genetic conditions. Clinical rotation experiences will include, but are not limited to prenatal, cancer, general genetics, metabolic genetics, cardiovascular genetics, neurogenetics, teleogenetic, and others. Clinical Rotation I will encompass 4 weeks of full-time, on-site training (or equivalent). Clinical Rotations II A and B will involve 2-3 days a week of training for 8 weeks each. Clinical Rotations III A and B will involve 4 days a week of training for 4 weeks. *This course is only open to Genetic Counseling MS students*.

GENC 765 – Clinical Rotation III B (3). Clinical training and fieldwork experiences with opportunities to have first-hand experience with individuals and families affected by a broad range of genetic conditions. Clinical rotation experiences will include, but are not limited to prenatal, cancer, general genetics, metabolic genetics, cardiovascular genetics, neurogenetics, teleogenetic, and others. Clinical Rotation I will encompass 4 weeks of full-time, on-site training (or equivalent). Clinical Rotations II A and B will involve 2-3 days a week of training for 8 weeks each. Clinical Rotations III A and B will involve 4 days a week of training for 4 weeks. *This course is only open to Genetic Counseling MS students*.

GENC 771/772 – Genetic Counseling Seminar (1). Weekly seminar involving review of published articles pertinent to the genetic counseling field, lectures from faculty, guest lectures, and/or patient panels. Each student is required to pick an article, have it approved by the course director, and present the article at one journal club per term. *P – POI*.

GENC 780 – Lab Rotation (1). This experiential 2.5-week course is designed to expose students to a variety of clinical genetic testing methodologies at a CLIA-approved, academic genetic testing laboratory. Students will observe cytogenetics, molecular genetics, and biochemical genetics testing techniques and perform tasks to familiarize themselves with the tools used in each modality.

GENC 784 – Simulated Patient Experiences in Genetic Counseling (1). This course is required in second (Spring 1) and last (Spring 2) terms for Genetic Counseling students. Students will have the opportunity to provide partial or full genetic counseling sessions to simulated patients for a wide variety of indications through the Center for Experiential and Applied Learning at Wake Forest. The patient encounters will be videoed and recorded, with feedback provided to students by the program faculty to

promote learning and skill growth in a safe environment. *This course is only open to Genetic Counseling MS students.*

GENC 791 – Introduction to Research (2). Overview of clinical research practices, including both qualitative and quantitative experimental design. Topics include critical review of the literature, research idea development, sound experimental design, IRB submission, data collection, data interpretation, and manuscript preparation. *P – POI.*

GENC 792/793 – Research (1-9). Students will have two options to fulfill the research requirement for the genetic counseling program. Option 1 will involve the creation and execution of a novel clinical research study with a resulting publishable manuscript. Option 2 will entail conducting a significant project to provide to the community around genetics or genetic counseling education. Each term, beginning in Spring I, students will have specific goals and deadlines to meet to achieve a satisfactory grade for their capstone requirement. *P - GENC 791. This course is only open to Genetic Counseling MS students.*

INTEGRATIVE PHYSIOLOGY AND PHARMACOLOGY (IPP)

Program Director	Paul Czoty
Professors	Graça Almeida-Porada, Susan Appt, Reto Asmis, Anthony Atala, Colin Bishop, Mark Chappell, Mark Cline, Suzanne Craft, Paul Czoty, Osvaldo Delbono, Debra Diz, Eric Donny, Ryan Drenan, Patricia Gallagher, Randolph Geary, William Gmeiner, Dwayne Godwin, Karen Haas, David Herrington, Tim Howard, Allyn Howlett, Sara Jones, Matthew Jorgensen, Kylie Kavanagh, Nancy Kock, Greg Kucera, Paul Laurienti, Tao Ma, Frank Marini, Jeff Martin, Brian McCool, Justin Moore, Michael Nader, Barb Nicklas, Tim Pardee, Christopher Porada, Kimberly Raab-Graham, Tom Register, Edgar Alfonso Romero-Sandoval, Hossam Shaltout, Carol Shively, Shay Soker, Leah Solberg-Woods, Richard Weinberg, Jeff Weiner, Jeff Willey, James Yoo
Associate Professors	Merideth Addicott, David Caudell, Rita Cervera-Juanes, Rong Chen, Katherine Cook, Tracy Criswell, James Daunais, Mark Ferris, Robert Gould, TanYa Gwathmey-Williams, Jim Jordan, Drew Kiraly, Ken Kishida, Nicole Levi, Ramon Llull, Sam Lockhart, Patrick McNutt, Christina Meade, David Soto Pantoja, Andrew South, Allen Tsang, Liliya Yamaleyeva, Raghu Yammani
Assistant Professors	Bumsoo Ahn, Sam Centanni, Sarah Cilvik, Rebecca Hofford, Sophie Maiocchi, Eric Marrotte, Josh Maxwell, Hooman Sadri, Dhanendra Tomar
Adjunct Graduate Faculty	Johanna Bolander, Miranda Orr

Overview

The Integrative Physiology and Pharmacology (IPP) graduate program at Wake Forest University is designed to train students for a research career in the physiological and pharmacological sciences. The IPP program has excelled in obtaining federal and foundational funding for many years, with dozens of well-funded investigators working in a highly collaborative research environment. Research interests of the IPP program include a strong emphasis on substance abuse, cardiovascular disease, regenerative medicine, cancer therapeutics, life-span physiology and neuropsychiatric disorders.

There are currently 32 PhD students in various stages of training, and there are more than 100 full-time primary faculty members.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Courses of Instruction

IPP 701 – Principles of Pharmacology (3). The first required course for physiology and pharmacology PhD students introduces students to basic principles of physiology and pharmacology and the cellular, ADME principles (administration, distribution, metabolism, elimination), pharmacokinetics, and pharmacodynamics (receptors and signal transduction).

IPP 702 – Systems Physiology and Pharmacology (1-6). The second required course for physiology and pharmacology PhD students is composed of six blocks on the physiology and pharmacology of neural (Block 1), endocrine (Block 2), renal/vascular (Block 3), gastrointestinal physiology and pharmacology/metabolism (Block 4), and cardiac/pulmonary (Block 5) as well as regenerative physiology (Block 6). *Each block can also be taken for 1 credit by students outside the IPP program. If all six blocks are taken, students must register for the 6-credit IPP 702 course rather than six individual blocks.*

IPP 703/704 – Student Seminar (1). Students present seminars once per academic year and attend seminars by other IPP students and post-doctoral researchers. Course may be repeated.

IPP 711/712 – Advanced Topics (1-3). An advanced lecture and conference course that considers various topics of current research interest and concepts under rapid development. Areas of interest within the program are covered on a rotating basis. Additional topics can be offered by announcement.

IPP 713/714 – Advanced Readings (1). Individualized instruction involving detailed review of literature pertaining to a specific area of interest in physiology or pharmacology.

IPP 715 – Physiological Techniques (1). Provides students with an introduction to the techniques used to assess physiological parameters by a combination of lectures and demonstrations.

IPP 716 – Translational and Educational Research Topics (1). Topics covered in this course include translational research, conducting clinical trials, inter-professional research, qualitative research, educational research, and an overview of statistical procedures. Professional skills developed during this course focus on team-effort, written and oral communications, and maximizing the mentor-mentee relationship. *This course is available for both MS and PhD students and is a co-requisite for THSS 761 and THSS 762.*

IPP 717 – Current Topics in Drug Abuse (3). Provides students with a contemporary perspective on the problem of drug abuse by introducing cutting-edge technologies, emerging issues and persistent controversies. Defines the basic issues central to the field of drug abuse, including concepts of tolerance, physical dependence and reinforcement mechanisms, and relates them to the current problems of drug abuse in society. Describes how current research in drug abuse contributes to the design of rational treatment and prevention programs. *Also listed as NEUR 717.*

IPP 718 – Making Medicines (1). Offers students an opportunity to experience the process of taking a preclinical product through the innovation life cycle from ideation to clinical trials and FDA approval. The course utilizes prepared online materials which students complete at their own pace, and a group project that is presented at the end of the term. Intended for PhD and MS students who are interested in learning about careers in the pharmaceutical and related industries. *Typically offered in the summer term.*

IPP 722 – Behavioral Pharmacology (3). Focuses on behavioral factors that influence the effects of drugs. Material presented provides a detailed review of the rate-dependent, reinforcing, and stimulus effects of drugs. Additional topics include behavioral factors related to tolerance and sensitization and a review of animal models of drug action. *This course is cross listed as NEUR 722. Typically offered in the summer term.*

IPP 724 – Biology of Alcohol Abuse—Alcoholism (3). Designed to instruct graduate and postdoctoral students on the pharmacological, physiological, and behavioral effects of alcohol. Lectures cover topics ranging from the epidemiology and etiology of alcohol abuse and alcoholism to the basic biochemistry, metabolism, and pharmacokinetics of alcohol in the mammalian system. Lectures focusing on the effects of alcohol on the nervous system include neuroreceptor interactions, ethanol's effects on intracellular signaling processes, neuroanatomical substrates for the actions of alcohol, systems electrophysiology, and mechanism of the behavioral effects of alcohol such as the reinforcing effects, anxiolytic effects, amnestic effects, and motor impairing effects. These lectures provide the basis for an exploration of the conditions leading to tolerance and dependence, and how the brain adapts to prolonged exposure to alcohol. This course is cross listed as NEUR 724.

IPP 726 – Toxicology (2). Lecture course designed to provide the student with the basic concepts and mechanisms underlying toxic responses to xenobiotics. Emphasis is on the toxicology relevant to the diagnosis and prevention of poisoning in humans from occupational, environmental, or iatrogenic origin. Broad area studies are general principles of toxicology, common toxic agents, and target organs. Experimental models and methodologies of risk assessment are explored.

IPP 730 – Lifespan Physiology and Pharmacology (1-2). Lectures on the physiology of development and aging and the study of drugs during development and aging. Presentations address current topics relevant to age-dependent changes in

various organ systems and theories of aging. The topics of age-related alterations in drug absorption, kinetics, and metabolism are also examined.

IPP 736 – Endocrinology (2). Recent advances in endocrinology, with emphasis on receptor-linked functions, hormonally active drugs, and influences of pharmacologic agents on endocrine function. In a tutorial setting, students study principles of structure and function, examine current technology and published literature, and design and critique experimental approaches.

IPP 738 – Advanced Cardiovascular Physiology and Pharmacology (2). Lectures, readings and discussions center on normal and abnormal cardiovascular physiology and recent developments in drugs affecting the heart and circulation.

IPP 740 – Neuropharmacology (2-3). General survey of neuropharmacology, emphasizing neurotransmitters, receptors and their interactions. Discussion of published literature with some lectures. Discusses general principles of drug action, including receptor binding, second messengers, and neurotransmitter metabolism. Surveys neurotransmitter function, including acetylcholine, biogenic amines, excitatory and other amino acids, and neuropeptides. Also covers techniques used to measure receptor function. *This course is cross listed as NEUR 740.*

IPP 741 – Quantitative Methods in Bioscience (3). An introduction to essential concepts and methods for the quantitative analysis of biological data, with a focus on descriptive and inferential statistics. General topics include basic concepts in statistics such as probability theory and chance models, samples and populations, analyses of the relationships between variables, analysis of normal data, analysis of non-normal data and non-parametric analyses, an introduction to Bayesian frameworks, clustering analysis, and multivariate analyses. Didactic lectures cover core frameworks, analytic approach, and the mechanics and intuitive logic behind the methods. Laboratory sessions provide experience using a software platform (R) for data analysis and visualization using practical problems. *This course is cross listed as NEUR 741.*

IPP 743/744 – Clinical Experience in Substance Abuse (1). This experience aims to introduce the student to the professional management of addiction medicine. Addiction is a multifactorial problem that involves complex biological, psychological, and social factors. The student will work with the Department of Psychiatry and Behavioral Medicine at the Jonestown Road clinic. The student will be given and expected to read the "Alcoholics Anonymous" book which describes the history and philosophy of the AA program as well as patient stories. Additional experience may also be obtained via attending AA meetings – which may be available online.

IPP 755 – Nanotherapeutics (3). Interdisciplinary survey course intended to introduce students to the potential benefits and challenges of nanomedicine. The primary focus will be on the development and characterization of nanoparticles and nano-structured materials for applications in imaging, drug delivery, diagnostics, and

tissue regeneration. Additional topics will explore the utility of nanomaterials in personalized medicine for mitigating cancer and infectious disease.

IPP 781/782 – Alcohol Research Journal Club (1). This journal club covers articles related to alcohol abuse and alcoholism including cellular/molecular, pharmacological, behavioral, and anatomical studies. Students are encouraged to review current research findings from all aspects of alcohol research including basic science, translational and clinical studies. Students present articles providing a thorough review of relevant background information drawing upon seminal and related papers. *P-POI*

IPP 783/784 – Cardiovascular Sciences Journal Club (1). This journal club discusses peer-reviewed articles related to molecular mechanisms of cardiovascular diseases and disorders including hypertension, congestive heart failure, coronary artery disease, stroke, atherosclerosis, cardio-oncology, angiogenesis, and obesity. Participating students will review current research reporting on all aspects of cardio-health from basic science to translational and clinical studies. Every week a student will present a published article and provide a comprehensive review of relevant background, methods, results, clinical implications, and conclusions. Students should also include a discussion of the article's rigor and reproducibility as defined by the NIH guidelines.

IPP 785/786 – Regenerative Medicine Journal Club (1). This journal club covers articles related to all aspects of regenerative medicine including stem cells, gene therapy and gene editing, tissue engineering, small molecules, nanotechnology, and cell and organ transplantation Students are encouraged to review current research findings from all aspects of regenerative medicine including basic science, translational and clinical studies. Each week a student presents an article, providing a thorough review of relevant background information drawing upon seminal and related papers.

IPP 797/798 – Research (1-9). Mentored research on physiological or pharmacological problems in preparation for the thesis. *Course may be repeated. Satisfactory/Unsatisfactory*.

MEDICAL PHYSICS (MPHY)

Program Director	Andy Dezarn
Program Assistant Director	Paul Black
Professors	Daniel Bourland, Andy Dezarn, William Hinson, Michael Munley, Jeff Willey
Associate Professors	Doris Brown, Mahta McKee, Jim Ververs
Assistant Professors	Paul Black, Maritza Hobson, Feng Liu, Megan Lipford

Overview

The WFU graduate program in Medical Physics provides a combination of didactic, laboratory, research and clinical experiences to educate and train MS and PhD medical physicists for competitive post-graduate training positions, eventual national board certification, and productive careers in clinical service, education and research.

Core courses include radiological physics, radiation therapy physics, medical imaging physics, medical health physics, radiation biology and anatomy. Electives include courses in the physical, biological, engineering and clinical sciences, as well as advanced and special topics. Board-certified faculty medical physicists in the Wake Forest School of Medicine serve as teachers and research advisors for the Medical Physics Program.

Medical Physics research areas include applications of multi-modality oncology imaging in radiation treatment, physical and biophysical modeling, radiation treatment optimization, small-field dose calculations, Monte Carlo modelling of gamma radiosurgery, scatter analysis of cone-beam CT for image-guided radiation treatment, biological effects of low-dose CT imaging, and biophysical aspects of radiation countermeasures. Flexibility is allowed for experimental and theoretical dissertation topics based on student interests and designated research funding, decided in discussion with the student's advisor and dissertation committee.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: Students are required to take a minimum of 42 graduate course credit hours.

Courses of Instruction

MPHY 712 – Ethics and Professionalism in Medical Physics (2). The guidelines of this new Code of Ethics have four major sections: professional conduct,

research ethics, education ethics, and business ethics. This course will be presented based as a didactic course in a classroom setting as well as a series of seminars where they are better suited for certain topics. The time spent on each topic depends on the case studies presented. The course is an interactive class and will explore scenarios directly applicable to clinical situations a Medical Physicist would encounter during normal practice.

MPHY 741/742 – Journal Club (1). Required for all graduate students in the Medical Physics program. This journal club covers publications of interest in the fields of Medical Physics, Health Physics, Nuclear Medicine, Medical Imaging, and Radiation Biology. Meetings will be held monthly and will feature presentations by faculty and students on a publication of interest to the group. Students are expected to review the selected publication in advance of each presentation and to participate in discussion of the presented manuscript.

MPHY 751/752 – Seminar Course (1). Required for all graduate students in the medical physics program. Practicing professionals and faculty in the field present overviews of selected topics in medical physics.

MPHY 760 – Image-Based Clinical Anatomy (3). This course will focus on major organ systems and disease areas. Anatomic structures will be presented from a radiologic or imaging (including cross-sectional) viewpoint in addition to a standard anatomy and physiology presentation. The fundamentals of various imaging modalities (X-ray Mammography and Computed Tomography, Magnetic Resonance, Positron Emission Tomography, Ultrasound) and their relevance to treatment planning will be addressed. Organs at risk and dose tolerance to normal structures will be discussed. Image Registration and Fusion will also be covered, as will motion management. Required for all graduate students in the medical physics program.

MPHY 761 – Radiation Therapy Planning Techniques (3). Students will learn practical and theoretical aspects of historical and modern radiation therapy planning techniques. The course covers algorithms used for photon, electron, and proton beam therapy dose calculations; radiobiological principles of normal tissue tolerance; patient and organ movement, positioning, and immobilization; treatment planning system commissioning and quality assurance; and treatment plan creation and evaluation for a range of anatomic sites and techniques including image guidance, intensity modulation, stereotaxy, and brachytherapy.

MPHY 762 – Practical Measurements in Clinical Physics (3). This course prepares students for the investigation of physical phenomena and offers models through which they can get acquainted with physics-based phenomena and methods in clinical practice. Students receive individual measurement tasks to introduce them to experimental work and the fundamental methods of data processing.

MPHY 771 – Radiological Physics (3). This course covers the nature and fundamental concepts of ionizing radiation including ionizing radiation, radiation

quantities, attenuation and stopping power, charged particle and radiation equilibria, radioactive decay, photon interactions, charged and uncharged particle interactions, x-ray production and quality, dosimetry concepts, ionization cavity theory, and calibration of ionizing radiation beams. *This course is cross listed as BMES 771 and PHY 771. P—POI.*

MPHY 773 – Radiation Therapy Physics (3). This course covers the physics of radiation treatment including radiation producing equipment, character of photon and electron radiation beams, radiation dose functions, computerized radiation treatment planning, brachytherapy, special radiation treatment procedures, quality assurance, and radiation shielding for high energy facilities. Required for all graduate students in the medical physics program. *This course is cross listed as BMES 773 and PHY 773.*

MPHY 774 – Ionizing Medical Imaging (2). This course covers the physical principles, mathematical algorithms and devices used in diagnostic medical imaging, including the following imaging modalities: x-ray physics, x-ray digital imaging, digital image receptors, computerized tomography and reconstruction algorithms, ultrasound imaging, magnetic resonance imaging, and nuclear medicine imaging. *This course is cross listed as BMES 774 and PHY 774.*

MPHY 776 – Medical Health Physics (3). Physical and biological aspects for the use of ionizing radiation in medical environments, biological consequences of human radiation exposure, principles of ionizing radiation protection, operational dosimetry, radiation exposure recommendations and regulations, physical principles of radiation shielding design, personnel monitoring, medical health physics instrumentation, and waste disposal. *This course is cross listed with BMES 776 and PHY 776.*

MPHY 778 – Radiation Biophysics (3). This course provides students with an overview of the biology of cancer and of the current methods used to diagnose and treat the disease. Lectures from faculty throughout the Biological Sciences Division will include presentations on cancer incidence and mortality, cancer prevention, a molecular biology perspective, the role of genetic markers, methods of treatment (radiation, chemotherapy) and prognosis. The course will be primarily for medical physics graduate students. *This course is cross listed as BMES 778 and PHY 778.*

MPHY 779 – Non-Ionizing Medical Imaging (2). This course covers the physical principles, mathematical algorithms and devices used in diagnostic medical imaging which uses ionizing radiation, including the following imaging modalities: x-ray physics, x-ray digital imaging, digital image receptors, computerized tomography and reconstruction algorithms, and nuclear medicine imaging.

MPHY 782 – Clinical Rotations (1-9). On-site clinical training in the principles of computed tomography (CT) simulator, associated radiation protection/design considerations, CT protocols. Understand the physics of imaging modalities, image guided radiotherapy, image archiving and communication systems, and perform quality

assurance on CT, MRI, ultrasound and PET as related to radiation therapy. On board imaging procedures are also covered.

MPHY 791/792 – Research (1-9). Lab research in all areas of medical physics. This course is taken in support of research done to fulfill degree requirements for the master's degree in medical physics. May be repeated. *Satisfactory/Unsatisfactory*

MPHY 793 – Internship (1-6). This course provides the student with exposure to medical physics responsibilities in a radiation oncology department, including simulation, treatment planning and preparation, monitor unit calculations, dose measurements and calculations, treatment delivery techniques, quality assurance, and radiation safety. *Satisfactory/Unsatisfactory*.

MICROBIOLOGY AND IMMUNOLOGY (MICR)

Program Director	Karen Haas
Professors	Martha Alexander-Miller, Waldemar Debinski, Patricia Dos Santos, Karen Haas, Guangxiang Luo, Charles McCall
Associate Professors	Sarah Esstman, Jason Grayson, Patrick McNutt, David Ornelles, Marlena Westcott, Xuewei Zhu
Assistant Professors	Regina Cordy, Volkan Koseoglu
Adjunct Graduate Faculty	Ammar Zafar

Overview

The Microbiology and Immunology program offers a graduate course of study leading to the PhD degree. The program prepares students for careers in research and teaching in the fields of bacteriology, immunology, molecular biology, and virology.

Students enter the program through the Molecular and Cellular Biosciences Track and participate in the MCB common curriculum in the first year. At the end of the first year, students select their research area and dissertation advisor. Students entering the program may choose to do their thesis work among the areas of bacterial and viral pathogenesis, cellular and molecular immunology, and the cell and molecular biology of the microbe-host interaction.

See the Department of Microbiology and Immunology homepage (www.wakehealth/microbio) for further information and detailed descriptions of faculty research interests.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: In addition to completion of the course curriculum, all students are required to take MCB 731 Fundamentals of Virology; MCB 732 Fundamentals of Bacteriology; and MCB 734 Fundamentals of Immunology. In the second and third years, all students are required to take MICR 749/750 Advanced Topics in Microbiology and Immunology.

Courses of Instruction

MCB Track Electives

MCB 731 – Fundamentals of Virology (2). Basic aspects of the structure, replication, and pathogenesis of animal viruses are taught through a mixture of lectures and discussions based on current literature. *Typically offered in the spring term. Intended for all graduate students in microbiology and immunology (MICR); open to students in other tracks or programs.*

MCB 732 – Fundamentals of Bacteriology (2). Basic aspects of bacterial structure, physiology, genetics, and pathogenesis are taught through a mixture of lectures and discussions based on current literature. *Typically offered in the spring term. Intended for all graduate students in microbiology and immunology (MICR); open to students in other tracks or programs.*

MCB 734 – Fundamentals of Immunology (2). This course focuses on the cellular, biochemical, and molecular aspects of innate, cellular and humoral immunity. *Typically offered in the fall term. Intended for all graduate students in microbiology and immunology (MICR); open to students in other tracks or programs.*

MICR Advanced Courses

MICR 704 – Microbiology of Infectious Diseases (3). An in-depth study of the role of microbial agents in host-parasite interactions. The course includes a survey of the basic properties of bacteria, viruses, fungi, and parasites. The pathways leading from exposure to successful infection to disease are examined. Specific examples of major pathogens and the diseases they cause are discussed in detail in the context of clinical situations employing the problem-based learning format. *P—POI.*

MICR 707 – Scientific Methodology (1). Instruction in the scientific method as applied to basic research in bacteriology, virology, and immunology Examples from the scientific literature and ongoing research projects are used to provide practical training in effective oral communication and scientific writing. *P—POI.*

MICR 711 – Tutorial in Medical Microbiology (1-3). Guided reading and discussion of the pathogenesis of infectious diseases.

MICR 716 – Practical Statistics in Microbiology and Immunology (1). Provides a practical introduction to the application of statistical methods commonly required for studies in bacteriology, virology, and immunology. Consists of a mixture of lectures and in-class exercises based on problems drawn from current research in the program. Topics include sampling principles, descriptive statistics, parametric and non-parametric tests, one-way analysis of variance, contingency tables, linear regression, and power calculations. Emphasis is on recognizing and applying the appropriate methods. *P—POI.*

MICR 719/720 – Research in Microbiology (1-9). *Satisfactory/Unsatisfactory.*

MICR 721/722 – Teacher Training (0). Advanced graduate students give a lecture in their areas of specialization in one of the graduate courses offered by the program. *P—Advanced standing.*

MICR 749/750 – Advanced Topics in Microbiology and Immunology (2). Seminar course dedicated to the analysis of current research literature on the fundamental biochemical and molecular processes involved in the growth, differentiation, and functions of bacteria, viruses, and eukaryotic cells. The course not only provides the student with experience in literature analysis, but also offers a broad exposure to timely and important themes and principles that link the disciplines of microbiology, virology, and immunology. *P—bacteriology, immunology, and virology or POI.*

MOLECULAR AND CELLULAR BIOSCIENCES (MCB)

Track Director Nichole Allred

Overview

Molecular and Cellular Biosciences (MCB) is an interdisciplinary PhD track that provides students with opportunities to choose from mentors whose research spans basic and translational fields of cutting-edge molecular and cellular biology. Graduate programs within the MCB track enable students to earn a PhD in Biochemistry and Molecular Biology (BAMB), Cancer Biology (CABI), Microbiology and Immunology (MICR), Molecular Genetics and Genomics (MOGN), or Molecular Medicine and Translational Science (MMTS), as well as a Certificate in Structural and Computational Biophysics (SCB).

Degree Requirements: Degrees are not awarded by Molecular and Cellular Biosciences. All students admitted to the track must select a program after completing the first year of the MCB core curriculum.

Program Requirements: In their first year, MCB students will complete a short course in analytical skills (MCB 700) followed by two core courses (MCB 701, 702). The first examines macromolecular structure, synthesis and function, as well as gene expression and genetics; the second focuses on cell structure, cell communication, organ systems integration and physiology and pathology. MCB students will also select three program-specific electives. They will explore a range of research opportunities by participating in three research rotations, each in a different MCB laboratory. These rotations introduce them to new techniques and guide their selection of a graduate program and dissertation research advisor.

Courses of Instruction

MCB 700 – Analytical Skills (1). Molecular and Cellular Biosciences students will begin their graduate education with this 1-credit course focused on data acquisition and analysis methods. Balancing theory and practice, it will refresh their mathematical skills; describe techniques for isolating and characterizing cells and their macromolecular components; explore methods for manipulating genes and performing high-throughput assays; and introduce bioinformatics approaches. A series of take-home exercises reinforce problem-based learning. *MCB 700 will be offered as 10 x 1.5 h sessions in the two weeks preceding the fall term. Required for all PhD students enrolled in MCB, or BMSC students with an MCB specialization. Open to students in all programs.*

MCB 701 – Molecular and Cellular Biosciences (1-6). Molecular and Cellular Biosciences students will take a two-term core course that will cover fundamental

principles of the discipline. The overall goal of the course is to develop the student's understanding of molecular and cellular biosciences in the context of biomedical research as it relates to human disease. In the first term students will focus on the basic building blocks of the cell, their synthesis, cellular metabolism and intracellular transport. The term is broken into five blocks or themes that in order roughly cover; 1) proteins and enzymes; 2) carbohydrates and lipids; 3) DNA and microbial genetics; 4), mammalian genetics and genomics; and 5) intracellular sorting, cytoskeleton, extracellular matrix. The course is in the format of didactic lectures and meets for 6 hrs per week (four 90-minute lectures/week). Students are evaluated on the performance of 5 written exams given at the end of each block. *Required for all PhD students enrolled in MCB, or BMSC students with an MCB specialization. Open to students in all programs. Other tracks or programs may elect to have students take one or more blocks as 1 credit hour courses.*

MCB 702 – Molecular and Cellular Biosciences (1-6). In the second term students will focus on additional cell biological topics followed by several units devoted to integrative physiology. The term is broken into six blocks or themes that cover 1) cell signaling and cell-cell communication; 2) cell cycle, cell death, cancer, and development; 3) vascular and renal physiology; 4) gastrointestinal physiology and metabolism; 5) cardiac and pulmonary physiology; and 6) microbiology and immunology. The course is in the format of didactic lectures and meets for 6 hours per week (four 90-minute lectures/week). Students are evaluated on the performance of 6 written exams given at the end of each block. *Required for all PhD students enrolled in MCB, or BMSC students with an MCB specialization. Open to students in all programs. Other tracks or programs may elect to have students take one or more blocks as 1 credit hour courses. Although not required, it is expected that students are familiar with material covered in MCB 701.*

MCB 703/704/705 – Introduction to Molecular and Cellular Biosciences Research (1-6). Molecular and Cellular Bioscience students will gain experience with the planning and execution of research, and the interpretation and presentation of experimental results in three separate rotations. To put these principles into practice, they will carry out mentored research projects in the laboratories of three different Molecular and Cellular Biosciences faculty members with an optional fourth rotation during the summer term. *Intended for all PhD students enrolled in MCB. Satisfactory/Unsatisfactory.*

MCB Electives: Biochemistry and Molecular Biology (BAMB) Focus

MCB 711 – Biological Systems and Structures (2). In depth study of macromolecular assembly and interactions, as well as the application of structural biology and proteomics technology. Contemporary concepts of the principles of protein and nucleic acid structure will be presented. Other topics include methods for structure determination such as X-ray diffraction, NMR spectrometry, and molecular modeling.

Typically offered in the fall term. Intended for all PhD students in biochemistry and molecular biology (BAMB), open to students in other tracks or programs.

MCB 712 – Biological Spectroscopy (2). Principles and practicalities of the study of biomolecules using spectroscopic techniques such as absorbance, fluorescence and circular dichroism analyses will be covered. Other biophysical approaches such as mass spectrometry and sedimentation analysis will be included. Topics in the study of enzymes utilizing these techniques will be discussed. *Typically offered in the spring term. Intended for all PhD students in biochemistry and molecular biology (BAMB), open to students in other tracks or programs.*

MCB 715 – Fundamentals of Redox Biology and Medicine (2). Redox chemistry as it applies to biological systems is a specialized field where a fundamental understanding of the underlying biochemistry and appropriate methodologies for evaluating redox regulation and its effects on cell signaling and human health are essential. This course will emphasize the need to use highly quantitative and robust approaches to evaluate redox changes when these are investigated 1) at the level of single molecules (e.g., working with redox-regulated recombinant proteins); 2) in vitro at the cellular level; 3) in vivo using animal models; and 4) in clinical studies.

MCB Electives: Cancer Biology (CABI) Focus

MCB 721 – Basic Concepts in Cancer Biology (2). This course will cover fundamental concepts in cancer biology including etiology, genetic abnormalities, gene expression reprogramming, signal transduction aberration, and stem cell regulation in various tumor types, such as, cancers of the breast, prostate, lung, CNS, lung, ovary, and bladder. *The course is open to all students.*

MCB 722 – Basic Concepts in Cancer Research (2). Over the last half century scientists have generated a complex body of knowledge illuminating the origins of cancer and revealed it to be a dynamic interplay between the genome and the cellular environment. MCB 722 is a hypothesis-driven and problem solving-based course that explores this interplay and the requirements for malignant transformation. This course is offered in the spring term. *The course is open to all students in thesis driven tracks and required for all PhD students in cancer biology (CABI). Students not performing thesis research are able to register but should recognize the course requires an understanding of experimental design and data analysis for course assignments.*

MCB 723 – Topics in Cancer Biology (2). Teaches students how to evaluate and communicate scientifically in the area of cell biology and cancer. Examples are taken from all areas of cancer in this advanced course. Uses current peer-reviewed journal articles to teach fundamental concepts and act as a medium for allowing the students to communicate ideas with an emphasis on presentation skills. *Typically offered in the spring term. Intended for all PhD students in cancer biology (CABI), open to students in other tracks or programs.*

MCB Electives: Microbiology and Immunology (MICR) Focus

MCB 731 – Fundamentals of Virology (2). Basic aspects of the structure, replication, and pathogenesis of animal viruses are taught through a mixture of lectures and discussions based on current literature. *Typically offered in the spring term. Intended for all PhD students in microbiology and immunology (MICR); open to students in other tracks or programs.*

MCB 732 – Fundamentals of Bacteriology (2). Basic aspects of bacterial structure, physiology, genetics, and pathogenesis are taught through a mixture of lectures and discussions based on current literature. *Typically offered in the spring term. Intended for all PhD students in microbiology and immunology (MICR); open to students in other tracks or programs.*

MCB 734 – Fundamentals of Immunology (2). This course focuses on the cellular, biochemical, and molecular aspects of innate, cellular and humoral immunity. *Typically offered in the fall term. Intended for all PhD students in microbiology and immunology (MICR); open to students in other tracks or programs.*

MCB Electives: Molecular Genetics and Genomics (MOGN) Focus

MCB 742 – Molecular Genetics and Genomics of Human Disease (2). This course will introduce students to applications of molecular genetic and genomic methods for the identification and functional characterization of genes contributing to human disease. In addition, complementary lectures will address the application of cell and animal model systems and methods which provide functional insights into the mechanism of action of genes that contribute to disease. *Typically offered in the spring term. Intended for all PhD students in molecular genetics and genomics (MOGN), open to students in other tracks or programs.*

MCB Electives: Molecular Medicine and Translational Science (MMTS) Focus

MCB 752 – Foundations of Translational Science (2). Builds on the student's basic biochemistry and cell biology knowledge with an intensive examination of the molecular basis of human disease and its' treatment. The course mixes lectures with a case-based approach to take students through the diagnosis, physiology, pathophysiology, and the molecular mechanisms of several diseases. Learning issues are developed by the group, centered upon treatment options, their mechanisms of action, the appropriate design of clinical trials to test new therapies, and the research base for further advances in prevention and treatment. MD and PhD facilitators assist with student-led discussions. Relevant, current literature is examined. *Typically offered in the spring term. Intended for all PhD students in molecular medicine and translational science (MMTS), open to students in other tracks or programs.*

MCB 753 – Advanced Topics in Regenerative Medicine (3). The remarkable advances in biomaterials, stem cell biology, and genetic manipulation over the last several years have now made it possible to begin devising means of treating diseases that were previously incurable and developing corrective therapies for crippling injuries. These advances have led to the emergence of the field of research/clinical investigation

that is known as Regenerative Medicine, and this field promises to revolutionize the way we treat/manage both disease and injury. In this course, students will learn about the major organ/tissue systems of the body, the key enabling technologies that make regenerative medicine possible, and how these technologies can be applied to each organ/tissue to mediate regeneration/repair to treat disease/repair injury. Students will then embark on projects that will require them to apply the knowledge gained from the lectures to develop realistic and clinically translational solutions to generate specific organs for transplantation. Students will present their projects to the class at the end of the term. *Typically offered in the spring term. Intended for all PhD students in molecular medicine and translational science (MMTS), open to students in other tracks or programs. This course is cross listed as BMES 753.*

MOLECULAR GENETICS AND GENOMICS (MOGN)

Program Director	Tim Howard
Professors	Rebecca Alexander, Martha Alexander-Miller, Nichole Allred, Colin Bishop, Laura Cox, Waldemar Debinski, Gagan Deep, Keith Gagnon, William Gmeiner, Greg Hawkins, Tom Hollis, Tim Howard, Fang-Chi Hsu, Daniel Kim-Shapiro, Carl Langefeld, Todd Lowther, Charles McCall, Lance Miller, Gloria Muday, Barb Nicklas, Michael Olivier, Tim Pardee, John Parks, Leslie Poole, Thomas Register, Beverly Snively, Shay Soker, Stephen Walker, Richard Weinberg
Associate Professors	Steve Kridel, Patrick McNutt, David Ornelles, James Pease, Ke Zhang Reid
Assistant Professors	Hannah Ainsworth, Derek Parsonage, Ellen Quillen, Kip Zimmerman
Adjunct Graduate Faculty	Martin Childers

Overview

The graduate training program in Molecular Genetics and Genomics is an interdisciplinary curriculum that leads to the PhD degree in Molecular Genetics and Genomics. The major goal of the program is to train students for independent research and teaching in the fields of laboratory molecular and cellular biology or computational analysis in genetics and genomics. The program faculty has departmental affiliations in both basic science and clinical departments of the Medical School, and departments on the Arts and Sciences Campus.

The graduate program in Molecular Genetics and Genomics provides specialized training in the field of Molecular Genetics and Genomics while integrating student training as much as possible with traditional departmental disciplines. Students may elect to pursue this program of study after successful completion of the first-year common curriculum of the Molecular and Cellular Biosciences (MCB) Track.

The program accepts students with a variety of undergraduate degrees including majors in the biological sciences, chemistry, mathematics, computer science and statistics. Students with a laboratory focus have typically completed courses in general biology, general chemistry, organic chemistry, physics, statistics, and mathematics through

calculus. Students with analytical interests have typically completed advanced courses in mathematics, statistics, and/or computer science.

Dissertation research is performed under the supervision of a program faculty member and is tailored to meet the interests and training objectives of the individual student.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: During the second year, students begin research in their dissertation laboratory and take specialty courses relevant to the area of research conducted in that laboratory. The majority of the required courses for the program are fulfilled in the first year MCB curriculum. A total of four (4) elective courses are required, three of which are usually completed in the first year MCB curriculum. Second-year courses include the advanced seminar-style courses, 741 and 742. Attendance at seminars is strongly encouraged to broaden the educational experience of graduate students. Each student is expected to present his/her research once each year in an appropriate seminar series, such as those within the advisor's home department. Each student must fulfill the following requirements for admission to candidacy in the PhD program: 1) pass the MCB required core courses with final grades of B or better (the cumulative GPA must be at least 3.0); 2) pass four approved elective courses; and 3) pass an oral defense of a written research proposal.

Courses of Instruction

MCB Track Electives

MCB 742 – Molecular Genetics and Genomics of Human Disease (2). Introduces students to applications of molecular genetic and genomic methods for the identification and functional characterization of genes contributing to human disease. In addition, complementary lectures address the application of cell and animal model systems and methods which provide functional insights into the mechanism of action of genes that contribute to disease. *Typically offered in the spring term. Intended for all graduate students in molecular genetics and genomics (MOGN); open to students in other tracks or programs.*

MOGN Advanced Courses

MOGN 701/702 – Research in Molecular Genetics (1-9). Research investigations in molecular genetics are conducted in the laboratories of program members studying a wide range of disciplines. *Satisfactory/Unsatisfactory.*

MOGN 726 – Genetic Epidemiology (2). Presents fundamental concepts and methods in genetic epidemiology. Introduces various genetic epidemiology study designs in related and unrelated individuals and covers basic analysis, inferences, plus their strengths and limitations. Lecture and lab. *P—MCB 701, THSS 720; THSS 730, or POI*

MOGN 734 – Human Molecular Genetics (2). A combined lecture/seminar course providing an overview of current theoretical and technical approaches for locating, identifying, and cloning human genes using molecular genetic methods. Emphasis is on the search for genes that contribute to simple single-gene disorders and common complex diseases. Topics include genetic mapping and association studies, chromosome structure at the molecular level, identification of coding sequences and disease susceptibility genes, and functional analysis of gene products. *Typically offered in the spring term. P—MCB 701 or POI.*

MOGN 741/742 – Tutorials in Molecular Biology (2). Seminar course that focuses on new and important aspects of research in molecular and cellular biology with an emphasis on the current literature. Each term, the course explores specific themes chosen by a committee of faculty and students. Students select topics for presentation and lead discussions with faculty and graduate students.

MOLECULAR MEDICINE AND TRANSLATIONAL SCIENCE (MMTS)

Program Director	Michael Olivier
Professors	Martha Alexander-Miller, Graça Almeida-Porada, Susan Appt, Reto Asmis, Anthony Atala, Werner Bischoff, Daniel Bourland, Arjun Chatterjee, Mark Cline, Laura Cox, Kerry Danelson, Osvaldo Delbono, Andy Dezarn, Clark Files, Barry Freedman, Cristina Furdui, Randolph Geary, William Gmeiner, Dwayne Godwin, Karen Haas, Jason Hoth, Tim Howard, Allyn Howlett, Sang Jin Lee, Kylie Kavanagh, Daniel Kim-Shapiro, Nancy Kock, Sang Jin Lee, Tao Ma, Charles McCall, Lance Miller, Michael Munley, Darrell Neufer, Michael Olivier, Emmanuel Opara, Leslie Poole, Christopher Porada, Thomas Register, Michael Shapiro, Carol Shively, Thomas Smith, Shay Soker, Leah Solberg-Woods, Stephen Walker, Jeff Willey, Richard Weinberg, James Yoo
Associate Professors	David Caudell, Rong Chen, Tracy Criswell, Swapan Das, Jason Grayson, TanYa Gwathmey-Williams, Timothy Hughes, John Jackson, Nicole Levi, Baisong Lu, Patrick McNutt, Sean Murphy, Neveen Said, Thomas Shupe, David Soto Pantoja, Andrew South, Allen Tsang, Liliya Yamaleyeva, Raghu Yammani, Xuewei Zhu
Assistant Professors	Bumsoo Ahn, Joshua Currie, Pooja Jadiya, Genesio Karere, Ji Hyun Kim, Chia-Chi Chuang Key, Xue Ma, Kristen Nicholson, Ellen Quillen, Tony Reeves, Michael Seeds, Dhanendra Tomar, Victoria Weis, Fei Xing, Kip Zimmerman
Adjunct Graduate Faculty	Ellie Rahbar

Overview

The graduate program in Molecular Medicine and Translational Science (MMTS), an interdisciplinary program offering the Doctor of Philosophy (PhD) and Master of Science (MS) degrees, is specifically designed to meet the challenge of training basic scientists to function successfully in clinical environments. The last decade has brought about fundamental and radical advances in a number of disciplines including biochemistry, cellular and molecular biology, and immunology. These changes have led to unparalleled opportunities to advance medical research and patient care. Both basic

and clinical scientists can now test novel and provocative hypotheses using tools such as recombinant DNA technologies, functional imaging techniques, mass spectrometry, and monoclonal antibody therapy and quickly acquire results that would have seemed fanciful science fiction only a few years ago. These new approaches have not only made it possible to understand cellular and molecular mechanisms of human disease, but they also offer the promise of new and revolutionary therapeutic options for clinicians.

Translating new advances in science to improved bedside care for patients requires erasing many of the historical divisions between basic and clinical scientists. For modern-day clinicians to understand and take advantage of new developments, a great deal of time must be spent at both the bedside and the bench. Conversely, the potential to understand mechanisms of illness and its treatment brings relevance and urgency to the work of basic scientists, moving them closer to their clinical colleagues. This movement into the clinical arena facilitates the challenge of viewing a complex clinical disorder through the eyes of the basic scientist. For these reasons, there has been a major emphasis by national, private, and industrial granting organizations to fund basic research that has the potential to immediately impact human disease. This creates a unique niche for basic (PhD) scientists who are trained on the cutting edge of molecular advances to perform “translational” research in human biology and disease.

The MMTS program provides training in the use of cellular, molecular, and integrative approaches to investigate biologic events with an emphasis on human disease. The multidisciplinary faculty consists of scientists who have major ongoing human research programs. The program offers PhD students a comprehensive knowledge of human biology and disease that allows them to develop basic research programs with fundamental clinical implications. It is also designed to train biomedical researchers to fill an important niche in academia or industry.

For MD, DVM or DO-trained physician-scientists on faculty or in training at Atrium Health Wake Forest Baptist Medical Center, a Master’s or PhD degree in MMTS is also available for qualified candidates. The overall objective of the clinician-scientist program is to train individuals who already hold an MD degree in the cellular and molecular techniques needed to integrate basic science with clinical applications involving human disease. An additional benefit of the program is that it enhances interaction between MDs in clinical departments and PhDs who are engaged in fundamental bench research focused on human disease.

The MMTS program participates in the Molecular and Cellular Biosciences (MCB) PhD track. Prospective students interested in MMTS apply to the MCB track and can indicate their interest in the MMTS program on the application. Applicants to the MCB Program should have a solid background in biological and/or physical sciences, prior research experience and a passion for scientific inquiry. Students enter the program through the MCB Track and participate in the MCB common curriculum in the first year. Curriculum in subsequent years includes participation in Translational Science Seminar Series,

Clinical Experience, Foundations of Translational Science, Scientific Development and Business of Science course, and electives of the student's choice.

Prospective students are encouraged to contact individual faculty members whose research is of particular interest.

Degree Requirements: As applicable, please see "Requirements for the Doctor of Philosophy Degree" of the "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: Students who enter the MMTS program are required to take the following set of courses: MCB 752, MMTS 711, 712, 715, 716, 724, 791, 792, and a statistics course. Students who have an MD or are in the combined MD/PhD program are exempt from MCB 752 and MMTS 715/716. Possible statistics courses include one of the following: HES 721 – Data Analysis and Interpretation; THSS 730 – Introduction to Statistics; IPP/NEUR 741 – Quantitative Methods in Bioscience. See statistics course descriptions within the appropriate program sections.

Before a student can schedule the defense of their dissertation, it is required that at least one first author publication of original data from their work at Wake Forest be accepted in a peer-reviewed journal.

Courses of Instruction

MCB Track Electives

MCB 752 – Foundations of Translational Science (2). Builds on the student's basic biochemistry and cell biology knowledge with an intensive examination of the molecular basis of human disease and treatment. The course mixes lectures with a case-based approach to take students through the diagnosis, physiology, pathophysiology, and the molecular mechanisms of several diseases. Learning issues are developed by the group, centered upon treatment options, their mechanisms of action, the appropriate design of clinical trials to test new therapies, and the research base for further advances in prevention and treatment. MD and PhD facilitators assist with student-led discussions. Relevant, current literature is examined. *Typically offered in the spring term. Intended for all graduate students in MMTS, open to students in other tracks or programs.*

MCB 753 – Advanced Topics in Regenerative Medicine (2). The remarkable advances in biomaterials, stem cell biology, and genetic manipulation over the last several years have now made it possible to begin devising means of treating diseases that were previously incurable and developing corrective therapies for crippling injuries. These advances have led to the emergence of the field of research/clinical investigation that is known as Regenerative Medicine (RM), and this field promises to revolutionize the way we treat/manage both disease and injury. In this course, students will learn about the major organ/tissue systems of the body, the key enabling technologies that make regenerative medicine possible, and how these technologies can be applied to each

organ/tissue to mediate regeneration/repair to treat disease/repair injury. Students will then embark on projects that will require them to apply the knowledge gained from the lectures to develop realistic and clinically translational solutions to generate specific organs for transplantation. Students will present their projects to the class at the end of the term. *Typically offered in the spring term. Intended for all graduate students in MMTS, open to students in other tracks or programs.*

MMTS Advanced Courses

MMTS 711/712 – Translational Science Seminar Series (1). Faculty and students jointly describe their research in a human disease, first in clinical terms and then to follow the development of the understanding of that disease to the molecular level with an emphasis on translational applications. Presentations introduce students to potential preceptors and experimental strategies used to study human disease. Students present their own research to gain experience and professional skills for seminars and national meeting presentations.

MMTS 713 – Advanced Readings in MMTS (1-2). This course allows individualized advisor-student discussion of literature pertaining to a specific area of interest in Molecular Medicine. *Satisfactory/Unsatisfactory*.

MMTS 715/716 – Clinical Experience (1). Students who choose to enter the MMTS program must take this course in the fall (MMTS 715) and spring (MMTS 716) term. This course serves as an introduction to clinical medicine for PhD students. Each student observes and participates in 10 hours of clinical immersion with his/her clinical mentor. Experiences are custom designed by the clinical mentor for each student. At the end of the term, students enrolled in the course meet and each student presents a case study, based on his/her personal clinical experience. *P—POI*.

MMTS 719/720 – Special Topics in Stem Cell Biology (2). This course utilizes directed readings and student presentations of primary literature to introduce students to the field of stem cell biology. Content focuses primarily on human stem cell properties, including pluripotency and its maintenance, the role of chromatin remodeling in fate determination and lineage restriction, self-renewal and differentiation, and the genetic conversion of somatic cells into pluripotent stem cells. The field is expanding rapidly, and course content will be modified as needed to incorporate new findings and applications in stem cell biology and translational medicine. A background in the form of undergraduate or graduate courses in developmental biology is strongly recommended. *This course is cross listed as MOGN 719/720. P—POI.*

MMTS 721 – Regenerative Medicine Immersion - Fundamentals, Principles and Clinical Applications (1-2). The course will provide a state-of-the-art review of various aspects of RM addressing the fundamental principles and progress in tissue engineering and regenerative medicine in recent years, including background material, key scientific components of RM, and ethical, economic and other issues important to

the field. RM has the potential to deliver cures for many diseases while also improving quality of life. RM integrates the principles of cell and molecular biology, materials science, biomedical engineering, and clinical science with the goal to develop materials and therapies to repair or replace cells, tissue, and organs damaged by disease, trauma, or congenital conditions. In recent years, approaches are being used routinely in daily clinical practice, with others in clinical studies, and multitudes in preclinical testing phase. The course addresses the interdisciplinary nature of RM, major components necessary to produce engineered tissues and organs, opportunities and today's most critical challenges. A series of eight topic areas features prominent faculty members of the Wake Forest Institute for Regenerative Medicine (WFIRM) along with distinguished invited experts in the field. The eight content areas are grouped thematically and address a breadth of topics spanning: stem cells, cell sources, biomaterials, cellular therapies, enabling technologies and animal models, as well as legal, commercial, regulatory and ethical issues. In addition to the formal presentations, students also have the opportunity to interact with speakers in smaller groups during lunch and other informal, social networking events and settings. *Typically offered in the summer term. This course does have enrollment limits, and registrations are accommodated on a first-come, first-served basis. Satisfactory/Unsatisfactory.*

MMTS 724 – Introduction to Grant Writing (2). This course teaches NIH grant proposal basics and guides students through writing an NIH grant proposal using the NIH F/K grant formats. The primary goal of the course is to teach students fundamental skills in scientific grant writing to prepare them for developing a successful preliminary exam proposal for advancement to PhD candidacy. The course consists of a series of lectures on key grant components to help students draft, in stages, 1) specific aims, 2) significance and innovation, and 3) approach sections. Feedback during each writing stage is given by faculty. An overview of NIH peer review and instruction on writing objective grant critiques are also covered. Each student's completed grant application is formally reviewed in a "mock" study section consisting of peer review by students and faculty. Class is capped at 10 students with preference given to MMTS students.

MMTS 730 – Big Data Omics Analysis Approaches (3). By the end of this course, the student will have a firm understanding of the publicly available data and resources related to large-scale "omics" and "big" data. Students will be able to search databases for suitable data to address specific research questions, download data and use publicly available data analysis tools to analyze and interpret the data. This will include a detailed understanding of the database data structures, a representative set of publicly available analysis tools, and an ability to generate and visualize results from integrated data analyses. An emphasis will be placed on hands-on learning to provide practical familiarization with tools and databases. Priority will be given to students in MMTS and MOGN with emphasis on students in their 2nd year, and additional students will be added with permission of the course directors.

MMTS 781/782 – MMTS Graduate Program Journal Club (1). This course is designed to enhance students' ability to critique and present high-quality papers from

current literature. The journal club will provide a forum for: 1) in-depth discussion of basic and translational research that reinforces the principles of multiple research approaches (including in vitro cell studies, animal models, human studies, “omics” studies and others); 2) practicing scientific presentation skills and developing skills to critically evaluate peer-reviewed high-impact research articles; and 3) discussing state-of-the-art technology in the field. The course will also include active audience (i.e., students, postdoctoral fellows, technicians, and faculty) discussion of results to stimulate learning effective presentation and discussion of scientific research findings.

MMTS 791/792 – Research (1-9). This course involves closely supervised research in various topics in molecular medicine, with a special emphasis on models of human disease, including research in preparation for the doctoral dissertation. *Satisfactory/Unsatisfactory*.

Other Electives:

In addition to the required courses, students in the PhD program may select, in consultation with their advisor, one or more other graduate-level science courses from a range of other programs, including but not limited to: biochemistry and molecular biology (BAMB), biology (BIO), biomedical engineering (BMES), cancer biology (CABI), chemistry (CHM), health and exercise science (HES), integrative physiology and pharmacology (IPP), mathematics and statistics (MST), microbiology and immunology (MICR), molecular genetics and genomics (MOGN), neuroscience (NEUR), physics (PHY), or translational and health system science (THSS). Students should complete these additional courses prior to the end of their third year.

NEUROSCIENCE (NEUR)

Program Director	Paul Czoty
Professors	Laura Baker, Mark Baxter, Ruth Benca, Terry Blumenthal, Gretchen Brenes, Jonathan Burdette, Cheryl Bushnell, Goldie Byrd, Jim Caress, Michael Cartwright, Ramon Casanova, Suzanne Craft, Paul Czoty, Dale Dagenbach, Waldemar Debinski, Osvaldo Delbono, Debra Diz, Eric Donny, Ryan Drenan, Laura Flashman, Lauren Fowler, Dwayne Godwin, Marina Gorbatyuk, Rob Hampson, Greg Hawkins, Allyn Howlett, Erik Johnson, Sara Jones, Paul Laurienti, John Li, Jian-Xing Ma, Tao Ma, Jeff Martin, Brian McCool, Michelle Mielke, Michael Nader, Cormac O'Donovan, Wayne Pratt, Kimberly Raab-Graham, Thomas Register, Edgar Alfonso Romero-Sandoval, Ben Rowland, Emilio Salinas, Maria Sam, Hossam Shaltout, Carol Shively, Mustafa Siddiqui, Sean Simpson, Leah Solberg-Woods, Terry Stanford, Barry Stein, Joel Stitzel, Stephen Tatter, Charles Tegeler, Stephen Walker, Christian Waugh, Jeff Weiner, Rebecca Wells, Chris Whitlow, John Wilson, Stacey Wolfe
Associate Professors	Merideth Addicott, Rita Cervera-Juanes, Rong Chen, James Daunais, Mark Ferris, Robert Gould, Christina Hugenschmidt, Timothy Hughes, Drew Kiraly, Ken Kishida, Sam Lockhart, Joost Maier, Christina Meade, Heidi Munger Clary, Christopher Peters, Araya Puwanant, Kiran Solingapuram Sai, Rebecca Sappington, Roy Strowd,
Assistant Professors	Eva Bach, Trey Bateman, Sam Centanni, Heather Douglas, Jason Fanning, Katie Holleran, Pooja Jadiya, Chinedu Momoh, Chris Schaich, Heather Shappell, Dhanendra Tomar, Jillian Urban
Adjunct Graduate Faculty	Christos Constantinidis, David Klorig, Katy Lack, Miranda Orr, Ashley Sanderlin

Overview

Neuroscience PhD training has been a component of graduate student training at Wake Forest University for approximately 30 years. The field of Neuroscience is at the cutting edge of scientific developments and the Wake Forest Neuroscience Program believes its long-term returns from student training will have positive consequences for our community and nation. Neurological disorders associated with trauma, an aging

population, drug addiction, and neurodevelopmental and psychiatric disorders represent urgent local and national needs. As scientists and educators, we are at an ideal position to train individuals capable of pioneering research into both normal development and function of the nervous system and into the causes and mechanisms underlying neurological disease.

The training faculty represent a wide range of specific research interests, who employ diverse human and animal techniques and methodologies with major strengths in neuropharmacology, behavioral neurobiology, aging, sensory neurobiology, neurophysiology, pain mechanisms, and neurodegeneration. One of the rewarding features of research at Wake Forest University is the extent of collaborative interactions between investigators both within, and equally importantly, between departments and centers. These interactions provide the means by which the trainees in the Neuroscience Training Program can readily interact with investigators and students in other labs, departments, and across campuses.

The goal of our Neuroscience training program is to provide students with:

- A fundamental understanding of all levels of nervous system organization, from genetics, molecular, and cellular to systems and behavioral
- A skill set that includes extensive training in experimental design and interpretation, statistical and quantitative methodology
- Hands-on experience in state-of-the-art laboratories that carry out meaningful and significant research in all areas of modern neuroscience
- A "bench to bedside" appreciation of how basic neuroscience research supports and translates into treatments for neurobehavioral pathologies

The program offers MS and PhD training. Competitive applicants to the neuroscience graduate program demonstrate proficiency in core disciplines such as biology, psychology, chemistry, physics, mathematics, statistics, computer programming, and have prior research experience.

Degree Requirements: As applicable, please see “Requirements for the Doctor of Philosophy Degree” of the “Requirements for the Master of Science Degree” in the “Degree Requirements” section of the Graduate Bulletin.

Program Requirements: All students are required to take a core curriculum of neuroscience courses, including statistical and quantitative analysis, over the first 1.5 years.

MS students obtain hands-on research experience by participating in thesis research beginning in the first term.

PhD students obtain hands-on research experience by participating in laboratory rotations during the first year. Students begin thesis research by the end of the summer of the first year. Additional graduate coursework is tailored to provide advanced training and meet the research goals of each student.

Courses of Instruction

Core Courses

NEUR 701 – Introduction to Neuroscience I (6). Introduction to Neuroscience I is the first in a required three-course series for first-year neuroscience graduate students covering basic topics in the neurosciences. Introduction to Neuroscience I is offered only in the fall term. In the first section, Neuroanatomy, students will develop expertise in identification and understanding of neuroanatomical structures and pathways and proficiently apply that knowledge to normal and pathological nervous system function. The Neuroanatomy section includes both didactic and laboratory sessions. In the second section, Neurophysiology and Neuropharmacology, students will expand their understanding to basic cellular, molecular and physiological mechanisms mediating nervous system structure and function. Basic neuropharmacology will also be covered. The second section includes didactic and discussion-based sessions. *For non-Neuroscience students, the sections can be taken individually as two three-credit-hour courses.*

NEUR 702 – Introduction to Neuroscience II (6). Introduction to Neuroscience II is the second in the series of required courses for first-year neuroscience graduate students covering foundational topics in neuroscience. Topics covered include sensory, motor systems, and cognitive neuroscience. Class format is a mixture of didactic lectures and student-led discussion of course material with faculty guidance and facilitation. For non- Neuroscience students, the sections can be taken individually as three two-credit-hour courses. *P—NEUR 701.*

NEUR 705/706 – Tutorial in Neuroscience (1). The Tutorial in Neuroscience runs during the fall, spring and summer terms. The format is one in which a faculty member or postdoc presents his/her research, and a student presents a paper on a topic related to that research topic. Additionally, students must submit a manuscript or review paper related to his/her own research at the end of each term.

NEUR 707/708 – Research (1-9). Lab research in all areas of modern neuroscience, including studies done as part of the first-year research rotations and the requirements for the doctoral dissertation. *Satisfactory/Unsatisfactory*.

NEUR 711/712 – Seminars in Neuroscience (1). This is a weekly seminar given by students, postdocs, faculty and external speakers. It runs throughout the year and is structured so that each student presents one research seminar in a given year. First year students give a 30-minute seminar and senior students give an hour seminar. First year students are assigned seminar slots during the summer between the first and second year. The remaining slots are used by postdocs, faculty, and visiting speakers. Departments and the WNCSfN Chapter take turns sponsoring the seminars by external speakers.

NEUR 741 – Quantitative Methods in Bioscience (3). An introduction to essential concepts and methods for the quantitative analysis of biological data, with a

focus on descriptive and inferential statistics. General topics include basic concepts in statistics such as probability theory and chance models, samples and populations, analyses of the relationships between variables, analysis of normal data, analysis of non-normal data and non-parametric analyses, an introduction to Bayesian frameworks, clustering analysis, and multivariate analyses. Didactic lectures cover core frameworks, analytic approach, and the mechanics and intuitive logic behind the methods. Laboratory sessions provide experience using a software platform (R) for data analysis and visualization using practical problems. *This course is cross listed as IPP 741.*

NEUR 751 – Advanced Multivariate Analysis in Neuroscience (3). An advanced class focusing on the methods of complex data analysis for real biological datasets, complete with mixtures of fixed and random effects, missing entries, errors, and outliers. The course is centered on analytic projects that utilize combinations of linear/nonlinear regression, mixed models, and Bayesian estimation to explore best practice approaches to complex problems. Each project introduces a set of new concepts and challenges that are commonly encountered in the laboratory. The approach is comprehensive, taking each analysis from "start" (importing data from various sources) to "finish" (generating a report of the findings). Students collaborate in groups to decide on next steps at each stage of the analysis and identify potential caveats, then construct implementations/solutions individually, and reconvene at the next class period to discuss their results and next steps with expert faculty guidance. The over-arching goal is to simulate complex data analysis in real world collaborative environments. *P—NEUR 741.*

NEUR 771 – Clinical Neuroscience (3). Lectures and class discussions dealing with topics in neurobiology, pathophysiology, and treatment of patients with neurological and behavioral/psychiatric problems. Includes a brief introduction to major concepts of patient treatment and care with utilization of up-to-date methodology in clinical neuroscience. Students have the opportunity to observe and participate in patient evaluation and diagnostic testing in the clinical setting and to visit many of the neuroscience-related clinical research and treatment centers. Taught by both clinicians and basic science researchers. *P—NEUR 701; NEUR 702.*

Advanced Courses

Behavioral Neuroscience

NEUR 714 – Behavioral Neuroscience (3). Behavioral neuroscience is a relatively new and rapidly expanding discipline utilizing techniques of molecular biology, neurochemistry, neurophysiology, and psychology to investigate the neurobiological basis of behavior. A broad overview of the field and its relationship to these individual disciplines is presented. The course provides a survey of the field from the cellular level to the complexity of molar aspects of behavior including learning and memory. An introduction to lab models of human neurobiological disorders is included. *P—NEUR 701; NEUR 702; NEUR 703.*

NEUR 722 – Behavioral Pharmacology (3). Focuses on behavioral factors that influence the effects of drugs. Material presented provides a detailed review of the rate-dependent, reinforcing, and stimulating effects of drugs. Additional topics include behavioral factors related to tolerance and sensitization and a review of animal models of drug action. *This course is cross listed as IPP 722. P—NEUR 701; NEUR 702; NEUR 703.*

Memory and Cognition

NEUR 715 – The Neuroscience of Memory (3). Historical vs. Modern Perspectives on the Role of Hippocampus and Memory: A combination reading and discussion course examining the neuroscience of history of memory – with particular emphasis on the changing understanding of hippocampus – it's neural circuitry, plasticity, function, and role in processing different types of memory. *P – NEUR 701, NEUR 702, NEUR 703*

NEUR 716 – Mind, Memory, and Consciousness (3). The Search for Neural Correlates of Consciousness: An exploration of the relationship between the observable mechanism of neural activity to the meta-phenomenon of consciousness. What are the leading theories of consciousness? How do we measure "intelligence" and what does that have to do with the mind? How does memory combine with sensory experience to produce a sense of awareness of "self?" *P – NEUR 701, NEUR 702, NEUR 703*

Computational Neuroscience

NEUR 723 – Computational Neuroscience (3). This course explores advanced topics in theoretical and computational neuroscience spanning multiple levels of abstraction, from models of ion channels and single neurons to decision-making and behavior. Major topics include models of individual neurons and populations, information theory, common network architectures involving oscillations and attractor dynamics, mechanisms of synaptic plasticity, neural encoding and decoding, and computation within large-scale neural networks. The course follows selected chapters from relevant textbooks to provide essential concepts and extends to discussions of recent literature. Classes consist of student-led lectures and discussion with faculty facilitation and commentary. Weekly take-home programming projects (MATLAB) reinforce concepts and provide practical hands-on experience with modeling neural systems. *P—NEUR 701; NEUR 702; NEUR 703.*

Structure and Function of Neurons

NEUR 721 – Advanced Molecular Approaches to Neuroscience (3). Introduces graduate and advanced undergraduate students to the basic principles of neurobiology as studied by cell and molecular biologists. Lectures introduce invertebrate and vertebrate model neuronal systems and the cellular and molecular methods to study them. *P—NEUR 701; NEUR 702; NEUR 703.*

NEUR 725 – Introduction to Neuroimaging (3). This course is a course for second year and above neuroscience graduate students covering basic topics in neuroimaging acquisition, processing, and analysis. Topics covered in this section include basics of MRI image acquisition, fundamentals of structural and functional MRI, and an introduction to other commonly used imaging methods (PET, MEG, spectroscopy, ultrasound). Faculty will be primarily clinical research scientists using neuroimaging in their laboratories, and also clinicians who incorporate imaging into their practice and research. Class format will include didactic presentations of core concepts; hands-on data processing and analysis using online, publicly available data and example image analysis pipelines; and student-mediated discussion of course material with faculty guidance. The goal is for students to understand basic technical, experimental, and statistical methodology in neuroimaging, and gain quantitative skills through this understanding, as a gateway to potential future research work involving neuroimaging. *P—NEUR 701; NEUR 702; NEUR 703.*

NEUR 726 – Synaptic Physiology for Biologists (3). In this course, graduate students will be introduced to theory, techniques, and mechanisms of synaptic physiology. We will focus on molecular underpinnings of plasticity at the synapse - both pre- and post-synaptically, specifics of electrophysiological and electrochemical tools used to probe synaptic function, and how alterations of synaptic physiology contribute to maladaptive states in the whole organism. In order to be adequately versed in basic synaptic physiology to take this course, students are required to have completed NEUR 701/702 coursework as a prerequisite to attending this course. *P—NEUR 701; NEUR 702.*

Development and Aging of the Nervous System

NEUR 742 – Development of the Nervous System (3). This is an advanced course to explore current topics regarding development of the nervous system. The course will rely on primary literature to delve into control of events that lay the foundation of the nervous system, regressive and progressive events, neural plasticity and regeneration, development of behavior, and developmental disorders. *P—NEUR 701; NEUR 702; NEUR 703.*

Sensory Neuroscience

NEUR 753 – Sensory Neuroscience I: Visual and Auditory Systems (3). This course is designed to introduce students to sensory neurobiology of visual, auditory, olfactory and gustatory systems from the cellular to systems level. Under each sensory system, the topics cover the receptors in the sensory organs, signal transduction, subcortical and cortical areas and higher order processing. The course also includes topics relevant to sensory perception such as attention, working memory, decision making and plasticity. The course is structured to enable the students to learn how individual sensory systems function and to recognize the parallels between sensory systems. *P—NEUR 701; NEUR 702; NEUR 703.*

NEUR 754 – Sensory Neuroscience II: Somatosensation and Multi-sensory Integration (3). This course is the second in a series that focuses on mammalian sensory systems. The course is designed to introduce students to somatosensory, pain and multisensory processing from the molecular to the systems level. The aim is to introduce key concepts of global organization that transcend individual modalities. Cellular, molecular, behavioral and pharmacological approaches will be covered against the backdrop of relevant model sensory systems. *P—NEUR 701; NEUR 702; NEUR 703; NEUR 753.*

NEUR 755 – Research Design in Sensory and Systems Neurobiology (3). This course combines didactic material with hands-on approaches so that students learn to properly design experiments in neurobiology and are able to analyze quantitatively the resulting experimental data. The didactic component provides a brief survey of fundamental mathematical and statistical concepts (e.g., probability, Bayesian inference, curve fitting, hypothesis testing, nonparametric statistics), which serves as a foundation for more advanced techniques used to analyze neuronal data (e.g., signal detection theory, cross-correlograms, information theory). Through computer-lab sessions and homework assignments tailored to each topic, students translate the theoretical knowledge to practical application as they learn to use the MATLAB programming environment. The specific quantitative methods covered, as well as the sample data used for the hands-on analysis assignments, are tailored according to the students' backgrounds, programming experience, and research interests. *P—NEUR 701; NEUR 702; NEUR 703; NEUR 741.*

Substance Abuse and Addiction

NEUR 717 – Current Topics in Drug Abuse (2-3). Provides students with perspective on the problem of drug abuse. Defines the basic issues central to the field of drug abuse, including concepts of tolerance, physical dependence and reinforcement mechanisms, and relates these issues to the current problems of drug abuse in society. Describes how current research in drug abuse contributes to the design of rational treatment and prevention programs. *This course is cross listed as IPP 717.*

NEUR 724 – Biology of Alcohol Abuse—Alcoholism (3). Designed to instruct graduate and postdoctoral students on the pharmacological, physiological, and behavioral effects of alcohol. Lectures cover topics ranging from the epidemiology and etiology of alcohol abuse and alcoholism to the basic biochemistry, metabolism, and pharmacokinetics of alcohol in the mammalian system. Lectures concerning effects of alcohol on specific organ systems include the hepatic system, the endocrine system, reproductive systems, the cardiovascular system, the gastrointestinal system, and the renal and pancreatic systems. Lectures focusing on the effects of alcohol on the nervous system include neuroreceptor interactions, ethanol's effects on intracellular signaling processes, neuroanatomical substrates for the actions of alcohol, systems electrophysiology, and mechanism of the behavioral effects of alcohol such as the reinforcing effects, anxiolytic effects, amnestic effects, and motor impairing effects. The

neuroscience lectures provide the basis for an exploration of the conditions leading to tolerance and dependence, and how the brain adapts to prolonged exposure to alcohol. *This course is cross listed as IPP 724.*

NEUR 740 – Neuropharmacology (3). General survey of neuropharmacology, emphasizing neurotransmitters, receptors and their interactions. Discusses general principles of drug action, including receptor binding, second messengers, and neurotransmitter metabolism. Surveys neurotransmitter function, including acetylcholine, biogenic amines, excitatory and other amino acids, and neuropeptides. *This course is cross listed as IPP 740. P—NEUR 701; NEUR 702.*

Neurosciences Journal Clubs

NEUR 765/766 – Approaches for Translational Neuroscience Research Journal Club (1). The theme for this Journal Club is to think outside of your typical research fields and learn about other CNS disorders, examining symptoms, underlying neurobiology, and/or treatment approaches spanning preclinical and/or human research studies focusing on translational research.

NEUR 773/774 – Neuro-computational Approaches to Investigate Conscious Experience, Willful Choice, and Related Disorders Journal Club (1). In this journal club we will discuss literature relevant to computational neuroscience approaches used to investigate human consciousness and related mental health disorders.

NEUR 775/776 – Health Inequity in Neuroscience Journal Club (1). Roots of Health Inequity (ROHI) consists of an online curriculum with guided in person discussions to expand upon the online content in ways that are relevant to the WFSM community within and outside the institution. This course will use the online component as a foundation and expand upon it with published reports from the literature exploring health inequities as they relate to neurological and related disorders.

NEUR 777/778 – Directed Journal Club in Pain and Anesthesiology (1). This journal club covers articles related to mechanisms of pain and somatosensory processing including cellular/molecular, pharmacological, behavioral, and anatomical studies of acute and chronic pain disorders. Students are encouraged to review current research findings from all aspects of pain research including basic science, translational and clinical studies. Each week a student presents an article providing a thorough review of relevant background information drawing upon seminal and related papers.

NEUR 780/781 – Directed Journal Club in Sensory Neuroscience (1). Correlates with the formal lecture courses in Sensory Neuroscience I-II. Students are required to read and critique papers chosen to complement the classroom lectures. Both seminal papers and current research are reviewed. The directed nature of the readings enhances the student's appreciation and understanding of the formal lectures. Students lead the presentation of the journal articles, thus providing opportunities for teaching in the area of sensory systems.

NEUR 783/784 – Directed Journal Club in Developmental and Molecular Neurobiology (1). Students are required to read and critique papers related to developmental, cell and molecular, or disease/pathological issues in the nervous system. Both seminal papers and current research are reviewed. The directed nature of the readings enhances the student's appreciation and understanding of the formal lectures. Students lead the presentation of the journal articles, thus providing opportunities for teaching in these areas.

NEUR 785/786 – Directed Journal Club in Network Science in Neuroimaging (1). This journal club covers articles related to network science and its application in biological systems, with a particular emphasis on the brain. The assigned reading will cover methodological foundation of network science, as well as the current literature on applications of network science in neuroimaging studies. Although the brain network will be of the main focus, readings may also include other types of networks such as biological, social and technological networks.

NEUR 787/788 – Memory, Cognition and Aging Journal Club (1). The topics in this journal club will cover all aspects of memory, cognition and cognitive aging from molecular and cellular/synaptic mechanisms to behavioral and imaging studies. Papers on basic research and translational science in any model system ranging from rodents, non-human primates to humans will be discussed. In the Journal Club course, each week a student will present a paper using a format indicated by the course director.

NEUR 789/790 – Translational Addiction Journal Club (1). The primary objective of this course is to provide a forum for students working in NIDA/NIAAA supported laboratories (or any students interested in addiction to present and discuss the latest research breakthroughs in the field of addiction research with a major focus on studies with high translational significance. Students are encouraged to present cutting-edge manuscripts that cover topics ranging from molecular adaptations that contribute to the etiology of drug or alcohol use disorder to the latest clinical trials on addiction treatments. *Satisfactory/Unsatisfactory.*

Special Topics

NEUR 713/714 – Advanced Readings (2). Individualized instruction involving detailed review of literature pertaining to a specific area of interest in physiology and pharmacology.

NEUR 719 – How to Write a Scientific Paper (1). The overall goal of this class is to provide a framework to learn how to write a scientific manuscript. The course will be geared toward basic scientists. Learning objectives include: Learn core elements included in a manuscript. Practice outlining a manuscript. Obtain experience in composing sections of a manuscript. Gain experience in critiquing manuscripts (from a writing perspective). The course will include a 1-hour lecture and 2 hours of peer teaching experience.

NEUR 760 – Neuroscience in the Public Eye (1). A scientific outreach class examining public perceptions of neuroscience, as well as outreach and education efforts to more effectively communicate neuroscience to the public.

NEUR 782 – Readings and Research in Neuropsychology (1-3). Allows the graduate student, working under the supervision of a faculty member, to pursue and receive credit for a special project in an area not covered by regular courses or a special research project not related to the master's thesis. Supervising faculty members and credit hours for the course are determined by graduate committee prior to registration. *This course is cross listed as PSY 782.*

NEUR 791/792 – Readings and Directed Study in Neurobiology (1-2). Designed to provide an opportunity for graduate students to learn specific topics in the field that may not be covered by regular courses. Materials from the primary literature are presented to other participants, including at least one faculty member. The format is intended to generate in-depth discussion in a setting where each student acts as the lecturer. The supervising faculty member and the student will determine together the schedule and credit hours (either 1 or 2) for the course.

NEUR 793/794 – Special Topics in Developmental Neurobiology (2). Designed to focus on a specific theme each term, including such topics as cell death and regressive events, synaptogenesis, determination and differentiation, axonal guidance and pathway formation, neuroglia interactions, and neurotrophic agents.

NEUR 795 – The Development and Anatomy of Sensory Systems (2). Designed as an introduction to the structure and ontogeny of the sensory pathways. Provides a foundation for the subsequent advanced coursework in sensory systems, which provides one of the most fertile experimental areas in developmental biology. Topics include basic genetic control of developmental processes; embryonic development of the sensory nervous system; development and organization of subcortical sensory pathways; development of sensory cortices; role of the environment in neural development; and the genetics of neuronal ontogeny.

NEUR 796/797 – Special Topics in Sensory Neuroscience: Hearing and Multi-Sensory Integration (2). Emphasizes current topics in neuroscience pertaining to sensory systems. Topics cover neurobiology of individual sensory systems such as visual, auditory, somatosensory, olfactory, and gustatory systems. The importance of multi-sensory integration, i.e., how different sensory systems function together to generate perception, is highlighted. Includes lectures, seminars, discussions, and reading assignments in the area of interest. *P—POI.*

NEUR 798 – Manuscripts, Seminars, and Posters (2). A highly interactive course with enrolled students receiving detailed feedback on all written assignments. Covers areas such as writing style, composing abstracts, constructing figures and legends, as well as simulating the e-submission process (text, figures, cover letter, etc.). In addition, previously published work is dissected for style, structure, and presentation.

Didactic lectures cover a wide range of subjects, including but not limited to, EndNote (for Web); basics of Adobe Illustrator; authorship issues, and responses to reviewer's comments. *Background in neuroscience not required. Open to graduate students from all programs.*

TRANSLATIONAL AND HEALTH SYSTEM SCIENCE (THSS)

Program Co-directors	Kristie Foley, Lindsay Reynolds
Professors	Walter Ambrosius, William Applegate, Hal Atkinson, Nancy Avis, Alain Bertoni, Werner Bischoff, Goldie Byrd, Haiying Chen, Ralph D'Agostino Jr., Suzanne Danhauer, Debra Diz, Stephen Downs, Doug Easterling, Matthew Edwards, Mark Espeland, Kristie Foley, Sabina Gesell, Metin Gurcan, Mark Hall, Kathleen Hayden, David Herrington, Jason Hoth, Denise Houston, Tom Houston, Tim Howard, Fang-Chi Hsu, Dalane Kitzman, Stephen Kritchevsky, Carl Langefeld, Paul Laurienti, Leon Lenchik, Michelle Mielke, David Miller, Michael Miller, Justin Moore, Wendy Moore, Michael Nader, Barb Nicklas, Katherine Poehling, Steve Rapp, Dave Reboussin, Scott Rhodes, Gary Rosenthal, John Salsman, John Sanders, Michael Shapiro, Avi Shetty, Sean Simpson, Joey Skelton, Beverly Snively, Elsayed Soliman, John Spangler, Erin Sutfin, Karl Thomas, Janet Tooze, Mara Vitolins, Lynne Wagenknecht, Kathryn Weaver, Joseph Yeboah, David Zhao
Associate Professors	Oguz Akbilgic, Mike Bancks, Prashant Bhave, Sarah Birken, Ajay Dharod, Emily Dressler, Timothy Hughes, Elizabeth Jensen, Marc Kowalkowski, Iris Leng, Zubin Master, Michael McCrory, Nicholas Pajewski, Jaime Speiser, Brian Wells
Assistant Professors	Asma Ahmed, Hannah Ainsworth, Shirley Bluethmann, Henry Bundy, Beata Debinski, Rachel Denlinger-Apte, Emilie Duchesneau, Capri Foy, Olivia Gilbert, Jaime Hughes, Byron Jaeger, Cara Janusz, David Kline, Amanda Kong, Beverly Levine, Meng-Yun Lin, Ellen McGinnis, Chi Momoh, Morgana Mongraw-Chaffin, Chandylen Nightingale, Ucheoma Nwaozuru, Nate O'Connell, Carolyn Park, Lindsay Reynolds, Joseph Rigdon, Heather Shappell, Anna Snavely, Stephanie Sohl, Rachel Zimmer
Adjunct Graduate Faculty	Sean Hannah, Jason Roberge, Ana Sucaldito, Pat Sweeney

Overview

The Master of Science degree in Translational and Health System Science (THSS) is hosted by the Division of Public Health Sciences and the Clinical and Translational Science Institute. The THSS program is open to individuals who already hold or are pursing advanced degrees, such as the MD, DVM, ScD, PhD, DPT, DDS, DSN, MMS (Physician Assistant), or MSN who are seeking training in the clinical and population aspects of translational research or improving the health system. The program also may be appropriate for qualified applicants with at least a BA or BS in a social science, public health, or other health-related field, although additional post-baccalaureate coursework may be required. For applicants without an advanced degree, previous experience in a health-related field is required.

The purpose of this program is to assist students in developing competencies (theoretical/conceptual, methodology, statistics) required for the conduct of translational research and the translation of knowledge gained from such research into improved human health through dissemination and implementation in the health system. Development of translational research skills is vital for the future success of researchers in the basic science and health professions. Translational research includes two areas of translation. One area involves the process of applying discoveries generated during laboratory research, and in preclinical studies, to the development of trials and studies in humans. The second area of translation concerns research aimed at enhancing the adoption of best practices in the health system and the community. This program focuses on clinical research and the second area of translational research described above, as well as implementation of evidence-based research in the learning health system. (Of note, the graduate program in Molecular Medicine and Translational Science focuses on the first area of translation described above.) There are two tracks which students may pursue in addition to completion of core coursework: Clinical and Translational Investigation (CTI), and Learning Health System Science (LHSS).

Translational and health system research comprises studies and trials in human participants including:

- Patient-oriented research – Research conducted with human participants (or on material of human origin such as tissues, specimens, and cognitive phenomena) for which an investigator (or colleague) directly interacts with human participants
- Epidemiologic and behavioral studies
- Outcomes research and health services research
- Implementation science

While a minimum of twelve months of full-time work or its equivalent in residence is required for the master's degree, this program normally requires 18 months to two years. In addition to coursework, all students complete a capstone project under the direction of a committee. Students may initiate original data collection or analyze existing data sets to write a research paper or develop a career development award application, dependent on the track. It is feasible to enroll as a part-time student. Students may matriculate only at the beginning of the fall term each year.

The Master of Science degree in Translational and Health System Science was initiated in the fall of 2020. It is one of a small number of similarly structured Master's degree programs in the U.S., placing it on the cutting edge of graduate education.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: All students are required to take a minimum of 32 graduate course credit hours, with 6 hours in capstone courses. All students are required to take the following set of courses: THSS 703, 704, 720, 730, 731, 736. 740, 741, 748, and 749. For the CTI track, 732, 742, and 751 are also required; for the LHSS track, 733, 735, 737, 738, 739, and either 751 or 752 are required.

Certificate Requirements: In addition to the Master of Science degree, two abbreviated THSS graduate certificates corresponding to the two tracks are also available for students who do not have time to complete a capstone project. The purpose and entrance requirements are identical to the Master's program. Although capstone coursework is not required, students who seek a certificate will need to complete at least 15 hours of specified THSS coursework, complete research ethics training requirements and demonstrate competency in basic biostatistics.

Courses of Instruction

THSS 703 – Ethics and Responsibility in Translational and Health System Science I (1). Provides students with an overview of topics related to ethics and the responsible conduct of human subjects research. Students utilize a case-based format to address such topics as: study oversight and research design, informed consent, selection of subjects, conflicts of interest, the social effects of research, the use of embryos, fetuses and children in research, genetic research, and authorship and publication of study findings. Students are required to complete the Collaborative Institutional Training Initiative (CITI) Human Research On-Line Curriculum as part of this course. *P—POI; Satisfactory/Unsatisfactory*.

THSS 704 – Ethics and Responsibility in Translational and Health System Science II (1). Provides students with an overview of topics related to ethics and the responsible conduct of human subjects research. Students utilize a case-based format to address such topics as: study oversight and research design, informed consent, selection of subjects, conflicts of interest, the social effects of research, the use of embryos, fetuses and children in research, genetic research, and authorship and publication of study findings. Students are required to complete the Collaborative Institutional Training Initiative (CITI) Human Research On-Line Curriculum as part of this course. *P—THSS 703 or POI; Satisfactory/Unsatisfactory*.

THSS 720 – Epidemiology (4). This course is designed to provide students with an introduction to the concepts and methods of epidemiology. Foundational elements covered throughout the course include study design, measurement of disease frequency and disease association, and threats to validity in epidemiologic and clinical research.

Topics and concepts discussed in the context of these elements include critical review of scientific literature, systematic bias, random error, confounding, interaction, sensitivity and specificity, regression and survival analysis, causal inference, interpretation of data, and policy implications. *P—POI.*

THSS 722 – Antimicrobial Stewardship (3). The Antimicrobial Stewardship (AMR) course will expose candidates to the challenges and opportunities faced by the healthcare epidemiology community and provide the understanding and tools to mitigate the threat of infectious pathogens present in patient care settings. This course will provide students with the competency regarding antimicrobials to reduce the occurrence of AMR in diverse healthcare settings through surveillance, research, new product development, and prevention and control. This course is mandatory for students pursuing the Antimicrobial Stewardship & Infection Prevention Concentration. *Typically offered in the spring term. P—THSS 720 or BMSC 713; POI.*

THSS 723 – Infection Prevention and Health System Epidemiology (3). This course will provide the knowledge base to apply epidemiological principles and determine appropriate infection prevention measures to reduce the occurrence of hospital associated infections and spread of communicable diseases in healthcare settings. The proposed training program will expose candidates to the challenges and opportunities faced by the healthcare epidemiology community and provide the understanding and tools to mitigate the threat of infectious pathogens present in patient care settings. This course is mandatory for students pursuing the Antimicrobial Stewardship & Infection Prevention Concentration. *Typically offered during the summer term. P—THSS 720; POI.*

THSS 725 – Global Health Seminar Series (1). The Global Health Seminar Series will teach the interaction between a pathogen, host, and environment, transmission modes and dynamics, and disease elimination pathways, with focus on issues affecting global populations. The course will address the causes and consequences of morbidity and mortality related to infectious diseases that cross regional or national boundaries, with emphasis on research and implementation of public health interventions in low and middle-income countries. *Typically offered in the fall term. P—POI.*

THSS 727 – Introduction to Theory and Methods in Decision Analysis (2). Health and medicine (like life in general) are full of hard decisions, characterized by difficult choices under conditions of uncertainty often with high stakes. Decision analysis represents a theoretical and methodological approach to these challenging decisions. This course will go over the theoretic and practical aspects of decision sciences, including Bayesian manipulation of probabilities, expected utility theory, decision trees, cost-effectiveness analysis, and Markov modeling. It is an overview course, but students will be given the opportunity to try many of the techniques. *P – Basic knowledge of statistics.*

THSS 730 – Introduction to Biostatistics (4). This course provides an introduction to statistical concepts and basic methodologies that are prevalent in

biomedical literature. It includes discussion topics such as descriptive statistics, probability, sampling distributions, hypothesis testing, simple linear regression, correlation, one-way analysis of variance, categorical data analysis, survival analysis, sample size and power analysis, and nonparametric methods. *Access to SAS/STAT required. P—POI.*

THSS 731 – Introduction to Biomedical Informatics for the Learning Healthcare System (2). The Introduction to Biomedical Informatics for the Learning Healthcare System course provides an introduction to the core domains of biomedical informatics, including bioinformatics, medical/healthcare informatics, public health informatics, imaging informatics, and the evolving role of biomedical informatics in the "Big Data" era. Course content is provided using didactic lectures, group discussions, selected readings, directed self-study and classroom demonstrations. *P—POI.*

THSS 732 – Statistical Modeling (4). The topics of the course include statistical concepts and basic methodologies related to the general linear model and its extensions. The basic statistical procedures discussed in the course include simple and multiple linear regression, analysis of variance and covariance, logistical regression, and repeated measures analysis. Emphasis is given to proper application and interpretation of statistical methods and results. *Access to SAS/STAT required. P—THSS 730 or POI.*

THSS 733 – Learning Health System Team Science Practicum (0.5-2). The Learning Health System Team Science Practicum is an experiential activity in which course participants are embedded in an interdisciplinary team at Wake Forest Baptist Health working to implement evidence-based strategies to improve healthcare quality, access, or costs. The goals of the Practicum are to enhance participants' 1) competency in working in interdisciplinary team; 2) awareness of the complexity of implementing organizational change in the complex milieu of a large integrated delivery system; 3) understanding of potential patient, provider and system level barriers to change; and 4) understanding of the marketplace challenges faced by healthcare delivery systems in rapidly changing environments. Trainees will develop a literature review that will describe 1) the significance of the issue that is being addressed by the team; 2) challenges or barriers that have to be overcome to address the issue; 3) interventions to address the issue that have been described in the literature; and 4) potential metrics to measure the impact of interventions to address the issue. *P—POI.*

THSS 735 – Building Successful Teams (0.5). This course provides an introduction to building successful teams, with a focus on building translational research teams in the health system. It will consist of two sessions that will provide an introduction to concepts of team building and leading teams, including team development, developing team charters, holding team members accountable, team dynamics, working in multi-disciplinary teams, minimizing conflict, and holding effective meetings. Students will be asked to write reflections of team building concepts addressed after completing each session. *P—POI.*

THSS 736 – Principles of Improvement and Implementation Science (2). The Principles of Improvement and Implementation Science course provides an introduction to dissemination and implementation (D&I) science and a theoretical foundation to translate evidence into clinical practice, health policy, or public health. Participants will be introduced to the foundations of implementation science and will explore a broad range of implementation research in health and healthcare. Topics include D&I research terminology, efficacy and effectiveness research, quality improvement methods, evidence-based interventions, D&I measures and analytic strategies, fidelity, developing sustainable partnerships, and evaluating and adapting D&I strategies. *P—POI*.

THSS 737 – Organizational Change in Health Systems (2). This course provides an introduction to models for leading effective change and open systems thinking. Students will not only study models for effective change leadership, but will apply knowledge to cases, simulation and practical projects in the Health Care setting. *P—POI*.

THSS 738 – Learning Health System Colloquium (0.5-1). The Colloquium brings together faculty, mentors, and trainees and utilizes two formats. The first format involves the discussion of emerging methods in health systems research using a "flipped classroom" design in which students are asked to read original studies using the methods being discussed and pose two questions about the topic on the Colloquium website. The second format involves student presentations of drafts of manuscripts or 'Chalk Talks' of research projects they are developing. The primary goal of these sessions is to teach skills in critical review and the features of well-written research. The format promotes a lively pre-class exchange of ideas and ensures that the presenter covers issues identified by trainees. The intimate nature of the Colloquium also enables presenters to learn about the interests of the students and mentors. Colloquium content will be well integrated and aligned with the course content to complement or reinforce learning competencies for the Translational and Health System Science MS and Learning Health System Science certificate programs in the area of development of research questions, review of the scientific literature, study design, statistical analysis, research ethics, scholarly communication, team science, implementation science, health system operations, and systems theory. *P—POI*.

THSS 739 – Leading Successful Teams (0.5). This course provides an introduction to leading successful teams, with a focus on leading translational research teams in the health system. It will consist of three sessions that will address the essential leadership skills for leading successful teams, including communication, negotiation, building trust, decision making, and problem solving. Students will be asked to write reflections of leadership concepts addressed after completing each session. *P—POI*.

THSS 740 – Scientific Writing for Papers and Proposals (2). This course provides students in the Translational and Health System Science MS or certificate programs with the knowledge and skills to develop a grant proposal to pursue funding in their areas of interest. It represents the second in a series of capstone courses for the MS

degree. The course will be taught over 6 weeks in the summer session with weekly 2.5-hour sessions. Topics covered include Human Subjects, Clinical Trials, Investigator, and Resource components of grant proposals; NIH review process; How to write a grant critique; mock study section; and how to revise a grant proposal. Sessions will be led by faculty and research staff with expertise in writing, developing, and critiquing grant proposals. *P—POI*.

THSS 741 – Research Grant Preparation (1). Provides students with the knowledge and skills to develop grant proposals to pursue funding in their areas of interest. Topics covered include: the role of external funding in biomedical research; how to identify public and private sources of funding; required components of grant submission; and human subjects and budgeting considerations. Students develop a research proposal for peer review and critical discussion. *P—THSS 740; POI*.

THSS 742 – Clinical Trial Methods (3). Provides students with knowledge of clinical trials methodology from Phase I through Phase IV and beyond. Topics include why trials are needed; specification of the trial question(s); basic trial designs; identification of the appropriate study population, interventions, and response variables; the randomization process; masking; sample size; data analysis; recruitment/retention/adherence; trial monitoring and interim analyses; assessing/reporting adverse effects; and interpreting trial results. *P—POI*.

THSS 747 – Topics in Cancer Survivorship Research (1). Provides students with an overview of topics related to cancer survivorship. Topics include epidemiology of cancer survivorship, quality of life issues, cancer and the family, disparities in morbidity and mortality, late effects of cancer treatment, ethical issues, complementary and alternative medicine, symptom management, behavioral and lifestyle issues post-treatment, health services research, and special populations. *The course may be repeated for credit. P—POI*.

THSS 748 – Translational Research Methods I (2). The course will focus on the development of integrated aims, literature reviews, and conceptual frameworks that provide the necessary foundation for successful community and health delivery translational research. To provide students with the opportunity to expand their ability to develop and communicate research concepts, the course will include numerous in-class activities and several written assignments. *Typically offered in the fall term. P—POI*.

THSS 749 – Translational Research Methods II (3). The course examines how study designs are selected and examines specific application of these designs within the community and health delivery settings. The latter part of the course focuses on measurement, with emphasis on the development of data collection forms and surveys. To provide students with the opportunity to expand their ability to develop and communicate research concepts, the course will include in-class activities plus a presentation and written assignments. *Typically offered in the spring term. P—THSS 748; POI*.

THSS 751 – Research Paper (1-9). The Research Paper is a capstone project for the Translational and Health System Science (THSS) MS program and is required for the Clinical and Translational Investigation track. The goal of the paper is to apply the knowledge and skills gained from coursework to the development of a research paper suitable for publication in a peer-reviewed journal. Students will work individually on the paper and will be the first author on the manuscript. The Research Paper course is intended to be taken after or concurrently with coursework. The Research Paper will be assessed by a Research Paper Committee comprised of the student's advisor, a statistician, and an additional member with subject area expertise. *P—POI*.

THSS 752 – Career Development Award Application (1-9). The Career Development Application is a capstone project for the Translational and Health System Science (THSS) MS program. The goal of the course is to apply the knowledge and skills gained from coursework to the development of a training grant suitable for submission to a funding agency. The Career Development Award Application course is intended to be taken after, or concurrently with coursework. The career development award application will be assessed by a Capstone Committee comprised of the student's advisor and two additional members with subject area expertise. The student is expected to select a scientifically relevant, feasible topic, in the area of clinical, translational, or health system science. Students are expected to develop a training plan and a research plan, as well as put together other essential elements of a career development award application. Students are expected to draft all sections of the training plan and research plan. *P—POI; Satisfactory/Unsatisfactory*.

THSS 761 – Detecting and Understanding Health Disparities (1). This course will define and measure health disparities, evaluate landmark reports, and examine the social determinants and health systems determinants of healthcare disparities. Professional skills developed in this course will include evaluation of implicit bias, critical thinking in health care ethics, adjusting to group dynamics, and practice in public speaking. *P—POI*.

THSS 762 – Promoting Health Equity (1). This course will address organizational and community points of interventions to reduce health disparities, strategies for policy intervention to address health disparities, development of platforms for community engagement, and incorporating service learning projects into the educational structure. Professional skills developed in this course will include problem-solving skills, adjusting to group dynamics, and written communications. *P—POI*.

THSS 765 – Translational Research in Aging and Alzheimer's Disease (2). The interdisciplinary graduate course will introduce learners to the basic concepts, topics, and methods of research on the biology of aging, gerontology, geroscience, Alzheimer's and Related Dementias (ADRD) and translational research within the Sticht Center for Healthy Aging and Alzheimer's disease Prevention. The Course is founded on the NIH mission "to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life,

and reduce illness and disability." This course explores the intersection between the biology of aging and the biology of age-related diseases with a focus on Alzheimer's disease and related dementias, and translational approaches to increase healthy years of life. Lectures will focus on aging mechanisms and their link with chronic disease, how to detect and measure aging and Alzheimer's disease across model systems, and therapeutic interventions to prevent and/or treat age-associated diseases. All lectures will highlight how the interconnection among tissues and systems modulates aging and disease throughout the lifespan. At the end of the course learners will be able to define biology of aging and distinguish it from disease; apply appropriate nomenclature used in aging and ADRD research; discuss clinical phenotypes and choose appropriate methods and models to experimentally research the biological underpinnings (i.e., pillars of aging) of age-related disorders.

THSS 766 – Individual Study in Translational and Health System Science (1-6). Provides students with opportunities to pursue advanced topics in their individual areas of interest with guidance from expert faculty. *May be repeated for credit. P—POI.*

TRANSLATIONAL BIOTECHNOLOGY (TBIO)

Program Director	Tracy Criswell
Professors	Graça Almeida-Porada, Anthony Atala, Colin Bishop, Vijay Gorantla, Robert Hampson, Sang Jin Lee, Jeong Ok Lim, Frank Marini, Sean Murphy, Emmanuel Opara, Christopher Porada, Shay Soker, Xiuzhi Susan Sun, Stephen Walker, James Yoo
Associate Professors	Tracy Criswell, John Jackson, Amol Joshi, Baisong Lu, Zubin Master, Patrick McNutt, Sean Murphy, Thomas Shupe, Yuanyuan Zhang
Assistant Professors	Xu Han, Young Min Ju, Ji Hyun Kim, Yalcin Kulahci, Josh Maxwell, Kimberly Reeves, Tony Reeves, Mostafa Rezapour, Hooman Sadri, Michael Seeds, William Vaughan, Victoria Weis, Weixin Zhao
Adjunct Graduate Faculty	Steven Bauer, Bita Nickkholgh, Lisa Winkler

Overview

The Master of Science degree in Translational Biotechnology (TBIO) is hosted by the Wake Forest Institute of Regenerative Medicine (WFIRM). The TBIO program is appropriate for individuals interested in research careers in academia or industry, or professionals interested in entering the biotechnology field.

The purpose of this program is to provide a solid foundation of core scientific knowledge required for success in the biomedical sciences. Research training, as either hands-on research experience or contextual learning, is critical as it allows the students to acquire a basic understanding of laboratory techniques and provides experience in the development of novel, hypothesis-driven research, while also conferring a strong and unique critical thinking skill set. Depending on the career goals of the student, the internship experience will allow students to experience either a research or business environment in an industrial setting and provide beneficial contacts and networking opportunities that could be used to further their career after graduation. In addition, students will be able to take elective courses in the “soft skills” mentioned previously including science communication and management. By the end of this program, students will have developed a strong knowledge base of basic science and the scientific method, will be able to demonstrate expertise in laboratory techniques, and will be able to integrate the knowledge of the translational process, pertinent regulatory issues and practices, and experimental design, while receiving training in the product development process, bringing technologies to market/commercialization and bio-manufacturing.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: All Business pathway students must take a minimum of 43 graduate course credit hours, including capstone credit hours. Students in the Research pathway are required to take 53 course credit hours, with a minimum of 6 research hours. All students must take the following courses: TBIO 702, 731, 732, and MMTS 721. For the Business pathway, TBIO 701, 704, 794, 795/796 and CRM 701 and 712 are also required; for the Research pathway, TBIO 711, 794, 797/798, IPP 785/786, GRAD 713, 714, and MCB 753 are required.

Certificate Requirements: In addition to the Master of Science degree, an abbreviated TBIO graduate certificate is also available. The purpose and entrance requirements are identical to the Master's program. Although capstone coursework is not required, students who seek a certificate will need to complete at least 15 hours of specified TBIO coursework, complete research ethics training requirements and demonstrate competency in translational biotechnology topics.

Courses of Instruction

TBIO 701 – Regenerative Medicine for Non-scientists (3). This course introduces non-scientists to the basics of the scientific process and the scientific principles of regenerative medicine and tissue engineering. This is an introductory course designed to provide the scientific knowledge required to lead and manage a biotech company. Topics will include the major characteristics of science and science-based evaluation, the cellular and molecular basis of life, an introduction to genetics and development, and the basic chemistry of biomaterials. An emphasis will be placed on how these topics are related to current issues such as stem cell therapy, genetic engineering, and biotechnology.

TBIO 702 – Introduction to Translational Medicine (3). This is an introductory course covering topics related to translational medicine. This course will introduce students to concepts related to taking basic scientific discoveries to the patient. Topics will include quality assurance, quality control, regulatory affairs, preclinical models, process development, and GMP development.

TBIO 704 – Introduction to cGMP Regulations (1). Current Good Manufacturing Practice (cGMP) regulations are the minimum standards for the design, production, and distribution of drugs, biologics, and medical devices in the U.S. and internationally. In the U.S., they are codified at the federal level in the FD&C Act and the Code of Federal Regulations and are actively enforced by the FDA. Additional sources of insight and guidance include the FDA's guidance documents and training manuals, industry trade publications, international compendia, and standards-setting organizations. Students will learn the scope and history of the regulations, industry-standard implementation strategies and "best-practices" approaches.

TBIO 711 – Fundamentals of Innovation Management (3). This course develops students' understanding of business fundamentals with learning design structured around timely, real-world case studies and examples. Key topics include the role of business, the global economic and legal environment, ethics, marketing, accounting and finance, and managing processes and operations.

TBIO 722 – Ethics and Biotechnology (1). This course uses a case study discussion approach to examine professional norms and obligations for the ethical practice of science in the United States in the context of industry and biotechnology. Content includes the principles underlying the responsible conduct of scientific research regarding the acquisition, management, sharing, and ownership of data.

TBIO 731 – FDA Case Studies (1). To work in the pharmaceutical industry, familiarity with Federal Regulations that govern the field is required. Final drug product regulations from 21 CFR 211, otherwise known as the current Good Manufacturing Practices and other regulations will be covered using real-life examples from the pharmaceutical industry. Current hot topics and FDA areas of concern will be highlighted.

TBIO 732 – Biotechnology Seminar (1). The Biotechnology Seminar introduces students to issues and challenges facing leaders of public and private-sector organizations as well as to communities seeking to achieve shared goals within the biotechnology industry. The course brings together diverse academic, science, and business disciplines (science, regulatory affairs, marketing, finance, legal, ethics, communications, etc.). It explores how these disciplines can be used as powerful tools to create effective leadership and productive collaborations within the industry while improving managerial decision-making.

TBIO 742 – Introduction to Tissue Engineering and Regenerative Medicine (3). This is an on-line asynchronous course. This introductory course is designed to provide a basic understanding of the scientific principles behind tissue engineering and regenerative medicine. Topics covered in this course include an introduction to the history of tissue engineering and regenerative medicine, cell and stem cell biology, tissue physiology, bio-materials, scaffolds for tissue engineering, enabling technologies, and current challenges in the field.

TBIO 794 – Externship (1-9). The overall goals of the Externship are to provide the participant with an in-depth view of the operation of a regenerative medicine organization; an understanding of the relationship between research or clinical practice and the business of clinical translation or bio-manufacturing of regenerative products or engineered tissues; exploration of career opportunities outside of traditional clinical or academic research tracks; and the development of career connections and professional networks. *Satisfactory/Unsatisfactory*.

TBIO 795/796 – Capstone (1-9). The Capstone course is an independent or group project that spans the duration of the TBIO program. We ask each participant to identify

a novel drug, therapeutic, device, or business early in their coursework that will serve as the basis of their project. This idea can relate to his/her organization or to a personal interest. Throughout the program, each student will work collaboratively with a variety of people including their peers, professional colleagues, course faculty, advisors, and chairs, integrating various perspectives across academic, industry, and regulatory sectors to develop a business plan for this idea. Students draw upon knowledge and skills from their coursework with an emphasis on collaborating across biotechnology sectors to develop strategic business plans. *Satisfactory/Unsatisfactory*.

TBIO 798/799 – Research (1-9). Mentored research on regenerative medicine/tissue engineering problems in preparation for the thesis. Course may be repeated. *Satisfactory/Unsatisfactory*.

Combination Degrees, Certificates, and Concentrations

COMBINATION DEGREES

The Biomedical Graduate Programs office administers the following combination degrees in conjunction with other university professional schools (Medicine and Business): PhD/MMS (in Molecular Medicine & Translational Science), PhD/MD (in all PhD programs), PhD/MBA (in all PhD programs), MS/MD (in Translational and Health System Science), and the MS/BA or BS (in Neuroscience). For information on the degree requirements for all other combination graduate degrees, please consult the Graduate Bulletin maintained and administered through the Arts and Sciences campus.

PhD/MMS (Molecular Medicine and Translational Science)

Program Co-Directors Gayle Bodner, Michael Olivier

Overview

The PhD/MMS is a 5- to 7-year program that combines a PhD in Molecular Medicine and Translational Science (MMTS) with a Master of Medical Science (MMS) in Physician Assistant (PA) Studies and is offered in conjunction with the Wake Forest School of Medicine Physician Assistant Program. The program targets students interested in clinical research, community research, and the translation of knowledge into improved human health. Graduates with the PhD/MMS will be basic scientists trained to function successfully in clinical environments and will have considerable professional flexibility. Graduates can work as clinician scientists on teams conducting clinical trials, for example, or they can teach and conduct research within academic health centers.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin. The PhD degree is conferred in the term in which all requirements for that degree are met. The MMS degree shall be awarded upon completion of the PA program.

Program Requirements: Applicants for the PhD/MMS dual degree program must be accepted first into the PhD program through the Biomedical Graduate Program's admission process. Students can apply for admission to the PA program during the first, second, or third year of study in the PhD program and will begin PA program studies after completing the dissertation defense.

Potential applicants should note the following:

- Students interested in the PhD/MMS program must meet the PA program course prerequisites to be eligible for admission to the PA program
- Students with the MMTS PhD who were involved with translational research and attached to a physician mentor are considered to have met the PA program admission requirement of 1,000 patient/clinical contact hours

- Because students with the MMTS PhD have completed a doctoral thesis, they are also considered to have met the PA program requirement to complete a graduate project

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PhD/MD

Program Director Chris Whitlow

Overview

A PhD/MD degree offers graduates outstanding opportunities in the new era of biomedical research of the 21st century. The invaluable perspective of a PhD/MD graduate positions the physician scientist as a crucial link in translating scientific research into improving human health and reducing disease. During the past decade, 62 percent of Nobel prizes in medicine and physiology were awarded to MD or PhD/MD researchers.

With the increasing sophistication of research tools, MDs without extensive formal research training rarely have the depth of knowledge needed to progress rapidly as a research scientist. The increasing pace of research, the need for knowledge in specific techniques, and the competition in funding have made it more difficult for MD clinicians to succeed in a research-intensive career. Optimal training is provided by combining an MD with a PhD academic program.

The PhD/MD program, a combined effort between the Biomedical Graduate Programs Office and the School of Medicine, is an integrated program where neither the MD nor the PhD degree is compromised. The student gains the full perspective for identification and analysis of problems related to human health while receiving rigorous training in a basic or translational research discipline: training which provides the depth of knowledge of scientific logic and techniques for an effective, exciting, and successful career in medical research.

The program seeks outstanding students who have already shown aptitude and enthusiasm for research.

Degree Requirements: Please see “Requirements for the Doctor of Philosophy Degree” in the “Degree Requirements” section of the Graduate Bulletin. The PhD degree is conferred in the term in which all requirements for that degree are met. The MD degree shall be awarded upon completion of the MD program.

Program Requirements: The duration of the program typically is seven years. Prior to entry into MD program, students are required to explore available research opportunities. A research rotation is conducted with a selected member of the participating graduate faculty. This research rotation (and subsequent ones, if needed)

familiarize students with faculty and their fields of expertise; usually one of these faculty are chosen as the student's graduate (PhD) advisor.

Years 1 and 2: The first two academic years are dedicated to the MD program. Phase I (seven months) introduces core biochemical knowledge, including development and structure of the human body (gross, microscopic, embryological, and radiological anatomy) and basic cellular functions (biochemistry, molecular biology and genetics, immunology, introduction to pathology).

Phase II (months 8-20) includes courses in systems pathophysiology (physiology, pharmacology, microbiology and pathology), and a two-month period for a second rotation in a lab of the selected graduate program in the summer after the first year.

Medicine as a profession, clinical decision making, and epidemiology studies are included in both Phases I and II.

During these years, the student usually attends a graduate seminar course. The seminar meets once a week and provides a continuing in-depth introduction to the chosen graduate discipline in addition to social and intellectual contact with other graduate students and faculty.

If possible, the student chooses a graduate adviser by the end of Phase II of the medical curriculum. Otherwise, the summer after Phase II may be used for another laboratory rotation, prior to choosing an adviser.

At the beginning of year three students will remain with their medical school class for a three-month clinical experience. These three months are spent learning basic clinical skills on internal medicine rotations and introduce the students to the practice of medicine providing basic skills in completing the history and physical exam experience during the biomedical graduate program enrollment in an out-patient clinic. These three months of training will also increase the flexibility for returning to medical school upon completion of the graduate degree. After completion of the three clinical months the students will then join their biomedical graduate program with the new cohort of graduate students.

Years 3 through 5: During the biomedical graduate program enrollment, the student participates in a monthly outpatient clinical experience. Students rotate at a clinic for the underserved, working with faculty and private practice physicians. Participation in this clinic not only helps to maintain clinical skills but gives the student experience with balancing research and clinical responsibilities.

The third year is spent taking advanced basic science courses and conducting research. Didactic coursework is intended to supplement the biomedical knowledge base built in the medical school curriculum. Program courses also provide a more discipline-specific focus and, therefore, depend on the chosen graduate program.

The duration of the dissertation research may vary but typically is completed in years three-to-five and, if needed, a portion of year six. The PhD dissertation is completed and defended prior to returning to clinical studies.

Years 6 and 7: The student completes eighteen months of required clinical rotations (Phase III of the clinical curriculum) which include internal medicine, surgery, pediatrics, obstetrics, women's health, neurology, psychiatry, radiology, anesthesiology, family and community medicine, and emergency medicine. Four months of elective time are spent in other clinical experiences or may be used for completion of graduate studies prior to returning to the medical curriculum. This part of the schedule is tailored to the individual student with the approval of the graduate advisor, MD/PhD program director, and the Associate Senior Associate Deans for medical education and student services.

Both the Biomedical Graduate Program and the School of Medicine evaluate the applicant's credentials. The MCAT is the required standardized test for all applicants. All biomedical PhD programs participate in the combination degree plan.

Initial application is through the American Medical College Application Service (AMCAS). When the School of Medicine receives AMCAS applications, students are sent supplemental forms for application to the School of Medicine. The applicant should indicate interest in the combined PhD/MD program on the supplemental application. The School of Medicine supplemental packet requests an evaluation by the applicant's premedical advisory committee. For the PhD/MD program, the applicant should also include letters of evaluation specifically addressing his or her research experience and abilities.

This is a highly competitive, limited program. Students who matriculate receive tuition scholarships throughout the program. In addition to outstanding grades and MCAT scores, the applicant should provide evidence of enthusiasm and aptitude for research, with prior research experience beyond that of college courses. This is an important factor in evaluation of the application.

After the supplemental application packet, MCAT scores, and letter(s) of evaluation are received, the completed application is reviewed by the committees on admissions of the MD/PhD program. Competitive applicants are scheduled for interviews.

PhD/MBA

Program Director — Dwayne Godwin

Overview

In addition to intensive doctoral training, the PhD/MBA program incorporates core knowledge of business and managerial skills to provide the student with a marketable, competitive advantage, whether the student finds employment in industry or academia. Graduates choosing to pursue a traditional tenure-track faculty position will have the

managerial and business training to initiate and operate their own research laboratories and to collaborate more effectively with the private sector. Graduates choosing a non-traditional career path will be prepared to exercise their research training in management positions in the pharmaceutical industry, private foundations, government agencies, or university research and technology transfer offices.

Degree Requirements: Please see "Requirements for the Doctor of Philosophy Degree" in the "Degree Requirements" section of the Graduate Bulletin. The PhD degree is conferred in the term in which all requirements for that degree are met. The MBA degree shall be awarded during the same term as the PhD.

Program Requirements: The program is a synthesis of curricula from the Biomedical Graduate Program and the Evening MBA Program of the Wake Forest University School of Business, with specialized coursework and opportunities for industrial and business internships. The combination program is open to all PhD-granting programs across all Wake Forest campuses. It has taken students approximately 5 years to complete the combination program, depending on the nature of the graduate research undertaken in the home program. The first year of the curriculum provides students with a core base of knowledge in biomedical sciences and includes training in the core competencies of the home graduate program. At the same time students begin to be exposed to issues related to research and design, career development, and journal clubs. Laboratory rotations usually occur in this first year in accord with Program or Track requirements. The students typically begin their dissertation research during the second year. At the end of the second year and before beginning MBA coursework, the student is required to take and pass a qualifying exam that will admit him or her to candidacy for the PhD.

A student enrolling in the PhD/MBA program will have 5-6 terms of evening MBA courses added to his or her graduate degree requirements. Opportunities for industrial projects and internships are possible after ascent to PhD candidacy and during the MBA coursework phase. The PhD and MBA degrees are awarded simultaneously at the completion of all requirements for both degrees.

Admissions are administered through the Biomedical Graduate Program. Students wishing to enroll in the program must apply to both programs and meet the respective admissions requirements of the Biomedical Graduate Program and the Wake Forest University School of Business. Admission to the MBA portion of the program can occur separately after gaining admission to the home graduate program and after securing appropriate release from the home program for participation in the combination program (this is in the form of a letter from the thesis advisor cosigned by the program director). In addition to the application a copy of the letter should be submitted to Dr. Dwayne Godwin, Senior Associate Dean, Biomedical Graduate Programs Office, and Director, PhD/MBA program. The Graduate Record Exam is accepted for admission to the combination program. Prospective students should also submit a one-page statement of interest indicating future plans for use of the combination degree, official

transcripts from each college or university attended, and three completed recommendation forms.

Before admission to the program, the applicants are required to complete a personal interview with the PhD/MBA program director and the Wake Forest University School of Business. After the interview phase, the top applicants may be offered admission to the combination program.

MS/MD (Translational & Health System Science)

Program Co-Directors — Kristie Foley, Lindsay Reynolds

Overview

Those interested in the MS/MD degree may choose to complete training in clinical research after the third year of medical school. Medical students may apply for admittance to the MS graduate program in the fall of their third year. The MS/MD in Translational and Health System Science is designed to develop competencies in clinical researchers interested in conducting translational or health system research as a physician scientist.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin. The MS degree is conferred in the term in which all requirements for that degree are met. The MD degree shall be awarded upon completion of the MD program.

Program Requirements: Students apply to the MS program through the Biomedical Graduate Programs Office during their enrollment in the MD program. Accepted applicants enroll full-time in the MS program during their fourth year of study and complete required coursework for the MS degree within that year. Upon completion of the MS curricula and their capstone project, students return to the MD program to complete the MD degree. In rare cases, students may request to continue work towards completion of the capstone project concurrently with their MD degree pursuit.

In addition to the Master of Science degree, two abbreviated certificates in THSS (Clinical and Translational Investigation, Learning Health System Science) are also available for medical students who for various reasons choose not to complete a full MS degree. Admissions requirements for the certificates are identical to that to gain admittance into the master's program. Please see the section on Certificates for additional information on the certificate requirements.

MS/BS-BA (Neuroscience)

Program Director — Paul Czoty

Overview

This program offers Wake Forest University, or partner school, undergraduates pursuing a BS or BA degree in a Neuroscience discipline the opportunity to earn a research-oriented MS degree in Neuroscience with one additional year of study. The program builds on the existing Neuroscience Minor and utilizes existing course and research opportunities associated with the Biomedical Graduate Programs Office's Neuroscience Program.

The goal is to provide highly motivated undergraduate students the opportunity to pursue sophisticated, graduate-level research training in neuroscience, critical thinking, data analysis, and experimental design skills. Students will gain graduate course credit and an enhanced research experience that will provide them with a competitive edge to apply to graduate or professional schools, or to pursue non-academic careers that require research expertise in the life sciences and Neuroscience.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: Wake Forest University undergraduate students wishing to enter the program are encouraged to declare and pursue the Neuroscience minor and should work with the director of the Neuroscience minor to ensure all requirements are met. Students begin this program as a junior and must identify a research mentor prior to beginning the program. Once enrolled in the 4+1 MS program, students will also take NEUR 791/792 (1) and NEUR 707/708 (1) each semester during the junior and senior year as an undergraduate student. The students will work with their research mentors to develop and begin their MS thesis research project. During the last year of the program, students complete the first-year curriculum for Neuroscience Graduate students and complete their MS thesis. Requirements for students entering from partner schools will be specified in an articulation agreement between the program and the partner school.

Current Partner Schools:

- Wake Forest University (Undergraduate students)

MS/BS-BA (Clinical Research Management)

Program Director Ralph D'Agostino Jr.

Overview

This program offers undergraduate students at partner institutions that are pursuing a BS or BA degree the opportunity to earn a MS degree in Clinical Research Management with one additional year of study.

The goal is to provide highly motivated undergraduate students the opportunity to pursue sophisticated, graduate-level training in clinical research management, critical thinking, and data analysis. Students will gain graduate course credit and an enhanced

experience that will provide them with a competitive edge to pursue careers in clinical research management in industry, academics, or government.

Degree Requirements: Please see "Requirements for the Master of Science Degree" in the "Degree Requirements" section of the Graduate Bulletin.

Program Requirements: Undergraduate students wishing to enter the program are encouraged to declare their interest before completing 75 undergraduate credit hours by emailing their intent to their partner school contact. A cumulative GPA of 3.0 is required both at the time of application and upon graduation from the undergraduate partner school. It is recommended, but not required, that the student complete a statistics course prior to applying.

Current Partner Schools:

- Cabarrus College of Health Sciences
- Carolinas College of Health Sciences
- Pfeiffer University
- Salem Academy & College

GRADUATE CERTIFICATES

The Biomedical Graduate Programs office administers the following graduate certificates: Clinical and Translational Investigation, Learning Health System Science, and Medical Physics. For information on all other graduate certificate offerings, including Bioethics (BIE), Curriculum, Instruction, and Assessment (CIA), Interpreting and Translation Studies (ITS), Medieval and Early Modern Studies (MDV), Structural and Computational Biophysics (SCB), and Sustainability (SUS), please consult the Graduate Bulletin maintained and administered through the Arts and Sciences campus.

Clinical and Translational Investigation

Certificate Co-Directors — Kristie Foley, Lindsay Reynolds

Overview

The objective of this certificate program is to provide training in epidemiology, biostatistics, and applied clinical and translational research methods to health professionals, research professionals, and health sciences students, residents, and fellows. Students trained in the program will develop skills to: 1) develop meaningful and feasible research questions, 2) critically appraise the scientific literature, 3) design and implement studies to answer clinical and translational research questions, 4) communicate scientific concepts orally and in writing, 5) perform and interpret basic biostatistical analyses, and 6) collaborate productively in multidisciplinary scientific teams. Courses are primarily taught by faculty within the Division of Public Health Sciences and are held on Tuesdays and Thursdays.

Certificate Requirements

Although a capstone project is not required, students are required to complete 15 credit hours of instruction of coursework from the Translational and Health System Science (THSS) program, including at least 6 hours from THSS 720, THSS 742, THSS 748, and THSS 749; complete ethics training requirements and demonstrate competency in basic biostatistics. A 3.0 GPA is required.

Learning Health System Science

Certificate Co-Directors — Kristie Foley, Lindsay Reynolds

Overview

The objective of this certificate program is to provide training to integrate research with practice to create and develop learning health systems. Students trained in the program will develop skills to: 1) critically appraise the scientific literature, 2) design and implement studies in health system settings, 3) utilize system science and organizational change management, 4) perform and interpret basic biostatistical analyses, and 6) lead multidisciplinary teams. Courses are primarily taught by faculty within the Division of

Public Health Sciences and the Clinical and Translational Sciences Institute and are held primarily on Mondays, Tuesdays and Thursdays.

Certificate Requirements

Students are required to complete 15 credit hours of instruction of coursework from the Translational and Health System Science (THSS) program or other approved courses, including at least 10 hours from THSS 731, THSS 733, THSS 735, THSS 736, THSS 737, THSS 738, and THSS 739; complete ethics training requirements; and demonstrate competency in basic biostatistics. A 3.0 GPA is required.

Medical Physics

Certificate Director Andy Dezarn

Overview

Ideal applicants for the Graduate Certificate program are those holding a PhD in a physical science discipline, and who are seeking lateral entry into clinical medical physics. Alternatively, candidates holding advanced degrees and previous healthcare work experience are highly encouraged to apply. Graduates of the Certificate program in good standing will have passing letter grades in the 6 core courses required and certified by the Commission on Accreditation of Medical Physics Education Programs (CAMPEP). This certification will satisfy the didactic requirement by the American Board of Radiology (ABR) for taking Part II of the Medical Physics Board Examination.

Enrolled Graduate Certificate students should expect to commit to a minimum of 2 academic terms, starting with a fall term enrollment and concluding in the following spring term, however no on-campus presence in Winston-Salem is necessary. All coursework required for Graduate Certificate students may completed as distance learners. Applicants wishing to pursue the certificate from outside of the United States should contact the Admission Chair to discuss prior to applying.

Certificate Requirements

Students are required to complete 18 credit hours of instruction of coursework from the Medical Physics program, specifically the following courses: MPHY 760, MPHY 771, MPHY 772, MPHY 773, MPHY 776, and MPHY 778. A cumulative 3.0 GPA is required.

Translational Biotechnology

Certificate Director Tracy Criswell

Overview

The primary objective of this program is to provide a strong foundation in the scientific, regulatory, and business skills required to build successful careers in biotechnology in academic, government, and industry settings.

Ideal applicants for the Graduate Certificate program are students with undergraduate degrees in science (biology, chemistry) interested in remaining in academia or looking to move to biotech. Additionally, inclusion of academically eligible professionals already working in healthcare, academia, business, regulatory affairs or law, with an interest in biotechnology, will also be eligible.

Students should expect to commit to a minimum of 2 academic terms, starting with a fall term enrollment and concluding in the following spring term, however no on-campus presence in Winston-Salem is necessary. All coursework required for Graduate Certificate students may be completed as distance learners.

Certificate Requirements

Enrolled students in the Graduate Certificate program are required to take at least 15 credit hours of coursework and remain in good standing with an overall cumulative GPA of 3.0 or higher. Courses will be chosen by the student, with final approval by the program director and the WFIRM curriculum committee. At least one course must include ethics training.

CONCENTRATIONS

The Biomedical Graduate Programs office administers the following graduate concentrations: Antimicrobial Stewardship and Infection Prevention, Cancer Biology, Integrative Physiology and Pharmacology, and Regenerative Medicine. The pursuit of a concentration is open to any student and requires no application. Successful completion of a concentration results in a note on the transcript that indicates the completed concentration at the awarding of the degree. Concentrations are not awarded without a completed degree. For information on all other graduate concentrations, including Religion and Public Engagement and Women's, Gender, and Sexuality Studies, please consult the Graduate Bulletin maintained and administered through the Arts and Sciences campus.

Antimicrobial Stewardship and Infection Prevention

Concentration Director — Werner Bischoff

Overview

The Antimicrobial Stewardship and Infection Prevention concentration provides the knowledge base to apply epidemiological principles and determine appropriate antimicrobial stewardship and infection prevention measures to reduce the occurrence of healthcare associated infections and spread of communicable diseases. The concentration exposes candidates to the challenges and opportunities faced by the global healthcare epidemiology community and provides the understanding and tools to mitigate the threat of infectious pathogens present in patient care settings. The collaboration with colleagues from diverse backgrounds will promote the exchange of different approaches to universal antimicrobial stewardship and infection prevention problems and open up opportunities to find and implement novel solutions.

The concentration in Antimicrobial Stewardship and Infection Prevention offers an opportunity for medical professionals to expand their field of study to the emerging threat of resistant pathogens and their successful reduction in global healthcare settings. The concentration therefore meets the needs and desires of students interested in Antimicrobial Stewardship and Infection Prevention and also provides a base of peers with similar interests and goals. The Antimicrobial Stewardship and Infection Prevention concentration also offers a value-added component, and competitive advantage, for students who choose to pursue careers that are not in the traditional academic career path, a frequent choice for current medical professionals.

Concentration Requirements:

- Epidemiology (THSS 720) OR Applications of Epidemiology (BMSC 713)
- Antimicrobial Stewardship (THSS 722)
- Infection Prevention (THSS 723)
- Global Health Seminar Series (THSS 725)

- Capstone project or thesis research completed in Antimicrobial Stewardship and Infection Prevention under the guidance of faculty members of the Section on Infectious Diseases and Global Health (for international students, the project will be selected on a relevant research topic executed in their home country)

Cancer Biology

Concentration Director Steve Kridel

Overview

The Cancer Biology concentration defines the unique educational and research experience for students pursuing an MS or PhD in the Cancer Biology Program, Molecular and Cellular Biosciences and all other tracks. The concentration will cover the topics in cancer research outlined by the Cancer Biology Training Consortium (CABTRAC) as being essential for students pursuing graduate degrees in cancer research.

Cancer Biology is a field of study that uses interdisciplinary approaches to understand the basic, clinical, and translational aspects of cancer. The Cancer Biology concentration would therefore meet the needs and desires of students interested in Cancer Biology and also provide a base of peers with similar interests and goals. The Cancer Biology concentration could also provide a value-added component, and competitive advantage, for students who choose to pursue careers that are not in the traditional academic career path, a frequent choice for current PhD students across the country.

Concentration Requirements:

MS students

- Basics Concepts in Cancer Biology (MCB 721)
- Basic Concepts in Cancer Research (MCB 722)
- Topics in Cancer Biology (MCB 723)
- Cancer Biology Seminar Series (CABI 701 & CABI 702)
- Thesis research completed in the laboratory of Cancer Biology Program faculty (6 hours)

PhD students

- Students must complete coursework with a B grade of higher, pass their written proposal, and advance to candidacy.
- Basics Concepts in Cancer Biology (MCB 721)
- Basic Concepts in Cancer Research (MCB 722)
- Topics in Cancer Biology (MCB 723)
- Cancer Biology Seminar Series (CABI 701 & CABI 702)
- Dissertation research completed in the laboratory of Cancer Biology Program faculty

Integrative Physiology and Pharmacology

Concentration Director — Paul Czoty

Overview

The Concentration in Integrative Physiology and Pharmacology is an integrated course of study under the sponsorship and direction of the Integrative Physiology and Pharmacology program. This concentration embraces the principles of pharmacology, and systems physiology and pharmacology, a unique educational experience that can enhance the program of MS students seeking application to medical school, MS or PhD students in non-biological (e.g., physical) sciences who plan to seek employment in the pharmaceutical or biotech industries, or MS students in a variety of biomedical programs who plan careers in the innovation or science support structures of academic or commercial organizations. The Concentration in Integrative Physiology and Pharmacology will not involve teaching faculty that are outside the IPP graduate program.

Concentration Requirements:

The concentration requires a minimum of 9 credit hours of IPP Graduate Program coursework, selected from the following courses:

- Principles of Pharmacology (IPP 701)
- Systems Physiology & Pharmacology (IPP 702, 4 or 6 credits)
- Any IPP Elective courses (to achieve no fewer than 9 credit hours)

Regenerative Medicine

Concentration Co-Directors — Anthony Atala, Joan Schanck

Overview

Regenerative Medicine is a highly interdisciplinary field which aims to repair diseased or damaged tissues using biological, engineering, and cell-based approaches and technologies. It is a rapidly growing area of biomedical research that encompasses many fields of science and medicine. The field encompasses numerous strategies including stem cell research, tissue engineering (TE), cellular therapies, gene therapy, and biomedical devices to address tissue/organ insufficiency. The concentration in Regenerative Medicine (RM) offers a unique educational and research experience for students pursuing a MS or PhD drawn primarily from four Biomedical Graduate Programs Office tracks (Biomedical Engineering, Integrative Physiology & Pharmacology, Molecular & Cellular Bioscience, and Neuroscience); students in all biomedical sciences graduate programs are eligible to pursue the concentration. The RM concentration will provide multi-disciplinary education and research training in the scientific principles and clinical applications of RM including stem cell biology,

biomaterials, gene therapy, nanotechnology, imaging, and enabling technologies and tissue/organ engineering. The RM concentration offers a balanced combination of theory and practice; and can serve either as preparation for a PhD or as a self-contained advanced qualification in its own right.

Concentration Requirements:

MS Students

- Regenerative Medicine Immersion - Fundamentals, Principles, and Clinical Applications (MMTS 721)
- Introduction to Regenerative Medicine I (BMES 631)
- Advanced Topics in Regenerative Medicine (MCB 753; crosslisted as BMES 753)
- Regenerative Medicine Journal Club (IPP 785/786)
- Additional Requirements - Select one of the options below:
    - Option 1: Regenerative Medicine concentration with Research Thesis completed in the laboratory of Regenerative Medicine program faculty (6 credits)
    - Option 2: Regenerative Medicine concentration with Capstone Project or Internship completed in the laboratory of Regenerative Medicine Program faculty. Projects should take two terms to complete. Credit hours based on length of internship (GRAD 702/703).

PhD Students

- Students must complete coursework with a B grade or higher, pass their written proposal, and advance to candidacy.
- Regenerative Medicine Immersion - Fundamentals, Principles, and Clinical Applications (MMTS 721)
- Introduction to Regenerative Medicine I (BMES 631)
- Advanced Topics in Regenerative Medicine (MCB 753; crosslisted as BMES 753)
- Regenerative Medicine Journal Club (IPP 785/786)
- Thesis research completed in the laboratory of Regenerative Medicine program faculty