

## Biochemistry and Molecular Biology

### School of Medicine Indianapolis

**Chairman**

Professor Zhong-Yin Zhang\*, Robert A. Harris Chair of Biochemistry and Molecular Biology

**Graduate Advisor**

Professor Mark Goebel\*

**Director of Biotechnology Certificate Program**

Sonal P. Sanghani

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**Departmental URL**

[www.biochemistry.iu.edu](http://www.biochemistry.iu.edu)

### Graduate Faculty

(An asterisk [\*] denotes membership in the University Graduate School faculty with the endorsement to direct doctoral dissertations.)

**Primary Biochemistry Faculty**

Zhong-Yin Zhang\*, Robert A. Harris Chair of Biochemistry and Molecular Biology

**Chancellor's Professors**

Howard Edenberg\*, Peter Roach\*

**Distinguished Professor**

Peter J. Roach\*

**Daniel and Lori Efroymson Professor of Oncology**

Hua Lu\*

**Professors**

Anna A. DePaoli-Roach\*, Keith Dunker\*, Mark G. Goebel\*, Maureen A. Harrington\*, Thomas D. Hurley\*, Suk-Hee Lee\*, Ronald C. Wek\*, Zhong-Yin Zhang\*

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**Associate Professors**

Millie M. Georgiadis\*, Lawrence A. Quilliam\*, Debbie C. Thurmond\*, Qi-Zhuang Ye\*

**Assistant Professors**

Charlie (Xiaocheng) Dong, Andy Hudmon\*, Hyun-Suk Lim, Samy Meroueh\*, Yuro Takagi\*, Mu Wang\*, Clark Wells\*

**Primary Emeritus Faculty**

William Bosron\*, David M. Gibson\*, Jean Hamilton-Steinrauf\*, Edwin Harper\*, Roger Roeske\*

**Associate Research Professor**

Xiaoling Xuei

**Assistant Research Professor**

Sonal Sanghani

### Secondary Biochemistry Faculty

**Professors**

W. Marshall Anderson\* (IUSM—Gary), Martin Bard\* (Biology), Simon Conway\*, David Crabb\* (Medicine), Rose Fife\* (Dean's Office), Larry Jones\* (Medicine), Mark Kelley\* (Pediatrics), Michael W. King\* (IUSM—Terre Haute), William McBride Jr.\* (Psychiatry), Harikrishna Nakshatri\* (Surgery), Simon Rhodes\* (Physiology), Jay Simon\* (Psychiatry), David Skalnik\* (Pediatrics), John Turchi\* (Hematology/Oncology), Claire Walczak\* (IUSM-Bloomington), David Wilkes\* (Pulmonary Medicine), Frank Witzmann\* (Physiology), Mervin Yoder Jr.\* (Pediatrics), Yaoqi Zhou\* (Informatics, Adjunct)

**Associate Professors**

Simon Atkinson\* (Nephrology), David Daleke\* (IUSM—Bloomington), Kenneth W. Dunn\* (Nephrology), Joseph Dynlacht\* (Radiation Oncology), Jeffrey S. Elmendorf (Physiology), Dipika Gupta (IUSM - Gary), David Ingram\* (Pediatrics), Reuben Kapur\* (Pediatrics), Daniela Matei\* (Surgery), Ed McKee\* (IUSM—South Bend), Irina Petrache (Pulmonary Medicine), Stephen Randall\* (Biology), Kent Redman (IUSM—Fort Wayne), C. Max Schmidt\* (Surgery), Weinian Shou\* (Pediatrics), James P. Walsh\* (Medicine)

**Assistant Professors**

Tracy Anthony (IUSM—Evansville), Kristin Chun\* (Pediatrics), Lindsey Mayo (Pediatrics, Adjunct), Manjari Mazumdar (IUSM - Bloomington), Nuria Morral\* (Medical Genetics), Julie Peller (IUSM - Northwest), G. Seetharamaiah (IUSM—Evansville)

**Associate Research Professor**

Mark Wagner (Nephrology)

### Assistant Scientist

Dan Spandau (Dermatology)

### Associate Emeritus Faculty

Walter Balcavage\* (IUSM—Terre Haute), Shao-Ling Fong\* (Ophthalmology), T-K Li\* (Medicine)

## Degrees Offered

Master of Science and Doctor of Philosophy; Ph.D. Minor in Diabetes and Obesity, Certificate in Biotechnology

## Special Departmental Requirements

(See also general University Graduate School requirements and departmental brochure.)

### Admission Requirements

Typically, a baccalaureate degree in biology, chemistry, or physics that includes calculus and organic chemistry is required for admission. The General Test of the Graduate Record Examination is required.

## Master of Science in Biochemistry and Molecular Biology with Biotechnology Track

### Admission Requirements

Students must complete the Biotechnology Certificate with a GPA of 3.0 or better before applying to the M.S. program. The GRE is not required for admission to the M.S. degree program.

### Course Requirements

The 30-credit curriculum for the M.S. program includes the 17 credits for the Biotechnology Certificate, plus one elective graduate course in Basic Sciences (3 credits), 9 credits of research with a faculty mentor, and a 1-credit tutorial in scientific writing and communication. A research thesis is required.

## Master of Science in Biochemistry and Molecular Biology

The department encourages most students to enroll in either the M.S. with Biotechnology track or the Ph.D. A minimum of 30 credit hours, including the core curriculum courses G715, G716, G655, G505; plus two of the six 2-credit Biochemistry core courses (G805, G807, G817, G848, G852, G825); and at least 9 credit hours in research. A thesis will be written and successfully defended to the thesis committee.

### Final Examination

Oral, covering thesis and course work.

## Doctor of Philosophy in Biochemistry and Molecular Biology

Students are admitted through the IBMG (Indiana University School of Medicine BioMedical Gateway) open enrollment program and will take a common curriculum in the first semester.

They will commit to the Biochemistry and Molecular Biology program after the second semester.

## CURRICULUM FOR BIOCHEMISTRY AND MOLECULAR BIOLOGY Ph.D. PROGRAM

### Year 1

#### Fall

- G715 Biomedical Science I—Biochemical Basis of Biological Processes (3 cr.)
- G716 Biomedical Science II—Molecular Biology and Genetics (3 cr.)
- G717 Biomedical Science III—Cellular Basis of Systems Biology (3 cr.)
- G718 Research in Biomedical Science (1st lab rotation) (2 cr.)

#### Spring

- G655 Research Communication Seminar (1 cr.)
- G718 Research in Biomedical Science Rotations 2 and 3 (4 cr.)

*Students will take 6 credits from the IBMG open enrollment electives in Spring.*

*Students must take at least **two of the six** 2-credit Biochemistry “core” courses (G805, 807, 817, 848, 852, 825) shown below (offered among the Spring IBMG electives or offered in Fall 2). These may also be taken in later years.*

- G817 Molecular Basis of Cell Structure and Function (2 cr.)
- G852 Concepts of Cancer Biology: Signaling Gone Awry (2 cr.)
- G807 Structural and Chemical Biology (2 cr.)
- G848 Bioinformatics, Genomics, Proteomics and Systems Biology (2 cr.)

### Year 2

#### Fall

- G805 Diabetes and Obesity (2 cr.)
- G825 Advanced Topics in Molecular Biology (2 cr.)
- G505 Responsible Conduct of Research (1 cr.)
- G855 Experimental Design and Research Biostatistics (1 cr.)

#### Spring

- B803 Advanced Biochemistry (1 cr.)
- This course in grant writing will culminate in the submission and oral defense of an “NIH or NSF style” grant proposal on the students intended research topic. The assigned grade for this course is dependent on the successful defense of the proposal that will serve as a qualifying exam and be required for Advancement to Candidacy.*

### Years 2-5

- Seminar B890 (2 cr./year)
- Total credits 33

- B855 Research project >60 credit hours
- Work in the field of the candidate’s thesis. Emphasis on ability to pursue research with relative independence and responsibility.*

## Notes:

- Students will be questioned on topics outside of their thesis work during their thesis proposal oral defense in B803. Passing of this defense (with B/3.0 grade or better) will be required for advancement to candidacy.
- Students will be enrolled for credit in B890 in years 2–5 in which they will present a seminar each year as well as attend all student and faculty seminars. Student seminars will generally be of a “journal club” format, where current, published work in the field of biochemistry is presented. Students who have advanced to candidacy may present their own lab work upon approval of course director and thesis advisor.
- After choosing a laboratory for thesis research, an advisory committee consisting of at least 3 Biochemistry and Molecular Biology and 1 external faculty member will be formed with the approval of the thesis advisor and departmental chairperson. Upon advancement to candidacy a thesis research committee will be similarly formed that may consist of different faculty.
- Students must score at least B– on each course and maintain at least a B average (3.0 minimal GPA).
- M.D./Ph.D. students will not be required to take G715-717 but will be expected to perform lab rotations (G718) during summer breaks from medical school classes. They will take B848 and at least one more of the 2-credit Biochemistry “core” courses (G805, 807, 817, 848, 852, 825) along with other courses required of Biochemistry and Molecular Biology Ph.D. students (G505, G655, G855, B803 and B890) plus 2 credits from other department offerings. In the case of combined M.D./Ph.D. students, the committee may approve substitution of appropriate medical school courses for the electives. The minor representative will be selected from outside the student’s major department and must be approved by the diabetes and obesity training program.

## Grades

A minimum grade point average of 3.0 (B) must be maintained in all nonresearch course work.

## Advancement to Candidacy

B803 Advanced Biochemistry is a course in grant writing which will culminate in the submission and oral defense of an “NIH- or NSF-style” grant proposal on the student’s intended research topic.

Students meet once every six months with an advisory committee to review progress in course work. Continuation in the program depends upon satisfactory performance and progress in each phase of the program. The final examination in the series is an oral defense of a written research proposal, which constitutes the written exam.

## Dissertation

A minimum of 45 credit hours in research, completed with a grade point average of 3.0 (B) or above. It is expected that the dissertation will qualify for publication in a recognized journal.

## Final Examination

Oral, covering dissertation, major, and minor.

## Ph.D. Minor in Cancer Biology

The Ph.D. Minor in Cancer Biology is administered by the Department of Microbiology & Immunology. Cancer Biology Training Program (CBTP) faculty are members of the Indiana University Cancer Center, the matrix organization for an extensive range of cancer efforts and activities. Ongoing NIH- and ACS-funded research programs focus on regulation of cell growth, hematopoiesis, experimental therapeutics, adult oncology, and pediatric oncology. CBTP students will fulfill the requirements of their individual basic science departments and complete the cancer biology minor.

## Ph.D. Minor in Diabetes and Obesity

Preceptors with diabetes-related projects are selected from the basic science department graduate programs or interdisciplinary programs. A minimum of 12 credit hours outside of the student’s major department including G805 Diabetes and Obesity. At least one credit of G504 Introduction to Research Ethics must also be taken. Other courses are selected from the following list:

**B800 Medical Biochemistry (3 cr.)**  
**B810 Cellular Biochemistry and Regulation (3 cr.)**  
**C603 General Pathology (6 cr.)**  
**F598 Drugs, Diseases, and Poisons (3 cr.)**  
**F804 Introduction to Pharmacology and Toxicology I (3 cr.)**  
**F809 Neuropharmacology (3 cr.)**  
**F810 Pharmacology of Autonomic Cardiovascular Control (3 cr.)**  
**F814 Introduction to Pharmacology and Toxicology II (3 cr.)**  
**G706 Cell-Cell Communication (3 cr.)**  
**G804 Cellular and Molecular Biology (3 cr.)**  
**G807 Structural and Chemical Biology (2 cr.)**  
**G817 Molecular Basis of Cell Structure and Function (2 cr.)**  
**G818 Cellular and Integrative Physiology (3 cr.)**  
**G865 Fundamental Molecular Biology (3 cr.)**  
**G910 Advanced Molecular Biology Methods (3 cr.)**  
**J805 Molecular Immunology (3 cr.)**  
**J807 Seminar in Immunology (2 cr.)**  
**J840 Mechanisms of Immune Regulation (3 cr.)**  
**L564 Molecular Genetics of Development (3 cr.)**  
**Q580 Basic Human Genetics (3 cr.)**

More information is available on the Diabetes and Obesity Research Training Program at the Center for Diabetes Research website: <http://medicine.iu.edu/body.cfm?id=4476>

## Certificate in Biotechnology

### Admission Requirements

A baccalaureate degree in a scientific field with a minimum science GPA of 3.0/4.0. Proficiency in English is required, and

must be demonstrated either by obtaining a degree from a certified U.S. university or a minimum score of 550 on the TOEFL.

### Specific Requirements

A fixed curriculum of 17 credits. This will include one introductory course in biochemistry, such as B500 Introductory Biochemistry. This course should be completed before enrolling in the laboratory courses. If a student has taken a recent biochemistry survey course, the student must substitute an advanced graduate lecture course that is relevant to biotechnology. Such courses may include G807 Structural and Chemical Biology, G817 Molecular Basis of Cell Structure and Function, K540 Topics in Biotechnology, or C636 Biochemistry Structural Aspects.

Students may take the remaining courses in any order. Three laboratory courses in biotechnology: G841 Methods in Proteomics (3 credits), G890 Methods in Molecular Biology and Pathology (3 credits), G823 Methods Cell Biology (3 credits). An ethics course, G505 Responsible Conduct in Research (1 credit), is required, as well as two semesters of a problem-based learning course in biotechnology, G828 Concepts in Biotechnology (2 credits).

Students will be required to have an overall GPA of 3.0 or higher and a minimum grade of B– in each of the required courses for the certificate, except for the B500 Introductory Biochemistry, which may be completed with a C+. Students who receive a grade of C in B500 will be required to do additional work in an advanced biochemistry tutorial course (e.g., B803) to bring them up to an acceptable level in basic biochemistry and biotechnology.

### Advisory Committee

The program and student advisory committee will include the program director, directors of the core courses, laboratory director for the program, and one or more representatives from a biotechnology-related company.

### Competency Requirements

In the laboratory and problem-based learning courses, students will be required to demonstrate basic competencies necessary for success as a researcher in industry or academia. These competencies include general skills in communication, problem-solving, and lifelong learning, as well as specific biotechnology skills in good laboratory conduct, laboratory units of measure, computational and statistical analysis, and biotechnology instrumentation.

## Courses

**B500 Introductory Biochemistry (3 cr.)** P: C341 or equivalent. Structures of carbohydrates, proteins, lipids, and nucleic acids. Basic principles of enzyme catalysis, protein synthesis, intermediary metabolism, and nutrition.

**B800 Medical Biochemistry (3 cr.)** P: One semester of organic chemistry. Structure and function of biological molecules, regulation of cellular processes by nutrients and hormones, biochemical and molecular basis of disease.

**B803 Advanced Biochemistry (cr. arr., max. of 3 cr.)** Tutorial instruction in biochemistry.

**B805 Diabetes and Obesity (3 cr.)** P: One semester of biochemistry. Biochemistry, cell biology, molecular biology, genetics, immunology, and pathophysiology of diabetes and obesity. Topics include metabolic regulation, signal transduction, insulin resistance, insulin production, beta-cell function, animal models, complications, nutrition, prevention, and therapy.

**B807 Protein Structure and Function (3 cr.)** P: Two semesters of organic chemistry; one semester of biochemistry. Physical forces stabilizing protein structure; protein folding. Essential features of macromolecular interactions. Introduction to enzyme kinetics and chemical mechanism in enzyme reactions.

**B808 Physical Biochemistry (3 cr.)** P: Two semesters of physical chemistry; two semesters of calculus; one semester of biochemistry. Thermodynamics and biophysical chemistry of protein, enzymes, nucleic acids, and membranes.

**B809 Advanced Organic Chemistry (1-3 cr.)** P: Two semesters of organic chemistry; two semesters of physical chemistry; B807 or consent of instructor. Tutorial instruction in organic chemistry, as applied to biochemistry.

**B810 Cellular Biochemistry and Regulation (3 cr.)** P: Two semesters of organic chemistry; one semester of biochemistry. Mechanisms of signal transduction and the control of cellular function by hormones, growth factors, and other extracellular regulators.

**B811 Advanced Intermediary Metabolism (1-3 cr.)** P: B810. Tutorial instruction in specialized areas of metabolism.

**B814 Advanced Enzymology (1-3 cr.)** P: B807 or B810. Tutorial instruction in enzyme isolation and kinetics.

**B821 Scientific Writing and Communication in Biotechnology (1 cr.)** Discussion and individual instruction in the preparation of a research proposal and thesis in the biotechnology track of the M.S. in Biochemistry and Molecular Biology.

**B822 Research in Biotechnology (1- 5 cr.)** Research for biotechnology track in M.S. thesis.

**B835 Neurochemistry (3 cr.)** P: Two semesters of organic chemistry; one semester of biochemistry, or consent of instructor. Metabolism of nervous system tissue. Neurochemical techniques.

**B836 Advanced Topics in Neurochemistry (2 cr.)** P: B835 or equivalent. Selected topics in neurochemistry dealing with specialized functions of the nervous system.

**B842 Instrumentation and Methods of Analysis II (3 cr.)** P: Two semesters of organic chemistry; one semester of biochemistry.

**B854 Introduction to Research (1 cr.)** P: Two semesters of organic chemistry; two semesters of physical chemistry, one se-



mester of biochemistry, or consent of instructors. Tutorial and laboratory instruction in biochemistry. Purpose is to introduce students in biochemistry to three different research programs.

**B855 Research (cr. arr.)**

**B868 Advanced Molecular Biology (1-3 cr.)** P: G865 or equivalent. Tutorial instruction in specialized area of molecular biology.

**B890 Seminar (1 cr.)**

**G749 Introduction to Structural Biology (1 cr.)** An introduction to structural biology including the fundamentals of macromolecular structure and interactions, methods used to determine three-dimensional structures, the relationship between protein sequence and structure, and prediction and analysis of macromolecular structure.

**G804 Cellular and Molecular Biology (3 cr.)** P: One semester of organic chemistry. Cellular and molecular biology that emphasizes the structural organization, biochemistry, and molecular biology of cells. Includes cellular processes, development, and differentiation and their relationship to medicine.

**G805 Diabetes and Obesity (2 cr.)** P: One semester of biochemistry. Biochemistry, cell biology, molecular biology, genetics, immunology, and pathophysiology of diabetes and obesity. Topics include metabolic regulation, signal transduction, insulin resistance, insulin production, beta-cell function, animal models, complications, nutrition, prevention, and therapy.

**G807 Structural and Chemical Biology (2 cr.)** Fundamentals of structural and chemical biology focused on state-of-the-art approaches to inhibitor discovery, use of inhibitors in elucidating biological function, and computational and structural approaches to rational inhibitor design.

**G817 Molecular Basis of Cell Structure and Function (2 cr.)** Organization and function of subcellular structures. Intracellular coordination of cell activities, including protein and RNA processing/trafficking/quality control, chromatin dynamics, and cell division.

**G823 Methods in Cell Biology (3 cr.)** P: B500 or equivalent. Discussion and laboratory instruction in modern methods for cell culture, microscopy, flow cytometry, and the use of cell culture to study cellular metabolism.

**G825 Advanced Topics in Molecular Biology (2 cr.)** The course will highlight selected topics adjusted each year to reflect the most current advancements in molecular biology and will include lectures and paper discussions on: chromatin structure and regulation; transcriptional control; RNA structure and processing; RNAi and miRNA; RNA decay; translational control and its integration in gene expression.

**G828 Concepts in Biotechnology (2 cr.)** P: B500 or equivalent. Case studies exploring topics on the cutting edge of biotechnology and tutorials in biotechnology calculations.

**G841 Methods of Proteomics (3 cr.)** P: B500 or equivalent. Discussion and laboratory instruction in modern methods for protein purification, analysis of purity, peptide mapping, and amino acid sequencing.

**G848 Bioinformatics, Genomics, Proteomics, and Systems Biology (2 cr.)** Biology has been transformed by various high-throughput technologies (genomics, proteomics, metabolomics, etc.), which in turn have led to a large number of massive databases and software analysis packages. This course focuses on the "omics" technologies, on the resulting databases, and on the computational tools used to analyze the data.

**G852 Concepts of Cancer Biology: Signaling Gone Awry (2 cr.)** Fundamentals of cancer biology; the signaling of events that regulate cell growth, survival, and differentiation; how mutation/dysregulation of signaling molecules leads to cancer and might be exploited for treatment.

**G865 Fundamental Molecular Biology (3 cr.)** P: B800 or equivalent. Principles of molecular structure, function, and biosynthesis; core information regarding prokaryotic and eukaryotic gene continuity and metabolic coordination; introduction to multicellular systems and problems. (Joint program: biochemistry, medical genetics, microbiology.)

**G890 Methods in Molecular Biology and Pathology (3 cr.)** P: G865 and/or J838, and consent of instructor. Basic principles and techniques in molecular biology and pathology. Particular emphasis will be on molecular techniques that can be used to study problems related to biochemistry and pathology.

**G910 Advanced Molecular Biology Methods (3 cr.)** P: G865 and/or G890 and consent of instructor. Advanced theory and techniques in molecular biology. The focus of the course will be on techniques related to manipulation of cloned DNA to study their expression, structure, and function.