School of Medicine and Dentistry

ADMINISTRATIVE OFFICERS

David S. Guzick, M.D., Ph.D., Dean
Howard J. Federoff, M.D., Ph.D., Senior Associate Dean for Basic Research
Paul L. La Celle, M.D., Senior Associate Dean for Graduate Education
Thomas A. Pearson, M.D., Ph.D., Senior Associate Dean for Clinical Research

COMMITTEE ON GRADUATE STUDIES

Paul La Celle, M.D. (Chair), Nazzareno Ballatori, Ph.D., William Bernhard, Ph.D., Dirk Bohmann, Ph.D., Nicholas Cohen, Ph.D., Robert Dirksen, Ph.D., Mark Dumont, Ph.D., Susan Fisher, Ph.D., James Fry, Ph.D., Victor Laities, Ph.D., Pieter LeRoux, D.Litt. et Phil., Dennis McCance, Ph.D., Michael McDermott, Ph.D., Robert Mooney, Ph.D., William O'Neill, Ph.D., Ekaterina Noyes, Ph.D., Robert Quivey, Ph.D., Sarah Trafton, J.D., David Yule, Ph.D. Ex-officio: Co-Presidents of the Graduate Student Society.

FACULTY OFFERING GRADUATE INSTRUCTION

Those listed herein have functions in graduate instruction either in formal teaching or in research.

George N. Abraham, M.D. (Buffalo) . . . Professor of Medicine, of Pediatrics, and of Microbiology and Immunology
Jacques S. Abramowicz, M.D. (Israel) . . . Professor of Obstetrics and Gynecology and of Radiology
Robert Ader, Ph.D. (Cornell) . . . Professor of Psychiatry, of Medicine, and in Clinical and Social Psychology
*Raymond B. Baggs, D.V.M. (California, Davis) . . . Professor of Laboratory Animal Medicine, of Pathology and Laboratory Medicine, and of Environmental Medicine
Nazzareno Ballatori, Ph.D. (Rochester) . . . Professor of Environmental Medicine
Robert A. Bambara, Ph.D. (Cornell) . . . Professor of Oncology in Biochemistry and Biophysics and of Microbiology and Immunology
William H. Barker, M.D. (Johns Hopkins) . . . Professor Emeritus of Community and Preventive Medicine and of Medicine
William S. Beckett, M.D. (Case Western Reserve) . . . Professor of Environmental Medicine and of Medicine
Theodore B. Begenisich, Ph.D. (Maryland) . . . Professor of Pharmacology and Physiology
Robert Berg, M.D. (Harvard) . . . Professor Emeritus of Community and Preventive Medicine
Bradford C. Berk, M.D. (Rochester) . . . Charles A. Dewey Professor of Medicine; Professor of Pharmacology and Physiology
William Bernhard, Ph.D. (Penn State) . . . Professor of Biochemistry and Biophysics
Jean M. Bidlack, Ph.D. (Rochester) . . . Professor of Pharmacology and Physiology
Neil Blumberg, M.D. (Yale) . . . Professor of Pathology and Laboratory Medicine
Dirk Bohmann, Ph.D. (Tuebingen) . . . Professor of Biomedical Genetics
William H. Bowen, D.Sc. (Ireland) . . . Margaret and Cy Welcher Professor of Dentistry in the Center for Oral Biology; Professor of Microbiology and Immunology and of Environmental Medicine
Brendan F. Boyce, M.D. (Glasgow) . . . Professor of Pathology and Laboratory Medicine and of Orthopedics
*Theodore M. Brown, Ph.D. (Princeton) . . . Professor of History and of Medical Humanities; Associate Professor of Community and Preventive Medicine

David A. Bushinsky, M.D. (Tufts) . . . Professor of Medicine and of Pharmacology and Physiology

Jack G. Caton, D.D.S. (California) . . . Professor of Dentistry

Chawnshang Chang, Ph.D. (Chicago) . . . George Hoyt Whipple Professor of Pathology and Laboratory Medicine; Professor of Oncology and of Urology

Thomas W. Clarkson, Ph.D. (Manchester) . . . J. Lowell Orbison Distinguished Alumni Professor of Environmental Medicine; Professor of Biochemistry and Biophysics and of Pharmacology and Physiology

Nicholas Cohen, Ph.D. (Rochester) . . . Professor Emeritus of Microbiology and Immunology, of Psychiatry, and of Oncology

Paul D. Coleman, Ph.D. (Rochester) . . . Professor of Neurobiology and Anatomy

I. Nicholas Crispe, Ph.D. (London) . . . Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology

Stephen Dewhurst, Ph.D. (Nebraska) . . . Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology, and of Oncology

Robert W. Doty, Ph.D. (Chicago) . . . Professor of Neurobiology and Anatomy

Philip J. Fay, Ph.D. (Rochester) . . . Professor of Medicine and of Biochemistry and Biophysics

Howard J. Federoff, M.D. (Albert Einstein College of Medicine) . . . Professor of Neurology in the Center for Aging and Developmental Biology, of Medicine, of Oncology, of Genetics, and of Microbiology and Immunology

*Jacob N. Finkelstein, Ph.D. (Northwestern) . . . Professor of Pediatrics, of Environmental Medicine, of Oncology, and of Radiation Oncology

Thomas H. Foster, Ph.D. (Rochester) . . . Professor of Radiology, of Biochemistry and Biophysics, of Oncology, of Physics and Astronomy, and in The Institute of Optics

Charles W. Francis, M.D. (Johns Hopkins) . . . Professor of Medicine and of Pathology and Laboratory Medicine

Richard Frankel, Ph.D. (CUNY) . . . Professor of Medicine and of Community and Preventive Medicine

John G. Frelinger, Ph.D. (California Institute of Technology) . . . Professor of Microbiology and Immunology

Robert D. Frisina, Ph.D. (Syracuse) . . . Professor of Surgery and of Neurobiology and Anatomy

Thomas A. Gasiewicz, Ph.D. (Rochester) . . . Professor of Environmental Medicine

Harris A. Gelbard, M.D. (Northwestern) . . . Professor of Neurology, of Pediatrics, and of Microbiology and Immunology in the Center for Aging and Developmental Biology

John E. Gerich, M.D. (Georgetown) . . . Professor of Medicine

Francis Gigliotti, M.D. (Virginia) . . . Professor of Pediatrics and of Microbiology and Immunology

Steven A. Goldman, M.D. (Cornell University Medical College) . . . Professor of Neurology

Gerald N. Graser, D.D.S. (Buffalo) . . . Professor of Dentistry

Richard M. Green, M.D. (Rochester) . . . Professor of Surgery and of Radiology

Robert A. Gross, M.D. (Washington University) . . . Professor of Neurology and of Pharmacology and Physiology

Thomas E. Gunter, Ph.D. (California, Berkeley) . . . Professor of Biochemistry and of Biophysics

Suzanne Haber, Ph.D. (Stanford) . . . Professor of Pharmacology and Physiology, of Neurobiology and Anatomy, and of Neurology

John T. Hansen, Ph.D. (Tulane) . . . Professor of Neurobiology and Anatomy

Russell Hill, Ph.D. (Rutgers) . . . Professor of Biochemistry and Biophysics and of Oncology

Patricia M. Hinkle, Ph.D. (California, Berkeley) . . . Professor of Oncology in Pharmacology and Physiology

Richard W. Hyde, M.D. (Columbia) . . . Professor of Medicine and of Environmental Medicine

Barbara H. Iglewski, Ph.D. (Penn State) . . . Professor of Microbiology and Immunology

Peter C. Keng, Ph.D. (Colorado State) . . . Professor of Radiation Oncology and of Biochemistry and Biophysics

* Part-time
Karl D. Kieburtz, M.D. (Rochester) . . . Professor of Neurology and of Community and Preventive Medicine
George A. Kimmich, Ph.D. (Pennsylvania) . . . Professor Emeritus of Biochemistry and Biophysics
Philip A. Knauf, Ph.D. (Rochester) . . . Professor of Biochemistry and Biophysics
Stephen J. Kunitz, M.D. (Rochester) . . . Professor Emeritus of Community and Preventive Medicine
Roger M. Kurlan, M.D. (Washington) . . . Professor of Neurology
Tai Kwong, Ph.D. (Toronto) . . . Professor of Pathology and Laboratory Medicine
Paul L. La Celle, M.D. (Rochester) . . . Professor of Pharmacology and Physiology
Harumut Land, Ph.D. (Heidelberg) . . . Robert and Dorothy Markin Professor of Biomedical Genetics,
  Professor of Oncology, and Professor of Biochemistry and Biophysics
Victor G. Laties, Ph.D. (Rochester) . . . Professor Emeritus of Environmental Medicine
Christopher W. Lawrence, Ph.D. (Birmingham) . . . Professor Emeritus of Biochemistry and Biophysics
Marshall A. Lichtman, M.D. (Buffalo) . . . Professor of Medicine and of Biochemistry and Biophysics
Edith M. Lord, Ph.D. (California, San Diego) . . . Professor of Oncology in Microbiology and Immunology
Mahin D. Maines, Ph.D. (Missouri) . . . Professor of Biochemistry and Biophysics
Lynne E. Maquat, Ph.D. (Wisconsin, Madison) . . . Professor of Biochemistry and Biophysics
Robert E. Marquis, Ph.D. (Michigan) . . . Professor of Microbiology and Immunology in the Center for Oral Biology
Dennis J. McCance, Ph.D. (Birmingham) . . . Professor of Microbiology and Immunology and of Oncology
Susan H. McDaniel, Ph.D. (North Carolina, Chapel Hill) . . . Professor of Psychiatry and Family Medicine
James E. Melvin, D.D.S. (Case Western) . . . Professor of Dentistry in the Center for Oral Biology and of Pharmacology and Physiology
Marilyn A. Menegus, Ph.D. (Cornell) . . . Professor of Microbiology and Immunology, of Pathology and Laboratory Medicine, and of Pediatrics
William H. Merigan, Ph.D. (Maryland) . . . Professor of Ophthalmology, of Environmental Medicine, and in the Center for Visual Science; Associate Professor of Brain and Cognitive Sciences
Edward M. Messing, M.D. (N.Y.U.) . . . Winfield W. Scott Professor of Urology; Professor of Oncology and of Pathology and Laboratory Medicine
Cyril Meyerowitz, D.D.S. (South Africa) . . . Professor of Dentistry and of Radiation Oncology
James Miller, Ph.D. (St. Louis) . . . Professor of Microbiology and Immunology in the Center of Vaccine Biology and Immunology
Leon L. Miller, M.D. (Rochester) . . . Professor Emeritus of Biochemistry and Biophysics and of Medicine
Carol Miller-Graziano, Ph.D. (Utah) . . . Professor of Surgery and of Microbiology and Immunology
*Richard K. Miller, Ph.D. (Dartmouth) . . . Professor of Obstetrics and Gynecology and of Environmental Medicine
Robert A. Mooney, Ph.D. (Johns Hopkins) . . . Professor of Pathology and Laboratory Medicine and of Medicine
Tim R. Mosmann, Ph.D. (British Columbia) . . . Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology
Arthur J. Moss, M.D. (Harvard) . . . Professor of Medicine and of Community and Preventive Medicine
Craig Mullen, M.D. (Chicago) . . . Professor of Pediatrics and of Microbiology and Immunology
Maiken Nedergaard, M.D. (University of Copenhagen) . . . Professor of Neurosurgery in the Center for Aging and Developmental Biology
Mark D. Noble, Ph.D. (Stanford) . . . Professor of Biomedical Genetics and of Neurobiology and Anatomy
Earnest J. Nordeen, Ph.D. (California, Irvine) . . . Professor of Psychology; Associate Professor of Neurobiology and Anatomy
Kathy W. Nordeen, Ph.D. (California, Irvine) . . . Professor of Psychology; Associate Professor of Neurobiology and Anatomy
Robert H. Notter, M.D. (Rochester) . . . Professor of Pediatrics, of Environmental Medicine, and of Chemical Engineering
David Oakes, Ph.D. (London) . . . Professor of Biostatistics and of Statistics
Guenter Oberdoester, D.V.M. (Giessen) . . . Professor of Environmental Medicine
Regis J. O’Keefe, M.D. (Harvard) . . . Professor of Orthopedics and of Oncology
Gary D. Paige, M.D. (Chicago) . . . Professor of Neurology, of Ophthalmology, of Surgery, and of Neurobiology and Anatomy; Associate Professor of Brain and Cognitive Sciences and in the Center for Visual Science
Kevin Parker, Ph.D. (M.I.T.) . . . Professor of Electrical Engineering and of Radiology
Tatiana Pasternak, Ph.D. (Copenhagen) . . . Professor of Neurobiology and Anatomy, of Brain and Cognitive Sciences, and in the Center for Visual Science
Thomas A. Pearson, M.D. (Johns Hopkins) . . . Professor of Community and Preventive Medicine and of Medicine
Alice P. Pentland, M.D. (Michigan) . . . Professor of Dermatology and of Oncology
*Charles E. Phelps, Ph.D. (Chicago) . . . Professor of Political Science, of Economics, and of Community and Preventive Medicine
Richard P. Phipps, Ph.D. (Medical College of Virginia) . . . Professor of Environmental Medicine, of Oncology in Microbiology and Immunology, and of Pediatrics
Eric M. Phizicky, Ph.D. (Cornell) . . . Professor of Biochemistry and Biophysics
Carl A. Pinkert, Ph.D. (Georgia) . . . Professor of Pathology and Laboratory Medicine in the Center for Aging and Developmental Biology
Terry Platt, Ph.D. (Harvard) . . . Professor of Biochemistry and Biophysics and of Biology
James M. Powers, M.D. (South Carolina) . . . Professor of Pathology and Laboratory Medicine and of Neurology
J. Edward Puzas, Ph.D. (Rochester) . . . Donald and Mary Clark Professor of Orthopedics; Professor of Pathology and Laboratory Medicine and of Biochemistry and Biophysics
Richard C. Reichman, M.D. (Pennsylvania) . . . Professor of Medicine and of Microbiology and Immunology
Patricia M. Rodier, Ph.D. (Virginia) . . . Professor of Obstetrics and Gynecology
Randy N. Rosier, M.D. (Rochester) . . . Professor of Oncology in Orthopedics and of Biochemistry and Biophysics
Daniel H. Ryan, M.D. (Johns Hopkins) . . . Professor of Pathology and Laboratory Medicine
Andrea Sant, Ph.D. (St. Louis) . . . Professor of Microbiology and Immunology in the Research Center for Vaccine Biology and Immunology
Ingrid H. Sarelius, Ph.D. (Auckland) . . . Professor of Pharmacology and Physiology
George J. Schwartz, M.D. (Case Western Reserve) . . . Professor of Pediatrics and of Medicine
Glynis A. Scott, M.D. (Albert Medical College) . . . Professor of Dermatology, of Pathology and Laboratory Medicine, and of Pediatrics
George B. Segel, M.D. (Jefferson Medical College) . . . Professor of Pediatrics, of Medicine, of Oncology, and of Genetics
Alan E. Senior, Ph.D. (Newcastle) . . . Professor of Biochemistry and Biophysics
Fred Sherman, Ph.D. (California, Berkeley) . . . Marie Curran Wilson and Joseph Chamberlain Wilson Professor of Biochemistry and Biophysics
Shey-Shing Sheu, Ph.D. (Chicago) . . . Professor of Pharmacology and Physiology, of Medicine (Cardiology Unit), and of Anesthesiology
Ira Shoulson, M.D. (Rochester) . . . Louis C. Lasagna Professor in Experimental Therapeutics; Professor of Neurology, of Pharmacology and Physiology, and of Medicine
Peter G. Shrag, Ph.D. (California, Berkeley) . . . Professor of Neurobiology and Anatomy, of Biochemistry and Biophysics, and of Pharmacology and Physiology
Trevor Shuttleworth, Ph.D. (New Zealand) . . . Professor of Pharmacology and Physiology
William Simon, Ph.D. (Harvard) . . . Professor of Biochemistry and Biophysics and of Medical Informatics

* Part-time
*Harold C. Smith, Ph.D. (SUNY, Buffalo) . . . Professor of Oncology in Biochemistry and Biophysics, of Environmental Medicine, and of Pathology and Laboratory Medicine
Charles E. Sparks, M.D. (Jefferson Medical College) . . . Professor of Pathology and Laboratory Medicine
J. Daniel Subtelny, D.D.S. (Pennsylvania) . . . Professor of Dentistry
Peter G. Szilagyi, M.D. (Rochester) . . . Professor of Pediatrics and of Community and Preventive Medicine
A. William Tank, Ph.D. (Purdue) . . . Paul Stark Professor of Pharmacology and Physiology
Saara M. Torstenson, M.D. (Oulu) . . . Professor of Radiology and of Orthopedics
Xin M. Tu, Ph.D. (Duke) . . . Professor of Biostatistics and of Psychiatry
Douglas H. Turner, Ph.D. (Columbia) . . . Professor of Chemistry and of Pediatrics
*Mark J. Utell, M.D. (Tufts) . . . Professor of Medicine and of Environmental Medicine
Nancy Wang, M.D. (Minnesota) . . . Professor of Pathology and Laboratory Medicine, of Pediatrics, and of Genetics
Richard E. Waugh, Ph.D. (Duke) . . . Professor of Biomedical Engineering, of Pharmacology and Physiology, of Biochemistry and Biophysics, and of Mechanical Engineering
Bernard Weiss, Ph.D. (Rochester) . . . Professor of Environmental Medicine and of Pediatrics
Hulin Wu, Ph.D. (Florida State) . . . Professor of Biostatistics, of Community and Preventive Medicine, and of Medicine
J. H. David Wu, Ph.D. (M.I.T.) . . . Professor of Chemical Engineering
Andrei Y. Yakovlev, M.D. (Leningrad) . . . Professor of Biostatistics and of Computational Biology
Hermes H. Yeh, Ph.D. (Texas, Dallas) . . . Professor of Pharmacology and Physiology in the Center for Aging and Developmental Biology
J. H. David Wu, Ph.D. (M.I.T.) . . . Professor of Chemical Engineering
William Bonnez, M.D. (France) . . . Associate Professor of Medicine
J. Scott Butler, Ph.D. (Illinois, Urbana) . . . Associate Professor of Microbiology and Immunology
Virginia Clark, Ph.D. (Rochester) . . . Associate Professor of Microbiology and Immunology
David J. Culp, Ph.D. (California, Berkeley) . . . Associate Professor of Pharmacology and Physiology in the Center for Oral Biology and of Dentistry
José L. de la Pompa, Ph.D. (Spain) . . . Associate Professor of Biochemistry and Biophysics in the Center for Aging and Developmental Biology
Mark E. Dumont, Ph.D. (Johns Hopkins) . . . Associate Professor of Biochemistry and Biophysics
Timothy D. Dye, Ph.D. (SUNY, Buffalo) . . . Associate Professor of Community and Preventive Medicine
Susan Fisher, Ph.D. (Chicago) . . . Associate Professor of Community and Preventive Medicine
*Mark W. Frampton, M.D. (N.Y.U.) . . . Associate Professor of Medicine and of Environmental Medicine

200 SCHOOL OF MEDICINE AND DENTISTRY
Robert S. Freeman, Ph.D. (California, San Diego) . . . Associate Professor of Pharmacology and Physiology, of Neurology, and of Oncology

*Barbara A. Gawinski, Ph.D. (Texas Tech) . . . Associate Professor in Family Medicine and Psychiatry
Barry M. Goldstein, M.D. (Rochester) . . . Associate Professor of Biochemistry and Biophysics
Ronnie Guillette, M.D. (Rochester) . . . Associate Professor of Pediatrics

Constantine G. Haidaris, Ph.D. (Cincinnati) . . . Associate Professor of Microbiology and Immunology
Jeffrey J. Hayes, Ph.D. (Johns Hopkins) . . . Associate Professor of Biochemistry and Biophysics and of Oncology

*Robert Holloway, M.D. (Connecticut) . . . Associate Professor of Community and Preventive Medicine
David A. Krusch, M.D. (Johns Hopkins) . . . Associate Professor of Surgery and of Medical Informatics
Pieter Le Roux, D.Litt. et Phil. (South Africa) . . . Associate Professor of Psychiatry and of Pediatrics
Richard J. Looney, M.D. (Rochester) . . . Associate Professor of Medicine and of Environmental Medicine

Dina G. Markowitz, Ph.D. (Columbia) . . . Associate Professor of Environmental Medicine
Michael J. McCabe, Jr., Ph.D. (Albany Medical College) . . . Associate Professor of Environmental Medicine

Michael P. McDermott, Ph.D. (Rochester) . . . Associate Professor of Biostatistics and of Neurology
Joseph M. Miano, Ph.D. (New York Medical College) . . . Associate Professor of Medicine in the Center for Cardiovascular Research and of Pathology and Laboratory Medicine
Jan Moynihan, Ph.D. (Rochester) . . . Associate Professor of Psychiatry and of Microbiology and Immunology

Dana Mukamel, Ph.D. (M.I.T.) . . . Adjunct Associate Professor of Community and Preventive Medicine
M. Kerry O'Banion, M.D. (Illinois) . . . Associate Professor of Neurology and of Neurobiology and Anatomy

John A. Olschowka, Ph.D. (California, Davis) . . . Associate Professor of Neurobiology and Anatomy
William E. O'Neill, Ph.D. (SUNY, Stony Brook) . . . Associate Professor of Neurobiology and Anatomy and of Brain and Cognitive Sciences
Michael O'Reilly, Ph.D. (Cincinnati) . . . Associate Professor of Pediatrics and of Environmental Medicine

Deborah J. Ossip-Klein, Ph.D. (Pittsburgh) . . . Associate Professor of Community and Preventive Medicine, of Oncology, and of Clinical and Social Psychology

James Palis, M.D. (Rochester) . . . Associate Professor of Pediatrics and of Oncology
David A. Pearce, Ph.D. (Bath) . . . Associate Professor of Biochemistry and Biophysics in the Center for Aging and Developmental Biology

Diane T. Piekut, Ph.D. (Boston) . . . Associate Professor of Neurobiology and Anatomy

*Gloria S. Pryhuber, M.D. (SUNY, Upstate) . . . Associate Professor of Pediatrics and of Environmental Medicine

Robert G. Quivey, Ph.D. (Texas) . . . Associate Professor of Microbiology and Immunology in the Center for Oral Biology and of Dentistry

James Ringo, Ph.D. (Duke) . . . Associate Professor of Neurobiology and Anatomy and in the Center for Visual Science

Ignacio Sanz, M.D. (Spain) . . . Associate Professor of Medicine and of Microbiology and Immunology

*Stanley Schaffer, M.D. (Sackler School of Medicine) . . . Associate Professor of Community and Preventive Medicine

Marc H. Schieber, M.D. (Washington University, St. Louis) . . . Associate Professor of Neurology, of Neurobiology and Anatomy, of Physical Medicine and Rehabilitation, of Brain and Cognitive Sciences, and in the Center for Visual Science

Edward M. Schwarz, Ph.D. (Albert Einstein) . . . Associate Professor of Orthopaedics and of Microbiology and Immunology

Cleveland G. Shields, Ph.D. (Purdue) . . . Associate Professor of Family Medicine and of Psychiatry

* Part time
Patricia J. Simpson-Haidaris, Ph.D. (Notre Dame) . . . Associate Professor of Medicine, of Microbiology and Immunology, and of Pathology and Laboratory Medicine
Alan V. Smrcka, Ph.D. (Arizona) . . . Associate Professor of Pharmacology and Physiology, of Oncology, and of Biochemistry and Biophysics
Janet D. Sparks, Ph.D. (Pennsylvania) . . . Associate Professor of Pathology and Laboratory Medicine
Suzanne Y. Stevens, Ph.D. (Indiana) . . . Associate Professor of Neurobiology and Anatomy and of Psychiatry
Andy Yen-Tung Teng, D.D.S. (Kaoshiung Medical College) . . . Associate Professor of Dentistry and of Microbiology and Immunology
Charles A. Thornton, M.D. (Iowa) . . . Associate Professor of Neurology
Sarah H. Trafton, J.D. (Suffolk) . . . Associate Professor of Community and Preventive Medicine
John J. Treanor, M.D. (Rochester) . . . Associate Professor of Medicine and of Microbiology and Immunology
William H. Watson, Ph.D. (Rosemead) . . . Associate Professor of Psychiatry and of Neurology
Fay Young, M.D. (Massachusetts) . . . Associate Professor of Medicine and of Microbiology and Immunology
M. Jacob Adams, M.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Anthony Almudevar, Ph.D. (Toronto) . . . Assistant Professor of Biostatistics and of Computational Biology
Lois J. Arend, M.D. (Michigan State) . . . Assistant Professor of Pathology and Laboratory Medicine
Bruce A. Barron, M.D. (Pennsylvania) . . . Assistant Professor of Environmental Medicine
Paul S. Brookes, Ph.D. (Cambridge, England) . . . Assistant Professor of Anesthesiology and of Pharmacology and Physiology
Andrew I. Brooks, Ph.D. (Rochester) . . . Assistant Professor of Environmental Medicine
Nancy Chin, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
*Lynne Davidson, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Mark Davies, M.D. (Trinity College) . . . Assistant Professor of Surgery
Barbara J. Davis, Ph.D. (SUNY, Upstate) . . . Assistant Professor of Neurobiology and Anatomy
Kevin Davis, Ph.D. (Boston) . . . Assistant Professor of Biomedical Engineering
Andrew W. Dick, Ph.D. (Stanford) . . . Assistant Professor of Community and Preventive Medicine and of Political Science
Ann Dozier, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Diana Fernandez, M.D. (Minnesota) . . . Assistant Professor of Community and Preventive Medicine
Steven Fine, M.D. (Washington University) . . . Assistant Professor of Medicine
Deborah Fowell, Ph.D. (Oxford) . . . Assistant Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology
Edward G. Freedman, Ph.D. (Pennsylvania) . . . Assistant Professor of Neurobiology and Anatomy
Bruce Friedman, Ph.D. (Minnesota) . . . Assistant Professor of Community and Preventive Medicine
Lin Gan, Ph.D. (Texas, Houston) . . . Assistant Professor of Neurobiology and Anatomy in the Center for Aging and Developmental Biology and of Ophthalmology
Greg Gdowski, Ph.D. (Boston) . . . Assistant Professor of Neurobiology and Anatomy
Roman Giger, Ph.D. (Zurich) . . . Assistant Professor of Neurology
Fred Hagen, Ph.D. (Calgary) . . . Assistant Professor of Biochemistry and Biophysics in the Center for Oral Biology
Kevin Hart, J.D., Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Denise C. Hocking, Ph.D. (Albany Medical College) . . . Assistant Professor of Pharmacology and Physiology and of Biomedical Engineering
Susan H. Horwitz, Ph.D. (Union Institute) . . . Assistant Professor of Psychiatry
Wei Hsu, Ph.D. (Mount Sinai) . . . Assistant Professor of Biomedical Genetics in the Center for Oral Biology
Jiaoti Huang, M.D. (Anhui Medical) . . . Assistant Professor of Pathology and Laboratory Medicine
Li-Shan Huang, Ph.D. (North Carolina) . . . Assistant Professor of Biostatistics
Rulang Jiang, Ph.D. (Wesleyan) . . . Assistant Professor of Biomedical Genetics in the Center for Oral Biology
Xia Jin, M.D. (Peiping Union Medical College) . . . Assistant Professor of Medicine
Baek Kim, Ph.D. (Arizona) . . . Assistant Professor of Microbiology and Immunology
Kerry Knox, Ph.D. (Northwestern) . . . Assistant Professor of Community and Preventive Medicine
David R. Kornack, Ph.D. (Cornell) . . . Assistant Professor of Neurobiology and Anatomy
Nancy S. Krieger, Ph.D. (Stanford) . . . Assistant Professor of Medicine and of Pharmacology and Physiology
Jill Lavigne, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Yi Fen Lee, Ph.D. (Wisconsin) . . . Assistant Professor of Urology
Willis Li, Ph.D. (Columbia) . . . Assistant Professor of Biomedical Genetics
Zhi-Wei Ma, M.D. (Shanghai) . . . Assistant Professor of Pathology and Laboratory Medicine
Sanjay B. Maggirwar, Ph.D. (India) . . . Assistant Professor of Microbiology and Immunology
Margot Mayer-Proschel, Ph.D. (Wuerzburg) . . . Assistant Professor of Biomedical Genetics and of Neurobiology and Anatomy
Scott McIntosh, Ph.D. (Missouri) . . . Assistant Professor of Community and Preventive Medicine
Wendy J. Nilsen, Ph.D. (Purdue) . . . Assistant Professor of Psychiatry
Ekaterina Noyes, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Lisa Opanashuk, Ph.D. (Rochester) . . . Assistant Professor of Environmental Medicine
Luciano Passador, Ph.D. (Canada) . . . Assistant Professor of Microbiology and Immunology
Martin S. Pavelka, Ph.D. (Rochester) . . . Assistant Professor of Microbiology and Immunology
Derick R. Peterson, Ph.D. (California, Berkeley) . . . Assistant Professor of Biostatistics
Ellen L. Poleshuck, Ph.D. (Kent State) . . . Assistant Professor of Psychiatry
Douglas Portman, Ph.D. (Pennsylvania) . . . Assistant Professor of Biomedical Genetics in the Center for Aging and Developmental Biology
Neil Price, Ph.D. (London) . . . Assistant Professor of Anesthesiology and of Pharmacology and Physiology
Ming Qi, Ph.D. (Pittsburgh) . . . Assistant Professor of Pathology and Laboratory Medicine and of Cardiology
Lizabeth M. Romanski, Ph.D. (Cornell) . . . Assistant Professor of Neurobiology and Anatomy
Jason Roy, Ph.D. (Michigan) . . . Assistant Professor of Biostatistics
Ana Rubio, M.D. (Spain) . . . Assistant Professor of Pathology and Laboratory Medicine
Sanjeev Sahni, Ph.D. (Kanpur) . . . Assistant Professor of Medicine
David B. Seaburn, Ph.D. (Union Institute) . . . Assistant Professor of Psychiatry and of Family Medicine
Benjamin M. Segal, M.D. (Brown) . . . Assistant Professor of Neurology and of Microbiology and Immunology
Scott H. Seidman, Ph.D. (Case Western Reserve) . . . Assistant Professor of Neurobiology and Anatomy and in the Center for Visual Science
Alice Sijts, Ph.D. (Leiden) . . . Assistant Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology
Patricia J. Sime, M.D. (Edinburgh) . . . Assistant Professor of Medicine and of Environmental Medicine
Tristram Smith, Ph.D. (California, Los Angeles) . . . Assistant Professor of Pediatrics
Jenny Speice, Ph.D. (Virginia Polytechnic) . . . Assistant Professor of Psychiatry and of Family Medicine
Yin Sun, Ph.D. (California, Los Angeles) . . . Assistant Professor of Biomedical Genetics

* Part time
James Tacci, M.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine  
Toru Takimoto, Ph.D. (Hokkaido, Japan) . . . Assistant Professor of Microbiology and Immunology  
Henkie Tan, M.D. (Loma Linda) . . . Assistant Professor of Surgery  
Nicholas Theodorakis, Ph.D. (Northwestern) . . . Assistant Professor of Surgery  
Sally W. Thurston, Ph.D. (Harvard) . . . Assistant Professor of Biostatistics  
David Topham, Ph.D. (Vermont) . . . Assistant Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology  
Berchman Vaz, M.D. (Bombay) . . . Assistant Professor of Medicine  
Peter Veazie, Ph.D. (Minnesota) . . . Assistant Professor of Community and Preventive Medicine  
Alice Villalobos, Ph.D. (Arizona) . . . Assistant Professor of Environmental Medicine  
Brian Ward, Ph.D. (Illinois) . . . Assistant Professor of Microbiology and Immunology  
Terry Wright, Ph.D. (Rochester) . . . Assistant Professor of Pediatrics and of Microbiology and Immunology  
Shuyuan Yeh, Ph.D. (Wisconsin) . . . Assistant Professor of Urology  
Yi-Tao Yu, Ph.D. (Case Western Reserve) . . . Assistant Professor of Biochemistry and Biophysics  
Dabao Zhang, Ph.D. (Cornell) . . . Assistant Professor of Biostatistics and Computational Biology  
Jiyong Zhao, Ph.D. (Iowa State) . . . Assistant Professor of Biomedical Genetics  
Wei-Ping Zheng, Ph.D. (SUNY, Buffalo) . . . Assistant Professor of Microbiology and Immunology

GENERAL INFORMATION

Graduate students in the School of Medicine and Dentistry are under the administrative supervision of the senior associate dean for graduate education. They may be enrolled in one of the following programs authorized for advanced degrees: biochemistry, biophysics, dental sciences, epidemiology, genetics, health services research and policy, microbiology and immunology, neurobiology and anatomy, neuroscience, marriage and family therapy, pathology, pharmacology, physiology, public health, statistics, and toxicology. Both master's and Ph.D. degrees are offered, except in dental sciences, marriage and family therapy, and public health, which offer only the master's degree. The program in dental sciences, while not offering a Ph.D. directly, sponsors Ph.D. candidates in several preclinical departments for studies with a direct bearing on dentistry. The Department of Community and Preventive Medicine sponsors the Master of Public Health degree program and the Ph.D. in epidemiology and health services research and policy.

The Ph.D. program in one of the biomedical sciences, or combined with an M.D., provides appropriate preparation for a career in teaching, and research in university, industry, and government. Four interdisciplinary programs are offered: biomedical engineering, genetics, neuroscience, and toxicology. The genetics program involves Medical Center faculty in conjunction with faculty in the biology and chemistry departments. In cooperation with the School of Medicine and Dentistry's faculty, the College's Departments of Brain and Cognitive Sciences, Computer Science, and the Center for Visual Science faculty participate in the neuroscience program. The Ph.D. programs in biology, chemistry, and biomedical engineering are based in corresponding departments in the College.

Students admitted into the Graduate Education in Biomedical Sciences program begin their studies in a training cluster, which serves as the route of admission to the Ph.D. programs. Training clusters include biochemistry and molecular and cell biology; biophysics and structural biology; cell and molecular basis of
Students have the option to pursue doctoral research with more than 200 faculty members dedicated to excellence in biomedical research, providing them with an exceptionally diverse choice of research areas.

Graduate students in some programs are required to assist, for a minimal period, in the School of Medicine and Dentistry teaching program or in another significant teaching experience as part of their regular training.

Under present regulations, responsibility for the M.S. degree programs rests with the Committee on Graduate Studies of the School of Medicine and Dentistry and the senior associate dean for graduate education. The Ph.D. programs are under the same aegis, but ultimate responsibility for approval of Ph.D. degrees and general regulations rests with the University Council on Graduate Studies and the University dean of graduate studies.

PH.D. DEGREE

The Ph.D. programs are operated according to the general regulations described under Regulations and University Policies Concerning Graduate Study. To promote program flexibility and maximal individual attention, students in the School of Medicine and Dentistry plan their Ph.D. programs with an advisory committee consisting of at least four members: two full-time members of the rank of assistant professor or higher from the candidate’s major department (these faculty must have a primary appointment in the candidate’s major department), one full-time faculty member assistant professor or higher from a department other than the candidate’s major department (usually referred to as the outside reader), and at least one representative of another department in either the medical school or the River Campus colleges. This committee also administers the qualifying examination, approves the thesis outline, and certifies eligibility for candidacy to the senior associate dean for graduate education.

Each Ph.D. candidate must submit a completed program of study within two years of initial registration in graduate studies. For School of Medicine and Dentistry departments the program of study must have the approval of the student’s faculty advisor, the department or program chair, the members of his or her advisory committee, and the senior associate dean for graduate education.

Each student must have an annual research progress conference, the first being held no later than one year after the qualifying exam. At this time the thesis advisory committee will assess the research progress and thesis content as well as the projected finishing date of the student. A report that this has occurred is to be sent by the research advisor to the senior associate dean for graduate education.
M.S. DEGREE

Departments offer the M.S. degree under Plan A (i.e., with research thesis) and/or under Plan B.

Plan A usually requires 18 months to two years to complete the coursework and an adequate thesis, although the actual academic requirement in most programs is only 30 credit hours. The usual requirement of 18 hours of correlated coursework of graduate character may be replaced by research credits to varying degrees in special cases where students have already had equivalent training as indicated by the M.D., other higher degrees, or other evidence acceptable to the Committee on Graduate Studies.

The M.S. degree under Plan B is modified and supplemented in many departments in the School of Medicine and Dentistry and is described in the individual departmental announcements. All departments require the writing of an essay and an examination conducted by at least three faculty members of the student; requirements for this degree are given on page 67.

A completed program for the M.S. degree, approved by the department chair and the faculty advisor, must be submitted to the senior associate dean for graduate education as described on page 65 of this bulletin. Only courses integral to the M.S. degree plan and whose subject matter may be included in the final examinations should be listed in this document. If any courses have been taken for other purposes they need not be listed. The number of credit hours expected will vary from department to department but must be at least 30, with distribution consistent with the objectives of the plan.

M.D./PH.D. AND M.D./M.S. PROGRAMS

Students especially interested in a program leading to both the M.D. and the Ph.D. degrees may apply for the combined degree program. The fields in which the Ph.D. degree is most likely to be obtained in the joint program at present are biochemistry, biology,* biomedical engineering,† biophysics, genetics, health services research and policy, microbiology, neurobiology and anatomy, neuroscience, pathology, pharmacology, physiology, psychology,* and toxicology. Areas of the social sciences and business management of particular pertinence to medicine have been developed for an M.D./M.S. degree and are available on an ad hoc basis for M.D./Ph.D. studies.

Admission to the combined degree program ordinarily is by joint application to the M.D. and Ph.D. programs; however, this may be after a year or two of study as either a graduate student or a medical student. The candidate must be acceptable as both a medical and a graduate student before he or she can be fully matriculated in the combined degree program. The M.D./Ph.D. curriculum is unique; the distinctive requirements for each degree are preserved, however, the time required is less than the two degrees if taken in sequence. The M.S. and M.P.H. degrees can also be combined with the M.D. by use of the special programs in the areas of health care delivery (master’s in public health, systems analysis, business administration, etc.).

* In the arts and sciences; see announcement in this bulletin.
† In the School of Engineering and Applied Sciences; see announcement in this bulletin.

206 SCHOOL OF MEDICINE AND DENTISTRY
TRANSFER CREDIT

Of the School of Medicine and Dentistry’s minimum required 120 credit hours for the Doctor of Philosophy degree, no more than 30 credit hours may be accepted as transfer credit for work previously taken at the University of Rochester or at another university.

Of the School of Medicine and Dentistry’s minimum required 30 credit hours for the master’s degree, no more than 10 credit hours may be accepted as transfer credit for work previously taken at the University of Rochester or another university.

All transfer hours, whether taken at the University of Rochester or at another university, must be approved by the cluster/program director and the course director. The senior associate dean for graduate education will make the final determination of transfer hours.

Work taken prior to matriculation in a graduate degree program is classified as possible transfer work. The credit-hour limit may be accepted toward degree requirements if the subjects taken form an integral part of the proposed program of study and if taken within five years of the date of matriculation with a grade of B or higher as interpreted in this University. Petition for transfer credit must be made at the time of matriculation.

Permission to take work at another institution for transfer credit after matriculation in a graduate program must be approved in advance by the cluster/program director, course director, and the senior associate dean for graduate education.

GRADUATE STUDENT SOCIETY

All graduate students in the School of Medicine and Dentistry are automatically members of the Graduate Student Society. This organization represents the graduate students of the School of Medicine and Dentistry in all aspects of student life, except those pertaining directly to individual progress in the academic program. Officers are elected each year, and there is representation to the Council of the Society by each department. In addition to acting as a clearinghouse for problems in graduate student life, the Society sponsors social functions, seminars, and lectures to promote cohesiveness and understanding among graduate students and sends a representative to meetings of the Committee on Graduate Studies and other groups involved in graduate student life. The Graduate Student Society receives mail at Box 355.
Biochemistry and Biophysics


Associate Professors *Butler, Dumont, Goldstein, Hayes, *Miller, Pearce, *Smrcka, Zain

Assistant Professors *†Bayer, Bulger, Hagen, Machonkin, *Theodorakis, Wedekind, Yu

Professors Emeriti Eberle, Kimmich, Marinetti, Miller, Stannard, *Young, Yuile

Biochemistry

The Department of Biochemistry and Biophysics offers programs of study leading to the M.S. (Plan A and Plan B) and Ph.D. degrees in biochemistry. Research areas include enzyme mechanisms; protein chemistry; DNA replication, repair, and recombination; RNA and protein synthesis and processing; molecular genetics; functional proteomics; gene expression and regulation; cell growth regulation; chromatin structure and function; structural biology; virology; molecular endocrinology; bioenergetics; membrane proteins, receptors and signal transduction; glycoproteins; oncology and oncogenes; and molecular basis of human disease. The application of chemistry to biological systems attracts students with academic backgrounds in biology and/or chemistry. Required coursework is kept to a minimum, allowing for development of individual programs of study appropriate to the students’ preparation and interests. A second-year written and oral examination comprises the qualifying examination for the Ph.D. and is generally completed by the end of the fourth semester in residence. Students are encouraged to choose from the numerous courses and seminars offered through the various departments in the School of Medicine and Dentistry and the Department of Biology in the College.

REQUIREMENTS

Core Courses (required for all programs of study): IND 408 (Biochemistry); IND 409 (Cell Biology); IND 410 (Molecular Biology and Genetics); IND 501 (Ethics in Research); BCH 412 (Advanced Topics in Biological Macromolecules); BCH 501/502 (Seminars in Biochemistry); BCH 395 or 595 (M.S. or Ph.D. Research).

Elective Courses (suggested but not limited to): BCH 510 (Enzyme Mechanisms); BIO 402 (Molecular Biology); BIO 419 (Advanced Cell Biology); BIO 426 (Developmental Biology); BIO 451 (Advanced Molecular Biology); BPH 509 (Molecular Biophysics); GEN 507 (Advanced Genetics); IND 407 (Structure and Function of Cell Organelles); IND 443 (Eukaryotic Gene Organization and Expression); MBI 456 (General Virology); MBI 473 (Immunology); MBI 421 (Microbial Genetics); PHP 403/404 (Pharmacology and Physiology: A Disease-Based Approach I/II); PTH 507 (Cancer Biology). In addition, numerous seminar courses including BCH 570 (Chromatin and Transcription in Higher Eukaryotes) are recommended.

M.S. PROGRAM (PLAN A)

The M.S. degree is awarded upon completion of at least 30 hours of credits which include required core courses (IND 408, 409, 410, 501, BCH 412) and approved electives. In addition, the student must defend a thesis developed from an independent research project accomplished under the supervision of a faculty member in the Department of Biochemistry and Biophysics.

* Primary appointment in another department
† Part-time
M.S. PROGRAM (PLAN B) AND QUALIFYING EXAMINATION

Upon completion of the required coursework, a research proposal is written which serves as the basis for determining the potential of the student for independent thought and his or her comprehension of the general field and perspective for exploiting a relevant problem in a scientifically sound manner. The student completes the requirements for a Plan B master’s degree upon successfully passing this qualifying examination.

PH.D. PROGRAM

Students admitted to the Ph.D. program choose a laboratory and advisor at the end of their first year of study after completing at least three laboratory rotations. Ph.D. students are required to work as Teaching Assistants for one semester and pass the qualifying examination in their third year of study. Students are also required to make at least six research presentations in approved seminar courses or seminar series during their course of study.

IND 408. Biochemistry
Prerequisite: a one-semester introductory course in biochemistry or equivalent.
Credit—four hours

This course is designed primarily for graduate students. Eighty-minute lectures cover selected topics in modern biochemistry including analysis of protein and domain structure by classical and modern methods, including mass spectrometry, NMR, X-ray crystallography, and other biophysical techniques; protein-ligand and protein-protein interactions; enzyme kinetics and catalytic mechanisms; cellular energy production and utilization; glycobiology; and translation. In addition to lectures, workshops are held once a week, during which time selected papers from the literature are discussed. (Fall)

IND 409. Cell Biology
Credit—four hours

This course is designed primarily for graduate students. One-hour lectures cover specific topics including cell cycle and its breakdown during cancer and apoptosis; cytoskeleton; intracellular compartments and protein sorting; signal transduction and cell-cell communication; membrane structure and transport. In addition to the lectures, workshops are held weekly to analyze examples from the literature. (Fall)

IND 410. Molecular Biology and Genetics
Credit—four hours

This course is designed primarily for graduate students. One-hour lectures cover modern topics of interest, including DNA replication; DNA repair and mutagenesis; recombination and transposable elements; regulation of gene expression in prokaryotes; and regulation of eukaryotic transcription and RNA processing. Emphasis is placed on both biochemical and genetic approaches to the study of these problems. Special additional topics include genomics as an approach to regulation and mammalian genetic techniques of analysis. (Spring)

BCH 412. Advanced Topics in Biological Macromolecules
Credit—five hours

An advanced biochemistry lecture course intended for senior undergraduates and graduate students. Topics include DNA structure; RNA structure and catalysis; nucleic acid-protein interactions; X-ray crystallography; NMR structure determination; membrane protein structure; glycoconjugates, protein modification, degradation and folding; protein-protein interactions; enzyme mechanisms; and substrate recognition in cascade reactions.

BCH 491. M.S. Reading
Credit to be arranged

BCH 493. M.S. Essay
Credit to be arranged

BCH 495. M.S. Research
Credit to be arranged
BCH 501/502. Seminars in Biochemistry  
Prerequisite: BCH 401.  
Credit—one hour per term  
A student seminar course is offered each semester and continuous registration is required of all graduate students in biochemistry. Seminars are presented by Ph.D. students and include topics in the areas of proteins, enzymes, nucleic acids, lipids, metabolic regulation, hormone action, biochemical genetics, physical biochemistry, membrane biochemistry, developmental biochemistry, and neurochemistry. (Spring and Fall)

BCH 510. Enzyme Mechanisms  
Prerequisite: IND 408 or equivalent.  
Credit—three hours  
This course provides an in-depth study of enzymatic mechanisms focusing on enzymes of biological significance and including phosphatases, proteases, hydrolases, and transferases among others. Emphasis is placed on structure-function correlates. Lectures are complemented by student presentations based on review of current literature. (Fall)

BCH 570. Chromatin and Transcription in Higher Eukaryotes  
Credit—two hours  
A literature-based course meeting once per week (two hours/session) where students read and discuss recent papers on the regulation of eukaryotic gene expression. The purpose is to familiarize students with a variety of contemporary research methodologies through student-led discussions of current publications in the field. Papers are chosen by the instructor and focus on transcription regulatory mechanisms related to transcription factors and coactivators, RNA polymerases, and the role of histone modifications and chromatin in the control of gene expression. Past topics have included cell cycle regulatory proteins, steroid receptors and coactivators, and mechanisms of histone acetylation. (Spring, odd-numbered years)

BCH 593. Special Topics in Biochemistry  
Credit to be arranged  
Directed studies in the field of biochemistry, supervised by a senior faculty member and organized to meet the needs of individuals or small groups of graduate students. May involve supervised readings, laboratory exercises, or organized discussions.

BCH 595. Research  
Credit to be arranged  
Research centers around the following problems: regulation of lipid metabolism, structure and function of cell membranes, cell surface glycoproteins, physical chemistry of hemoproteins, biological energetics, structure of ATPases, hormonal regulation of mammary tissue and mammary tumors, hormone receptors, regulation of protein biosynthesis, DNA synthesis and repair, molecular genetics, and human diseases.

Biophysics  
The Ph.D. program in biophysics teaches students how to employ the methods of mathematics, physics, chemistry, and biology in biomedical research. It emphasizes the use of physics and physical chemistry to understand how living organisms work at a molecular level. This interdisciplinary program is administered by faculty from a variety of departments: biochemistry and biophysics, pharmacology and physiology, and radiology in the School of Medicine and Dentistry; biomedical engineering, and chemistry in the College. Collectively this group of faculty and their students form the Biophysics and Structural Biology Cluster (BSB).

BSB has a variety of state-of-the-art facilities available for students. They include 600, 500, and 400 MHz NMR spectrometers, a macromolecular X-ray crystallography laboratory, 2 EPR spectrometers, computer workstations for molecular graphics and structure calculations, confocal microscope, and confocal fluorescence imaging system. In addition, laboratories are well equipped for modern biochemistry and molecular biology.

Students enter the program with a wide range of backgrounds. The most common backgrounds are centered on either physics or chemistry but engineers, biology/biochemistry majors, and mathematicians also enter the program. The program is experienced at bringing students from the physical/chemical sciences up to speed in the biological sciences and teaching the more biological students how to apply the tools of biophysics in biomedical research. Financial assistance is provided to all students.

The curriculum consists of core course requirements, general seminar and distribution requirements, elective courses, and laboratory rotations. The core courses include Molecular Biophysics,
General Biochemistry, Cell Biology, Molecular Biology and Genetics, and Methods in Structural Biology. The goal is to provide a balanced set of courses that brings the candidate to the forefront of current knowledge in the selected area while providing general familiarity in related fields. All first-year students are required to complete three laboratory rotations during the first year, one of which must be with the Biophysics and Structural Biology Program faculty. Participation in seminar programs is an important part of the graduate education experience and remains a component of the experience throughout residence.

Formal graduate course requirements generally are fulfilled within the first two years in residence. Ph.D. thesis advisors are generally selected by the end of the second semester in residence and research on the thesis problem generally begins at the end of the first year. A first-year written and oral examination and a second-year written and oral examination comprise the qualifying examination for the Ph.D. and are generally completed by the end of the fifth semester in residence.

402. Mathematical Methods of Physiology and Medicine
Prerequisite: elementary calculus.
Credit—three hours

Computer modeling, mathematical description of biological and physical systems, analytical and numerical solutions of differential equations, Laplace transforms, Fourier series, partial derivatives. Calculus is reviewed as needed. There are a number of short computer laboratory sessions. (Fall)

403. Mathematics for Molecular Biophysics
Credit—three hours

Wave motion, Fourier Series and complex representation, Fourier transforms, delta functions, analysis of scattering, repetitive structures, intensity, Maxwell’s equations, electromagnetic forces, spin, angular momentum and magnetic moment, Bloch equations, spectra, absorption and dispersion, vector analysis, partial differential equations, and interatomic forces. (Fall)

408. Mathematical Methods of Biophysics
Prerequisites: BPH 403 or its equivalent, and permission of instructor.
Credit—four hours

Advanced mathematical techniques applied to problems of classical physics, biophysics, and three-dimensional image reconstruction. Electromagnetic theory, potential calculations, Green’s functions, properties of waves, calculus of variations, Fourier transforms, tomography, two-dimensional signal filters, NMR theory. Additional topics chosen by students.

411. Methods in Structural Biology
Prerequisites: calculus; physics or permission of the course coordinator.
Credit—five hours

A practical introduction to the theory and application of the major techniques used in the determination of atomic-resolution structures of biological macromolecules. These include X-ray crystallography, NMR spectroscopy, and computational and modeling methods. The goal is to allow nonspecialists from any discipline to critically read the relevant literature and understand the limitations of these techniques. (Spring, alternate years)

509. Molecular Biophysics
Prerequisite: calculus-based physics; permission of course coordinator.
Credit—five hours

This course is designed to show how physical concepts and techniques are used to explore and understand biological phenomena. A major portion of the term focuses on thermodynamics of biological molecules and systems; the remainder covers the structure and physical properties of biological membranes and transport. Students are expected to have had basic courses in physics, chemistry, and biology, with an in-depth background in at least one of these areas. Students not in the biophysics program should consult the course coordinator before registering. (Fall)

571/572. Biophysics Seminars
Credit—one hour each

A student seminar course is offered each semester and continuous registration is required of all graduate students in biophysics. Seminars are presented by Ph.D. students and include topics relevant to the interests of the department.
574/580. Specialty Seminars
Credit—one or two hours each
Specialty seminars are offered by faculty as interest and time permit.

591. Ph.D. Reading Course
Credit to be arranged

592. Special Topics in Biophysics
Credit—two hours
Special topics courses are offered each year that examine different aspects of biophysics in considerable depth.

Biostatistics and Computational Biology

Professors *Hall, Oakes, Tu, Wu, Yakovlev (Chair)
Associate Professors McDermott, Zhao
Assistant Professors Almudevar, Huang, Peterson, Roy, Thurston, Zhang
Joint Appointments: Professors Fisher, Mudholkar, Poduri

The activities of the Department of Biostatistics and Computational Biology include biostatistical research, collaborative research, and teaching. The department conducts a program of teaching and research in statistical methodology oriented toward the health sciences and in statistical theory and stochastic modeling growing out of research in the health sciences. The department has recently expanded to include a unit devoted to methodological and collaborative research in the rapidly emerging area of computational biology. Research interests include survival analysis, sequential methods, clinical trial design, longitudinal data analysis, missing data methods, causal inference, analysis of categorical data, measurement error models, analysis of gene expression data, statistical genetics, nonparametric smoothing and curve estimation, model selection techniques, robust inference, mathematical and stochastic modeling, order restricted inference, ROC curve analysis, nonparametric inference, Bayesian inference, functional response models, and small-sample asymptotics.

Faculty of the department have played major roles in important breakthroughs in medical research at Rochester. Examples include the better understanding of the role of calcium channel blockers in treating patients who have had a heart attack, demonstration of both the clinical effectiveness and the cost effectiveness of implantable defibrillators in reducing mortality among certain heart disease patients, demonstration of the effectiveness of deprenyl in slowing onset of disability in early Parkinson's disease, and of surfactant therapy for respiratory distress syndrome in premature infants, and an ongoing epidemiologic study of the assessment of the effects of low levels of dietary mercury intake on childhood development. Faculty are currently involved in wide-ranging collaborative activity with the Environmental Health Sciences Center, the Cancer Center, the Center on Aging and Developmental Biology, the Center for Oral Biology, the General Clinical Research Center, the Heart Research Follow-Up Program, the School of Nursing, and the Departments of Medicine, Neurology, Community and Preventive Medicine, Pediatrics, Psychiatry, Emergency Medicine, Obstetrics and Gynecology, Ophthalmology, and Dentistry. The department houses the Biostatistics Centers for the Parkinson's Study Group, Huntington's Study Group, Muscle Study Group, and Tourette's Syndrome Study Group and is responsible for the statistical analysis of many recent and ongoing multicenter clinical trials of new treatments for those diseases.

* Part-time
The department provides education to Medical Center students, residents, fellows, faculty, and staff. Faculty provide instruction in biostatistics to first-year medical students as part of the course in Mastering Medical Information. The department also offers a three-course sequence for faculty, fellows, postdoctoral trainees, and graduate students from basic science and clinical departments (BST 463, 464, 465). Various occasional lectures and informal short courses are also offered.

A training grant in Environmental Health Sciences Biostatistics funded by NIEHS supports predoctoral and postdoctoral training.

Up-to-date computer hardware and software are available to support biostatistical research, consulting, and teaching.

**PH.D. DEGREES**

**Program for the Degree of Doctor of Philosophy in Statistics**

The department administers the doctoral program in statistics, which is taught jointly by biostatistics faculty and faculty of the Program in Statistics in the College. The department interprets the term “statistics” very broadly. Programs permit specialization in probability, statistical theory and analysis, biostatistics, and interdisciplinary areas of application. Students have opportunities for supervised teaching and supervised consulting experience, requiring approximately 12 to 15 hours of effort per week.

A candidate for admission to the Ph.D. program should have a background in college mathematics, including a year of advanced calculus or mathematical analysis (similar to MTH 265, 266), a course in linear and/or matrix algebra, and a year of probability and statistics (similar to STT 201, 203); a course in statistical methods is also recommended. However, promising students may make up deficiencies after matriculation.

Doctoral students are expected to attain some competence in each of the following (overlapping) areas: I. statistical inference; II. statistical analysis (theory and methods); III. probability and stochastic processes. In addition, each student is expected to qualify at a more advanced level in two areas, designated major and minor. Minor areas, in addition to those three above, include IV. mathematics; V. epidemiology; VI. biostatistics; and VII. a specific field of application, such as econometrics, psychometrics, computer science, genetics, engineering, etc. Students are required to acquire some proficiency in statistical computation, using at least one high-level language and several statistical packages.

Specifically, the course requirements (A) are that students take a minimum of 16 formal courses, including:

A1. Basic courses: at least two courses in each of the areas I, II, and III and at least three in areas IV–VII combined.

A2. Major area: at least three additional courses (12 credits), ordinarily at the 500 level, in one of the areas I–III (or IV–VII with permission).

A3. Minor area: at least two additional courses in another one of the seven areas.

Beginning students should expect to spend all of their first year, most of their second year, and some of their third year taking formal courses. The balance of time is spent on reading and research. Students entering with advanced training in statistics may transfer credits at the discretion of their advisors. Typical programs for an entering student without previous advanced training are as follows:

<table>
<thead>
<tr>
<th>Year 1: Fall</th>
<th>Year 1: Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>BST 401 (4 credits)</td>
<td>BST 402 (4 credits)</td>
</tr>
<tr>
<td>BST 411 (4 credits)</td>
<td>BST 412 (4 credits)</td>
</tr>
<tr>
<td>BST 477 (2 credits)</td>
<td>BST 426 (4 credits)</td>
</tr>
<tr>
<td>BST 478 (2 credits)</td>
<td>BST 497 (1 credit)</td>
</tr>
<tr>
<td>BST 497 (1 credit)</td>
<td>Three additional credits</td>
</tr>
<tr>
<td>IND 501 (noncredit)</td>
<td>Three additional credits</td>
</tr>
<tr>
<td>Three additional credits</td>
<td></td>
</tr>
</tbody>
</table>
Year 2: Fall  
BST 450 (4 credits)  
BST 511 (4 credits)  
BST 514 (4 credits)  
BST 497 (1 credit)  
Three additional credits

Year 2: Spring  
BST 479 (4 credits)  
BST 413 (4 credits)  
BST 541 (4 credits)  
BST 497 (1 credit)  
Three additional credits

Year 3+
Mostly reading and research, with some 400-level (e.g., BST 452 or 465) and 500-level courses.

Notes
1. BST 402 may not be offered every year, in which case courses in advanced probability offered by the mathematics department may be substituted, or BST 479 may be taken in the first year.
2. BST 497 Seminar (1 credit) is offered every semester. Topics covered vary. Ph.D. students are required to register for at least six semesters.
3. All Ph.D. students are required to have at least four credits of supervised teaching and/or supervised consulting (BST 590, 592).
4. Advanced courses listed as BST 511, 512, 550, or 570, for varying numbers of credits, are offered depending on interests of students and instructors. Recent and current examples include
   Frailty Models                  Statistical Classification and Pattern Recognition
   Permutation Tests             Generalized Nonlinear Mixed Models
   Multiple Comparisons          The Bootstrap, The Jackknife, and Resampling Methods
   Variance Components           Order-Restricted Inference
   Psychometric Theory           Introduction to Modern Nonparametric Methods
   Smoothing Methods             High-Dimensional Data Analysis
   Multiple Comparisons          Introduction to ROC Methodology
   Semiparametric Inference       Statistical Methods in Epidemiology

These requirements are to be interpreted as guidelines, rather than as regulations. A balanced program is worked out with the student's advisor and the graduate advisor.

The examination requirement (B) consists of:
B1. Written examination in two parts. The basic part covers basic material in areas I–III, based on undergraduate preparation and some of the first-year graduate courses. It is taken after one year of study. The advanced part covers advanced material from two to three core courses in each of areas I–III taken during the first two years of graduate study. This part is usually taken after two years of study.
B2. Qualifying examination (oral) on the general area of proposed research and other topics as necessary.
B3. Final examination on the completed dissertation.

The dissertation (C) will consist of substantial scholarly contribution, worthy of publication, in one of the areas I–III or in any other area approved by the faculty committee.

There is no formal specific language requirement, but students undertaking certain areas of research may find it necessary to undertake appropriate language study.

Considerations for Students in the M.D./Ph.D. Program

Students admitted to the M.D./Ph.D. program follow essentially the same course of study as students in the Ph.D. program, except that coursework in statistics begins during the fall of the third year in the program. During the first year, students spend three months (June–August) with a mentor to begin the process of orientation toward research in statistical methodology. This may be implemented either as a formal reading course (BST 491) or as involvement in an applied project that may motivate a methodological research problem. This is repeated during the second year of the program (March–August) just prior to the start of coursework. The main goals of these interactions are to
provide the student some insight regarding the process of research in statistical methodology and to facilitate the process of choosing a research advisor.

**MASTER'S DEGREES**

**Program for the Master of Arts Degree in Statistics**

The requirements for entry into the M.A. program are the same as those for entry into the Ph.D. program. The M.A. degree requires satisfactory completion of at least 32 credits and a final examination (the basic part of B1 above or an oral examination); no thesis is required. Of the 32 credits, at least 24 must be in departmental courses primarily at the 400 level or above. All three areas (I–III above) must be represented. Appropriate substitutions may be made as long as the spirit (distribution and level) of the requirements is met. The program must also include at least one semester of BST 497. A balanced program is worked out with the student's advisor.

Students in the Ph.D. program receive an M.A. degree upon satisfactory completion of the requirements for this degree (typically during the second year of graduate study).

**Program for the Master of Science Degree in Medical Statistics**

For entry into the two-year M.S. program in medical statistics, two semesters of calculus (such as MTH 143, 152, or 162) are required. Candidates wishing to complete the M.S. program in a single year require substantially the same background as entering Ph.D. students.

The master's program in medical statistics consists of one core year (two semesters) of coursework as well as an internship/applied project (BST 470), which may be taken in the summer before or after the core program. There are no thesis or language requirements. The degree requires 32 credit hours consisting of all the 400-level courses listed below; substitutions may be made with approval of the faculty program advisor. A comprehensive oral examination to determine the student's qualifications for the M.S. degree will be administered after the end of the coursework.

The one-year (plus summer) core program is open to students with a substantial background in statistics in an approved bachelor's degree program. The program is also suitable for a 3-2 option at the University of Rochester, so that undergraduates can complete both a bachelor's degree and the master's degree after a total of five years of study.

Students with less background in statistics may have to spend a preparatory year in acquiring the (largely undergraduate) preparation that would allow them to enter the core year of the master's program.

The **Preparatory Year**: Prerequisites: Two semesters of calculus (such as MTH 141–3, 151–2, or 161–2).

<table>
<thead>
<tr>
<th>Year 1: Fall</th>
<th>Year 1: Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>STT 201 (3 credits)</td>
<td>STT 203 (3 credits)</td>
</tr>
<tr>
<td>STT 212 (3 credits)</td>
<td>BST 416 (4 credits)</td>
</tr>
<tr>
<td>MTH 165 (3 credits)</td>
<td>Electives (0–5 credits)</td>
</tr>
<tr>
<td>Electives (0–3 credits)</td>
<td></td>
</tr>
</tbody>
</table>

The **Core Year**: Prerequisites: Preparatory year or three semesters of calculus, some linear algebra, three semester-long courses in probability and statistics, including data analysis.

<table>
<thead>
<tr>
<th>Year 2: Fall</th>
<th>Year 2: Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>BST 411 (4 credits)</td>
<td>BST 422 (2 credits)</td>
</tr>
<tr>
<td>BST 476 (4 credits)</td>
<td>BST 441 (2 credits)</td>
</tr>
<tr>
<td>BST 477 (2 credits)</td>
<td>BST 464 (4 credits)</td>
</tr>
<tr>
<td>BST 478 (2 credits)</td>
<td>BST 479 (4 credits)</td>
</tr>
</tbody>
</table>

**Summer**

BST 470 (8 credits)
Notes
1. Students with a strong undergraduate background may have already taken a course in regression equivalent to BST 476. Students exempted from this course should substitute an appropriate number of elective credits.
2. Students spending a preliminary year in this program may be able to complete BST 464 in their first year.

Program for the Master of Arts Degree in Mathematics and Statistics
Students should contact the Department of Mathematics for information regarding this program.

The following courses are offered; see also offerings in mathematics (including the program in statistics), computer science, and in the Simon School. Unless otherwise noted all courses carry four credit hours.

401. Probability Theory
Prerequisite: MTH 265 or equivalent (or permission).
Probability spaces; random variables; independence; distributions; expectation; characteristic functions and inversion theorems; convergence; laws of large numbers; central limit theorem.

402. Stochastic Processes
Prerequisite: BST 401.
Markov chains; birth-death processes; random walks; renewal theory; Poisson processes; Brownian motion; branching processes; martingales; with applications.

411. Statistical Inference
Prerequisites: STT 203 and MTH 265 or equivalent.
Probability distributions, transformations and sampling distributions; statistical models; estimation, hypothesis testing, and confidence intervals for parametric models; introduction to large-sample methods.

412. Large-Sample Theory and Methods
Prerequisites: BST 401 and BST 411.
Weak convergence; asymptotic linearity; local analysis; large sample estimation, maximum likelihood estimation and M-estimation; Wald, likelihood ratio, and score tests; confidence regions; nuisance parameters; efficiency; multinomial chi-square tests.

413. Statistical Decision Theory and Bayesian Analysis
Prerequisite: BST 411.
Introduction to statistical decision theory; loss functions; admissibility; minimax, Bayes and empirical Bayes procedures; modern numerical techniques, including Markov chain Monte Carlo.

416. Applied Statistics
Prerequisite: STT 211 or STT 212 or BST 463 or equivalent.
One- and two-way analysis of variance; simple and multiple regression; analysis of covariance; analysis of residuals, use of transformations; topics from contingency table analysis and nonparametric statistics. Emphasis on real examples from the biomedical and social sciences, with extensive use of statistical software.

421. Sampling Theory
Prerequisite: STT 165 or STT 203.
Sampling designs; theories of inference in finite populations; sampling with varying probabilities; stratified, systematic, multistage and multiphase sampling; estimation based on ratio and regression methods.

422. Design of Experiments
Prerequisite: BST 416 or BST 464 or BST 476.
Credit—two hours
Basic designs and their principles; randomization; blocking; use of concomitant information.

426. Linear Models
Prerequisites: STT 203 and MTH 235.
Theory of least-squares; point estimation in the general linear model; projection operators, estimable functions and generalized inverses; tests of general linear hypotheses; power; confidence intervals and ellipsoids; simultaneous inference; linear and polynomial regression; analysis of variance and analysis of covariance models; fixed, random, and mixed effects; correlation; prediction.
441. Applied Multivariate Analysis
Prerequisite: BST 426 or BST 476.
Credit—two hours
Methodology and applications of multivariate analysis; Hotelling's $T^2$; multivariate regression and analysis of variance; classification and discrimination; principal components, clustering, and multidimensional scaling; use of statistical software.

450. Data Analysis
Prerequisites: BST 426 and BST 477 or BST 478.
Statistical analysis of data under nonstandard conditions; examination of adequacy of model assumptions; goodness-of-fit testing; transformations; robust inference.

451. Exploratory Data Analysis
Prerequisites: BST 416 or BST 476 and BST 478.
Graphical techniques to reveal structure in data; model fitting to describe structure; model checking; transformations; outliers and resistant fitting methods.

452. Design of Experiments
Prerequisites: BST 426 and BST 477 or BST 478.
Completely randomized designs; replication; covariate adjustment; randomized block designs; fixed vs. random effects; Latin and Graeco-Latin squares; confounding; nesting; factorial and fractional factorial designs; split-plot designs; incomplete block designs; response surfaces.

463. Introduction to Biostatistics
Introduction to statistical techniques with emphasis on applications in the health sciences. Summarizing and displaying data; introduction to probability; Bayes' theorem and its application in diagnostic testing; binomial, Poisson, and normal distributions; sampling distributions; estimation, confidence intervals, and hypothesis testing involving means and proportions; simple correlation and regression; contingency tables; use of statistical software.

464. Statistical Methods for Biomedical Applications
Prerequisite: BST 463 or equivalent.
Simple linear regression and correlation; one-way and two-way analysis of variance; multiple comparisons involving means; analysis of covariance; multiple linear regression; logistic regression; log-linear models; introduction to survival analysis, including Kaplan-Meier curves and the Cox proportional-hazards regression model; sample size determination; confounding; multicollinearity; model checking.

465. Clinical Trials
Prerequisite: BST 463 or equivalent.
Introduction to the principles of clinical trials; clinical trial protocols; overview of the drug development process; hypotheses/objectives; specification of response variables; defining the study population; randomization; blinding; ethical issues; factorial designs; crossover designs; equivalence trials; trial monitoring and interim analyses; sample size and power; data collection and management; issues in data analysis and reporting; evaluating clinical trial reports.

470. Internship/Applied Project
Credit—eight hours
As required for completion of the M.S. degree in medical statistics, the student works on a medical research project under the guidance of department faculty or under supervision in an industrial setting. The student should have contact with medical investigators as well as statisticians. The work should be coherently summarized in a written document. Oral presentation of the work is required.

476. Introduction to Linear Models
Prerequisite: STT 203 or STT 212 or BST 463.
Simple and multiple regression models; least-squares estimation; hypothesis testing; interval estimation; prediction; matrix formulation of the general linear model; polynomial regression; analysis of variance; analysis of covariance; methods for simultaneous inference; residual analysis and checks of model adequacy.

477. Introduction to Statistical Software I
Prerequisite: STT 212 or BST 463.
Credit—two hours
Introduction to a statistical software package. The software to be introduced may vary from semester to semester; a common choice is SAS. Generally offered during the first half of a semester.

478. Introduction to Statistical Software II
Prerequisite: STT 212 or BST 463.
Credit—two hours
Introduction to a statistical software package. The software to be introduced may vary from semester to semester; a common choice is S-Plus. Generally offered during the second half of a semester.
479. Statistical Modeling Techniques  
Prerequisites: BST 411 and BST 426.

Generalized linear models; computational techniques for model fitting; logistic and conditional logistic regression; log-linear models; models for nominal and ordinal categorical data; introduction to survival analysis, including Kaplan-Meier curves, the log-rank test, and the proportional hazards model; nonlinear least squares; with applications.

491. Reading Course at the Master's Level  
Credit—varies

495. Research at the Master's Level  
Credit—varies

497. Seminar in Statistical Literature  
Credit—one hour

511. Topics in Statistical Inference I  
Prerequisite: BST 412 or BST 413.

Advanced topics in statistical inference and/or decision theory.

512. Topics in Statistical Inference II  
Prerequisite: BST 412 or BST 413.

Advanced topics in statistical inference and/or decision theory.

513. Analysis of Longitudinal and Dependent Data  
Prerequisites: BST 401 and BST 411 and BST 426.

Modern approaches to the analysis of longitudinal and dependent data; random and mixed effects models; marginal models; generalized estimating equations; models for continuous and discrete outcomes.

514. Survival Analysis  
Prerequisites: BST 411 and BST 412 or BST 402.

Parametric, nonparametric, and semiparametric methods for the analysis of survival data. Right censoring; Kaplan-Meier curves; log-rank and weighted log-rank tests; survival distributions; accelerated life and proportional hazards regression models; time-dependent covariates; partial likelihood; models for competing risks and multiple events.

520. Current Topics in Bioinformatics  
Prerequisites: BST 411 and 464 or equivalent.

Basic concepts of modern molecular biology; bioinformatics technologies; sequence analysis of nucleic acids and proteins (methods of sequence alignment and associated search algorithms); prediction of structure and functions; protein folding and RNA secondary structure; statistical methods for microarray gene expression data analysis: (1) univariate methods for selecting differentially expressed genes (SAM, step-down and step-up resampling methods, empirical Bayes method) and (2) multivariate methods for identifying subsets of differentially expressed genes and pathway recognition (distance-based and error-based approaches, successive selection of subsets of genes, testing significance in multivariate settings); selection bias in multivariate analysis and cross-validation of classification rules; Support Vector Machines in the analysis of microarrays; unsupervised learning with microarray data; identification of gene regulatory networks from gene perturbation experiments; prognostic value of molecular signatures of cancer cells; common pitfalls in gene expression data analysis and a critical overview of the existing methods; methods for analysis of complex genetic traits and gene finding in genetic epidemiology; promising avenues for future statistical research in the field of bioinformatics.

531. Nonparametric Inference  
Prerequisite: BST 411.

Statistical procedures based on ranks, order statistics, signs, permutations, and runs; tests for randomness, symmetry, and independence; invariance considerations and optimality; treatment of ties; distributional problems and asymptotic theory; U-statistics; Chernoff-Savage theorem; robustness and efficiency.

536. Sequential Analysis  
Prerequisite: BST 412.

The Wald sequential probability ratio test and generalizations; tests of composite hypotheses; nonparametric sequential procedures; sequential estimation and confidence intervals; Brownian-motion based sequential methods, with applications to clinical trials; group sequential methods; optimal stopping rules.

541. Multivariate Analysis  
Prerequisites: BST 411 and BST 426.

Multivariate normal and Wishart distributions and associated distributions; estimation; invariance reduction; Hotelling’s T²; multivariate general linear model; simultaneous confidence bounds; step down procedures; optimality properties; classification; discrimination; principal components.

550. Topics in Data Analysis  
Prerequisite: Permission of instructor.

Advanced statistical methods for data analysis.
570. Topics in Biostatistics  
Prerequisite: Permission of instructor.  
Advanced biostatistical techniques.

582. Introduction to Statistical Consulting  
Prerequisite: Permission of instructor.  
Formal instruction on developing and managing consulting relationships.

590. Supervised Teaching  
Credit—varies  
One to two classroom hours per week of discussion and problem solving with University of Rochester students, under the guidance of a member of the faculty.

591. Reading Course at the Ph.D. Level  
Credit—varies  
Special work for doctoral candidates, arranged individually.

592. Supervised Statistical Consulting  
Credit—varies  
Supervised consulting with medical and other scientific researchers under the guidance of a member of the faculty.

595. Research at the Ph.D. Level  
Credit—varies

Community and Preventive Medicine

Professors *Brown, Pearson (Chair),*Phelps  
Assistant Professors Adams, Chin, *Davidson, Dick, Dozier, Fernandez, Friedman, Hart, Knox,  
*Lavigne, McIntosh, Noyes, Tacci, Veazie  
Adjunct Professors Mukamel, *Woodard  
Research Associate Professor Temkin-Greener  
Instructors Braus, Huang, Tomaszewski  
Senior Associate *Coburn  
Research Associates Arkoulis-Sinclair, Guido  
Professors Emeriti Barker, Berg, Kunitz, Zimmer

The Department of Community and Preventive Medicine offers programs of study leading to the degrees of Master of Public Health and Doctor of Philosophy in both health services research and policy in epidemiology. Within the M.P.H. program, there is a Generalist track and a Clinical Investigation track (latter requires M.D., D.O., D.D.S., Ph.D.). The Master of Public Health (M.P.H.) is designed to train current and future health professionals by developing and enhancing their planning, evaluative, research, and management skills. The doctoral programs train students to teach and conduct independent research in a specific field of study.

The M.P.H. Generalist track is approximately 51 credit hours. It can be completed in two years of full-time study. The M.P.H. Clinical Investigation track is 32 credits. It can be completed in one full-time or two part-time years of study. Required courses for both tracks include epidemiology, biostatistics, research methods, social and behavioral factors affecting health and illness, health policy, management and evaluation of health service organizations, environmental and occupational health, and SAS programming. All M.P.H. students complete a research project in the area of public health and/or population research using epidemiological and other analytic methodologies. The project is designed, carried out, analyzed, and written by the student under the supervision of a faculty preceptor and an advisory committee.

The program of study leading to the Ph.D. in health services research and policy is predicated on the belief that there is a critical need in academia, government, and the private sector for health care researchers. These researchers require backgrounds in statistics, economics, and policy analysis combined with an understanding of the institutions, structure, and functioning of the U.S. health care system. They also require knowledge of the important issues in health services research and

* Primary appointment in another department
policy and a command of the special methods and research approaches that have been developed specifically in this field. In the Ph.D. program offered at the University of Rochester, there are special tracks for students interested in health systems research and policy and clinical decision and evaluation sciences.

The doctoral program in epidemiology is designed to foster scholarly achievement in the area of disease prevention and health promotion through the conduct of independent community and population research. The formal curriculum emphasizes the sequential process of reasoning that is inherent in epidemiology, while encouraging the integration of multiple disciplines in health investigations that span the biopsychosocial continuum. Graduates will have mastered a unique set of methodologic and analytic skills necessary for the practice of preventive medicine and the formulation of public health practice. Currently, there is a significant demand for epidemiologists interested in research and education to assume positions in public health organizations, universities, government, and industry.

The M.P.H. program can be combined with the M.B.A. program or the M.D. program. A combined 3-2 B.A./M.P.H. program allows for the acceptance of a limited number of University of Rochester undergraduates at the completion of their third year of study.

The M.P.H. program can be combined with the M.B.A. program or the M.D. program. The M.P.H. program can also be combined with the 3-2 program. The 3-2 program allows for the acceptance of a limited number of University of Rochester undergraduates at the completion of their third year of study.

Eligibility for Admission: Candidates for admission to the program must have earned a baccalaureate degree, or the equivalent, with the exception of University of Rochester undergraduates applying to the 3-2 program. Applicants must submit a completed application form; transcripts from all previous academic work; at least two letters of recommendation from former instructors or employers; score reports from the Graduate Record Examination aptitude tests or the equivalent (taken within the past five years); and a sample of written work (other than the application essay). The TOEFL (Test of English as a Foreign Language) is required of applicants from foreign countries where English is not the primary language. When possible, applicants will be interviewed by faculty members. Applicants are encouraged to apply by June 1 for the fall semester. Selection is based on the previous experience and academic record of the candidate, and on evidence of interest in and serious commitment to a career in the fields for which the program is designed. Applicants who wish to pursue the M.P.H. degree on a part-time basis will be considered. Partial tuition assistance and research and teaching assistantships are available to qualified full-time M.P.H. students. Doctoral students are eligible to receive tuition assistance and a stipend. More detailed information on each of the combined degree programs is available upon request.

Application: Inquiries may be addressed to, and application forms requested from, the program director:

Director of Graduate Studies
Department of Community and Preventive Medicine, Box 644
University of Rochester School of Medicine and Dentistry
601 Elmwood Avenue
Rochester, New York 14642-8644
Telephone: (585) 275-7882 or fax: (585) 461-4532
E-mail: cpm_admissions@urmc.rochester.edu
Web site: www.urmc.rochester.edu/cpm/index.html

The Department of Community and Preventive Medicine is housed on the fourth floor of Helen Wood Hall, 255 Crittenden Blvd.
PM 407/ANT 218. Birth and Death: The Anthropology of Vital Events
This course explores the ways in which men and women in a variety of cultures conceive of and deal with population problems—at the individual, family, and societal levels. Using the tools of demography, anthropology, and other social sciences we examine issues such as the population explosion and the demographic transition, the baby boom, and the birth dearth; sexuality and family planning; abortion, teenage pregnancy, and single parenthood. The material is useful for students interested in aspects of social work, public policy, and international health and reproductive health. (Fall)

410. Introduction to Data Management and Data Analysis Using SAS
Prerequisite: BST 463 or permission of the instructor.
This course presents a thorough introduction to the SAS system for data management, statistical analysis, and reporting. Students gain an appreciation of what SAS can do and a solid understanding of how to use it in their work. (Fall)

411. Health Care for the Elderly: Financing and Organization
Credit—3 hours
The aging of the U.S. population and the projected growth of the “oldest old” (those age 85+) will have a major effect on the demand for and the supply of services and resources needed to provide services to this population. Already today, older Americans with serious and disabling chronic conditions are the largest, highest-cost, and fastest-growing consumer group. What are the needs of this growing demographic? How is the U.S. health care system responding to those needs? What kinds of services are available, how are they managed, and are they sufficient? Who provides the care? How much do those services cost? Who pays for what? What about quality of care? These and other issues important to the financing and the organization of health services for older Americans are examined in the course of this seminar. (Spring)

412. Survey Research
This course provides students with an overview of the role of survey methods and tools in the research process, with a particular focus on survey research applications in health care research and epidemiology. The course incorporates an integrated perspective, which includes a qualitative approach to conducting appropriate and accurate survey research.

413. Field Epidemiology
Prerequisite: introduction to epidemiology or permission of instructor.
Through a series of didactic lectures, examination of case studies, and hands-on fieldwork and data analysis, this course explores the application of traditional epidemiologic methods to public health practice. Issues, problems, and methodology relevant to the following topics are covered to provide an in-depth understanding of how epidemiology is the diagnostic discipline of public health: outreach and cluster investigations; public health surveillance; community intervention trials; outcomes research; risk assessment; screening; cost benefit analysis; and informing public health policies. Emphasis is placed on how partnerships between universities and health agencies can promote community-wide health promotion and disease prevention. (Fall)

414. History of Epidemiology
The overall objective of this course is to focus the attention and raise the awareness of students on the historical perspectives of epidemiology. The course familiarizes the student with the growth of epidemiology, as a basic science, and shows the interrelationship between epidemiologic methods and intellectual, social, political, and technological progress that has occurred throughout history. All of these events are crucial to a deeper understanding of how diseases have influenced history and what major contributions epidemiologists have made to medicine. This course emphasizes the relationship between epidemiology and other scientific disciplines by demonstrating the influence of methodologic techniques used by epidemiologists. Additionally, the framework of this course fosters an appreciation for the role of epidemiology in society through its impact on public health from its roots to its dynamic responsibilities in present trends. (Fall)

415. Principles of Epidemiology
An introduction to epidemiologic concepts of disease and interventions to ameliorate them. Discussion of population-based aspects of disease, morbidity and mortality statistics, basic study designs (cross-sectional, case-control, cohort, and clinical trials), and the use of epidemiologic data to draw conclusions about disease causation. At the end of the course, students should have a broad view of denominator-based medicine and be prepared for higher-level courses in epidemiologic methods. (Fall)
416. Epidemiologic Methods
Prerequisites: PM 415 and one semester of graduate-level statistics or permission of instructor.

This course is designed to provide an in-depth coverage of the quantitative methodologic issues associated with population-based epidemiologic research. Issues specific to study design, conduct, and analysis are emphasized. Topics covered include issues in study design, measurement, methods of data collection, methods in environmental and occupational health research, confounding and effect-modification, and analytic techniques.

417. Molecular Epidemiology
Prerequisite: PM 415.

Using the same paradigm as traditional epidemiology, this course explores the opportunities of the use of increasingly powerful biologic markers of exposure, disease, or susceptibility to provide high-resolution answers in relation to the causes of disease. The course focuses on the practice of molecular epidemiology, as an interdisciplinary science, and the use of biologic markers to advance our knowledge about health and disease among groups of people in a manner that is appropriate for inference to larger populations. (Spring)

420. Politics and Policy in the U.S. Health Care System

The seminar is designed to provide an understanding of the principal health institutions and their behavior. Readings are used to explore selected topics of importance for national health policy and local decision making. Contemporary health politics and policies are examined in terms of the influence of political and economic forces on the health care system and the particular historical development of health services in the United States. (Fall)

421. Introduction to the U.S. Health Care System

This course is intended to provide an overview of the U.S. health care system. This includes a description of the major components such as hospitals, physicians, managed care plans, and long-term care institutions; finance and reimbursement processes such as DRGs and RBRVS; and system outcomes such as quality and access. The course is intended to provide a comprehensive summary allowing the student to place more detailed studies in context. (Fall)

422. Quality of Care and Risk Adjustment

The purpose of this course is to explore the various methods and opportunities available to track and assess effectiveness and efficiency of clinical practices, medical technologies, health services, and policies. The material covered introduces the analytic approaches, databases, and settings available for studies addressing clinical practices, patient preferences and satisfaction, practice patterns, interventions, and strategies that constitute the content of health care. The course focuses on the use of patient populations and databases as laboratories for the generation of new knowledge and information. (Fall)

428. Health Services Research Seminar
Credit—none

A noncredit course required of all doctoral and postdoctoral students. A variety of topics are presented for discussion by faculty and students.

429. Introduction to SAS for Windows
Prerequisite: BST 463 or equivalent and knowledge of MS Windows.

This is a course requirement for MPH-Clinical Investigation students only. It does not meet SAS requirements for the Generalist track. This six-week course presents an introduction to the SAS System for Windows. The focus of the course is on data management and statistical analysis using SAS. Students gain an understanding of SAS as a research tool through the completion of a research project of their own design.

433. Epidemiology and Public Health of Aging

The twentieth-century demographic transition to an aging society is a universal phenomenon with profound implications for present and future disease patterns and health services. The first half of this course provides students with a working knowledge of major epidemiologic studies of disease and disability associated with the epidemiologic studies of aging and disability associated with the aging population and of the application of contemporary public health and medical care strategies to these emerging patterns. Concepts covered include compression of morbidity, functional status assessment, active life expectancy, essential roles of public health. In the second part of the course, epidemiologic and public health approaches to aging are applied to case studies (including local examples) of selected major disabling conditions, including influenza, cardiovascular disease, musculoskeletal disease, mental health, tobacco, hypertension, and other risk factors. Student evaluation is based upon several written assignments and presentations during the course and a final paper. (Fall)
436. Health Policy
Prerequisites: statistics and PPA 407.
Analysis of factors that affect supply and demand in the market for medical care: risk, insurance, externalities, and regulation. (Fall)

438. Practical Skills in Grant Writing
This course is intended to provide the student interested in a career in the life sciences with practical skills related to procuring external support for research. The course content includes a variety of didactic lectures on grant-related topics, discussion sessions with the opportunity to examine grants that others have written, examination of tools and resources available to assist in grant writing, and the opportunity to write a grant for support of the student’s own research project and have it critiqued. At the end of the course, the enrollee should be able to write a research grant. (Spring)

439. Seminar in Health and Health Care of the Elderly
The goal of this course is to provide a basic multidisciplinary perspective to the health and health care of the elderly and, through seminar presenters from a wide variety of institutions, departments, and programs, stimulate students' interest in and interaction with the variety of institutions and programs that deliver health care services to the aged. This course focuses exclusively on persons 65 and older, with special attention being paid to the old-old (those age 85 and over), people with cognitive impairment, and residents of nursing homes. (Spring)

440. Legal Issues in Health Care
Prerequisite: PM 420.
This seminar exposes students to a broad array of the legal issues that arise in the context of health care and health services. Topics include the legal basis for government involvement in health care, the rights of patients and providers, including principles that have developed for the protection of specific patient groups including infants, children, and those who lack capacity, and the legal aspects of health care financing and regulation. (Fall)

441. Methodological Issues in Conducting Research on Elderly Populations
The purpose of this course is to familiarize students with unique and prevalent issues, problems, difficulties, and challenges of conducting health services research with elderly persons, and to provide students with approaches and tools to address those issues and problems in order to successfully conceptualize, plan, carry out, and conclude research with the aged. This course focuses almost exclusively on persons age 65 and older, with special attention being paid to the old-old (those age 85 and over), people with cognitive impairment, and residents of nursing homes. (Spring)

442. Nutritional Epidemiology
Prerequisites: introductory courses in epidemiology and statistics.
The course is designed to give the students the tools to critically review the nutritional epidemiologic literature and to conduct epidemiologic studies of diet, nutrition, and disease. Concepts on nutritional epidemiology are applied to nutrition and nutritional-related disorders prevalent in the United States and globally (e.g., descriptive epidemiology of breastfeeding, new national and international growth curves, examples of the role of diet in cancer prevention). The course is focused mainly but not exclusively on maternal and child health issues. (Spring)

443. Maternal and Child Health Epidemiology
This course provides an overview of current topical and methodological issues in maternal and child health epidemiology. Topics covered include identification of MCH indicators; epidemiological performance and organization of MCH services; analytic techniques in MCH epidemiology; race and ethnicity; maternal, fetal, infant, and child mortality analyses; morbidity in pregnancy and infancy; social determinants of MCH problems; and perinatal regionalization. Students are expected to use the Internet in the conduct of coursework. Guest speakers present practical applications of MCH epidemiology in public health and medicine. (Fall, alternate years)

447. Workshop in Technology Transfer/Working with Industry
This workshop is a joint effort by the Office of Technology Transfer and the Rochester Clinical Research Curriculum, with its overall goal to introduce trainees and faculty to the relationships between university-based research and private industry. The workshop recognizes that universities are a growing source of intellectual property for which credit and benefits to the university need to be recognized. At the same time, the private sector is a growing source of research and development support, career opportunities, and the means to apply and disseminate discoveries.
This 11-week workshop explores a number of issues to prepare the university-based researcher for productive interactions with industry. This workshop series provides an introduction to types and sources of research funding, including the UR SMART system. It also addresses legal issues in clinical research, copyright, patenting, licensure, and other intellectual property issues, as well as program management and marketing by industry. (Fall)

448. Health Policy Analysis
This course introduces the students to a variety of tools that are used to analyze governmental health policy. The tools and concepts are those found in economics (e.g., market analysis, efficiency), political science (e.g., analysis of voting behavior, interest groups, public opinion), and econometrics (e.g., regression analysis). Class discussions are based primarily on selected journal articles. (Fall)

449. The Writing Workshop
Strong writing skills are an asset in public health research, business, and public life. This workshop addresses word usage, effective use of outlines and quotations, the use of transitions and other components of good writing. The two-part class features five writing workshop sessions followed by individual tutorial sessions with a subgroup of students. (Fall)

450. Management and Evaluation of Health Services Organizations
Prerequisite: one semester of epidemiology or permission of instructor.
This course provides an understanding of executive-level management and leadership in nonprofit health and human service organizations. In addition, students study organizational context, program design and implementation, and the evaluation of health care services. Students complete a health and human service not-for-profit agency-based project that involves an analysis of management and leadership issues, as well as an exercise that is a component of a needs assessment, program evaluation, or quality assurance assessment. (Spring, May, June)

451. Infectious Disease Epidemiology
Infectious diseases are a main contributor to global morbidity and mortality. Through course readings and small group discussion, participants gain a better understanding of the distribution, transmission, and pathogenesis of infectious diseases, and how this knowledge can be applied to the prevention and control of pathogens. (Spring)

453. Child and Adolescent Epidemiology
Topics cover three age groups: preschool, school-age, and adolescence. Course goals are to present an overview of current issues in child and adolescent epidemiology. The course familiarizes students with the tools to understand the epidemiologic literature in order to make informed public health decisions based on available scientific evidence and to analyze epidemiologic data on child and adolescent issues. (Spring)

454. Global Health Informatics
This course presents students with an overview of trends in a wide range of global public health indicators and the methodological tools available for addressing the analysis of international health data. The course prepares students to conduct research in international settings and focuses upon the blending of methodologies to achieve research objectives. Further, the course emphasizes Internet tools and modes of communication to facilitate the conduct of global health research. Students are required to conduct an Internet-based project sequentially conducted throughout the semester in consultation with public health researchers and officials in a variety of international settings. The course emphasizes hands-on, applied analyses of global health issues. (Fall, alternate years)

456. Advanced Health Economics II: The Industrial Organization of Health Care Markets
This course develops key theoretical concepts of industrial organization and applies the concepts to health care markets. Topics covered include theory of the firm, typology of markets, strategic behavior and game theory, integration, the role of information, regulation, and antitrust laws. (Spring)

458. Qualitative Health Care Research
The increasing complexity of health services and their delivery requires the search for new research methods. Qualitative methods, long used in the social sciences, allow access to areas that quantitative methods cannot adequately access such as health beliefs or actual (as opposed to stated) health or health delivery practices. In addition, qualitative methods can function as a prerequisite to quantitative methods by hypothesis generation or identifying lay terminology for accurate survey developed. This course covers standard qualitative methodologies through readings from the literature and discussion. (Spring)
459. Assessing Health Status of Older Adults
Students typically read about various assessment instruments that are used to measure the health status of the elderly but often do not have the opportunity to administer them unless they are in a clinical educational program. The objective of this course is to give them such experience through field trips to various settings including nursing homes, assisted living facilities, adult day care programs, senior centers, and patients’ homes where home care agencies provide services. We cover Activities of Daily Living and Instrumental Activities of Daily Living, the Mini Mental State Exam, the Geriatric Depression Scale, social functioning, the SF-36, the nursing home Minimum Data Set, and several performance-based measures. The class is limited to four to six students, and preference is given to students interested in receiving our Graduate-Level Certificate in Health & Aging. (Fall)

460. Master’s Essay
Credit—six hours or 12 hours with Honors Essay (with prior approval of the faculty)
This research project is designed, carried out, analyzed, and written up by the student under supervision of and consultation with an essay advisor and an advisory committee.

462. Genetic Epidemiology
The goal of genetic epidemiology is to understand the genetic etiology of disease through the study of genetic characteristics and their interactions with environmental exposures. This provides a framework for understanding the etiology and distribution of disease among relatives and within diverse human populations, which can facilitate early identification of high-risk individuals and families and inform the development of effective interventions.

463. Introduction to Mathematical Statistics, Part I
The goal of this course is to familiarize students with basic elements of probability and mathematical statistics. At the completion of this course students are familiar with set theory and notation and with special distributions, both discrete and continuous; understand probability theory, and how to approach both functions of random variables and limit theorems in statistics. (Fall)

464. Introduction to Regression Analysis, Part II
Prerequisite: PM 463 or permission of instructor.
The course focuses on becoming familiar with the theory of ordinary least squares regression analysis and its assumptions as well as the necessary alterations required to conduct valid analysis when those assumptions are not met. To the extent possible, examples are taken from the health services research literature. (Fall)

465. Applied Advanced Multivariate Analysis, Part III
Rather than concentrating on theory and math, this course focuses on hands-on training. By the end of the course, students should be comfortable performing routine statistical and econometric analysis, testing the assumptions of the standard ordinary least squares regression model, and presenting and interpreting data. Students should also be comfortable working with Stata. (Spring)

466. Cancer Epidemiology
The purpose of this course is to provide students with a basic understanding of the biology, prevention, treatment, and burden of malignancy in the United States. The course includes discussions of patterns of cancer incidence, etiologic factors, individual risk assessment, stages of neoplastic development, recent laboratory techniques for measurement of biomarkers, and interventional approaches related to prevention, screening, and treatment. Seminars are generated from a series of selected papers from the literature, each representing either a seminal contribution or a new strategy in cancer research. In-depth critiques of the research design and statistical approaches of each paper are also included.

467. Cancer Screening and Prevention
The purpose of this course is to provide students with a strong background in the principles of disease screening, diagnostic test usefulness, and implications of public health policies related to cancer screening. Major cancers sites for which screening recommendations are available are discussed. The implications of screening related to human costs are considered. Seminars are generated from a series of selected papers from the literature.

468. Epidemiology of Mental Disorders
The goal of this course is to understand the etiology and distribution of mental disorders, including major depressive disorders and suicidal behaviors, anxiety disorders, schizophrenia, late-life dementias and other disturbances of mental behavior. Emphasis is placed on identifying and understanding an epidemiologic framework for risk factor research and its application for developing and implementing universal, selected, and targeted interventions in diverse populations as
defined by the Institute of Medicine. Therefore, the epidemiology of alcohol and drug dependence, including other drug dependence such as cocaine, is also considered. Issues related to ethical conduct of mental health-related research across the life cycle are discussed.

469. Multivariate Models for Epidemiology
The purpose of this course is to provide students with a strong understanding of and experience in the more advanced quantitative methods for the analysis of epidemiologic studies. Detailed presentations of the analysis issues of confounding and interaction are presented and a complete presentation of most multivariate techniques. To reinforce understanding, students are required to complete exercises that assure practice and experience with the application of each technique.

470. Public Health and the Environment
The objective of this course is to present an overview of public health issues that are associated with the environment. Areas of emphasis include the evolution of environmental health from its roots in communicable diseases; current environmental health issues; epidemiology of occupational hazards and their relevance to public health; environmental health policy and regulation; and the prevention and control of environmental hazards. (Spring)

471. Technology Assessment in Medicine
Prerequisite: a background in basic epidemiology and biostatistics is helpful or permission of the instructor.

An overview of the role of diagnostic imaging as a representative technology in the practice of medicine is presented. Consideration of the effects of imaging technology on patient outcomes at various levels is discussed.

472. Measurement and Evaluation of Research Instruments
The purpose of this course is to provide students with a comprehensive background in the development and testing of research instruments for epidemiologic research purposes. A review of the principles of survey development begins the course, however, it rapidly moves to the comparative analysis of various instrument designs as well as testing of these tools.

476. RCRC Seminar Series
A weekly seminar series for Rochester Clinical Research Curriculum participants. This series includes presentations from University of Rochester training mentors, guest lecturers, experts in technological innovations in clinical research, as well as trainee presentations.

477. Advanced SAS Programming for Statistical Analyses
The purpose of this course is to provide students with more advanced knowledge and experience in SAS programming. As an extension of the Introduction to SAS class, this more accelerated course presents advanced file manipulation techniques in order to conduct multivariate analyses and modeling of follow-up data. Methods included are programming steps for ANOVA, linear regression, generalized linear models, logistic regression, and survival analysis (time to event). A detailed presentation that links statistical testing presented in other courses to software availability and programming is included. (Spring)

478. Workshop in Scientific Communication
Credit—none
A noncredit course required of all Rochester Clinical Research Curriculum trainees, Ph.D., and postdoctoral fellows. This workshop series addresses the principal elements of scientific presentation and communication such as abstract preparation, poster development, slides preparation, manuscript review and critique, oral presentations, and working with the media/public relations. (Spring)

PM 479/HIS 208. Health, Medicine, and Social Reform
Pursuit of the theme of public health and medical reform in leading writers committed, from different positions along the political spectrum, to the social and economic reorganization of modern society. (Spring, alternate years)

480. Changing Concepts of Disease
Historical account of the way disease has been conceptually understood in the Western tradition. Emphasizes the scientific, epidemiological, philosophical, social, cultural, and professional forces that have shaped the development of ideas. (Spring, alternate years)

481. Public Health Practice
This course focuses upon systematic approaches to public health decision making and upon the role of evidence, method, and community collaboration in the practice of public health. Of particular interest in this class is the collection and assessment of evidence in public health practice and of the central role of public health data in the assessment process. The class draws significantly upon local (Monroe County) experience in the assessment of community need through the Health Action community coalition process, through the Health Action
Report Card surveillance and tracking approach, and through case studies of specific areas of public health where evidence has been systematically evaluated and published (immunization, cardiovascular disease prevention, lead poisoning prevention, and child health and nutrition). Students gain experience using Healthy People 2010 indicators and the corresponding Data 2010 surveillance system for tracking HP 2010. Students gain competency in using risk statistics (e.g., population attributable risk percent, summary odds ratios) as tools for prioritizing health problems. Finally, students gain appreciation for the process of developing community-public health partnerships to deploy public health interventions. Guest speakers provide lectures addressing course priorities and content areas. (Spring)

482. Clinical Evaluation and Outcomes Research
Prerequisite: one semester of graduate-level statistics or of epidemiology.

This course covers the types of study design and settings available for original observations about clinical interventions and practice patterns. It focuses on the use of patient populations and databases as laboratories for the generation of new knowledge and information. Ways to improve the outcome and efficiency of personal health services through evaluating their effectiveness, quality, appropriateness, and cost are explored. The material covered introduces the methods, databases, and settings available for such studies. (Fall)

483. Advanced Health Economics, Part I
Prerequisite: Knowledge of the U.S. health care system and microeconomic theory.

The study of how three major parties in the health care system, insurers, hospitals, and physicians, interact and how the nature of these interactions affects the system's overall economic performance. (Spring, alternate years)

484. Cost-Effectiveness Research
Prerequisite: one semester of graduate-level statistics.

Decision analysis is increasingly used to evaluate alternative choices in clinical practice and to enlighten and inform health policy determinations. In this course, students are introduced to the concepts underlying the quantitative analysis of medical decisions. They are provided with the basis to understand decision and cost-effectiveness analyses, which appear in the clinical and health services research literature as well as to be able to set up and perform such analyses themselves. (Spring)

494. Special Topics in Preventive Medicine
Credit to be arranged

Special studies and investigative projects can be arranged with individual members of the department in the areas of medical care research, medical economics, medical sociology, health care administration and policy, and epidemiology.

Dentistry

Professors Berkowitz, Billings, Bowen, *Caton, Graser, Melvin, Meyerowitz (Chair), Subtelny, *Tallents, Westesson
Associate Professors Malmstrom, Nehrke, Saunders, Thierer, Watson
Assistant Professors Ercoli, Jensen, Kyrkanides, Ren

The Eastman Department of Dentistry offers graduate dental residency programs in postdoctoral general dentistry (advanced education in general dentistry and general practice residency), oral and maxillofacial surgery, orthodontics, pediatric dentistry, periodontics, and prosthodontics. In addition, the department cooperates with other departments in the School of Medicine and Dentistry in offering programs leading to the M.S. or Ph.D. degree in one of the basic medical sciences or the M.S. degree with a major in dental sciences as described under the Center for Oral Biology. Both the M.S. and Ph.D. programs are open only to postdoctoral students who already hold the D.D.S., D.M.D., or equivalent degree. These programs are integrated with advanced clinical training programs and are designed for those planning a career in teaching and research in dentistry. In addition, selected residents in oral and maxillofacial surgery pursue an M.D. degree linked to their residency training.

* Part-time.
M.S. and Ph.D. candidates are registered with the basic science department where the degree will be granted and are required to fill the requirements of coursework and research in that department.

Further details of programs that integrate clinical training and work for a graduate degree are given in the Official Bulletin: School of Medicine and Dentistry (www.urmc.rochester.edu/smd/bulletin).

Genetics


Associate Professors Butler, Dumont, Freeman, Hayes, Jordan, Palis

Assistant Professors Bi, Bottaro, Bulger, Fowell, Fry, Gan, Giger, Hagen, HSU, Jiang, Kane, Kim, Li, Maggirwar, Mayer-Pröschel, O'Reilly, Pearce, Portman, Sun, Zhao

Research Associate Professor Grayhack

The graduate program in genetics offers doctoral training in the general areas of molecular and cellular biology with emphasis on biomedicine, genomics, and animal development. This is a very dynamic field with creative, multidisciplinary research addressed to problems of medical and biological relevance. The program of genetics combines faculty from multiple basic science and medical departments to provide a well-rounded training for a successful career in this area.

Training in the first year of the program comprises introductory graduate level classes in molecular biology, biochemistry, and cell biology. These classes lay the foundation for advanced courses on specialized topics such as animal developmental genetics and various electives such as signal transduction or microbial genetics.

The genetics program emphasizes practical work in the research laboratory. Three laboratory rotations are a major component of the first year. During these rotations graduate students perform research projects in the laboratory of a faculty member affiliated with the program. The purpose of the rotation is to give the student experience in conducting independent research and to provide them with an in-depth view of the scope of research pursued by the program faculty. Typically, but not necessarily, graduate students chose one of the labs that have hosted the rotations for their Ph.D. research.

Training in the second and the following years includes in-depth specialized elective courses and participation and presentation in departmental and laboratory seminar series, as well as journal clubs. Students are also expected to assist in the teaching of at least one course. In addition students will receive education on issues of science ethics. An external seminar series with high-caliber, invited speakers in the areas of genetics, genomics, development, and cancer biology provides students with the opportunity to gain up-to-date insight into cutting-edge science in their field and to interact with experts in their field of study. In addition there is a wide and vibrant spectrum of relevant internal and external seminars throughout the School of Medicine and the basic science departments of the College.

Graduate student research projects are supported and monitored by the respective mentor and a graduate committee that consists of four faculty members. Typically after the second year of the program students have to pass a midterm examination that qualifies the candidate for pursuing a Ph.D. in genetics.

* Part-time

1Department of Biochemistry and Biophysics, 2Department of Biology, 3Department of Biomedical Genetics, 4Department of Medicine, 5Department of Microbiology and Immunology, 6Department of Neurobiology and Anatomy, 7Department of Neurology, 8Department of Orthopedics, 9Department of Pathology and Laboratory Medicine, 10Department of Pediatrics, 11Department of Pharmacology and Physiology.
Required Courses

IND 408. Biochemistry
This course is designed primarily for graduate students. One-hour lectures cover selected topics in modern biochemistry including analysis of protein and domain structure by classical and modern methods; protein-ligand and protein-protein interactions; enzyme kinetics and catalytic mechanisms; and a discussion of selected examples of biochemical circuits and regulatory systems. These include protein kinases, protein phosphatases, and G proteins, and their biochemical roles in signal transduction and the regulation of metabolic pathways; biochemistry of glycosylation and protein sorting; nucleic acid protein interactions; and the biochemistry and regulation of protein synthesis, folding, and degradation. In addition to the lectures, workshops are held once a week, during which time additional examples from the literature are discussed. (Fall)

IND 409. Cell Biology
This course is designed primarily for graduate students. One-hour lectures include discussion of specific modern topics including cell cycle and its breakdown during cancer and apoptosis; cytoskeleton; intracellular compartments and protein sorting; signal transduction and cell-cell communication; membrane structure and transport. In addition to the lectures, workshops are held weekly to analyze examples from the literature. (Fall)

IND 410. Molecular Biology and Genetics
This course is designed primarily for graduate students. One-hour lectures cover modern topics of interest, including DNA replication; DNA repair and mutagenesis; recombination and transposable elements; regulation of gene expression in prokaryotes; and regulation of eukaryotic transcription and RNA processing. Emphasis is placed on both biochemical and genetic approaches to the study of these problems. Special additional topics include genomics as an approach to regulation and mammalian genetic techniques of analysis. In addition to the lectures, workshops are held once a week to study further examples from the literature. (Spring)

IND 501. Ethics in Research
Credit—none
This course is offered online and is required of all first-year graduate students and new post-doctoral fellows in the School of Medicine and Dentistry. The course features seven modules that provide information about the various topics that the National Institutes for Health consider essential to understanding the responsible conduct of research.

GEN 503/504. Genetics Seminar
Seminar courses are given each semester, and continuous registration is required of all students in genetics. The genetics seminar is a forum for presentation of current research in genetics. Students in the genetics program are required to present their research in the seminar every 12–16 months starting at the end of year two. Seminars are held weekly.

GEN 507. Advanced Genetics
This course constitutes in-depth discussions of several genetic model systems, including yeast, Drosophila, Caenorhabditis elegans (a nematode), Arabidopsis, zebrafish, and mouse. Studies of the particular questions that can be addressed with advantage in each genetic model, and the special genetic approaches feasible in these respective systems, are emphasized. The course builds upon a strong prior background in Mendelian and molecular genetics. Topics covered include genetic basis of pattern formation, cell-fate determination, control of cell function, structure-function relationships in macromolecules, and searching for genes important in human health. The yeast paradigm will emphasize the utility of a simple, eukaryotic microorganism in addressing fundamental biological questions by genetics. Studies of Drosophila, nematode, Arabidopsis, and zebrafish genetics illuminate the general principles behind the control of pattern formation and the cell-fate specification in complex organisms across wide evolutionary scales. The zebrafish and mouse models illustrate two alternative approaches to vertebrate genetics.

GEN 595. Ph.D. Research
Ph.D. research may be undertaken in any of the participating departments under the direction of a faculty advisor.
Suggested Elective Courses

**BIO 402. Molecular Biology**
This course deals with the molecular mechanisms of gene replication, gene expression, and the control of gene expression in both prokaryotic and eukaryotic cells. Topics include enzymatic mechanisms of DNA replication, recombination and repair, transposable elements, DNA transcription, RNA splicing, RNA translation, repressors, activators and attenuators, recombinant DNA, and genetic engineering.

**BCH 412. Advanced Topics in Biological Macromolecules**
An advanced biochemistry lecture course intended for senior undergraduate and graduate students. Topics include DNA structure, RNA structure and catalysis, nucleic acid-protein interactions, X-ray crystallography, NMR spectroscopy, protein folding, molecular chaperones, membrane proteins, posttranslational modifications of proteins, ATPases, G protein and function, protein-protein interactions, proteases, and clotting.

**MBI 421. Microbial Genetics**
An in-depth examination of some representative genetic systems in bacteria and bacterial viruses. Topics include mutations and mutagenesis, recombination and repair, mechanisms of genetic exchange, transposable elements, and the control of gene expression. (Alternate years)

**IND 443. Eukaryotic Genome Organization and Expression I**
This course examines in detail the organization of eukaryotic genomes and the mechanisms and control of gene expression. Topics include content and arrangement of DNA sequences in the genome, structure of specific genes, RNA synthesis and processing, and the structure and composition of chromatin and chromosomes.

**BIO 451. Advanced Molecular Biology**
This course deals with molecular mechanisms of maintenance, propagation, and expression of genetic material. Topics include transcription, translation, gene regulation and replication, repair and recombination of DNA. Experimental approaches to the understanding of these processes are emphasized and students read original research literature.

**IND 447. Signal Transduction**
Cellular signal transduction is a widely studied topic in the biomedical sciences. Cells have multiple-signal transduction mechanisms for sensing their chemical environment and converting the external signals into coordinated physiological responses. The course covers a spectrum of topics including basic principles and mechanisms in cell signaling, contemporary experimental approaches to understanding signaling processes, and the role of signal transduction in normal and pathophysiology.

**GEN 508. Genes, Development, and Disease**
A graduate-level developmental biology course aimed at providing students with the up-to-date scientific information and background knowledge behind the biomedical research into the molecular mechanisms of normal developmental processes and diseases. The course runs in modular format with lectures and student reading/presentations in each module. Seven biweekly modules are taught, each by an instructor(s) most familiar with the topic. The modules include embryogenesis in human and model organisms; hematopoiesis; CNS development; organ formation and developmental disorders; genomics and proteonomics; modeling and systems biology; and cancer.

Interdepartmental Courses

Described below are interdepartmental courses for intercollege programs and other purposes. These offerings draw widely on the special qualifications of the faculty in the area independent of faculty departmental affiliations. They should be considered in conjunction with the courses, especially advanced courses, and in the closely allied subjects offered by the individual departments. The courses numbered in the 400 series are taught at a level suitable for beginning graduate students and advanced undergraduates. All courses listed under this heading should be entered on registration materials with an “IND” designation.
408. Biochemistry
Prerequisite: a one-semester introductory course in biochemistry or equivalent.
Credit—five hours

This course is designed primarily for graduate students. Eighty-minute lectures cover selected topics in biochemistry including analysis of protein and domain structure by classical and modern methods including mass spectrometry, NMR, X-ray crystallography, and other biophysical techniques; protein-ligand and protein-protein interactions; enzyme kinetics and catalytic mechanisms; cellular energy production and utilization; glycobiology; and translation. In addition to the lectures, workshops are held once a week, during which time selected papers from the literature are discussed. (Fall)

409. Cell Biology
Credit—four hours

This course is designed primarily for graduate students. One-hour lectures include discussion of specific modern topics including cell cycle and its breakdown during cancer and apoptosis; cytoskeleton; intracellular compartments and protein sorting; signal transduction and cell-cell communication; membrane structure and transport. In addition to the lectures, workshops are held weekly to analyze examples from the literature. (Fall)

410. Molecular Biology and Genetics
Credit—four hours

This course is designed primarily for graduate students. One-hour lectures cover modern topics of interest, including DNA replication; DNA repair and mutagenesis; recombination and transposable elements; regulation of gene expression in prokaryotes; and regulation of eukaryotic transcription and RNA processing. Emphasis is placed on both biochemical and genetic approaches to the study of these problems. Special additional topics include genomics as an approach to regulation and mammalian genetic techniques of analysis. (Spring)

411. Methods in Structural Biology
Prerequisites: calculus; physics or permission of course coordinator.
Credit—five hours

A practical introduction to the theory and application of the major techniques used in the determination of atomic resolution structures of biological macromolecules. These include X-ray crystallography, NMR spectroscopy, and computational and modeling methods. The goal is to allow nonspecialists from any discipline to critically read the relevant literature and understand the limitations of these techniques. (Spring, alternate years)

IND 443. Eukaryotic Gene Regulation
Prerequisites: introductory course in genetics and either an introductory course in biochemistry or molecular biology.
Credit—four hours

This course examines the organization of eukaryotic genomes, DNA packaging into inactive and active chromatin, higher order structure, mechanisms of transcription initiation and mechanisms of regulated gene expression. (Spring)

447. Signal Transduction

Cellular signal transduction is one of the most widely studied topics in the biomedical sciences. It has become clear that cells have multiple mechanisms for sensing the environment and converting the external signals into intracellular responses. The goal of this course is for students to learn modern concepts in signal transduction. The lectures cover a spectrum of topics ranging from basic principles and mechanisms of signal transduction to contemporary techniques for doing research in this area. (Spring)

501. Ethics and Professional Integrity
Credit—none

This course aims to bring to light some of the issues related to ethics and responsible conduct in clinical and basic science biomedical research arenas. The course is offered online and is required of all first-year graduate students and new postdoctoral fellows. There are seven modules in the course and each includes learning objectives, links to Web-based readings, key points to consider as the students complete the required readings, case examples and a brief online quiz to assess understanding. The course follows the National Institutes of Health requirements for training in the responsible conduct of research and covers the following topics: Human and Animal Subjects in Research, Conflict of Interest, Academic Honesty and Misconduct in Scholarship, Data Management, Responsible Authorship, and Intellectual Property and Copywriting. (Fall)

502. Ethical Issues in Human and Animal Research
Credit—two hours

The objective of this course is to explore the ethical and philosophical foundations regarding the involvement of human and animal subjects in research. Ethical theories, laws, and national regulations that have been developed prompt
discussion of contemporary ethical problems and proposed solutions. This seminar course is designed for small group discussion with individual exploration of current ethical issues in the research enterprise. (Spring)

507. Advanced Genetics
Prerequisite: introductory course in genetics.
Credit—four hours

This course constitutes in-depth discussions of several genetic model systems, including yeast, Drosophila, Caenorhabditis elegans (a nematode), Arabidopsis, zebrafish, and mouse. Studies of the particular questions that can be addressed with advantage in each genetic model and the special genetic approaches feasible in these respective systems are emphasized. The course builds upon a strong prior background in Mendelian and molecular genetics. Topics covered include genetic basis of pattern formation, cell-fate determination, control of cell function, structure-function relationships in macromolecules, and searching for genes important in human health. The yeast paradigm emphasizes the utility of a simple, eukaryotic microorganism in addressing fundamental biological questions by genetics. Studies of Drosophila, nematode, Arabidopsis, and zebrafish genetics illuminate the general principles behind the control of pattern formation and the cell-fate specification in complex organisms across wide evolutionary scales. The zebrafish and mouse models illustrate two alternative approaches to vertebrate genetics. (Spring)

520. New Frontiers in Mitochondrial Medicine
Credit—two hours

A seminar/reading course on current topics in mitochondrial research. The objective is to gain experience discussing and critically evaluating primary research articles that focus on mitochondrial biology in topics related to human developmental biology and aging, mammalian evolution and genetics; nuclear: mitochondria trafficking, mtDNA disease pathogenesis, oxidative phosphorylation and oxidative stress, or degenerative disorders. The course is guided by an instructor who meets with the students on a weekly basis to assist in the selection of relevant readings and to discuss key issues. This elective course is designed for graduate students who have an interest in mitochondrial biology but it (and presentations) is open to graduate students, upper-division undergraduate students, medical students, residents, staff, and interested members of the faculty. (Fall)

Laboratory Animal Medicine

Professor Baggs
Adjunct Associate Professor Wyatt
Assistant Professor Moorman-White (Acting Chair)
Senior Instructor Bates

Graduate instruction is currently offered by the faculty of the Division of Laboratory Animal Medicine in areas related to the use of animals in medical research and teaching programs. No separate degree is given in this field at present. Residency training in laboratory animal medicine has been offered as a three-year program for veterinarians preparing for careers in this specialty.

402. An Introduction to Laboratory Animal Biomethodology
Prerequisite: B.S. in biological sciences or professional degree (M.D., D.D.S., or D.V.M.).
Credit—one hour

The selection of the appropriate animal model, the principles of animal care and research techniques using animals is presented. Through the use of lectures, readings, and laboratories the principles necessary to properly and humanely use laboratory animals are taught. This course is recommended for young scientists who will be using laboratory animals as models for the investigation of biological phenomena or as surrogates for man in their professional careers. (Spring)

* Part-time.
526. Toxicologic Pathology
Prerequisites: PTH 505 or equivalent and TOX 521.
Credit—one hour
A laboratory course in which microscopic sections of various lesions, mostly induced by toxic compounds, are examined. Discussions emphasize the description and interpretation of histologic changes as well as pathogenetic mechanisms. (Spring)

Marriage and Family Therapy

Assistant Professor Horwitz, Nilsen
Joint Appointments: Professor McDaniel; Associate Professors *Gawinski, le Roux (Director), Shields, Watson; Assistant Professors Poleshuck, Seaburn, Speice; Senior Instructor Bennett;
Associate Rousseau
Senior Instructor Pisani
Clinical Associate Professor Driscoll
Clinical Assistant Professor Alexander
Clinical Senior Instructors Briody, McCabe, Klausz, Platt
Professor Emeritus Wynne

The Department of Psychiatry offers a Master of Science degree in marriage and family therapy through the Family Therapy Training Program, an international leader in medical family therapy. Coursework provides a broad-based, integrative, biopsychosocial approach to clinical practice. The program is committed to a systems and relational understanding of human functioning. The faculty is recognized for developing Transitional Family Therapy, a model that blends structural, transgenerational, and ecosystemic approaches, while using family strength and competence in therapy. Special attention is given to the family in the context of larger systems issues, using family and other natural supports as well as the role of gender, race, culture, health, ethnicity, and spirituality.

Family programs has a long history of providing family therapy training and continuing education locally, nationally, and internationally. Built on the work of faculty pioneers in the areas of serious mental illness, substance abuse, and cultural transition, postgraduate training has been provided since 1983. The program prides itself on training professionals from multiple disciplines (medicine, nursing, social work, psychology, clergy, education) and serving disadvantaged populations.

The goal of the M.S. in marriage and family therapy is to prepare creative and competent marriage and family therapists to work with individuals, couples, and families in a variety of settings. The program combines rigorous coursework with intensive clinical training. All courses are taught by experienced family therapy faculty, and all clinical supervisors are approved supervisors or supervisor candidates in the American Association for Marriage and Family Therapy (AAMFT).

Courses in the program blend conceptual, clinical, and self-of-the-therapist considerations to prepare family therapists for professional practice. Clinical training is provided in a variety of supervised formats and settings. Each student has a clinical placement in one of several settings. These include the Strong Family Therapy Services in the Division of Family Programs (Strong Behavioral Health), as well as numerous off-site clinics, including a community hospital, primary care health center, program for the seriously and persistently mentally ill, community mental health centers, and school-based and home-based programs.

Applicants should have completed a bachelor's degree in education, psychology, social work, sociology, or pastoral studies. In order to graduate, students must successfully complete 45 credit hours: 24 credit hours in the core didactic courses, 6 credit hours from selective and elective courses, 12 credit hours in clinical coursework/supervision (leading to a minimum of 500 clinical contact hours and a minimum of 100 hours of supervision), and a Master's Project (3 credit hours) that integrates conceptual and clinical learning.

* Part-time.
All courses meet the standard curriculum requirements of the Commission on Accreditation for Marriage and Family Therapy Education.

**Theoretical Foundations**

**PSI 539. Family Therapy Theory and Technique**

This seminar introduces students to the leading schools of family therapy—structural, strategic, transgenerational, narrative, etc.—as well as introducing students to Transitional Family Therapy.

**PSI 560. Narrative Approaches to Psychotherapy**

This course focuses on the use of language, storytelling, metaphor, and the construction of meaning in family therapy and in the life of the therapist. Students review cutting-edge literature from multiple disciplines interested in how language and storytelling shape peoples’ lives.

**PSI 564. Transitional Family Therapy**

Transitional Family Therapy is a model developed at Rochester that blends here-and-now, transgenerational, and ecosystemic factors in the practice of family therapy. The course is an in-depth examination of the theory and practice of this approach.

**Clinical Practice**

**PSI 541. Introduction to the Clinical Practice of Family Therapy**

In this course, students are taught interviewing and documentation skills, have exposure to families in nonclinical settings, learn the biopsychosocial model, and explore person-of-the-therapist issues.

**PSI 542/562. Clinical Practice I and II**

These courses prepare students specifically for Clinical Practicum.

**Individual Development and Family Relations**

**PSI 545/546. Life-Span Development and Intergenerational Patterns**

This course teaches developmental issues across the life span and relates these developments to intergenerational patterns as well as family of origin theory and its role in clinical practice.

**PSI 566. Couples Therapy**

Couples therapy teaches students couples therapy theory and technique using readings in the field and examination of videotape and other material.

**Professional Identity and Ethics**

**PSI 547/548. Family Therapy-Ethics and Professional Practice**

Students learn the AAMFT Ethical Code expectations dealing with such issues as confidentiality, dual relationships, individual and family welfare, etc. Students also address personal issues related to the impact of values, beliefs, race, and ethnicity on the practice of family therapy. In addition, the course focuses on key aspects of professional practice.

**PSI 543/544. Psychopathology and Systems**

Students learn traditional diagnostics and psychopathology within a systems framework. The course enables students to approach families from a biopsychosocial systems assessment paradigm.

**PSI 570. Gender, Race, and Culture in Family Therapy**

Students learn the role that gender, race, ethnicity, sexual preference, and cultural beliefs play in family life and clinical practice.

**PSI 574. Child-Focused Family Therapy**

This course teaches students to work with families in which the primary focus is child behavioral difficulties and parenting issues. Students earn both theoretical and clinical skills in dealing with problems that arise at different developmental stages.
Research

PSI 572. Family Therapy Research
Students are introduced to quantitative and qualitative methods in family therapy research and learn to critically examine and use research findings in clinical practice.

Electives

PSI 426. Families Coping with Long-Term Mental Illness
Students learn how to diagnose and treat patients and families dealing with persistent mental illnesses, such as schizophrenia, bipolar disorder, and major depression.

PSI 428. Group Psychotherapy
Students learn about group theory and dynamics and also have the experience of functioning within a small group.

PSI 492. Medical Family Therapy Institute
This course is based on a week-long, intensive lecture that blends didactic and experiential methods to teach students how to work with families dealing with illness and how to collaborate with physicians and other health care professionals.

PSI 580. Death and Mourning
One of the most influential forces in family life is loss in its many forms. This course enables students to understand loss and mourning as it is shaped by current family factors as well as trans-generational influences.

Microbiology and Immunology

Research Associate Professor Livingstone
Research Assistant Professors Bousee, Fan, Hilchey, Patel, Robert, Zeng
Scientist Holtfreter
Professors Emeriti Abraham, Allen, Bowen, Christensen, Cohen, Hare, W. Iglewski, Maniloff

* Primary appointment in another department.
† Part-time.
Applicants for admission to graduate study in the Department of Microbiology and Immunology should have an undergraduate major in biological or physical sciences. The usual minimal requirements are general biology, general chemistry, analytical chemistry, and organic chemistry. Applicants seeking the Ph.D. degree are expected, in addition, to have a year of mathematics and physics. Physical chemistry and biochemistry are desirable. The major goal of the graduate program in microbiology and immunology is to prepare students, through a Ph.D. training program, for a scientific career in one of the several areas included in the broad categories of microbiology and immunology. All programs will involve a basic grounding in biochemistry, and will include an important emphasis in biology at the molecular and cellular levels. The department offers several tracks leading to a Ph.D. in microbiology and immunology. Particulars about the Ph.D. programs in the various tracks are available from the departmental office on request.

The M.S. degree (Plan A) is intended for those whose career goals are in research. Individuals whose primary interest is in seeking subsequent admission to medical school are not encouraged to apply. The course program includes microbiology, biochemistry, and additional courses appropriate to the individual's area of research plus thesis research. The thesis, while not expected to be as extensive as a Ph.D. thesis, must be based on research of significant scientific value. In most cases the candidate must spend approximately two years to complete the program.

Persons who wish to increase their training in microbiology and immunology, but whose career goals are other than research, may earn the M.S. through Plan B. These career goals might include technical employment or nonuniversity teaching. The program consists of approximately 30 hours of coursework, selected for the most part from courses satisfying the core requirement for the Ph.D. In addition, a written essay consisting of a critical review of some area of microbiological literature plus a final oral examination based on the essay and on the relevant material covered in courses are required.

414. Mechanisms of Microbial Pathogenesis
Prerequisites: MBI 220 and 221.
Credit—four hours undergraduate, three hours graduate

An examination of host-parasite interactions and the mechanisms by which microbes evade the host response and cause disease. The emphasis is on an understanding at the molecular level of microbial pathogenesis, including colonization, invasion, antigen variation, toxin production, and mode of action. Graduate students must register for MBI 514 seminar. (Spring, alternate years)

421. Microbial Genetics
Prerequisite: MBI 220.
Credit—four hours undergraduate, three hours graduate

This course provides an in-depth examination of representative genetic systems in bacteria and bacterial viruses. Emphasis is placed on the methods of genetic analysis used to study biological function. The material covered includes the nature of bacterial variation, processes affecting gene synthesis and integrity, the nature of gene transfer in bacteria, and the regulation of gene expression in prokaryotes.

431. Microbiology Physiology
Prerequisite: a course in biochemistry.
Credit—four hours undergraduate, three hours graduate

This course provides a survey of microbial physiology with emphasis on metabolism, regulation, cell walls, membranes, ecology, and adaptation to extreme environments. The class meets twice per week for two lectures of 75 minutes each. Extensive handout materials are provided, and readings are from the current literature. Ph.D. students must register for MBI 531 seminar. (Spring, alternate years)

456. General Virology
Credit—five hours undergraduate, four hours graduate

Provides an introduction to virology. Topics covered are general methodology of virus research, virus structure, biochemistry of viral replication, and general features of virus-host cell interaction. (Spring, alternate years)
473. Immunology
Prerequisites: BIO 121; BIO 150 or equivalent.
BIO 202 strongly recommended.
Credit—four hours undergraduate, three hours graduate

Innate and adaptive immunity; structure and genetics of immunoglobulins and T cell receptors; lymphocyte development, immune regulation, immunological diseases, tumor immunity. (Fall)

491. Reading Course at the Master's Level
Credit to be arranged

493. Master's Essay
Credit to be arranged

495. Master's Research
Credit to be arranged

501. Microbiology and Immunology Student Seminar Series
Credit—one hour

A seminar program is presented each semester; continuous registration is required of all Ph.D. students in the Department of Microbiology and Immunology. Seminars are held once a week and are conducted by graduate students. First- and second-year Ph.D. candidates present a topic from the current literature. Senior graduate students present a seminar on their research progress. (Fall and Spring)

507. Graduate Microbiology Laboratory Rotations
Credit—eight hours

Consists of a series of laboratory experiences, each of approximately six weeks, in laboratories of several faculty members. Usually, Ph.D. students are expected to enroll for three rotations.

509. Scientific Communications
Credit—two hours

This 12-session course provides basic instruction in oral and written communication skills for microbiology and immunology graduate students. The course offers a brief introduction to scientific logic and the construction and experimental testing of scientific hypotheses. This grounding is then used as a platform from which to provide specific instruction in presentation skills, with an emphasis on practical, hands-on instruction and experience in both written and oral communication. Students are required to complete assigned readings, to write a short research paper (1,000 words), and to prepare and deliver a short oral presentation (10 minutes). For most students, it is expected that the research paper and oral presentation be based on data from any one of their three research rotations; additional flexibility is permitted (if needed) to best meet the learning objectives of this communication course. (Fall)

514. Pathogenic Mechanism Seminar
Credit—one hour

Seminar offered concurrently with MBI 414. Required for Ph.D. students. (Spring, alternate years)

521. Topics in Microbial Genetics
Credit—one hour

This is the concurrent seminar required for graduate students registering for MBI 421. (Spring, alternate years)

531. Microbial Physiology Seminar
Credit—one hour

Seminar offered concurrently with MBI 431. Required for all Ph.D. students taking MBI 431. (Fall, alternate years)

540. Advanced Topics in Immunology
Prerequisite: permission of instructor.
Credit—two hours

An in-depth inquiry (via student seminars, class discussions, original literature) into one contemporary facet or subfield of immunology. Selection of the topic for a given seminar is at the discretion of the students and the immunology faculty member who is responsible for the course that semester. Previous topics include T-cell Recognition in Tumor Immunity and Autoimmunity, Behavioral Regulation of Immunity, and The Genetics of the Mouse and its Application in Immunology. (Spring)

570. Molecular Biology Seminar
Credit—one hour

Seminar and journal club series required for all Ph.D. microbiology students. This course involves the discussion of the primary literature to explore the molecular mechanisms used by various microbes to regulate expression of products involved in pathogenesis. Students are required to present papers and participate in discussion of the presented material. (Fall and Spring)

573. Immunology Seminar
Credit—two hours

This course covers a particular aspect of immunology in depth with an emphasis on critical reading of original journal articles. Two to four papers are read each week with oral presentation by the students. (Fall)
580. Immunology Journal Club and Research-in-Progress Seminar  
**Prerequisite:** MBI 473.  
Consists of two parts: Part I is the Immunology Journal Club (meets one hour per week), in which students read and discuss recent papers from the immunology literature; Part II consists of attendance at the weekly one-hour Immunology Research-in-Progress seminar series. (Fall and Spring)

581. Oral Microbiology  
**Credit—two hours**  
The bacteriology of dental caries and periodontal disease is considered in terms of current research on physiology, genetics and pathogenic mechanisms. Virology and mycology related to oral disease are reviewed, as well as sterilization and disinfection. There is no textbook for this course, but there is a handout and assigned readings from the literature for each session, which includes a lecture and a seminar based on student reviews of current research papers. (Fall, alternate years)

582–589. Specialty Seminars  
**Prerequisite:** permission of instructor.  
**Credit to be arranged**  
In any semester various faculty members may offer seminar courses related to the area of their research interests. Announcement is made on the department bulletin board.

588. Virology Research Seminar  
**Credit—one hour**  
This course provides a forum for discussion of ongoing work in virology research laboratories at the University of Rochester. Topics include vaccine research, drug development and testing, gene therapy, and basic virology. (Fall and Spring)

589. Advanced Topics in Virology  
**Credit—one hour**  
Advanced topics in virology are investigated in a discussion course. Previous topics include anti-viral therapy, vaccine design, and viral transcription regulation. Students present reviews of the literature and write critiques. (Fall)

593/594. Special Topics in Microbiology  
**Credit to be arranged**  
Directed studies in the field of microbiology, supervised by a senior faculty member and organized to meet the needs of individuals or small groups of graduate students.

595. Ph.D. Research  
**Credit to be arranged**  
Research may be undertaken in virology, general medical microbiology, animal parasitology, immunochemistry, genetics, physiology, bacterial cytology, and cellular immunology.

### Neurobiology and Anatomy

Associate Professors B. Davis, Dickerson, Freedman, *Fudge, *Kyrkanides, Luebke,  
Assistant Professors K. Davis, Gan, G. Gdowski, M. Gdowski, *Huxlin, Kornack, Pinto, Romanski, Seidman  
Research Associate Professors *Wood, *Walton  
Research Assistant Professors Hurley, Quessy, Sobotka  
Professors Emeriti DelCerro, Thomas

The Department of Neurobiology and Anatomy is recognized for its excellence in research programs and for its commitment to teaching and leadership in both graduate and medical education. Over 35 faculty (primary and joint) are actively engaged in research on the structure and function of the nervous system across several levels of inquiry. Areas of interest cover a broad spectrum, including sensory, motor and integrative systems, cell signaling and transmission, development and aging, neurobiology of disease, learning and plasticity, neuro-engineering, and computational neurobiology. Extensive state-of-the-art instrumentation and methodologies are available for investigators, students, and staff, both within labs and across a set of departmental research cores. Close interactions among departments and centers sharing interests in neuroscience ensure that this discipline holds a

* Primary appointment in another department.
leading presence throughout our unified medical and college campus, while the Department of Neurobiology and Anatomy remains central to Rochester's research and teaching programs in the neural sciences. For students as well as fellows and visiting faculty, this translates into a highly attractive environment for training and career development. This environment has recently expanded with an influx of new faculty, accompanied by a new diversity of interests and talents that has catalyzed a variety of novel educational and research opportunities and plans. Our Web site provides an evolving guide to our community and its programs (www.urmc.rochester.edu/smd/nana).

An enduring departmental role continues to be its commitment to education. This commitment includes extensive participatory and leadership roles in medical, graduate, and undergraduate curricula at the University of Rochester. Faculty in the department have received a continuous stream of awards for teaching and leadership efforts over the years, including a fifth of all Dean's Teaching Scholars Awards, and recurrent commendations conveyed by students.

The department plays a central role in graduate education within the neural sciences community at the University. In addition to our own Graduate Program in Neurobiology and Anatomy, commitments include extensive instructional and leadership roles in the Interdepartmental Graduate Program in Neuroscience, and participation in the graduate programs of brain and cognitive sciences, biomedical engineering, and others. Interconnections between different levels of clinical education and graduate education are also strong. In addition to committed involvement in the M.D./Ph.D. program, we offer a new Academic Honors Program in Medical Neurobiology (M.D./M.S.), which adds an additional year of study, research and teaching experience to the medical curriculum, culminating in an M.S. degree in neurobiology and anatomy along with the M.D. degree upon graduation.

The Ph.D. program in neurobiology and anatomy is particularly well suited to students in the University's M.D./Ph.D. program and to Ph.D. candidates interested in the characteristics of, and mechanisms underlying, function and dysfunction of the nervous system. The program is specifically directed toward preparation for academic careers within a medical school setting, where teaching in medical and graduate school curricula comprises a strong component of faculty mission, and where research interests include systems, integrative, and translational/clinical attributes of neural science.

The curriculum shares a core first year with the Interdepartmental Graduate Program in Neuroscience to instill a firm foundation in broad aspects of neurobiology. In the second year, a rare opportunity is offered—students choose one of the two medical school courses associated with the department, depending upon interest; Human Structure and Function includes gross anatomy, yielding an appreciation of the peripheral nervous system and its diverse interactions with numerous functions of the body, while Mind, Brain, and Behavior approaches neuroscience from a distinctly human perspective with emphasis on clinical implications and mechanisms. Additional electives are chosen to provide a more specialized emphasis as students approach their extended research training. Graduate students in neurobiology and anatomy are encouraged to exploit the multidisciplinary talents of our faculty in basic and clinical disciplines to achieve the research goals of their dissertation projects. Numerous collaborative research programs offer opportunities with colleagues in associated departments. Finally, teaching requirements and opportunities are prominent in the program, in order to instill the confidence necessary to impart knowledge to others, and to prepare students for their eventual roles as teacher/researchers of the future.

491. M.S. Reading

495. M.S. Research

512. Cellular Neuroscience
Credit—six hours

  Cellular and molecular mechanisms in the nervous system are discussed in detail. Among the topics covered are overview of cellular components and molecular approaches, voltage and transmitter gated ionic channels, second messenger modulation of ionic channels, biochemistry of synaptic transmission, inhibitory and excitatory amino acids, neuronal and glial cell lineage and growth factors, axonal path-finding, and experience-dependent plasticity. Sessions include lectures, discussions, and presentations of papers from the literature. (Fall)

521/522. Graduate Seminar
Credit—one hour

  Provides experience for year-two graduate students in formulating and presenting an oral seminar based on the students' own research or
in an area of interest in the scientific literature. Skills involved in library searches, designing effective visual aids, and abstract writing culminate in the presentation of a seminar open to the medical school community.

525. Mind, Brain, and Behavior  
**Credit—eight hours**

This nine-week course provides a multidisciplinary overview of the structures, functions, and dysfunctions of the human nervous system, integrating both basic and clinical sciences. Basic science portions of this course include the disciplines of neuroanatomy, neurophysiology, neuro- and psychopathology, and neuro- and psychopharmacology. The basic science material is fully integrated with the clinical disciplines of neurology and psychiatry. Overview lectures, problem-based learning sessions, and laboratory exercises introduce you to the basic and clinical sciences underlying neurological and psychiatric disorders. This course provides a foundation for students interested in understanding and teaching neuroscience in undergraduate, graduate, allied health, and medical school settings. (Weekday mornings, mid-August–mid-October)

526. Human Structure and Function  
**Credit—twelve hours**

This 14-week course provides a rare opportunity to join the medical school curriculum in learning the essential concepts and mechanisms underlying human biology from an integrated perspective, including both basic and clinical applications. Didactic lectures are matched with problem-based learning sessions, problem-solving conferences, and laboratory exercises that introduce students to the systematic study of human structure and function. This integrated course encompasses the disciplines of anatomy, embryology, histology, and physiology. The course includes comprehensive laboratory sessions in gross anatomy and histology, and the qualitative and quantitative aspects of human physiology, including fundamental principles and clinical relevance. Students of the nervous system come to appreciate firsthand the intricacies and ubiquity of the brain's structural and functional interactions with the various systems of the body, as well as their evolutionary and developmental attributes. The course provides an introductory foundation for students interested in understanding and teaching these disciplines in undergraduate, graduate, allied health, and medical school settings. (Mid-September–late December)

531. Integrative and Systems Neuroscience  
**Prerequisites: NSC 512, NSC 201/BCS 240 or equivalent introductory neuroscience course. Credit—six hours**

This course provides a critical overview of current knowledge of systems neuroscience. The topics include an overview of approaches and techniques, a comprehensive account of functional connectivity, transmitters, neurophysiology, and behavioral measures of sensory and motor systems, the basal ganglia, the limbic and hypothalamic systems, as well as memory, attention, and neurobiology of language. In addition, a number of classes deal with neurobiology of disease. (Spring)

581. Teaching Tutorial in Gross Anatomy  
**Credit—three hours**

This course is designed to provide an opportunity for students to acquire and develop skills in teaching human gross anatomy. Students are expected to attend all staff meetings, provide instruction in the laboratory, and present a formal lecture to the first-year medical students. Additionally, students participate in writing and grading examinations. Although designed primarily for advanced graduate students in the Department of Neurobiology and Anatomy, other graduates may elect this course if they have taken a formal course in human gross anatomy. (Fall)

583. Teaching Tutorial in Neurobiology  
**Credit—three hours**

This experience is designed to provide an opportunity for students to acquire and develop skills in teaching and course management in neurobiology (particularly related to Mind, Brain, and Behavior). Students are expected to attend staff meetings, provide instruction in the laboratory, bear responsibility for small group teaching, prepare and deliver formal lectures, assist in the preparation and grading of examinations, and participate in staff-evaluation sessions. Although designed primarily for advanced graduate students in the Department of Neurobiology and Anatomy, other graduates may elect this experience with permission of the instructor. (Fall)

591. Ph.D. Readings  
592. Neuroscience Journal Club  
**Credit—one hour**

A seminar/reading course on current topics in neuroscience research for year-one students. The objective is to gain experience discussing and critically evaluating primary research articles covering a broad range of topics in neuroscience.
New and Developing Electives in the Department

513. Neuroinflammation
Prerequisite: NSC 512 and MBI 473/573 recommended.
Credit—four hours

Inflammation contributes to secondary injury following brain trauma or stroke, and is often a direct cause of neuropathology in the nervous system. And yet, neuroinflammation may also be critical for regeneration and repair. This course examines the role of inflammation in the central nervous system, and highlights common mechanisms of response to a variety of neural insults, including autoimmunity, trauma, neurotoxicology, and neurodegeneration. Further topics include the roles glia, the acquired immune system, and the innate immune system play in response to neural insults in the unique "immune-privileged" environment of the CNS. (Spring)

515. Advanced Topics in Neural Control of Movement
(Same as BME 515)
Prerequisite: ANA/NSC 531 recommended.
Credit—two hours

This advanced graduate course brings students with a basic understanding of the motor system to the forefront of modern investigation. Topics include movement selection, motor learning, distributed control, basal ganglia function, control of gaze, vestibulo-motor responses, muscle compartmentalization, and others based on student interests. (Spring)

517. Advanced Topics in Sensory Systems
(Same as BME 517)
Prerequisite: ANA/NSC 531 recommended.
Credit—two hours

This modular course provides in-depth analysis of sensory system function, from molecules to behavior. Each module focuses on a particular topic within or across sensory modalities, e.g., localization, pattern recognition, multisensory integration, object- vs. self-motion, figure-ground segregation, temporal resolution, plasticity, and aging. (Spring)

518. Computational Neuroscience
(Same as BME 518)
Prerequisite: ANA/NSC 531 or BME260 recommended.
Credit—three hours

This course covers computational aspects of neuroscience research. The course begins with a brief review of Hodgkin-Huxley channel dynamics, and extends to advanced topics including cable equations, neural circuits and control systems, and biologically plausible neural models of behavior. There is an emphasis on simulation and modeling of both single neurons and neural networks and systems. (Spring)

519. Neurophysiological Techniques
(Same as BME 519)
Prerequisite: ANA/NSC 531 recommended.
Credit—two hours

Provides training in the instrumentation and techniques required for acute and chronic recording of neuronal activity (including evoked potentials, extracellular single and multiunit recording, intracellular recording, and patch-clamp), and online processing of recorded data. (Fall)

523. Advanced Topics in Structural Neurobiology
Prerequisite: ANA/NSC 512 and 531 recommended.
Credit—three hours

The course starts with the discussion of the development of neuronal structure covering embryology, structural genetics, and cellular development (multiplication, differentiation, maturation, function). A series of classes dealing with each system follows. Among other topics the following issues are addressed: how structure determines function and how function determines structure; neuroanatomy of health and disease (by system), and structural changes in aging. (Fall)
242. Stem Cells of the CNS in Development and Disease
Credit—three hours

This course covers the most recent and relevant advances in the field of stem cell biology with a focus on the CNS. In the first series of lectures we address the basic questions: what makes a cell a stem cell. The differentiation potential of stem cells in vitro and in vivo are discussed, along with mechanisms of fate determination and the control of differentiation versus proliferation. Students learn the basic aspects of stem cell biology and the role of stem cells in disease paradigms. Topics include the involvement of stem cells in pathological conditions of malnutrition and carcinogenesis and the potential use of stem cells for transplantation therapies. (Fall)

530. Neural Basis of Cognitive Neuroscience
Credit—two hours

A part lecture, part journal club course, covering neurobiological approaches to the study of cognition and impairments of cognition. Topics include types of memory and clinical aspects of memory impairment and animal models; neurobiological basis of emotion; symptoms of autism and animal models; neurobiology of schizophrenia. (Fall)

Neuroscience

Professors Aslin, Bidlack, Cohen, Coleman, Dewhurst, Doty, Dworkin, Federoff, Frisina, Gelbard, Griggs, Haber, Hayhoe, Ison, Joseph, Kellogg, Makous, Merigan, Nedergaard, Newport, Noble, E. Nordeen, K. Nordeen, Oghara, Paige, Pasternak, Pinkert, Powers, Rodier, Sheu, Shrag, Tank, Williams, Yeh, Zlokovic

Associate Professors Blair, Calkins, Dickerson, Dirksen, Duffy, Freedman, Freeman, Fudge, Gross (Co-Director), Knill, Luebke, Mink, Moynihan, O’Banion, O’Neill, Olschowka

Assistant Professors Bavelier, Davis, Dirksen, Freedman, Gan, G. Gdowski, 5 M. Gdowski, 5 Giger, Huxlin, Kornack, Kyrkanides, Lee, Maggirwar, Mayer-Proschel, Pearce, Portman, Romanski, Segal, Seidman, Weliky

Research Associate Professors Bowers, Emerson, Loy, Madden, Walton, Wood

Research Assistant Professors Callahan, Lu, Maguire-Zeiss

The Graduate Program in Neuroscience at the University of Rochester is designed to provide the interdisciplinary training required to understand nervous system function at many levels of analysis. The program includes over 70 faculty members from 10 different departments and centers spanning both the School of Medicine and Dentistry and the College. This unique program offers its students the opportunity to study a wide range of modern neuroscience disciplines organized as specific programmatic themes including Sensory and Motor Systems, Cognitive and Behavioral Neuroscience, Molecular and Cell Signaling, Development and Aging, and Neurobiology of Disease.

The Graduate Program in Neuroscience at the University of Rochester attracts students from a variety of scientific backgrounds. We engage our students in research early in their career and provide them with a rigorous core curriculum in cellular and systems neuroscience that builds a solid foundation for more advanced, specialized coursework relevant to their individual interests.

Neuroscience faculty primary appointments are in the following departments as annotated: 1Department of Brain and Cognitive Sciences, 2Department of Pharmacology and Physiology, 3Department of Microbiology and Immunology, 4Department of Environmental Medicine, 5Department of Neurobiology and Anatomy, 6Department of Anesthesiology, 7Department of Otolaryngology, 8Department of Neurology, 9Department of Ophthalmology, 10Obstetrics and Gynecology, 11Department of Neurosurgery, 12Department of Psychiatry, 13Department of Computer Science, 14Department of Pathology and Laboratory Medicine, 15Department of Biomedical Engineering, 16Department of Dentistry, 17Department of Biomedical Genetics, 18Department of Biochemistry and Biophysics.
During the first year of study, students attain an understanding of cellular and molecular neurobiology and acquire a strong background in systems neuroscience. Coursework focuses on cell anatomy, molecular biology, chemistry, and electrophysiology presented in the context of neuronal signaling and transduction, neurotransmission, and neuronal development and plasticity. The anatomy, physiology, and chemistry of neuronal systems are examined as they relate to functions as diverse as movement, sensation and perception, cognition, and homeostasis. An understanding of neuropathology and neurological disease at both the cellular and systems levels is also emphasized.

Laboratory rotations form an important component of the neuroscience students’ first year, providing them with opportunities to work closely with mentors and learn about different experimental approaches and levels of analysis. In consultation with a faculty advisory group an optimal sequence of laboratory rotations is planned. Two or three separate rotations are typically completed within the first year. Most students select a dissertation laboratory after these rotations.

Coursework in the second year is intended to provide students with expertise in their chosen area of research. In consultation with their research advisor, students typically chose two or three neuroscience course electives that define a theme tailored to their individual area of specialization. The rich variety of upper-level courses and interest-specific tutorials offered by the diverse faculty comprising the Graduate Program in Neuroscience insures that students have the flexibility to develop a curriculum that will both augment their research effort and broaden their view of neuroscience.

Critical thinking and practical consideration of experimentation, data analysis, and funding issues are addressed by coursework and seminars in statistics, experimental design, biomedical science ethics, and grant writing and review. A regular journal club attended by all first- and second-year students focuses on new findings in the neuroscience literature and provides additional experience in critical thinking and experimental design. Students learn important teaching and speaking skills by completion of a one-semester teaching assistantship and presentation of their research at regular student seminars. Students are also involved in organizing the weekly Neuroscience Colloquium that brings noted speakers to the University. Additional seminar platforms are provided through series sponsored by the participating departments and centers.

Upon completion of the neuroscience core curriculum, students in the Graduate Program in Neuroscience have the option of pursuing one of five degrees; these degrees include a Ph.D. in neuroscience via the Graduate Program in Neuroscience and degrees in neurobiology and anatomy, brain and cognitive sciences, pharmacology and physiology, or biomedical engineering. The latter three programs also admit students directly into their own graduate programs.

508. Neural Plasticity in Learning and Development  
Credit—three hours  
An examination of neural plasticity in development as well as in adult learning and memory. Topics covered are approached from the joint perspectives of behavior, computational modeling, and neural mechanisms. Readings are drawn from review and primary research articles. Students write a critique of a relevant journal article as well as a critical overview of a research topic germane to the course. This is a course designed for graduate students and undergraduate students who have a background in the neurosciences.

510. History of Neuroscience  
Credit—one hour  
This series of lectures and discussions covers various aspects of the historical development of our knowledge about the nervous system and the evolution of modern neural science. Some of the topics covered from this standpoint are the brain as mind, cortical localization, neuron doctrine, development of clinical neurology, development of electrophysiology, connection theory of higher function, memory and dementia, frontal lobe function, corpus callosum function, and others. This course is open to graduate students, medical students, residents and interested members of the faculty. (Fall, odd numbered years)

512. Cellular Neuroscience  
Credit—six hours  
This course presents a detailed view of cellular and molecular aspects of neuroscience. Identification and characterization of cellular components of the nervous system. Electrical properties of neurons. Development of membrane potentials and signal propagation. Molecular properties of ion channels and their role in neuronal signaling. Organization of the nervous system. Regional neuroanatomy of brain, brain stem, and spinal...

525. Biology of Neurological Diseases
Prerequisite: NSC 512 or permission of instructor.
Credit—three hours

This course explores the neurobiological basis of human neurological disease, emphasizing the relationship between behavioral dysfunction and neuropathology or neural dysfunction. While this is an overview, we emphasize those diseases for which significant information is available in terms of genetic or molecular control of disease mechanisms or therapeutic approaches. The course is designed for graduate students in neuroscience or in other disciplines who have a background in neurobiology. (Spring, even years)

530. Neural Basis of Learning, Memory, and Higher Function
Prerequisite: NSC 512 or equivalent; or permission of instructor.
Credit—three hours

A part lecture, part discussion course covering the physiologic bases of learning and memory. Topics include types of memory, evidence of memory in single unit responses, computational approaches, habituation, conditioned reflexes, electrophysiologic indices, neuroanatomy of amnesia, interhemispheric relations, and clinical amnesia. Advanced undergraduates may elect this course with approval of course director. (Fall semester, odd years)

531. Integrative and Systems Neuroscience
Prerequisites: NSC 512, NSC 201/BCS 240 or equivalent introductory neuroscience course.
Undergraduate students with permission from instructor only.
Credit—six hours

This course provides a critical overview of current knowledge of systems neuroscience. The topics include an overview of approaches and techniques, a comprehensive account of functional connectivity, transmitters, neurophysiology, and behavioral measures of sensory and motor systems, the basal ganglia, the autonomic limbic and hypothalamic systems, as well as memory, attention, and cognition.

581. Teaching Tutorial in Neuroscience
Credit—three hours

This experience provides an opportunity for students to acquire and develop skills in teaching and course management in neuroscience. Students assist in teaching NSC 201 or NSC 203 and are expected to attend staff meetings, provide instruction in the laboratory, bear responsibility for small-group teaching, assist in the preparation and grading of examinations and papers, and participate in staff-evaluation sessions. In addition, students devote time to the preparation of teaching aids such as videotapes and slides.

590. Lab Rotations in Neuroscience
Credit—to be arranged

Laboratory rotations are intended to familiarize students with a technique, to gain an appreciation of different scientific approaches to a problem, and to gain exposure to an area of research that eventually leads to a focused area of investigation. Consultation with the advisory committee is required to plan rotation.

592. Neuroscience Journal Club
Credit—one hour

A seminar/reading course on current topics in neuroscience research. The objective is to gain experience discussing and critically evaluating primary research articles covering a broad range of topics in neuroscience.

595. Ph.D. Research
Credit to be arranged
Center for Oral Biology

Associate Professors Culp, *Haidaris, Quivey, *Teng
Assistant Professors Hagan, Hsu, Jiang
Research Assistant Professors Bedi, Gonzalez Begne, Lan, Nakamoto, Ovitt, Srivastava, Zheng

The principal objective of the Center for Oral Biology is to train dentists and other qualified and interested persons in research related to oral health and disease for academic careers. In pursuit of these aims, the Center cooperates closely with the basic science departments of the School of Medicine and Dentistry and the College. There is also close cooperation with the Eastman Department of Dentistry and other clinical departments such as medicine, pediatrics, and pathology and laboratory medicine. Joint degree programs are offered with these various departments.

Graduate students who hold appointments in the Center for Oral Biology may work for the Ph.D. degree in disciplines including anatomy, biochemistry, biology, biophysics, genetics, microbiology and immunology, neuroscience, pathology, pharmacology, physiology, or toxicology. Entrance requirements are in accordance with the policies of the individual departments, centers, and programs. The Ph.D. candidate is registered in the department or center in which the degree will be granted. Classes and seminars are attended, and a research program directed toward the solution of some problem pertinent to oral science is carried out in the appropriate basic science department or center. Guidance and supervision are available from the faculty members of the Center for Oral Biology, consultants on the staff, and members of the collaborating departments and centers.

Studies leading to the M.S. degree with a major in dental science typically cover two calendar years and a total of at least 30 hours of credit consisting of 18 for coursework and 12 for research. Prerequisites for acceptance in this program are the D.D.S., D.M.D. degree, or equivalent. Predoctoral candidates will be considered for the master's program in special circumstances. Each student will be required to participate in didactic courses and seminars offered by the Center for Oral Biology. In addition, all candidates must choose a particular area in the basic sciences as a minor (biochemistry, pharmacology, etc.) for advanced study and to develop knowledge in this field by attending appropriate courses. The candidate must also conduct a research project in an area of oral biology. The results of this work must be presented in a thesis acceptable to the candidate's committee (Plan A, thesis only). Fellowship stipends sufficient to meet living costs are available to selected students on a competitive basis.

University grants-in-aid and grants from industrial sources enable the Center for Oral Biology to offer fellowships to dental school graduates and others of unusual ability and promise who desire special training in disciplines including anatomy, biochemistry, biophysics, dental science, genetics, microbiology, molecular biology, neuroscience, pathology, pharmacology, physiology, and toxicology in order to equip themselves for careers in teaching and research.

The Training Program in Oral Infectious Diseases provides support for pre- and postdoctoral (D.D.S. or Ph.D.) fellows to receive training for three years. The objective of the program is to prepare creative, imaginative, and highly skilled professionals in the fields of oral microbiology and immunology.

The Oral Cellular and Molecular Biology Program trains individuals committed to careers in oral science in the approaches of cellular and molecular biology. Training is provided in these areas to the Ph.D. level for dentists and predoctoral candidates who have a commitment to careers in oral science.

* Primary appointment in another department
414. Mechanisms of Microbial Pathogenesis  
Prerequisites: MBI 220, 221 or permission of instructor.  
Credit—three hours  
The molecular mechanisms by which bacteria cause disease are examined. The emphasis is on understanding how bacteria colonize the host, evade host immune defenses, and cause damage to the host, as well as understanding the regulation of synthesis, structure, function, and mode of action of bacterial toxins. (Spring, odd years)

493. Fundamentals of Oral Microbiology  
Prerequisite: permission of instructor.  
Credit—two hours  
The major groups of microorganisms causing oral disease are reviewed with emphasis on basic biology, genetics, physiology, and pathogenic mechanisms. (Fall, odd years)

495. M.S. Research  
Prerequisite: D.D.S., D.M.D., or equivalent.  
Credit to be arranged  
The research program of the dental fellows is usually directed toward the solution of some problem pertinent to dentistry. Laboratory facilities are available in the Center for Oral Biology, the Eastman Department of Dentistry, and the preclinical departments of the School of Medicine and Dentistry. (Ph.D. research is registered with the appropriate preclinical department.)

501–504. Dental Research Seminar  
Prerequisite: permission of instructor.  
Credit—one hour each term  
The purpose of this series is to provide experience to participants in preparing, organizing, and presenting material to a critical audience. The first semester is devoted to a systematic review of recent significant research developments in one of the basic sciences fundamental to dentistry. In the second semester the dental fellows report on original research. Required of all graduate students in dental research and open to other graduate students and dentists.

556. Biology of the Periodontium  
Prerequisite: permission of instructor.  
Credit—one hour  
Stressing the biological behavior of the periodontium, the course reviews the fundamentals as well as the latest developments in periodontal research. Topics covered are the development, morphology, and physiology of the periodontal tissues; the epidemiology, etiology, and histopathology of periodontal diseases, plus current concepts regarding mechanisms of periodontal tissue destruction and repair. (Spring, odd years)

558. Growth and Development  
Prerequisite: permission of instructor.  
Credit—one hour  
This series covers the prenatal embryogenesis and postnatal growth and development of the craniofacial complex. Mechanisms of growth control, the development of occlusion, and methods of study and timing are presented. Clinical implications for normal and abnormal facial development are discussed. (Spring, odd years)

563. Pharmacology and Therapeutics  
Prerequisite: permission of instructor.  
Credit—one hour  
Pharmacotherapeutics of drugs most often used in dentistry are reviewed with emphasis on critical analysis of the related literature and current directions in pharmacological research. (Fall, odd years)

570. Introduction to Dental Epidemiology and Research Design  
Prerequisite: permission of instructor.  
Credit—one hour  
Students are introduced to the fundamentals of epidemiology. Emphasis is placed on the natural history of common dental diseases. (Spring)

579. Saliva and Salivary Glands  
Prerequisite: permission of instructor.  
Credit—two hours  
This course gives students an understanding of the fundamental biology of the salivary glands. The regulation of salivary gland physiology is discussed, as is the structure/function relationship of salivary proteins and lipids. The molecular basis of salivary gland gene expression is explored. The etiology, pathogenesis, and consequences of salivary gland diseases are also discussed. (Spring, even years)

580. Fundamentals of Dental Caries  
Prerequisite: permission of instructor.  
Credit—one hour  
This course presents the latest developments in many aspects of dental caries, from the most fundamental basic science to its clinical application. (Fall)
589. Mucosal Immunology
Prerequisite: MBI 473 or permission of instructor.
Credit—two hours

This course focuses on immunological mechanisms pertinent to the oral cavity. Subject areas include nonspecific and specific immunological factors and the effects of mucosal immunity on oral health. There is an emphasis on the molecular and cellular aspects of immunology as they relate to the oral cavity. (Spring, odd years)

593. Complex Carbohydrates
Prerequisite: permission of instructor.
Credit—one hour

The synthesis, structure, and function of complex carbohydrates is considered with emphasis on recognition phenomena. (Spring)

Pathology and Laboratory Medicine

Research Assistant Professors J. Reeder, L. Xing

The Department of Pathology and Laboratory Medicine offers a program of education and research leading to the degree Doctor of Philosophy in pathology. While the program is sponsored by the Department of Pathology, the participating faculty are drawn from at least six departments. This provides diverse education and research experiences and thesis opportunities for the student. The graduate program in pathology is designed for the student who is interested in applying the latest advances in cell biology, biochemistry, and molecular biology to the understanding of human disease mechanisms. Pathology is a bridging discipline between basic research and clinical medicine. The objective of the graduate program in pathology is to prepare the student for successful, independent careers in research and teaching. Through coursework, seminars, and research experiences, the student will be well prepared to address the complex but rewarding problems in human disease in either an academic or industrial setting.

Students enter the graduate program in pathology after completion of their first year of study in one of the graduate research clusters in the Graduate Education in the Biomedical Sciences (GEBS) program. For those who enter the program through the Pathways of Human Disease Cluster, the first year is designed to give trainees a strong foundation in biochemistry (IND 408), cell biology (IND 409), molecular biology/genetics (IND 410), and in fundamentals of pathobiology (PTH 509/510). The course requirements are common to most degree programs in the first year and afford the students maximum flexibility. At the end of the first year of study, students request admission to the graduate program in pathology. After approval by the Steering Committee of the Graduate Program, the students follow a disease-oriented curriculum in elective studies and in advanced coursework during the second year. Students usually designate a thesis advisor at the time of admission. Admission requirements include successful completion of course requirements, approval of the program director, and a desire to pursue thesis research that has a relationship to human health and disease.

The faculty of the graduate program in pathology represent at least eight departments within the Medical Center and offer many exciting research opportunities to students. Faculty research interests include cellular structure and function, nuclear receptors, gene regulation, cell-cell interactions, chemotaxis, extracellular matrix, genetic and molecular analysis of chromosome structure and gene

* Primary appointment in another department
expression, growth factors, lipoprotein structure and function, oncogene and tumor susceptibility, and gene products. Diseases under active investigation include diabetes; cardiovascular disease; osteoporosis; breast, prostate, and bladder cancer; and arthritis to name just a few. Several experimental approaches used by our students include production of new molecular and immunological probes for genes and their products, quantitative high-resolution image analysis of cells and tissues, quantitative single-cell measurements by flow cytometry and cell sorting, receptor biology and signal transduction, and RNA processing.

504. Current Topics in Experimental Pathology
Prerequisite: permission of course director.
Credit—one hour

This course introduces students to the diverse experimental and intellectual approaches for studying disease processes, in a seminar format. Investigators from both outside and within the University present the current view of pathogenesis for the disease of their specialty and discuss classical and molecular methods to probe for disease mechanisms. In addition to attending the seminar, students read one or two of the guest speaker's current publications and discuss this area of research in a session prior to the seminar. Students are also required to present a 30-minute research seminar based on their own research studies. (Fall and Spring)

505. General Pathology
Prerequisites: biochemistry, e.g., IND 408 or equivalent, a course in mammalian physiology, or permission of instructor.

This course is designed to provide a background in basic principles of mammalian pathology. The first three weeks are devoted to a survey of histology (composition, structure, and function of tissues). Next, the following topics are studied: cell and tissue injury, edema, hemorrhage, shock, thrombosis, embolism, infarction; inflammation; introductory immunopathology; pathology of infectious diseases; and neoplasia. The course is conducted by means of lectures, laboratory exercises, demonstrations, and discussions. The laboratory exercises consist of gross and microscopic studies and discussions of lesions that illustrate the lecture material. Two three-hour sessions per week. (Spring, even years)

507. Cancer Biology
Credit—three hours

The course is intended primarily for students interested in cancer research. Cancer biology is introduced through lectures on the history of early scientific inquiry as a foundation for understanding the current state of cancer research. The genetic basis of cancer is emphasized in familial cancer syndromes, acquired somatic mutations, and micro-evolution of neoplasia.

509/510. Pathways of Human Disease I and II
Credit—four hours

This two-semester course is the signature course of the graduate program in pathology. Its objective is to provide students with an introduction to human disease processes with an emphasis on the molecular and genetic mechanisms of disease. Students learn the basic anatomy, histology, and physiology of all major organ systems in the context of examples of human disease. They complete the course with an understanding of the basic principles of human disease processes at the whole animal, organ, cellular, and molecular levels. Additionally, they obtain an understanding of the current applications and limitations of modern diagnostic medicine and the importance of basic translational research. The course is divided into six modules, three per semester. Each module uses two organ systems (e.g., the cardiovascular system, the musculoskeletal system, the liver, the respiratory system, etc.) as the basis for an in-depth discussion of one major theme of human pathobiology.
There are three weekly sessions—two didactic and one laboratory. Laboratory exercises use the vast resources of the Medical Center to provide practical experience in current and cutting-edge analytical methodologies. (Fall I, Spring II)

520. Frontiers in Mitochondrial Medicine  
Prerequisite: permission of the instructor.  
Credit—two hours  
A seminar/reading course on current topics in mitochondrial research. The objective is to gain experience discussing and critically evaluating primary research articles that focus on mitochondrial biology in topics related to human developmental biology and aging, mammalian evolution and genetics, nuclear:mitochondria trafficking, mtDNA disease pathogenesis, oxidative phosphorylation and oxidative stress, or degenerative disorders. Mitochondria are uniquely positioned to integrate a host of cellular information and then influence function in every cell type. In “Frontiers in Mitochondrial Medicine,” a foundation for understanding normal mitochondrial biology is established and then the importance of mitochondria in disease is explored—from neurodegeneration to cancer. This elective course meets weekly and is designed for graduate students who have an interest in mitochondrial biology. It is also open to upper-division undergraduate students, medical students, residents, staff, and interested members of the faculty. (Spring)

593. Molecular Mechanisms of Human Disease  
Prerequisite: PTH 505 or equivalent.  
Credit—four hours  
The focus of this course is to cover our current knowledge of the underlying cellular processes and molecular events that cause human disease. The course is a series of lectures by the faculty who discuss the history, etiology, presentation, and the standard treatments and outcomes for specific human diseases (i.e., diabetes, osteoporosis, arthritis, etc.). A significant emphasis is placed on defining the limits of our understanding and the design of future experimentation, which will lead to breakthrough discoveries and a cure. There is a mid-term and final exam, which is a take-home/essay format. (Fall)

595. Ph.D. Research  
Credit to be arranged  
Ph.D. research is done under the direction of a faculty member of the Medical Center with the approval of the graduate program in pathology.

Pharmacology and Physiology

Research Associate Professors *Krieger, Sharma  
Adjunct Professor Curry  
Adjunct Assistant Professor Arreola  
Research Assistant Professors Beutner, Malik, Sun  
Professors Emeriti Anders, Craig, Rivera-Calimlim

The objective of the graduate programs in pharmacology and physiology at the University of Rochester is to provide a thorough understanding of basic pharmacology and physiology and to prepare graduates for careers as investigative pharmacologists and physiologists. The programs include coursework in pharmacology, physiology, and the basic biomedical sciences; participation in the departmental seminar program; and original laboratory investigations in pharmacology or physiology. The Ph.D. program can lead to either a Ph.D. degree in pharmacology or a Ph.D. degree in physiology. The Ph.D. degree is awarded upon completion of scholarly work and research described in a publishable dissertation.

* Primary appointment in another department
In general, a bachelor's degree in biology or chemistry is the preferred undergraduate training for entrance. These courses are ordinarily required for admittance to the Ph.D. program in pharmacology and physiology: introductory courses in organic and physical chemistry, biology and biochemistry; courses in molecular biology, statistics, and physics are recommended, but not required. Applicants are required to submit the results of the Graduate Record Examination. First-year graduate students typically enroll in required core courses in biochemistry (IND 408), cell biology (IND 409), and molecular biology and genetics (IND 410); and in courses (PHP 403, 404, and 502) that fulfill the degree requirements for the Ph.D. programs in pharmacology or physiology. In addition, all graduate students must complete the Ethics and Professional Integrity course (IND 501). Second-year courses are selected from a menu of electives.

403. Pharmacology and Physiology: A Disease-Based Approach I
Credit—four hours
This course is designed to provide a firm foundation for students interested in how cells, organs, and organisms work; the mechanisms underlying some human diseases; and how therapeutic drugs target these disease states. The first semester of this two-semester course covers (1) Basic Pharmacological Principles at a molecular and cellular level including drug binding, metabolism, and pharmacokinetics; (2) Neuromuscular Disorders including the physiology and pathology of nerves and muscles; (3) Drugs of Abuse and Mood Disorders, which includes basic mechanisms of addiction and specific neurological and psychiatric diseases such as depression, schizophrenia, epilepsy, and Parkinsonism and the drug treatments for these diseases; (4) The Pharmacology and Physiology of Cardiac Electrical Activity including the origin of the electrical cardiogram (ECG), the mechanism of cardiac arrhythmias, and the drugs to treat them. (Fall).

404. Pharmacology and Physiology: A Disease-Based Approach II
Prerequisite: PHP 403 or permission of course director.
Credit—four hours
This course continues the study of human physiology and therapeutic drug mechanisms begun in PHP 403. A major emphasis of this semester is an in-depth study of the various issues surrounding heart failure. These include the basics of cardiovascular and renal biology. Hypertension and heart failure are described as well as the various cardiovascular drugs for their treatment. The physiological mechanisms relevant to diabetes, cystic fibrosis, and asthma are included as well as the therapies for treating these diseases. Finally, the principles of cardiovascular, respiratory, renal, and endocrine physiology come together to provide an understanding of the response of the human body to the natural stress of exercise. (Spring).

440. Topics in Vascular Biology
Prerequisite: graduate physiology recommended and permission of instructor.
Credit—four hours
This course provides an in-depth coverage of selected topics in vascular biology. Major topics and concepts are introduced in the context of current literature. These include vascular functional anatomy, angiogenesis, hemodynamics, vascular control mechanisms, vessel-blood interactions, signaling, mechanotransduction, leukocyte-endothelial cell interactions, vascular disease, and gene therapies. (Spring, odd years)

502. Seminar
Credit to be arranged
General topics presented by students and staff members. Organized surveys of selected fields may be presented upon request.

530. Advanced Topics in Pharmacology
Credit—two hours
This is an elective course designed as a small group class (4–12 students) and focuses on six topics related to diseases and their current therapeutic modalities. The didactic goals for each topic is to understand: (1) the basic anatomy, histology, and physiology of the organ system; (2) alterations in physiological, cellular, and/or biochemical mechanisms associated with a disease; (3) current therapies, their mechanisms of actions, and limitations; and (4) potential targets for future therapies. Each topic is presented over two sessions by two to four students working as a group, and in consultation with the topic instructor. Besides a presentation describing key results and putting forward the authors “take home message,” students discuss the appropriateness of the model(s) used, pitfalls or limitations of the methods, alternative methods
or approaches not used, how the work advances the field, and potential directions for future research. Students learn the basics of additional physiological systems and current therapeutic approaches to address corresponding health-related issues and also develop essential skills not readily obtained in lecture-based courses.

550. Ion Channels and Disease
Credit—two hours

Advances in molecular biology, cellular physiology, and structural biology, coupled with the recent progress in sequencing of the human genome, have revealed an increasing number of human and animal diseases that arise from defects in ion channel function. Many of these diseases, caused by mutations in genes encoding ion channel proteins, are now referred to as channelopathies. This course focuses on the function of ion channels in normal physiological processes in the brain, skeletal, and cardiac muscle and how these functions are altered in certain channelopathies. These advances are examined through readings of the original literature integrated with didactic material where useful. Topics include the biophysical basis of excitation in nerve and muscle, excitation-contraction coupling, synaptic plasticity, and other topical subjects. Special emphasis is placed on the molecular basis of important ion channel diseases and other pathologies involving ion channels including genetic defects that lead to cardiac arrhythmias, skeletal muscle myotonias and paralyses, and epilepsy. (Spring)

552. Readings in Systems Physiology
Credit to be arranged

This readings course includes detailed critical discussion of original scientific publications. Readings are chosen to illustrate current topics in cell and molecular physiology as they relate to the integrated function of organ systems in health and disease.

593. Special Topics in Pharmacology and Physiology
Credit to be arranged

Directed studies in the field of pharmacology or physiology, supervised by a faculty member and organized to meet the needs of individuals or small groups of graduate students. May involve supervised readings, laboratory exercises, or organized discussions.

Toxicology

Professor Ballatori (Program Director)
The core faculty involved in the Toxicology Graduate Training Program are drawn predominantly, but not exclusively, from the Department of Environmental Medicine. These are listed below. However, research projects dealing with significant toxicological issues may be performed with other faculty within the Medical Center.


Associate Professors Baggs, Ballatori, R. S. Freeman, Mooney, O'Reilly, McCabe, Pryhuber

Assistant Professors Brooks, Markowitz, Opanashuk, Sime, Stodgell, Villalobos

By its nature toxicology is highly interdisciplinary. It combines the knowledge base and approaches of such fields as physiology, pharmacology, psychology, biochemistry, and molecular biology to address fundamental questions regarding the mechanistic effects of chemicals on living organisms.

Our program is among the most established and renowned research-oriented, degree-granting toxicology programs in the nation. Since 1966, graduates from the Toxicology Program at the University of Rochester have been making significant contributions to science through their positions in universities, chemical and pharmaceutical companies, government, and research institutes. It is one of a select few programs funded by the National Institute of Environmental Health Sciences. The presence of this center and the strength of the associated faculty offer a unique opportunity for students to learn the theory and techniques of modern research approaches while applying them to address real and significant issues in toxicology from the molecule to the whole organism. On average, about 30 students are in residence.
The major disciplinary areas within toxicology at Rochester are the following. It should be recognized that there is a great deal of overlap among these categories.

**Neurotoxicology.** Chemicals acting on the nervous system, either directly or indirectly, are studied in many different species by a variety of techniques. For instance, recent experiments have studied vision, indices of behavior, motor activity, discriminative control and learning, neuroimmune interactions, as well as effects on neurotransmitters and their receptors. Heavy metals (e.g., lead, mercury), organic solvents (toluene, carbon disulfide), nerve poisons (acrylamide), abused drugs (cocaïne, d-amphetamine), and aversive airborne substances (ozone) are among the agents that have been studied.

**Pulmonary toxicology.** Physiological and biochemical studies of the lung are made in order to discover how inhaled aerosols cause injury. Mechanisms of deposition and clearance of inhaled particles are studied in both laboratory animals and man. Cellular and molecular aspects of chronic lung injury (e.g., pulmonary fibrosis, lung cancer, and immunological aspects) are investigated in animals and extrapolation models then developed in order to predict effects in humans and, perhaps, develop protective measures.

**Osteotoxicology.** Investigations are conducted of the molecular and cellular biology of the skeletal system and its development.

**Molecular modifiers of toxicity.** Some faculty in this group attempt to identify specific molecular receptors underlying the selective action of poisons, the location of these receptors within the cell, and the role of receptor occupancy in order to explain both tissue selectivity and the comparative toxicity of the agent. Currently under investigation are the estrogen and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) receptors. Other faculty are studying the mechanisms by which oncogenes transform cells, DNA-repair mechanisms, bioactivation processes, the role of glutathione and biotransformation in the defense against toxicants, the role of heme oxygenase in cellular regulation, mRNA regulation, and the molecular mechanisms underlying metal ion toxicity.

**Carcinogenesis.** Several of the faculty are investigating the mechanisms of carcinogenesis; the molecular mechanisms of prostate cancer progression; the mechanisms of radiation sensitivity in solid tumors; the control of malignant lymphoma cells and the growth factors in the normal and abnormal regulation of cell growth and metabolism.

**Immunotoxicology.** The faculty are focused on how the immune system is involved in both tissue injury and repair as well as the effects of environmental chemicals on lymphocyte development and the regulation of antibody-producing lymphocytes by prostaglandins.

**Reproductive and developmental toxicology.** Current investigations focus on a range of problems associated with oogenesis, implantation, placental function, developmental immunology, CNS development, growth, teratogenesis and transplacental carcinogenesis. A particular interest has been establishing the mechanisms of action for metals (cadmium, lead, methylmercury, tellurium) 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), retinoids, steroids, and drugs used for the treatment of HIV infection during reproduction and development.

The curriculum for predoctoral students provides broad exposure to biochemistry, molecular biology, physiology, pathology, pharmacology, and toxicology. While fulfilling the program’s course requirements during the first year or so, students work on abbreviated research projects in several laboratories. Seminars provide students an opportunity to explore particular areas in greater depth as their interests focus upon specialized research problems. Some seminars are organized on an ad hoc basis when there is a need to explore an area not covered in regular offerings. After the first two years almost all of the student’s time is devoted to laboratory research.

Graduate study in the program is intended primarily for students pursuing the Ph.D.
493. Special Topics in Toxicology—Toxicology in the Workplace Environment
Credit—two hours

This course focuses on toxicologic effects of widely used workplace substances. The course has a seminar format. Students choose an area of interest (usually a workplace toxin or category of toxins), and a faculty member to work with who has expertise in the area. The student then prepares and presents a seminar on this topic to the other students in the course. (Fall, even years)

493. Special Topics in Toxicology—Immunotoxicology
Credit—one hour

Selected topics relevant to current issues and problems in immunotoxicology are covered. The course draws on recent peer-reviewed publications and/or reviews that are discussed and critiqued by the participants in a colloquium-style format. (Spring, odd years)

521. Biochemical Toxicology
Prerequisites: BCH 401, PSO 407, and permission of course director.

A study of the actions of toxic substances. Prediction of exposures, doses and critical cellular concentrations, adverse effects in organisms, and responses in populations. Mechanisms leading from reactions with molecular ligands to pathological signs and symptoms are emphasized. This course introduces principles and current theories of biochemical and molecular mechanisms, as they apply to certain organ systems including kidney, immune system, skin, pulmonary system, and nervous system. (Spring)

522. Organ Systems Toxicology
Prerequisite: TOX 521.

This course continues TOX 521 with a discussion of mechanisms of reproductive toxicology and carcinogenesis. The selective toxicity of certain chemicals is discussed to emphasize dose dependency and mechanisms of action. Finally, current issues and principles applied to the environment, clinical toxicology, modeling, and risk assessment are discussed. (Fall)

529. In Vitro Systems in Biochemical Toxicology
Credit—one hour

This course is designed to study the various in vitro systems currently in use in biological research with special emphasis on the techniques of cell and tissue culture. The objective of the course is to provide both practical techniques and fundamental information to permit the student to evaluate and utilize these systems and determine their applicability in formulating research questions. Experimental systems are examined in detail, with a special emphasis on the techniques involved in applying the approach. Readings from the current available literature combined with the extensive background materials provided by experts in the various areas allow a recognition of the limitations as well as attributes of specific in vitro methods that are used in the research laboratory. The relevance to in vivo systems is discussed where appropriate information is available. The topics covered include methods of isolation and purification of cells, choices of culture media and other culture conditions, use of primary cells as compared to established cell lines, organ cultures, and perfusion systems. (Offered in odd-numbered years)

530. Reproductive and Developmental Toxicology
Prerequisite: either medical school pharmacology or PHM 542, or TOX 521.

Credit—two hours

This course emphasizes the problems associated with infertility, embryonic development, maternal physiology, and postnatal growth following exposure to environmental and therapeutic agents. (Spring, even years)

533. Neurotoxicology
Credit—one hour

This is a special topics course where subjects are presented and discussed in depth. For example: environmental risk factors for neurodegeneration, developing nervous system as a target for neurotoxicity, glia as targets for neurotoxicity. (Spring, even years)

558. Seminar in Toxicology
Credit—one hour

Seminars by students examine critically the published research on selected problems in toxicology. Required of toxicology doctoral candidates. (Spring)
564. Pulmonary Toxicology
Credit—one hour
A specialty seminar which requires presentations from recent literature considering the effects of lung-directed toxic agents on pulmonary anatomy, physiology, and biochemistry. (Spring, even years)

591. Ph.D. Reading Course
Credit to be arranged

592. Current Topics in Immunotoxicology
Credit—one hour
Selected topics relevant to current issues and problems in immunotoxicology are covered. The course draws on recent peer-reviewed publications and/or reviews that are discussed and critiqued by the participants in a colloquium-style format.

593. Forensic Toxicology
Prerequisite: PTH 505 or permission of the instructor.
This is a seminar course that examines the application of the physical and biological sciences to criminal investigation. Topics include forensic pathology, forensic chemistry, forensic archeology, forensic anthropology, forensic entomology, forensic toxicology, forensic dentistry, forensic engineering, forensic ballistics, fire and explosion investigations, engineering failures and accidents, and forensic computing. (Fall, odd years)

594. Molecular Toxicology
This course includes the review of recent and significant research publications describing approaches used to discern fundamental principles of cellular and tissue response to environmental stimuli. A thorough knowledge of molecular biology is not essential for participation in this class, although an understanding of basic principles in molecular genetics is helpful. (Fall, even years)

595. Ph.D. Research in Toxicology
Credit to be arranged