

PHYS 282. Experimental Investigations of Strongly Correlated Materials (2) Seminar, 2 hours. Prerequisite(s): graduate standing; consent of instructor. Examinations of thermodynamic and transport properties in strongly correlated materials which often exhibit unusual broken-symmetry ground states. Topics include measurements of specific heat, resistivity, magnetoresistivity, thermopower, and the Hall effect of existing and previously uncharacterized compounds. Students who present a seminar or submit a paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. **Beyermann**

PHYS 283. Techniques of Microscopy (2) Seminar, 2 hours. Prerequisite(s): graduate standing; consent of instructor. Explores current techniques of microscopy. Covers optical and electron microscopy and novel techniques of scanning microscopy such as scanning tunneling microscopy, near-field scanning optical microscopy, and atomic force microscopy. Students who present a seminar or submit a paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. **Mohideen**

PHYS 284. Optical Techniques for Measurements in Physics (2) Seminar, 2 hours. Prerequisite(s): graduate standing; consent of instructor. Explores current topics in optical physics and the use of optical and nonlinear optical techniques to make measurements of interest in atomic, molecular, chemical, and condensed matter physics. Emphasizes advances in science enabled by advances in laser technology. Students who present a seminar or submit a paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. **Tom**

PHYS 285. Experimental Techniques in Particle Physics (2) Seminar, 2 hours. Prerequisite(s): graduate standing; consent of instructor. Review of experimental techniques used in particle physics experiments, including tracking, calorimetry, and muon detection. Analysis of experiments at future super-colliders and their physics capabilities, focusing on the searches for the Higgs, top quark physics, and super-symmetric particles. Students who present a seminar or submit a paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. **Ellison**

PHYS 288. Current Research Themes in Physics (2) F Seminar, 1 hour; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Introduces first-year graduate students to current issues in physics research at UCR. Involves seminars by faculty on their research and interaction with advanced students and postdoctoral researchers. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

PHYS 289. Colloquium in Physics (1) Colloquium, 1 hour. Prerequisite(s): graduate standing; consent of instructor. Specialized discussions by visiting scientists, faculty, and students on current research topics in physics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Chair in charge**

PHYS 290. Directed Studies (1-6) Outside research, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor; consent of advisor or Department Chair. Individual study, directed by a faculty member, of specially selected topics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

PHYS 291. Individual Study in Coordinated Areas (1-6) Individual study, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor. Faculty-assisted programs of individual study for candidates who are preparing for examinations. Graded Satisfactory (S) or No Credit (NC). Course is repeatable within the following limits: Up to 6 units may be taken prior to award of the Master's degree, such units to be in addition to minimum unit requirements for the degree. Up to 12 additional units may be taken (continued) prior to advancement to candidacy for the Ph.D.

PHYS 297. Directed Research (1-6) Outside research, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor. Original research, in an area selected for the advanced degree, performed under the direction of a faculty member. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

PHYS 299. Research for Thesis or Dissertation (1-12) Thesis, 3-36 hours. Prerequisite(s): graduate standing; consent of instructor. Original research, in an area selected for the advanced degree, performed under the direction of a faculty member. This research is to be included as a part of the dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

PHYS 301. Teaching of Physics at the College Level (2) Lecture, 2 hours. Prerequisite(s): graduate standing in Physics or consent of instructor. Required of all Teaching Assistants in the Department. Designed to introduce effective methods for teaching physics and to evaluate and improve teaching skills. Topics covered include lecture techniques, effective visual aids, improving laboratory and recitation section learning situations. Credit not applicable toward degree course requirements. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Chair in charge**

PHYS 302. Teaching Practicum (1-4) Consultation, 1 hour; laboratory, 3-12 hours; practicum, 3-12 hours. Prerequisite(s): Appointment as a departmental Teaching Assistant; graduate standing. Supervised teaching in Physics courses and regular consultation with faculty supervisor(s) regarding teaching responsibilities. Credit not applicable toward degree course requirements. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units. **Chair in charge**

PHYS 401. Scientific Writing and Illustration (1) Lecture, 1 hour. Prerequisite(s): consent of instructor. The research notebook. The thesis. References. The form of a technical article. Figures and slides. Patent requirements. Periodical requirements. Graded Satisfactory (S) or No Credit (NC).

Plant Biology

See Botany and Plant Sciences (Graduate Program)

Plant Pathology and Microbiology

Subject abbreviation: PLPA
College of Natural and Agricultural Sciences

Michael F. Allen, Ph.D., Chair
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Professors

James E. Adaskaveg, Ph.D.
Michael F. Allen, Ph.D. (Plant Pathology/Biology)
Katherine Borkovich, Ph.D.
James G. Borneman, Ph.D.
Michael D. Coffey, Ph.D.
Donald A. Cooksey, Ph.D.
Shou-Wei Ding, Ph.D.
Howard S. Judelson, Ph.D.
A. L. N. Rao, Ph.D.
Michael E. Stanghellini, Ph.D. *Cy Mouradick Chair in Desert Agriculture*

Professors Emeriti

Salomon Bartnicki-Garcia, Ph.D.
J. Allan Dodds, Ph.D.
Joseph W. Eckert, Ph.D.
Robert M. Endo, Ph.D.
Donald C. Erwin, Ph.D.
Dennis D. Focht, Ph.D.
John A. Menge, Ph.D.
Donald E. Munnecke, Ph.D.
Howard Ohr, Ph.D.
Alberto O. Paulus, Ph.D.
Caroline Roper, Ph.D.
Joseph S. Semancik, Ph.D.
James J. Sims, Ph.D.
Peter H. Tsao, Ph.D.
Seymour D. Van Gundy, Ph.D. (Plant Pathology/Nematology)
Jan Walter, Ph.D.
Lewis G. Weathers, Ph.D.

Associate Professor

Hailing Jin, Ph.D.

Assistant Professors

Greg Douhan, Ph.D.
Hailing Jin, Ph.D.
Wenbo Ma, Ph.D.
James Ng, Ph.D.
Caroline Roper, Ph.D.
Jan Walter, Ph.D.

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Lecturers

Akif Eskalen, Ph.D.
Deborah Mathews, Ph.D.
Georgios Vidalakis, Ph.D.
Francis P. Wong, Ph.D.

Affiliated Faculty

Ellis F. Darley, Ph.D. (Plant Pathologist Emeritus)
Thomas Eulgem, Ph.D. (Botany and Plant Sciences)
Steven Garnsey, Ph.D. (Citrus Virology)
Isgouhi Kaloshian, Ph.D. (Nematology)
Philip Roberts, Ph.D. (Nematology)
Linda Walling, Ph.D. (Botany and Plant Sciences)

Undergraduate Curriculum

The Department of Plant Pathology and Microbiology participates in the Biological Sciences interdepartmental major, in which students may specialize in areas such as Microbiology, Plant Sciences, and Entomology.

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It also participates in the Botany and Plant Sciences major leading to the baccalaureate degree. See the Biological Sciences or Botany and Plant Sciences section of this catalog.

Graduate Program

The Department of Plant Pathology and Microbiology offers the M.S. and Ph.D. degrees in Plant Pathology.

Admission In addition to meeting the requirements for admission to the Graduate Division, students typically have a baccalaureate major in a biological science or training equivalent to that given in the Plant Science curriculum of the College of Natural and Agricultural Sciences. Majors in the physical sciences are welcomed, but students must be prepared to augment their undergraduate preparation with courses in the biological sciences. All domestic applicants must provide GRE General Test scores (verbal, quantitative, analytical).

All candidates for the M.S. or the Ph.D. degree should have good basic preparation in chemistry and biology. It is common for students to have completed courses in biochemistry, organic chemistry, cell and molecular biology, elementary college mathematics, general physics, general botany, microbiology, statistics, genetics, plant physiology, mycology, and plant pathology. If these courses have been completed as an undergraduate, graduate study is facilitated. If students have not completed these courses prior to admission, they may be required to take them early in their graduate career.

Master's Degree

The Department of Plant Pathology and Microbiology offers the M.S. degree in Plant Pathology.

General university requirements are given in the Graduate Studies section of this catalog. The master's degree in Plant Pathology is offered under Plans I or II.

Plan I (Thesis) requires 36 units of upper-division and graduate courses, of which at least 24 must be in the 200 series courses in Plant Pathology or Nematology. A maximum of 12 units may be in graduate research for the thesis.

Plan II (Comprehensive Examination) requires 36 units of upper-division and graduate courses, of which at least 18 must be in the 200-series courses in Plant Pathology or Nematology, excluding graduate research for a thesis or dissertation, and a comprehensive final examination in the major subject.

The departmental graduate advisory committee, in consultation with the student's major professor or curriculum advisor, is responsible for prescribing the course of study, which normally includes as a minimum PLPA 200, PLPA 203, PLPA 204, PLPA 206/NEM 206, and participation in PLPA 250 for each term the student is registered.

Doctoral Degree

The Department of Plant Pathology and Microbiology offers the Ph.D. degree in Plant Pathology.

In accord with the student's preparation and specific interests, the departmental graduate advisory committee, in consultation with the student's major professor or curriculum advisor, prescribes areas where study is required. In addition to selected subjects in plant pathology, related fields in which some degree of competence may be expected is drawn normally from biochemistry, biology, chemistry, cell and molecular biology, entomology, genetics, mathematics, microbiology, nematology, plant physiology, soils, and statistics.

The departmental graduate advisory committee, in consultation with the student's major professor or curriculum advisor, is responsible for prescribing the course of study.

Course Work The course of study normally includes, as a minimum, PLPA 200, PLPA 203, PLPA 204, PLPA 206/NEM 206, and participation in PLPA 250 each term.

Written and Oral Qualifying Examinations

Students must demonstrate to the departmental graduate advisory committee, by written and oral examination, adequate preparation in the fields fundamental to plant pathology and in any area in which students have placed special emphasis in their training. A written dissertation research proposal is to be prepared before the qualifying examination and defended during the oral examination. After successful completion of the qualifying examination and all other formal requirements to the satisfaction of the dean of the Graduate Division, the student is advanced to candidacy for the Ph.D. degree.

Dissertation and Final Oral Examination A dissertation is required of every candidate. The dissertation must be approved by the dissertation committee before the candidate may take the final oral examination. The final oral examination deals primarily with defense of the dissertation and its relation to the field in which its subject lies.

Normative Time to Degree 18 quarters

Lower-Division Course

PLPA 010. Microbes and Society: A Window into the Microbial World around Us (4) F, W Lecture, 3 hours; extra reading, 3 hours. An introduction to the remarkable diversity and biology of microorganisms.

Emphasizes the areas microorganisms impact human affairs, including food production, agriculture, medicine, and history. Includes cheese-, yogurt-, wine-, beer- and bread-making; the Irish potato famine; tulipomania; antibiotics; mushrooms and mushroom lore; food preservation; microbial toxins and food poisoning; and vaccines and useful viruses. **Douhan, Ng**

Upper-Division Courses

PLPA 120. Introduction to Plant Pathology (3) F

Lecture, 3 hours. Prerequisite(s): BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C, CHEM 001C or CHEM 01HC, CHEM 112C, MATH 009B or MATH 09HB, PHYS 002C, PHYS 02LC, BCH 100 or BCH 110A, one course in statistics; or consent of instructor. An introduction to the study of plant diseases. Topics include diseases and disease-causing agents, pathogen interaction during disease development, and strategies for disease management. An optional, separate laboratory is offered. Cross-listed with BIOL 120 and MCBL 120. **Stanghellini**

PLPA 120L. Introduction to Plant Pathology Laboratory (1) F

Laboratory, 4 hours. Prerequisite(s): BIOL 005A, BIOL 005B; concurrent enrollment in BIOL 120/MCBL 120/PLPA 120 or consent of instructor; BIOL 121/MCBL 121 and BIOL 124/MCBL 124 recommended. Covers fundamentals in the use of laboratory instruments and techniques for the detection, isolation, and identification of representative infectious agents that cause disease in plants. Cross-listed with BIOL 120L and MCBL 120L.

PLPA 123. Introduction to Comparative Virology (4) S

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C, CHEM 001C or CHEM 01HC, CHEM 112C, MATH 009B or MATH 09HB, PHYS 002C, PHYS 02LC, BCH 100 or BCH 110A, one course in statistics; or consent of instructor. Considers viruses as infectious agents of bacteria, plants, and animals (vertebrates and invertebrates). Compares the major groups of viruses to each other with respect to their biological and biochemical properties, molecular and genetic characteristics, and modes of replication. Cross-listed with BIOL 123 and MCBL 123. **Ding, Rao**

PLPA 134. Introduction to Mycology (3) F

Lecture, 3 hours. Prerequisite(s): BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C, CHEM 001C or CHEM 01HC, CHEM 112C, MATH 009B or MATH 09HB, PHYS 002C, PHYS 02LC, BCH 100 or BCH 110A, one course in statistics; or consent of instructor. Introduction to the morphology, taxonomy, genetics, physiology, ecology, and economic importance of the major groups of the fungi. Cross-listed with BIOL 134.

Adaskaveg

PLPA 134L. Introduction to Mycology Laboratory (1) F

Laboratory, 3 hours. Prerequisite(s): BIOL 005A, BIOL 005B, BIOL 005C, or equivalents; concurrent enrollment in BIOL 134/PLPA 134; or consent of instructor. Introduces fundamentals in the use of laboratory instruments and techniques for the isolation, cultivation, and identification of representatives of the major taxa of fungi. Cross-listed with BIOL 134L. **Adaskaveg**

PLPA 190. Special Studies (1-5) Prerequisite(s): consent of instructor. To be taken as a means of meeting special curricular problems.

PLPA 197. Research for Undergraduates (1-4)

Prerequisite(s): consent of instructor. Individual research in plant pathology performed under the guidance of members of the staff.

Graduate Courses

PLPA 200. Fungal Diseases of Plants (4) W, Even Years

Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 134/PLPA 134 or consent of instructor. A study of important fungal diseases of plants, including biology of development of pathogens, host-parasite relations, and survival strategies. Emphasis will be on

disease physiology, epidemiology, etiology, and control measures including breeding for resistance and chemical and biological control. **Coffey**

PLPA 201. Functional Diversity of Prokaryotes (3)

Lecture, 3 hours. Prerequisite(s): BCH 110A, BCH 110B, BIOL 121/MCBL 121; or equivalents; or consent of instructor. In-depth coverage of bacterial and archaeal bioenergetics, cell structure, diversity of metabolism, regulation of metabolism, growth, and biosynthesis, and cell-cell interactions between prokaryotes and eukaryotes. Project involves analysis of metabolic pathways from complete, annotated, prokaryotic genome sequences. Cross-listed with ENSC 205 and MCBL 201.

PLPA 203. Bacterial Diseases of Plants (4) W, Odd Years

Lecture, 2 hours; laboratory, 6 hours. An extensive introduction to bacterial diseases of plants, including: symptomatology, epidemiology, diagnosis, control, and the physiology and biochemistry of plant-bacterial interactions. **Cooksey, Ma**

PLPA 204. Viral Diseases of Plants (4) S, Even Years

Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): BIOL 120/MCBL 120/PLPA 120 or consent of instructor. A study of viral diseases of plants and the agents causing them. Topics include historical developments, symptomatology, transmission, epidemiology, management, and classification of viruses pathogenic to plants. Special emphasis placed on the molecular nature of the pathogens and the processes of pathogenesis. **Ding, Ng**

PLPA 205. Signal Transduction Pathways in Microbes and Plants (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing in the biological sciences, BIOL 107A or BIOL 113 or BIOL 114 or CBNS 101; or consent of instructor. Advanced topics in signal transduction pathways that regulate growth and development in plants and prokaryotic and eukaryotic microbes. Areas covered include two-component regulatory systems; quorum sensing; signaling via small and heterotrimeric G proteins; mitogen-activated protein kinase cascades; cAMP signaling; photoreceptors; plant hormone signaling; responses to low-oxygen stress; calcium signaling; and plant pathogenesis. Cross-listed with BCH 205, BPSC 205, CMDB 205, GEN 205, and MCBL 205. **Borkovich**

PLPA 206. Phytopathogens: Nematodes (2) S, Odd Years

Lecture, 1 hour; laboratory, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Recognition, diagnosis, biology, and control of major nematode diseases of plants. Laboratory covers identification techniques, soil sampling and processing techniques, and process of pathogenesis. Cross-listed with NEM 206. **Baldwin, Roberts**

PLPA 215. Genetics of Fungi (3)

Lecture, 3 hours. Prerequisite(s): BIOL 102 or consent of instructor. Molecular and cellular mechanisms of fungal reproduction and genetic recombination. Classical and molecular genetic methods used in mycological research. Genetics aspects of fungal metabolism, development, pathogenesis, systematics, and evolution.

PLPA 219. Molecular Plant Virology (3)

Lecture, 3 hours. Prerequisite(s): PLPA 204. Molecular biology of plant, animal, and bacterial viruses and viroids with emphasis on plant viruses; replication strategies; evolution; genetics; viruses as genetic vectors; and recombination. **Rao**

PLPA 220. Advanced Mycology (4) F, Even Years

Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): BIOL 134/PLPA 134 or equivalent; graduate standing. Provides an in-depth examination on topics in fungal biology. Includes aspects of the ecology, pathology, genetics, and evolution of fungi. **Douhan**

PLPA 221. Chemical Control of Plant Diseases (3) W, Even Years

Lecture, 3 hours. Prerequisite(s): consent of instructor. A study of the principles of selective toxicity as applied to the control of plant diseases; the chemistry and mechanism of action of antimicrobial agents. **Wong**

PLPA 226. Microbial Genetics (4) W

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 110C or BIOL 107A; BIOL 102. In-depth coverage of the genetics of microbes with emphasis on the primary data and the foundation of modern techniques using *Escherichia coli* and other prokaryotic systems. Includes genome organization, plasmids, restriction-modification systems, mutation, transposable elements, regulation of gene expression, viruses, recombination, repair, and responses to stress. Cross-listed with BIOL 221 and MCBL 221. **Borkovich**

PLPA 230. Molecular Plant-Microbial Interactions (3) F, Odd Years

Lecture, 2 hours; discussion, 1 hour. Prerequisite(s): BCH 100, BIOL 120/MCBL 120/PLPA 120, or equivalents. A study of the physiology of host-pathogen interactions with emphasis on the metabolism of diseased plants, nature of pathogenicity, and defense mechanisms in plants. Cross-listed with BPSC 230, CMDB 230, and GEN 230. **Eulgem, Jin, Kaloshian**

PLPA 235. Epidemiology of Plant Disease (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 120/MCBL 120/PLPA 120. An introduction to the study of plant disease epidemics and their management. Topics will include: temporal, spatial, and genetic aspects of disease development in plant populations; assessment and prediction of disease and crop loss; inoculum density-disease relationships; and modeling. **Adaskaveg**

PLPA 240. Field Plant Pathology (1) F

field trips. Prerequisite(s): consent of instructor. This course will deal with diagnosis of plant disease in the field, collection methods, identification of pathogens, and control methods. Graded Satisfactory (S) or No Credit (NC). **Adaskaveg**

PLPA 241. Special Topics (2)

Lecture, 2 hours. Prerequisite(s): graduate standing or consent of instructor. Oral presentations and intensive small-group discussion of selected topics in each faculty member's area of specialization. Course content emphasizes recent advances in the special topic area and varies accordingly. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with MCBL 241.

PLPA 245. Field Mycology (1)

field trips. Prerequisite(s): BIOL 134/PLPA 134 or consent of instructor. This course will deal with observation, collection and identification of fungi both in the field and the laboratory. Graded Satisfactory (S) or No Credit (NC).

PLPA 246. Diagnosis of Plant Disease (2) W

Lecture, 1 hour; laboratory, 1 hour; field, 2 hours. Prerequisite(s): graduate standing or consent of instructor. Field trips to observe symptomatology of diseases in nature, identification by laboratory and greenhouse tests, approaches to control, culture practices for major California crops, and influences of crop management on disease development. **Adaskaveg**

PLPA 250. Seminar in Plant Pathology (1)

Seminar, 1 hour. Reports and discussions of selected topics in plant pathology by graduate students. Graded Satisfactory (S) or No Credit (NC).

PLPA 260. Current Research in Plant Pathology (1)

Seminar, 1 hour. Prerequisite(s): graduate standing. Topics in plant pathology will be discussed by outstanding workers in the field from this and other campuses and by graduate students. Graded Satisfactory (S) or No Credit (NC).

PLPA 261. Seminar in Genetics, Genomics, and Bioinformatics (1)

Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Oral reports by visiting scholars, faculty, and students on current research topics in Genetics, Genomics, and Bioinformatics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with BCH 261, BIOL 261, BPSC 261, ENTM 261, and GEN 261.

PLPA 265. A Colloquium on the Principles of Plant Pathology (3)

Lecture, 3 hours. Prerequisite(s): advanced standing in the program. Faculty members will rotate as leaders in structured discussions leading to a synthesis of concepts from other courses, the heterogeneity of plant pathology as a scientific discipline, and its unifying principles. Graded Satisfactory (S) or No Credit (NC).

PLPA 290. Research or Study on Special Topics by Individual Graduate Students (1-6)

Outside research, 1-6 hours. Prerequisite(s): graduate status. This course is designed to allow graduate students to study an area or areas not covered by formal course work under a professor who will direct the amount and judge the quality of the work. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

PLPA 291. Individual Study in Coordinated Areas (1-6)

Outside research, 1-6 hours. Prerequisite(s): graduate status. A program of study designed to advise and assist candidates who are preparing for examinations. A student may take up to 12 additional units prior to successful completion of the Ph.D. qualifying examination. Graded Satisfactory (S) or No Credit (NC).

PLPA 297. Directed Research (1-6)

Graded Satisfactory (S) or No Credit (NC).

PLPA 299. Research for Thesis or Dissertation (1-12)

Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Political Science

Subject abbreviation: POSC

College of Humanities, Arts, and Social Sciences

Shaun Bowler, Ph.D., Chair
Department Office, 2206 Watkins Hall
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Professors

Shaun Bowler, Ph.D.
John C. Laursen, Ph.D.
David S. Pion-Berlin, Ph.D.

Professors Emeriti

Francis M. Carney, Ph.D.
Max Neiman, Ph.D.
Frank Way, Ph.D. (Political Science/Religious Studies)

Associate Professors

Juliann E. Allison, Ph.D.
Benjamin Bishin, Ph.D.
Kevin M. Esterling, Ph.D.
P. Martin Johnson, Ph.D.
Ronald O. Loveridge, Ph.D.
John N. Medearis, Ph.D.
S. Karthick Ramakrishnan, Ph.D.